A BIBLIOGRAPHICAL STUDY OF WESTERN PUBLICATIONS (1800-1985) ON TRADITIONAL CHINESE SCIENCE

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A B S T R A C T

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This bibliographical study is designed to: (i) identify Western-language works published between 1800 and 1985 that deal specifically with traditional Chinese science and are written by those *best* described as representatives or members of academic, scholarly, professional, and similar communities from a West European country, America, Canada, Australia and New Zealand; (ii) provide a profile of these Western contributions through a systematic description of the works and the study trends that they demonstrate; (iii) review bibliographic access to and control of these publications; (iv) organise this body of material into a classified bibliography.

There are two parts to this bibliographical study. **PART I** is the main text or literature survey. It consists of ten chapters: **1.** Introduction; **2.** Traditional Chinese Science -- General Works; **3.** Traditional Chinese Science -- Fundamental Concepts; Philosophy; Social and Cultural Relations; **4.** Mathematics; **5.** Astronomy; **6.** Earth Sciences; **7.** Physics; **8.** Alchemy; Early Chemistry; **9.** Biology; **10.** Conclusion.

The eight subject chapters outline titles concerned in a roughly chronological order starting with the earliest works, and give an indication of the shapes and contours Western interests in the areas had assumed. Additionally, they review the level of activity of various countries and the professional training and specialisations of those responsible for the studies, address the forms which these publications have taken, and examine bibliographic provision and control.

PART II is made up of two classified bibliographies. The first contains all the works covered by the main survey; the second is a supplementary bibliography of other titles relevant to the subject.

The study is meant to be of interest to scholars, students and librarians with or without prior knowledge of traditional Chinese science. It is also hoped that the broad overview will persuade those in the field to pay closer attention to historiographical issues and bibliographic concerns.

C O N T E N T S

PART I
(Chapter 1 - 10)

CHAPTER 1 : INTRODUCTION

Why a bibliographical study of Western works on traditional Chinese science? Why this particular subject? Why in the form of a chronological account and not a simple bibliographic listing? Why those published between 1800 and 1985? Why is this a valid, legitimate and useful undertaking?

The plans to conduct such a study took shape shortly after I became responsible for a library collection specialising in the history of East Asian science, technology and medicine. It was initially intended as an exercise to familiarise myself with the available Western literature and as a practical working aid for my own reference: I was not previously exposed to the field and had much to learn. I was also intrigued by the remark made routinely that precious little had been written on the Chinese scientific traditions, and that all works stood in the shadow of those by Joseph Needham. Moreover, some of the researchers whom I served informed me that they experienced difficulties with collecting bibliographic information on Western-language materials.

Trusting that works of a bibliographical or historiographical nature could provide me with some guidance and assistance, I searched for broadly-based and informed accounts devoted specifically to tracing the contours of past Western scholarship on and involvement with the subject, comparing activities in one area with those in another, and giving hints and directions for navigating one's way out of the fog. But I soon discovered to my dismay that these were extremely rare commodities. So were reliable, up-to-date, well-organised and easy to use bibliographies for Western works in all branches of traditional Chinese science.

I began to feel more and more compelled to carry out my own investigation into the matter. My suspicion that Western interests and publications in the history of Chinese science were more varied and complex than generally assumed also increased as time progressed.[1] Furthermore, I was very keen on sharing the bibliographic inquiry and literature survey with others as it could be a handy reference tool that would benefit all and sundry.

The research and actual composition of the study took a very long time, during the course of which its emphasis, objectives, format, and findings were subjected to a number of revisions and modifications. As with most first attempts and works that survey a vast area much of which has hitherto been left uncultivated, my bibliographic project sprouted new shoots as it grew and ran into unforeseen ~~unforseen~~ complications and obstacles. Moreover, very often one has little to guide one's progress or fall back on except one's intuition and experience, gained through trial-and-error. The present overview should thus be considered more as a report of work in progress than a definitive study.

Nevertheless, even a limited report cannot fail to bring to light unfamiliar or neglected material, and this small contribution should function well as a sound, responsible, systematic and practical guide that can inform one of the basics as well as the overall pattern. It can be read with profit and interest by scholars as well as librarians who travel occasionally to the land of traditional Chinese science as well as by those who dwell there most or all of the time. It is also hoped that it may persuade everybody into paying closer attention to the issues of historiographic trends and bibliographic provision when dealing with the subject of traditional Chinese science.[2]

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[1]I was encouraged, for instance, by Nathan Sivin's review "Science and Medicine in Imperial China: The State of the Field" which appeared in 1988. It gives ample justification to the view that by mid-late 1980s, research on traditional Chinese science, technology and medicine in both East Asian and Western countries can no longer be regarded as an academic backwater and oddity to be dismissed summarily. The article ends with three short but stimulating sentences: "There is a frontier of research. It is well populated and vigorous. Everyone can contribute to extending it": Nathan Sivin, "Science and Medicine in Imperial China: The State of the Field," Journal of Asian Studies, 47 (1988), 73.

[2]Though hard evidence is lacking, there are grounds to speculate that these issues have fallen through the cracks and not received the dedicated treatment they need and deserve because those few within the circle who are best qualified to tackle them rarely perceive the urgency of such matters (since they themselves are already in the

1.1 OBJECTIVES AND SCOPE

This bibliographical study is designed and written with the following aims, functions, and concerns in mind:

* To identify Western works published between 1800 and 1985 that deal specifically with traditional Chinese science.
* To provide a profile of Western contributions to this field of study through the coherent and systematic description of these writings, the authors involved, and their forms of publication.
* To review bibliographic access to and control of these studies with an eye to assisting researchers and librarians with building their own bibliographic inventories or library collections.
* To organise this body of material into a classified bibliography.

These statements cannot be left unqualified and unclarified. Certain caveats need to be stressed and some of the terms must be carefully explained:-

(1) A "Western" publication in this study is interpreted as one written in English, French or German; also included is an extremely small percentage of titles in other West European languages (e.g. Italian). Difficulty with obtaining bibliographic information on titles in these other languages has meant that a comprehensive coverage of *all* literature in West European languages was not possible. Russian and East European works have been omitted because of my lack of a working knowledge in these languages, and in the main they belong to a rather different academic and scholarly tradition.

(2) As well as the language requirement, a "Western" publication has to be authored by an individual who is *best or most appropriately* described as a representative or member of an academic, scholarly, professional, religious, and similar community in a West European country, America, Canada, Australia or New Zealand.[1] Hence, studies by such authorities on Chinese science as Yabuuti Kiyoshi, Nakayama Shigeru, and Xi Zezong are not discussed even though some of their

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know), while persons outside are ill-equipped to mine the rich fare that lies within.

[1]Typically on account of the places and institutions where they undertook their education and training, and / or made their long-term professional affiliations.

publications were written in or have been translated into English. On the other hand, contributions from missionaries, engineers, scientists, medical doctors, government officials, etc. from the West who have spent a significant part of their working lives in China are taken into consideration (e.g. Joseph Edkins, Herbert Chatley); as are accounts from individuals who have pursued a good portion of their teaching or research careers at institutions in the West even though they received their education initially in non-Western countries (e.g. Wang Ling). This seemingly peculiar selection criterion arises largely out of pragmatic considerations: it is felt that such strategy affords the best way of isolating literature that indeed represents and demonstrates *Western* activities in and sensitivities towards this area of study.[1]

(3) In the main survey, not only is a publication referred to as "Western", but often also designated as one from a particular country. What exactly is an "American" or a "French" contribution? How should one handle scholars who have been trained and / or have worked during the early part of their careers in one country, but later

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[1]Admittedly there will always be room for disagreement and there are indeed some troublesome cases. The situation with Emil Bretschneider, Yoshio Mikami, and Lam Lay Yong in fact posed so much difficulties that in the end it was decided to admit their relevant English publications into the main survey: *not* because they should be considered as contributions from the West or as part of the Western experience -- it would be unfair to rate them as such -- but because the story of the development of Western efforts would be incoherent and imprecise if these works were to be left out. In commenting on a 1967 reprint of the late 19th century work Botanicon Sinicum: Notes on Chinese Botany from Native and Western Sources by Bretschneider -- physician at the Russian Legation in Peking for seventeen years -- Sivin wrote: "Still the leading source on Chinese botany in a Western language": Nathan Sivin, annotation for this title, ISIS Cumulative Bibliography, 1966-1975, vol. 2, ed. John Neu (London: Mansell, 1981-85), pp. 247. The Japanese mathematician Mikami played a decisive role in early 20th century Western research into traditional Chinese mathematics, and his The Development of Mathematics in China and Japan published in 1913 has influenced a generation of Western scholars. And out of fifty titles published between 1960 and 1985 on the history of Chinese mathematics, Lam -- Professor at the University of Singapore's Faculty of Mathematics -- was responsible for thirteen.

moved to another.[1] In this matter one does not benefit from being too rigid. The general rule of thumb is to count the work as one from the country the individual was in at the time it was published. After all, one should bear in mind that the ultimate purpose of this study is not that of "totting up scores" for the various countries; the overall pattern is of far greater interest to us.

(4) It is easy to understand our concern for materials from the 20th century, especially the post-1950 collection which in terms of quantity, variety, and scholarship is truly impressive -- though not all pieces are worthy of high praise. But one may be curious to know why coverage has been extended to the preceding century. Viewing more recent literature in the light of what has been done in the past is always illuminating, and in this particular case, there is room to go back to the 19th century, but not any further than that. Besides, more than a few writers were active in the period that stretched from the late 19th to the early 20th century.

(5) Publications on traditional Chinese technology and traditional Chinese medicine, belonging as they are to the disciplines of history of technology and history of medicine respectively, call for separate studies, and are therefore not included here.

There is, nevertheless, the problem of how and where to draw the line between science and technology -- an issue about which tomes have been written and academic careers forged. Suffice to say, for our present purpose, the following areas are deemed as falling into the domain of technology, and thus are not considered: agricultural technology; engineering and mechanical technology; materials and processes; and military technology.[2] Note that studies discussed in

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[1]e.g. Wittfogel received his doctorate from Frankfurt, taught there till the mid-1930s when he moved to the U.S., and stayed at the University of Washington for over two decades; Jock Hoe, Senior Lecturer at Victoria University of Wellington, held higher degrees from Université Paris VII as well as Cambridge University.

[2]More specifically, the following aspects: under agricultural technology -- agricultural implements and techniques, soil science, cultivated crops, horticulture, sericulture, pisciculture, animal husbandry, food technology; under engineering and mechanical technology -- south-pointing chariots, ship-building, aeronautics, energy conversion, mechanisms and mechanical technology, clockwork and timekeepers; under materials and processes -- ceramic technology, papermaking and printing technology, glass technology, coal and salt

Chapter 2: Traditional Chinese Science -- General Works and *Chapter 3: Traditional Chinese Science -- Fundamental Concepts; Philosophy; Social and Cultural Relations* occasionally include topics on technology as well as medicine. In addition, some aspects treated in certain chapters may involve technological skills (e.g. magic mirrors, early chemistry).

(6) To be eligible for admission into the survey, a publication should contain ample evidence that its main theme or subject deals substantially with and bears directly and explicitly on traditional Chinese science -- not that it is merely relevant to its study. An article or a book (by a single author) with individual chapters or sections on traditional Chinese science, but with an overall emphasis that lies elsewhere is therefore not treated.[1] This stems primarily from the need to concentrate on a clearly-defined and well-circumscribed group of material.[2]

Nevertheless, two formidable obstacles remain. First, the goals and intentions of authors are always open to debate.[3] Second,

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mining and technology; under military technology -- armour, weapons with and without gunpowder, siege technology.

[1]J. P. Abel-Rémusat, Histoire de la Ville de Khotan, tirée des annales de la Chine et traduite du chinois; suivie de recherches sur la substance minérale appelée par les chinois pierre de *iu*, et sur le jaspe des anciens (Paris: Doublet, 1820), Alexander Wylie Notes on Chinese Literature (Shanghai: American Presbyterian Mission P / London: Trübner, 1867), Herbert A. Giles Adversaria Sinica (Shanghai: Kelly & Walsh, 1914-15), and George Sarton, Introduction to the History of Science, 3 vols. (Baltimore: Williams and Wilkins, 1927-47), are some of the works that spring to mind.

[2]To minimise random shifts in one's focus, it is always best to start with a relatively strict rule which can be applied consistently; chances of ending up with a confusing diversity are then less likely.

[3]Seldom are they stated openly and articulated expressly by the authors themselves. The following cases are rare exceptions: (i) "This chapter is to be on the cosmology of ancient and medieval China; and I think we may fairly give about a third of it to the astronomical aspects and two-thirds to eschatology": Joseph Needham, "The Cosmology of Early China," in Ancient Cosmologies, ed. Carmen Blacker, and Michael Loewe (London: Allen & Unwin, 1975), pp. 87. (ii) "Where the historian of Chinese science tends to be concerned with the accuracy of such ratios and measurements as the obliquity of the ecliptic and the length of the solar years as determined by the astronomer-astrologers of T'ang, I am much more concerned with the

although what exactly constitutes traditional Chinese science is unclear, and the function of this study does not extend to exploring this key question conceptually, one can hardly avoid asking it when seeking to determine a publication's theme.[1] All this being so, the assessment of a publication's suitability as a candidate for this survey can never in reality be completely free from all fuss and subjectivity.[2]

(7) There exists a body of historical studies on those Chinese scientific activities that involved a significant measure of Western influence or reflected recognisably Western elements.[3] These accounts are not considered as they exhibit distinctive characteristics of their own (e.g. special attention to scientific and technological knowledge and writing from the West at the time).

(8) Brief notes that consist merely of a few sentences as well as book reviews that do not contain a large proportion of original research and observations are generally excluded. As are unpublished materials, which include a handful of doctoral theses that have not appeared as monographs in one form or another.

(9) The attentive reader will have noticed that thus far no mention is made regarding the scholarly standard and the merit of a study in the selection process. This matter has not been raised because the

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benign or alarming visions that signalled to them from the black vault. . .": Edward H. Schafer, Pacing the Void: T'ang Approaches to the Stars (Berkeley, Calif.: U of California P, 1977), pp. 3.

[1]See discussion of this problem in *1.2 Organisation and Treatment of Titles* below.

[2]That the main areas of interest in a work are only partially or tangentially concerned with traditional Chinese science, I must hasten to add, in no way implies that the study has nothing important to say. In fact, when seeking bibliographic information on *all* relevant Western-language accounts on a given topic, it would be unwise to ignore some of these other titles.

[3]One of the most important periods for such activities was the 17th century when the presence of the Jesuits was keenly felt. The tale is intriguing and scholars have undertaken the task of investigating these scientific and technological exchanges from different strategic points. Among the questions asked regularly is the extent to which "traditional" or "indigenous" Chinese scientific and technological thinking and operations were affected or modified as a result of this encounter.

worthiness of a publication, its views, approach or conclusions do not govern and should not influence its inclusion or exclusion even though it is indeed legitimate to question the practical use of some works and the value of certain observations.[1] After all, the provision of critical reviews or a list of what I (or anybody) consider to be "the best" or "most favoured" works is not the main role and function of this guide, which rather is concerned with the identification of titles, description of the contents and significant elements in these writings, portrayal of study trends, publication patterns, and participants.

Nevertheless, even in the process of straightforward description and narration no one can totally abjure the application of some sort of value judgment no matter how subtle and innocuous. And I do not wish to make any claim that all titles have been given equal treatment.[2] (More is said in *1.2 Organisation and Treatment of Titles.*)

(10) To assist those who are interested in *all* works in Western-languages, irrespective of why, when, by whom or in what form they have been written and published, a *Supplementary Bibliography for Other Works on Traditional Chinese Science* is provided. Assembled in this list are titles which have been removed from the main discussion for various reasons (e.g. the thesis is not available in published form; the author is regarded as "non-Western"; the work is not focused expressly on traditional Chinese science; it is only a very brief note with a few short sentences; I have not been able to verify the existence of the study or the journal cited -- though others may wish to pursue the detective work further).[3] There is no claim, however,

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[1]For example, according to the calculation of Franz Kühnert and others, the beginning of the Chinese astronomical system dated back to 14,000 B.C. or even earlier.

[2]This is reflected, for instance, in differences in the amount of space allotted, the kind and length of excerpts and quotations.

[3]One of the most striking examples of titles that cannot be verified is the following. According to Science and Civilisation in China, an article by G. Vacca supposedly on the mathematical text *Chou pei suan ching* was published in 1904, but this item still remains elusive and much of a mystery. In Science and Civilisation in China, vol. 3, Bibliography C, it is given as "Vacca, G. (4) (tr.) Translation of the Chou Pei Suan Ching. BBSSMF, 1904, 7". There is

that this supplementary list is comprehensive.

(11) In seeking to establish as faithful an overall profile as possible and to assess properly how well bibliographic sources have done their job, no efforts have been spared in seeking out titles of potential relevance. But needless to say, the result cannot pretend to completeness and it would be false to claim that I have not left any stone unturned. I have relied heavily (though not exclusively) on -- and hence have been limited by -- what is supplied in two principal types of sources.

I. GENERAL BIBLIOGRAPHIES FOR CHINESE / ASIAN STUDIES AND THE HISTORY OF SCIENCE:

(a) Henri Cordier, Bibliotheca Sinica; Dictionnaire bibliographique des ouvrages relatif à l'Empire chinois. . . . 2. éd., rev., cor. et considérablement augm. . . ., 4 vols. (Paris: E. Guilmoto, 1904-08). Supplement et index. . . (Paris: P. Geuthner, 1922-24).

(b) John Lust (with the assistance of Werner Eichhorn), comp., Index Sinicus: A Catalogue of Articles relating to China in Periodicals and other Collective Publications, 1920-1955. . . (Cambridge: W. Heffer, [1964]).

(c) Magda Whitrow, ed., ISIS Cumulative Bibliography: A Bibliography of the History of Science formed from ISIS Critical Bibliographies 1-90, 1913-65, 6 vols. (London: Mansell, in conjunction with the History of Science Society, 1971-74). John Neu, ed., ISIS Cumulative Bibliography, 1966-1975: A Bibliography of the History of

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also a remark on page 20 of the same volume that this Chinese mathematical classic "has been translated in full by E. Biot (4), and in part by Vacca (4)." However, the translation is not to be found in that particular issue of the Bollettino di Bibliografia e di Storia della Scienze Matematiche e Fisiche [Boncompagni's]. Frank J. Swetz and Ang Tian Se have also made the comment that, "Vacca has been credited with a translation of the Chou Pei Suan Ching (Zhou Bei Suan Jing) [Needham 1954, 3:796], however, it does not exist under the reference given. Vacca did translate some passages from the Chou Pei [1905], but apparently not the whole work": Frank J. Swetz, and Ang Tian Se, "A Brief Chronological and Bibliographic Guide to the History of Chinese Mathematics," Historia Mathematica, 11 (1984), 50. Moreover, the Vacca title is not listed in the bibliographies of major publications in the field such as Ulrich Libbrecht's Chinese Mathematics in the Thirteenth Century: The *Shu-shu chiu-chang* of Ch'in Chiu-shao (Cambridge, Mass.: MIT P, 1973) or Jean-Claude Martzloff's Histoire des mathématiques chinoises (Paris: Masson, 1988).

Science formed from ISIS Critical Bibliographies 91-100, Indexing Literature published from 1965 through 1974, 2 vols. (London: Mansell, in conjunction with the History of Science Society, 1980-85). John Neu, ed., ISIS Cumulative Bibliography, 1976-1985: A Bibliography of the History of Science formed from ISIS Critical Bibliographies 101-110, Indexing Literature published from 1975 through 1984, 2 vols. (Boston: G. K. Hall, in conjunction with the History of Science Society, c.1989). John Neu, ed., ISIS Current Bibliography of the History of Science and Its Cultural Influences 1986- (Chicago: U of Chicago P for the History of Science Society).

(d) Bulletin of Far Eastern Studies 1936-40, 5 vols. (Washington, D.C.: Committee on Far Eastern Studies of the American Council of Learned Societies); then Far Eastern Bibliography 1941-55 [issued as part of Far Eastern Quarterly]; then Bibliography of Asian Studies 1956- [from 1956 to 1968 issued as part of Journal of Asian Studies] (Ann Arbor, Mich.: Far Eastern Association, later Association of Asian Studies).[1]

(e) Bulletin Analytique. Philosophie 1947-55; then Bulletin Signalétique. Philosophie; Sciences Humaines 1956-60; then Bulletin Signalétique. 19 Sciences Humaines; Philosophie 1961-63; then Bulletin Signalétique. 19-23 Sciences Humaines; Philosophie 1964; then Bulletin Signalétique. 19-24 Sciences Humaines; Philosophie 1965-67; then Bulletin Signalétique. C (19-24) Sciences Humaines 1968; then Bulletin Signalétique. 522 Histoire des Sciences et des Techniques 1969-90; then Francis: Bulletin Signalétique. 522 Histoire des Sciences et des Techniques 1991- (Paris: Centre National de la Recherche Scientifique, Centre de Documentation).[2]

(f) Revue Bibliographique de Sinologie 1-15 (1955-70); new ser., 1- (1983-) (Paris: Mouton).

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[1]Volumes for 1941 to 1965 cumulated as: Cumulative Bibliography of Asian Studies: Author Bibliography, 1941-65, 4 vols., and Cumulative Bibliography of Asian Studies: Subject Bibliography, 1941-65, 4 vols. (Boston: G. K. Hall, 1969-70). Volumes for 1966 to 1970 cumulated as: Cumulative Bibliography of Asian Studies: Author Bibliography, 1966-70, 3 vols., and Cumulative Bibliography of Asian Studies: Subject Bibliography, 1966-70, 3 vols. (Boston: G. K. Hall, 1972-73).

[2]The name of the section within CNRS that sponsors the publication varies.

(g) Tōyōgaku Bunken Ruimoku 1963- (Kyoto: Kyoto Daigaku Jinbun Kagaku Kenkyūjo).

II. SPECIALISED BIBLIOGRAPHIC SOURCES:

For instance, Nathan Sivin, "An Introductory Bibliography of Traditional Chinese Science: Books and Articles in Western Languages," in Chinese Science: Explorations of an Ancient Tradition, ed. Nathan Sivin (Cambridge, Mass.: MIT P, 1973), pp. 279-314, supplemented by his "A Supplementary Bibliography of Traditional Chinese Science; Introductory Books and Articles in Western Languages," Chinese Science, 7 (1986), 33-41. Various "Bibliography C: Books and Journals Articles in Western Languages" in Science and Civilisation in China (Cambridge: Cambridge UP, 1954-) are particularly important. Not all subject areas have special bibliographic guides to offer.

Additionally, much use was made of the library catalogue and other finding aids at the Needham Research Institute. Attention was also been paid to references and citations in the studies themselves.

(12) With the exception of seventeen entries, I have personally examined all eight hundred or so titles considered in the main text.[1] The initial plan was not to include any work I did not inspect, but I felt uncomfortable omitting those that bore every indication that they deal primarily with our subject area. In most of these cases, their contents have been described in another work or their authors wrote similar studies that were inspected, and they can be made available if pursued further (e.g. libraries have confirmed that they own copies). More is said in *1.2 Organisation and Treatment of Titles.*

(13) Finally, it cannot be emphasized enough that the selection of entries is an operation of considerable complexity; even given the same set of guidelines and criteria, and applying due caution, no two

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[1]The task of locating and gaining access to a copy of hundreds of works (including many that were found to be unsuitable for inclusion) proved exceedingly time-consuming and laborious, involving many wranglings with inter-library loans departments and trudging in the bookstacks of not a few libraries. Hopefully that has helped ensure that bibliographic details are accurate, errors are not perpetuated, and contents are described properly.

persons would come up with identical lists.

1.2 ORGANISATION AND TREATMENT OF TITLES

How should the titles be grouped? What terms should be used for the various classes and sub-divisions?

The task of categorisation and of devising an appropriate classification system is not simple. No existing scheme or arrangement is available for adoption with only minimal modification. Besides, the present bibliographic survey and its accompanying list seeks to cater to a wide variety of users, some with intricate needs; whatever ruling method or principle be followed, it is bound to displease one group or neglect one consideration at some point. Furthermore, there are still ambiguities and uncertainties in defining the nature and branches in traditional Chinese science, and these problems have compounded those ever-present difficulties and confusions experienced by all who have tried their hands at classifying hundreds of publications covering a broad array of topics. For instance, that some topics and works can legitimately be placed under two or more classes certainly has a familiar ring to one's ear.[1] Another challenge is that different authors emphasize different facets or aspects of the same subject or lean on different types of evidence and disciplinary approaches.

As the primary aim of the present study is to reflect the content of a distinct block of material and to strive for ease of access, it is felt that the most sensible way to organise the literature concerned is to apply as far as is practicable those categories and vocabulary commonly employed in the publications themselves, while at the same time taking care that they be comprehensible to readers not heavily exposed to the history of science or Chinese studies. It is important that this decision be regarded as resul-

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[1]e.g. (i) "Paleontology" (such as studies on traditional Chinese knowledge of fossil fish) can be considered a sub-class under "Earth Sciences" or under "Biology"; this topic is treated differently in each of the respective classification systems used by <u>ISIS</u>, <u>Bulletin Signaletique 522</u>, and <u>Science and Civilisation in China</u>); (ii) literature on metrology and weights and measure can be subsumed under either "Mathematics" or "Physics".

ting from expediency and not confuse it with claims for the organisation of traditional Chinese scientific, technological or medical knowledge.[1] Also essential to note is that with all the complica-

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[1]It is hoped that such arrangement would raise the least amount of objection and inconvenience, but criticism is inevitable -- and for good reasons.

In a stimulating discourse on the nature and study of Chinese science, Sivin has argued persuasively that Chinese alchemists did not look upon themselves and their tasks as modern chemists do, that "the understanding of living phenomena never emerged as a distinct issue in Chinese natural philosophy or in the operative sciences", that "'mechanical engineering' suggests a coherent basis in principles and technics that was not found in ancient China": Nathan Sivin, "Introduction," in Science and Technology in East Asia, ed. Nathan Sivin (New York: Science History Publications, 1977), pp. xiv.

In classifying the Chinese sciences, he (as well as Christopher Cullen and Hans Ågren) have advocated dividing them up into first, the "Qualitative sciences" (which are "concerned primarily with number and its application to physical reality"): i.e. "Mathematics", "Mathematical harmonics", and "Mathematical astronomy". Second, the "Quantitative sciences" (which are concerned with "applications of yin-yang, Five Phases (*wu hsing*), and other verbal concepts to different realms of human experience": i.e. "Medicine", "Materia Medica", "Alchemy", "Astrology", "Geomancy", and "Physical Studies": Sivin, "Introduction," pp. xiii.

Following the way "the Chinese themselves organize [the fields of science] in the course of conceptualizing the phenomenal world" is also articulated in another article of his: Nathan Sivin, "Preface," in Chinese Science: Explorations of an Ancient Tradition, ed. Shigeru Nakayama, and Nathan Sivin (Cambridge, Mass.: MIT P, 1973), pp. xix. Likewise, Ågren has stressed in no uncertain terms that "analyzing Chinese scientific reasoning in terms of European subdivisions like physics, chemistry, biology, and so on, can produce serious misrepresentations of Chinese ambitions for always seeing interrelations between various fields of knowledge", and that "craftsmen were unlikely to be classically educated and thus the probability of thinking along natural philosophical lines was small": Hans Ågren, "Chinese Science," in Dictionary of the History of Science, ed. W. F. Bynum, E. J. Browne, and Roy Porter (London: MacMillan, 1981), pp. 65-66.

I share their view and have long struggled with the discomfort of being cast in the unfortunate role of seeming to encourage the "tendency of those who write on East Asian technical history to impose modern Western rubrics on it": Sivin, "Preface," pp. xiv. But whether I -- or anybody faced with the task at hand -- condone or condemn what Sivin called "positivistic assumptions" is irrelevant here: ibid. Ultimately, the one question that concerns us is whether this way of classifying the subjects and disciplines works in this particular instance. Though some of the terms suggested are useful (and have been adopted), such system cannot be borrowed as the basis of arrangement here. For instance, it is not clear as to exactly what titles are to be grouped under the divisions "Physical Studies" or "Natural Philosophy". And the simple reality is that authors --

tions just mentioned, a certain degree of arbitrariness will always attend the designation of a study as one belonging to a particular sub-section or chapter, and sometimes the positioning of titles or topics has much to do with sheer bibliographic convenience.

There are three parts to this bibliographical study:-

PART I: This is the main text or literature survey. It consists of ten chapters: 1. Introduction; 2. Traditional Chinese Science -- General Works; 3. Traditional Chinese Science -- Fundamental Concepts; Philosophy; Social and Cultural Relations; 4. Mathematics; 5. Astronomy; 6. Earth Sciences; 7. Physics; 8. Alchemy; Early Chemistry; 9. Biology; 10. Conclusion.[1]

The main bulk of each of the eight subject chapters is occupied by the characterisation of the titles concerned and the indication of the shapes and contours Western interests in the areas had assumed. Within each chapter are numbered subject sub-divisions (e.g. "4.2 Arithmetic; Numbers and Numeral Notations; Abacus; Algebra", "6.5 Mineralogy").[2] Works in each sub-division are treated in a roughly chronological order.

For the vast majority of studies some form of brief introduction (e.g. how it is arranged, what sources it has used, what its main themes are) is furnished so that readers can learn more about them. It is felt that merely providing an inventory is not of much service to those who are not acquainted with the subject or not sure what to expect from these titles; and even for those that are more

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including Needham -- responsible for the Western works included in this survey by and large have employed Western terminology and categories in their writings and for differentiating between the various branches and aspects. Besides, the majority of those seeking bibliographic information is likely to be more familiar with "Earth Sciences" or "Botany" rather than "Physical Studies". Hence, for example, an article on records relating to snow crystals from the T'ang period is placed in the "Meteorology" section even though in no way does that imply that individuals who made the observations consciously regarded themselves as professional meteorologists.

[1]This order is modelled after the Science and Civilisation in China arrangement. ISIS prefers (roughly): mathematics; physics; chemistry; astronomy; earth sciences; biology. Bulletin Signaletique 522, on the other hand, has opted for: mathematics; astronomy; physics; chemistry; earth sciences; biological sciences.

[2]The exception is Chapter 3 which has period sub-divisions.

familiar with the field, these descriptions would help jog or refresh one's memory. In other words, these "annotations" are intended primarily to serve as pointers, as signposts to provide a sense of direction; as mentioned, description and characterisation, not analysis and evaluation is the watchword. At times an assessment of the standard of scholarship of a work is important (e.g. the positions taken may be extreme or the theses espoused may be long outdated). When such occasions arise, the appraisal is based chiefly on published comments and interpretations made, for instance, in book reviews.

In each chapter, following the discussion of the literature are three additional sections: one concentrates on reviewing the level of participation of various countries -- in particular that of Britain, France, Germany, and America, and the professional training and specialisations of those responsible for the studies; another addresses the forms which these publications have taken (e.g. whether as journal articles or monographs, the types of periodicals involved); and the third is devoted to bibliographic provision and control. This last section goes through one by one the seven general bibliographies and indexes for Chinese studies and for the history of science mentioned above to consider how effectively they handled the topics and areas discussed in that chapter (e.g. how many and what kind of titles they have supplied, how they have classified these works). Special bibliographic sources that are of major significance and assistance in the bibliographic provision and control of the particular subject area concerned are also examined.

PART II: This is made up of two classified bibliographies. The first contains all the works covered in Part I; the second is a supplementary bibliography for other works of interest that cannot be included in the main survey.

Titles within each sub-division are arranged chronologically (as the discussion is conducted in like manner). Titles that I have not examined are dealt with as follows: in the main chapters they are marked "[I have not seen this title]" and descriptions or comments given to them in other works are provided; in the bibliographies they are labelled "[NOT SEEN; CITED IN:. . .]". The date given for a work is that of the earliest publication.

APPENDICES: *(i) Glossary* lists Chinese persons, terms, titles of works, etc. mentioned in the main text (but not when they appear in quotations). It is arranged alphabetically by Wade-Giles romanisation in one sequence with Chinese characters and English translations.

Romanisations in this bibliographic study are in Wade-Giles (except in quotations from works which use other systems). Nowadays one encounters some publications that follow Wade-Giles and others that employ Pinyin.[1] However, Wade-Giles is found in nearly all works treated here (since they belong to the period before Pinyin became widely accepted), and there is little chance that the Science and Civilisation in China series will ever switch to Pinyin. For the convenience of those readers not thoroughly conversant with both systems, the Pinyin equivalent is given.[2]

Translations of Chinese titles are taken from Science and Civilisation in China whenever they are available -- not because they are perfect, but because mine are likely to be worse. More importantly, this seems to be the most practical: first, there is no standard translation for a title or a single source of reference used universally by everyone in the China field; second, some titles have not been translated elsewhere (or into English); third, using basically the same translation as that in Science and Civilisation in China -- which is consulted by a large percentage if not all of those interested in traditional Chinese science -- should be less confusing for those who do not read Chinese.[3] On those rare occasions when a *significantly different* translation of a title came to my attention,

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[1]Chinese Science, for instance, accepts both systems.

[2]e.g. Ch'ien Han shu = Qian Han shu

[3]For the sake of comparison, the more dedicated readers can also refer to other sources such as the The Indiana Companion to Chinese Literature, ed. & comp., William H. Nienhauser, jr. (Bloomington, Ind.: Indiana UP, 1986). This reference work, for example, translates *Shih ching* as "Classic of Poetry" while Science and Civilisation in China calls it "Book of Odes; <ancient folksongs>", and *Pao p'u tzu* is "The Master who Embraces Simplicity" in the former work, but "Book of the Preservation-of-Solidarity Master" in the latter.

the alternative is given together with its source.[1] Similarly, when the translation is not taken from Science and Civilisation in China, this is indicated.

(ii) Works Consulted lists auxiliary and supporting material, for instance those related to bibliographic control and literature surveys, some of which are cited in the main text.

Finally, a word on several studies that have provided inestimable aid, guidance and inspiration throughout the reading, writing, thinking, and research process.[2]

(1) Nathan Sivin, "Science and Medicine in Imperial China: The State of the Field," Journal of Asian Studies, 47 (1988), 41-90.

(2) Christopher Cullen, "Science and Medicine in China," in Information Sources in the History of Science and Medicine, ed. Pietro Corsi, and Paul Weindling (London: Butterworth Scientific, 1983), pp. 476-99.

(3) Hans Ågren, "Chinese Science," in Dictionary of the History of Science, ed. W. F. Bynum, E. J. Browne, and Roy Porter (London: MacMillan, 1981), pp. 65-67.

(4) Nathan Sivin, "Introduction," in Science and Technology in East Asia, ed. Nathan Sivin (New York: Science History Publications, 1977), pp. xi-xxiv.

(5) Nathan Sivin, "Preface," in Chinese Science: Explorations of an Ancient Tradition, ed. Nakayama Shigeru, and Nathan Sivin (Cambridge, Mass.: MIT P, 1973), pp. xi-xxxvi.

Item two is discussed in *Chapter 2: Traditional Chinese Science -- General Works*, and three, four and five in *Chapter 3: Traditional Chinese Science -- Fundamental Concepts; Philosophy; Social*

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[1]To give an example: Sivin argued that, ". . .'Dream Pool Essays' for *Meng ch'i pi t'an* (and analogously for *Liang ch'i man chih*) is impossible in point of diction. *Ch'i* has to mean 'creek' or 'brook', namely the one which made a circuit of Shen Kua's estate": Nathan Sivin, rev. of Science and Civilisation in China, vol. 4 pt. 3, in T'oung Pao, 57 (1971), 316. In his essay on Shen Gua, he suggested the translation "Brush Talks from Dream Brook" instead. Thus the following appears in the entry for *Meng ch'i pi t'an* in the Glossary: "[Dream Pool Essays]; [Brush Talks from Dream Brook -- Sivin, "Shen Gua"]".

[2]Yet valuable as they are, the aims and objectives they seek to fulfil are quite different from the ones intended for the present study.

and Cultural Relations. The first is outside the scope of this study as it was published in 1988, but I do not want to pass over it in silence. Anybody that has an interest in the present bibliographical study should first read Sivin's article. The observations, analysis and suggestions in his review tie in well with themes and concerns explored in the present work.[1]

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[1]The two works, however, are pitched at entirely different levels, have different frameworks, and serve different functions. For example, in this study bibliographic sources and control is one of the major concerns, and the coverage stretches back to the 19th century. Sivin's provocative and critical account, on the other hand, probes into the prevailing academic and intellectual milieu associated with research into the Chinese scientific and medical traditions in the East and West, how the discipline is currently being -- and more importantly, how it should be -- interpreted and tackled, the appropriate apparatus and methodology, relationships with other fields of study, and the standard of scholarship in the literature involved.

CHAPTER 2: TRADITIONAL CHINESE SCIENCE -- GENERAL WORKS

This opening chapter is not concerned with a specific scientific discipline or topic. Instead, it seeks to bring under one roof those general works that span or are relevant to the study of a number of subject areas and branches in traditional Chinese science. They are organised as follows: accounts that cover characteristics and features of various aspects of the subject, works on recent study trends and information sources, directories of researchers, works on terminology, biographical study, essay collections and collective works, and bibliographical compilations.

One need not be particularly shrewd and alert to notice that some of the publications treated contain substantial discussions on a broad range of technologically-related subjects (and occasionally medicine). Technology and the medical sciences are outside the scope of this thesis. Yet weeding out general studies that include technology and / or medicine is neither easy nor justified. Very often authors of these accounts have interpreted science, technology and medicine loosely and broadly: the information provided by their works is intended to appeal to those interested in science as well as technology, and the themes addressed are germane to the study of both traditional Chinese scientific and technological activities.

For studies that confront such questions as "Why modern science did not develop in China?", or "Why the Scientific Revolution did not take place in China?", and for literature devoted to Chinese scientific thought and the essence of traditional Chinese science, see *Chapter 3: Traditional Chinese Science -- Fundamental Concepts; Philosophy; Social and Cultural Relations.* Although such works cut across subject boundaries, their specialised nature and sheer number call for treatment in a separate chapter.

2.1 ACCOUNTS THAT COVER MULTIPLE FIELDS AND TOPICS

In his survey of 1835 on traditional Chinese skills and understanding in various technological and scientific domains (e.g. "le sucre de fécule"; "fabrication du papier, minerals, expèces d'acier"; "séparer l'or de l'argent"; "fabrication de la céruse"; "plomb"; "préparations mercurielles") Édouard Biot has indicated that to garner his material, "j'ai cherché à étudier principalment deux des ouvrages chinois que possède la Bibliothèque du roi: d'une part l'Encyclopédie japonaise, et de l'autre une petite encyclopédie des ents et métieres intitulée Tien-kong-key-we. . . ."[1] Selected passages from these treatises are indeed important components of his article.

Likewise, Stanislas Julien and P. Champion also relied on the 17th century treatise _T'ien kung k'ai wu_ for details on traditional Chinese processes and knowledge in their _Industries anciennes et modernes de l'empire chinois. . ._ (1869). They supplemented these descriptions with additional commentaries based their own visit to China in 1867.[2]

D. J. MacGowan also appealed to written sources for his "On the Cosmical Phenomena Observed in the Neighborhood of Shanghai, during the Past Thirteen Centuries" (1860), but those of a completely different kind, namely, the "Topographies or Miscellanies of Sung-kiang and Shanghai".[3] This is not insignificant because for a long time such local records were seldom exploited and valued in the study of Chinese history and culture. The paper itself is essentially a register of four main types of "cosmical phenomena", namely, "subterranean", "meteorological", "botany", and "zoology", with occasional

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[1]Édouard Biot, "Notice sur quelques procédés industriels connus en Chine au XVIe siècle," _Journal Asiatique_, 2nd ser., 16 (1835), 131.

[2]Among topics that received more extended coverage are: "Chlorure de sodium, sel ordinaire"; "Mercure"; "Fabrication des gongs ou tams-tams"; "Huiles, suif végétal et graines oléagineuses"; "Fabrication de l'encre de Chine"; "Papiers"; "Impression sur planches de pierre gravées en creux"; "Renseignements sur la plante textile *chou-ma* (*urtica nivea*)"; "L'agriculture et les engrais"; "Culture et fabrication du thé"; "Le salaire et le régime alimentaire"; "Notes pour faire suite au forage des puits (p. 18). Extraites des *Annales de la Propagation de la foi*".

[3]MacGowan, D. J., "On the Cosmical Phenomena Observed in the Neighborhood of Shanghai, during the Past Thirteen Centuries," _Journal of the North China Branch of the Royal Asiatic Society_, 2 (1860), 46.

explanatory comments.[1]

When a reader in the 1880s and '90s turned the pages of the widely-circulated science periodical Nature, was he able to learn about traditional Chinese science? What kind of portrayal did he get? He would have found three general accounts, but the messages sent by these one-page reports differed.[2]

All three were anonymous and were said to be summaries of views expressed elsewhere (two of which were in the North China Herald). We read in "Promise and Performance in Chinese Science" (1883) that, "there is. . . neither research nor knowledge; science has no existence. There is indeed a considerable natural literature. From ancient times the Chinese have taken note of natural phenomena. Their record of solar eclipses is perhaps the most ancient and accurate in the world. The have more or less elaborate works on astronomy, mathematics, botany, zoology, mineralogy, physiology, and many other sciences. Yet there is scarcely any true science in them. Classification, even in regard to plants and animals, there is none. Mineralogy is mainly a description of curious stones. . . ."[3] And all that "is mainly owing to the narrow and perverted system of education."[4] On the other hand, "The Priority of Chinese Inventions" (1889), as the title indicates, ventures to educate one on the store of scientific inventions and knowledge possessed by the Chinese, mainly in the fields of mathematics and astronomy, but also concave and convex mirrors for magnifying objects as well as the use of the magnet for navigation. The third article -- that from 1895 -

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[1]"Section I. Subterranean" is split into: "1. Earthquakes"; "2. Submarine action"; "3. Depressions of land"; "4. Eruptions". "Section II. Meteorological" into: "1. Freshets"; "2. Typhoons and storms"; "3. Watersprouts"; "4. Droughts"; "5. Famines"; "6. Epidemics"; "7. Irregular seasons and extremes of temperature"; "8. Meteors"; "9. Atmospheric illusions". "Section III. Botany" into: "1. Strange productions"; "2. Abundant harvests". "Section IV. Zoology" into: "1. Heteralogous"; "2. Rare visitors"; "3. Psychological".

[2]There were also synoptic pieces on particular sciences -- for instance astronomy -- in Nature.

[3]"Promise and Performance in Chinese Science," Nature, 40 (1883), 417.

[4]ibid.

- offers characterisations similar but not exactly identical to that from 1883: "It cannot be denied that the Chinese of the present day have very elementary ideas on any branch of science. This however, was not so formerly. . . . The Chinese possessed undoubtedly a great knowledge of astronomy. . . . Apparently, chemistry has never been studied, unless by a certain sect, the Tao-tse, who spent all their time endeavouring to discover the philosopher's stone and the elixir of life. . . . The Chinese have not a great knowledge of geology. . . . Coal was extracted as early time as 200 B.C. in the dynasty of Han. Although the mode of extraction was very primitive, enough was obtained to satisfy all wants. . . . Research work has not been carried far in natural science. . . . With regard to medical science, it is very elementary."[1]

Contrasting sharply with these accounts were two papers from the same decades which were less disparaging of Chinese experiences. The address Joseph Edkins delivered to the Peking Oriental Society in 1888 as the Society's President traces Chinese beliefs and efforts in the realms of science, technology and medicine from legendary times to the Ming dynasty. Some are applauded, but others not, and most are seen in the light of pertinent cultural and political elements and contacts with other civilisations, all of which extend to the essay a dimension often lacking in straightforward chronicles of achievements.

It was again the Journal of the Peking Oriental Society that issued "Chinese Discoveries in the Arts and Sciences" (1898) by William A. P. Martin, President of the Chinese Imperial University in Peking. The opening paragraphs of this study have a certain ring to them that may lead one to mistake them for words spoken in the post-1950 era.[2] However, dotted here and there are remarks which suggest

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[1]"Scientific Knowledge of the Ancient Chinese," Nature, 52 (1895), 622.

[2]". . .so little pains have been taken to point out the extent of our indebtedness to the ancient civilization of the Far East. In many instances our obligations can be proven. In others, where the evidence is not conclusive, the fact of priority creates a presumption in favor of the Chinese. . . . It might be difficult to show that the Chinese are distinguished for inventive talent, but intelligent and practical they are, and it is inevitable that in the course of ages they should accumulate a considerable stock of arts and of

that the author's understanding and appreciation of traditional Chinese science was afterall not quite the same as that voiced by the majority of scholars in recent decades.[1] Martin was most interested in establishing priorities and routes of transmission, and in his article, he dealt with gunpowder, the mariner's compass, printing, porcelain, the manufacture of silk, paper, alchemy, astronomy, mathematics, physics, "Biological Evolution", and "the conservation of energy".[2]

The five essays mentioned above, published within the space of sixteen years, are of historiographical interest (though some scholars might long have relegated them to rubbish heaps). First, in all five accounts the abundance of pertinent Chinese documentary sources is mentioned, suggesting that the blame for any inadequacies and failings these articles may have cannot be laid solely at the door of the original author's lack of awareness of or restricted access to Chinese materials. Second, there are significant variations in the arguments and opinions articulated.[3]

Biot, Julien, Edkins, and Martin were armed with considerable

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those observations which constitute the rudiments of science": William A. P. Martin, "Chinese Discoveries in the Arts and Sciences," Journal of the Peking Oriental Society, 4 (1898), 19-20.

[1]For example: ". . .Alchemy, which in the western world has expanded into a vast body of science which in no mean sense fulfils its promise of transmuting baser elements into gold. In its native soil it continues to be an occult art laden with all the superstitions of the middle ages": Martin, "Chinese Discoveries," 25. The concluding statements, in particular, clearly echo sentiments expressed in late 19th century writings rather than in those of later generations: ". . .why the Chinese failed to profit by their discoveries? The answer is brief but decided: In the arts, the slavish habit of following in the footsteps of their fathers acted as a bar to improvement. In the sciences progress was rendered impossible by a system of state education which made the ancient classics the only basis of public instruction": Martin, "Chinese Discoveries," 28.

[2]Martin, "Chinese Discoveries," 27.

[3]While comments belittling and misconstruing Chinese scientific and other activities may not come as a surprise -- depending on how sceptical one is of 19th century Western sensitivities and understanding towards the subject -- it should be noted that opposite views (i.e. those that called attention to the ingenuity of the Chinese), though less typical and delivered more hesitantly, had also appeared in print.

knowledge of the language, literature, history, and traditions of China. Those responsible for profiles from the first half of the present century were, in this respect, equally qualified.

Giovanni Vacca's "La scienza nell'Estremo Oriente" (1912) sketches briefly what the Chinese had done in the areas of science, technology, and medicine, and comments on issues related to their development.[1] His article in the 1915 Revista degli Studi Orientali, on the other hand, is concerned with several events and episodes as recorded and told in the *Sou shen chi* and *Meng ch'i pi t'an*: a silkworm legend, the fall of a meteorite, the invention of printing with movable type, the formulation of a mathematical problem, and the activities of an eleventh-century alchemist. In yet another paper (1930), Vacca argued that knowledge in the fields of astronomy, mathematics and chemistry in ancient and mediaeval China was minimal, and that only in metallurgy, pharmacopia, the vegetable kingdom and cartography could one find contributions of some significance.

To suggest the presence of scientific endeavours and interests in pre-modern China and that they merit further exploration and serious study, Herbert Chatley noted in an article in the Journal of the North China Branch of the Royal Asiatic Society (1923) major Chinese treatises and achievements in astronomy, botany, chemistry, engineering, geography, geology, mathematics, medicine, meteorology, physics, psychology, sociology, and zoology.

Rudolf P. Hommel's China at Work bears the rather poignant subtitle, An Illustrated Record of the Primitive Industries of China's Masses, whose Life is Toil and thus an Account of Chinese Civilization. First published in 1937, it was the result of the author's eight-year expedition in China in the 1920s. The book is probably best known and used most often for its valuable and meticulously-produced drawings and photographs, many of which are not available from other sources. In addition to these illustrations, the author

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[1]The article contains twelve sections: "I. Relazioni tra la Cina e l'Europa"; "II. Scienze politiche"; "III. Astronomia"; "IV. Cartografia"; "V. Matematica"; "VI. Scienze naturali"; "VII. Tecnologia ed Industria"; "VIII. Astrologia ed alchimia"; "IX. Discussioni in Europa sul valore della scienza cinese"; "XII. Avvenire della scienza in Cina. La scrittura cinese non è di impedimento alla scienza".

had supplied a wealth of detailed technical descriptions on a bewildering array of traditional Chinese tools, instruments, gadgets and devices as well as pondered on what they were used for and how they were employed.[1]

Two titles from the first half of the 20th century remain to be mentioned. "A Chronology of the XVI Century: China and Japan" (1941) by Y. Mikami itemises developments in mathematics, astronomy, medicine, etc. in the Ming period. Derk Bodde's China's Gifts to the West (1942) -- the first of the series Asiatic Studies in American Education -- presents colourful and lively descriptions of a galaxy of discoveries, inventions and initiatives from silk and porcelain to tea, lacquer, and the umbrella, with emphasis on things that were transmitted to and adopted by the West.

Earnest and spirited attempts to outline and delineate a host of scientific, technological and medical advancements in pre-modern China have been made by Pierre Huard in three studies published in the 1950s and one in 1962.

His La science et l'Extrême-Orient (1950a) elicited the following criticism from Needham: "This paper, though admirable in choice of subject and intention, was written in difficult circumstances; it contains many serious mistakes, and must be used with circumspection."[2] It consists of three separate parts: (1) "Definition de l'Extrême-Orient"; (2) "Le contenu de la science extrême-orientale" (sub-divided into "A: Les sciences dites exactes: les nombres; géométrie; astronomie; alchimie et chimie; geographie", "B: Les sciences naturelles: zoologie; botanique; la medicine et les sciences

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[1]These are organised into five major categories: "Chapter I. Tools to make tools" (e.g. "Miner's rope making"; "Stone blasting"; "Wire drawing"; "Wrought iron"). "Chapter II. Tools for procuring food" (e.g. "Plows"; "Tilling tools"; "Animal power mills"; "Distilling"). "Chapter III. Tools for making clothing" (e.g. Spinning wheels"; "Weaving"; "Needles"; "Scissors"). "Chapter IV. Tools for providing shelter" (e.g. "Hatchet and adzes"; "Reciprocating lathe"; "Brick bonds used in brick walls"; "Doors"). "Chapter V. Tools for enabling transport" (e.g. "Carts drawn by animals"; "Boat building"; "Making earthenware with and without the potter's wheel"). Several sub-sections (e.g. "Water ways"; "On cattle"; "Notes on the pewterer's trade") are not on specific kinds of tools.

[2]Joseph Needham, Science and Civilisation in China, vol. 3, pp. 768.

annexes dans les cultures sinoides"); (3) "Les étapes de la science extrême-orientale" (sub-divided into "La science et l'Eurasia", "l'antiquité (-2205 -- 202)", "moyen age", "la renaissance et les temps modernes"). Needham did not seem to regard the second study from Huard as significantly better than his first. "Science et techniques de l'Eurasie" (1950b), "though correcting a number of errors in [La science et l'Extrême-Orient], still contains many mistakes and should be used with care; nevertheless it is valuable on account of several original points."[1] This paper concentrates on technology (which is not treated in the other work) and carries the following sections: "I. Sources et origines des techniques traditionnelles extrême-orientales"; "II. Caractères de la technique traditionnelle extrême-orientales"; "III. Étude particulière des techniques".[2] In his third study, published in Revue de Synthèse in 1956, Huard spelled out ideas and philosophical concepts which, in his opinion, had influenced the evolution of traditional science, technology and medicine in China in addition to furnishing basic historical sketches.[3] Its three indexes are of special interest.[4] His "Le développement de la technologie dans la Chine du XIXe siècle"

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[1]ibid.

[2]The third section is further broken down into: "conception de la guerre"; "armement"; "marine de guerre"; "fortifications"; "animaux de guerre"; "poterie et céramique"; "textiles"; "imprimerie"; "empreintes digitales"; "techniques de locomotion"; "techniques de navigation maritime"; "techniques de navigation aérienne"; "ameublement"; "calcul"; "mannaie"; "jeux"; "sports"; "musique"; "architecture"; "travaux publics"; "outillage"; "techniques de l'alimentation".

[3]"Première partie: Le cosmos scientifique chinois" contains: "I. Les deux principes"; "II. Les 8 trigrammes primitifs"; "III. Les 5 éléments"; "IV. Les modes de connaissance: mythe; connaissance rationnelle; langue et logique"; "V. Doctrines philosophiques et religieuses: Méitisme; Bouddhisme; Taoisme; Confucianisme". "Deuxième partie: Survol de quelques disciplines scientifiques" contains: "Sciences physiques"; "Astronomie"; "Mathématique"; "Alchimie"; "Arts chimiques"; "Sciences naturelle et sciences géographiques".

[4]"I. Index succinct des principaux astronomers et mathématiciens chinois"; "II. Index biographique des mathématiciens Européens ayant contribué à la diffusion des mathématiques en Chine"; "III. Index très succinct des naturalistes Européens ayant travaillé en extrême-orientales".

(1962) retains more or less the same flavour and mix of ingredients that characterise his other general surveys. Once again, Huard (and co-author) Ming Wong recited the most important Chinese advancements and supplied a few relevant Western studies. The study has two distinct parts. The first, "A. Les sciences et les techniques traditionnelles" includes: "Agriculture"; "Zootechnie"; Mines"; "Métallurgie"; "Travaux publics"; "Céramique"; "Le service postal". The second part is concerned with "La technologie occidentale en Chine".

Justin D. Schove was one of the contributors to the first issue of the Bulletin of the British Society for the History of Science (1952). Within the limited space of a couple of pages, he itemised an assortment of scientific, technological and cultural interchanges that took place along the Silk Road from 6th B.C. onwards. Maria Teresa Zoli's "La cultura della Cina antica" (1954) is another brief article which attempts to bring to one's notice the then dimly lit subject of traditional Chinese science and technology.

While Bodde's pamphlet brims with enthusiasm over significant scientific, technological, and medical progress made by the Chinese, L. C. Goodrich's "Scientific Development in China: A Question of Independence" (1954), though also an account written for the interested layman and one that encompasses a wide selection of topics, is much more hesitant and cautious in accrediting priority of invention to China.[1]

The remaining three items from the 1950s were published as articles in multi-volume sets. "La science chinoise antique" (1958) in the "Première partie: Les science antiques de l'Orient" of Réne Taton's Histoire générale des sciences was written by Needham. In it, sufficient information and insight has been provided to permit readers to gain a good grasp of three areas in traditional Chinese

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[1]Goodrich's presented his position in the opening paragraph: "it is unquestionably true that many of the stimuli for scientific thought came to China from abroad; it seems to be true too that the Chinese failed to create any consistently scientific attitude in their culture, except possibly in the fields of historiography and epigraphy. Nevertheless there were moments in their history where scientific ideas came to the surface, and made a contribution to their culture": L. C. Goodrich, "Scientific Development in China: A Question of Independence," in Introduction to Chinese History, and Scientific Developments in China (Santiniketan, West Bengal: Sino-Indian Cultural Society, 1954), pp. 11.

science: mathematics, astronomy, and the physical and natural sciences.[1] A. Haudricourt was responsible for "Les sciences en Chine médiévale" (1958) in the same compilation (placed under "Troisième partie: Le moyen age"). It covers more or less the same subject areas as those in Needham's essay.[2] In the English rendition (1963) of this French reference work, the essay by Needham appears as "Ancient Chinese Science" while that by Haudricourt bears the title "Science in Medieval China". Marcello Muccioli's contribution was written for a collected work in a very different field. His fairly lengthy "Scienze della Cina" (1958) in Le civiltà dell' oriente: Storia, letteratura, religioni, filosofia, scienze, e arte lays emphasis on charting and highlighting major episodes and undertakings rather than the critical review of the following branches of knowledge in ancient and mediaeval China: "1. La medicina"; "2. L'alchimia"; "3. Le science esatte" ("a. L'astronomia", "b. La matematica"); "4. La storia della geografia"; "5. Lo studio della natura nell'antica Cina".

Literature from the 1960s, '70s, and '80s involving multiple fields was a potpourri containing on the one hand, original studies that were sophisticated and insightful, and on the other, chronicles and narratives based on secondary works that sought primarily to attract lay persons with their engaging stories, wide subject range, and accessible language; and these were further mixed with publications that lay somewhere in between the popularisations and the scholarly treatments.

For his article in the 1963 Chung Chi Journal, George H. C. Wong

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[1]"I. Les mathématique" is divided into: "Les nombres"; "Le calcul. La géometrié"; "Arithmétique et algèbre"; "Deux mathématiciens"; "Les gammes". "II. L'astronomie" is divided into: "Astronomie officielle"; "Le calendrier"; "Le repérage des étoiles"; "Les origines"; "Le catalogue des étoiles"; "Les théories cosmologiques". "III. Sciences physiques et naturelles" is divided into: "La physique de Mo Ti"; "Les théories physiques"; "Médecine et biologie"; "Pharmacie, botanique et chimie".

[2]"I. Les mathématique" is divided into: "Les calculs"; "Le progrès de algèbre et les grands mathématiciens". "II. Astronomie et géographie" is divided into: "Astronomie"; "Géographie et cartographie"; "Cosmologie". "III. Sciences physiques et naturelles" is divided into: "Les fossiles"; "La boussole"; "Chimie et botanique"; "Médecine".

assembled evidence to show the "independent development" of astronomy and calendar-making, mathematics, technology, geography and maps in China before the arrival of the Jesuits in the 16th century "as well as certain foreign influences which to some extent enriched Chinese science in spite of its slow development and the low estate into which it had fallen during the late Ming period."[1] For the most part, historical evidence of Chinese accomplishments and acumen are enumerated rather than weighed and analysed, but references to Chinese, Japanese and Western sources are liberally supplied in the endnotes.

The "proper title" of Needham's "Science and China's Influence on the World" (1964), according to its author, "ought to be 'The ten (or the twenty or thirty) discoveries (or inventions) that shook the world'."[2] First, the question of whether China should be indebted to the West or vice versa is raised; then reviewed in the main section are scientific as well as technological discoveries and inventions, with particular attention to the reasons behind their generation and consolidation.[3] It concludes with the issue of transmission and a summary of the author's thesis and arguments. Sivin has called the study "an exceptionally compendious overview of Needham's major theses, written so as to be an excellent first introduction for the

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[1]George H. C. Wong, "Some Aspects of Chinese Science Before the Arrival of the Jesuits," Chung Chi Journal, 2 (1963), 169.

[2]Joseph Needham, "Science and China's Influence on the World," in The Legacy of China, ed. Raymond Dawson (Oxford: Clarendon P, 1964), pp. 241.

[3]Scientific topics include: "*(a)* explosives chemistry or proto-chemistry; *(b)* magnetic physics and the mariner's compass; *(c)* astronomical coordinates and instruments, mechanical clockwork, and the 'open' cosmology": Needham, "Science and China's Influence," pp. 257. Technological areas include: "*(a)* the use of animal-power, with the inventions of the stirrup, the efficient equine harnesses, and the wheelbarrow; *(b)* the use of water-power, with associated inventions such as the driving-belt, the chain-drive, the crank, and the morphology of the steam-engine; *(c)* iron and steel technology, bridge-building, and deep drilling; *(d)* nautical inventions such as the stern-post rudder, fore-and-aft sailing, the paddle-wheel boat, and watertight compartments": ibid.

university student."[1] Extracts from this seventy-four-page study can be found in the 1966 Eastern Horizon.

T'ien kung k'ai wu has long been a focal point of Western research into many different aspects in traditional Chinese science and technology. The Western scholarly community's access to this treatise was much improved with the publication of a partial translation by E-Tu Zen Sun and Sun Shiou-chuan in 1966. Besides the main body of translation, the book is equipped with: (1) a "Translator's preface" which contains a simple outline of the life and time of the author Sung Ying-hsing and a quick overview of editions of the Chinese work; (2) two bibliographies, one for Chinese sources and the other for non-Chinese items; (3) a glossary; (4) four appendices on Chinese dynasties, the twenty-four Chinese solar terms, the equivalence of Chinese weights and measures in metric units, and the transmission of certain techniques from China to the West.

Giorgio Nebbia's brief note to draw attention to the *T'ien kung k'ai wu* was also published in 1966. He listed the main subject areas covered by chapters 5, 6 and 7, and mentioned in general terms the significance of several of these topics as well as certain pertinent Western studies (especially Science and Civilisation in China).[2]

Three principal concerns are laid out succinctly in Mark Elvin's "Skills and Resources in Late Traditional China" (1975). First, to "establish at least the outlines of technological progress in China during Ming and Ch'ing times."[3] The technologies and technical advances taken into consideration include, for example, the Chinese

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[1]N. Sivin, annotation for "Science and China's Influence on the World" by Joseph Needham, in ISIS Cumulative Bibliography 1966-1975, vol. 2, pp. 242.

[2]e.g. "Nel campo della metallurgia il trattato di SUNG contiene la prima descrizione dell'ottenimento dello zinco dal minerale (7) secondo un metodo sostanzialmente diverso da quello seguito in Europa; la smithsonite, posta in crogioli, veniva disposta a strati alterni con carbone; il tutto era scaldato al calore rosso e alla fine i crogioli erano rotti e le masse di metallo erano ricuperate e rifuse": Giorgio Nebbia, "Alcune notizie su un trattato di merceologia e tecnologia cinese del 1600," Quaderni di Merceologia, 5 (1966), 138.

[3]Mark Elvin, "Skills and Resources in Late Imperial China," in China's Modern Economy in Historical Perspective, ed. Dwight H. Perkins (Stanford: Stanford UP, 1975), pp. 86.

windmill, "adaptation of close-in rotary fan to the ventilation of mineshafts", "various forms in the control of heat and humidity", initiatives in metallurgy, agricultural technology and seafaring techniques.[1] Second, "try to find a way of accounting for the pattern of changes that emerges from the preceding survey" -- an objective rarely taken up in other general works, but which enlivens and enhances any study.[2] Third, "evaluate what impact the technical aspects made in the late traditional period had on output", an aspect handled much more cursorily than the other two.[3]

Many would agree with Lynn White, jr. that, "*Science and Civilisation in China* is formidable to produce and formidable to read."[4] "Shorter" versions therefore seem to be a worthwhile undertaking and certainly sound very appealing to those readers with limited time and interest. Two such volumes, prepared by Colin A. Ronan, were published before 1985. The first (1978) summarises vol. 1 "Introductory Orientations" and vol. 2 "History of Scientific Thought" of the original. The second (1981) treats "Mathematics"; "Astronomy"; "Meteorology"; "Geography and map-making"; "Geology and related sciences"; "Physics" (i.e. vol. 3 and a section of vol. 4 pt. 1). It is, however, regrettable that they drew the following comments from Sivin: "A readable but mechanical condensation, which does not correct errors, even those corrected by Needham in later volumes. Idiosyncratic short bibliographies. Not recommended to those capable of skimming the originals."[5] Some readers would indeed find these unadorned offerings rather dry and simplistic.

There are also those who prefer to read Science and Civilisation in China in another language. The Italian translation of vol. 1 was published in 1981, vol. 2 in 1983, and vol. 3 in 1985. Translators

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[1]Elvin, "Skills and Resources," pp. 87.

[2]Elvin, "Skills and Resources," pp. 86.

[3]ibid.

[4]Lynn White, jr., and Jonathan Spence, "Science in China," Isis, 75 (1984), 173.

[5]N. Sivin, annotation for The Shorter Science and Civilisation in China; . . . vols. 1 and 2 by Colin A. Ronan, in "A Supplemental Bibliography in Western Languages," Chinese Science, 7 (1986), 35.

for each volume of Scienza e civiltà in Cina were different.

Among the virtues of Ho Peng Yoke's *Li, Qi, and Shu*: An Introduction to Science and Civilization in China (1985) for teaching purposes are its clear presentation and well-defined topics and chapters. The first part is devoted to the characterisation and explanation of fundamental ideas and terminology.[1] Three succinct descriptive overviews on historical progress made in mathematics, astronomy and alchemy follow.[2]

Within the repertory of works from the 1970s and '80s were several accounts intended for those ignorant of or insisted on turning a blind eye to traditional Chinese experiences in the scientific and technological fields. Students in introductory classes and lay readers are perhaps the most likely individuals to benefit from these narratives which enumerate and recount feats and achievements.[3]

(1) In Wonders of Ancient Chinese Science (1969), the "wonders" singled out by Robert Silverberg are astronomy, the south-pointing chariot, the magnetic compass, the wheelbarrow, paper, printing, the umbrella, the fishing rod reel, the spinning wheel, explosives, flight, and earthquake studies. The author also prepared an opening chapter -- "Behind the Great Wall" -- and a concluding one on "The Chinese as scientists".[4]

(2) The emphasis of Hans Breuer's Kolumbus war Chinese (published originally in 1970 and translated into English in 1972) is on transmissions of Chinese discoveries and inventions to other cultures and

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[1]It is organised into: "Chapter 1: *Li*, *Qi* and *Shu*"; "Chapter 2: The concepts of *Yin* and *Yang* and *Wuxing*"; Chapter 3: *Wuxing* and their mutual relationships"; "Chapter 4: Some applications of numbers and *Wuxing*"; "Chapter 5: The system of *Yijing*"; "Chapter 6: The binary system and the *Xiantian* and *Houtian* orders".

[2]Also included are two bibliographies, one for Chinese works published before 1800, and the other for literature after 1800 (mostly in Chinese, with several Japanese and English titles).

[3]Those with access to primary sources and related scholarly apparatus would find little that is new.

[4]This book is considered a "Juvenile - Non-fiction" item in Norman E. Tanis, David Perkins, and Justine Pinto, China in Books: A Basic Bibliography in Western Language (Greenwich, Conn.: Jai P, 1979).

civilisations.[1] Breuer wisely consulted the writings of experts such as T. F. Carter, Chang Kwang-chih, J. J. L. Duyvendak, Wang Ling, Miyasita Saburo, Needham, M. A. Stein, and B. E. Wallacker.

(3) A brief sketch by Ho highlighting salient features in traditional Chinese mathematics, astronomy, alchemy, acupuncture and medicine was published in the 1972 Hemisphere.

(4) Although Oracle Bones, Stars, and Wheelbarrows: Ancient Chinese Science and Technology (1982) is not a book to which one would turn in search of scholarly documentation and discourse, its author Frank Ross, jr. made an admirable attempt to bring to life and to position properly various discoveries and inventions.[2] It was translated into Italian in 1984.

2.2. WORKS ON STUDY TRENDS AND INFORMATION SOURCES

Several accounts and summaries of current historical research on Chinese science, technology and medicine appeared in the late 1970s. Although none of them was aimed at offering a total perspective or comprehensive treatment, they have spelled out key elements and provided some background information on this critical but neglected matter.

Nathan Sivin's "Next Steps in Learning about Science from the Chinese Experience" (1974), a contribution to the symposium on "Science and Society in China and Japan" at the 14th International Congress of the History of Sciences, pinpoints three major approaches taken in the study of traditional Chinese science in recent decades:

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[1]Chapters that make up the book are: "1. Novae and pulsars"; "2. Abacus, binary numbers, and magic squares"; "3. Maps on paper, silk, and stone"; "4. The Great Wall"; "5. The oldest seismograph: dragon heads and toad mouths"; "6. The compass"; "7. Kites, rotors, balloons, and parachutes"; "8. A cheap substitute: paper"; "9. The black art"; "10. Paper money, inflation, and currency reform"; "11. Gunpowder and cannons"; "12. Silk, caravans, and profits: The Silk Road"; "13. Columbus was Chinese".

[2]There are six chapters: "Introduction"; "Astronomy"; "Ancient Chinese medicine"; "Ancient Chinese technology: paper, printing, gunpowder, compass"; "Inventions, inventions, inventions"; "Engineering in ancient China".

(1) textual studies; (2) chronological and biographical investigations as represented by the Science and Civilisation in China Project, the Academia Sinica in China, and the Kyoto Research Institute of Humanistic Studies; (3) a relatively new school in East Asia and the West "whose first priority is to comprehend exactly and integrally the inner texture and external connections of scientific thought and work as originally understood by Chinese practitioners."[1] According to Sivin, these research initiatives have far-reaching consequences for the universal history of science, as they suggest firstly, "an enormous contrast between traditional Chinese and modern European approaches to historical explanation", and secondly, "constant movement of ideas and mechanisms to and from other cultures."[2]

The report by Sivin in the 1978 Chinese Science and that by John S. Major in the 1980 issue of the same journal were both inspired by trips to the People's Republic of China.[3] Reading these accounts of meetings and first-hand observations gives one a fairly good sense of the Chinese institutions, organisations and individuals involved as well as the general trends and directions of research in that country (e.g. the growing importance attached to material artifacts and archaeological findings).[4]

E-tu Zen Sun's "Chinese History of Technology: Some Points for Comparison with the West" (1979) has a totally different orientation. This paper for the Symposium on the History and Philosophy of Technology is essentially an introduction to features associated with

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[1]Nathan Sivin, "Next Steps in Learning about Science from the Chinese Experience," in Proceedings. . . 14th International Congress of the History of Sciences, Tokyo / Kyoto, 1974 (Tokyo: Science Council of Japan, 1974-75), vol. 1, pp. 12.

[2]Sivin, "Next Steps," pp. 13-16.

[3]Sivin went as "a member of a group of ten astronomers, one of five scientific delegations sent to China each year as part of an exchange program between the Committee on Scholarly Communications with the P.R.C. (U.S.A.) and the Scientific and Technical Associations (P.R.C.)": Nathan Sivin, "Current Research on the History of Science in the People's Republic of China," Chinese Science, 3 (1978), 39. Major went with the Han Studies Delegation, also sponsored by the Committee on Scholarly Communications with the P.R.C.

[4]One can also learn some handy practical tips such as the language to use in communicating with Chinese historians of science.

recent Chinese, Japanese and Western scholarship on traditional Chinese technology. The author first identifies "two main areas of concentration: 1) The reconstruction and explication of traditional techniques and practices, and 2) an examination (still at an early stage of development) of the effect of Western influence on Chinese technology."[1] Within this broad framework, various elements and practical matters are reckoned and addressed: field investigations, the abundance of Chinese written records on the technical traditions, the publication of several Chinese, Japanese and Western translations of Chinese classical works on technology, research projects by Needham and the Kyoto group led by Yabuuchi Kiyoshi, the beginning of serious studies in the U.S. on the history of Chinese technology, two ground-breaking publications by contemporary Chinese scholars, the problem with Chinese technical terms, the awareness of the importance of placing technological developments within their socio-economic settings and contexts, and the reliance on etymological inferences versus the use of archaeological evidence. While these were indeed vital concerns and prominent landmarks in the research on traditional Chinese science and technology in the 1960s and '70s, one may be excused for doubting if the particular manner in which these trends and characteristics have been distilled, articulated, and portrayed are suitably balanced or helpful. In some instances, the point in question is so heavily condensed that the scope of the matter and the extent of the complexities is not even hinted at.[2] On other occasions, extended treatment is given to a

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[1]E-Tu Zen Sun, "Chinese History of Technology: Some Points for Comparison with the West", in The History and Philosophy of Technology, ed. George Bugliarello, and Dean B. Doner (Urbana: U of Illinois P, 1979), pp. 38.

[2]For example, after reading or listening to the paper one learns little about Western endeavours and output in the field except for Needham's Science and Civilisation in China and the MIT East Asian Science series -- something of which one might already have prior knowledge -- as other activities are taken care of in only two sentences: "If translations of entire works are rather scarce, surveys and monographic studies are more plentiful and of high quality", and "Chinese science and technology as a serious academic discipline has also made its appearance in the United States": Sun, "Chinese History of Technology," pp. 41-42. It should not take more than a couple of sentences or minutes to mention the names of others who have carried out seminal research in various traditional Chinese

single item or a particular element.[1]

Christopher Cullen has taken a three-pronged approach in his contribution to the reference work Information Sources in the History of Science and Medicine (1983). First, he introduces to the reader major Chinese sources and Western-language publications that can provide further information.[2] Next, an outline of some aspects of Chinese philosophy is offered. The last part is a systematic presentation of the main disciplines and departments in Chinese science. Here, central issues and main themes in each subject area as well as titles of a few pertinent Western studies are highlighted.[3]

The fate of the Science and Civilisation in China Project is a matter that cannot be easily ignored, and its research as well as publication process is of substantial interest to both critics and faithful followers. Though not to be regarded as a solemn pronouncement or detailed statement on the matter, some clues were supplied by Needham himself in an article in the 1980 Interdisciplinary Science Review. Three aspects are mentioned: "Description" [of the project]; "Methodology" (divided into: "Chinese sources", "Iconography", "Living tradition", "Terminology", "Skeletal structure", "The unity of the Old World"); "Organisation" (divided into: "The side-dishes", "Financing").

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technologies (e.g. Margaret Medley in ceramics technology, Noel Barnard in metallurgy, John Combridge and André Wegener Sleeswyk in mechanical engineering, Tsien Tsuen-hsuin in paper and printing, Else Glahn in building technology). By doing so, the neophyte can go away with concrete leads to pursue.

[1]For example, a detailed explication on different interpretations given to a type of ploughing instrument is furnished in order to illustrate the need to consider not only documentary sources, but also archaeological remains, depictions on frescoes, etc.

[2]Chinese materials introduced include the thirteen canons or classics, the official dynastic histories, topically arranged encyclopaedia, and collectanea. Information on Western aids include, for instance, the availability of good translations for most of the classics, and the usefulness of E. Wilkinson's The History of Imperial China: A Research Guide (Cambridge, Mass.: Harvard UP, 1974) as a guide to the standard histories.

[3]Cullen's classification and terminology are similar to those used by Sivin (e.g. the division into "qualitative" and "quantitative" sciences).

2.3 DIRECTORIES OF RESEARCHERS

Two directories of individuals engaged in the study of traditional Chinese science, technology and medicine can be found in Chinese Science. The earlier one, compiled by Sivin in 1975 and which constituted the first issue of the journal, lists forty-two individuals in Western countries. Names and information of the researchers were culled mainly from Sivin's own personal knowledge. Arrangement is alphabetical by name, under which are the individual's academic degrees, current employment, current address, character of published work, current study, and publications. Additionally, the directory provides an index according to special fields of study as well as a table of the number of persons from each country. The second list, "A Directory of Scholars in East Asia Engaged in Research on Traditional Chinese Science" (1983) was the result of joint efforts made by Sivin and Nakayama Shigeru. Apart from two individuals from Singapore and two from Korea, the rest were based in Japan.[1] Chinese scholars were not considered. The type of information supplied is the same as that in the previous directory.

2.4 WORKS ON TERMINOLOGY

One of the most critical and vexing problems facing historical research into traditional Chinese science, technology and medicine is the associated terminology. Recognising the seriousness of this obstacle, Needham articulated the complexities in an essay published in 1958. He begins by alerting readers to two general characteristics concerning the Chinese language.[2] Hence one can "look into the

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[1]The compilers cautioned that, "the list is neither complete nor up to date", and only relatively active Japanese scholars in the field have been represented: "A Directory of Scholars in East Asia Engaged in Research on Traditional Chinese Science," Chinese Science, 6 (1983), 33.

[2]First, "in Chinese the parts of speech are not so rigidly separated as they are in other languages such as the Indo-European; a particular word can function as several different parts of speech, depending, to some extent, like all Chinese grammar, on the order of the words in the sentence": Joseph Needham, "The Translation of Old Chinese Scientific and Technical Texts," in Aspects of Translation, ed. A. D. Brown et al. (London: Secker & Warburg, 1958), pp. 66. This occurs, for instance, in certain mathematical terms. Second,

mode of origin of some of the basic words used in scientific and technical discourse" or "find technical information from these ancient pictograms."[1] Needham then emphasizes that, "one of the greatest difficulties about technical terms is that now and again the same word covers two different things; the thing changed while the word remained unchanged. This is a great nuisance from the point of view of the history of technology, because there is nothing for it but to read every possible text you can find in order to throw light on the point when the change in the 'thing' occurred."[2] To help overcome this hurdle, one can consult traditional Chinese technical glossaries and also "study the usage of terms" (for instance those related to metallurgy and engineering).[3] Another problem is caused by the fact that "all through the centuries, the Chinese (like mediaeval Europeans) found great difficulty in coining new technical terms."[4] Very often, then, they "were faced with a dilemma of translation or transliteration."[5] The article ends with a review of several short texts in order to "see how it feels to get something scientific and technical from them."[6]

Ho has also written a paper (1974) "to survey what Chinese science originally had in terms of technical language and to discuss some aspects concerning the adoption of a modern scientific termino-

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"we have a lexicographic tradition which takes us back at least to the -3rd century": Needham, "The Translation," pp. 68.

[1]Needham, "The Translation," pp. 68-69. For example, the word for boat and that for cross-bow trigger.

[2]Needham, "The Translation," pp. 71. For example, *t'ung* "which meant 'copper' long before it meant 'bronze'": ibid.

[3]Needham, "The Translation," pp. 75.

[4]Needham, "The Translation," pp. 77. For example, when dealing with clockwork or in "discussions of the properties of minerals like jade": Needham, "The Translation," pp. 79.

[5]Needham, "The Translation," pp. 80.

[6]Needham, "The Translation," pp. 81. e.g. "Chhiwu Huai-Wen's method of making steel (the co-fusion process) c.+545", "The armillary sphere of Jamal al-Din (+1267)".

logy."[1] The "technical language" examined is restricted chiefly to that in mathematics and chemistry.

Furthermore, the interpretation and translation of *wu hsing* and *hsiu* -- two special terms central to Chinese science and scientific thought -- were explored and rendered more precise in a series of exchanges in the 1976 and 1977 Early China: one by Major (with comments quoted from a letter by Sivin), the second by Richard Kunst (with replies from Major and John S. Cikoski). The translation "five phases" for *wu hsing*, and "lunar lodge" for *hsiu* were proposed and discussed.

2.5 BIOGRAPHICAL WORK

Biographical studies, an important, well-established and beloved genre in many disciplines, are apparently not deemed appropriate when it comes to writing about traditional Chinese science since only one such work has found its way into this section.

Paradoxically, the first thing to say about Sivin's article on Shen Kua (1975) in the standard biographical reference work Dictionary of Scientific Biography is that it is more than a mere biographical sketch of the 13th century astronomer and polymath. It is a systematic, interpretive, and extremely informative study that goes beyond the itemisation of Shen's contributions to the field of astronomy and a host of other sectors to unravel the deeper significance of his efforts' impact on the Chinese scientific, technological, and medical traditions.[2] Background material on Shen's life history -- and just as essential -- political and social settings are discussed in two separate sections. Furthermore, to provide the proper perspective and to increase awareness of the multiple dimen-

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[1]Ho Peng-Yoke, "Chinese Scientific Terminology," Papers on Far Eastern History, 9 (1974), 1.

[2]His contributions are given under the rubrics of: "Quantity and measure" (sub-divided into: "Mathematical harmonics", "Astronomy"); "Configuration and change" (sub-divided into "Magnetism", "Cartography", "Formation of the earth", "Atmospheric phenomena", "Products of the earth", "Optical phenomenon"); "Productive techniques and materials" (sub-divided into "Contemporary techniques", "Ancient techniques"); "Medicine".

sions of Shen's work and concepts, Sivin concludes the article by addressing critically the following five issues: "The relation of scientific thought to reality"; "Other kinds of knowledge"; "Confucianism and science"; "The civil service and science"; and "Attitudes towards nature". Equally helpful is the extensive bibliography that follows.

2.6 ESSAY COLLECTIONS AND COLLECTIVE WORKS

Collections of essays from one or more authors covering a wide spectrum of aspects and disciplines in the Chinese scientific, technological and medical traditions are available for researchers working in the field as well as non-specialists.

For those seeking to sample or to familiarise themselves with Needham's writings and thinking on the subject, there are several volumes to choose from. The Grand Titration: Science and Society in China and the West: Lectures and Addresses on the History of Science and Technology (1969) contains eight previously published essays -- some incorporating revisions -- that assess and rationalise various facets in the intricate relationship between the development of the society as a whole and that of science and technology in ancient as well as modern China, generously laced with comparisons with the Western scene.[1] While The Grand Titration focuses on issues of a more sociological and philosophical nature, a much broader range of themes and topics dealing with scientific, technological and medical matters is covered in Clerks and Craftsman in China and the West (1970), some of which are highly technical and specialised.[2] Needham himself has

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[1]In Needham own words, the overarching aim in these accounts is to "'titrate' the great civilisations against one another, to. . . analyze the various constituents, social or intellectual, to see why one combination could far excel in medieval times while another could catch up later on and bring modern science itself into existence": Joseph Needham, The Grand Titration: Science and Society in East and West (London: Allen & Unwin, 1969), pp. 12.

[2]For instance, astronomy, horology, meteorology, mariner's compass, iron and steel production, mechanical engineering, proto-endocrinology, hygiene and preventive medicine. There are also general essays such as "The Translation of Old Chinese Scientific and Technical Texts" and "The Roles of Europe and China in the Evolution of Oecumenical Science".

provided an admirable characterisation of the different categories into which these essays fall and the audience for which they are meant in his preface. Nevertheless, underlying these nineteen essays -- first published in the 1940s, '50s and '60s, some revised -- is the message, in Sivin's words, of "the undeniable comparability of Chinese and European-Islamic traditions before the Scientific Revolution (often asserted by Needham as superior on the Chinese side), the inability of Chinese science to make the connections which would have revolutionized it and made it universal, the interplay of essential elements from all the great civilizations in the formation of modern science in Europe."[1] A bibliography (according to chapters), a chronology of Chinese dynasties, and an index are supplied. In reviewing The Grand Titration, Knud Lundbeck remarked that the book "as a whole is extremely stimulating and especially useful for readers who cannot find time to study the Magnum Opus."[2] To A. G. Molland Clerks and Craftsman in China and the West fulfils a similar function in that it "provides a good introduction to Needham's work in much shorter scope than his monumental *SCC*."[3] But in Sivin's opinion, the latter title is "far more useful on the whole" than the other collection.[4]

Needham occasionally wrote his papers in French; moreover, some of his English articles were translated into French. The French version of The Grand Titration -- translated by Eugène Jacob -- appeared in 1973 as La science chinoise et l'occident: le grand titrage. (Also published in 1973 was the Italian translation of The Grand Titration -- Scienza e società in Cina -- prepared by M. Baccianini). A collection of eleven French essays (most of which were originally written from 1949 to 1970 in English) can be found in

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[1]Nathan Sivin, rev. of Clerks and Craftsman in China and the West by Joseph Needham, in Isis, 64 (1973), 418.

[2]Knud Lundbeck, rev. of The Grand Titration by Joseph Needham, in Centaurus, 16 (1972), 327.

[3]A. G. Molland, rev. of Clerks and Craftsmen in China and the West by Joseph Needham, in British History of the History of Science, 5 (1971), 413.

[4]Sivin, rev. of The Grand Titration by Joseph Needham, in Journal of Asian Studies, 30 (1970), 873.

La tradition scientifique chinoise (1974). It is divided into three sections: "I. Confrontations"; "II. Science et technique"; "III. Société et philosophie".[1]

Science in Traditional China; A Comparative Perspective (1981) is composed up of four lectures which began life as the Second Series of Ch'ien Mu Lectures at the Chinese University of Hong Kong. Commencing with an introductory essay which glances at various aspects and themes in the history of Chinese science, technology and medicine, these lectures deal respectively with gunpowder and fire-arms, comparative microbiology, acupuncture and moxibustion, and attitudes towards time.

A cross-section of studies by other scholars were gathered in three essay collections:

(1) Chinese Science: Explorations of an Ancient Tradition (1973) edited by Nakayama and Sivin is a valuable volume on two counts. The first four papers deliver a thoughtful and informed introduction to as well as a critique of the theory and reasoning behind Needham's reconstruction and appraisal of the historical status of Chinese science and technology. The second part is "a sample, as representative as possible, of the kinds of exploration now proceeding at the various frontiers of Chinese science."[2] These encompass astronomy, optics, medicine, the Chinese concept of nature, and a bibliography of Western works.

(2) Science and Technology in East Asia (1977) edited by Sivin carries nineteen papers originally published in Isis between 1914 and 1976, including two that focus on Japan. In the editor's words, "most of the papers in this book are concerned with identifying some aspects of the special style of Far Eastern science and technology or its effects upon the encounter between East and West."[3] The essays

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[1]Of interest is the list: "Reférences des citations des textes chinois".

[2]Nathan Sivin, "Preface," in Chinese Science: Explorations of an Ancient Tradition, ed. Nakayama Shigeru, and Nathan Sivin (Cambridge, Mass.: MIT P, 1973), pp. xii.

[3]Nathan Sivin, "Introduction," Science and Technology in East Asia, ed. Nathan Sivin (New York: Science History Publications, 1977), pp. xxi.

are grouped under four categories.[1]

(3) The most recent collection of articles is a festschrift compiled in honour of Needham's eightieth birthday. Published in 1982 and involving East Asian as well as Western specialists, it offers biographical reminiscenes and original studies on a variety of topics including mathematics, alchemy, gunpowder, mining, agricultural technology, textiles technology, medicine, etc. Some papers are written in Chinese and others in English, but all are furnished with summaries in English.

Taken as a whole, these essay collections and collective works can do much to enhance the serious student's understanding and appreciation of the field of traditional Chinese science since a fairly generous range is represented, some directed at specific problems while others are more broadly-oriented. Besides, not only were several of Needham's major studies incorporated into these collections, but perhaps even more importantly, one can savour the views and findings of other authorities and workers in the field. However, the technical details, complex interpretations and elaborate arguments in some papers may be too daunting to the absolute novice or too sophisticated for those looking for a simple, accessible and basic first introduction to the subject.

2.7 BIBLIOGRAPHICAL WORKS

One can single out four bibliographies compiled with the specific aim of assisting those interested in traditional Chinese science, technology and medicine with navigating their way through the unmapped bibliographic jungle. Each of them bears a different orientation, and concentrates on a different set of literature.

J.-D. Dehergne's "Bibliographie de quelques industries chinoise: techniques artisanales et histoire ancienne" (1949) deals with writings with information on the production of textiles, gunpowder,

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[1]"Quantitative sciences" (with articles on mathematics and mathematical harmonics); "Qualitative sciences" (with articles on dietetics, astrology, and alchemy); "Technology" (with articles on gunpowder and firearms, and salt mining); and "Cultural interaction" (with articles on astronomical instruments, calendar, anatomy, and chemistry).

paper and printing, and ceramics; there is also a section on general works.[1] Each of the five parts of the bibliography is divided further into smaller subject areas (e.g. paper; printing; porcelain and pottery from different provinces) or according to the language of the titles listed (e.g. Chinese works; translations into Western-languages). Entries are arranged chronologically and they include books, journal articles as well as sections of monographs. Although the Science and Civilisation in China bibliographies for textiles technology, gunpowder, paper and printing, etc. are unquestionably more comprehensive and up-to-date, Dehergne's bibliography demonstrates a sincere attempt to register and make accessible literature on some of the most important aspects in traditional Chinese science and especially technology at a time when systematic research into these areas was barely visible.

A rather limited bibliography compiled by Robert Schrimpf (1963) lists Chinese monographs published between 1950 and 1960 mainly on the history of mathematics, astronomy, and hydraulic engineering.[2] Full bibliographic detail, Chinese characters, French translation of Chinese titles, occasional annotations, and introductions to the subjects considered are given.

Huard and Wong's "Les enquêtes française sur la science et la technologie chinoises au XVIIIe siècle" (1966) deals, as the title indicates, primarily with French sources and scholarship. The objectives of the authors, however, are more ambitious than the mere identification of the literature. The bibliography is in effect a detailed account of 18th century French characterisation and portrayal of various departments and aspects of traditional Chinese sci-

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[1]The perimeters of the bibliography are stated very clearly in the opening paragraphs: ". . .en nous limitant: aux industries spécialement étudiées par nos deux Chinois au cours de leur enquête dans la France du XVIIIème siècle et, dans ces matières, aux seuls ouvrages décrivant soit l'histoire de l'industrie (ou l'une de ses phases anciennes), soit les procédés employés. C'est dire que nous laisserons de côte les études économiques de plus en plus nombreuses concernant l'époque contemporaine et la grande industrie": J.-D. Dehergne, "Bibliographie de quelques industries chinoise: techniques artisanales et histoire ancienne," Bulletin de l'Université l'Aurore, 3rd ser., 10 (1949), 198.

[2]Several general works and studies on metallurgy, paper and printing are also provided.

ence, technology and medicine as found in a vast array of French documents. The first three sections -- "Le contexte historique"; "Les vues du gouvernement français"; "Les collecteurs de documents" -- communicate background material. The bulk of the study is taken up by "Les enquêtes scientifique" and "Les enquêtes technologiques", which together list, introduce, paraphrase or offer extended summaries on a wealth of works and sources, some little known.[1] This is succeeded by two extensive bibliographies: "Bibliographie occidentale" features 18th century as well as later Western publications; "Bibliographie chinoise complémentaire" gives an annotated register of 18th, 19th and 20th centuries Chinese publications. Furthermore, Huard and Wong assembled a valuable inventory of manuscripts and unpublished materials in various institutions and collections in France (e.g. Bibliothèque Nationale; Museum National d'Histoire Naturelle; Société Asiatique).

The fourth bibliography, Nathan Sivin's "An Introductory Bibliography of Traditional Chinese Science: Books and Articles in Western Languages" (1973) is in the words of the compiler, "a selected and informatively annotated guide to basic books and articles on Chinese science in Western languages. It has been planned to serve those who want to begin exploring Chinese science and its background for their own purposes, whatever these may be. In order to make the Bibliography as useful as possible, considerable space is devoted to books on more general topics that are especially pertinent to the development of science and to bibliographies that will lead the reader to more specialized studies."[2] The first four sections are concerned, therefore, with general bibliographies such as Cordier's <u>Bibliotheca Sinica</u>, general biographical works such as Hummel's <u>Eminent Chinese of the Ch'ing Period (1644-1912)</u>, indexes of translations such as

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[1]"Les enquêtes scientifique" is sub-divided into: "1. Astronomie et mathématiques"; "2. Physique et météorologie"; "3. Géographie"; "4.Ethnographie"; "5. Zoologie"; "6. Botanique"; "7. La Médecine". "Les enquêtes technologiques" is sub-divided into: "1. Agriculture"; 2. L'horticulture"; "3. Architecture urbaine et paysagiste"; "4. Art militaire"; 5. Céramique et arts du feu"; "6. Industrie chimique"; "7. Le laque"; "8. La métallurgie"; "9. La musique"; "10. Fabrication du papier et imprimerie"; "11. Poides et mesures"; "12. Textiles"; "13. Transports".

[2]Sivin, "Preface," pp. xxxiv.

Frankel's Catalogue of Translations from the Chinese Dynastic Histories for the Period 220-960, background studies on historiography, culture, economic and social history, philosophy, etc. Western publications devoted to Chinese science are covered in the final section in which entries are organised into "General" (nine titles); "Mathematics" (two titles); "Astronomy" (eleven titles); "Alchemy and early chemistry" (ten titles); "Medicine" (twenty-four titles); "Biology" (five titles). Nearly all items in this select group of titles receive critical and thoughtful comments. The bibliography is also equipped with a conversion table for seven systems of romanisation.[1]

2.8 CONCLUSION

Only a small portion of the literature of a general nature originated in the 19th and first half of the 20th century. In that period works that proceeded through major branches in traditional Chinese science, technology and medicine, identifying, depicting and outlining landmarks and accomplishments (or their absence) were standard fare. While such a manner of addressing the subject can be looked upon as limited and one-dimensional, the expression of efforts to introduce the subject to the academic as well as public audience should be properly acknowledged.

Narratives designed to portray and promote successes in different areas of traditional Chinese science, technology and medicine by no means faded away even as interest and scholarship in the field as a whole progressed steadily and promisingly into the 1960s, '70s, and beyond. Some were sophisticated and critical while others were sketchy and mechanical, but all placed traditional Chinese understanding and skills within a modern Western cultural and scientific landscape. In other words, whatever priorities and ingenuities the writers accorded to the Chinese, they were chiefly the results of measuring particular Chinese performances against comparable Western ones.

Nevertheless, the topic by topic, precedent-hunting approach was

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[1]A supplement was published in the 1988 Chinese Science.

less of a norm in post-1970 works, and one began to witness the first signs of experimenting with other methods and genres: there were preliminary attempts at mapping and highlighting study trends in recent decades; directories of researchers were compiled; the issue of terminology was raised; the invaluable treatise *T'ien kung k'ai wu* was translated; essay collections were made available.

It remains to be seen whether bids to employ alternative and adventurous strategies and frameworks of synthesis and distillation would continue, and above all, successfully yield general works that are informed and comprehensive, and that can satisfy readers with different needs and from various levels.

2.9 PARTICIPATING COUNTRIES AND INDIVIDUALS

In the period between 1835 and 1949, a dozen or so individuals from European countries as well as America articulated their interest in traditional Chinese science by publishing general works that cover multiple topics.[1] With some notable exceptions (e.g. the French Sinologists and academics Biot and Julien), these Westerners, while they were working in China, did not spend their time primarily as researchers of Chinese history and culture.[2]

Since the 1950s and '60s, American researchers have assumed an active role; Sivin, in particular, has injected an enormous impetus into the field, surveying study trends, putting together directories of researchers, editing collections of essays, and compiling bibliographies.[3] Output from Europe continued to be significant, and was not limited to Needham's undertakings; consider, for instance, Elvin and Cullen from Britain, Huard, Wong, and Haudricourt from France, Muccioli from Italy. Ho from Griffith University in Australia and later the University of Hong Kong also contributed. This new generation of individuals were nearly all academics, including Chinese

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[1]e.g. Biot and Julien from France; Edkins and Chatley from the U.K.; Vacca from Italy; Hommel and Bodde from America.

[2]e.g. Chatley was an engineer by profession, and MacGowan a medical doctor.

[3]Others from that country included Goodrich, Sun, and Major.

historians of science, China specialists, and historians of Western science and medicine.[1]

The total number of authors responsible for these 19th and 20th century general works remained small, and they belonged for the most part to that core group of scholars who wrote on various aspects and branches of Chinese science, technology or medicine (e.g. Edkins, Needham, Bodde, Huard, Ho, Sivin).

2.10 FORMS OF PUBLICATION

In sharp contrast to the customary practice encountered in other chapters in which observations and opinions were largely communicated through journal articles, half of the general works were written as essays in collective works or issued in the form of monographs and pamphlets.

Disciplinary orientation of the essay collections which house the articles varies; consider, for instance, Dictionary of Scientific Biography, Information Sources in the History of Science and Medicine, The History and Philosophy of Technology, China's Modern Economy in Historical Perspective, Chinese Science: Explorations of an Ancient Tradition. This can be viewed as excellent opportunities for members of the traditional Chinese science community to speak to different groups of audience and constituents, but may cause headaches in terms of bibliographic control.

As for journal articles, the large majority of them were published in journals in the Chinese / Asian studies field.[2] Chinese Science carried four contributions, three from Sivin. Among other periodicals chosen as vehicles were Nature, Interdisciplinary Science Review, Bulletin of the British Society for the History of Science,

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[1]Silverberg, however, was a "Columbia University graduate, devotes his time to writing, travelling and collecting rare books; written 50 books, mainly on scientific and historical subjects": Robert Silverberg, Wonders of Ancient Chinese Science, (New York, Hawthorn Books, [1969]), title page.

[2]e.g. Journal Asiatique, Revista degli Studi Orientali, Journal of the North China Branch of the Royal Asiatic Society, Bulletin de l'École Française d'Extrême Orient, Papers on Far Eastern History.

Revue de Synthèse, and Quaderni di Merceologia.

2.11 BIBLIOGRAPHIC PROVISION AND CONTROL

I. GENERAL BIBLIOGRAPHIES FOR CHINESE / ASIAN STUDIES AND THE HISTORY OF SCIENCE

(a) Henri Cordier, Bibliotheca Sinica. . . (1904-08); (1922-24):

All eight works from the 19th century are listed.[1] Four are placed under "XII. Sciences et Arts - Industries diverses", while Martin's essay and the three anonymous accounts can be found in an appendix headed "Science en Général". Vacca's studies from 1911 and 1915 are not listed in the supplement.

(b) John Lust, Index Sinicus. . . , 1920-55 (1964):

Of the seven articles published within the period covered by Lust's index, three from Chinese / Asian studies are recorded in the "XVIII. Science and Technology" section.[2] Mikami's "A Chronology of the XVI Century: China and Japan" in Archeion is also included (under "IV. History - b. Historical period - iv. 1277-1643").

(c) ISIS Cumulative Bibliography, 1913-65; 1966-75; 1976-85:

Broadly speaking, these volumes have provided a reasonably good coverage of 20th century publications mentioned in this chapter. Most monographic titles -- which make up a fair portion of the literature -- have been indexed.[3] ISIS is also a good resource for papers in science and history of science journals and conference proceedings as well as those in general collective publications.[4]

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[1]MacGowan's article and three anonymous accounts published in Nature between 1883 and 1895 do not appear in other general bibliographic sources.

[2]Huard's "Sciences et techniques de l'Eurasie" in the Bulletin de la Société des Études Indochinoises was omitted.

[3]However, oddly enough, Sun and Sun's translation of the *T'ien kung k'ai wu* is missing (even though a Chinese edition and a Japanese one can be found in the *Personality* section under "Sung Ying-hsing"). Also overlooked is Explorations in the History of Science and Technology in China; Compiled in honour of the 80th Birthday of Dr. Joseph Needham.

[4]For example, it is the only source for Schove's essay in the Bulletin of the British Society for the History of Science (1952) and Needham's review of the Science and Civilisation in China project in

Some studies from Chinese / Asian studies journals were noted, including George H. C. Wong's article in the 1963 Chung Chi Journal, curiously not given in other general bibliographic aids. Relevant titles are located in the "A. Science" section under "39 Far East" or "4. China".

(d) Bibliography of Asian Studies, 1936- :

Among the seven general bibliographic compilations, only the Bibliography of Asian Studies lists the books by Silverberg, Breuer (German original and English translation), and Ross, and the festscrift for Needham's eightieth birthday. It also reported all other monographs.[1] Information on most essays from journals and collective works are provided, including several from non-Chinese / Asian fields.[2] However, it is very surprising not to find Ho's 1974 study in Papers on Far Eastern History and items from the 1975 and 1978 Chinese Science (though the one in the 1980 issue was recorded).

Happily, apart from a few exceptions (e.g. Elvin's "Skills and Resources in Late Traditional China" in the "China - Economics" section), indexed titles are presented under "China - Science and Technology".[3]

(e) Bulletin Signalétique, 1947- :

It noted ten titles, most of which, interestingly, being essay collections (as a result of its efforts at indexing book reviews).[4]

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the Interdisciplinary Science Review (1980).

[1]A minor point: it is not possible to retrieve the two Science and Civilisation in China abridgements by Ronan by looking up his name in the author index.

[2]e.g. Huard's study in Revue de Synthèse (not indexed elsewhere), contributions by Needham and Haudricourt to History of Science: Ancient and Medieval Science from the Beginnings to 1450 (but not their French versions in Histoire générale des sciences).

[3]This applies even to works in the two cumulations which regularly place publications devoted to science, technology and medicine in sections other than that specifically for these subjects.

[4]e.g. Science and Technology in East Asia, Chinese Science: Explorations of an Ancient Tradition, and five collections of essays written by Needham -- one of which (i.e. La science chinoise et l'occident: le grand titrage) has not found its way into any of the other bibliographies.

The short paper by Zoli in Atti della Fondazione Giorgio Ronchi -- which appears only in this index -- is in the sub-section "I. Généralités - Histoire générale des sciences et des techniques". Other works are also under headings of a general nature.[1]

(f) Revue Bibliographique de Sinologie, 1955-70; 1983- :

Even though almost twenty titles fall within its indexing range (e.g. Huard and Wong's "Le développement de la technologie dans la Chine du XIXe siècle" in Cahiers d'Histoire Mondiale, and Ho's *Li, Qi* and *Shu*: An Introduction to Science and Civilization in China), only two from 1966 were reviewed; namely, "Les enquêtes françaises sur la science et la technologie chinoises au XVIIIe siècle" in Bulletin de l'École Française d'Extrême-Orient, and the translation of Sung Ying-hsing's book by Sun and Sun.[2]

(g) Tōyōgaku Bunken Ruimoku, 1963- :

The benefit of consulting the Tōyōgaku Bunken Ruimoku for works treated in the present chapter is rather limited: titles reported are chiefly essay collections and books, mostly listed under "IX. Science - I. General".[3] Ho's article on terminology is under "XV. Philology - 2. Chinese".

II. **CONCLUSION**

Little additional help is available beyond that supplied by these general bibliographies. Together, they have furnished almost ninety percent of the literature discussed. But among works overlooked are some which no student would want to miss: Sun's "Chinese History of Technology: Some Points for Comparison with the West"; Needham's "The Translation of Old Chinese Scientific and Technical Texts"; three studies by Sivin (i.e. "Current Research on the History of Science in the People's Republic of China"; "Directory [of Persons

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[1]e.g. "Histoire générale des sciences et des techniques - Extrême-Orient", "Technologies - Histoire - Extrême-Orient".

[2]Note that Needham's essay in The Legacy of China (1964) edited by Dawson can be retrieved by looking up his name in the Author Index (which gives the number for Dawson's book), but searching under terms related to science or technology in the Subject Index would not yield that number.

[3]Explorations in the History of Science and Technology in China; Compiled in honour of the 80th Birthday of Dr. Joseph Needham is only given under its Chinese title in the Chinese section.

Studying Chinese Science in the West]"; and "Shen Kua"). Half of these titles are tucked away in essay collections (e.g. The History and Philosophy of Technology, Aspects of Translation) which may explain why they escaped the indexing mechanism, but then two of Sivin's articles are in Chinese Science.

Moreover, this chapter has provided some interesting examples of how unpredictable bibliographies can be: (i) Mikami's paper in Archeion (1941) appears in Index Sinicus, but not in ISIS; (ii) ISIS, but not the Bibliography of Asian Studies, lists Ho's "Chinese Scientific Terminology" in Papers on Far Eastern History (1974); (iii) Major's "Notes on the Studies in the History of Science in the People's Republic of China" in Chinese Science (1980) was registered by the Bibliography of Asian Studies, but not by ISIS.

CHAPTER 3 : TRADITIONAL CHINESE SCIENCE -- FUNDAMENTAL CONCEPTS; PHILOSOPHY; SOCIAL AND CULTURAL RELATIONS

"What characterises traditional Chinese science and scientific thought?"; "Why did not China develop modern science and technology?"; "Why was there no Scientific Revolution in China?"; "How were the Chinese scientific traditions related to other facets in China's history?". These are questions and problems that every historian of Chinese science, technology and medicine has to confront at least once; and not only the answers, but the manner in which they are perceived, conceptualised, formulated and articulated has serious implications for understanding all aspects of the scientific, technological and medical traditions. However, while works discussed in this chapter are all motivated by and take aim at these issues, sharing the common goal of seeking to better comprehend this formidable set of concerns, different approaches and avenues have been chosen, varying considerably in scope and focus. Some studies, for instance, concentrate on social and economic factors and mechanisms, but others speak more directly to links and associations with Chinese philosophical systems.

Publications in this chapter do not lend themselves conveniently to being arranged according to subject categories and topics. The discussion will instead proceed chronologically in one sequence. But with eighty titles, some form of demarcation or signposting is necessary to render the text less monotonous and the reader's task less wearisome. Five chronological divisions are therefore provided: 1911-36; 1946-59; 1960-69; 1970-79; 1980-85.

3.1 1911-36

In seeking clues to early 20th century Western efforts at grappling with the fundamental characteristics of Chinese science and the goals of its practitioners, one can turn to several works, each representing a different mixture of views and intent.

The first is "Science among the Chinese" (1911) by C. K. Edmunds who, in this article, denies vehemently and categorically that China had or anticipated modern science. His assertions and arguments are laid out in some detail in four sections: "Introduction"; "The content of 'Chinese science'"; "Alleged anticipation of modern science"; "Causes of China's backwardness".[1]

In his brief article published as an appendix to Aldo Mieli's <u>Manule di storia della scienza</u>, Giuseppe Tucci (1925) considers the bearing of such philosophical ideas and structures as *wu hsing* upon Chinese science, referring occasionally to original Chinese sources.

Alfred Forke's <u>The World-Conception of the Chinese: Their Astronomical, Cosmological and Physico-Philosophical Speculations</u> (1925) explores four areas in traditional scientific thought of the Chinese, especially their cosmological systems and their perception of the universe.[2] The content of the treatise spreads over a wide tract.[3] Translations of passages (of which there is a number) are accompanied by the Chinese text in question. After reading Forke's book, George Sarton wrote: "There is very little of that, if anything, which deserves to be called <<science>>. In fact the whole book is a painful study of scientific aberration."[4] But Needham (not unexpectedly) viewed the situation as one in which it was Forke who failed to fully grasp and appreciate fundamental Chinese precepts rather than that key scientific qualities were lacking in the Chi-

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[1](1) "Introduction" is broken down into: "Chinese science a case of arrested development"; "Their inventions, arts, engineering, not evidence of scientific attainment". (2) "The content of 'Chinese science'" into: "Anatomy"; "Materia medica, botany, zoology"; "Geography"; "Astronomy, astrology"; "Mathematics"; "Action and reaction of elements"; "Chemistry, alchemy"; "General cosmological ideas". (3) "Causes of China's backwardness" into: "Some salient aspects of modern scientific knowledge"; "Some salient features of the Chinese conception of the universe -- 1. absence of inductive method, 2. spirit of inaccuracy, 3. lack of mathematical knowledge or method, 4. the language, 5. the system of education, 6. the influence of astrologers and fortune-tellers. . . ."

[2]"Book I. The Universe"; "Book II. Heaven"; "Book III. Yin and Yang"; "Book IV. The Five Elements".

[3]e.g. "The six astronomical systems"; "Nature of Heaven"; "Yin and Yang as fluids and primary elements"; "The Five Elements in the Later Chou epoch".

[4]George Sarton, rev. of <u>The World-Conception of the Chinese</u> by Alfred Forke, in <u>Isis</u>, 8 (1926), 374.

nese.[1] Both Sarton and Needham referred to the muddle caused by Forke's incorrect dating of various Chinese writings and his attempts at comparing Chinese experiences with those in other civilisations. A slightly modified German edition of the book was published in 1927.

In contrast to Forke, H. C. Zen's "Science East and West, its Evidences in the China of Yesterday and Today" (1931) begins with the following comment: "Science is a Western product. But if we are to follow Herbert Spencer in saying that science is nothing but systemized common sense, it should not be surprising to find in the early record of Chinese history certain collections of materials which can be regarded as the embryo of science, however rudimentary it may be. Thus in the matter of meteorological and astronomical observations, China holds one of the earliest records on earth."[2] In spite of this apparently positive attitude and interpretation, Zen concedes China's "backwardness in science", and goes on to identify the different areas of modern science and describe their introduction into China and effects on the country up to the 20th century.[3]

Unlike the above authors, Derk Bodde approached the issue by tracing the positions taken by Late Chou and Ch'in thinkers towards science and scientific method. He concludes his article in the 1936 T'ien Hsia Monthly by stating that, "such a failure to develop science was owing, not to fundamental inability, but rather deliberate choice and a compelling interest in other things."[4]

Although this handful of early studies should be viewed only as preliminary inquiries, they heralded a class of Western literature which grew dramatically in both numbers and significance in the ensuing decades: one that probed into the supposed failure of China to develop Western science and the absence of modern science in China.

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[1] *See* Science and Civilisation in China, vol. 2, pp. 216.

[2] H. C. Zen, "Science East and West, its Evidences in the China of Yesterday and Today," Pacific Affairs, 4 (1931), 479.

[3] ibid.

[4] Derk Bodde, "The Attitude towards Science and Scientific Method in Ancient China," T'ien Hsia Monthly, 2 (Feb 1936), 139.

3.2 1946-59

The surge in activity which began in the late 1940s and early '50s was spearheaded by writings from Joseph Needham. There was, however, a short essay written by Giovanni Vacca in 1946 in memory of Ting Wen-ch'iang, the renowned Chinese scientist and founder of the China Geological Survey, in which Vacca gives a somewhat hurried and sketchy account of the lack of scientific progress in China's past.

Two of Needham's earliest public addresses devoted specifically to the history of Chinese science were the Conway Memorial Lecture from 1947 (titled "Science and Society in Ancient China") and a lecture given at the opening session of Unesco in 1946 (titled "The Chinese Contribution to Science and Technology" and published in 1948).[1] This is not without significance as seldom before had the subject been exposed to such a vast general audience, and in such an impassioned while at the same time erudite way.

Needham starts off his Conway Memorial Lecture (1947) by outlining the characteristics of Confucian philosophy ("entirely social -- a feudal ethic, no doubt, but extremely social-minded") contrasting it with Taoist philosophy, especially the Taoist's interest in understanding nature.[2] The political implications of Taoist philosophy are then emphasized. Following this is a discussion on connections between ancient Chinese feudalism, technological inventions (especially the case of the efficient harness for animals), social factors, and ethical issues (e.g. slavery). In all of this, Needham holds on to Chinese feudalism's inability to give rise to capitalism in his attempt to answer the question why Western science and techno-

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[1]So was another paper from the 1940s, "The Unity of Science: Asia's Indispensable Contribution". We are told that, "the two sections of this article were two broadcasts from London in the BBC Third Programme, Oct. 1949, and were based on a lecture delivered at Beirut, Lebanon, on the occasion of the Unesco General Conference there, Nov., 1948": Joseph Needham, "The Unity of Science: Asia's Indispensable Contribution," Asian Horizon 2.3 (1949/50), 55. Also Human Laws and the Laws of Nature in China and the West, a 1951 Hobhouse Memorial Lecture.

[2]Joseph Needham, Science and Society in Ancient China (London: Watts, 1947), pp. 6. "So in ancient China it is quite clear that Confucian ethical rationalism was antagonistic to the development of science, whereas Taoist empirical mysticism was in favour of it": Needham, Science and Society, pp. 10.

logy did not take root in traditional China. His Unesco lecture (1948) pursued a slightly different course. The audience was indeed introduced to Chinese achievements.[1] But Needham was equally eager to instruct and stimulate them with features in Chinese philosophy, especially attitudes and conceptions of the Taoists towards nature. He was, above all, concerned with the questions, "Why they did not succeed, as Europe's civilisation did, in giving rise to *modern* science and technology? Why did their science and technology always remain primarily empirical? Why was there no indigenous industrial revolution in China?"[2] And the answer he suggested has been echoed repeatedly in his later publications: "I think one of the great reasons is that Chinese is fundamentally an irrigation-agricultural civilisation, as against the pastoral-navigational civilisation of Europe; with the consequent prevention of the merchants' rise to power" -- a point of view that has since been hotly contested by other scholars.[3]

Another facet Needham has identified in the comparative study of Chinese and Western science is that of interaction and diffusion. In "L'unité de la science: l'apport indispensable de l'Asie" (1949), Sino-Indian contacts and transmissions from Asia to Europe are highlighted and rationalised. Included are astronomy, medicine, cartography, mathematics, mineral acids, etc., as well as "inven-

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[1]For example, in alchemy, the mathematical sciences, technology (e.g. the chariot, paper and printing, the magnetic compass, gunpowder, method of boring), medicine (e.g. anatomy, vaccination, the Great Pharmacopoeia, the question of deficiency disease).

[2]Joseph Needham, "The Chinese Contribution to Science and Technology," in Reflections on Our Age: Lectures delivered at the Opening Session of Unesco at the Sorbonne University, Paris, ed. David Hardman, and Stephen Spender (London: Allan Wingate, 1948), pp. 212. As Lynn White, jr. shrewdly observed in 1984 in a thoughtful reflection on Needham and his work, "unfortunately, Needham habitually phrases that question [i.e. "Why modern science originated only in Europe", one that was raised by the "able Chinese graduate students at Cambridge" with whom Needham made contact in the 1930s] in reverse: 'Why did modern science not originate in China?'": Lynn White, jr., and Jonathan Spence, "Science in China," Isis 75 (1984), 172-73.

[3]Needham, "The Chinese Contribution," pp. 222. But again, as Lynn White, jr. pointed out, Needham modified his answer over the years; *see* White and Spence, "Science in China," 175.

tions techniques qui, filtrant à travers les barrières dont nous avons parlé, ont constamment passé d'Asie orientale en Europe depuis le début de l'ère chrétienne" (e.g. paper and printing, water-wheels, water-mills, and paddle-wheels).[1] Chinese sources are mentioned and selected passages translated. "The Unity of Science: Asia's Indispensable Contribution" (1949) is similar in content and conveys the same message, namely, "that there was no lack of contact between Arabic and East Asian science, but it still remains true that the science of eastern Asia did not filter through to the Franks and Latins, that is to say to precisely our part of the world where, perhaps by a series of historical accidents, modern science and technology were to develop later. But this barrier or filter, it is important to notice, was operative only in the case of the abstract or pure sciences; it was definitely not effective for technology. Technical inventions show a slow but massive infiltration from east to west throughout the first 13 centuries of the Christian era."[2]

Yet another conceptual tool Needham employed to delve into the nature of traditional Chinese science was that of comparing human laws and the laws of nature in China with that in the West. This formed the main theme of the Hobhouse Memorial Lecture he delivered in 1951, which is peppered generously with quotations from Chinese texts.[3] On this topic of traditional Chinese views of nature and the position they occupied in Chinese scientific thought, Needham at-

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[1]Joseph Needham, "L'unité de la science: l'apport indispensable de l'Asie," Archives Internationales d'Histoire des Sciences, 2 (1949), 573.

[2]Needham, "The Unity of Science: Asia's Indispensable Contribution," Asian Horizon, 2.3 (1949/50), 57.

[3]It consists of: "1. Introduction"; "2. The common root of the natural law of the Jurists, and the laws of nature of science"; "3. Natural law and positive law in the history of Chinese civilisations; the resistance to codification"; "4. Stages in the Mesopotamian-European differentiation of natural laws and laws of nature"; "5. Chinese thought and the laws of nature"; "6. The words *fa* and *li*"; "7. The word *lü*"; "8. The word *tu*"; "9. The words *chi kang*"; "10. The words *li* and *tsê* of the spontaneity and freedom of nature"; "12. Neo-confucianism as a philosophy of organism"; "13. Buddhist thought concerning law"; "14. Contrasting European and Chinese attitudes to animal abnormalities"; "15. The comparative philosophy of law in China and Europe"; "16. Conclusion".

tended especially to those of the Taoists in 3rd century B.C.. In his article (1953a) for a volume in honour of Charles Singer, their concepts as well as political position (which were closely linked to the "proto-scientific tendencies" of their ideas) are contrasted with the situation of "scientists of the European Renaissance" and "the brethren of sincerity in ten century A.D. Arabia" respectively.

"Thoughts on the Social Relations of Science and Technology in China (1953c) is one of Needham's early papers specifying the socio-economic environment, social milieu, political climate, government bureaucracy and other related elements as factors responsible for the non-development of modern science in traditional China. In it, he contends that "the ending of the first feudalism in China did not give rise to mercantile capitalism and industrial capitalism, but brought about instead a bureaucratic system involving the loss of the aristocratic and hereditary principle from Chinese society", and that "it is precisely in the inhibition of the rise of merchants to power in the state that we have to look for the reasons for the inhibition of modern science and technology in Chinese culture."[1]

At the 7th International Congress of the History of Science held in Jerusalem in 1953, Needham (1953b) again sought to acquaint fellow scholars with the history of communication, transmission and simultaneous development of techniques and scientific ideas in the East and West. His paper examines them at some length under the headings of "Gifts of Practice" and "Gifts of Theory".[2] A discussion by Leslie Donald followed, elaborating on the "problem of action at a distance which still has a considerable number of philosophical

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[1]Joseph Needham, "Thoughts on the Social Relations of Science and Technology in China," Centaurus, 3 (1953), 40; 46. Although this theme became one of Needham's (and other's) favourites in the 1960s, '70s and '80s, it was singled out for special consideration only once in the 1950s.

[2]"Gifts of Practice" is divided into: "(a) Introduction"; "(b) Diffusion and convergence"; "(c) Priority and transmission"; "(d) Simultaneous developments"; "(e) The Watcher of the Tides and the Man from Chhin". "Gifts of Theory" is divided into: "(a) Introduction"; "(b) The symbolic correlations"; "(c) The theory of the two fundamental forces"; "(d) Correlative thinking and its significance"; "(e) Macrocosm and microcosm"; "(f) European antitheses and the Chinese synthesis".

thorns for the scientist."[1]

The issues and problems of transmissions, contacts, and priorities in fact constitute the most important theme in the first volume of Science and Civilisation in China (1954). In the main section -- "Conditions of travel of scientific ideas and techniques between China and the West" -- Needham and Wang Ling investigate, among other aspects: "The development of overland trade routes"; "The development of the maritime trade-routes"; "The Old Silk Road"; "Chinese-Western cultural and scientific contacts as recorded by Chinese historians"; "Chinese-Indian cultural and scientific contacts"; and "Chinese-Arab cultural and scientific contacts".[2] The second volume (1956), on the other hand, emphasizes the role played by the major schools of thought and systems of philosophy in shaping the history of scientific ideas and activities in China. Needham and Wang, drawing upon an amazing array of Chinese sources, survey masterfully and comment critically on the following topics and concerns: "Confucians and Confucianism"; "Taoists and Taoism"; "Mohists and Logicians"; "Legalists"; "The pseudo-sciences and the sceptical tradition"; "Buddhist thought"; "Chin and T'ang Taoists, and Sung Neo-Confucians"; "Sung and Ming idealists, and the last great figures of indigenous naturalism"; "Human law and the laws of nature in China and the West".

So how did the world receive the first two volumes in what has since become a series of world renown? What did the reviewers say in the 1950s? That Needham's achievement was a major one, almost no one seriously disputed, but opinions varied as to the degree and the future significance of his accomplishment -- and the charges of errors and incompetence (petty and insignificant though they may in fact be) could well surprise a newcomer to the field.[3]

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[1]Leslie Donald, "From Magic to Science in Early China," In Actes du 7e Congrès International d'Histoire des Sciences, Jerusalem, 1953 (Paris: Hermann, [1953?]), pp. 186.

[2]The other sections are: "Preface"; "Plan of the work"; "Geographical introduction"; "Historical introduction".

[3]**VOL. 1: (1) L. S. Yang** pointed out that only one Japanese title is listed in the Bibliography, that the level of the background information given is uneven, and that "there is already evidence that the author is rather careless with regard to philological matters": L. S. Yang, rev. of Science and Civilisation in China, vol. 1, in

Harvard Journal of Asiatic Studies, 18 (1955), 274. (2) **L. C. Goodrich**'s review in Isis 46 (1955) questions certain ideas and techniques that Needham claims to have travelled from East to West. (3) **H. H. Dubs** expressed the opinion that, "in the generally good and illuminating account of contacts between China and the West. . . Dr. Needham has here unfortunately relied too much on older work and neglected important recent work, especially that done by Japanese": H. H. Dubs, rev. of Science and Civilisation in China, vol. 1, in Philosophy, 30 (1955), 362. And further that, "as an introduction to a study of Chinese technology and science, this book is very good. But it cannot be relied upon in detail. Dr. Needham in part realizes his difficulties (p. 295), but not sufficiently so. He has ventured to deal with domains which specialists find difficult and in which there is a large amount of misleading information in European languages. Sinology is like "Europology," a vast field, which can only be handled adequately by specialists in separate fields. Specialists will, it is to be feared, find many flaws in what is mainly good work": Dubs, rev. of Science and Civilisation in China, vol. 1, 363.

VOL. 2: (1) **Arthur F. Wright** stated rather bluntly that, "the way in which Chinese thought was analyzed in this volume seems to me to bring into doubt the validity and ultimate value of Needham's study as a whole", that "at their best, from Rémusat to Paul Démiéville and Arthur Waley, they [i.e. Western Sinologues] have tried to avoid reading into the ancient texts ideas which were not there. They have shown far more respect for Chinese utterances than Needham -- the apologist for Chinese culture -- does in this volume", and concludes that "the flaws in its edifice of method and interpretation seem to me gravely to impair its value both for the specialist and the general reader": Arthur F. Wright, rev. of Science and Civilisation in China, vol. 2, in American Historical Review, 62 (1957), 918-20. (2) To **Rufus Suter**, Needham's characterisations of Chinese contributions in sciences other than biological sciences and chemistry "seem less convincing, and the evidence cited for early Chinese knowledge of the sphericity and motion of the earth was. . . unconvincing": Rufus Suter, rev. of Science and Civilisation in China, vol. 2, in Science and Society, 22 (1958), 75. (3) **D. C. Lau** indicated that, "when one takes a closer look at Dr. Needham's interpretation of Chinese thought, one finds a good deal which leaves room for disagreement": D. C. Lau, "Chinese Thought and Science," Nature, 178 (1956), 1201. (4) **Derk Bodde** suggested that, "perhaps the most controversial [of the challenging hypotheses in the book] will prove to be Needham's interpretation of Taoism. By minimizing the mystical aspects of early Taoism, emphasizing its role as a movement of social protest. . . , and linking this social interest to its interest in science, he comes up with the equation. . . : Taoism = democracy (or 'primitive democracy') = science. . . . Exciting though this thesis is, there are many steps to it which, it seems to me, are open to question": Derk Bodde, "Needham on Chinese Philosophy and Science," Journal of Asian Studies, 16 (1956), 263. (This review article also contains the following sections: "Inconsistencies"; "Translations and etymologies"; "Citation of sources"; "Romanization"; "Bibliography"; "Index"; "Miscellaneous points".) (5) **Owen Lattimore and David Lattimore** commented on "the lack of expertness" in the section on the Chinese language, and called attention to "doubtful cases for which

Several accounts by Needham remain to be mentioned before we can move on to studies published in the 1950s by two other scholars. By analysing the relations of mathematics to natural science in Renaissance Europe as well as in mediaeval China, Needham came to the conclusion, in a paper from 1956 (with a German as well as a French version, both published in 1957), that, "interest in nature was not enough, controlled experimentation was not enough, empirical induction was not enough, eclipse-prediction and calendar-calculation were not enough -- all of these the Chinese had. Apparently a mercantile culture alone was able to do what agrarian bureaucratic civilisation could not -- bring to fusion point the formerly separated disciplines of mathematics and nature-knowledge."[1] "Ondes et particules dans la pensée scientifique chinoise" (1959) by Needham and Kenneth Robinson explores a rather different frontier. It introduces certain peculiarities in ancient and mediaeval Chinese approaches and sensitivities to the physical world. Aspects discussed include "L'atomisme dans la Chine ancienne"; "Le mouvement ondulatoire du Yin et du Yang"; "Concepts cycliques"; "La Chine et le stoicisme"; "Identification par les chinois du son comme vibration"; "L'atomisme et les alphabets";

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the records suggest simultaneous appearance" [of techniques in East and West]: Owen Lattimore, and David Lattimore, rev. of Science and Civilisation in China, vol. 2, in Review of Metaphysics, 11 (1957), 270. In their discussion of Needham's social thought, they made the following observation: "We have another clue to Needham's social thought in the term 'feudal bureaucracy,' which is listed 23 times in the index to Vol. II. . . . It is the current Marxist term for Chinese society from the third century B.C. to modern times, and we think it thoroughly unsatisfactory. . . . We do. . . question Needham's sociology. If there is truth here, it lies buried deep. We put the question to historians of science and society: were there not positive stimuli lacking, as well as negative barriers present? Why *should* the Chinese have developed modern science? By similar criteria, we could be castigated for not having discovered the Chinese science of 3000 A.D., and no doubt a suitable group of culprits could be found": Lattimore and Lattimore, rev. of Science and Civilisation in China, vol. 2, 275-76.

[1]Joseph Needham, "Mathematics and Science in China and the West," Science and Society, 20 (1956), 343. The article is arranged as follows: "Nature and achievements of Chinese mathematics"; "The social background of Chinese mathematics"; "Origins of the method of modern natural science in Europe"; "The Galilean method and its world-view"; "The empirical component"; "Chinese neo-Confucians"; "The social matrix in Europe and China".

and "Continuité et discontinuité".

Finally, three noteworthy titles from the 1950s, one by Chan Wing-tsit and two by Bodde, on the nature of Chinese scientific thought. Chan's "Neo-Confucianism and Chinese Scientific Thought" in the 1957 Philosophy East and West looks at "the question of the status of science in relation to Chinese thought, the question of the reason China has not developed natural science, the question as to whether Neo-Confucianism, especially, is consonant with modern scientific thinking."[1] Although the emphasis is placed on Neo-Confucianism, also addressed are Buddhism, Confucianism, and Taoism. In his contribution to a festschrift dedicated to Bernhard Karlgren Bodde (1959) concentrates on the notion and meaning of *hou ch'i* (translated as "watching for the ethers") and tries to fathom the extent to which this practice and belief can be considered as having scientific, pseudo-scientific, or superstitious elements. His "Evidence for 'Laws of Nature' in Chinese Thought" (1957) further expostulates on Needham's thesis concerning these "laws of nature".

3.3 1960-69

The 1960s boasted fifteen titles on areas treated in the present chapter. Eleven of them came from Needham.[2] The ground covered in some of his essays is broad and ~~emcompasses~~ encompasses a host of topics (e.g. "Science and China's Influence on the World"; "Glories and Defects of the Chinese Scientific and Technical Traditions"); others concentrate on specific themes (e.g. Time and Eastern Man: The Henry Myers Lecture; "The Role of Europe and China in the Evolution of Oecumenical Science"). But it is most convenient -- and creates the least amount of confusion -- to describe them in chronological order:

(1) "Science and Society in Ancient China" in the 1960 Mainstream differs only marginally from the 1947 Conway Memorial Lecture that

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[1]Chan, Wing-tsit, "Neo-Confucianism and Chinese Scientific Thought," Philosophy East and West, 6 (1957), 309.

[2]It is, however, important to remember that an original work was sometimes translated, abridged or slightly altered. These are mentioned in the text and listed separately in the bibliography. But unmodified reprints are only indicated in the bibliography.

bears the same title.

(2) "Poverties and Triumphs of the Chinese Scientific Tradition" (1963) outlines the link between the Chinese feudal-bureaucratic system and historical experiences in the sciences as well as the bearing of the Confucian-Taoist view of the world on Chinese scientific thought.

(3) The French version of title number 2 was translated by Michel Charlot and published in the 1963 *La Pensée*.

(4) There is also an English abridgement of title number 2 -- renamed "Science and Society in China and the West" -- in the 1964 *Science in Progress*.

(5) The implications and functions of several broad categories of elements in the formation and progression of traditional Chinese science and technology are considered in "Glories and Defects of the Chinese Scientific and Technical Traditions" (1964), namely, the social position of scientists and engineers in traditional China, feudal-bureaucratic society, invention and labour power, philosophical and theological factors, the linguistic factor, and the role of merchants.

(6) The thrust of "Science and Society in East and West" (1964) is on traditional Chinese social, intellectual, and economic frameworks and their differences from structures in the West as being responsible for "both the earlier predominance of Chinese science and technology and also the later rise of modern science in Europe alone."[1] In reviewing this work Nathan Sivin suggested that, "real comprehension of social causes of scientific change, East and West, will come neither out of plays on words like <<action at-a-distance>> nor out of fuzzy concepts like <<proto-feudalism>>. This pioneering paper, in its weaknesses as in its strengths, will encourage what is needed: a close look at actual scientific discoveries and their social conditions; and, in conceptualization a willingness to <<fol-

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[1]Joseph Needham, "Science and Society in East and West," in *The Science of Science: Society in the Technological Age*, ed. Maurice Goldsmith, and A. McKay (London: Scientific Book Club, 1964), pp. 149.

low where the evidence leads>>."[1]

(7) "Naturvidenskab og samfund i øst og vest" (1966) in Dansk Udsyn is a Danish translation of the above title.

(8) In Time and Eastern Man; The Henry Myers Lecture (1965) Needham carries out an intensive and path-breaking inquiry into the concept of time in Chinese philosophy, society and culture, and its multiple roles in influencing scientific and technological components in traditional China.[2]

(9) The above account was reprinted in 1966 with minor modifications as "Time and Knowledge in China and the West".

(10) "The Roles of Europe and China in the Evolution of Oecumenical Science" (1967) inspects Chinese science (and to some extent Western science) from a unique angle, one that strives imaginatively if not conclusively to answer "two quite distinct questions. . . , first when in history did a particular science in its Western form fuse with its Chinese form so that all ethnic characteristics melted into the universality of modern science; and second at what point in history did the Western form decisively overtake the Chinese form? We may thus try to define the date of what may be called the 'fusion point' on the one hand, and that of the 'transcurrent point' on the

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[1]N. Sivin, annotation for "Science and Society in East and West" by Joseph Needham, in Revue Bibliographique de Sinologie, (1964), pp. 449.

[2]It ends with the pronouncement that, "if Chinese civilisation did not spontaneously develop modern natural science as Western Europe did (though much more advanced in the fifteen pre-Renaissance centuries) it has nothing to do with her attitude towards time. Other ideological factors, of course, remain for scrutiny, apart from the concrete geographical, social and economic conditions and structures, which may yet suffice to bear the main burden of the explanation": Joseph Needham, Time and Eastern Man; The Henry Myers Lecture, 1964 (London: Royal Anthropological Institute of Great Britain & Ireland, 1965), pp. 52.

The lecture is divided into: "Time in Chinese philosophy and natural philosophy"; "Time, chronology and Chinese historiography"; "Mechanical and hydro-mechanical time measurement"; "Biological change in time"; "Time and social devolution or evolution, *ta thung* and *thai phing*"; "The deification of discoveries and the recognition of ancient technological stages in time"; "Science and knowledge as co-operative enterprise cumulative in time"; "Time and history in China and the West".

other."[1] By carefully chronicling and comparing historical paths taken by several branches of the physical as well as biological sciences (e.g. astronomy, botany, and especially medicine) Needham argues that, "on the physical side, the mathematics, astronomy and physics of West and East united very quickly after they first came together."[2] However, "the more 'biological' the science, the more organic its subject-matter, the longer the process seems to take; and in the most difficult field of all, the study of the human and animal body in health and disease, the process is as yet far from accomplished."[3] The list of references contains nearly a hundred Chinese and Western items.

Publications from the 1960s were not confined to those by Needham. Contrasting his studies with those by others makes manifest the very different levels at which investigations into the operation of traditional Chinese scientific and technological systems were conducted.

Manfred Porkert, in a paper for the 1960/61 Antaios, engages in a discourse on the fundamental principles and peculiarities in Chinese scientific thought in relation to traditional Chinese philosophical schemes and theories, confronting especially such issues as synchronicity and symbolic correlations.

While Porkert's inquiry undoubtedly speaks directly to specialists, one wonders if J. Levêque's "Les 'Pa Koua" et le "Yin-Yang' de la Chine antique, précurseurs de la science moderne des ondes", published in Initiation et Science in seven instalments beginning with the first from 1962, would appeal to an academic or a general audience (or both, or neither). [I have not seen this title]. According to extended annotations supplied by Bulletin Signalétique 522, this work is a stouthearted attempt at offering in the language of modern physics a sweeping and fanciful interpretation of concepts such as *yin yang* and the positions they occupied in traditional Chinese science and cosmology (e.g. in siting, alchemy,

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[1]Joseph Needham, "The Roles of Europe and China in the Evolution of Oecumenical Science," Advancement of Science, 24 (1967), 84.

[2]ibid.

[3]Needham, "The Roles," 95.

astronomy and astrology).

Pursuing a totally different track is a study by E-tu Zen Sun (1965) which ventures to locate Chinese technological and scientific elements within society and to ascertain the social positions of practitioners. Zen traces in particular the background, life and times of Wu Ch'i-chün (1789-1847) through two treatises he wrote -- the *Tien nan k'uang ch'ang t'u lüeh* and the *Chih wu ming shih t'u k'ao*. Their content, the type of information they provide, and whether their intended purposes are practical or intellectual are highlighted. These in turn lead to comments on Wu's official duties, status, and his life.

In an inaugural lecture delivered at the University of Malaya in 1966, Ho Peng Yoke reviews a favourite theme found in Needham's works mentioned above, namely "the failure of traditional Chinese science in giving birth to modern science."[1] Sivin's annotation for this title reads as follows: "A concise roundup of factors which prevented an autochthonous scientific revolution in China. . . -- features also largely characteristic, the reader notes, of Europe in the late Middle Ages."[2]

3.4 1970-79

The scene turned increasingly lively in the 1970s. As will be evident in the account that follows, by and large writers did not merely rehash and recycle the same old ideas. Bids to unravel the guiding principles and origins of Chinese science by viewing them against various belief systems and traditions of Chinese thought

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[1]Ho, Peng-Yoke, The Birth of Modern Science in China; An Inaugural Lecture delivered at the University of Malaya. . . (Kuala Lumpur: U of Malaya, 1967), pp. 5. In Ho's opinion, "it seems possible to classify the inhibiting factors responsible for the decline and non-development of Chinese science broadly into various groups. The long-term ones are the difficulties which are inherent in Chinese science itself. Then there are political and social factors, and finally that of inter-cultural transmission with neighbouring countries": Ho, The Birth, pp. 10.

[2]N. Sivin, annotation for The Birth of Modern Science in China. . . by Ho Peng-Yoke, in ISIS Cumulative Bibliography, 1966-1975, vol. 2, pp. 242.

still went on with great fervour. But a sharp accent was also placed on the controversial issues of "Why did modern science not develop in China?" and "Why didn't the Scientific Revolution take place in China?". In addition, there were several studies on the connections between science and society.[1] A grand total of twenty-two works were published during this period.

(1) A. C. Graham's "China, Europe and the Origin of Modern Science" (1971), a review essay prompted by the publication of Science and Civilisation in China vol. 1 and Needham's The Grand Titration, was one of the earlier studies which raised serious doubts as to the meaningfulness in fixing one's gaze on the question of why modern science did not occur in China. It remains a valuable contribution in terms of both its point of departure and the arguments it puts forth.[2]

(2) An article titled "Taoist Thought and the Development of Science" by Chang Tzu-kung can apparently be found in the M & B Pharmaceutical Bulletin of 1972. [I have not seen this title]. The first part is sub-titled "A Missing Chapter in the History of Science and Culture-Relations"; according to the annotation, it was "first written in 1947" and received an introduction by Needham.[3] The second part "suggests Chinese origin of Emerald Table".[4]

(3) "On the Significance of the Question Did China have Science?" (1972) written by David Mungello while he was a graduate student at

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[1]One should always keep in mind that there are common themes and cross-currents between these categories.

[2]In this essay, Graham is of the opinion that, "although the positive question [i.e. 'Why was there a Scientific Revolution in Europe about 1600?'] is real and important, there is something wrong with the negative question [i.e. 'Why was there no Scientific Revolution in China or India?"], but whether it is conceptually confused or not there is no doubt that important social and cultural differences between China and the West have been brought to light by those who insist on asking it": A. C. Graham, "China, Europe and the Origins of Modern Science: Needham's *The Grand Titration*," Asia Major, 16 (1971), 178-79.

[3]Alan Pritchard, Alchemy: A Bibliography of English Language Writings (London: Routledge & Kegan Paul, and The Library Association, 1980), pp. 251.

[4]ibid.

the University of California, Berkeley seizes hold of several scholars' views on the thorny why-no-modern-science-in-traditional-China question (notably those from Needham, Sivin, and Joseph Levenson) and constructs a series of largely negative responses based on his own interpretations of these views.[1]

(4) Needham's "Le temps et l'homme oriental: le temps dans la philosophie et la physique chinoise" (1972) is a translation by Robert Dessureault of sections of Time and Eastern Man from 1965.

(5) Robert S. Cohen's article is simply titled "The Problem of 19 (k)" (1973), "19 (k)" being the sub-section "What brought mathematics together with craft techniques and knowledge of nature in Renaissance Europe but nowhere else?" under "Mathematics" in Science and Civilisation in China vol. 3. Rather than risk a simplistic solution, Cohen was another scholar from the 1970s who stressed the complexity and multiple dimensions involved in preparing answers to this question.[2]

(6) In an essay written as the preface to the collective work Chinese Science: Explorations of an Ancient Tradition (1973), Sivin clarifies, illuminates and gives a sophisticated treatment to the basic difficulties involved in defining Chinese science. A compelling case is made for his system of ordering the main disciplines in the Chinese sciences -- a system which corresponds closely to how "the Chinese themselves organize [the sciences] in the course of conceptualizing the phenomenal world."[3] The essay also features a section on "Chinese science and contemporary issues", and concludes with a brief review of the articles in the book.

(7) Needham's "Why didn't China Give Rise to Modern Science" (1974) is merely a "transcribed excerpt from a speech" given at a meeting in Hong Kong, skimming over such spheres as economic imperatives, laws

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[1]For Sivin's rebuttal and Mungello's reply, *see* Philosophy East and West, 23 (1973), 413-22.

[2]The following aspects are considered: "2. The enormity of the problem"; "3. Breaking down the problems"; "4. The difficulty of the problem"; "5. The typical Western character of the problem"; "6. Attempt to orientalize the problem".

[3]Nathan Sivin, "Preface," in Chinese Science: Explorations of an Ancient Tradition, ed. Nakayama Shigeru, and Nathan Sivin (Cambridge, Mass.: MIT P, 1973), pp. xix.

of nature, the sense of time, and the question of logic and linguistics as he sketches out responses to the question raised in the paper's title.[1]

(8) In his contribution "Mandarini e macchine" (1975) to the Convegno Internazionale di Studi Cinesi held in Venice in 1973 Mark Elvin dwells on factors that influenced and the peculiar matrix that characterised the history of traditional Chinese technology -- including the bureaucratic system, the social structure, the economic situation, etc. -- by comparing textiles manufacturing in China and Europe from the 16th to 18th century and their implications.

(9) Concerns articulated by Cohen were further examined by Arnold Koslow who, in "More on 19 (k)" (1975), concentrates on and threshes out in elaborate detail various methodological issues generated by Cohen's and Needham's explanations of the question of "19 (k)".

(10) The intricate relationship between the roots, essence, and shaping of early Chinese science on the one hand and ancient Chinese myths and cosmology on the other constitutes the main subject of inquiry in the first of two studies by John S. Major from the 1970s. This paper for the 14th International Congress of the History of Science (1975) ends with the remark that, "as one no longer confidently assert that Chinese science had its beginnings in the Warring States Period, detailed problems of origins are reopened; long and patient research into literary, archaeological, and iconographic sources of evidence will be required to provide new answers."[2]

(11) Needham's paper prepared for the same history of science congress (1975b) outlines the social position of the following three groups of individuals in traditional Chinese society: astronomers; engineers, technicians and technologists; physicians and the medical profession. A brief review and portrayal of the social strata occupied by these individuals is given. Although the paper does not offer much by way of critical assessments and analysis, the topic

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[1]Joseph Needham, "Why didn't China Give Rise to Modern Science," Ching Feng, 17.2/3 (1974), 90.

[2]John S. Major, "The Origins of the Fundamental Concepts of Chinese Science in Archaic Mythology," in Proceedings. . . 14th International Congress of the History of Science, Tokyo / Kyoto, 1974 (Tokyo: Science Council of Japan, 1974-75), vol. 3, pp. 318.

chosen is one of great interest and import.

(12) In another conference -- one held in Venice the papers from which were published as Sviluppi scientifici prospettive religiose movimenti rivoluzionari in Cina -- Needham (1975a) re-introduces once again his familiar questions: "First of all, what did China accomplish on her own before the era of world science unification? Secondly, why did the scientific revolution, the birth of modern science, happen only in Europe? Thirdly, why was China often more advanced, and sometimes much more advanced, than Europe for fourteen centuries previous to the time of Galileo?"[1]

(13) In a slim monograph published in 1976 Libbrecht endeavours to elucidate and expound on certain salient features of ancient Chinese scientific thinking by comparing them with Greek characteristics.[2]

(14) Convinced that the absence of modern science and the Scientific Revolution in China was still very much a subject worthy of serious reconsideration, C. Y. Cheng (1977) gave it another round of scrutiny in a review essay of Chinese Science: Explorations of an Ancient Tradition (edited by Nakayama and Sivin and published in 1973). In it Cheng also confronts sharply and critically Sivin's characterisation of Chinese science.

(15) Re-joining the debate briefly, Needham in a short article in the 1977 Leonardo reiterates the point that it was not due to the Chinese concept and attitude towards time that modern science did not arise in China as it did in Europe.

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[1]Joseph Needham, "On Chinese Society, Technology and Science," in Sviluppi scientifici prospettive religiose movimenti rivoluzionari in Cina, ed. Lionello Lanciotti (Florence: Leo S. Olschki, 1975), pp. 50.

[2]Two examples:- (1) "The Greek natural philosophers started from the presupposition that the world has a structure that is intelligible by human mind. . . . Chinese thinkers were convinced that there is a fundamental order in the cosmos": Ulrich J. Libbrecht, Scientific Thinking in Ancient China (Brussels: Institut Belge des hautes études chinoises, 1976), pp. 12-13. (2) "Thus Greek thinking is always in search of the general in phenomena, which is worded in the general concept: the man, the horse, the good. . . . Chinese thinking, which is very empiricism minded, was very attentive to the particular, to the exception in the ordered course of the cosmic event. In the astronomic field the Chinese noted all uncommon phenomena, such as eclipses, halos, northern lights, meteors and comets": Libbrecht, Scientific Thinking, pp. 16-17.

(16) For the introduction to a collection of articles on East Asian science and technology previously published in Isis, Sivin (1977) concentrates on four complex and pivotal themes: "1) What were the scientific and technological traditions? 2) What were the sources of new ideas, techniques, and problems? 3) How were the sciences related to other kinds of thought and activity? 4) What shaped and constrained movements in new directions?"[1] Also articulated is the weighty issue of categorising the Chinese scientific disciplines.
(17) For a succinct and well-considered account of the unique traits and key concepts in Chinese science (namely, *yin yang*, *ch'i*, and *wu hsing*) as well as their practical applications as seen especially in siting (which is a practice "used to map out the flow of cosmic energy as it courses through and over the earth, so that houses and tombs can be placed in areas with favorable energetic qualities") one can turn to an essay written by Steven J. Bennett in 1978. Moreover, it offers an intelligent synthesis and interpretation of views expressed by Needham and Sivin.[2]
(18) The ground covered in Major's (1978) second, more detailed article on connections between science and myths in ancient China is given in its opening paragraph: "This paper will explore the proposition that the principal features of early Chinese science existed as a system of beliefs that long predated the supposed invention of that science by Tsou Yen and his school during the Warring States period, and that those beliefs were expressed in a coherent body of myths of great antiquity. Furthermore it is proposed that the cosmology expressed in these myths was a kind widely shared by the ancient civilizations of the Eurasian continent, but that it contained in addition certain unique features, and that in the shift from the language of myth to the language of philosophy that took place in China during the Chou period the cosmology was modified in certain ways that produced a unique Chinese science. The theoretical framework of that science was completed by the early Han peiod, and, with

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[1]Nathan Sivin, "Introduction," in Science and Technology in East Asia, ed. Nathan Sivin (New York: Science History Publications, 1977), pp. xv.

[2]Steven J. Bennett, "Chinese Science: Theory and Practice," Philosophy East and West, 28 (1978), 447.

later modifications and additions, formed the basis for scientific thought in China down to the early modern times."[1]

(19) Observing the territory from a new vantage point and measuring it with a stringent yardstick, Sivin's "On the Word 'Taoist' as a Source of Perplexity with special reference to the Relations of Science and Religion" (1978) is a critique on the use (or rather, misuse) of the word "Taoist" in discourses on traditional Chinese science and religion.[2]

(20) In his article for the 1979 Harvard Journal of Asiatic Studies Bodde reflects and voices his opinion again on the laws of nature and their contributions to the comprehension of Chinese philosophy as well as scientific knowledge. The paper aims at supplying new evidence and imparting a set of new interpretations.[3]

(21) The binary system of the *I ching* as a distinctive element in traditional Chinese scientific thinking was highlighted by Ho in a public lecture delivered at the University of Hong Kong, a modified version of which appeared in the 1979 Eastern Horizon.

(22) Finally, a work which earned the praise of being an "excellent sociological assessment."[4] This erudite inquiry by Sal P. Revisto

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[1]John S. Major, "Myth, Cosmology, and the Origins of Chinese Science," Journal of Chinese Philosophy, 5 (1978), 1.

[2]The article contains the following sections: "Definitions and their limits"; "Perplexity"; "Bones of contention"; "Taoism, Confucianism, and science"; "Taoism and popular religion"; "The case of Ko Hung"; "Conclusions".

[3]In summing up, Bodde writes: "Does the new evidence invalidate Dr. Needham's strongly argued thesis that the concept of 'laws of nature' was alien to Chinese philosophical thinking? Probably not, as far as the overwhelming bulk of Chinese philosophical writing is concerned. What it does oblige us now to recognize, however, is that in addition to the dominant viewpoint argued for by Dr. Needham, a minority viewpoint also existed, expressed by a very few early Chinese thinkers, which was a good deal more congenial to the ideas underlying the 'laws of nature' then would at first thought be suspected": Derk Bodde, "Chinese 'Laws of Nature': A Reconsideration," Harvard Journal of Asiatic Studies, 39 (1979), 154.

[4]Nathan Sivin, annotation for "Joseph Needham and the Comparative Sociology of Chinese and Modern Science" by Sal P. Restivo, in "A Supplemental Bibliography of Traditional Chinese Science; Introductory Books and Articles in Western Languages," Chinese Science, 7 (1986), 36.

(1979) carries objectives shared by several other studies discussed in this chapter.[1] However, Revisto generated fresh insights and needed perspectives by evaluating these problems and concerns using sociological concepts and methods of discourse and investigation.[2] The four appendices are definitely not to be bypassed.[3]

3.5 1980-85

The enthusiasm evinced by Western scholars in their bid to come to grips with the overarching concepts in and the social and cultural relations of traditional Chinese science remained very much in evidence in the first half of the 1980s. They still shared an interest in those familiar issues raised repeatedly in previous decades,

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[1]These objectives are: "to (1) outline the basic queries, rationales, assumptions, hypotheses, and world view guiding Needham's Science and Civilisation in China project, (2) discuss promising and problematic aspects of Needham's views on Chinese and modern science, and (3) briefly consider the relationship between contemporary scientific activity in China and the West, and the future of science": Sal P. Revisto, "Joseph Needham and the Comparative Sociology of Chinese and Modern Science," Research in Sociology of Knowledge, Sciences and Art, 2 (1979), 25.

[2]The methodology adopted by Revisto is reflected in the subsection headings. **"(1) Introduction"** is organised into: "Basic queries"; "Rationale and positive hypotheses"; "Negative hypotheses"; "The general sociocultural hypothesis"; "World view". **"(2) Problems and prospects"** examines the following themes and topics in considerable depth: "Needham's problem"; "Needham's factors approach"; "Needham's general sociocultural hypothesis"; "World view: modern science, Chinese science, and human nature"; "Chinese and modern science"; "History of science as anthropology of knowledge"; "The psychic unity of mankind"; "Culture and cognition"; "Pathways to science". **"(3) Conclusion"** touches briefly on the issue of continuities in the history of science and society in China.

[3]"Appendix A: Basic queries (Needham's problem)". "Appendix B: Factors conducive to the emergence of modern science in China and Western Europe". "Appendix C: Factors inhibiting the emergence of modern science in China and Western Europe". "Appendix D: Needham's general sociocultural hypothesis: three illustrative formulations, and selected subhypotheses".

These appendices are very interesting and informative as they are essentially lists of references selected from Needham's works (with the page from which a reference is chosen also provided). They serve well as preliminary guides and convenient summaries of Needham's positions on these issues.

but from time to time alternative routes and strategies were devised. In particular, studies that dealt expressly with the knotty and involved problems of why the Scientific Revolution did not take place spontaneously in China were increasingly vocal and insistent in questioning whether it was constructive and meaningful to draw connections between paths taken by traditional Chinese science and the birth of modern science in the West.

Reappraising grand and provocative schemes conceived and promulated by masters is often a standard item in a historian's repertoire; it is therefore hardly surprising to find inquiries from the 1980s directed specifically at Needham's theories. One such account for a symposium sponsored by Past and Present in 1980 to assess the contributions of Needham was written by Willard Peterson. In it, Peterson considers ideas in what Needham called "Chinese scientific philosophy" and "philosophy of organism"; he also touches upon the Chinese conception of the universe.

Needham's own response to all the excitement and rhetoric was, however, difficult to fully gauge. Just when the research he had inspired was steadily gathering momentum, his published views on this particular matter -- especially after the mid-'70s -- were limited mainly to occasional remarks in volumes of Science and Civilisation in China (e.g. vol. 5 pt. 4). "Perché la scienza moderna si è Sviluppata in Occidente e non in Oriente" in the 1980 Quaderni di Critica Marxista seems to be another place to check. [I have not seen this title].

The social structure of scientific activities in China from 1650 to 1900, for instance its inner workings and external affiliations -- scarcely addressed in previous works, but undoubtedly worth mining -- received special attention from Jonathan Porter. The purpose of his first paper in the 1980 Journal of Asian Affairs "partially, is to explain the distinctive character of Chinese science in the early modern period from the perspective of the 'external' sociology of science."[1] Porter based his research on the *Ch'ou jen chüan* of *Juan Yüan* -- a collection of 240 biographies of scientists from the Ch'ing dynasty, most of whom associated with the quantitative scien-

[1]Jonathan Porter, "The Social Structure of Scientific Activity in China ca. 1650 to 1900," Journal of Asian Affairs, 5 (1980), 34.

ces. A list of mainly Western references, three Tables and three Figures complete the study.[1] His second article, "The Scientific Community in Early Modern China" (1982) analyses differences between patterns of developments in traditional Chinese science and Western science by examining the biographies of individuals connected with the mathematical sciences in Ch'ing time. Porter looks upon science and scientific activities in China in this period as a social institution and organisation with its own value, function and community. Statistics and data are again provided graphically through charts and tables.

As with his two introductory papers to volumes of collective works mentioned above, Sivin's "Science in China's Past" (1980) -- one of twenty-nine contributions characterising the state of a number of modern scientific fields in China in the late 1970s -- offers a succinct and systematic overview of the essential features of traditional Chinese science. First, the divisions of "Quantitative Sciences" (i.e. "Mathematics", "Mathematical Astronomy", "Mathematical Harmonics") and "Qualitative Sciences" (i.e. "Astrology", "Medicine", "Alchemy", "Siting", "Physical Studies") are defined and explained. Then, considerable emphasis is laid on distinctions between the Chinese and Western scientific traditions as well as on the positive recognition and appreciation of their dissimilarities as vital to historical research on Chinese science. Observations are also made regarding the interaction of China with other cultures and the current study of the history of science in China.

In his distillation of concerns central to the proper comprehension of traditional Chinese science, technology and medicine (especially by the Western audience) Hans Ågren stresses the following elements in the entry "Chinese Science" (1981) in the <u>Dictionary of History of Science</u>: "an urge for numerological classification and correlative thinking"; "no clear limit between natural laws and human

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[1]Tables: "Distribution of principal specializations in the *Ch'ou-jen chuan*"; "Chronological scope of *Ch'ou-jen chuan*"; "Official positions held by Ch'ing scientists". Figures: "Associations between Ch'ing scientists"; "Associations between Ch'ing scientists: provincial origins"; "Associations between Ch'ing scientists: principal figures". Such tables and figures are uncommon features in Western studies on traditional Chinese science.

laws; between Nature and human society"; "a division of the Chinese traditional sciences into Quantitative and Qualitative Sciences"; "the origins of the Chinese sciences"; "the Scientific Revolution did not emerge in traditional China, and the Chinese science consequently are Mediaeval in character"; "modern scientific knowledge was forced upon the Chinese in the late 19th century by Western tradesmen and missionaries"; and "glimpses of Chinese science were perceived by Western travellers from Marco Polo (*c.* 1254-1324) onward".[1]

The declared objective of Richard Hubert Jones' "Joseph Needham's Mysticism and Science: Against Needham on Taoism" (1981) "is to show that Joseph Needham in his classic, Science and Civilisation in China, distorts the nature both of science and of 'philosophical Taoism' (*Tao chia*) as presented in the *Tao te ching* and the *Chuang tzu*."[2]

Otto T. Benfey's brief note in the 1982 Journal of Chinese Philosophy points out that though seemingly contrary to accepted notions, "the Chinese culture was steeped in geometric modes of thinking, the West by contrast contributing algebraic-arithmetic thought forms," suggesting that "what a culture finds obvious it tends not to analyze"; thus, "the Chinese merely saw no need to prove geometric propositions and hence developed little deductive geometry."[3]

"Natural Knowledge in a Traditional Culture: Problems in the Study of the History of Chinese Science" (1982) by Kim Yung Sik offers the novice a helpful guide to the controversies. Before launching his own brand of arguments and observations Kim furnishes a summary of opinions and stance articulated by various scholars, categorising and making frequent reference to recent Western writing, and commenting on aspects in the scholarship that have been

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[1]Hans Ågren, "Chinese Science," in Dictionary of the History of Science, ed. W. F. Bynum, E. J. Browne, and Roy Porter (London: MacMillan, 1981), pp. 66-67.

[2]Richard Hubert Jones, "Joseph Needham's Mysticism and Science: Against Needham on Taoism," Journal of Chinese Philosophy, 8 (1981), 245.

[3]Otto T. Benfey, "Continuity and Discontinuity in China and the West," Journal of Chinese Philosophy, 9 (1982), 353-54.

progressing well and those that have not.

Sivin's "Why the Scientific Revolution did not take place in China -- or Didn't It?" (1984) seeks to decode and dissect the fascination many have with possible links between the evolution of traditional Chinese science and the Scientific Revolution. It provides an illuminating excursion into early Chinese ideas of the sciences, assumptions generally made about the Scientific Revolution, the "fallacies of historical reasoning", the "dimensions of the Scientific Revolution", and the "Scientific Revolution in 17th century China".[1] The discourse concludes with Sivin affirming that, "the breakthroughs coming up in the study of Chinese science . . . will have to do with understanding in depth and in an integral way the circumstances of people who did science and technology. These are issues about which we understand very little with respect to China or to Europe. It will take much further study and reflection on both sides before the comparative history of science is ready to take off. My prognostication is that by that time we will no longer be asking why the transition to modern science did not first take place in China."[2]

More of Sivin's reasoning and contentions can be gleaned from his "Chinesische Wissenschaft: Ein Vergleich der Ausätze von Max Weber und Joseph Needham" (1983), with a revised English version -- "Max Weber, Joseph Needham, Benjamin Nelson: The Questions of Chinese Science" -- published in 1985. In these two essays, he expounds on the challenges posed by Nelson's juxtaposition of Needham and Weber on the comparative sociology of science as well as the perennial

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[1]Some of these fallacies are: the "inhibiting factors"; the fallacies and assumptions that "encourage us to devaluate, without troubling ourselves first to comprehend on their own terms, scientific quests other than the one from which modern science most directly sprang"; "the fallacious assumptions that one can make sense of the evolution of science by looking at intellectual factors alone, or socio-economic factors alone, according to preference": Nathan Sivin, "Why the Scientific Revolution did not take place in China -- or Didn't It?" Chinese Science, 5 (1984), 54-62.

[2]Nathan Sivin, "Why the Scientific Revolution," 65-66.

question "Why there was no Scientific Revolution in China?".[1]

Ralf Moritz's paper, on the other hand, is a roughly chronological narrative -- a treatment seldom employed. His "Die Herausbildung des wissenschaftlichen Denkens im alten China" (1983) in the Deutsche Zeitschrift für Philosophie outlines scientific concepts and thinking in the *I ching* and during the San Kuo period, and closes with Mohist thought and logic.

Isis invited two noted scholars -- Lynn White, jr. and Jonathan D. Spence -- to share their reflections on and assessment of the basic philosophy, guiding principles, and vision that lie behind the volumes of Science and Civilisation in China (nine up till 1984), in particular Needham's answer to the riddle of why China did not experience a Scientific Revolution similar to that of the West. In this review (1984) one gets the unique opportunity to savour and benefit from the critical opinions and interpretive judgments of two foremost authorities from different scholarly fields. White writes chiefly from the point of view of a historian of European mediaeval technology, while Spence addresses aspects of particular interest to Chinese historians.[2]

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[1]Sections include: "Vorbemerkung"; "Needhams Herausforderung"; "Needhams Beitrag"; "Soziologische Perspektiven"; "Theorie und Praxis"; "Die Marginalität des revolutionären Wandels"; "Ergebnis".

[2]It is not possible (or fair) to summarise this fresh, bracing, rich and fascinating piece which is a pleasure to read and re-read.

But very briefly, how did White respond to Needham? In the final section, White writes: "In his Great Question the term 'modern science,' as Needham often emphasizes, means the Western quantifying and laboratory-centered science of which Galilieo remains the prime symbol. Moreover to Needham, 'modern science' is not. . . an artifact historically conditioned by the Occidental culture that created it: it is Truth. By contrast, the pure sciences of the other great civilizations, in his opinion, lack the 'ultimate value' of 'modern science'; but fortunately their valid discoveries have long been (to use one of his favorite expressions) 'flowing like rivers into the ocean' of Western, that is, universal, science. Not a few Asian intellectuals find such a view neo-imperialist. . . . The issue, one must recognize, is not whether his position gives offense but whether it is valid. . . . I suspect that very few, at least of the younger, historians of science today share Needham's total confidence in the style of science that emerged in Europe during the baroque era. . . . The chief reason is the emergence of a profound interest in the ecology of science; that is, in how theoretical science in any period and place has shaped its total context, and in how reciprocally it has been shaped by its environment, cultural and other. The history

Eight years after the publication of Cheng's "On Chinese Science: A Review Essay" mentioned above, two short articles on the essential components of Chinese science were drafted in response to its ideas and contents. Po K. Ip (1985) disagreed with Cheng's renditions and representations, arguing that "what Cheng takes as a characteristic feature of science is a mistaken one."[1] James Sellman and Jesse Fleming (1985) in turn criticized Ip for his failure to comprehend Cheng's views.[2]

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of modern science is not a triumphalist process of chalking up an endless series of discoveries of absolute truth achieved by Galilean methods. It is integral to all the rest of history and is in no way different in kind from all the other sorts of human experience": Lynn White, jr., and Jonathan D. Spence, "Science in China," Isis, 75 (1984), 179.

Spence took his cue from the following sentences in Science and Civilisation in China vol. 5 pt. 4: "It will readily be allowed that few historical events were so rich in consequence as the decision taken by certain southern Chinese officials in + 1583 to invite into China some of the Jesuit missionaries who were waiting in Macao. It was the first decisive step in the long process of unification of world science in Eastern Asia, and the better mutual understanding of the great cultures of China and Europe:" White and Spence, "Science," 180. Spence's reaction was that: ". . .the more I reflect on them [i.e. the prism and the clock that Matteo Ricci brought with him to Chao-ch'ing in 1583], the more they seem to me to suggest how magisterially the attempt at interchange failed, and why one can argue with some force that China did not enter the world of universally valid modern science in any significant way until the twentieth century": White and Spence, "Science," 180-81. And again at the end of his essay: "One can certainly argue that 'world science' as a recognizable concept only began to have substance during the 1850s, when a desperate Manchu leadership, facing rebellion and attack on all points, encouraged Sino-Western cooperation as a means of national reintegration": White and Spence, "Science," 188.

[1]Po K. Ip, "A Response to Dr. Cheng's Proposal 'On Chinese Science'," Journal of Chinese Philosophy, 12 (1985), 317.

[2]Their article sets out to accomplish the following tasks: (1) "examine his [i.e. Ip's] claim that Cheng seeks an autonomous notion of Chinese science, and show that Ip has not grasped the full implications of Cheng's explications of N. Sivin's complex or two-sided means of defining Chinese science"; (2) "examine Ip's analysis of the value-neutral characterization of science"; (3) "show that Ip's rebuttal of Cheng is unsound and that four of his conclusions agree with Cheng's proposals"; (4) "point out that the problem of defining 'science' and/or 'Chinese science' is a complex issue in which it might be better to attempt to avoid 'essentialism' by basing such a definition on a 'family resemblance' rather an essential trait or set of traits": James Sellman, and Jesse Fleming, "Understanding Profes-

One of the boldest and most ambitious (but perhaps vain) attempts to challenge Needham's overarching assumptions and fundamental convictions was The Great Inertia: Scientific Stagnation in Traditional China (1985a), a treatise written by Qian Wen-yuan (who pursued doctoral studies at the University of Michigan in the mid-'80s, after having taught theoretical physics in China until 1980). Reviews have been negative and very unfavourable, including one by Sivin which condemns it as "a shallow 'answer' to the Scientific Revolution Problem uninformed by acquaintance with Chinese scientific writings before modern times."[1] Qian's monograph is divided into four chapters: "(1) The Great Inertia: an introduction"; "(2) The phenomenology of Chinese stagnation in physical sciences"; "(3) Science and technology in traditional China: a source itself inert"; "(4) Scientific philosophies: China's past -- the world's future?"

In the same year that his book was published, Qian (1985b) gave a paper in the session on science, logic, and cognition in the 17th International Congress of the History of Science. In it he confronts "China's nondevelopment of modern science" through such precepts as the laws of nature (defined as "those formulations that, according to the standard of the Scientific Revolution, is typically exemplified by the Newtonian mechanical laws and other physical laws"), and "the standard of scientific truth" (which in his opinion is "best represented by: empirical verification, rigorous logic, and ~~exiomatic~~ axiomatic aestheticism").[2] Though also concerned with the historical route taken by Chinese science, Kim's (1985) presentation at the same conference takes aim instead at the science-religion relationship's supposed importance and cautions one that, unlike the situation with

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sor Cheng's Proposal: A Response to Po K. Ip," Journal of Chinese Philosophy, 12 (1985), 323.

[1]Nathan Sivin, annotation for The Great Inertia: Scientific Stagnation in Traditional China by Qian Wen-yuan, in "Science and Medicine in Imperial China: The State of the Field," Journal of Asian Studies, 47 (1988), 84.

[2]Qian Wen-yuan, "The Idea of the Laws of Nature as a Logical as well as a Historical Question," in 17th International Congress of History of Science, Berkeley, 1985. Abstracts of Papers presented in Scientific Sections (Berkeley, Calif.: Office for History of Science & Technology, U of California, 1985), vol. 1, Qe.

Western civilisations, there are problems in applying it to explain China's scientific past: ". . .in China, neither science nor religion was very important in any period. Nor was there, in their ideas of science and religion, such an obvious link between the two."[1]

3.6 CONCLUSION

Orientation of the works discussed above is overwhelmingly thematic, occasionally disciplinary, and rarely chronological. Although an intelligent lay reader can peruse a handful of pieces with interest and gain a general appreciation of the subject, much of the literature would appeal more to those scholars and students with some prior acquaintance with the topics addressed.

The preoccupation Needham had with a core group of issues, assumptions, and messages, and the recurrence of responses to these issues as well as to some other earlier published views have led to the heavy -- though by no means exclusive -- presence of familiar and highly visible themes. Hence, in contrast to other areas in which research efforts made by different individuals were frequently only loosely related to one another, writings here have revolved round a relatively tightly-knit pattern. At times it appeared narrow and confined, a case of more of the same. Thankfully though, sounds of imaginative reappraisals and reinterpretations, of experimentations with original ideas and reasoning were heard once in a while. There were also indications of a willingness to tackle difficult and complex concerns, and to seek help from methodologies employed in the forefront of research in the fields of Chinese studies and the history of science. Above all, the vigour and interest shown in recent decades have demonstrated that the fundamental concepts, philosophy, and the social and cultural relations of traditional Chinese science and scientific thought is a deep and rich mine. More diversity in defining the problems and their boundaries would cer-

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[1]Kim Yung Sik, "Some Problems in the Study of the Science-Religion Relationships in Traditional China," in <u>17th International Congress of History of Science, Berkeley, 1985. Abstracts of Papers presented in Scientific Sections</u> (Berkeley, Calif.: Office for History of Science & Technology, U of California, 1985), vol. 1, Section 16.3.

tainly yield even broader perspectives and sharper understanding. Bringing in hitherto unexplored documentary and other sources can also throw new light on perplexing questions.

3.7 PARTICIPATING COUNTRIES AND INDIVIDUALS

No one needs to be reminded of the fact that on themes and topics treated in the present chapter, Needham stood out as the standard-bearer. His numerous trail-blazing publications in the 1950s and '60s have compelled even bystanders and sceptics to at least acknowledge the significance and serious implications posed by the issues he raised.

This is not to say that he was the sole contributor. Sivin, in particular, has deepened our understanding and increased our knowledge manifold with seminal works and regular critiques. Due credit must also be extended to such scholars as Forke, Bodde, and Chan in the earlier period, as well as to the body of individuals who gave it voice and substance in the 1970s and '80s -- their research being sparked off, one should nevertheless add, primarily by Needham's pioneering effort and the originality of his theses and ideas.[1] But as mentioned above, Needham himself did not seem to have devoted much of his energy to publications specifically on these aspects and themes after the first half of the 1970s.

The majority of participants pursued academic careers in America.[2] The share borne by other countries was relatively small, though it cannot be said that they were woefully under-represented. The notable exception was France. England, of course, was served chiefly by Needham -- and also by Leslie, Graham, and Elvin. Other researchers included Forke, Porkert and Moritz from Germany; Tucci and Vacca from Italy; Libbrecht from Belgium; Ågren from Sweden; Ho from Malaysia and later Australia.

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[1] e.g. Ho, Graham, Cohen, Major, and Restivo in the 1970s; Peterson, Porter, and Kim in the early / mid-'80s.

[2] e.g. Bodde and Sivin at the University of Pennsylvania, Cohen at Boston University, Major at Dartmouth College, Restivo at Rensselaer Polytechnic, Peterson at Princeton University, Porter at the University of New Mexico.

Needham, Sun, Bodde, Ho, Porkert, and Sivin have published extensively on the history of traditional Chinese science, technology and / or medicine. But the specialisations of others lay in different areas of Chinese studies (e.g. philosophy, religion, economic history, intellectual history) or in some other fields and arenas (e.g. history of Western science and technology).[1]

3.8 FORMS OF PUBLICATION

Of the different kinds of journals involved, those from the Chinese / Asian studies field (e.g. T'ien Hsia Monthly, Harvard Journal of Asiatic Studies, Journal of Asian Affairs) were chosen most frequently throughout the 20th century. Journal of Chinese Philosophy in particular published eight articles in the 1970s and '80s, while Philosophy East and West had three. Journals concerned chiefly with the history of science / technology (e.g. Centaurus, Technology and Culture, Isis) were also fairly popular. But it is worth underscoring the fact that the remaining journal articles were scattered in a remarkably wide array of serial publications ranging from Popular Science Monthly and Sciences, Deutsche Zeitschrift für Philosophie and La Pensée, Researches in Sociology of Knowledge, Sciences, and Art and Science and Society, to Minerva, History of Religion, Leonardo, Tel Quel, and M & B Pharmaceutical Bulletin.

Furthermore, no less than fifteen titles were first published in essay collections, festschriften, or conference proceedings; a quick glance reveals that the disciplines and subject areas to which these collective publications belong also vary considerably.[2]

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[1]In Edmunds' case, he was President of the Canton Christian College and Carnegie Institution of Washington's Observer-in-charge for the Magnetic Survey of China.

[2]e.g. Reflections on Our Age; Lectures delivered at the Opening Session of Unesco at the Sorbonne University, Paris; Science, Medicine and History: Essays on the Evolution of Scientific Thought and Medical Practice written in honour of Charles Singer; proceedings of the Congress of the History of Science; Neue Beiträge zur Geschichte der alten Welt; Band I: Alter Orient und Griechenland; Science in Contemporary China; Civilizations East and West: A Memorial Volume for Benjamin Nelson.

In addition to the two volumes of Science and Civilisation in China, two other studies by Needham, one each from Forke, Libbrecht, Ho, and Qian appeared in the form of monographs or booklets.

3.9 BIBLIOGRAPHIC PROVISION AND CONTROL

I. GENERAL BIBLIOGRAPHIES FOR CHINESE / ASIAN STUDIES AND THE HISTORY OF SCIENCE

(a) Henri Cordier, Bibliotheca Sinica. . . (1904-08); (1922-24):

All titles in this chapter came after the time of Cordier's work except for Edmunds article from 1911 (which is not listed).

(b) John Lust, Index Sinicus. . . , 1920-55 (1964):

Eight articles were published during the period indexed. Lust noted several items from Chinese / Asian studies journals, and interestingly, also the ones from Journal of the History of Ideas, Science, Medicine and History: Essays on the Evolution of Scientific Thought and Medical Practice written in honour of Charles Singer, and Centaurus. They can be found in "XVIII. Science and Technology - a. General - I. General" or "XVIII. Science and Technology - a. General - II. History".

(c) ISIS Cumulative Bibliography, 1913-65; 1966-75; 1976-85:

The general impression one has that this bibliographic source is quite reliable for accounts in history of science journals and collective works holds true for literature from the present chapter -- the only oversights being Leslie's paper in Actes du 7e Congrès International d'Histoire des Sciences, Jerusalem, 1953 (1953), Sun's article in Technology and Culture (1965), and strangely, White and Spence's contribution in Isis (1984).[1]

It is not as dependable for articles in Chinese / Asian studies journals and collections or those in the general science, social sciences, and humanities subject areas. Nevertheless, not all works from such categories of material were neglected.[2] It has also

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[1]This is probably because review essays and review symposia, to which the White and Spence piece belongs, are not indexed.

[2]Studies in Pacific Affairs (1931), Studia Serica Bernhard Karlgren Dedicata (1959), Journal of Asian Affairs (1980), Philosophy East and West (1978), for instance, are listed -- but note that

recorded writings not provided by any other general bibliographies.[1] With few exceptions, indexed titles were assigned to the part for civilisations in the "A Science" section.[2]

(d) Bibliography of Asian Studies, 1935-

This bibliography has been quite thorough in its effort to provide articles from Chinese / Asian studies journals and essay collections, the only omissions from this kind of material being Graham's article in Asia Major (1971), Elvin's and Needham's papers in Sviluppi scientifici prospettive religiose movimenti rivoluzionari in Cina (1975), Koslow's study in Journal of Chinese Philosophy (1975), and Sivin's contribution in Max Webers Studie über Konfuzianismus und Taoismus: Interpretation und Kritik (1983).[3] Some items from journals outside the Chinese / Asian studies field were recorded as well.[4]

Nevertheless, it contains only slightly over half of the publications treated in this chapter -- which, incidentally, is similar to the quantity carried in ISIS -- and several important studies do not

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Mungello's article from the 1972 Philosophy East and West is not included.

[1]e.g. Tucci's essay in Manule di storia della scienza. Antichità (1929), Forke's book (1925), Needham's paper in the Actes du 7e Congrès International d'Histoire des Sciences, Jerusalem, 1953 (1953), Restivo's study in Research in Sociology of Knowledge; Sciences and Art (1975), Sivin's article in Max Webers Studie über Konfuzianismus und Taoismus: Interpretation und Kritik (1983) -- but the name of the editor was mispelled.

[2]Exceptions are: The World-Conception of the Chinese in "FU China - The Universe; Cosmology and Cosmogony"; "The Chinese Cosmic Magic known as 'Watching for the Ethers'" in "FUu China - Cosmology - popular aspects of the subject"; "The Pattern of Nature Mysticism and Empiricism in the Philosophy of Science: Third Century B.C. China, Tenth Century A.D. Arabia, and Seventeenth Century Europe" in the non-civilisation part under "Ahf Historiography and particular aspects of the history of science - philosophical aspects".

[3]It is also the only general bibliography where one can find Needham's "Glories and Defects of the Chinese Scientific and Technical Traditions" (1964) published in Neue Beiträge zur Geschichte der alten Welt; Band I: Alter Orient und Griechenland.

[4]e.g. articles in Centaurus (1953), Aufbau (1957), Science in Progress (1964), Technology and Culture (1965), Minerva (1982), and Civilizations East and West: A Memorial Volume for Benjamin Nelson (1985).

receive attention.[1] Moreover, more than ten titles are situated outside the "Science and Technology" section, most of them in "Philosophy and Religion".[2]

(e) Bulletin Signalétique, 1947- :

Though not a completely satisfactory bibliographic tool for us, it nevertheless provides thirteen accounts from various types of material.[3] Four of these studies are not reported in any general bibliographies.[4] Levêque's study is housed in "Sciences et techniques physiques - Electromagnétisme, électronique et électrotechnique" and other titles in several different sub-divisions related to general works in history of science and technology.[5] The best way to retrieve them is through the subject index.

(f) Revue Bibliographique de Sinologie, 1955-70; 1983- :

Over ten studies from the 1950s, '60s and '80s were noted. Among those unreported are articles in La Pensée, Sciences, and Deutsche Zeitschrift für Philosophie as well as Ho's book. The

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[1]e.g. Needham's Science and Society in Ancient China (1947), his "The Social Position of Scientific Men and Physicians in Mediaeval China" (1974), Restivo's "Joseph Needham and the Comparative Sociology of Chinese and Modern Science" (1979).

[2]e.g. Mungello's "On the Significance of the Question Did China have Science?", Cohen's "The Problem of 19 (k)", Libbrecht's Scientific Thinking in Ancient China, Major's "Myth, Cosmology, and the Origins of Chinese Science", Sivin's "On the Word 'Taoist as a Source of Perplexity with special reference to the Relations of Science and Religion in Traditional China", Peterson's "'Chinese Scientific Philosophy' and some Chinese Attitudes towards Knowledge about the Realm of Heaven-and-Earth".

[3]e.g. Asia Major (1971), Journal of Chinese Philosophy (1977), Minerva (1982), Deutsche Zeitschrift für Philosophie (1983).

[4]i.e. J. Levêque's paper in Initiation et Science, Needham's translation "Le temps et l'homme oriental: le temps dans la philosophie et la physique chinoise" in Tel Quel, and the papers by Kim and Qian for the 1985 International Congress for the History of Science.

[5]e.g. "01.F Histoire des sciences dans leurs rapports avec la philosophie et la pensée religieuse ou morale - Religion" (1985 Kim); "Histoire générale des sciences et des techniques - Orient et Extrême-Orient" (1983 Porter) (1976 Major) (1979 Cheng); "01.G Histoire sociale de la science et de l'organisation de la recherche - Science" (1984 Kim).

"Histoire des Sciences" section is an obvious site for these titles, but Needham's Time and Eastern Man appears in "Philosophie et Religion".

(g) Tōyōgaku Bunken Ruimoku, 1963- :

Almost twenty titles are listed, and with merely four from Chinese / Asian studies journals having slipped through the net, the index handled this category of sources fairly well.[1] However, it is very inadequate so far as journals specialising in other disciplines are concerned, even though Porter's article in Isis and Moritz' account in Deutsche Zeitschrift für Philosophie gained entry. Note that "Joseph Needham's Mysticism and Science: Against Needham on Taoism" is in the "Chinese Philosophers" section, while his Time and Eastern Man as well as "Die Herausbildung des wissenschaftlichen Denkens im alten China" are subsumed under "Philosophy, thought and education".

II. SPECIALISED BIBLIOGRAPHIC SOURCES

Consulting Lu Gwei-djen, Mikuláš Teich, and Robert Young's "Bibliographies of Works by Joseph Needham" in Explorations in the History of Science and Technology in China, ed. Li Guohao, Zhang Mengwen, and Cao Tianqin (Shanghai: Shanghai Chinese Classics Publishing House, 1982), pp. 703-20 can reap considerable benefit as the vast majority of Needham's works mentioned above are listed there, including seven not recorded in the general bibliographies.[2]

III. CONCLUSION

A number of works failed to enter any of the seven general bibliographies for Chinese / Asian studies and history of science. As it is not customary practice -- except in highly specialised compilations tailored for specific functions -- to index introductory articles in essay collections or to furnish separate entries for each

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[1] i.e. those in Philosophy East and West (1973), Ch'ing Feng (1974), Eastern Horizon (1979), and Journal of Asian Affairs (1980).

[2] i.e. "Ondes et particules dans la pensée scientifique chinoise" in Sciences; Science and Society in Ancient China; "Science and Society in Ancient China in Mainstream; "Poverties and Triumphs of the Chinese Scientific Tradition" in Scientific Change; "Grandeurs et faiblesses de la tradition scientifique chinoise" in La Pensée; "Naturvidenskab og samfund i ost og vest" in Dansk Udsyn; "Perché la scienza moderna si è Sviluppata in Occidente e non in Oriente" in Quaderni di Critica Marxista.

individual item in reference works and dictionaries, it is understandable that two contributions from Sivin and one by Ågren from such places have not made their way into any bibliographic aid.[1] But there are other absentees.[2]

It would not be wise, therefore, to put one's trust in any single source for supplying all (or even the vast majority of) relevant 20th century works on the fundamental concepts, philosophy, and the social and cultural relations of traditional Chinese science. To catch as many titles as possible, the net has to be cast extremely wide.

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[1]This extends perhaps also to the review essay by White and Spence.

[2]e.g. Edmund's "Science among the Chinese" in Popular Science Monthly (1911), Vacca's "Perchè non si è sviluppata la scienza in Cina" in Quaderni di Sintesi (1946), Porkert's "Wissenschaftliches Denken im alten China -- das System der energetischen Bezielungen" in Antaios (1961), and seven studies by Needham.

CHAPTER 4 : MATHEMATICS

It is worth beginning by recognising and laying special weight on a couple of accounts written by two leading Western authorities on traditional Chinese mathematics: Jean-Claude Martzloff and Ulrich Libbrecht. The chapter "Le contexte historiographique" in Martzloff's Histoire des mathématiques chinoises contains a succinct overview and assessment of 18th, 19th and 20th century research on Chinese mathematics.[1] A similar appraisal by Libbrecht, evaluating the work and influence of those who have laboured in the field during the past two centuries can be found in his "Joseph Needham's Work in the Area of Chinese Mathematics".[2] References to this pair of studies are made repeatedly in the present chapter.

As explained in *Chapter 1: Introduction*, publications by Yoshio Mikami (from Japan) and Lam Lay Yong (from Singapore) are discussed here even though according to the perimeters drawn for this bibliographical survey their works ought not be regarded as "Western" contributions. Note also that Chinese mathematical writings and activities that carry within them recognisable concepts and ingredients from Europe -- chiefly as a result of contacts and exchanges with the Jesuits in the late 16th and the 17th century -- are not treated.[3]

4.1 GENERAL WORKS

Much of 19th and 20th general Western literature on traditional Chinese mathematics has to do with Chinese mathematical texts, either characterising specific treatises or calling attention to them while

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[1] Jean-Claude Martzloff, Histoire des mathématiques chinoises (Paris: Masson, 1988).

[2] U. J. Libbrecht, "Joseph Needham's Work in the Area of Chinese Mathematics," Past and Present, 87 (1980), 30-39.

[3] They have prompted some ground-breaking investigations in the past decade by historians of Chinese mathematics in France; see for instance Jean-Claude Martzloff's Recherches sur l'oeuvre mathématique de Mei Wending (1633-1721).

tracing the development of mathematical knowledge in China through the ages.

This approach was adopted by scholars from the second quarter of the 19th century. An article by Édouard Biot in the 1839 Journal Asiatique contains a translation and description of the detailed table of contents or chapter headings found in the late 16th century work *Suan fa tung tsung* by Ch'eng Ta-wei. According to Libbrecht, "in Europe virtually nothing was known about Chinese mathematics" before the publication of this paper.[1] This was succeeded by another article in the same journal in 1841 on the oldest Chinese mathematical treatise extant -- the *Chou pei suan ching* -- in which Biot provides an introduction to and apparently full translation of the work.[2] A short supplement appeared in 1842.

A pivotal study that had a definite role to play in enhancing 19th and early 20th century Western historical scholarship on and understanding of the Chinese mathematical traditions was Alexander Wylie's "Jottings on the Science of the Chinese; Arithmetic", which first appeared in various instalments in the 1852 North China Herald. It was not overlooked as a resource even in the 1970s and '80s, and has been given a place regularly in bibliographies. By making frequent reference to Chinese mathematical treatises, offering coherent interpretations of key elements, and comparing Chinese experiences with those in the West, Wylie had shed light on important Chinese mathematical procedures and concepts. This account was translated into German by Karl L. Biernatzki as "Die Arithmatik der Chinesen" (1856). The following observation was made of this particular translation: ". . .cette traduction contenait, hélas, de nombreuses erreurs qui furent ensuite reproduites par les historiens des

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[1]Libbrecht, "Joseph Needham's Work," 30.

[2]Curiously, this study is only mentioned in Science and Civilisation in China. There is no reference to it in Libbrecht's Chinese Mathematics in the Thirteenth Century. . ., or Martzloff's Histoire des mathématiques chinoises, or in Frank and Ang's "A Brief Chronological and Bibliographic Guide to the History of Chinese Mathematics". This may be due in part to its doubtful scholarly value; as Needham remarked, "this translation is not always very sure of itself": Science and Civilisation in China, vol. 3, pp. 20.

mathématiques."[1] The German version was subsequently rendered into French by O. Terquem in 1862, and by J. Bertrand in 1869.[2]

The first three decades of the 20th century witnessed the publication of a number of studies of a general nature. These can be grouped into two broad categories.

Continuing past trends, there is a collection of articles devoted to individual Chinese mathematical treatises including the following:

(1) The *Hai tao suan ching* from the end of the 3rd century. This work was treated by Louis Van Hée in two separate papers. The first (1921) carries translations of "Problem 1" and the commentary by its author Liu Hui; the second (1932) contains "1. Tableau général des mathématiciens chinois"; "2. Bibliographie des livres en langues européennes"; "3. Tableau des mesures"; "4. Historique de l'ouvrage".[3]

(2) The *Ssu yüan yü chien*, written in 1303 by Chu Shih-chieh. Its contents, mathematical problems as well as the evolution of Chinese mathematics were briefly sketched by Emma Louise Konantz (1924). Van Hée also dealt with this valuable textual source, delivering a synoptic account in the 1931 Asia Major.[4]

(3) The *Hsia-hou Yang suan ching*, (the date of which is not known). Again it was Van Hée who explored some of the terms used in a short article from 1924.

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[1]Colette Diény, rev. of Chinese Mathematics in the Thirteenth Century: A Study of the Shu-Shu Chiu-Chang of Ch'in Chiu-Shao by Ulrich Libbrecht, in T'oung Pao, 65 (1979), 88.

[2]In commenting on these translations and their influence on Western historians of mathematics such as Hankel, Zeuthen, Vacca and Cantor, Martzloff also expressed similar sentiments: "Mais comme elles contenaient des erreurs, et que ces derniers n'avaient pas accès aux textes chinois originaux, il en résulta de graves distorsions: on attribuait systématiquement les incohérences aux auteurs chinois anciens plutôt qu'aux traducteurs": Martzloff, Histoire des mathématiques chinoise, pp. 3.

[3]Section 4 gives a translation of the nine problems which make up the text as well as an explanation using modern procedures.

[4]In his opinion, "le système de Tchou est clair, symétrique, mais lourd et encombrant": Louis Van Hée, "Le precieux miroir des quartre éléments," Asia Major, 7 (1931), 244.

The second group of studies consists of articles on the level of competence attained by the Chinese in the field of mathematics. Among these are several relatively short ones:

(1) An essay by Giovanni Vacca (1905) which includes the rendering of selected passages from the *Chou pei suan ching* into Italian and description of early Chinese mathematical works.

(2) Two short critiques by Mikami in the 1909 and 1911 Archiv der Mathematik und Physik respectively on Moritz Cantor's treatment of Chinese mathematics in his Über die Geschichte der Mathematik published in 1907-08.

(3) A chronological account, also by Mikami (1926), outlining major mathematical texts, personalities, and progress in China and Japan.

More importantly, within this body of essays from the opening decades of the 20th century on the substance and worth of traditional Chinese mathematics were studies works by Gino Loria and David Eugene Smith. Contrasting the findings and views articulated by these two scholars is revealing. Loria writes in the conclusion to his "Documenti relativi all' antica matematica dei cinesi" (1922): ". . .se anche le opera inserite nella B. M. S. non basteranno a costruire una storia vera e propria dell'antica matematica cinese -- specialmente perchè ciascuna rappresenta il frutto di elaborazioni secolari -- pure constitutuiscono quella base solida da lungo tempo augurata, per fissare le caratteristiche proprie della matematica presso il popolo più numeroso, se non più grande, che si trovi sparso sulla superficie della terra."[1] His three papers (two from 1921 -- one being the English translation of the other -- and another from 1922) which review studies by Van Hée and discuss Chinese activities in various sectors of mathematics have been looked upon by Needham, Libbrecht, and Martzloff as so erroneous and unreliable and so biased against Chinese mathematics that they are practically useless.[2]

Smith (1912), on the other hand, was anxious to convey the message that the work done in the area of mathematics by the Chinese

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[1]Gino Loria, "Documenti relativi all' antica matematica dei cinesi," Archivo di Storia della Scienza, 3 (1922), 149.

[2]*See*, for example, Science and Civilisation in China, vol. 3, pp. 1; Libbrecht, Chinese Mathematics, pp. 322-24; Martzloff, Histoire des mathématiques chinoise, pp. 4.

"ranked with that which was being done in other branches of science, and had not the low standing that would be inferred from Dr. Edmunds' statements."[1] Smith, however, sounded more hesitant in 1931 when he gave a chronological survey of the Chinese mathematical tradition. Nevertheless, several points raised in his "Unsettled Questions concerning the Mathematics of China" (1931) regarding the study of the subject deserve a special note. In it, Smith points out that, "of all the works needing critical study those of the thirteenth and fourteenth centuries are the most prominent"; he also stresses "the obscurity of certain statements in the works of three mathematicians, Ch'in Chiu-shao, Li Yeh and Chu Shih-chieh" as well as the importance of "the evidences of foreign influence in such matters as the calendar, problems, and methods of treatment of equations, including those of the indeterminate class and the approach to determinants."[2] Although Smith's call for intensive investigations into key Chinese mathematical treatises and his conclusion that "the question of our debt to ancient and medieval China, in the field of mathematics, therefore resolves itself largely into that of textual criticism and of finding more source material" apparently stemmed from his doubts about the authenticity and reliability of Chinese documents, his concern reminds one of observations made by A. P. Youshkevitch fifty years later in 1982.[3] Had Smith been here in the

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[1]David Eugene Smith, "Chinese Mathematics," Popular Science Monthly, 80 (1912), 597. The "statements" refer to those made in C. K. Edmunds, "Science among the Chinese," Popular Science Monthly, 79 (1911), 521-31; 80 (1912), 22-35.

[2]David Eugene Smith, "Unsettled Questions concerning the Mathematics of China," Scientific Monthly, 33 (1931), 248, 250.

[3]Youschkevitch, in his review of Lam Lay Yong's A Critical Study of the *Yang Hui Suan Fa* and E. I. Bériozkina's Matematika drevnego Kitaia insists that, "mais ce qui a toujours manqué aux historiens des sciences européens ou américains, dont la grande majorité ne pouvait pas et ne peut pas lire les textes chinois en version originale, ce sont les traductions. C'est dans ce domaine précis que se réalise maintenant une véritable révolution grâce à laquelle l'étude des mathématiques chinoises devient de plus en plus accessible à tous les historiens intéressés": A. P. Youshkevitch, "Nouvelles recherches sur l'histoire des mathématiques chinoises," Revue d'Histoire des Sciences, 35 (1985), 98.

He also emphasizes that, ". . .il faut espérer que cet ouvrage et tous les autres ourvages classiques chinois de l'époque seront en last quarter of the 20th century, he would have been pleased to learn that Western historians of Chinese mathematics in the late 1970s and '80s have indeed poured much of their energy into the analysis, historical reconstruction and re-assessment of these texts.

While we are on the issue of positive and negative influences, a few words on Van Hée's contributions are called for. No stranger to the land of traditional Chinese mathematics with his many publications on the subject written in the early part of the 20th century and his facility with the Chinese language, he was however strangely incapable of attributing credit to Chinese mathematicians.[1]

Last to be considered in the literature from the first quarter of the 20th century is a work that stands in a class of its own. Although half of the book is concerned with Japanese mathematics, The Development of Mathematics in China and Japan by Mikami (1913) (together with Wylie's "Jottings on the Science of the Chinese; Arithmetic") had fed historical information on Chinese mathematics to major as well as less influential history of science and mathematics publications. For those non-specialists striving to come to grips with traditional Chinese mathematics at a time when the history of Chinese accomplishments, though not entirely neglected, was as a rule poorly understood and treated slightly, the book was of enormous assistance. Inaccuracies and problems with language have been stressed repeatedly by reviewers, but this monograph still receives much respect over half a century after its first publication mainly on account of its author's ability to interpret original Chinese texts, and to put together a survey that identifies and illuminates the chief elements in the history of Chinese mathematics systemati-

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leur temps traduits dans des langues européennes même ceux qui ont été dejà analysés par Lam, Libbrecht et Hoe. Il faut absolument les rendre accessibles à tous les historiens des sciences": Youshkevitch, "Nouvelles recherches," 106.

[1]In Libbrecht's memorable words, Van Hée's work was "a mish-mash of valuable research and shallow interpretation, of respect for China and scorn for its mathematical achievement. . . .any realistic evaluation of the scientific value and methodology of his work must be a negative one": Libbrecht, "Joseph Needham's Work," 32. Libbrecht also suggested that Smith seemed to have come under the influence of Van Hée's works from the 1920s; *see* Libbrecht, "Joseph Needham's Work," 31.

cally and judiciously.[1] The book follows a more or less chronological track, starting with the earliest period and the *Chou pei suan ching*, and concluding with chapters on "Later progress of the solution of equations", "The studies about the values of π by later Chinese mathematicians", and "Analytical studies about circle-measurement. Infinite series".[2]

There is an article by Ho Peng Yoke on the *Chou pei suan ching* in the 1957 Bulletin of the Malayan Mathematical Society. [I have not seen this title]. But on the whole very little can be said about general Western studies on traditional Chinese mathematics from the late 1930s, '40s and '50s. Thus when volume 3 of Science and Civilisation in China appeared in 1959 with a section dedicated to mathematics, it constituted a major event for those interested in the subject. "Mathematics" takes up 170 pages of the fattest volume in the Science and Civilisation in China series, and is divided into the following sections: "Introduction"; "Numeral notation, place-value, and zero"; "Arithmetica and combinatorial analysis"; "Logistic of natural numbers"; "Mechanical aids to calculation"; "Artificial numbers"; "Geometry"; "Algebra"; "Influences and transmissions"; "Mathematics and science in China and the West". In the "Introduction" Needham offers us his invaluable and customary reconnaissance of secondary Chinese and Western output on the subject, and in "Survey of the principal landmarks in Chinese mathematical literature" that of Chinese sources.[3] A comparison of the review made in 1961 by D. Struik with Libbrecht's appraisal of the work in 1980 is

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[1]*See*, for example, Science and Civilisation in China, vol. 3, pp. 2; Martzloff, Histoire des mathématique chinoise, pp. 3; Libbrecht, "Joseph Needham's Work," 31-32.

[2]Nevertheless, this work cannot be taken as a comprehensive guide. The author himself indicated that, "the results of my studies are by no means complete as a history. . . . My accounts are rather a collection of historical materials. . . and we must in advance inform our readers that there are still numerous other subjects considered by the old mathematicians of Japan and China, of which no mention is made in our book": Yoshio Mikami, The Development of Mathematics in China and Japan (New York: Chelsea Publishing, 1913), pp. VI.

[3]The survey is divided into: "From antiquity to the San Kuo period (+3rd century)"; "From the San Kuo to the beginning of the Sung (+10 century)"; "The Sung, Yuan, and Ming periods".

not without interest. The most important message Struik wished to communicate was that we should warmly welcome this magnus opum as a giant leap towards supplementing and vastly improving upon previous efforts.[1] Libbrecht, while sincerely applauding the greatness of Needham's accomplishments, nevertheless cautioned that the volume itself should be viewed as an endeavour would require and invite further studies.[2]

When one entered the late 1960s and moved forward to the 1970s and '80s, one stepped over the threshold into a new era of research activities. Though the actual number of researchers in this new generation was by no means large, they generated a distinct body of literature, and one of a very high standard. Some of these publications dealt specifically with one of the branches of mathematics treated in the latter sections, but others entertained a broader orientation and coverage.

A convenient way to treat the general works from the 1960s, '70s and '80s is to address, first, the four monographs -- all of which focus on a particular Chinese mathematical treatise.[3]

The *Chiu chang suan shu*, a critically important handbook from the Han period that shaped and stamped its mark on most subsequent Chinese writings on mathematics, received a German translation by

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[1]*See* review by Struik in Science and Society, 25 (1961), 371-75.

[2]*See* Libbrecht, "Joseph Needham's Work," in particular the following assessments: "Needham's work on Chinese mathematics in Science and Civilisation in China has all the characteristics of a first *ad interim* synthesis: while it does not satisfy in every respect, this is only something to be expected, for a synthesis of this sort is inevitably dependent on the analytical studies which precede it and upon which it is based. . . . When such a work of synthesis appears, other scholars are prompted to enter the field, applying themselves to all the various subject areas they consider to have been insufficiently well treated. In such a way did the publication of Science and Civilisation in China stimulate my own work, and the major contributions to the field of Chinese mathematics of scholars like Lam Lay Yong, John Hoe and Ang Tian Se. . . . When this secondary analytic phase has been completed, a new synthesis can be attempted, better and more balanced than Science and Civilisation in China. But Needham's achievement should never be forgotten or minimized": Libbrecht, "Joseph Needham's Work," 37-38.

[3]Except for the one by Kurt Vogel, the others originated as doctoral theses.

Kurt Vogel in 1968. This translation itself was based chiefly on that in Russian by E. Berezkina, with additional annotations and comments concerned primarily with mathematical terms and principles in the footnotes.[1] Vogel also enhanced the translation by providing helpful orientation in three supplementary chapters (i.e. "Der mathematische Inhalt"; "Die Aufgaben"; "Die Methoden") as well as several appendices and indices (i.e. "Die Masse"; "Chinesische Wörter (insbesondere der mathematischen Fachsprache)"; "Literaturverzeichnis"; "Namen- und Sachregister"; "Schrifttafel".[2]

Ulrich Libbrecht's Chinese Mathematics in the Thirteenth Century: The Shu-shu chiu-chang of Ch'in Chiu-shao (1973) was published as the first of the M.I.T. East Asian Science series. It is organised as follows: "I. Ch'in chiu-shao and his *Shu-shu chiu-chang*"; "II. Mathematics in the *Shu-shu chiu-chang*: numerical notation and terminology"; "III. Elementary mathematical methods"; "IV. Algebra"; "V. The Chinese remainder theorem: a monograph"; "VI. Socioeconomic information". This highly original work furnishes the reader with a wealth of richly textured historical analyses as well as details on matters handled by the treatise including indeterminant analysis, numerical equations of higher degree, the *t'ien yüan* notation, the Pascal Triangle, series and progressions, the *ta yen* rule -- all of which are presented, intrepreted, and evaluated with exceptional care and clarity.[3] Another valuable aspect of the book is the author's effort at comparing techniques suggested in the Chinese work with

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[1]E. I. Berezkina, "Drevnekitajskij Traktat Matematika v devjati Knigach," Istoriko-matematičeskie issledovaniya, 10 (1957), 423-584.

[2]"Der mathematische Inhalt" is divided into: "Die Zahlen und ihre Wiedergabe"; "Die Brüche"; "Die Grundrechnungen"; "Quadrat- und Kubikwurzel"; "Weitere Kenntnisse aus Arithmetik und Algebra"; "Geometrische Kenntnisse". "Chinesische Wörter" supplies Chinese characters, romanisation, German translation, and page reference.

[3]*See* Nathan Sivin's preface to the book; reviews by Dianna Gregory-Smith in Philosophy East and West, 29 (1979), 21-23; by Nakayama Shigeru in British Journal for the History of Science, 8 (1975), 252-54; by Kurt Vogel in Isis, 67 (1976), 309-11; by Colette Diény in T'oung Pao 65 (1979) 81-93.

procedures used in other cultures to solve similar problems.[1] Libbrecht is equally sensitive to Ch'in's life and work, devoting, for instance, an entire chapter to composing a biography of Ch'in (including a full translation of Chou Mi's note on him). He also did not miss the non-intellectual aspects and activities found in the Shu shu chiu chang, and in the final section adroitly assembled together "information on artisanal, economic, administrative, and military affairs dispersed throughout Ch'in's problems," which "provides a trove of sidelights on Chinese life a millennium ago."[2] The glossary of Chinese mathematical terms is a handy reference tool.[3] Likewise, the Bibliography is a very useful source for Chinese, Japanese and European works.[4] Finally, one cannot help but notice a rather unusual feature: original French or German passages were rendered into English in quotations.

Another thirteenth century Chinese mathematical treatise, the Yang Hui suan fa, was subjected to intensive investigation in the 1970s. Lam Lay Yong begins her critical study (1977) of this ad-

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[1]Libbrecht himself writes in the Preface: "Chinese mathematics forms part of medieval mathematics, of the algorithmic phase we find in all civilized countries at that time. In reading Ch'in's text, I tried to place it within this algorithmic mathematical conception": Ulrich Libbrecht, Chinese Mathematics in the Thirteenth Century: The Shu-shu chiu-chang of Ch'in Chiu-shao (Cambridge, Mass.: MIT P, 1973), pp. xvii.

For example, there are sections such as "Indeterminate analysis of the first degree outside China: general historical survey", and "Historical outline of the investigation of the Chinese ta-yen rule in Europe". The excellent historiographical account which traces European studies on the *ta yen* rule is of particular interest here as it reveals and unravels the truly bewildering errors and misinterpretations that could occur in the course of translating Chinese treatises and drawing on older works of Western scholars. Perhaps only a by-product of the author's main line of research, this review is nonetheless one of a number of gems found in Libbrecht's book.

[2]Nathan Sivin, "Preface," in Libbrecht, Chinese Mathematics, pp. xv.

[3]It is arranged alphabetically according to romanisation. Each entry carries Chinese characters, an explanation or translation of the term, the number of the problem in the treatise where the term is used, and in some cases the pages where the term are discussed in Libbrecht's book. About 300 terms mentioned in the Shu shu chiu chang are given.

[4]*See* discussion in *4.5 Bibliographical Works*.

vanced work with a thorough examination and review of the background and origins of the tractates and parts that make up the *Yang Hui suan fa*, thus providing an outline of the history of Chinese mathematics at its high point as well as a framework for the subsequent discussion. A complete translation of the treatise is followed by a section devoted to sophisticated and detailed commentaries. References and comparisons are made to Greek, Arabic, and Indian mathematical knowledge during early and mediaeval times throughout the study.[1] Lam does not, however, deal with social, political, economic, or institutional settings or concerns. The Bibliography is divided into three sections similar to those in Science and Civilisation in China. The book has been highly regarded as a significant contribution to the field, but reviewers have also cautioned that the translation as well as the manner in which mathematical terms and theories are explained are at times not clear, precise or accurate enough.[2]

Les systèmes d'équations polynômes dans le *Siyuan Yujian* (1303) by John Hoe [also known as Jock Hoe] (1977) begins with a quick glance at Western studies on traditional Chinese mathematics, followed by a short clarification of the Chinese title and an introduction to fundamental traits in Chinese mathematics. The main section of the book is taken up by the translation and delineation of the four important initial problems given in this textbook by Chu Shih-chieh. Through closely scrutinising and patiently elucidating these key problems, Hoe furnishes a detailed and finely crafted account of the methods by which Chu formulated and solved polynomial equations in 1, 2, 3, or 4 unknowns (which involve notations that are very difficult to comprehend, especially to those not acquainted with Chinese mathematics). Hoe then prepares a listing of the subject matter and topics covered in the many mathematical problems and

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[1] Comparisons could perhaps have gone even further as Youschkevich suggested in his review "Nouvelles recherches sur l'histoire des mathématiques chinoises", *see* pp. 103-05.

[2] *See* reviews by Sivin in Bulletin of Sung and Yuan Studies, 16 (1980), 91-94, and by J. Hoe in Annals of Science, 39 (1982), 491-504. Hoe in fact found it instructive to elaborate at great length on a number of points which he considered to be inadequately treated by Lam.

exercises Chu provided for the student (e.g. problems involving areas and volumes, simultaneous linear equations, series). A distinctive characteristic of Hoe's translation and explication of the problems is his adoption of what François Hominal called "un langage 'semi-symbolique'".[1] The monograph concentrates on mathematical reasoning and problems. Little material and discussion is offered on Chu's life and work, on the role of the *Ssu yüan yü chien* in the Chinese mathematical tradition, or on social and cultural contexts.[2]

In addition to the books, there were half a dozen of so general papers from these decades -- several of which were written by Lam, Hoe, and Libbrecht -- devoted to mathematical texts, mainly from the 13th century. They are here presented in chronological order. Nine years prior to the publication of her book on the *Yang Hui suan fa*, Lam underlined and alerted researchers to the historical importance of the treatise in a short introductory essay in the 1968 Chung Chi Journal. In a study from 1978 Donald B. Wagner argues persuasively that on the strength of the evidence which he has brought to light suggesting that there are two passages in the commentary on the *Chiu chang suan shu* commonly attributed to Liu Hui that Liu probably did not write, one should re-examine the grain measures and the "*hu*" of Wang Mang, the value of the π, and the volume of a sphere mentioned in the passages. In her paper in the Archive for History of Exact Sciences of 1979 not only does Lam delineate the mathematical problems -- in particular the numerical equations of higher degree -- in the 13th century manual *Suan hsüeh ch'i meng*, but she also considers

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[1]Hominal observes in his review that, "les quatre problèmes introductifs sont traduits dans un langage <<semi-symbolique>>, puis transcrits dans notre symbolique algébrique moderne. Dans la traduction, J. Hoe cherche à rendre compte de la capacité de la langue chinoise ancienne à se prêter à une <<algèbre rhétorique>> dont les signes peuvent être manipulés selon certaines règles et former des assemblages": François Hominal, rev. of Les systèmes d'équations polynômes dans le Siyuan Yujian (1303) by John Hoe, in Revue d'Histoire des Sciences, 31 (1978), 375-76.

[2]Information on such things as weights and measures used at the time or current surveying practices can be gleaned from the 284 problems in the exercises, which Hoe indeed translated, but unfortunately not incorporated into the publication. For this unpublished part, one would have to consult Hoe's thesis submitted to l'Université Paris VII in 1976 on which the monograph was based.

the handbook's contents, its association with contemporary works and influence on the Chiu chang suan shu. Hoe continued his interest and research on the Ssu yüan yü chien with two papers (1978) (1981) which further articulate and illustrate the algebraic processes found in this thirteenth century textbook. They also stress the difficulties and complexities in translating Chinese mathematical literature, especially the hurdles posed by the Chinese language. Documents of a very different kind are assessed in Libbrecht's (1982) contribution to a festschrift for Needham's eightieth birthday. According to Libbrecht, mathematical texts from the Tun-huang manuscripts kept in the British Museum (Stein collection) and the Bibliothèque Nationale in Paris (Pelliot collection) "nowhere excel the level of the old *Sun-tzu suan-ching*, nevertheless they give a good idea of the development of mathematics during the T'ang period. . . . The main value of these manuscripts lies in the details on metrology and decimal values, and on mathematical terminology in general."[1] The article Lam co-authored with Ang Tian Se (1983) takes a close look at the setting of yet another 13th century work and its author, and the two methods for the "construction and formation of quadratic equations derived from problems on squares, circles, rectangles and trapeziums" with which the work is concerned.[2]

Given that traditional Chinese mathematical writings, techniques, and landmarks are not hard to identify and assemble, it is a little surprising that sketching broad descriptive narratives and outlines was not a more regular undertaking in the post-1950 period. Within this small group of literature was a handful of relatively short papers, mostly derived from recent secondary literature. D. J.

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[1]U. J. Libbrecht, "Mathematical Manuscripts from the Tunhuang Caves," in Explorations in the History of Science and Technology in China, ed. Li Guohao, Zhang Mengwen, and Cao Tianqin (Shanghai: Shanghai Chinese Classics Publishing House, 1982), pp. 229.

[2]Lam Lay Yong, and Ang Tian Se, "Li Ye and his *Yi gu yan duan* (Old Mathematics in Expanded Sections)," Archive for History of Exact Sciences, 29 (1983), 240. Lam and Ang conclude their study by emphasizing that, "by writing down the *tian yuan* method using *tian yuan* notations reproduced from the counting board in both his mathematical works, Li Ye confirmed and established the algebraic thought process of the mediaeval Chinese mathematician in constructing equations": Lam and Ang, "Li Ye," 264.

Struik's chronological account in the 1963 Mathematics Teacher is an "interesting summary, clear and reliable."[1] Frank Swetz's "The Amazing *Chiu Chang Suan Shu* [Nine Chapters on the Mathematical Art]" (1972) -- also in Mathematics Teacher -- offers a cursory description of the work and the strides made by the Chinese in the realm of mathematics in early times. Another article of his (1979) gives a short profile up till the Sung dynasty.[2] In her "Il ruolo della matematica nella antica società Cinese" (1977), Maria Elena di Stefano alludes to the importance of taking social factors and cultural premises into consideration when learning about Chinese mathematics. In her paper for the 17th International Congress of History of Science's section on transmission of ancient and mediaeval mathematics, Lam (1985) seeks to assist Western scholars in gaining a better appreciation of China's place on the historical map of world mathematics by identifying certain key general elements in traditional Chinese mathematics and their paths of development, especially the use of and computation with counting rods. Sciences et Avenir devoted two pages to "mathématiques chinoises très anciennes" in 1985. [I have not seen this title]. It received the following annotation: "textes chinois d'arithmétique trouvés dans une sépulture datant du IIe - IIIe siècle av. J.-C."[3]

Though also relatively short and not aimed primarily at specialists in the field, two articles written in 1985 by Karine Chemla and Martzloff respectively are sophisticated enough to stimulate those with lesser as well as greater familiarity with the subject. The

[1]Libbrecht, Chinese Mathematics, pp. 326. Sivin also credited it with being "a concise orientation, with excellent examples, based on Russian sources as well as Mikami and Needham": Nathan Sivin, "An Introductory Bibliography of Traditional Chinese Science: Books and Articles in Western Languages," in Chinese Science: Explorations of an Ancient Tradition, ed. Nakayama Shigeru, and Nathan Sivin (Cambridge, Mass.: MIT P, 1973), pp. 296.

[2]It carries the engaging headline "Early Chinese mathematical accomplishments reveal arithmetic and algebraic approaches based on sophisticated inductive knowledge", and features the following sections: "Legend and fact"; "The systematization of early Chinese mathematics"; "Trends in Chinese algebraic thought"; "Conclusions".

[3]Annotation for "Mathématiques chinoises très anciennes," Bulletin Signaletique 522, 1986, item no. 2046.

first part of Chemla's "Les mathématiques anciennes retrouvées" (1985) opens with a short historical reflection which supplies useful clues to the question "quelle est la spécificité de cette tradition, pour ce qui est du style, des méthodes et des intérêts?"[1] One is then introduced to Wylie's efforts and the work done in recent years.[2] After this, the issue of the reception of European mathematical works in China is briefly considered.[3] The second half of the review is devoted to "la représentation des nombres avec baguettes" -- not only its essentials, but also the important role it played in shaping the Chinese mathematical tradition.[4] Martzloff (1985), in his contribution to Le matin des mathématiciens; entretiens sur l'historie des mathématiques, emphasizes the need to employ archaeological as well as written sources to strengthen one's understanding of the unique aspects of and the historical path taken by traditional Chinese mathematics.

Not fitting neatly into this batch of introductory accounts or the set of studies on individual mathematical treatise is a paper by Marco Adamo (1968) in Osiris. The author takes stock of the foundations of Chinese mathematical knowledge and the manner in which mathematical reasoning was executed (especially that communicated in older texts), and arrives at a conclusion highly disparaging of its originality and techniques. Among his claims are the following: that the theories and applications of traditional Chinese mathematics were

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[1]Karine Chemla, "Les mathématiques anciennes retrouvées," Sciences et Avenir, no. 459 (1985), 43.

[2]The comment is made that, ". . .dans les vingt dernières années, des thèses sont rédigées (moins d'une dizaine), qui analysent, à fond et en des langues accessible au commun des Occidentaux, le contenu de traités mathématiques chinois anciens. Il est donc possible, depuis peu, de disposer d'informations détaillées sur ce que fut la mathématique en Chine": Chemla, "Les mathématiques," 45.

[3]Chemla maintains that, "on pourrait demander à quoi fut due cette éclipse de ces branches de la mathématique chinoise. Les hypothèses sont nombreuses, mais aucune n'est concluante. On peut alors se rappeler l'éclipse que connut la tradition géométrique des Grecs, celle de la tradition arabe. Se rappeler, au contraire, la rapidité avec laquelle elles devinrent, à d'autres périodes, productrices de savoir mathématique. . .": Chemla, "Les mathématiques," 48.

[4]Chemla, "Les mathématiques," 46.

limited, with much borrowings from India and Greece; that arithmetic was the only possible area that could reveal some ingenuity; and that discourse is an important element in these mathematical texts.

We arrive finally at the short but judicious review "Joseph Needham's Work in the Area of Chinese Mathematics" (1980) by Libbrecht already referred to. Starting with a succinct and insightful appraisal of early endeavours in the West (and elsewhere) on the subject, it proceeds with comments on Needham's treatment and coverage of different issues in and branches of Chinese mathematics in Science and Civilisation in China vol. 3, and rounds off with an overall evaluation.

4.2 ARITHMETIC; NUMBERS AND NUMERAL NOTATIONS; ABACUS; ALGEBRA

"Algebra was dominant in Chinese mathematics as far back as we can trace it."[1] This probably accounts for the large number of 19th and 20th century publications focusing on its characteristics and evolvement. A sub-section exclusively for publications on algebra would not, however, function satisfactorily, the reason being that Western research and writing on algebra, on arithmetic, on numbers and numeral notations, and on the abacus bear closely upon one another. For instance, in discussions on the use and origin of the counting boards and the abacus, reference was often made to the nature of the Chinese mathematical notation; in explaining algebraic operations as well as formulae and solutions from early and medieaval Chinese mathematical treatises, scholars frequently found it necessary to bring in reasoning, techniques, and procedures that involve the concept of numbers or the counting boards or fundamental operations in arithmetical computation.[2]

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[1]Science and Civilisation in China, vol. 3, pp. 112.

[2]Both Needham and Libbrecht have stressed that the algebraic tradition in China was associated with a number of other important elements in the history of Chinese mathematics. *See* Science and Civilisation in China, vol. 3, pp. 112; Libbrecht, Chinese Mathematics, pp. xvii. Martzloff's Histoire des mathématiques chinoises in fact does not have a separate section for algebra. Instead, the following classification was devised to cover aspects in algebra: "Les nombres et la numération"; "Les instruments à calculer"; "Technique de calcul numérique"; "Problèmes indéterminés"; "Les formules

Two characteristics stand out in 19th century Western publications on the numeration system, aids to calculation, and arithemetical and algebraic methods employed by traditional Chinese mathematicians: first, a great interest in the abacus; second, seminal research by L. Matthiessen on indeterminate analysis. But two papers by Biot and one by Joseph Edkins should first be mentioned.

Several years prior to the publication of his general portrayal of the *Suan fa t'ung tsung* in 1839, Biot called attention to an illustration in that treatise of what is generally known to the West as the "Pascal triangle" method of solving higher numerical equations. Biot noted in this three-page communication (which does not bear a title) to the 1835 Journal des Savants that the Chinese already possessed the knowledge in the 16th century.[1] The *Suan fa t'ung tsung* inspired yet another paper by Biot. In "Note sur la connaissance que les chinois ont eue de la valeur de position des chiffres" (1839) Biot gives a brief introduction to the Chinese numeral notations as well as simple arithmetical operations based on this treatise. Edkins was also interested in the same subject. His study in the 1886 Journal of the Peking Oriental Society seeks to cast light on the principle of local value in arithmetical notation, but in the end he assigned the origin of the principle to the Babylonians from whom, according to Edkins, the Chinese learned this form of notation.

Linear indeterminate equations or indeterminate analysis of the first degree were critical to the advancement of traditional Chinese mathematics. This involves two different kinds of problems and procedures for solving them. One method is the *ta yen* rule (known in the West as the Chinese remainder problem or theorem), and it first appeared in China in the *Sun tzu suan ching*. It roused considerable curiosity in 19th and early 20th century Western scholars, and the Chinese technique's resemblance to the Indian kuṭṭaka method prompted debates over origins and borrowings.

Ludwig Mattheissen pursued the *ta yen* rule with much rigor

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sommatoires des Li Shanlan"; "Séries infinies"; "Carrés et autres figures 'magiques'".

[1]Remarks are also made regarding two copies of the work in the Chinese collection of the Bibliothèque de Roi.

during the last quarter of the 19th century, and his relatively short articles greatly improved our comprehension of the topic. The first is a short communication -- "Zur Algebra der Chinesen; Auszug aus einem Briefe an M. Cantor" (1874) -- which contends that Biernatzki made an error when translating that part of Wylie's "Jottings on the Science of the Chinese; Arithmetic" on indeterminate analysis in the *Sun tzu suan ching*. In his second paper (1876) the respective Chinese and Indian methods are supplied after delivering such preliminary information as textual sources in which the accounts can be found. Mattheissen's three other articles from 1881 also concentrate on providing a correct Western mathematical expression of the problem and solution. The value of his findings were analysed in depth by Libbrecht in his Chinese Mathematics in the Thirteenth Century.[1] However, on the only occasion in Science and Civilisation in China vol. 3 where Mattheissen's works are mentioned, Needham remarks nonchalently that the author "was very much confused".[2]

All other 19th century scholars were drawn towards the Chinese abacus. In two separate accounts, A. Westphal (1875) (1876) illustrated the traditional ways the abacus had been used to aid mathematical calculations and operations including solving numerical equations.[3] Also assisted by diagrams, Léon Rodet demonstrated and explained the manipulation of the abacus in an article from 1880, with translations by A. Vissière of relevant sections in the *Suan fa t'ung tsung*. A. Van Name's (1880) short paper describing the employment of the abacus for computational purposes, on the other hand, was based on a 19th century Japanese mathematical treatise.

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[1]*See* especially pages 312-18 in which Mattheisen's main conclusions are summarised. Libbrecht accredited Mattheisen as "the first who was able to understand the *ta-yen* rule," even though "it is a pity that Matthiessen, who did so much to correct Biernatzki's mistakes and to make the *ta-yen* rule known in Europe, was himself a victim of Biernatzki's carelessness": Libbrecht, Chinese Mathematics, pp. 313.

[2]Science and Civilisation in China, vol. 3, pp. 121.

[3]e.g. "Über die Chinesisch-Japanische Rechenmaschine" (1875) is divided into: "Addition"; "Substraction"; "Multiplication"; "Division" (sub-divided into "1. Division durch einstellige Divisoren", "Division durch merrstellige Divisoren"); "Quadratwurzeln"; "Cubikwurzeln".

More substantial and historically-oriented are the works by Terrein De Lacouperie, Cargill G. Knott, and Vissière. De Lacouperie (1883) concludes his lengthy account by asserting that, "the various inquiries we have instituted in linguistics and palaeography, ancient and modern numismatics, mathematical works and historical traditions, have all tended to the same result, a convergence of negative evidence against the supposed antiquity of the Swan-pan in China."[1] To open up his extensive study on the abacus Knott (1886) begins "Part I: The historic aspect" by considering "comparatively the systems of numerical notation that have been invented amongst civilised peoples, and then proceed to compare the systems of numeration or nomenclature of numbers."[2] "Part II: The scientific aspect" examines the manipulation of the abacus in performing multiplication, division, extraction of square root and extraction of cube root. Vissière's "Recherches sur l'origine de l'abaque chinois et sur sa dérivation des anciennes fiches a calcul" (1892) earned the compliment -- shared with De Lacouperie's paper -- of being "the most valuable contributions in Western languages" to the historical study of the abacus.[3] Unlike the others, Vissière turned almost exclusively to Chinese documentary sources, including dynastic histories and mathematical writings, the extracts from a number of which he critically translated or summarised.[4]

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[1]Terrein De Lacouperie, "The Old Numerals, the Counting-Rods and the Swan-Pan in China," The Numismatic Chronicle, 3rd ser., III (1883), 303.

[2]Cargill G. Knott, "The Abacus, in its Historic and Scientific Aspects," Transactions of the Asiatic Society of Japan, 14 (1886), 20.

[3]Science and Civilisation in China, vol. 3, pp. 70.

[4]Vissière's scrutiny of the relevant texts led him to propose the following conclusion: "En résumé, quoi qu'il puisse être de l'existence de l'abaque chinois à l'époque des Song méridionaux, si l'on se croit fondé à l'admettre sur le seul témoignage, fort douteux, de la Table chronologique des ouvrages de mathématiques due à Yang Houei, il ressort de tous les autres documents que nous avons cités que cet instrument de calcul n'est entré dans l'usage général que dans la seconde moitié du XIVe siècle de notre ère, au commencement de la dynastie Ming. Les livres de mathématiques, qui nous sont parvenus et dont la composition remonte à une date antérieure, attestent l'emploi des fiches arithmétiques par leurs auteurs. En

Output from the 1900s to 1930s consisted mainly of articles by Van Hée, but several studies by Mikami, R. Petrucci, and L. Gauchet also deserve attention.

In six of Van Hée's papers (1911; 1912; 1913a; 1913b; 1913c; 1930) different algebraic procedures and techniques are dealt with by looking into -- and in most cases translating appropriate sections in -- the available pool of Chinese mathematical literature. Among the topics covered are series and progressions, indeterminate analysis in the form of the "hundred fowls" problem, equations of the second degree, and algebraic equations for solving problems on the right-angled triangle.[1] Van Hée also wrote an account on the use and the role played by "0" in Chinese mathematics in the 1914 T'oung Pao.

In preparing their respective explorations into traditional Chinese algebraic procedures other scholars from the early decades of the 20th century also reached out to major Chinese treatises on mathematics. Mikami (1911) has thrown light on the antiquity and early employment of fractions by reviewing relevant sections of the *Chou pei suan ching*, *Chiu chang suan shu*, *Sun tzu suan ching* and *Chang Ch'iu-chien suan ching*. Needham wrote: "Van Hée has devoted a special paper to equations of the second degree, basing his exposition, however, largely on the 18th-century mathematician Li Jui, whose principal relevant work was the *Khai Fang Shuo* (Theory of Equations of Higher Degrees). Gauchet has given us a similar study

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1303, Tchou Che-kie, des Yuen, s'en servait exclusivement; quatre-vingts ans plus tard, Kouo Pe-yu faisait ses calculs astronomiques au moyen de l'abaque, et, depuis ce temps, les fiches paraissent n'avoir plus été employées; elles cessent de figurer dans tous les traités élémentaires de mathématiques. C'est donc pendant cette période de quatre-vingts ans, se terminant en 1383, que nous sommes autorisés à limiter l'époque de transition durant laquelle tantôt les fiches et tantôt les boules de l'abaque s'agitaient sous les doigts des calculateurs chinois": A. Vissière, "Recherches sur l'origine de l'abaque chinois et sur sa dérivation des anciennes fiches a calcul," Bulletin de Géographie Historique et Descriptive, 28 (1892), 75-76.

[1]e.g. "Problèms chinois du second degré" (1911) considers the thirty-four problems given by Li Chih-ch'ang; "Li-yé, mathématicien chinois du XIIIe siècle" (1913b) includes the translation of the sixty-four algebraic problems found in the *I ku yen tuan*, (accompanied by the preface and text in Chinese).

of the *Chiu Chang* equations based on the work of Lo Shih-Lin."[1] The said translation and appraisal by Van Hée of Li Jui's text on the right-angled triangle is titled "Algèbre chinoise" (1912), and it prompted critical comments from R. Petrucci (1912).[2] And the article by L. Gauchet mentioned by Needham is his "Note sur la généralisation de l'extraction de la racine carrée chez les anciens auteurs chinois et quelques problèmes du *Chiu-chang suan-shu*" (1914). Western literature on the abacus no longer flourished in the 20th century, but it remained a viable topic for a handful of scholars from the first half of the century, who wrote briefly on this mechanical aid for mathematical purposes. Mikami characterised the types of abacus, their functions and significance in an essay from 1911. "Das Rechenbrett der Chinesen" by Johannes Gehrmann (1913) shows how addition, subtraction, multiplication and division is done on the abacus. Dickson H. Leavens introduced the basics of the abacus to readers of the 1920 *American Mathematical Monthly*, especially undergraduates. A short paper in the 1936 *Unterrichtsblätter für Mathematik und Naturwissenschaften* by A. Rohrberg touches on forms of the abacus in different parts of the world and highlights the procedures in which mathematical computations are carried out on the Chinese abacus. And L. Carrington Goodrich (1948), after studying a rare edition of a mathematical primer acquired by the Columbia University Library in 1941, concluded that, "the first known illustration of a

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[1] *Science and Civilisation in China*, vol. 3, pp. 123.

[2] In Petrucci's opinion, "si nous comparons l'histoire européenne et chinoise de la découverte du théorème essentiel énonçant les conditions de structure du triangle rectangle, nous voyons que les mathématiciens grecs arrivent à sa démonstration par une voie purement géometrique, tandis que les Chinois semblent y être parvenus par une voie algébrique. L'application directe de l'algèbre à la géométrie est une des grandes conquête de la science. Maintenant que le P. Vanhée a contribué à éclaircir la terminologie de la vieille langue mathématique chinoise, il sera possible de faire des recherches fécondes. Il faudra surtout, à mon avis, se placer au point de vue de l'histoire et ne pas se laisser aveugler par une éducation mathématique européenne et moderne. La question est intéressante au point de vue de l'évolution des connaissances et je suis convaincu qu'il y a plus qu'à <<glaner>>": R. Petrucci, "Sur l'algèbre chinoise," *T'oung Pao*, 13 (1912), 563-64.

Chinese abacus is pushed back to the year 1436."[1] This communication from Goodrich and another one on measurements of the circle from the same year were the only two published pieces from the 1940s dedicated to traditional Chinese mathematics.

On reaching the 1950s, however, one encounters a large and rich collection of works on a wide range of areas and topics in algebra and arithmetic.

The method assumed by traditional Chinese mathematicians to solve numerical equations of higher degree was regarded by Needham as "the most characteristic Chinese mathematical contribution", and by Libbrecht as "one of the most important contributions of the Chinese to the development of algebra."[2] The procedure is, moreover, similar to that developed and described by W. G. Horner in 1819. Questions of its first discovery were therefore raised in a fair number of Western discussions on traditional Chinese mathematics.[3] Yet no paper aimed specifically at investigating the Chinese method appeared until the publication of Wang Ling and Needham's "Horner's Method in Chinese Mathematics: Its Origins in the Root-Extraction Procedures of the Han Dynasty" (1955).[4] This inquiry marked a new phase as well as level of sophistication in Western scholarship on the algebraic tradition in Chinese mathematics. The authors concentrated on the obscure account of the extraction of square and cube roots in the *Chiu chang suan shu*, and analysed its limitations and historical significance. Spreading over fifty pages are the following sections: "I. Introduction"; "II. Examination of the relevant passages of the *Chiu Chang Suan Shu*; with examples and demonstrations of the detailed

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[1]L. Carrington Goodrich, "The Use of Abacus in China," Isis, 39 (1948), 239.

[2]Science and Civilisation in China, vol. 3, pp. 126; Libbrecht, Chinese Mathematics, pp. 176.

[3]e.g. in Wylie's "Jottings on the Science of the Chinese; Arithmetic"; Mikami's The Development of Mathematics in China and Japan; Gauchet's "Note sur la généralisation de l'extraction de la racine carrée chez les anciens auteurs chinois et quelques problèmes du *Chiu chang suan shu*"; Loria's "The Debt of Mathematics to the Chinese People"; Struik's "On Ancient Chinese Mathematics".

[4]It is also interesting to note that not much space is given to this issue in Science and Civilisation in China vol. 3.

operations on the counting-board"; "III. Comparison of Han procedures with Horner's Method"; "IV. How was the method discovered in China?"; "V. Conclusions".[1]

Other historical studies on methods for solving higher numerical equations followed. Focusing on the 5th century treatise Chang Ch'iu-chien suan ching Ho (1965) reconstructed two problems that could illustrate the early application by the Chinese of the same procedures later expressed by Horner. In 1977, Swetz introduced to Western mathematics teachers one of the traditional Chinese "algebraic-geometric solution techniques" -- *chi chü* (or "the piling up of squares" as he called it) -- found in the Chiu chang suan shu as "a knowledge of this method can provide insights into the development of algebra as well as become a source for classroom activities."[2]

Moreover, original research into higher degree equations was carried out vigorously by Lam in the 1980s. In a paper from 1980, she approaches the topic of the prior knowledge of Horner's method in China by reviewing ancient mathematical strategies for the extraction of square and cubic roots and the triangular array of numbers (or Pascal triangle) which can be traced back to Han time. In her opinion, these led to the evolution of methods for the solution of numerical equations of any degree used by the 13th century Chinese algebraists. Continuing this theme, her "Chinese Polynomial Equations in the Thirteenth Century" (1982) compares the contributions made by four noted mathematicians from that century (i.e. Li Chih, Ch'ien Chiu-shao, Yang Hui, and Chu Shih-chieh) to the understanding

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[1]III. is broken down into: "a) *Chiu Chang* examples solved according to the method of Horner"; "b) The extension of the method by Han mathematicians for solving a type of quadratic equation other than square root extraction, and the influence of this on later mathematicians in the complete achievement of Horner's method"; "c) The continuation of the root into decimal places"; "d) The maintenance of the constant term as integer"; "e) The basic common principles, and the special contribution both by Horner and the author of the *Chiu Chang*". IV. is sub-divided into: "a) Division and root extraction"; "b) Division processes and their corresponding geometrical cutting processes"; "c) How was the square root extraction process derived from the geometrical cutting?"; "d) How was the cube root extraction process derived from the geometrical cutting?"; "e) Did the author of the *Chiu Chang* actually use diagrams and solid models?".

[2]Frank Swetz, "The 'Piling up of Squares' in Ancient China," Mathematics Teacher, 70 (1977), 73.

of polynomial equations. By revealing the merits and characteristics of the methods devised by each mathematician, she seeks to demonstrate the way in which "the processes of forming the equations and the methods of solving them formed two parallel streams in the development of Chinese polynomial equations."[1]

Significant though linear indeterminate equations were in the history of Chinese mathematics, special Western inquiries devoted to them were nevertheless scarce. Papers by Mattheissen from the 1870s and the paper by Van Hée in 1913 have already been mentioned. In his "On the Chinese Remainder Theorem" (1958) Kurt Mahler informs us of his intention "to reproduce. . . the mathematical content of this old Chinese method. This method is entirely different from that in Gauss' Disquisitiones Arithmeticae, and I cannot remember finding it in Western books."[2] Though short, this study was in Libbrecht's opinion, "an article of great importance from the mathematical point of view."[3]

Wang (1964) made a few observations on the dating of the *Sun tzu suan ching* and the Chinese technical term for referring to the "Chinese remainder problem", appealing to the modern edition and notation by Ch'in Pao-tsung (one of the most prominent Chinese scholars of traditional Chinese mathematics in the 20th century) in a contribution to the 10th International Congress for the History of Science. Libbrecht's review (1975) of indeterminate analysis was also delivered at the International Congress of the History of Science: an appropriate venue as Libbrecht alerted historians of mathematics to the fact that "indeterminate analysis is an important part of comparative mathematics."[4] Moreover, he explains that "there

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[1]Lam Lay Yong, "Chinese Polynomial Equations in the Thirteenth Century," in Explorations in the History of Science and Technology in China, ed. Li Guohao, Zhang Mengwen, and Cao Tianqin (Shanghai: Shanghai Classics Publishing House, 1982), pp. 272.

[2]Kurt Mahler, "On the Chinese Remainder Theorem," Mathematische Nachrichten, 18 (1958), 120.

[3]Libbrecht, Chinese Mathematics, pp. 325.

[4]Ulrich Libbrecht, "Indeterminate Analysis; Historical Relations between China, India, Islam and Europe," in Proceedings. . . 14th International Congress of the History of Science, Tokyo / Kyoto, 1974 (Tokyo: Science Council of Japan, 1974-75), vol. 3, pp. 311.

are two kinds of algorithms to solve them", i.e. the "hundred-fowls problem" solved by using "a set of mutual dependent numbers"; and the "Chinese remainder problem" (from the Sun tzu suan ching) solved by the *ta yen* procedure in China.[1] Though necessarily brief, the complexities involved in tracing the roots and genealogy of various methods are effectively conveyed, and throughout the paper, Libbrecht points to murky areas which those interested in the development of Chinese and comparative mathematics can seek to clarify.[2]

Mention should also be made of an article by Lam from 1974 concerned with solving simple linear equations of the kind ax + b = 0. In it she discusses a particular method for dealing with such equations found in Yang Hui's commentary on the seventh chapter of the Chiu chang suan shu.[3]

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[1]ibid.

[2]The following excerpt gives a good sense of the unresolved questions and the layers of confusion which criss-cross and overlap one another: "The 'Hundred-fowls'- problem in Alcuin's work is a real challenge. . . It is said that Rabbi ben Ezra (c. 1140) who influenced the later Elia Misrachi, and Leonardo Pisano made use of some of Alcuin's problems. But it is more likely that Leonardo derived his problem from an Arabian source. . . . Investigations into his sources show that the greater part of his problems were derived from Al-Khwârizmî and Abû-Kâmil. However, we do not see any similarity between Fibonacci's and Abû-Kâmil's method; and a comparison with Alcuin is impossible, as he does not give any method. I compared Abu-Kâmil's method for solving the 'Hundred-fowls'- problem to that of Bhâskara, and I can only state that the latter makes use of the kuṭṭaka, whereas the former applies an entirely different method. As we do not know the method of Chang Ch'iu-chien, no valuable comparison can be made. On the other side, there cannot be any doubt upon to the authenticity of the Chinese problem, because we meet it four times before it is known elsewhere, viz. in the works of Chang Chiu-chien (ca. 465), Chên Luan (c. 570), Liu Hsiao-sun (end 6th) and Li Shun-fêng (7th), but the methods of all last three are all wrong": Libbrecht, "Indeterminate Analysis," 312-13.

[3]Lam summarises her study as follows: "The seventh chapter of the Chiu chang suan shu is called *ying nu* or *ying pu tsu* meaning 'too much and not enough' or 'surplus and deficiency'. It has been pointed out by historians of mathematics that the method known in Europe as the Rule of False Position is the same as the Chinese *ying pu tsu* method used in this chapter. Yang has made a detailed and thorough study of the twenty problems in this chapter. He has not only explained and expanded the method of *ying pu tsu*, but he has also suggested alternative and simpler solutions for some of the problems. This paper endeavors to translate the twenty problems, to analyse the *ying pu tsu* method and above all to present a critical

The articles by Wang, Libbrecht, and Lam were the only accounts on indeterminate analysis and simple linear equations from the 1960s and '70s. This could well suggest that with the full documentation and exposition of its ancestry in Science and Civilisation in China vol. 3 as well as Libbrecht's authoritative and comprehensive treatment in his 1973 book (which includes a historiography of Western studies on this subject) we reached a stage in which the final word on the "Chinese remainder problem" has more or less been said.

Interest in the abacus displayed in the late-19th and early-mid 20th centuries was barely visible in the second half of the 20th century. The paper Li Shu-t'ien presented to a meeting of the Association for Computing Machinery in 1959 includes sections on "Pre-Chinese-abacus computing device"; "Half-size *chu pan* with beads having two colors"; "Arithmetic accounts about the *chu pan*"; "Chinese abacus with unattached beads"; "Perfection of the Chinese abacus"; "Development of calculation methods"; "Japanese modification"; and "Latest improvements". In 1985 Joseph C. Y. Chen resurrected the issue of the date of the primer containing an illustration of the abacus reviewed by Goodrich in 1948. Based on a newly discovered edition in Japan, he argued that "it is probable that the illustration for the abacus first appeared in the original version of the primer of the Southern Sung (1127 to 1279)."[1]

Neither did numerical notations and systems receive much thought and attention in the 1950 to 1985 period. The topic was singled out for discussion only in two papers by Wang in the 1950s. At the International Congress of Orientalists in 1954 Wang maintained that the decimal place-value system in the notation of numbers had its origin in China, arguing that "the Chinese counting rod numerals involved blank space for the zero and eighteen symbols for the nine digits", and these numerals could be seen in "Tunhuang MSS., the Han

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study of Yang's alternative methods": Lam Lay Yong, "Yang Hui's Commentary on the *Ying Nu* Chapter of the *Chiu Chang Suan Shu*," Historia Mathematica, 1 (1974), 47-48.

[1]Joseph C. Y. Chen, "On the Dating of the Oldest Extant Illustration of a Chinese Abacus," in 17th International Congress of History of Science, Berkeley, 1985. Abstracts of Papers presented in Scientific Sections, vol. 1 (Berkeley, Calif.: Office for History of Science & Technology, U of California, 1985), Ma.

bamboo-slips and the knife-money inscriptions", the last of which dated back to the fourth century B.C.."[1] He further contended that this place-value idea or indicators could have been suggested by oracle-bone expressions (fourteen century B.C.), and the place-value system was transmitted to India where the zero was first mentioned in 499 A.D. In another international conference (1958), Wang traced briefly the development of decimal fractions in China and raised the following question: "The history of decimal fractions shows that the decimal place-value notation and the method of root-extraction are two inspiring factors. China achieved both as early as in the pre-Christian era. But why were decimal fractions never fully defined and systematically treated in China until the coming of Western influence?"[2]

On the other hand, a new topic -- magic squares -- attracted several special accounts in the 1960s and '70s. Finding all previous coverage and views on the knowledge and development of magic squares in China unsatisfactory, Schuyler Cammann developed his own version.[3] In the 1960 article, Cammann first tracks routes of transmissions and influences, then delivers his verdict: "the Chinese probably did invent the magic square of three, centuries before anyone else; but. . . far from showing a continuous advance since 1275 -- as described by Needham -- the Chinese apparently made no real progress since some time before that date; and the whole tradition gradually weakened as it declined. Meanwhile, other people con-

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[1]Wang Ling, "The Chinese Origin of the Decimal Place-Value System in the Notation of Numbers," in Proceedings of the 23rd International Congress of Orientalists, Cambridge, 1954, ed. Denis Sinor (London: Royal Asiatic Society, n.d.), pp. 300.

[2]Wang Ling, "The Development of Decimal Fractions in China," in Actes du 8e Congrès International d'Histoire des Sciences, Florence / Milan, 1956 (Paris: Hermann, 1958), vol. 1, pp. 16.

[3]He argued that Smith has made "exaggerated claim for China (c. 2200 B.C.)", that Ahrens has gone "to the opposite extreme, trying to deny any Chinese knowledge of magic squares before mediaeval times, in order to try to prove the priority of the Arabs, who did so much to develop them", and that Needham, in his attempt "to demonstrate that Chinese progress in this field has been both continuous and impressive. . . quite misrepresented the actual story": Schuyler Cammann, "The Evolution of Magic Squares in China," Journal of the American Oriental Society, 80 (1960), 116.

tinued to make conspicuous advances, finding new and easier solutions to the old problems."[1] In the second study (1962), Cammann focuses on the magic squares recorded in Yang Hui's *Hsü ku chai ch'i suan fa* from the 13th century as well as those from a later time. Ho Peng Yoke also wrote an article on magic squares titled "The Earliest Chinese Magic Square and Magic Squares in the Islamic World" (1972). [I have not seen this title]. And profiting from writings by Needham and Cammann, Swetz furnished an introductory account -- "Mysticism and Magic in the Number Squares of Old China" -- in the 1978 *Mathematics Teacher*.

Finally there is an ensemble of articles composed by Lam between 1966 and 1972 on fundamental processes in computations recorded in Chinese sources: (1) In an account from 1966, Lam compares the Chinese method of division in the *Sun tzu suan ching* with the Hindu division method which is commonly supposed to have been the origin of the European galley method. (2) Her study (1969) on the fragments of Yang Hui's *Hsiang chieh chiu chang suan fa* gathered by Li Yen [also called Li Nien] and printed in his 1954 collection of essays gives a partial translation of the text with commentaries. Various methods of multiplication and division as well as the "Pascal triangle" are treated. (3) Another essay (1970) analyses the oldest surviving diagram of the square-root extraction process.[2] Translations, commentaries, and a comparison with Theon of Alexandria's ~~Alex's~~ method of extracting square root are provided. (4) Finally, ten problems on multiplication and division from the fragments of the *Jih yung suan fa* by Yang Hui, also collected in Li Yen's work, are translated and pursued in a paper in the 1972 *Isis*.

4.3 GEOMETRY

For much of the 19th and 20th centuries, it was generally thought that the position theoretical geometry occupied in the formation and evolutionary processes of the Chinese mathematical tradi-

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[1]Cammann, "The Evolution of Magic Squares," 123.

[2]It is also found in the *Hsiang chieh chiu chang suan fa*, and exhibits a geometrical origin.

tions was neither critical nor major. This might account for the relative lack of Western activities dedicated to this subject area until the more recent decades when it began to engage a significant portion of the research interest of historians of traditional Chinese mathematics. By the mid-1980s, over a dozen studies on this topic were published.

The aspect on which investigators have spent most of their time was the approximation of π and ways to determine the volume of a sphere. This topic was covered on a few occasions prior to 1970. In his paper in the Bibliotheca Mathematica (1910), Mikami traces the historical development of computation methods for "circle-squaring" employed by various Chinese mathematicians, and contrasts them to those used elsewhere. J. M. Barbour (1933) seized upon the work of Chu Tsai-yü -- who has been accredited with the discovery of equal temperament in the 16th century -- "to show possible skeptics that it is not unreasonable to suppose that Tsai-yü [sic] was familiar with Ch'êng's approximation 22/7. . . ."[1] In the "Notes and Correspondence" section of the 1948 Isis is a short account from Goodrich on the approximations of π, especially that proposed by Tsu Ch'ung-chih, giving references to relevant documents. Erwin Reifler informed us in 1965 that, "some time between A.D. 1 and 5 the famous astronomer, calendar expert and bibliographer *Liu Hsin* supervised, by order of the "usurper" *Wang Mang*, the making of sets of five calibrated standard grain measures. . . . The metrological and mathematical details of these standard measures are recorded in the histories of the Han and Sui dynasties, in commentaries to the CHIU CHANG SUAN SHU, etc., and also in inscriptions on the extant set. The author of these inscriptions is assumed to have been *Liu Hsin* himself. Much has been written in ancient and modern times on the philological and mathematical problems involved and most Chinese scholars studying the inscriptions have come to the conclusion that the presumed mathematical inaccuracies were -- to use the verdict and wording of *Tsu Ch'ung-Chih* -- 'brought about by the imperfection of

[1]J. M. Barbour, "A 16th Century Chinese Approximation for π," American Mathematical Monthly, 40 (1933), 72. Note that throughout his article, Chu Tsai-yü is referred to as "Tsai-yü".

Liu Hsin's mathematical skill'."[1] After meticulously dissecting original and secondary material pertinent to the subject and interpreting each one mathematically as well as philologically, Reifler had this to say: "This judgement may be justified if we judge the mathematics of Liu Hsin, a scholar of the early part of the first century A.D., in light of the quite advanced mathematics of the third to fifth centuries. But, . . . this judgement was nevertheless based on wrong premises."[2]

The popular topic of the value of π was represented in the 1970s and '80s by half a dozen papers, including two brief ones from T. Kiang and Stefano respectively. Kiang's "An Old Chinese Way of Finding the Volume of a Sphere" (1972) is aimed at demonstrating the method in a straightforward and matter-of-fact fashion to teachers and students of mathematics, while Stefano's "Il Pie' veloce achille ed il corridore cinese: occasione per un confronto?" (1980) offers an account of Chinese efforts based chiefly on secondary works such as those written by Mikami, Lam, and Libbrecht.

More weighty are studies crafted by Wang, by Wagner, and by Lam and Shen. The strategy Tsu Ch'ung-chih adopted in finding the value of π was tackled by Wang in 1977. In his opinion, Tsu's achievement "lies not so much in the result itself as in the method used."[3] For an original examination and reconstruction of the particular processes explored by Liu Hui and Tsu Keng-chih (the son of Tsu Ch'ung-chih), Wagner's paper from 1978 remains invaluable. It is directed towards "a proof of a formula for the volume of a sphere written by Tsu Keng-Chih in the late 5th century A. D." found in "some lost book in Li Ch'un-feng's (602-670) commentary on the Chiu-chang suan-shu" which has been customarily attributed to Liu Hui. Not only did Wagner translate relevant passages and commentaries but he also

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[1]Erwin Reifler, "The Philological and Mathematical Problems of Wang Mang's Standard Grain Measures: The Earliest Chinese Approximation to π," in Symposium in honor of Dr. Li Chi on his Seventieth Birthday (Taipei: Ching hua hsüeh pao she, 1965-67), vol. 1, pp. 387.

[2]Reifler, "The Philological," pp. 388.

[3]Wang Ling, "A New Suggestion of Tzu [sic] Ch'ung-chih's Method of Finding the Value of π and its Significance in the History of Mathematics," Papers on Far Eastern History, 16 (1977), 165.

scrutinised the proofs as well as an intriguing textual problem.[1] Supplementing Wagner's article is Lam and Shen's "The Chinese Concept of Cavalieri's Principle and its Applications" (1985). Liu Hui's (3rd century) and Tsu Keng-chih's (5th century) exploitation of the method of indivisibles for deriving the volume of a sphere (which resembles that developed by Cavalieri in the 16th century) is reviewed and the influence of Tsu's application on later mathematical developments considered.

An inquiry into attempts made by Chinese mathematicians to determine areas of solid figures is also available. Wagner's "An Early Chinese Derivation of the Volume of a Pyramid: Liu Hui, 3rd Century, A.D." (1979) is organised as follows: "Introduction"; "The text"; "Rectilinear solids treated by Liu Hui"; "The *Fang-t'ing*: an example of Liu Hiu's method"; "Summary of the derivation of the volume of a *yang-ma*"; "Translation of the derivation"; "Conclusions" (in which problems posed by Liu's work, such as its difficult terminology and Liu's failure to generalise, are sensitively addressed).[2]

Chinese knowledge of the right-angled triangle and the Pythagorean theorem, rarely investigated before mid-1970s, was pursued in several special publications.

Having determined that there may be grounds to believe that the Pythagorean Theorem was employed by early Chinese mathematicians, Swetz and Kao thought it instructive to translate the *Yung lo ta tien*'s edition of the ninth chapter of the *Chiu chang suan shu*. It contains the "richest source of problems from antiquity dealing with the right triangle", but was never translated into English in full. Their endeavour yielded the monograph Was Pythagoras Chinese?: An

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[1]Donald Blackmore Wagner, "Liu Hui and Tsu Keng-chih on the Volume of a Sphere," Chinese Science, 3 (1978), 59.

[2]We are told that, "the *Chiu-chang suan-shu* (Arithmetic in Nine Chapters) is a mathematical book of the first century A. D. It gives practical problems and states algorithms for the solution, with no explanation. A commentary attributed to Liu Hui, of the third century A. D., gives an explanation of each algorithm; these explanations satisfy many of the criteria for what we would call a proof. In this article, Liu Hui's explanation of the formula for the volume of a particular kind of pyramid is translated and discussed": Donald B. Wagner, "An Early Chinese Derivation of the Volume of a Pyramid: Liu Hui, 3rd Century, A.D.," Historica Mathematica, 6 (1979), 164.

Examination of Right-Angle Theory in Ancient China (1977).[1] Rather than supply readers with a definitive answer, the authors reckoned that, "while we hope a convincing case has been made for the primary of right triangle theory in ancient China, further research will have to be conducted to resolve the basic question of this monograph. This research will have to be part of the much broader effort of trying to understand the influence of early oriental mathematics and that of other cultures in general on the development of science and scientific thinking in the West. . . . Until that time, the question remains: Was Pythagoras Chinese?"[2]

Also published in 1977, Brendan S. Gillon's article contributed to the study of right-angled triangles by focusing on a particular commentary of the *Chou pei suan ching*, namely Chao Chün-ch'ing's "Notes to the Diagrams of Short Legs and Long Legs and of Squares and Circles". It opens with an introduction to the Chinese treatise and the passage under consideration, followed by a full translation as well as critical discussion of the mathematical virtues of the procedures. Lam and Shen also sought to steer attention towards early references to right-angled triangles and proofs of the Pythagoras Theorem. Their paper on this topic in the 1984 Archive for History of Exact Sciences consists of five sections: "1. Introduction"; "2. The *Jiu zhang suanshu*"; "3. General rules and their derivations"; "4. Classification into types and groups"; "5. Conclusions". In addition to an examination of relevant sections in Chinese texts, the authors shed light on the role these early activities played in the formation of mathematical reasoning in China as well as on the outward

[1]The book contains three sections: "Perspectives" (divided into "The Pythagoras Theorem: historical significance", "Early evidence of Chinese work with the right angle", "The *Chiu Chang Suan Shu*: its content and form"; "The Chiu Chang's problems involving right triangles"; "Conclusions" (divided into "The value of the kou-ku as a mathematical thesis", "Right triangle solution techniques of ancient China", "Was Pythagoras Chinese?").

[2]Frank J. Swetz, and T. I. Kao, Was Pythagoras Chinese?: An Examination of Right-Angle Theory in Ancient China (University Park, Penn.: Pennsylvania State U, 1977), pp. 67-68.

transmission of this knowledge.[1] And in 1985 Wagner published in the "Education" section of the Historia Mathematica a diagram taken from Liu Hui's commentary of the *Chiu chang suan shu* which can serve as an illustration of a "proof" of the Pythagoras Theorem.

Finally, two accounts on issues associated with traditional Chinese concepts and knowledge in the area of trigonometry: (1) Kuo Shou-ching's remarks and calculations as recorded in dynastic histories (e.g. *Ming shih*, *Yüan shih*) were translated by Gauchet in 1917. He also included translations of and references to texts that deal with trigonometry in other sources (e.g. *Meng ch'i pi t'an*, *Hu shih suan shu*). (2) The contents, origin, and objectives of "a table of functions equivalent to a tangent table making use of third-order finite differences" composed by the Buddhist monk I-hsing around 725 A.D. were subjected to an in-depth and insightful study by Christopher Cullen in 1982.[2] According to Cullen, this table "played an important role in I-hsing's work on mathematical astronomy" and was constructed for a practical purpose; furthermore, it "preceded the shadow tables used by Moslem astronomers of the 9th century A.D." and "was apparently an independent development based on Indian influence about the use of sines".[3]

The comment was made in 1984 that "there is a particular scar-

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[1]They argue that, "it is indisputable that the study of right-angled triangles is one of the important subjects of mathematics in ancient China. . . . The ancient Chinese knowledge of right-angled triangles can be said to be compact and comprehensive. . . . that there is a continuous logical accumulation and synthesis of facts on right-angled triangles in China. Furthermore, there is also a strong case to presume that fragments of these materials were transmitted westward": Lam Lay Yong, and Shen Kangsheng, "Right-Angled Triangles in Ancient China," Archive for History of Exact Sciences, 30 (1984), 110-11.

[2]Christopher Cullen, "An Eighth Century Chinese Table of Tangents," Chinese Science, 5 (1982), 1.

[3]ibid. The article is made up of: "Introduction"; "Reconstruction of the tangent table"; "The accuracy of the table and its role in the Ta Yen Li"; "The tangent table and the survey results"; "The origin of I-hsing's tangent table"; "The accusation of plagiarism against I-hsing"; "Conclusion".

city of Western literature on Chinese geometry."[1] Although more studies and perspectives on the topic were still needed in order to fill in gaps and lacunae, judging from the output from the 1970s and '80s described above, publications on this branch of traditional Chinese mathematics were not exceptionally limited.

4.4 BIOGRAPHICAL WORKS

Chinese mathematical texts have served as the focus of many Western accounts. Yet the lives, experience, and intellectual outlook of those responsible for writing, compiling or commenting on them have not given rise to serious studies. This may be attributed in part to the fact that details of these men's life and personality is lacking, thus making it very difficult to paint their full portraits.[2]

Entries in the multi-volume Dictionary of Scientific Biography published in the 1970s on Ch'in Chiu-shao (ca. 1202 - 1261), Chu Shih-chia (1280 - 1303), Li Chih [also called Li Yeh] (1192 - 1279), Liu Hiu (fl. ca. A.D. 250), and Yang Hui (fl. ca. 1261 - 1275) -- all written by Ho -- are therefore particularly noteworthy. Roughly the same type of information is given for all five essays. The little that is known of these mathematicians' personal histories is first provided; then Ho carefully traces versions, editions, commentaries, and reconstitutions of their writings, often indicating their relative value.[3] Accents are laid on the mathematical content of the

[1]Frank J. Swetz, and Ang Tian Se, "A Brief Chronological and Bibliographic Guide to the History of Chinese Mathematics," Historia Mathematica, 11 (1984), 50.

[2]Martzloff writes in the section "Les mathématiciens chinois": "un problème de définition se pose: comment sait-on qu'un personnage donné serait 'mathématicien'? Pour cerner cette question, nous nous fonderons sur les notices biographiques relatives aux mathématiciens chinois de l'antiquité et du Moyen-Age qu'a rassemblées Li Yan car, pour le moment, il n'existe aucun travail aussi complet sur le sujet": Martzloff, Histoire des mathématiques chinoises, pp. 72.

[3]e.g. magic squares in the first chapter of Yang Hui's *Hsü ku chai ch'i suan fa* are "found only in the rare Sung edition and is missing from the *I-chia-t'ang ts'ung-shu* version, which is commonly available": Ho Peng-yoke, "Yang Hui," in Dictionary of Scientific Biography, vol. 14 (New York: Charles Scribner's, 1976), pp. 544.

men's writing. Nevertheless, in addition to delineating and explaining succinctly the wide range of mathematical procedures featured in the literature, Ho highlights their historical significance by situating them within broader contexts.[1] Furthermore, Chinese as well as Western titles are provided in the attached bibliographies. These essays can arguably be placed in the section on general works instead of being considered as biographical studies since they function admirably (especially when read together) as first introductions to major texts and key elements in traditional Chinese mathematics: they contain the appropriate amount of details and illustrations to communicate all the essential information, but not so bogged down by particulars and trivia as to overwhelm newcomers.[2]

Notice should also be drawn to Van Hée's essay in the 1926 Isis on the famous collection of biographies from 1799 of Chinese individuals in calendrical science and mathematics: the *Ch'ou jen chüan* compiled by Juan Yüan (romanised by Van Hée as Yüan Yüan).[3] Van Hée

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[1]e.g. (1) "Li Chih and Ch'in Chiu-shao were contemporaries, but they never mentioned each other in their writings. . . . It is very likely that the two never even heard of each other. The terminology they used for equations of higher degree is similar but not identical. They also employed the so-called celestial element in different ways. Li Chih used it to denote the unknown quantity; but to Ch'in Chiu-shao the celestial element was a known number, and he never used the term in connection with its numerical equations. Ch'in Chiu-shao went into great detail in explaining the process of root extraction of numerical equations, but he did not describe how such equations were constructed by algebraic considerations from the given data in the problems. On the contrary, Li Chih concentrated on the method of setting out such equations algebraically without explaining the process of solving them. Thus Li Chih was indeed, as Geroge Sarton says, essentially an algebraist": Ho Peng-yoke, "Li Chih," in Dictionary of Scientific Biography, vol. 8 (New York: Charles Scribner's, 1973), pp. 320. (2) "After Chu Shih-chieh, Chinese mathematicians made almost no progress in the study of higher series. It was only after the arrival of the Jesuits that interest in his work was revived": Ho Peng-yoke, "Chu Shih-chieh," in Dictionary of Scientific Biography, vol. 3 (New York: Charles Scribner's, 1971), pp. 269.

[2]Joseph W. Dauben considered these biographical essays "excellent for reference purposes": Joseph W. Dauben, The History of Mathematics from Antiquity to the Present Time (New York: Garland, 1985), pp. 423.

[3]This article was translated into English from a French manuscript.

firmly believed that, "the works of Yüan Yüan substantiate much of what I've written. From a scientific point of view however, it's essential that scholars should verify all the passages from the originals. This will be a long and thankless task. The criticism in these biographies is weak; fanaticism has warped their perspective. Many of the Chinese are intensely interested in astronomical questions and in works concerning the calendar. Despite finesse and ingenuity their geometric mind is totally lacking. Rigorous exactness and ability for serious research are not to be numbered among gifts from the gods."[1] Such assertions and sentiments prompted Mikami (1928), in his reply to Van Hée, to comment that the latter's account "contains many statements to which no Sinologue could object, and for which all will be indebted to this learned Jesuit scholar. There are, however, certain other statements to which exception must be taken as a wrong impression of certain phases of the development of Chinese mathematics."[2]

4.5 BIBLIOGRAPHICAL WORKS

Pai fu t'ang suan hsüeh ts'ung shu is a collection of mathematical literature -- traditional Chinese as well as translations from European sources -- compiled by Ting Ch'ü-chung in 1875. The twenty-three works concerned were assessed by Van Hée in 1914. Under each title is a brief summary of its prominent features and the topics treated, background information on its history and its author, together with Van Hée's own evaluations.

Van Hée also translated the contents of the *Chung hsi suan hsüeh ta ch'eng* into French in 1926 (with a revised English version by

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[1] Louis Van Hée, "The Ch'ou-jen chuan of Yüan Yüan," Isis, 8 (1926), 118. The article is structured as follows: "Introduction"; "General plan of the work"; "A notable characteristic of the Chinese mind"; "Tsu Ch'ung-chih"; "Mathematicians of the Sung Dynasty (960-1278)"; "The writers of the Yuan Dynasty (1278-1360)"; "Foreign influences"; "The supplement"; "Conclusion".

[2] Yoshio Mikami, "The Ch'ou-jen chuan of Yüan Yüan," Isis, 11 (1928), 123. Mikami reminded us that the compilation is in fact concerned primarily with individuals one would commonly refer to as astronomers, although they were also interested in mathematics.

Smith in the 1926 American Mathematical Monthly.) Van Hée explains that "the recent appearance in this Monthly of several interesting and valuable articles upon early Chinese mathematics suggests the desirability of calling attention to a notable source book that appeared in China in 1889, but which seems to be little recognized in the West. It is known as *The Great Treasure House of Chinese and European Mathematics* and was edited by Ch'en Wei-kei. It consists of a selection from some of the best mathematical treatises published in China, both native and European, and is made up of a hundred parts, some of these being classical treatises and others being mere compilations. The following list with comments, affords an idea of the scope of this monumental compendium."[1]

Yet another collection of Chinese mathematical texts, namely the *Suan ching shih shu*, has benefited from scholarly consideration. According to Needham, the *Suan ching shih shu* is "probably the *editio princeps* of the mathematical classics."[2] Hermann Kogelschatz's register (1981) aims at furnishing an alphabetical listing of authors and titles found in this enormous compilation. For title entries: Chinese characters and German translations are provided together with dates, editions and brief bibliographic history; chapters, sections, and scope are also noted and occasionally discussed in passing. In author entries: Chinese characters, dates, main works and contributions to the field are mentioned. Four appendices follow: "Die Titel der 'Zehn Klassiker' in chronologischer Reihenfolge (nach Ch'ien Pao-tsung)"; "Die wichtigsten Autoren im Zusammenhang mit den 'Zehn Klassiker' in chronologischer Reihenfolge (bis 1084)"; "Übersichts-tabelle zu den wichtigsten Ausgaben und den darin enthaltenen Titeln"; "Stammbaum zur Textüberlieferung der 'Zehn Klassiker" (von 1084 bisheute)".

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[1]Louis Van Hée, "The Great Treasure House of Chinese and European Mathematics," trans. & rev. D. E. Smith, American Mathematical Monthly, 33 (1926), 502.

[2]Science and Civilisation in China, vol. 3, pp. 18. This is largely because "edited by officials in +656 for use as a text-book and first printed in +1084, most of it was copied into the *Yung-lo Ta Tien* encyclopaedia in the 15th century, but subsequently became rare. The corpus was recovered by Tai Chen and printed, with his editing, in the Palace collection *Wu Ying Tien Chü Chen Pan Tshung-Shu* in the years preceding +1794": ibid.

Vogel's "Bericht über neuere, in westlichen Sprachen erschiene Arbeiten zur Mathematik der Chinesen" (1977) begins with a sweeping summary of the major events in the history of Chinese mathematics and description of Western research since the publication of the mathematics section of Science and Civilisation in China. It then supplies readers with a list of seventy-seven titles that stretches from Biernatzki's "Die Arithmetik der Chinesen" from 1856 to an article by Berezkina published in 1975. Of the titles addressed in the present chapter, only a small percentage are mentioned in Vogel's compilation. However, it takes note of studies from Soviet scholars written in Russian (especially those from E. J. Berezkina) as well as literature not expressly concerned with traditional Chinese mathematics.[1]

It is fair to state that Swetz and Ang's "A Brief Chronological and Bibliographic Guide to the History of Chinese Mathematics" (1984) has succeeded in its intention to show that "there does exist a rich albeit dispersed, literature on the history of Chinese mathematics in Western languages" and to "call the reader's attention to this literature and to the history of Chinese mathematics in general."[2] The guide is presented in three sections, each performing a different function. "A perspective" takes one on a lightning tour of Western scholarship on traditional Chinese mathematics and of issues worth registering (especially when coming into contact with the subject for the first time). "A chronological outline of the development of Chinese mathematics" is a table with five columns: 1. "Date" (from -1400 to +1859); 2. "Accomplishment" (e.g. "Decimal numeration system in use", "Formula of interpolation for equidistant intervals", "Solution of numerical higher equations", "Complete translation of Euclid appears"); 3. "Person"; 4. "Work or artifact" (e.g. "oracle bones", "*Ch'i Ku Suan Ching* (*Qi Ku Suan Jing*) [Continuation of Ancient Mathematics]"); 5. "References" (which indicates one or several pertinent Western studies). Finally, "References" delivers 122

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[1]e.g. H. A. Giles, Chinese Biographical Dictionary; Yves Hervouet, Bibliographie des travaux en langues occidentales sur les Song parus de 1946 à 1965.

[2]Frank J. Swetz, and Ang Tian Se, "A Brief Chronological and Bibliographic Guide to the History of Chinese Mathematics," Historia Mathematica, 11 (1984), 39.

titles in Western langugages from 1835 to 1982 arranged alphabetically by author.[1] Users would appreciate several features in this outline. In "Person" and "Work or artifact", both Wade-Giles and pinyin romanisations -- and for "Work or artifact" also the English translation of titles -- are provided, with Chinese characters given in a separate glossary. And for those who would like to consult the original Chinese texts, such sources are indicated in the "Work or artifact" column. Likewise, readers are informed of and can go directly to secondary materials that deal with a specific topic that interest them. Major studies in Western languages up to 1982 (especially those from the second half of the 20th century) are listed in the bibliography section.[2] (See also remarks made in *4.9: II. Specialised Bibliographic Sources*).

Martzloff's "Aperçu sur l'histoire des mathemtiques chinoises telle qu'elle est pratiquée en République Populaire de Chine" (1985) is indispensable to anyone (especially those who do not read Chinese) interested in research and publishing activities that originated from China: all Chinese titles carry romanisation as well as French translation, and are made easily accessible through the subject and author indices. "Recherches chinoises", which occupies the first six pages, is a systematic portrayal.[3] The rest of the article contains bibliographies and indices; of these the main ones are: "II-3. Liste de revues et ouvrages regroupant uniquement dans articles de revues"; "II-4. Bibliographie des articles d'HMC"; "II-6. Index pour la bibliographie des articles d'HMC".[4] Not only is it

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[1]Also included are some works by scholars from China, Japan, and the Soviet Union, written in English or Russian.

[2]Note several inconsistencies in romanisation and typographic errors; e.g. on page 47, "Zhu (instead of *Zhou*) Bei Suan Jing", on page 46 "Si Yuan Yu Jien (instead of *Jian*)", on page 52 "Li Chi (instead of *Chih*)" for Ho's biographical essay.

[3]This is sub-divided into: "I-1 Chercheurs et organismes de recherche"; "I-2 Orientation des recherches"; "I-3 Editions critiques de textes anciens"; "I-4 Découvertes d'objets intéressant l'HMC" (i.e. histoire de mathématiques chinoises); "I-5 Note sur l'historiographie chinoise actuelle des mathématique chinoises".

[4]II-3 has sixty-three items arranged by romanised title with Chinese characters attached. II-4 contains 238 entries from 1952-1984, organised by author according to pinyin romanisation with

convenient to have an extensive bibliography of Chinese writings from the past three decades, but Martzloff's comments, combined with his detailed indices, have yielded a quick and informed guide; it also affords a good basis for comparison with contributions from other countries.

4.6 CONCLUSION

In the 19th century, the importance of certain Chinese mathematical texts was underscored by Biot, Wylie's "Jottings on the Science of the Chinese; Arithmetic" was studied and translated, the abacus was a popular theme, and Mattheissen drafted seminal works on indeterminate analysis. The first quarter of the 20th century was characterised by general commentaries on the mathematical understanding of the Chinese as well as accounts by Van Hée and others on a number of Chinese mathematical treatises and aspects of Chinese arithmetic and algebra. It is therefore not fair to speak of an absence of Western publications on traditional Chinese mathematics in the 19th and early 20th century. However, the findings and opinions expressed in some of these writings were later found to be unsound and erroneous (e.g. those from Loria and to some extent from Van Hée).

The pace slackened noticeably from the mid-1930s to the mid-'50s, but thanks largely to the mathematics section in Science and Civilisation in China vol. 3 published in 1956, the study of the Chinese mathematical tradition began to gain momentum and attract dedicated researchers in the immediate decade following its appearance. Papers confronting a host of topics emerged, from the translation of the *Chiu chang suan shu*, the Chinese remainder problem, magic squares, to the approximation of π. The substantial body of

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titles in Chinese characters, romanisation and French translation. II-6 is divided into: "I. Sujets purement mathématiques" (with thirty-six subjects, e.g. "analyse indéterminée, "calcul", "carrés magiques); "II. Autres sujets": "1. Mathématiciens chinois" (with twenty-four pre-20th century mathematicians and three from the 20th century); "2. Historiens des mathématique chinoises" (i.e. Li Yen and Qian Baozong); "3. Ouvrages chinois" (with sixteen works); "4. "Autres sujets" (with twenty-seven subjects, e.g. "astronomie", "chiffres arabes", "Chine-pays occidentaux", "méthodologie".)

scholarship from the 1970s continued this trend of probing into various regions and elements. Thorough examinations were given to three 13th century treatises, other mathematics texts were explored, operations in arithmetical computation and methods used in geometry were studied, and accounts of mathematical accomplishments were written. New areas were identified in the early-mid 1980s, but old concerns were not abandoned; above all, there was an expansion of historiographic and bibliographic efforts.

All in all, by the early 1980s, Western historians have shone more than a dim light on the surface of the subject of traditional Chinese mathematics, and their works have demonstrated a keen awareness of Chinese knowledge in the area of mathematics. Moreover, one can point to masterpieces that deserve not only wide recognition and appreciation among devotees of traditional Chinese mathematics, but also represent some of the finest works in the entire field of Chinese science. Serious forays have been made into all significant mathematical texts, and original Chinese sources have been put to good use and thoughtfully exploited. Also available are several introductions written primarily for mathematics teachers, students, and non-specialists. There is every indication -- judging by the amount and standard of the current repertory and the training and commitment of the participants -- that the vigour will continue.[1]

Nevertheless, unexamined areas or topics that warrant deeper investigations still remain, one of which is the emergence and roots of Chinese mathematics.[2] As are special inquiries that confront, highlight, and analyse intellectual and social contexts and perspectives. Integrated thematic overviews and chronological surveys that draw all the scattered excursions together are also conspicuously lacking.

Moreover, while it is no doubt essential to stress the increa-

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[1]An interesting element to note is the sensitivity which a number of publications have shown towards the course this field of study has run. It is not uncommon to find brief paragraphs or prefaces tracing former contributions, and references were frequently made to older Western titles on the topic under discussion.

[2]Youschevitch, for instance, mentioned several neglected aspects in his "Nouvelles recherches sur l'histoire des mathématiques chinoises".

sing sophistication of and new directions taken by publications from the post-1950 period, it would be irresponsible not to call attention to features these studies share with their predecessors.[1] In both early and more recent works, written Chinese sources constitute the main subject of inquiry or stand in the background. And broadly speaking, although the investigators' expertise and their interpretations differed dramatically, in all periods, the bulk of the literature was targeted towards specific and relatively well-defined issues (may it be a particular text, passage in a treatise or a technique). Furthermore, since the days of Biot modern Western mathematical concepts and procedures have been used routinely as the basis for establishing and demonstrating the ingenuity (or incompetence) of the Chinese.

4.7 PARTICIPATING COUNTRIES AND INDIVIDUALS

The field of traditional Chinese mathematics can boast an impressive team of past and present contributors who resided and worked outside Britain, France, Germany and the U.S., including Mikami from Japan, Loria from Italy, Van Hée and Libbrecht from Belgium, Wagner from Denmark, Wang from Britain / Australia, Ho from Malaysia / Australia, Hoe from New Zealand, Gillon from Canada, and Lam from Singapore.

This is not to say that those four countries did not participate actively. In addition to Wylie and Needham, the U.K. was represented by researchers such as De Lacouperie, Edkins, Knott, Cullen. After the burst of interest in the 19th century (e.g. from Biot, Vissière), one had to wait till the third quarter of the present century to witness significant effort to issue from France, carried out vigorously by Martzloff and Chemla. German contributions from the 19th century (e.g. by Matthiessen and Westphal) should not be forgotten,

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[1]The majority of these works were highly successful at revealing the skills of Chinese mathematicians, in particular their employment of those mathematical processes long held in the West to have been devised first by Europeans (e.g. the Pascal triangle method, Horner's root extraction algorithm, Pythagoras theorem, Cavalieri's principle for finding the volume of a sphere). Note, however, that several studies (e.g. those by Adamo and Cammann) sought to convince readers of the opposite.

but for the 20th century, there was little else besides the important works of Vogel and Kogelschatz. Publications from American scholars have appeared intermittently throughout the 20th century, starting with papers by Smith (Columbia University), Barbour (Ithaca College), Goodrich (Columbia University), and succeeded by studies from Cammann (University of Pennsylvania), Struik (Massachusettes Institute of Technology), Reifler (University of Washington) in the 1960s, and by those from Swetz (Pennsylvania State University) in the 1970s and '80s.

The picture that emerges, therefore, is one that contains an untypically large assortment of countries, but without any single one dominating the field for an extended period of time. The number of individuals involved is, however, another story. One person was often responsible for two or three studies -- and in some cases five or six -- not to mention fifteen articles by Van Hée and another dozen by Lam.

In the earlier period, Sinologists (e.g. Biot), missionaries and Jesuits such as Wylie, Van Hée, Gauchet as well as mathematicians and historians of mathematics (e.g. Mikami, Smith) played an important role, and they were joined by various other personalities (e.g. Vissière -- Premier Interprète de la Légation de France en Chine and Correspondant du Ministère de l'Instruction Publique). The majority of researchers from the mid-1950s onwards specialised in the history of Chinese mathematics and / or other areas in Chinese science.[1] All of them were able to approach original Chinese sources with ease, although some were trained initially as mathematicians or in other branches in the sciences. Nevertheless, there were exceptions to this general pattern; for instance, Cammann and Reifler were Sinologists, and Vogel was primarily a historian of Western mathematics, as was Swetz.

4.8 FORMS OF PUBLICATION

Of the over a hundred and twenty titles addressed in the present chapter, eight appeared as individual monographs, a little over ten

[1] e.g. Wang, Ho, Lam, Libbrecht, Wagner, Cullen, Martzloff.

percent in collective works and conference proceedings, and the rest as articles in journals.

Except for Mikami's The Development of Mathematics in China and Japan the books were published between 1968 and 1981, with the ones by Hoe, Lam, and Swetz and Ang all in 1977: a mere coincidence, but also testifying to the fact that the mid-late 1970s was a robust period in the study of traditional Chinese mathematics.

Festschriften (e.g. Explorations in the History of Science and Technology in China, Symposium in honor of Dr. Li Chi on his Seventieth Birthday, Prismata: Naturwissenschaftsgeschichtliche Studien; Festschrift für Willy Hartner), conference proceedings (e.g. Sitzungsberichte der mathematisch-naturwissenschaftlichen Section in der 30. Versammlung deutscher Philologen und Schulmänner in Rostock, 1875, Scientific Japan, Past and Present; prepared in connection with the Third Pan-Pacific Science Congress, Tokyo, 1926, Actes du 8e Congrès International d'Histoire des Sciences, Florence / Milan, 1956), and the reference work Dictionary of Scientific Biography all assisted in publishing Western scholarship on historical aspects of Chinese mathematics.

A number of articles published before mid-20th century were featured in Chinese / Asian studies journals.[1] This type of journal appeared on several occasions in the 1960s and '70s (e.g. Oriens Extremus, Papers on Far Eastern History, Sinologica), but much less regularly than in the 19th and early 20th centuries. History of science journals were equally important channels, supplying almost thirty articles on traditional Chinese mathematics in the 20th century.[2]

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[1] Four out of five papers by Biot can be found in Journal Asiatique; T'oung Pao delivered ten articles, eight of them by Van Hée.

[2] e.g. Bollettino di Bibliografia e di Storia della Scienze Matematiche e Fisiche [Boncompagni's], Archivo di Storia della Scienza [later called Archeoin], Quellen und Studien zur Geschichte der Mathematik (B. Astronomie und Physik), Isis (six articles, two each in the 1920s, '40s, and '70s), Osiris, Historia Mathematica (eight studies between 1974 and 1985), Archive for History of Exact Sciences (four articles in the 1970s and '80s), Chinese Science (which published Wagner's study in 1978 and Cullen's in 1982), and Historia Scientiarum.

One should also mention mathematics journals. Over a dozen of them were involved, ranging from the Bulletin de la Société Mathematique [de France] (1880), Jahresbericht der Deutschen Mathematiker-Vereinigung (1911), American Mathematical Monthly (1920, 1926, 1933), Mathematische Nachrichten (1958), Mathematics Teacher (1964, 1972, 1977, 1978) to Mathematical Chronicle (1978).

The rest of the papers were scattered in several general science periodicals as well as other journals such as Bulletin de Géographie Historique et Descriptive and Past and Present.[1]

4.9 BIBLIOGRAPHIC PROVISION AND CONTROL

I. GENERAL BIBLIOGRAPHIES FOR CHINESE / ASIAN STUDIES AND THE HISTORY OF SCIENCE

(a) Henri Cordier, Bibliotheca Sinica. . . (1904-08); (1922-24):

Information on thirteen publications from the 19th century, another thirteen from the 1900s and 1910s, and one from 1921 is given under the divisions "Mathématiques pures" and "Souan-pan". Titles not listed are mainly those from non-Chinese / Asian studies periodicals.[2]

(b) John Lust, Index Sinicus. . . , 1920-55 (1964):

Its usefulness for articles on traditional Chinese mathematics is rather limited. Of the twenty titles published between 1920 and 1955 -- a period with relatively little activity in the field -- Lust recorded four works from Chinese / Asian studies periodicals, three from Isis, and one from Archivo di Storia della Scienza, chiefly in "b. Mathematics and Metrology" under "XVIII. Science and Technology".[3] With the exception of Wang's contribution to the 23rd International Congress of Orientalists, all the omitted titles appear in mathematics, science, or history of science journals.

(c) ISIS Cumulative Bibliography, 1913-65; 1966-75; 1976-85:

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[1]General science journals were mainly responsible for earlier studies; e.g. Revue des Questions Scientifiques (1913), Popular Science Monthly (1912), Scientific Monthly (1921, 1931).

[2]e.g. five works by Mattheissen, and four articles by Mikami.

[3]Van Hée's and Mikami's essays on the *Ch'ou jen chuan* are housed in sub-section "c. Astronomy and Calendar".

For Western works on traditional Chinese mathematics, much can be gained by first approaching this bibliographic aid. Under "B Mathematics" in the part for China or the Far East can be found all seven monographs, and most of the journal articles, including a number from Chinese / Asian studies periodicals.[1] Furthermore, eight works are recorded only in this general bibliography, some of which of considerable value.[2]

Excellent though ISIS's coverage is, a dozen or so articles from journals, conference proceedings and festschriften are missing, including those in the history of science area.[3]

(d) Bibliography of Asian Studies, 1936- :

This bibliography has performed rather poorly: out of the sixty or so studies issued after the index came into existence, only half of them were recorded. This may be due to the decrease in the number of accounts published in Chinese / Asian studies journals and festschriften after 1950. Indexed works include nearly all items in Chinese / Asian studies journals, eight articles in history of science periodicals, and six monographs.[4]

One piece of good news though: problem with subject retrieval here is less serious than that normally encountered when using the bibliography. Almost all mathematics titles are located appropri-

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[1]In addition, several works are given in the "Personalities" volume; e.g. three articles by Lam on Yang Hui.

[2]e.g. Van Hée's "Bibliotheca mathematica sinensis Pé-Fou" (1914 T'oung pao), Vogel's "Bericht über neuere, in westlichen Sprachen erschiene Arbeiten zur Mathematik der Chinesen" (1977 Prismata. . . Festschrift für Willy Hartner), Kogelschatz's Bibliographische Datem zum frühen mathematischen Schrifttum China im Umfeld der "Zehn mathematischen Klassiker" (1. Jh.v. Chr. bis 7. Jh.n. Chr.) (1981), Swetz and Ang's "A Brief Chronological and Bibliographic Guide to the History of Chinese Mathematics" (1984 Historia Mathematica).

[3]e.g. three papers presented at the International Congress of History of Science (1975, two in 1985), two contributions to the volume for Needham's eightieth birthday (1982), Van Hée's "Les séries en extrême-orient" (1930 Archeion).

[4]Only one work is from mathematics journal (i.e. Struik's article in the 1963 Mathematics Teacher).

ately under "Science, Technology, and Medicine".[1]

(e) Bulletin Signalétique, 1947- :

It supplies one with information on Chemla's "Les mathématiques anciennes retrouvées" (1985), Lam's "Some General Characteristics of Mathematics in Traditional China" (1985), Martzloff's "La Chine" (1985), Libbrecht's "Indeterminate Analysis: Historical Relations between China, India, Islam and Europe" (1974), and Chen's "On the Dating of the Oldest Extant Illustration of a Chinese Abacus" (1985) -- accounts that do not appear in other general bibliographic tool. The 1961 reprint of Mikami's book as well as the monographs by Libbrecht, Lam, and Hoe are also listed. But overall, only a third of the articles published since 1947 are indexed, culled chiefly from non-Chinese / Asian studies periodicals.

(f) Revue Bibliographique de Sinologie, 1955-70; 1983- :

With merely nine titles in the "Histoire des Sciences" section, this index can for the most part be laid aside. Nevertheless, it gives separate listings for Lam's and for Libbrecht's contributions to Explorations in the History of Science and Technology in China as well as Reifler's paper in the symposium in honour of Dr. Li Chi. Its annotations are also worth consulting.

(g) Tōyōgaku Bunken Ruimoku, 1963-:

As with the French bibliography above, this Japanese index has not functioned well, providing only a quarter of all titles from the years it covers, but it is the only source that lists -- in "IX Science - 3 Mathematics" -- Ho's article on Islamic and Chinese magic squares in the little-known Majallah Pantai from the University of Malaysia.

II. SPECIALISED BIBLIOGRAPHIC SOURCES

Bibliographic control of Western works in traditional Chinese mathematics has benefited from three special bibliographies. For works published before the 1950s, "Bibliography C: Books and journal articles in Western languages" in Science and Civilisation in China vol. 3 is indispensable; as is "Books and Articles in Western Languages" in Libbrecht's Chinese Mathematics in the Thirteenth Century:

[1]Note, however, that Wagner's "Doubts concerning the Attribution of Liu Hui's Commentary on the *Chiu-chang suan-shu*" is hidden under "Library and Information Science - Manuscripts".

A Study of the *Shu-Shu Chiu-Chang* of Ch'in Chiu-Shao. They must, nevertheless, be supported by bibliographies with more recent titles.

The third is Swetz and Ang's "A Brief Chronological and Bibliographic Guide to the History of Chinese Mathematics". Although it contains only five relevant articles from the 19th century, it offers a reasonably good -- but by no means comprehensive -- register of 20th century Western studies. Twenty of its entries are not found in ISIS, and twenty do not appear in Libbrecht's bibliography. Two further (relatively minor) points to note. First, Swetz and Ang's aid does not seem to be designed solely for "scholars and students without training in classical Chinese" or to "present a selection of introductory material available in Western languages on the history of Chinese mathematics."[1] The works chosen do not strike one as particularly "introductory" if "introductory material" is taken to mean material that seeks to appeal and aims at introducing the subject to those that have little exposure or familiarity with it.[2] And second, it lists studies that have little direct connection to Chinese mathematics.[3]

III. CONCLUSION

The need to consult different bibliographic compilations and the danger of depending on a single source still exists.[4] But all in all, traditional Chinese mathematics has been better served bibliographically than most other study areas in the history of Chinese

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[1]Swetz and Ang, "A Brief Chronology," 43.

[2]Consider, for example, Gauchet's "Note sur la généralisation de l'extraction de la racine carrée chez les anciens auteurs chinois et quelques problèmes du *Chiu chang suan shu*", Adamo's "La matematica nell'antica Cina", Wagner's "Doubts concerning the Attribution of Liu Hui's Commentary on the *Chiu-chang suan-shu*".

[3]e.g. E. Kosibowiez, "Un missionaire polonais oublié, le Père Jean Nicolas Smogulecki S. J., missionaire en Chine au XVIIe siècle", R. Wilhelm, 'Li Gi' das Buch der Sitte des älteren und jüngeren Dai.

[4]For example, Ho's essays on the five mathematicians in the Dictionary of Scientific Biography were noted by Swetz and Ang (as well as by Libbrecht and by Vogel in his "Bericht über neuere, in westlichen Sprachen erschiene Arbeiten zur Mathematik der Chinesen), but not by any general index. Moreover, there are works which can only be retrieved from one particular bibliography.

science. Subject access does not pose a challenge; several excellent bibliographic aids are available; and except for the two articles by di Stefano in Archimede; revista per gli insegnanti e i cultori matematiche pure e applicate (1977, 1980) all works have been noted by one source or another.

5 : ASTRONOMY

The corpus of 19th and 20th Western literature on traditional Chinese astronomy is vast.[1] The provision of a customised description for every title is therefore not always possible.

Due to fundamental differences between Chinese and Western astronomical traditions, which in turn influenced the way the former was studied and written about, the categorisation of titles in this chapter and the terminology used for section headings is based largely on that in the astronomy section of Science and Civilisation in China, and is markedly different from the arrangement found in the ISIS and Bulletin Signaletique 522 classification schemes.[2]

For many decades, opportunities offered by identifiable astronomical events (especially eclipses and planetary conjunctions) recorded in Chinese sources were eagerly seized upon by Western scholars as research subjects. They were convinced that these incidents would offer help in the accurate dating of the age of the records, which could then vastly improve our reconstruction of historically significant terrestrial events that supposedly happened contemporaneously. While some works on Chinese chronology are of particular interest or special use to historians of astronomy, readers are urged to bear in mind that most of them are not.[3] Similar reasoning

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[1]A glance at the 1913-1965 ISIS Cumulative Bibliography tells us that about one hundred titles in non-Asian languages are listed under "Astronomy" in the China section, second only to "Medicine" with around a hundred and thirty. "Mathematics", which also attracted considerable interest, has netted close to fifty items. The 1966-1975 cumulation gives roughly twenty-seven titles on astronomy, forty-five on medicine, and fifteen on mathematics. In the 1976-1985 cumulation, medicine has approximately forty-four titles, so does astronomy, and mathematics has thirty.

[2]Guidance was also sought from Christopher Cullen, "Joseph Needham on Chinese Astronomy," Past and Present, 87 (1980), 39-53, especially in adopting its heading "The pole, equator and *hsiu*".

[3]In other words, do not expect a discussion on all studies on dates of establishment of Chinese dynasties and their exact span.

applies to astrology.[1]

A word regarding the astronomical clock is also called for. Mechanisms and techniques used in mediaeval China for constructing astronomical clocks were fundamentally identical to those for mechanical clocks -- consider, for instance, the clock escapement and the clepsydra technique. However, works such as Heavenly Clockwork: The Great Astronomical Clocks of Medieval China; A Missing Link in Horological History (1960) by Needham, Wang Ling and Derek J. de Solla Price, and ground-breaking research carried out by John Combridge and André Wegener Sleeswyk on timekeepers and clockwork in the 1960s, '70s and '80s are not treated here. These studies deal principally with developments in mechanical and horological engineering; consideration is not routinely paid to astronomical concerns and knowledge, and themes are not explored primarily within the context of China's astronomical tradition. These publications are thus not taken first and foremost as expressions of overriding interests in traditional Chinese astronomical instruments, though they no doubt shed important light on the subject.[2]

Once again, here as in other chapters, literature that focuses on practices and skills that were closely linked to contacts with European visitors -- especially the Jesuit missionaries in the seventeenth century -- do not concern us.

5.1 GENERAL WORKS

To trace the pattern of 19th century Western inquiries into Chinese traditional astronomy, one can begin with five titles which cover various issues and aspects. Among these J. B. Biot's "Précis de l'histoire de l'astronomie chinoise" (1861) is the most substantial. Making frequent reference to Chinese treatises such as the *Chou pei suan ching* and the *Shu ching*, it addresses matters connected with the Chinese astronomical system from calendars, gnomons, to

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[1] And writings on astrology that fall directly within our boundaries often involve such a variety of astronomical activities that it is neither wise nor convenient to accord them a special category.

[2] Relevant titles are nevertheless listed in the Supplementary Bibliography.

eclipses. This study was incorporated into Biot's Études sur l'astronomie indienne et sur l'astronomie chinoise, which was considered by Needham as "a book still as important as those of Gaubil. . . much more systematic than any which had preceded it."[1] The Appendix on astronomy provided by John Chalmers (1865) in James Legge's time-honoured translation of the *Shu ching* outlines major topics in this branch of Chinese scientific knowledge; for instance, the calculation of shadows, the calendar, chronology, the determination of seasons and months, the division of the ecliptic, equinoxes, the sixty-year cycle, intercalary months, and the eclipse of the sun. While Chalmers was of the opinion that the Chinese borrowed their astronomical skills from the West and from the Hindus, L. P. E. A. Sédillot -- Secrétaire du Collége impérial de France et de l'École des langues orientales -- sought to convey a sense of Chinese achievements which he sketched briefly in an article for the 1868 Bollettino de Bibliografia e di Storia delle Scienze Matematiche e Fisiche.

These accounts from the 1860s were followed by several from the 1880s in China Review. In his "Babylonian Origin of Chinese Astronomy and Astrology" (1885), Joseph Edkins attempts to steer one's attention towards the emergence of "astrology and the doctrine of lucky and unlucky indications" in China as evidence of Babylonian influence, especially "the use of the five colours and the position held by Mercury in Chinese astrology."[2] He also argues that, "the double hour, the astrolobe, the dial, the intercalary month and the knowledge of the length of the year were all communicated from Babylon to China at different periods by land or by sea, between about B.C. 2200 and B.C. 820."[3] E. H. Parker's short notes were typical of jottings on a kaleidoscope of subjects featured regularly in China Review. The one from 1887 mentions the eclipse of the sun, armillery sphere, and predictions of planetary conjunctions; and that from 1890 highlights what the *Chin shu*, *T'ang shu*, etc. had to say on

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[1]Joseph Needham, and Wang Ling, Science and Civilisation in China. Vol. 3: Mathematics and the Sciences of the Heavens and the Earth (Cambridge: Cambridge UP, 1959), pp. 184.

[2]Joseph Edkins, "Babylonian Origin of Chinese Astronomy and Astrology," China Review, 14 (1885), 91, 93.

[3]Edkins, "Babylonian Origin," 91.

such topics as the three systems about the universe and calculating the median line.[1]

Of all Western scholarship on traditional Chinese astronomy published within the past two hundred years, Henri Maspero's "L'astronomie chinoise avant les Han" (1929) must be one of the most highly regarded.[2] It is an intensive investigation and analysis that pays rigorous attention to Chinese as well as Western sources, and leading themes in the study of traditional Chinese astronomy are expounded masterfully under the rubrics of: "L'astronomie au temps des Royames Combattants"; "L'equateur et l'ecliptique et leurs divisions"; "Le soleil et la lune"; "Les planètes"; "Les étoiles"; and "La forme générale du monde".[3]

The other general paper from the 1920s was an introductory account by L. Woitsch (1922) with pictures of astronomical instruments and "gods" of various planets.

The 1930s was distinguished by serious assessments from Wolfram Eberhard and Herbert Chatley. There was also a monograph by Anton Lübke. Filled with illustratrative matter (including music), Lübke's Der Himmel der Chinesen (1931) ventures to relate various facets of Chinese culture to astronomical understanding and undertakings.[4]

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[1]The journal also communicated some of his other statements on astronomy, but each of these pieces consists only of a single sentence.

[2]Nathan Sivin, for instance, commented that Chinese astronomy is "treated with great authority" in this work: Nathan Sivin, "Cosmos and Computation in Early Chinese Mathematical Astronomy," T'oung Pao, 55 (1969), 3.

[3]It is worth noting that Maspero opens his erudite discourse with the observation that, "l'astronomie chinoise a été souvent étudiée, depuis le temps où le l'ere Gaubil connaitre les grands traits de mon histoire. La période antique en particulier a été, l'objet de nombreux travaux: J.-B. Biot, Schlegel, L. de Saussure lui ont consacré de gros ouvrages, Chalmers un article bref, mais important": Henri Maspero, "L'astronomie chinoise avant les Han," T'oung Pao, 26 (1929), 267.

[4]The book is organised as follows: "1. Die Vorstellung des chinesen vom Kosmos"; "2. Das Yang- und Yin- Prinzips"; "3. Der chinesische Kalender und die Astrologie"; "4. Astronomische Feste in China"; "5. Chinesische Uhren und astronomische Instrumente"; "6. Glocken und Trommeln als Zeitkünder in China"; "7. Das astronomische Tiersymbol"; "8. Astronomische Farben- und Zahlenmystik"; "9. Die

Eberhard's "Neuere chinesische und japanische Arbeiten zur altchinesischen Astronomie" (1933) is an early Western account that emphasizes the value of Japanese scholarship. The first half of the article is divided into three parts: "System der Astronomie"; "Westöstliche Beziehungen"; and "Echtheitsfragen an Texten". The second part is concerned with the review and critique of studies and ideas put forward by Iijima Tadao and Shinjo Shinzō -- authorities on traditional Chinese astronomy from Japan. Eberhard also penned a short essay on elements in early Chinese astronomical and calendrical knowledge in the 1936 Naturwissenschaften.

As a further note to Arthur de Carle Sowerby's "Astronomy in Ancient China" (1934) which highlights chronologically the progress made by the Chinese, Chatley reminded readers of the 1935 China Journal of Science and Arts that by 1930, "the foreign literature on Chinese astronomy is fairly extensive, but is not always accurate", and described some of the Chinese experiences.[1] He elaborated his views in "Ancient Chinese astronomy" (1938) and "'The Heavenly Cover': A Study in Ancient Chinese Astronomy" (1938). Needham took heed of certain suggestions and computations articulated in the latter article when writing his Science and Civilisation in China vol. 3. But it was Chatley's paper in the 1939 Occasional Notes of the Royal Astronomical Society that was rated by Needham as one of two pieces of Western-language work that could supply "the most succinct information as to the best recent opinion on the problems of Chinese astronomy."[2] In this article, Chatley first supplies an overview of the state of the field over the past several decades (e.g. areas of Western interest, discovery of new sources), then moves on to portray the salient characteristics of the Chinese astronomical tradition, and ends with "a tentative summary" which "indicates the probable stages of development down to A.D. 350 according

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Astronomie in der chinesischen Architektur"; "10. Astronomie und chinesische Schrift"; "11. Astronomie und chinesische musik".

[1]Herbert Chatley, "Further Notes on Ancient Chinese Astronomy," China Journal of Science and Arts, 22 (1935), 6.

[2]Science and Civilisation in China, vol. 3, pp. 182.

to modern critical opinion."[1]

The period between 1940 and 1958 witnessed a concern for the role played by astrology and astronomy in government and politics in early and mediaeval China, especially with regard to the concept of the Emperor's legitimacy to rule. By placing a 12th century star chart from Su-chou within the context of the chief functions of astronomical activities, W. Carl Rufus (1945) claimed that the chart was "idealised" and meant to serve "a practical political purpose."[2] Such idealisation, according to Rufus, might explain why "effort. . . made [by Laplace, Gaubil, Biot, Schlegel, John Williams, Chavannes, and Chatley] to identify not merely each asterism but also every star. . . is an impossibility and has led to much confusion and many contradictions ~~contraditions~~."[3] The *Ch'ien Han shu*, in Bielenstein's words, "records a great number of protents such as: Solar eclipses, comets, meteors, strange stars by day or night. . . winter without ice, the unreasonable behaviour of plants, monstrosities among animals or people, fires, etc."[4] His study in the 1950 *Bulletin of the Museum of Far Eastern Antiquities* analyses the nature of these records in order to reveal the correlation between portents and criticisms of the Emperors. Eberhard's "The Political Function of Astronomy and Astronomers in Han China" (1957) also dwells on the subject of portents, but this essay carries a broader scope than that in Bielenstein's paper, with the author entering into a discussion on: "1. The question of despotism and its limitations in ancient China"; "2. The data concerning natural phenomena"; "3. The political character of the calendar"; "4. Factors militating against a developing of sci-

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[1]Herbert Chatley, "Ancient Chinese Astronomy," *Occasional Notes of the Royal Astronomical Society*, 5 (1939), 71.

[2]W. Carl Rufus, "A Political Star Chart of the Twelfth Century," *Journal of the Royal Astronomical Society of Canada*, 39 (1945), 41.

[3]ibid.

[4]Hans Bielenstein, "An Interpretation of the Portents in the *Ts'ien-Han-shu*," *Bulletin of the Museum of Far Eastern Antiquities*, 22 (1950), 127.

ence"; "5. The domination of political interest."[1] A German version of this paper, which bears the title "Die politische Funktion der Astronomie und der Astronomen in der Han-Zeit" (1970), can be found in his Sternkunde und Weltbild im alten China.

Two other items of a general nature were produced in the 1940s and '50s. Eberhard's "Index zu den Arbeiten über Astronomie, Astrologie und Elementenlehre" (1942) is a straightforward index of terms, concepts, persons, and texts related to astronomy contained in ten of his studies. Chatley's short article "The Chinese Astronomy of *Huai-Nan-tzu*" (1952) summarises -- under the headings of "Jupiter"; "Mars"; "Saturn"; "Venus"; "Mercury"; "Soli-Lunar Period"; "Moon" -- book (or chapter) three of the *Huai nan tzu*, a work that holds some of the most important clues to the appreciation of Han and early Chinese views of the universe.

Section 20 "Astronomy" in Science and Civilisation in China vol. 3 (1959) -- although published over 30 years ago -- is still the most comprehensive general work available, and its index and bibliographies still offer an invaluable assistance not found elsewhere. The 290 pages of text are divided into eleven sub-sections, some with further divisions.[2] "Introduction" and "Bibliographical Notes" call for more than a passing mention for they are particularly relevant to the present study. Located in "Introduction" is a historiographical review of 18th, 19th and early 20th century European writings on Chinese astronomy, with comments on their value, the validity of their conclusions as well as possible reasons for and significance behind this European interest. The overview of Western studies under

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[1]Eberhard concludes that, "the function of astronomy, astrology, and meteorology, as defined in these chapters, was purely political: on the basis of a vague belief that there was a connection between abnormal natural phenomena and social life, there grew up a practice of utilizing this belief as a tool in the political struggle": Wolfram Eberhard, "The Political Function of Astronomy and Astronomers in Han China," in Chinese Thought and Institutions, ed. J. K. Fairbank (Chicago: U of Chicago P, 1957), pp. 70.

[2](a) Introduction; (b) Definitions; (c) Bibliographical notes; (d) Ancient and mediaeval cosmological ideas; (e) The polar and equatorial character of Chinese astronomy; (f) The naming, cataloguing and mapping of stars; (g) The development of astronomical instruments; (h) Calendrical and planetary astronomy; (i) Records of celestial phenomena; (j) The time of the Jesuits; (k) Summary.

"Bibliographical Notes" is also carried out along these lines.[1] But here we are shown what is essentially Needham's own list of recommended titles.[2] Chinese and Japanese secondary literature are considered under "Bibliographical Notes" as well, but much briefer than that given to Western materials, with only one page devoted to Chinese works and half a page to Japanese studies.[3] The rest of this sub-section on bibliographical matters deals at length with "The principal Chinese sources".[4] The Science and Civilisation in China volumes are so richly grounded in primary documents and hitherto untapped sources, and so filled with original insights and interpretations that one frequently fails to realise that at times Needham and his collaborators preferred to take advantage of secondary works and findings of other scholars. In the case of astronomy, this dependence on the research of others (e.g. that of Tung Tso-pin and Henri Michel) has been the subject of critical remarks.[5] But perhaps

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[1]Readers may at first be a little confused by these two subsections as they cover more or less the same ground.

[2]These titles give a clue as to the sources Needham trusted and the views he favoured. Besides, one is always curious as to the literature Needham would recommend.

[3]Research on traditional Chinese astronomy by Japanese scholars already assumed great sophistication even in the first half of the 20th century. Ho Peng Yoke has delineated the development of the "Historians school" and "Astronomers school" in some detail in his Modern Scholarship on the History of Chinese Astronomy, and Christopher Cullen lamented that "parts of Needham's writing on astronomy are based on European secondary literature, and important Japanese scholarship is left to one side. . .": Cullen, "Joseph Needham," 40.

[4]It is divided into: "The 'official' character of Chinese astronomy"; "Ancient calendars"; "Astronomical writings from the Chou to the Liang (+6th century)"; "Astronomical writings from the Liang to the beginning of the Sung (+10th century)"; "Sung, Yuan and Ming".

[5]For example: (1) "He [i.e. Needham] is convinced of a much greater age of Chinese astronomy than Maspero, de Saussure, and others accepted, and Needham bases his opinion mainly upon the interpretations of An-yang bone inscriptions made by Tung Tso-pin and, partly, by Liu Ch'ao-yang. . . . Tung's interpretations, as far as I have checked them, are based upon a great number of individual assumptions": **W. Eberhard**, rev. of Science and Civilisation in China, vol. 3 by Joseph Needham and Wang Ling, in Journal of Asian Studies, 19 (1959/60), 66. (2) "He [i.e. Needham] accepts Tung Tso-pin's conclusions concerning China in the second millennium B.C. without realizing that this very eminent paleographer is quite naive regar-

paradoxically, these efforts at synthesis, performed expertly by Needham, help account for some of the work's unique and enduring strength.

Differences in foci, points of departure, goals and intentions have created substantial variations in general works from the 1960s, '70s, and '80s in terms of sophistication as well as contents. They ranged from brief and compact sketches to an authoritative translation and critique of the astronomical chapters in the *Chin shu*.

In a lecture delivered in 1962, Needham stressed the basic distinctions between the aims and purposes entertained by the Chinese and Western astronomical systems in order to drive home his point that there were good reasons for the special endeavours and directions taken by the Chinese.[1]

Among the few major monograph-length studies from the second half of the 20th century that enhanced dramatically our knowledge of the history of Chinese astronomy was Ho Peng Yoke's The Astronomical Chapters of the *Chin Shu*; with Amendments, Full Translation and

ding astronomy and calendrical science, so that his reconstruction of the Yin calendar and dates is based on erroneous assumptions. Not even an encyclopaedist can examine in detail each original document. Here the author appears to have depended upon unduly nationalistic Chinese advisers": **H. H. Dubs**, rev. of Science and Civilisation in China, vol. 3 by Joseph Needham and Wang Ling, in Endeavour 19 (1960), 118. **(3)** "The section on astronomy. . . although typically perceptive, is primarily a survey of earlier research, and is more superficial than other parts of the book": **Nathan Sivin**, rev. of Sternkunde und Weltbild im alten China: Gesammelte Aufsätze by Wolfram Eberhard, in Journal of the History of Astronomy, 8 (1977), 59. **(4)** "In. . . the alleged jade circumpolar constellation template (*hsüan chi*) with its sighting-tube (*yü heng*), Needham has been misled by his reliance on the work of H. Michel. A check of Michel's apparently conclusive documentation against the original texts reveals that the entire conception of these instruments is bogus": **Cullen**, "Joseph Needham," 42.

[1]For instance, "from the Chinese polar-equatorial emphasis two great instrumental consequences flowed, the invention of the equatorial mounting of sighting tubes and telescopes, and the invention of the clock-drive and the mechanical clock": Joseph Needham, "Astronomy in Classical China," Quarterly Journal of the Royal Astronomical Society, 3 (1962), 94.

Annotations.[1] Originally a doctoral thesis, it was revised for publication in 1966. Ho first untangles adroitly such key issues as textual concerns, the prevailing scientific setting, and technical terms in an introductory chapter. The perceptive translation is supported by illustrations and a detailed bibliography which includes "Primary sources", "Dictionaries and atlases", and "Modern books and journals".

Ho was also responsible for one of two studies directed expressly towards the structure and organisation of the Astronomical Bureau. In an article in the 1969 Journal of Asian History he gives a succinct survey of this imperial institution in early and late Ming: its functions, tasks, instruments, accomplishments, and how it was affected by the arrival of the Jesuits.

Sivin's "Cosmos and Computation in Early Chinese Mathematical Astronomy" (1969) is exceptional in its objectives, in its content as well as its research methods. Moreover, though its title may seem to indicate a limited focus, the inquiry in fact is cast in a relatively broad mould and delivers unique perspectives on several intertwining themes and problems central to the study of Chinese astronomy. Among the issues it dissects and illuminates is the rationale behind early computation techniques, calendrical treatises, eclipse predictions, cosmological knowledge, and the astronomical system's

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[1]In one reviewer's opinion, "la publication de ce texte, assortie de tout l'appareil critique désirable, a permis de résoudre nombre de questions relatives aux connaissances et aux opinions sur l'astronomie et l'astrologie en Chine médiévale": Viviane Alleton, "L'astronomie dans la Chine ancienne," Annales: Economies, Sociétés, Civilisations, 28 (1973), 470. And Sivin's annotation for this title reads as follows: "This is a definitive translation of the Astrological Treatise (*T'ien wen chih*), which provides abundant data on positional astronomy and the astrological interpretation of observational data -- not on mathematical astronomy, which is discussed in the Treatise on Harmonics and the Calendar (*Lü li chih*). Ho supplements this first translation of its kind with full explanatory notes and valuable introductory remarks on historiography and observatory practice": Nathan Sivin, "An Introductory Bibliography of Traditional Chinese Science: Books and Articles in Western Languages," in Chinese Science: Explorations of an Ancient Tradition, ed. Nakayama Shigeru, and Nathan Sivin (Cambridge, Mass.: MIT P, 1973), pp. 297-98.

official character.[1] The work is organised into: "Form and content"; "The meaning of the Chinese eclipse cycle"; "How crises might have been averted"; "The demise of the cosmos". It is supplemented by three Appendixes (e.g. "Shen Kua (1031-1095) on planetary motions"), eleven Tables (e.g. "Comparison of calendrical constants", "A series of lunar eclipse predictions by the triple concordance technique", "Centrality and visibility of all eclipses in a saros series"), and nine Figures (e.g. "Movement of the lunar nodes", "Use of a cycle to predict all eclipses").

Ho's and Sivin's treatises are excellent examples of the meticulous, critical, and informed treatment some workers on Chinese traditional astronomy brought into the arena in the latter half of the 20th century.

Except for the book by Ho, an article by Eberhard, and an essay by Vincenzo Chessa, no other general study constructed chiefly from a single Chinese text and which sought mainly to shed light on it was published in the post-1950 period. Eberhard (1970) translated and commented on two passages on astronomical matters in the third century B.C. work *Shen tzu* in 1936, but this did not appear in print until 1970 in his essay collection Sternkunde und Weltbild im alten China: Gesammelte Aufsätze. Chapters three and five of the *Huai nan*

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[1]The study begins with the suggestion that, "a careful consideration of the Han astronomers' mathematical procedures can indicate the presence of grave contradictions between their assumptions about the necessary character of the celestial motions on the one hand, and the necessity for accurate predictions on the other": Nathan Sivin, "Cosmos and Computation in Early Chinese Mathematical Astronomy," T'oung Pao, 55 (1969), 4.

And it ends with the following proposition: "With the aid of hindsight, we might propose that the Chinese had formulated their classic conception of the universe as a congeries of cyclical time relationships on the basis of too primitive a model. The assumption of simple cyclical behavior could not have survived for long. In the Han it was maintained because it made mathematical astronomy possible, but at the cost of compromising the integrity of the system. When this cost became intolerable, the assumption was discarded. It was never replaced by new assumptions more conformable to the complexity of celestial motions, for by the time of its rejection the technical tasks of astronomy could be carried out without such assumptions. Later Chinese calendrical science was marked by an indifference toward cosmology -- but this was the indifference of the disenchanted, not that of the inexperienced": Sivin, Cosmos and Computation, pp. 67.

tzu were chosen by Chessa (1979) in his inquiry.[1] Chessa's labour yielded a detailed and rigorous study and translation of these two chapters into Italian, interspersed with commentaries and analysis.

In 1970 sixteen articles by Eberhard on Chinese astronomy (almost all of which originally published between 1932 and 1942) were collected into a single monograph titled Sternkunde und Weltbild im alten China: Gesammelte Aufsätze. It contains all his major works on the subject, and serves to furnish easy access to essays that deal with aspects rarely treated elsewhere or to articles that might be difficult to locate. It was also sensible of the publishers to have included the subject index to Eberhard's astronomy publications. In reviewing the book some years later, Sivin pointed out the merits and weaknesses of these essays as well as Eberhard's overall contribution to the field.[2]

1974 saw the arrival of two accounts that could not have been more dissimilar. On the one hand was Needham's (1974) paper for a symposium on astronomy in the ancient world organised by the Royal

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[1]In Needham's words: Chapter three, "concerned wholly with gnonoms and their shadows, is distinctly obscure, and no satisfactory interpretation has yet been made. It seems inescapably to point, however, to a theory on which the sun at the the meridian is five times further away from the earth than at its rising and setting, which would at least involve a very elliptical cover or shell": Science and Civilisation in China, vol. 3, pp. 224. Chapter five "gives social-ceremonial directions for the months, enumerating them according to the point indicated by the star *Chao yao* (Twinking indicator). . . . As *Chao yao* is probably to be identified with γ Bootis, a star which must have left the area of perpetual visibility about - 1500, it can be seen that this text seems to report a very ancient tradition": Science and Civilisation in China, vol. 3, pp. 250.

[2]For instance: "The strength of his work is philological rather than in the exact sciences. . . . Two problems arise fairly often. Eberhard's notion of ancient science is severely positivistic. . . . A second problem, . . . a tendency to ask either-or questions and to draw highly arbitrary distinctions instead of trying to understand the interplay of all the dimensions. . . . Eberhard was the first scholar of Chinese history to convey to a considerable readership that reconstructing instrumental techniques and computational processes is only a small aspect of rediscovering the astronomical past. In this respect as in many others, his work is still as useful as when it was written": Sivin, rev. of Sternkunde und Weltbild. . . by Wolfram Eberhard, in Journal of the History of Astronomy, 8 (1977), pp. 60.

Society and the British Academy.[1] In it, he again underscores two essential differences between Chinese and Western astronomy, three leading Chinese cosmological ideas, and early advances China made in astronomical instrumentation. At the other end of the spectrum was Daniel J. Hoffheimer's "Science and Symbolism in Chinese Astronomy" (1974), castigated by Sivin as a piece of "tendentious and uncritical synthesis of secondary sources in English and French, which finds the idea of scientific progress 'obsolete' and suggests that 'the objective paradigms of physical reality are rather meaningless outside the social context'."[2]

One of the few Western researchers from the third quarter of the 20th century who surveyed the history of Chinese astronomy from a fresh vantage point was Yasukatsu Maeyama. He did so by tackling a fundamental issue that has been at the periphery of most historians' concern. His contributions sought specifically to scrutinise quantitatively observational data in primary Chinese documentary sources as well as those stated in Western, Chinese and Japanese secondary works. The results were then used to gauge past Chinese astronomical activities and progress. The first was a short paper for the 14th International Congress of the History of Science (1975) in which findings were summarised without supporting statistics and documentation. The second, "On the Astronomical Data of Ancient China (ca. -100 -- +200): A Numerical Analysis" (1975) is an elaborate and ambitious analysis complete with all the attending tables, charts, calculations etc. as well as bibliographic references to Chinese records and Western literature.[3] This thorough investigation is broken

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[1]Incidentally, this was Needham's only study dedicated solely to astronomical concerns from the 1970s and '80s, a period better known for his writings on alchemy and medicine.

[2]N. Sivin, annotation for "Science and Symbolism in Chinese Astronomy" by Daniel J. Hoffheimer, in <u>ISIS Cumulative Bibliography 1976-1985</u>, vol. 2, pp. 250. But perhaps one should take into consideration the fact that the article appeared in an undergraduate journal for the history of science.

[3]Readers are informed that, "in the historical development of Chinese astronomy a certain discontinuity is noticeable at the transition between the Earlier (-202 -- +9) and the Later (+25 -- 220) Han periods. The historical records bear witness to a remark-

down into seven chapters: "1. Definitions of technical terms and fundamental computing methods"; "2. Equatorial extensions of 28 lunar mansions (*hsiu*)"; "3. Ecliptic extensions of 28 lunar mansions (*hsiu*)"; "4. 24 fortnightly periods (*chhi*) and solar positions"; "5. Polar distances of the ecliptic (sun) and shadow lengths"; "6. Day and night lengths"; "7. Culminating stars at dawn and dusk".

The monthly magazine Sterne und Weltraum; Zeitschrift ~~fuer~~ für Astronomie carried in 1976 a two-page notice by Michael Seler titled "Neue Entdeckungen der chinesischen Archäo-Astronomie". [I have not seen this title].

"Further Comments on the Use of Statistics in the Study of the Han Dynasty Portents" (1977) is also on computation matters. Challenging an article by R. R. Newton that questions Bielenstein's study of Han portents from 1950, Bielenstein and Sivin contended that, "Dr. Newton's sweeping condemnation of the particular methodology of the essay does not stand up, although we quite agree that the danger of false correlations is fascinating in the abstract."[1]

Sivin's "History of Astronomy" (1979) pursues a very different track.[2] After shrewdly articulating the rationale behind research

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able difference between the two Han periods, concerning above all the numerical data, their quantity and their accuracy. . . . Numerical data are deduced either from theory or from observation. The former are computed and therefore easily reproducible, while the latter somehow or other reflect the prevailing theories because, in general, observation, at least if systematic, is not made without some bearing on theory. This indicates that observation and its relationship to theory must throw light on the actual scientific status of astronomy at the time concerned. . . . When Willy Hartner suggested the analysis of a series of astronomical data of the *Hou Han Shu*. . . , I began with the above considerations, as these data have been interpreted only in terms of the then prevalent theories, in a qualitative instead of a quantitative manner. The main concern of the present paper therefore was an independent numerical analysis, and the following results were obtained from a reconstruction of the given numerical data": Yasukatsu Maeyama, "On the Astronomical Data of Ancient China (ca. -100 -- +200): A Numerical Analysis," Archives Internationales d'Histoire des Sciences, 25 (1975), 247-48.

[1]Hans Bielenstein, and Nathan Sivin, "Further Comments on the Use of Statistics in the Study of Han Dynasty Portents," Journal of the American Oriental Society, 97 (1977), 187.

[2]It is part of the 1977 report of the visit of an American delegation of astronomers to China submitted to the Committee on Scholarly Communications with the People's Republic of China.

efforts made in the field of traditional astronomy in present-day China, Sivin outlines succinctly the history of Chinese astronomy, its characteristics, evolution, and interaction with astronomical systems of other cultures, thus providing an immensely helpful orientation to scientists, astronomers and historians intrigued by, but not familiar with, the subject.

General readers of the 1979 Hemisphere were given an opportunity to acquaint themselves with the subject of traditional Chinese astronomy. Ho alerted them to such issues as the purposes and features of ancient and mediaeval Chinese astronomy (e.g. the importance of calendar-making and astrology), the preservation of Chinese astronomical records, the value of these records and the application of them in recent decades to the study of such phenomena as pulsars, supernovae, and sunspots.

We must now turn to works from the first half of the 1980s: three from 1980 and two from 1985.

Although F. R. Stephenson's "Chinese Roots of Modern Astronomy" (1980) was written for a journal with a readership very different from that of Hemisphere, Stephenson, like Ho, had the general audience in mind. This brief overview in the weekly magazine New Scientist gives a non-technical introduction to the special functions of and advances made by Chinese astronomers in historic times, especially their observations of supernovae, sunspots, solar eclipses, etc.

Continuing the story of the Astronomical Bureau from where Ho had left it, Jonathan Porter (1980) carried it down to the Ch'ing. In tracing the history of the Bureau's organisation and its personnel, Porter's goal extended further than that of documenting the work performed and the people responsible for them. He was above all, interested in learning about "the bureaucratic organisation of scientific activity and its implications for the development of science" during this period.[1]

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[1]Jonathan Porter, "Bureaucracy and Science in Early Modern China: The Imperial Astronomical Bureau in the Ch'ing Period," Journal of Oriental Studies, 18 (1980), 61. In addition to the main text (divided into "The milieu"; "The organization of scientific activity"; "The political implications of science") there are four tables: "Organization of the Imperial Astronomical Bureau (ca.

To provide some needed perspectives on the relative weight and merits of Science and Civilisation in China's astronomy section twenty years after its publication, Christopher Cullen participated in a symposium on the work of Needham sponsored by Past and Present in 1980 and drew attention to certain materials used by Needham and the conclusions he reached. Cullen favoured the adoption of a more critical approach when consulting this section of Science and Civilisation in China and offered supplementary references and alternative interpretations. The review also served as a forceful reminder of previous research activities and what remained to be done in the area of Chinese traditional astronomy.

Concluding this section on general studies is a publication that entertains a set of rather unusual themes and investigative strategies. Uranologie chinoise (1985) aspires to viewing and treating various elements in Chinese astronomy through a multi-disciplinary approach, combining for instance palaeographical, archaeological and astronomical methods. The author Jacques A. Lavier -- Chargé de Cours de Paléographie Chinoise à l'Université Paul-Valéry de Montpellier -- also advocated the application of what one learns in studying the Chinese astronomical tradition to help appreciate other branches of Chinese science, especially traditional Chinese medicine.[1]

5.2. COSMOLOGY

Only those studies on cosmology that bear directly on the traditional Chinese astronomical system or have special astronomical interest are treated here.[2]

1900)"; "Organization of the Imperial Astronomical Bureau (ca. 1644)"; "Directors of the Imperial Astronomical Bureau"; "Careers of selected functionaries of the Imperial Astronomical Bureau".

[1]The book contains five chapters and forty-six sub-sections: "Chap. I. La Science du Ciel"; "Chap. II. L'observation du soleil"; "Chap. III. Les repères sidéraux"; "Chap. IV. Le ciel planétaire"; "Chap. V. Quelques thèmes de recherche".

[2]Hence John B. Henderson, The Development and Decline of Chinese Cosmology and Needham's "The Cosmology of Early China", for instance, are excluded. So are essays in Explorations in Early Chinese Cosmology; Papers presented at the Workshop on Classical Chinese Thought held at Harvard University, August 1976. (One of its papers, John S.

19th century scholars did not seem to be particularly attracted to theories and ideas the Chinese had expressed concerning the universe -- a forbidding topic in the study of past Chinese astronomical understanding. Edkins did publish a short article in the 1887/88 China Review claiming that, "the opinion that the earth is a sphere suspended in space being found both in Plato's Timaeus, B.C. 380, and in the Chinese Su wen, a work of about the same age, is a proof that the Chinese received the doctrine from the west."[1]

But one really should start with a handful of articles by Léopold de Saussure from the 1920s and by Wolfram Eberhard from the 1930s. In a paper for the 1921 Revue Générale des Sciences Pures et Appliquées, de Saussure characterises the Chinese cosmological system in terms of "I. La région centrale et les quatre régions périphériques"; "II. Le dualisme du yin et du yang"; "III. Le système binoquinaire"; "IV. L'année tropique, type de la révolution dualistique"; "V. Le calendrier"; "VI. La théorie des cinq éléments"; "VII. Les erreurs de la critique". He also addressed specific issues in several articles (1922a) (1922b) (1923), in particular the significant role played by the *yin yang* theory and the concept's similarity to elements in Iranian systems.

Eberhard's "Beiträge zur kosmologischen Spekulation Chinas in der Han-Zeit" (1933) is a substantial and in-depth discourse that employs copious primary material and painstaking categorisation.[2]

Major's "The Five Phases, Magic Squares, and Schematic Cosmography" is discussed in the chapter on earth sciences.)

[1]Joseph Edkins, "The Earth a Sphere," China Review, 16 (1887/-88), 119.

[2]This hundred-page article is divided into five sections. **"Einleitung"** is sub-divided into "1. Kapitel: Grundlagen des kosmischen Weltbildes der Chinesen und der kosmologischen Spekulation der Han-Zeit"; "2. Kapitel: Material, Umfang und Ziele der Untersuchung". **"I. Teil: Das Wu-hsing chih des Han shu, seine Bedeutung und sein Inhalt"** is sub-divided into "1. Kapitel: Disposition, Quellen und Geschichte des Textes des Wu-hsing-chih"; "2. u. 3. Kapitel: Der theoretische Teil des Textes des Wu-hsing chih, sowie Abschnitte des praktischen Teils des Wu-hsing chih in Übersetzung"; "4. Kapitel: Bemerkungen zum weltanschaulichen Inhalt des Wu-hsing chih". **"II. Teil: Zur Systematik und zum inneren Aufbau der Elementenlehre"** -- this takes up almost half of the article -- sub-divided into "1. Kapitel: Die Reihenfolge der Elemente"; "2. Kapitel: Die Elementengleichungen". **"III. Teil: Die Sonnenfinsternistabelle des**

Whether one agrees with Eberhard's findings or not, this study devoted to cosmological models and concepts in Han times -- a period "of intense speculation in cosmology and astronomy" -- is of historiographical interest for this theme occupied a key position in Western research on Chinese cosmology in the third quarter of this century.[1] Additionally, in a short paper in the 1936 Sinica, Eberhard proposes that sorting out and establishing the date for the commencement of the beginning of the Chou dynasty astronomically can be instructive in understanding Han cosmology and thought.

The next period of serious activities did not begin until three decades later in the late 1960s.

Recognising the value of looking into pre-Han contributions, Jordan D. Paper published an article (1974) which "is an analysis of the components that led to Tsou Yen's theories; it is an attempt to trace as far back into history as presently possible the development of the major Chinese cosmological concepts."[2] In "Note sulla teoria dei <Quattro movimenti> della terra in Cina e in Occidente" (1976) Alessandro Bausani sketches and compares the main schools and theories of cosmological thinking influential in early China (e.g. the *kai t'ien*, *hun t'ien*) with European ideas, and searches for possible transmissions from East to West. And teasing out for close examination "a short passage found at the end of the third chapter" of the *Huai nan tzu*, Cullen contends in his 1976 article that "this passage is probably not part of the original *Huai Nan tzu* text"; more importantly, he underscores its uniqueness in Chinese astronomy and ideas of the universe.[3]

Han shu" is sub-divided into "1. Kapitel: Astronomische Ergebnisse; ihre Beziehungen zur kosmologischen Spekulation und zur Elementenlehre"; "2. Kapitel: Texthistorische und kalendarische Ergebnisse; Liu Hsin's Datenkorrektion"; "3. Kapitel" Bedeutung der Ergebnisse". "Anhang: Literaturverzeichnis; Umschreibung; Verzeichnis der Abkürzungen".

[1] Science and Civilisation in China, vol. 3, pp. 210.

[2] Jordan D. Paper, "The Early Development of Chinese Cosmology," Chinese Culture, 15.2 (1974), 15.

[3] Christopher Cullen, "A Chinese Eratosthenes of the Flat Earth: a Study of a Fragment of Cosmology in *Huai Nan Tzu*," Bulletin of the School of Oriental and African Studies, 39 (1976), 106. In Cullen's

Certain ancient specimens of the *shih* were discovered in archaeological sites in the 1970s, prompting efforts in the late 1970s and early '80s to explore its significance, especially in terms of its association with the shaping and interplay of cosmological, divinatory, and astrological ideas and practices in early China. Among those who have written on the *shih* were Donald J. Harper, Cullen, and Marc Kalinowski. Though apparently stimulated by the same category of objects, their views and accounts have little in common. The second (1981) of a pair of essays by Harper is aimed primarily at discrediting points made by Cullen (1981) who adopted a line of treatment that was very different from that taken in Harper's first essay (1979). The disagreement ranged from the translation of *shih* -- "cosmic board" said Harper, and "cosmic model" said Cullen -- interpretations of passages, basic premises, to Harper's blanket condemnation of Cullen's scholarship and research tactics.[1]

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opinion, "the text consists largely of a probably hypothetical attempt to find the dimensions of the world by large-scale geometry using the gnomon, or simple vertical pole, which was the basic instrument of ancient Chinese astronomy and surveying. This is nothing unusual in the literature of the pre-T'ang cosmological debate. The unique feature of this author, however, is that the main method he proposes is based on a geometrical principle which is simple and accurate, needing none of the false but traditional assumptions used elsewhere. Despite his early date, his work is never referred to again by other astronomers, nor do they use any similar method": ibid.

[1]To take one example: in his article, Cullen, seeks to "raise a few points on the relation of the shih to the development of Chinese astronomy. Further, it is possible that the shih may provide the key to an ancient problem of classical scholarship": Christopher Cullen, "Some Further Points on the *shih*." Early China, 6 (1980/81), 31. The "problem" in question is the interpretation of certain words from the *Yao tien* chapter which, in a "free rendering", is as follows: "(Shun) attended to the rotating (divination) device, and the Dipper (marked on it), so as to set in order the seven (concerns) of government": Cullen, "Some Further Points," 40.

Among the criticisms Harper flung at this particular issue of the *Yao tien* words and how they relate to the *shih* is the following: "In the case of the "Yao Tien" passage, Shun's examination of the hsüan chi yü heng is meant to signify the initiation of a new reign by a ritual act which aligns the new monarch with the model of heaven. . . . An adjustment in the calendar for ritual purposes is probably involved as well. For Cullen to suppose that the compilers of the "Yao Tien" had a specific object in mind by the term hsüan chi yü heng is quite reasonable. However for him to attempt to identify the object being denoted simply by juxtaposing this term with the

Judging from the content of his hundred-page exposition from 1983, Kalinowski did not seem to have an axe to grind (though he referred to Cullen and Harper's papers on several occasions). Instead his paper focuses on the effective conveyance and critical examination of the distinctive connection between developments of a particular type of *shih* and certain cosmological concepts.[1] Kalinowski's handling of the subject matter is both chronological and thematic, with the main bulk of his study devoted to delineating and discussing whatever was known as well as the significance of these *shih* (or "tables de divination" as he called them), followed by an explication of the method of divination called *liu jen* which employed the *shih*, all accomplished with the aid of thirty figures and tables.[2]

By turning to the intriguing subject of mediaeval Taoist cosmology, by concentrating on the grand aurora as a specimen, and by drawing from the rich mines that lay deep in the Taoist Canon and Taoist poetry, Edward H. Schafer's "The Grand Aurora" (1983) exemplifies the kind of research he excels at -- one that transcends conventional routes and interpretations. To Schafer, then, "Taoist cosmology was not abstract, geometrical, or rational. It was concrete, qualitative and sensible. It was indifferent to measurement and

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cosmic board, while at the same time ignoring the rich literary and material evidence which sheds light on the concepts associated with the type of cosmological model represented on the cosmic board, is solipsistic scholarship": Donald J. Harper, "The Han Cosmic Board: A Response to Christopher Cullen," <u>Early China</u>, 6 (1980/81), 51.

[1]Those *shih* specimens which served as the tool and means of his investigation "sont pour plus de la moitié issus des fouilles entreprises depuis le début du siècle sur des sites funéraires allant de ce qui est aujourd'hui la Corée pour s'étendre jusqu'aux provinces de la Chine centrale": Marc Kalinowski, "Les instruments astro-calendriques des Han et la methode *liu ren*," <u>Bulletin de l'École Française d'Extrême-Orient</u>, 72 (1983), 309-10.

[2]Kalinowski, "Les instruments astro-calendriques," 310. "Première partie: les tables de divination *liu ren*" separates into: "A. Présentation générale"; "B. Les tables de divination existantes (subdivided into: "I. Le *shi* des Han antérieurs", "II. Le *shi* des Han postérieurs", "III. Les fragments des Han", "IV. Le *shi* des Six Dynasties, "V. Les quatre Coins"). "Deuxième partie: La méthode *liu ren*" separates into: "I. Fonctionnement de la méthode"; "II. Des origines aux premiers manuels"; "III. Des Song jusqu'aux temps modernes".

computation. All descriptions of it were profoundly dependent upon analogy, similarity and metaphor. The operations, both ritual and meditative, based upon these descriptions were ultimately an expression of the great Principle of Correspondence, basic to Chinese metaphysics."[1]

5.3 POLE, EQUATOR AND *HSIU*; STAR NAMES AND CATALOGUES; CALENDRICAL AND PLANETARY ASTRONOMY

One major problem in the study of the history of Chinese astronomy that had long fascinated 19th and early 20th century Western researchers and which had stirred up quite a storm was the origin and function of the *hsiu* -- which are "28 unequal divisions, . . . the determinative stars of which lay near the equator but were keyed to bright stars of the same right ascension in the vicinity of the celestial pole."[2] Interest in this element which lies at the heart of Chinese traditional astronomy in turn led to a vigorous examination and heated debate especially over the interpretation and dating of the *Yao tien* passage in the Shu ching, and the relationship between the *hsiu* and similiar arrangements in Indian and Arabian astronomy.[3] The study of the *hsiu* was, moreover, closely intertwined with discussions on such topics as the basis on which the positions of stars were measured and defined, the Chinese calendrical system, planetary astronomy, and the computation of time. Additionally, the pursuit of all these matters was often accompanied -- more conspicuously in some than in others -- by views regarding and

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[1]Edward H. Schafer, "The Grand Aurora," Chinese Science, 6 (1983), 32.

[2]Nathan Sivin, "History of Astronomy," in Astronomy in China: A Trip Report of the American Astronomy Delegation, ed. Leo Goldberg, and Lois Edwards (Washington D.C.: National Academy of Sciences, 1979), pp. 14.

[3]Needham rightly observed that, "the apparent exactness of this passage has long offered to scholars an irresistable invitation to determine its date by the precession of the equinoxes": Science and Civilisation in China, vol. 3, pp. 246.

efforts to fathom the antiquity of Chinese astronomy.[1] The frequent juxtaposition and cross-referencing of these aspects and controversies in the pool of Western literature concerned makes it more sensible, therefore, to combine them all in one section.[2] One further remark before we proceed to review these publications: as with chronology, in handling the topic of calendars, we look for works that aim chiefly to unravel or that provide a considerable volume of information specifically on practices and knowledge in astronomy (e.g. systems and techniques of computation used; scientific aspects of the sexagenary cycles or intercalary months; elements in traditional Chinese mathematical astronomy).[3]

The question of the nature of the *hsiu* and the computation of its ancestry had already captured Westerners' attention in the early-mid 19th century; so did the *Yao tien* passage.[4]

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[1]As Ho put it: "In Chinese astronomy. . . many lances had been broken among scholars both of the East and West in this same period [i.e. 19th and early 20th century] over the question of its antiquity": Ho Peng Yoke, Modern Scholarship on the History of Chinese Astronomy (Canberra: Faculty of Asian Studies, Australian National U, 1977), pp. 4.

Eberhard also pointed out that, "special studies in Chinese astronomy, astrology, and calendar systems began in the early years of the century and developed again mainly in the twenties. Main foci of interest were: 1. The age of Chinese astronomy and the question whether it developed in China or was influenced by the West. I mention here the names of men like L. de Saussure, H. Maspéro, E. Chavannes, Sh. Shinzō, I. Tadao, and Tung Tso-pin, among others. In connection with this was raised the question of the age of Chinese civilization and especially of certain historical texts": Wolfram Eberhard, "The Political Function of Astronomy and Astronomers in Han China" in Chinese Thought and Institutions, ed. John K. Fairbank (Chicago: U of Chicago P, 1957), pp. 33-34.

[2]As these problems are also related to traditional Chinese prediction and observations of eclipses and other celestial phenomena, studies in sections that concentrate specifically on these latter issues should be consulted for important discussions as well.

[3]Hence, for instance, material whose main function is that of correlating and comparing Chinese calendars with European ones and which contains little on the astronomical content of the calendars is not treated here.

[4]*See* Science and Civilisation in China, vol. 3, pp. 172, 173, 182, 183, 184, and Ho Peng Yoke Modern Scholarship on the History of Chinese Astronomy pp. 3, 4, 5.

In Robert Morrison's A Dictionary of the Chinese Language. . . can be found a special contribution by John Reeves (1819), the intention of which is to "identify the Stars of the Chinese Constellations with the Constellations of the European Globes."[1] The constellations are arranged alphabetically according to "Bardin's globes", giving corresponding Chinese names in romanisation and Chinese characters.[2] Even if chance played a role in the publication of this list, the fact that this particular subject managed to secure a position in a renowned dictionary by one of the most prominent 19th century British missionaries to China remains significant. Reeves was not ignorant of the existence of relevant Chinese historical materials and experiences. And his thinking -- as seen in his introductory comments -- was very much in line with that held by his contemporaries living in China at the time, most of whom were convinced that China had little knowledge of science (by which they meant modern or Western science) or that whatever the Chinese knew was borrowed from elsewhere.[3] John Francis Davis (1823) also asserted that the Chinese took from others the *hsiu* system and the

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[1]John Reeves, "Chinese Names of Stars and Constellations collected at the Request of the Author of this Dictionary," in Robert Morrison, A Dictionary of the Chinese Language. . ., pt. II vol. 1 (Macao: Printed at the Honorable East India company's press by P. P. Thoms, 1819), pp. 1063.

[2]Reeves, "Chinese Names of Stars," pp. 1065.

[3]Consider the following criticisms: "They may indeed have divided the Stars in and near the Zodiac, into their Twenty-eight Constellations. . . . they may have given names of their own invention to some groupes of stars, and to a few of the more brilliant single stars that are visible to them -- they may have recorded Eclipses -- but this will be found the extent of their performance; and to record an Eclipse, or to name a star, does not constitute an Astronomer. . . . All the books written by the Chinese, and containing accounts of the Stars, are intended only for Astrological purposes, and though mention is made of the precession of the equinoxes, in the books of the ninth century, yet it must be remembered, that the Mahomedans had entered China before this period, and therefore 'tis probable, that the Chinese acquired their first notions of Astronomy (as a Science) from some of those foreigners who accompanied the Tartar Monarchs in their conquests of the country, and who probably brought with them those Astronomical instruments which are described [by Du Halde] as having been found at Nanking and Peking": John Reeves, "Chinese Names of Stars," pp. 1063.

method for the computation of the year.[1]

J. B. Biot, on the other hand, was not overly anxious in discrediting the Chinese. His acclaimed memoir in the 1839 Journal des Savants, prompted by Ludwig Ideler's Über die Zeitrechnung der Chinesen, confronts critically various issues, including the coordination between the *hsiu* and circumpolar stars, and the differences between the *hsiu* and the Indian system. Much of Biot's reasoning was adopted by Needham.[2]

A work devoted to the translation of the *Yao tien* and associated commentaries was published in the 1840 Chinese Repository, accompanied by attempts to work out and clarify various computational matters.[3]

Scholars from the second half of the 19th century, though still interested in matters addressed in the above studies, were not all drawn to the same territory, and did not hold identical or matching stand and opinions regarding traditional Chinese astronomical initiatives, practices, and beliefs.

J. H. Pratt (1862), for instance, in contrast to others who seemed to have full faith in employing the *Yao tien* passage to define astronomical eras, suggested that its dependability was not beyond doubt.

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[1]Davis, Fellow of the Royal Society and Governor of Hong Kong, had this to say concerning Chinese understanding of astronomy: "All investigation into the Chinese knowledge of astronomy tends only to prove, that before the introduction of that science, into the empire, first by the Arabians, and afterwards by the European missionaries, they were wholly ignorant of its principles": John Francis Davis, "On the Chinese Year," Philosophical Transactions of the Royal Society, 113 (1823), 91.

[2]*See* Cullen, "Joseph Needham," 43.

[3]The account was intended "to introduce to the reader as a veritable translation of that portion of the Yaou Teën which relates to astronomy, with such parts of the commentary as are either necessary to its explanation, or may serve to show the Chinese views of astronomy, at the time the commentator wrote, which was A.D. 1210. To these are added a few explanations of the writer to assist the reader in comprehending the system of the commentator, and likewise contrasting the Chinese calculations with those of the west": [W. J. Boone], "The *Shoo King*; An Extract containing the Astronomy of the *Yaou Teën*, with Explanations from the Commentary of *Tsae Chin*. . .," Chinese Repository, 9 (1840), 573.

Several scholars dealt with stars and constellations. In an account in the 1855 Monthly Notices of the Royal Astronomical Society, Williams furnishes the Society with "a complete Chinese celestial atlas, in 32 maps, traced (with one exception) to a work forming part of Dr. Morrison's Chinese Library now in University College London" as well as "a pair of celestial planisphere of large size, published in England about a century ago"; the twenty-eight *hsiu* are also mentioned in passing.[1]

Schlegel's massive, nine-hundred-page *Sing Chin Khao Youen*; Uranographie chinoise, ou preuves directes que l'astronomie primitive est originaire de la Chine. . . (1875) is structured as follows: the first part consists of "Livre premier -- de la première division en quatre constellations cardinales"; "Livre deuxième -- de la seconde division en 214 groupes d'étoiles"; "Livre troisième -- de la troisième division en 8 groupes d'étoiles"; "Livre quatrième -- astérismes des époques historiques et modernes"; "Livre cinquième -- des zodiaques et des planètes"; the second part contains "Livre premier -- rapports de l'uranographie chinoise ancienne avec celle des autres peuples anciens" and "Livre second -- Preuves géologiques, historiques et ethnologiques des rapports entre les anciens chinois et les autres peuples anciens".[2] One can argue that the obviously flawed computation and erroneous interpretation of Chinese chronology makes

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[1]John Williams, "Notes on Chinese Astronomy," Monthly Notices of the Royal Astronomical Society, 15 (1855), 19-20.

[2]Readers are given a bonus in the form of a succinct "Résumé", and in its final statements we are told that: "I. Les noms des constellations que nous avons dans notre sphère, telle qu'elle nous a été transmise par les Égyptiens et les Grecs, ne conviennent, à quelques exceptions près, à aucun de ces peuples de l'Antiquité, auxquels on a voulu les attribuer. II. Les noms des constellations et des astérismes dans la sphère chinoise conviennent, par contre, exclusivement aux Chinois, et remontent à environ 17000 avant l'ère chrétienne. III. Ces noms d'astérismes chinois se retrouvant presque tous dans les anciennes sphère occidentales, ont dû avoir été empruntés à la sphère chinoise primitive par les Occidentaux qui y ont ajouté, pour leur compte, quelques nouvelles constellations. IV. L'antiquité de l'Uranographie chinoise est corroborée par les témoignages de la tradition et de l'histoire chinoises, ainsi que par les recherches scientifiques des géologues européens": Gustave Schlegel, *Sing Chin Khao Youen*; Uranographie chinoise, ou preuves directes que l'astronomie primitive est originaire de la Chine. . . (The Hague: Martinus Nijhoff / Leiden: Brill, 1875), pp. 798.

it impossible for the work to hold the status of a study that offers reliable historical explanation. However, the author's valiant attempt at comprehensive coverage of the subject must be acknowledged. Indeed, in Sivin opinion, "Schlegel's extravagant views on the antiquity of Chinese astronomy in no way vitiate the eminence of this work as the basic reference on Chinese constellations and stars."[1]

T. W. Kingsmill compared the name and meaning of each of the stars in the *hsiu* system with Indian, Greek, Arabic, Persian stars to determine primacy in 1891. And Wylie combined and contrasted a Chinese star atlas published in 1839 that made use of sources originating from China (including those from Verbiest) with a handful of 18th and 19th century European star maps and catalogues. The resulting "List of Fixed Stars" appeared in published form in his posthumous collection Chinese Researches in 1897.

Intrigued by Chinese observations of the movement of the planets and planet worship (especially the importance they apparently attached to Mercury and Jupiter) and the beginnings of such practices, Edkins (1885b) and Chalmers (1885a) (1885b) exchanged views on this subject. Chalmers, for example, queried Edkins' "main argument, that the Chinese began about B.C. 806 to observe the movements of the planets after the fashion of the Babylonians."[2] In reply to this, Edkins' penned his "Astrology in Ancient China". References to Chinese documents (e.g. passages in the *Kuo yü* and *Tso chuan*) surface frequently in their discussions. In another, more extended paper (1888) Edkins amplifies his thesis on the foreign origin of Chinese astrology by concentrating on the development and significance underlying Chinese observations and naming of stars.

J. R. Hind (1877) turned to a specific case within the topic of planetary observations and elucidated mathematically the only two planetary occultations listed in Gaubil's "Observations chinoises. .

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[1]Sivin, "An Introductory Bibliography," pp. 299. The book even carries an asterisk "which signals a degree of enthusiasm that would be boring if expressed at greater length": Sivin, "An Introductory Bibliography," pp. 281.

[2]John Chalmers, "Astronomy in China," China Review, 14 (1885), 166.

." from 1810, "in which the hour, or rather the particular two-hourly interval, at which the occultation took place is distinctly stated."[1]

Pursuing yet another channel, Franz Kühnert, E. Chavannes, and others investigated primarily issues associated with the calendrical system and the making of calendars; for instance, the twenty-four fortnightly periods, the unbelievably ancient appearance of the calendar, and the chapter concerning calendars from the *Shih chi*. Kühnert's studies (1888) (1890) (1891) typify an older historiography that, though long superseded, was in all likelihood judged satisfactory according to standards set by the late 19th century Western scholarly community. They can even be memorable and stir later generations of readers in some curious, perhaps nostalgic, way. Indeed, the concluding paragraph of his "Das Kalenderwesen bei den Chinesen" in the 1888 Österreichische Monatschrift für den Orient is probably the source of Needham's translated excerpt which precedes the title page of Science and Civilisation in China vol. 3.[2] Among the short accounts scattered in the China Review is one signed "J. M." from 1883 which aims at eliciting the exact meanings of certain expressions and phrases crucial to learning about the length of the Chinese moon. Was the calendar described in the twenty-sixth chapter of the *Shih chi* really from the Shang dynasty? The prominent 17th century Chinese mathematician Mei Wen-ting believed so. Chavannes (1890) attempted to ascertain this by examining the way the calendar worked and the principles guiding its compilation. Kingsmill (1877) also had an interest in this calendar, and translated selected passages in order to determine "how far it may be made to support the

[1] J. R. Hind, "On the Two Ancient Occultations of Planets by the Moon Observed by the Chinese," Monthly Notices of the Royal Astronomical Society, 37 (1877), 243.

[2] It runs as follows: "Diese ganze Einrichtung des chinesischen Kalenderwesens mit allen diesbezüglichen Vorkehrungen lässt uns gleichfalls einen Blick in die hervorragende Geistesrichtung dieses Volkes werfen; und wahrscheinlich sind die Chinesen auch deshalb in den Augen manches Europäers Barbaren weil sie sich unterfangen, die Astronomen -- ein höchst unnützes Völkchen nach der Ansicht dieser Erdenpilger im hoch culturellen Western -- im Range gleichzuhalten den Sectionschefs und ersten Ministerialsecretären. -- O grässliche Barbarei!": Franz Kühnert, "Das Kalenderwesen bei den Chinesen," Osterreichische Monatschrift für den Orient, 14 (1888), 116.

claims of a high antiquity for the Chinese computation of time."[1]

As we have seen, a host of 19th century scholars tried their hands at unlocking the doors of traditional Chinese astronomy and evaluating what they discovered. By contrast, the thirty or so works published between 1907 and 1924 all came from Léopold de Saussure, with the exception of four short pieces from E. B. Knobel, Parker, William F. Rigge, and C. Bezold respectively.[2] Knobel (1909) described an undated Chinese planisphere at an exhibition held in the Royal Scottish Museum. Like Williams half a decade ago, he also informed readers of the Journal of the Royal Astronomical Society of the *hsiu* system.[3] Rigge (1915) brought to one's notice and reproduced parts of an 18th century Chinese star-map bearing a preface from 1757. And Bezold (1920) traced certain similarities between early Chinese and Babylonian planetary astrology.

de Saussure's role in getting the West nearer to a proper understanding of Chinese astronomy has been ably characterised by Needham and in Alexander Pogo's review of an essay collection by de Saussure.[4] Here we can only indicate briefly several salient features. The main themes explored in de Saussure's publications on Chinese astronomy include the essential nature of the Chinese astronomical system, the *hsiu*, the beginning of Chinese astronomy, and the *Yao tien* passage, all of which have been handled with varying degrees of thoroughness. Also studied are topics on calendrical and planetary astronomy (e.g. the so-called "animal cycle", Jupiter cycle, *chieh ch'i*). The historical significance of his works resides primarily in

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[1]T. W. Kingsmill, "The Chinese Calendar, its Origin, History and Connections," Journal of the North China Branch of the Royal Asiatic Society, 32 (1897), 2.

[2]Two other studies by de Saussure were published posthumously in 1930 and 1932.

[3]Guidance was apparently sought from writings of Biot and a few others, especially that of Schlegel whose Uranographie chinoise was regarded as "a very exhaustive work on the subject, and must always be considered of the highest value": E. B. Knobel, "On a Chinese Planisphere," Journal of the Royal Astronomical Society, (1909), 435.

[4]*See* Science and Civilisation in China vol. 3, esp. pp. 182, 184, 229; Alexander Pogo, rev. of Les origines de l'astronomie chinoise by Léopold de Saussure, in Isis 17 (1932), 267-71.

de Saussure's refusal to join the camp of most other scholars influential in the field at the time; instead he approached the subject from a fresh perspective, often arriving at notions and findings that have proved to be much more revealing. However, as there were constant re-evaluations and corrections to his own positions as his research progressed, the scholarly value of his writings varies, and the opinions articulated are sometimes confusing and conflicting. Based on comments by Needham and Pogo, the following titles (in chronological order) are among the most important ones to note: (1) "Prolégomènes d'astronomie primitive comparée" (1907c).[1] (2) "Le texte astronomique du *Yao Tien*" (1907d) and "Le texte astronomique du *Yao Tien*; note rectificative et complémentaire" (1907e).[2] (3) "Le cycle de jupiter" (1908).[3] (4) "Les origines de l'astronomie chinoise: l'origine des *sieou*". (5) "Le système astronomique des Chinois" (1919).[4] (6) "Astronomie et mythologie dans le *Chou King*".[5]

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[1]This article, considered essential reading by Needham, discusses: "Le problème sidéro-solaire"; "L'observation a l'horizon base originelle de l'astronomie écliptique"; "le problème tropique"; "Role secondaire de l'équateur et de l'ecliptique dans les astronomies écliptique et équatoriale"; "Adoption de la méthode horaire en Occident"; "Genèse de la méthode équatoriale des chinois".

[2]The first is divided into: Avant-propos"; "I. L'oeuvre du P. Gaubil et de J.-B. Biot"; "II. Genèse de l'astronomie -- Origines de l'astronomie zodiacale; Origines de l'astronomie chinoise"; "III. Examen du texte"; "IV. La détermination des saisons"; "V. Inconséquences et contradictions des interprétations admises"; "VI. Le zodiaque lunaire d'Ideler"; "VII. La théorie de Biot"; "VIII. 'The Lunar zodiac' de Whitney"; "IX. Sédillot"; "X. Kühnert"; "XI. Ginzel"; "Conclusion".

[3]Pogo expressed regret that this paper was not reprinted in de Saussure's essay collection as it was "a paper not superseded, in 1913 and 1914, by the two instalments of chapter G bearing the same title but treating the subject in quite a different manner": Pogo, rev. of Les origines de l'astronomie chinoise, 267. However, Needham's annotation for this title reads: "This paper contains many mistakes in the opinion of the author who desired that it should be considered as cancelled and replaced by (12) [i.e. "Les origines de l'astronomie chinoise: le cycle de jupiter," T'oung pao, 14 (1913), 387-426; 15 (1914) 645-96]": Science and Civilisation in China, vol. 3, pp. 788.

[4]It consists of: "Preuves de l'antiquité du système"; "Rôle fundamental de l'étoile polaire"; "La théorie des cinq eléments"; "Changements dynastiques et réformes de la doctrine"; "Le symbolisme zoaire"; "Le cycle sexagésimal et la chronologie". This is one of

Finally, a word on Les origines de l'astronomie chinoise which was published posthumously in 1930. It brought together various articles that appeared initially in T'oung Pao -- chiefly the "Les origines de l'astronomie chinoise" series -- in a monograph. Although it is handy to have eleven of his works in one place, typographical errors abound and cross-references in the footnotes are impossible to locate in the monograph since page numbers mentioned there refer to pages in the original articles rather than those in the book.[1] Above all, this volume should be read together with his other important studies mentioned above.

In the decade and a half following the demise of de Saussure, the field received a wave of mostly short articles from new players, penned chiefly by Willy Hartner, Eberhard, and Chatley. Some of the interpretations and conceptual vocabulary adopted in these inquiries are piquant and imaginative, others less so, while their styles as well as foci are decidedly different.

Hartner, an authority who broke new grounds in the study not only of the history of astronomy in China, but also that of other civilisations, gave in three short essays (1928) (1930a) (1930b) careful consideration to the names of stars in the *hsiu* asterism, and to calendrical and astronomical matters as revealed in the *Hsia hsiao*

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three accounts by de Saussure recommended by Needham, and reckoned by Pogo as "a more homogenous presentation of his views than the analytic *T'oung Pao* series, *Les origines de l'astronomie chinoise*": Pogo, rev. of Les origines de l'astronomie chinoise, 270.

[5]This contribution contains de Saussure's final statement on several familiar issues: "a) le texte du *Yao tien* contient les traits essentiels du système exposé dans le *Che ki*. Une telle constatation recule des temps postconfuceéns aux temps préconfucéens, l'apparition du système. b) le système du *Yao tien* et du *Che ki* est essentiellement différent du système greco-babylonien: il est équatorial et en connexion avec l'origine du zodiaque lunaire. c) ce système est indo-iranien. d) on pourrait admettre à la rigueur, et provisoirement. . . qu'il a été introduit en Chine dans les premiers siècles de la dynastie Tcheou; je crois néanmoins qu'il ya a des raisons sérieuses qui empéchent d'admettre une importation aussi tardive du système": Léopold de Saussure, "Astronomie et mythologie dans le *Chou King*," T'oung Pao, 29 (1932), 366-67.

[1]Pogo's review which contains a list of corrections is therefore indispensable.

cheng -- especially with regard to computations.[1]

Chatley's views on the following topics can be gleaned from a number of brief portrayals published in the 1930s: (1) origins and nature of planetary cycles (1933) (1934a); (2) astronomical chronology, planetary conjunctions, and the *Yao tien* passage (1934b) -- a response to de Saussure's "La chronologie chinoise et l'avénement des Tcheou"; (3) Chinese planetary observations (1936a); (4) planetary periods as set down in the Han shu (1936b); (5) the reduction, in his opinion, of "astronomy to arithmetic rule for calendarization and calculation of history" (1936c); (6) the date and antiquity of the Hsia hsiao cheng calendar and the *Yao tien* (1938).[2] One of Chatley's chief intentions was apprently to demonstrate outside (especially Babylonian) influence and borrowing.

Writings by Eberhard can be grouped into first, a series of papers on the Han and San Kuo periods -- the first two with the collaboration of Rolf Müller and Robert Henseling (1933a) (1933b), and the last two that of Müller (1936) (1937). The Han studies examine in detail the accuracy of the *san t'ung* calendar system -- how and why, in Eberhard's estimation, it had been altered and revised. Thought was also given to the shaping, computational techniques and historical meaning of the *ssu fen li*, and to literary documents such as the Chu shu chi nien (which, according to Eberhard, might have been falsified). The San Kuo article concentrates on an astronomical text by Wang Fan. Wang's Hun t'ien hsiang shuo was translated and the accuracy of its date subjected to scrutiny by applying astronomical computations.[3] Second, several works (1936) (1937) (1940) that

[1]Note that the content of "Chinesische Kalenderwissenschaft" (1930b) is almost identical to that of "Die astronomischen Angaben des *Hia Siau Dscheng*" (1930a).

[2]Herbert Chatley, "*T'ai Chi Shang Yuan*: The Chinese Astrological Theory of Creation," Journal of the North China Branch of the Royal Asiatic Society, 67 (1936), 7.

[3]Sivin observed that, "in addition to surveying the computational systems, these articles take up a number of subsidiary themes which would have occurred only to a sinologist of exceptional ingenuity"; nevertheless, Eberhard's "attempts to date texts and test their authenticity astronomically, has not generally been accepted by more recent workers": Sivin, rev. of Sternkunde und weltbild im alten China: gesammelte Aufsätze, 60.

reveal special connections Chinese efforts (such as popular calendars and ephemerides) had with domains that generally went unnoticed (such as Turkish calendars and the Buddhist Tripitaka).[1] Third, "Eine neue These über die Chronologie des *Ch'un-ch'iu* und der Chou-Zeit" (1939) which aims at contributing to the perennial debate on the calendrical question and astronomical chronology.

Two other studies from the 1930s should also be noted. Homer H. Dubs (1935) reflected on the exact date of the conjunction which supposedly marked the establishment of the Han dynasty. It was recorded in the *Ch'ien Han shu* as having occurred in 207 B.C., but Dubs (with computation help from J. K. Fotheringham) argued that it should have been May 205 B.C.. Louis Chochod's "La notion du temps et le calendrier dans l'ancienne Chine" in the 1939 Mercure de France describes the planetary cycles and the method of calculation used in making Chinese calendars.

After this burst of enthusiasm in the 1920s and '30s the pace slackened considerably. For the next several decades, accounts trickled through, including a couple of skilfully-executed and original studies, but for the most part this particular region of Western research on traditional Chinese science remained relatively bare. It was towards the latter part of the 1970s and beginning of the 1980s, facilitated especially by the innovative research of Michel Teboul, that areas in planetary and calendrical astronomy as well as topics concerning stars and star maps were again cultivated attentively.

One of the few Western works concentrating on a Chinese star-map was W. C. Rufus and Tien Hsing-chih's (1945) close study of the famous early 12th century planisphere and attached text engraved in the stone steles in the Wen Miao near Su-chou. Though short for a monograph (less than thirty pages), it probes into such matters as the identification and representation of asterisms, reiterating Rufus' arguments in his "A Political Star Chart of the Twelfth

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[1] "Untersuchungen an astronomischen Texten des chinesischen Tripitaka" (1940), for example, is divided into: "1. Das Material"; "2. Die Mondstationen"; "3. Tierkries; Zwöferzyklus"; Jupiterzuklus"; "4. Planeten und Planetenzyklen"; "5. Der grosse Bär"; "6. Zusammenfassung und Schlussbemerkungen".

Century" about deliberate idealisation.[1]

In 1950 Philip Yampolsky outlined and translated statements, without critical comments, of "two divergent opinions concerning the origin of the concept of lunar mansions as held by two Japanese authorities in the field, Dr. Iijima Tadao and the late Dr. Shinjô Shinzô."[2] Yampolsky's account also summarises views of Biot, de Saussure, Whitney, Müller, Weber, and Hommel.

Perimeters drawn by Dubs for his "The Beginnings of Chinese Astronomy" (1958) are not as wide as the title suggests. Steering preoccupation away from the Han and later periods for a change, Dubs dealt with several selected elements from an even earlier era: intercalation using measurements of the shadow at the winter solstice, the bearing sexagesimal cycle terms had on determining the length of the solar year, the watching of new moons and official announcements of new months, the observation of the revolution of planets, and "the steps which led to the use of the Chinese cyclical terms for years as well as for day" based on a Chinese book by Liu T'an on the Jupiter cycle and the calendar published in 1955.[3]

W. Allyn Rickett's (1960) investigation of a calendar chart in _Kuan tzu_ (compiled in the fourth to the second century B.C.) serves to remind us of the sea of Chinese materials involving calendars

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[1]Chatley, however, takes a different stand in his review of the book: "Copyists were probably the greatest offenders. . . . Doubtless an unconscious tendency to improve the shapes of the constellations would increase the dissimilarity to the true forms, but the reviewer doubt if this was deliberate": Herbert Chatley, "A Chinese Star Map," _Observatory_, 67 (1947), 35.

[2]There is an interesting remark from Needham concerned indirectly with this paper. While commenting on how de Saussure showed that Legge, Chalmers, Russell, Schlegel and Ginzel had not "understood the reference to times of meridian passages of stars in the *Shu Ching*, and that all had failed to appreciate the equatorial character of the *hsiu*, and the way in which these were keyed to circumpolar star", Needham mentioned in a footnote that, "the mistake seems ineradicable; Yampolsky and Weinstock continue to confuse in 1950 what Sédillot confused in 1849": _Science and Civilisation in China_, vol. 3, pp. 184.

[3]Homer H. Dubs, "The Beginnings of Chinese Astronomy," _Journal of the American Oriental Society_, 78 (1958), 298.

untouched by Western scholars.[1] As Rickett explains: the text "is composed of a seasonal calendar coupled with a treatise on military strategy."[2] The full and richly annotated translation is preceded by an "Introduction" in which "Meaning of title"; "Background of calendar in *Yu kuan*"; "Other early calendars"; "Content of calendar in *Yu kuan*"; "Essay portion of *Yu kuan*"; "Dating of essay portion"; "Dating of calendar portion"; "Dating of chart" are reviewed in considerable depth.

We have seen keen attention paid to traditional Chinese calendrical and planetary astronomy by the academic world. The topic, however, did not find a place in the popular or non-specialist sector as was the case with supernovae, comets, and pulsars. Nevertheless, in the 1960s there was an elementary introduction to sixty-year cycles and the way Chinese calendar operates in the magazine Sky and Telescope by Rabbi Jacob L. Friend (1963), and an uncomplicated outline of the Chinese -- and Japanese -- calendrical system by Joachim W. Ekrutt (1966).

A short note from Schafer describing "parts of two [Chinese] articles [from the journal *Wen wu*] on a recently discovered star map painted on the ceiling of the tomb of a Chinese gentleman who was buried. . . in A.D. 1116, under the Liao Dynasty" was communicated to the 1977 Journal for the British Astronomical Association.[3]

Persisting in his mission to fathom the accuracy and reliability of historical Chinese astronomical data, Maeyama in his "The Oldest Star Catalogue of China, Shih Shen's *Hsing Ching*" (1977) analyses not only the date of the work, but also such complex concerns as the knowledge of armillary rings, the problem of the position of the north celestial pole and the calculation of polar distan-

[1]The calendar is not, for instance, mentioned in Science and Civilisation in China vol. 3.

[2]W. Allyn Rickett, "An Early Chinese Calendar Chart: *Kuan-tzu* III, 8 (*Yu kuan*)," T'oung Pao, 48 (1960), 195.

[3]Edward H. Schafer, "An Ancient Chinese Star Map," Journal for the British Astronomical Association, 87 (1977) 162.

ces of stars.[1]

Did the theme of astronomical chronology survive into the 1970s and '80s? So far as Friedrich Cornelius and David Pankenier were concerned, it was an area still worth spending time on. Cornelius' "Astronomische Fixierung der frühchinesischen Chronologie" (1971) is a short account of materials and issues associated with the use of astronomical data to date Chinese historical periods, based chiefly on the author's reading of secondary works. Pankenier's two articles, on the other hand, entertain more elaborate aims.

Pankenier wished to ascertain if one could employ Chinese records of planetary phenomena to determine the exact dates of significant events in China's ancient history. In his paper in Early China (1982a), he proposes a series of dates, among which are: "the earliest confirmed date in Chinese history and one which bears importantly on the historicity of the Xia dynasty" -- 1576 B.C.; the "probable date for the founding of Shang" -- 1554 B.C.; the "dates of King Wen's reign" -- 1099 to 1050 B.C..[2] These were obtained as a result of the author's painstaking inspection of "verifiable accounts of the general conjunctions of planets witnessed by Shang and Zhou dynasty observers" noted in the *Chu shu chi nien*.[3] The possible link between planetary phenomena and the Mandate of Heaven is also addressed.[4] In "Early Chinese Positional Astronomy: The *Guoyu*

[1]Convincing evidence is provided to show that previous calculations by such experts as Ueta J., Yabuuchi Kiyoshi, and Xi Zezong were done "simply by substitution of the pole according to the modern theory for the one actually considered at that time"; instead his study "has deduced an epoch of observations with a certain reliable range of 70 B.C. +/- 30 years": Y. Maeyama, "The Oldest Star Catalogue of China, Shih Shen's *Hsing Ching*," in Prismata: Naturwissenschaftsgeschichtliche Studien; festschrift für Willy Hartner, ed. Y. Maeyama, and W. G. Saltzer (Wiesbaden: Franz Steiner, 1977), pp. 211-12.

[2]David W. Pankenier, "Astronomical Dates in Shang and Western Zhou," Early China, 7 (1981/82), 24.

[3]Pankenier, "Astronomical Dates," 1.

[4]"Introduction"; "1. The Conjunction of 1059 B.C." ("1.1 The absolute dates of King Wen's Reign"); "2. Great Fire and Quail Fire in Zhou astrology" ("2.1 The identificatin of Quail Fire and the Red Bird", "2.2. The Astronomical significance of the First Red Bird Augury", "2.3 The role of Jupiter in Zhou astrology", "2.4 Periodic

Astronomical Record" (1982b), the part of the *Chou yu* that "pertains to the locations of the various celestial bodies in the late autumn of 1947 B.C." is put to the test and good use.[1] And Pankenier confirms that that it "does indeed derive from eyewitness observation of the event described."[2] As for dates: "this series of positional observations can be understood to uniquely identify the period November 26 to December 3, 1947 B.C., some seven weeks prior to the climactic Battle of Muye."[3]

While Pankenier was busy reconstructing ancient Chinese chronology, Teboul was conducting research into the history of Chinese astronomy of a distinctly different kind, one that succeeded in combining new materials, perspectives, objectives with erudition.

Teboul's short note in the Transactions of the International Conference of Orientalists in Japan (1981) suggests that the discovery of the *Wu hsing chan* manuscript in the Ma-wang-tui Han tombs has thrown light on writings and concepts about planetary movements that preceded those in the *Huai nan tzu* and the *San t'ung li*. His "Les premiers développements de l'astronomie chinoise des Royaumes Combattants au début de l'ère Chrétienne" (1982) deals principally with traditional Chinese astronomical perception and knowledge concerning the five planets -- Mercury, Venus, Jupiter, Mars, and Saturn -- since the Han. Especially noteworthy is the creative method Teboul employed in this and other works in translating Chinese technical terms. By using modern mathematical equations, he has not only circumvented a serious problem with no easy solution, but also contributed to a better appreciation of the underlying Chinese reasoning. His much acclaimed monograph, Les premières théories

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appearances of the Red Bird"); "3. The Red Bird at Luo and the two campaigns" ("3.1 Liu Xin vs. Sima Qian", "3.2 The aborted campaign"); "4. Jupiter, conjunctions, and chronology"; "5. The mandate of Shang" ("5.1 The conjunction of 1567 B.C.", "5.2 Great Fire and the founding of Shang"); "6. The date of compilation of the Bamboo Annals"; "7. Conclusion".

[1]David W. Pankenier, "Early Chinese Positional Astronomy: The *Guoyu* Astronomical Record," Archaeoastronomy, 5.3 (1982), 12.

[2]Pankenier, "Early Chinese," 18.

[3]ibid.

planétaires chinoises, appeared in 1983. The first part is a rigorous exposition as well as full translation of the *San t'ung li* -- one of the most ancient treatises on Chinese astronomy formulated about two thousand years ago -- with special emphasis on computational analysis. The second part is an excursion into an even earlier age before the composition of the treatise, boldly venturing into such areas as the possible interplay between astrology and the generation of planetary theories. Chinese, Western, and in particular Japanese sources (which are of utmost importance in studies of Chinese mathematical astronomy) have been consulted.[1] In light of the equatorial and polar characteristic of Chinese astronomy, mining Chinese records and impressions of ancient pole-stars along the polar path is a task worth pursuing. Further to de Saussure's "Les origines de l'astronomie chinoise: les anciennes étoiles polaires" from 1921, and to discussions of the matter by Maspero, Biot, and Gaubil, Teboul critically reassessed their views and focused attention particularly on the expressions or names *T'ai i* and *T'ien i* in an article published in 1985.

5.4 RECORDS OF ECLIPSES, COMETS, NOVAE, AND OTHER CELESTIAL PHENOMENA

It has been mentioned earlier that understanding Chinese astronomical chronology and planetary astronomy often involves having to wrestle with Chinese reports of celestial phenomena such as eclipses and conjunctions of planets; this point is stressed once again at the beginning of this section as a reminder of the necessity to consult publications presented elsewhere. These records and the activities associated with their making, maintenance and interpretation were indeed of paramount importance in many facets of the traditional Chinese astronomical structure, motivating and supporting its practi-

[1]Although the book is essentially a fascimile copy of a typescript and is rather difficult to read, Chinese characters are inserted directly into the text and a detailed Table of Contents is provided.

tioners century after century.[1]

A feature typical of most 19th and 20th century Western publications on Chinese observations of celestial phenomena was the penchant for assembling lists and translating accounts of observations extracted patiently from Chinese sources and compilations. Each succeeding work carried the primary aim of improving upon the previous ones by increasing the size of the pool rather than that of essaying an interpretive and nuanced analysis of the contents of the records or going an extra mile to situate and appraise them in the appropriate historical context and setting.

Nevertheless, this familiar approach no doubt had its advantages and appeal, and was used in early 19th century works. In a posthumously published work (1810) by Antoine Gaubil -- "Interpreter-General and Father-Superior of the history of Chinese astronomy" -- materials on Chinese observations of eclipses and planetary conjunctions from 147 B.C. onwards are listed with occasional explicative remarks.[2] The special interest in culling pertinent details from Chinese works is also evident in two of Abel-Rémusat studies (1819a) (1819b) on aerolites and meteors in which information was derived chiefly from Ma Tuan-lin's *Wen hsien t'ung k'ao*. This Chinese collection also features prominently in several of Édouard Biot's works (1841) (1846a) (1846b) (1846c) (1848) which enumerate and translate evidence of Chinese sightings of meteors, meteorites, comets (including Halley's Comet), novae and supernovae stretching

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[1]Nakayama Shigeru stated astutely that "Chinese court astrology consists purely in the accumulation of portents in the form of celestial, meteorological, and seismological phenomena -- supernovae, planetary conjunctions, comets, hailstorms, earthquakes -- and their empirical correlation with events in human society which are relevant to the success of the Imperial rule. . . . The Chinese term *t'ien-wen* is now used simply to mean 'astronomy', but this is a decided shift in denotation; in classical writings it is ordinarily used in the sense of 'portent astrology'": Nakayama Shigeru, "Characteristics of Chinese Astrology," Isis, 57 (1966), 442.

[2]Science and Civilisation in China, vol. 3, pp. 182. Our bibliography contains two titles by Gaubil. They were published after his death (in 1759) and brought to light by P. S. Laplace, who turned to Gaubil's accounts of Chinese historical observations in order to learn more about secular patterns in astronomical events.

from the remote past to the 17th century.[1] These studies from the 1840s formed the basis and backbone for compilations and inquiries by later scholars.

The only non-French publication from the first half of the 19th century, and the only one that did not involve cataloguing efforts was a paper by R. W. Rothman in the 1840 Memoirs of the Royal Astronomical Society in which the author puts forward his own method for calculating the exact date of the solar eclipse mentioned in the *Shu ching*.

Considerable curiosity in eclipses (in particular that mentioned in the *Shu ching*) was expressed in the second half of the 19th century, but Chinese recordings of other astronomical phenomena also received some notice, and a wider range of literary documents was consulted.

John Williams, Assistant Secretary of the Royal Astronomical Society, published no less than six articles in the Monthly Notices of the Society between 1855 and 1873, the first of which on planispheres we have already met with. The others are concerned with solar eclipses and with sunspots: the 1863 study gives an account of his investigation into the *Shu ching* eclipse which, according to his reckoning, occurred in 2158 B.C.; two short papers list observations of solar eclipses, one (1864a) extracted from the *Ch'un ch'iu* as a supplement to data furnished by Gaubil and Ideler, and continued by the other (1864b) from a Ming compilation; and an article from 1873 provides a catalogue of forty-five sunspots from A.D. 301 to 1205 located in the *Wen hsien t'ung k'ao* together with a brief explanation of the encyclopaedia's arrangement. Williams' most conspicuous contribution was probably his Observations of Comets from 611 B.C. to A.D. 1640, Extracted from the Chinese Annals. . . (1871), intended as a supplement to Biot's 1846 catalogue on comets and other inventories in European languages (which Williams found to be incomplete or not

[1]Note that "Catalogue général des étoiles filantes et météores observés en Chine pendant vingt-quartre siècles depuis le septième siècle avant J.-C., jusqu'au milieu du dix-septième de notre ère", published in Comptes Rendus Hebdomadaire des Séances de l'Académie des Sciences over the course of five years (i.e. 1841, 1842, and 1846), is an early announcement for the two hundred and thirty page of the same name in the 1848 Mémoires présentés par divers savants à l'Académie Royale des Sciences.

readily accessible). A total of 372 observations is given.[1]

Seven of the remaining works from this half-century focused on eclipses. Of these Wylie's "Notes of the Opinions of the Chinese with regard to Eclipses" (1866), though primarily a potpourri of reflections, may be the most suggestive. He also drafted a catalogue (1867) of 925 solar and 574 lunar eclipses pulled from thirty-five Chinese sources.[2] And among the scholars from this period who tried their hands at computing the year in which the *Shu-ching* eclipse was supposed to have occurred were: (1) T. Von Opplozer (1880), respected for his widely-used Canon der Finsternisse; (2) S. M. Russell (1888) who also complained of the backwardness of Chinese astronomy -- an opinion not untypical at the time; (3) Schlegel (1890), professor of Chinese literature at the University of Leiden, who joined forces with Kühnert. Also on solar eclipses were the following short works: (1) G. B. Airy's "Comparison of the Chinese Record of Solar Eclipses in the *Chun-Tsew* with the Computations of Modern Theory" (1864); (2) Samuel J. Johnson's (1875) remarks *a propos* William's two lists of solar eclipses; (3) an English translation of a French paper by H. C. F. C. Schjellerup (1881) which seeks to verify the dates of the eclipses observed in China in B.C. 708, 600 and 548 again using Western tables such as those by Adams and Delaunay.

Exploring a different vein, Lovisato (1875) [I have not seen this title], and Alexander Hosie (1877) (1879) identified and itemised Chinese sunspot records instead.[3]

While eclipses still engaged a major portion of early and mid-20th century interest, the manner in which they were studied and the special areas chosen for investigation differed at times from patterns characteristic of the previous century. The same can be said of the few works that focused on establishing the chronology of the Shang era astronomically. Moreover, plain and mechanical tabula-

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[1]Williams' list was in turn updated by Lundmark in 1921.

[2]Appended to the lists is "Notes on the eclipses, &c. mentioned in the *Si-Yu-ki*".

[3]Hosie's piece in Nature (1879) is a summarised version of his earlier article "Sun-Spots and Sun-Shadows Observed in China, B.C. 28 to A.D. 1617" in Journal of the North China Branch of the Royal Asiatic Society (1877).

tions were recognised less in this fifty-year period as appropriate tools for understanding and portraying the history of Chinese records of eclipses, comets and sunspots. Nevertheless, publications aimed at bringing to light additional evidence of sightings -- now generally accompanied by translations and placed within the framework of world astronomy -- were still commonplace. And a new topic, the Crab Nebula, which featured in the majority of literature from the second half of the century, started to receive special treatment in 1942.

First, five accounts that are not eclipse-related. Kühnert once took aim at a topic rarely discussed, namely the celestial phenomenon known as earth-shine or earth-light. Writing as "Privatdocent für chinesischen Sprache", his extended but largely unreferenced paper from 1901 endeavours to demonstrate that the Chinese had long been aware of this effect.[1] Parker (1910) translated relevant Chinese texts to confirm the dates of the appearances of Halley's Comet. Further to Williams' list published in 1873 and Hosie's from 1877, J. de Moidrey compiled a third in 1904 with ninety-one observations of sunspots. Lundmark, for his part, combed through previous translations and writings by Biot and Williams as well as other sources such as Chavannes' translation of the _Shih chi_ and Knobel's partial translation of _Nihongi_, trusting that his "Suspected New Stars Recorded in Old Chronicles, and among Recent Meridian Observations" (1921) could then "contribute to the question what has become of ancient novae which must exist in thousands in the heavens."[2] His register remained the fullest available for Chinese observations of comets and novae until Hsi tse-tsung compiled another in 1955 (translated into English in 1958). J. J. L. Duyvendak was also among those who reviewed inventories of novae compiled by Biot. He and two co-authors (1942a) (1942b) advanced the hypothesis that the supernova of 1054 A.D. documented in Chinese records and mentioned by Biot might be identified with the Crab Nebula, citing evidence from such texts

[1]Franz Kühnert, "Über die von den Chinesen *Te-sing* oder Tugendgestirn genannte Himmelserscheinung," Sitzungsberichte der mathematisch-naturwissenschaften Klasse der kaiserlichen Akademie der Wissenschaften [Wien], 110 (1901), 619.

[2]Kunt Lundmark, "Suspected New Stars Recorded in Old Chronicles, and among Recent Meridian Observations," Publications of the Astronomical Society of the Pacific, 33 (1921), 226.

as the *Sung shih*, *Sung hui yao* as well as Japanese chronicles.[1] One of Duyvendak's co-authors J. H. Oort also delivered a brief note to the 1942 T'oung Pao communicating his opinion that "it is thus only through old Chinese and Japanese records that it has been possible to establish with certainty that a supernova outburst is accompanied by the throwing off of gaseous shell such as is seen at present in the Crab nebula."[2]

Early-mid 20th century preoccupation with eclipses was manifested in more ways than one. J. K. Fotheringham, for instance, chose to narrate the so-called "story of Hi and Ho" -- the title of his article from 1932. Fortheringham furnishes a summary of eclipse ceremonies and procedures employed by astronomers in ancient China, concluding that "the celestial phenomenon of 525 B.C., which happened near the new moon and was taken for an eclipse and which the historiographer-astronomer made the occasion for a demand for offerings of silk was, as it seems, not an eclipse after all. The same may have been the case with the eclipse mentioned in the *Shu King* which appears to have been connected with the accusation against Hi and Ho."[3]

Western scholars have kept themselves busy for over a century making reassessments and readjustments to the precise date in which the event referred to in the *Shu ching* was supposed to have occurred -- since none appeared totally flawless -- labouring over it as if that alleged eclipse held the master key that could unlock the secret door to China's astronomical past. But rarely was the possibility that they might be knocking on the wrong door seriously considered. Instead of suggesting another possible solution to the mystery of this eclipse -- which "is clearly legendary in character" as Needham put it succinctly -- Hartner was among the first in the second quarter of the 20th century to shift direction.[4] He turned

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[1]This connection was disputed by Ho in the 1970s.

[2]J. J. Oort, "Note on the Supernova of 1954," T'oung Pao, 36 (1942), 180.

[3]J. K. Fotheringham, "The Story of Hi and Ho," Journal of the British Astronomical Association, 43 (1932), 256-57.

[4]Science and Civilisation in China, vol. 3., pp. 409.

towards the eclipse mentioned in the *Shih ching* instead as a better window to espy the significance of China's past eclipse recordings. Sophisticated computation techniques as well as philological expertise were put to good use in his lengthy discourse "Das Datum der Shih-Ching-Finsternis" (1935).[1] The value of researches from Chinese scholars was also beginning to be recognised; for instance, L. C. Hopkins' "Sunlight and Moonshine" (1942) considers one of the essays in the treatise *Chia ku wen tzu yen chiu* by Kuo Mo-juo published in 1931, namely the one that deals with the Chinese character for eclipse.

Nevertheless, though the *Shu ching* eclipse could no longer take pride of place on the research agenda (especially with the discovery in the 1940s of records inscribed in Shang oracle bones), setting out Chinese observations of eclipses according to modern scientific knowledge and structure as well as the quest to date Chinese historical periods remained vital concerns, as shown in Hartner's work and in four studies by Dubs -- another major 20th century Western contributor to the field.

In the first (1935) of two articles on eclipses observed during the Former Han, Dubs seeks to ascertain the precise date in which each of the twelve eclipses from the first fifty years of the dynasty occurred; his second (1938) paper provides translations of descriptions of solar eclipses. It is worth noting that in both studies, thought has also been given to the practice of predicting, recording, computing eclipses as executed by the Chinese watchers of the heavens at the time, and how that relates to the reliability of the evidence.[2] His other pair of articles concentrates on the Shang

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[1]The main portion of the study is the "Astronomischer Teil", which is divided into: "Kapitel I: Die Sonnenfinsternis von -775 September 6 (Oppolzer No. 1013); "Kapitel II: Feststellung des Datum der Shih-ching-Finsternis"; "Kapitel III: Zusätze und Nachträge". Preceding that is "Einleitung: Historische Uebersicht über frühere Datierungsversuche" (separated into "Ältere chinesische Datierungen" and "B. Europäische und neuere chinesische Datierungen").

[2]For instance, in the article on solar eclipses, the conclusion reached is that, "the outstanding impression left by the Chinese recordings of eclipses in the Former Han period is their high degree of fidelity to fact. The Chinese were not to any great extent interested in fabricating eclipses as portents and it was too dangerous to do so. They had not yet begun to predict eclipses. They

period. "A Canon of Lunar Eclipses for Anyang and China, 1400 B.C. to 1000 A.D." (1947) is a register compiled according to the Shang oracle bones (and with the help of ecliptic tables by Paul Victor Neugerbauer and T. von Oppolzer), and "differs from all preceding ones by the inclusion of visible prenumbral lunar eclipses."[1] "The Date of the Shang Period" (1951) is a critique of Tung Tso-pin's interpretation of the information regarding six lunar and one solar eclipses derived from oracle bone inscriptions. Dubs' own verdict is that "the Jou conquest occurred in the 11th century B.C., not the twelfth, and that King Wu-ding reigned about 1200 B.C."[2]

Interest in eclipses began to be overshadowed by that in comets and novae as the 1950s drew near. Needham indicated in 1959 in Science and Civilisation in China vol. 3 that, "the extent to which the Chinese records of 'guest-stars' remain of living interest to current astronomical research may be seen in the field of radio-astronomy, where during the past few years great additions to knowledge have been made."[3] Ho, in his 1977 treatise Modern Scholarship on the History of Chinese Astronomy also remarked that, "with the advent of radio astronomy after the Second World War, a great enthusiasm for the study of novae and supernovae arose. The crab nebula was regarded as the result of a supernova explosion. The linking of Chinese observations with this supernova turned the attention of astronomers to Chinese astronomical records."[4] Further, that, "in recent years there has been another outburst of interest in Chinese supernovae after the first discovery of pulsars at Cambridge towards

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watched for eclipses, at times with great pertinacity, and succeeded in observing eclipses that were quite small and required the use of special means to be seen. It is but natural that the original records should have suffered errors of transmission; as a whole they are surprisingly correct": Homer H. Dubs, "Solar Eclipses during the Former Han Period," Osiris, 5 (1938), 522.

[1]Homer H. Dubs, "A Canon of Lunar Eclipses for Anyang and China, -1400 to -1000," Harvard Journal of Asiatic Studies, 10 (1947), 162.

[2]Homer H. Dubs, "The Date of the Shang Period," T'oung Pao, 40 (1951), 325.

[3]Science and Civilisation in China, vol. 3, pp. 428.

[4]Ho, Modern Scholarship, pp. 13-14.

the end of 1967."[1] Thus, ever hopeful and spurred on by the promise that Chinese materials can provide a unique tool in enhancing present-day understanding of these celestial phenomena -- but regrettably allotting considerably less space to the status of and position these accounts occupy within the Chinese scientific or astronomical traditions, or to the inner workings and reasoning that characterise these Chinese efforts -- Western literature on Chinese historical observations of novae, supernovae and sunspots during the years 1950 to 1985 far exceeded that for earlier decades. And given the leading objective and intention of most researchers in pursuing Chinese documentary evidence on novae and comets mentioned above, refinements, reviews, and additions to former compilations quite naturally developed into a favourite theme.

An excursion into post-World War II Western contributions to the study of ancient and medieval Chinese comets and novae observations can take as its starting point several articles written by Ho and his collaborators in the late 1950s and the 1960s. Statements from various Chinese documents that could indicate the possibility that "spiked" comets might have been observed in ancient China are available in translation in the 1957 The Observatory, thanks to Needham, Beer, and Ho. At the 9th International Congress of the History of Science, Ho (1959) alerted fellow historians of science to the existence of errors in Western catalogues on ancient and mediaeval Chinese cometary observations. He gave this particular issue meticulous and informed treatment in a later article (1962) which contains a detailed register of 581 observations from 14 B.C. to A.D. 1600. Several features in this study recurred in various other Western works; for example, the introduction to materials used (especially if these were not previously cultivated), references to different Western compilations, and the translation of selected passages. In another paper, B. R. Goldstein and Ho (1965) presented new data from fourteen Chinese and Japanese sources on the supernova from 1006, one which was reported also by other civilisations.

In addition to the above four articles in academic journals and proceedings, two short ones were published in Nature in 1969 in which

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[1]Ho, Modern Scholarship, pp. 15

the possibility of making use of ancient Chinese reports to determine dates of pulsars are indicated by authors C. S. Shen (from the Department of Physics at Purdue University) and T. Kiang (from the Dunsink Observatory in Dublin) respectively.

Pressing ahead to writings from the 1970s and '80s, we come upon four more papers by Ho on comets and novae. The one in the 1970 Physics Bulletin highlights core elements in Chinese astronomy and astronomical documentations, and above all, the value and benefit they can bring to the reconstruction of the backgrounds and peculiarities of supernovae, pulsars, comets and meteor showers. Moreover, Ho and Ang Tian-se (1970) assembled an impressive chronological inventory of Chinese evidence of comets and so-called guest stars for the period 1368 to 1911, each sighting accompanied by a brief description.[1] A more narrowly focused paper on the Crab Nebula written by F. W. Paar, Ho and P. W. Parsons (1972) contends that "there is considerable doubt whether the object of A.D. 1054 and the Crab Nebula are connected at all."[2] Ho (1985b) also communicated to the 17th International Congress of the History of Science new sources on Ming observations of Halley's Comet.

Besides Ho, Stephenson was also vocal in encouraging the identification and analysis of early records kept by the Chinese (and people from other cultures) in order to learn about the historical changes and past lives of comets, novae and supernovae. In one of several specific cases Stephenson examined in the 1970s and '80s -- "a suspected supernova in A.D. 1181" (1971) -- he begins with the translation of eight Chinese and Japanese passages, then proceeds to confront various issues involved in decoding Chinese information and in understanding supernovae; for instance: "1. Observations of the star"; "2. Stellar nature of the guest star"; "5. Oriental star maps"; " 6. The lunar mansion *k'uei*"; "7. Asterisms mentioned in the guest star records"; and "10. Identification of a radio source

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[1] They took great pains to scout out materials to supplement such standard items as the *Ming shih* and the *Ch'ing shih kao.*

[2] F. W. Paar, Ho Peng-Yoke, and P. W. Parsons, "The Chinese Guest Star of A.D. 1054 and the Crab Nebula," Vistas in Astronomy, 13 (1971), 1.

associated with the guest star".[1] Stephenson has also traced the association of the Crab Nebula with the supernova of 1054. This subject and the supernova of 1106 are reviewed in his "Historical Observations of Supernovae" (1974). And as all those serious about comets were almost obliged to express an interest in the ever-popular Halley's Comet, Stephenson and Kevin K. C. Yau contributed their share in an article for the 1985 Journal of the British Interplanetary Society. Not only did they compile a comprehensive catalogue from the earliest observations in East Asia, but more importantly, strove to evaluate the accuracy of each observation. Apart from these articles, Stephenson, together with David H. Clark, have written a book that covers a remarkably broad canvas. Although according to the authors, the work is meant for non-specialists, it draws on all major Chinese records and secondary studies. Sivin commented in a review that, "along the way, the authors explain the East Asian records to astronomers and supernovae to Orientalists, and assess the theoretical significance of their findings. This labor is meticulously and sensibly performed. It concerns an issue of great contemporary astronomical concern, and provides clear and usable answers for the first time."[2]

Another researcher who has worked through Chinese accounts of comets and novae was Kiang. In 1971 he calculated the orbital periods of Halley's Comet, taking advantage of a host of data in Chinese collections such as the dynastic histories and the *Wen hsien t'ung kao*, and also in Western literature.

A problem resulting from the enthusiasm in applying historical Chinese observations to support efforts at identifying and studying comets and novae was that in the eagerness to come up with more and better information, too often not enough questions were asked. Among the few who did pause to ask and re-consider the reliability of the

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[1]According to Stephenson's interpretation, "their [i.e. Chinese and Japanese] observational evidence favours the identification of the star as a supernova of type I. It is proposed that the radio source 3C58 is the remnant of the new star": F. R. Stephenson, "A Suspected Supernova in A.D. 1181," Quarterly Journal of the Royal Astronomical Society, 12 (1971), 10.

[2]Nathan Sivin, rev. of The Historical Supernovae by David H. Clark, and F. Richard Stephenson, in Chinese Science, 4 (1980), 68.

route and the ultimate value of the goal was Cullen. His article "Can we find the Star of Bethlehem in Far Eastern records?" (1979) raises serious doubts concerning Clark, Parkinson, and Stephenson's claim that the Chinese recorded this bright nova as having appeared in 5 B.C.. And addressing the subject of comet observations in ancient China from a more contextual perspective is Michael Loewe's "The Han View of Comets" (1980). Instead of offering tabulations and computations, Loewe examined the contents of a Han manuscript unearthed at the Ma-wang-tui tombs in the 1970s -- the *T'ien wen ch'i hsiang tsa chan*, shedding light on such matters as "The place of the manuscript in Chinese astronomy and divination", "Chinese views of the origin of comets", and "The value and purpose of the manuscript" in addition to supplying the core section "Terms used to denote comets in (i) the manuscript and (ii) the Standard Histories".[1]

The long-standing Western interest in Chinese accounts of eclipses by no means faded from sight though attending works have obviously declined in sheer numbers in the 1960s, '70s, and '80s, seemingly nudged into the periphery by new research on comets, novae and supernaoae. With a few exceptions, Western publications on eclipses from these decades were lengthy works ranging from forty-eight to eighty-two pages.

In these studies, greater emphasis has been given to later periods. Awareness of motivating factors and influence of non-technical elements is also evident. One example is Karl-Heinz Reck's "Materialen zur Naturbeobachtung der Chinesen und Koreaner im 10-14 Jahrhundert" (1963). It contains a meticulously compiled list of solar eclipses from 911 to 1398 lifted from Chinese dynastic histories and Korean annals, and checked against other East Asian and Western sources. The list is -- as had been the practice in the past -- the point and heart of the study. But Reck also endeavoured to relate these reports to government actions statistically. The emperor and government officials also occupy a key position in Guy Van Esbroeck's (1971) attempt to understand what he termed the "so-called eclipse mentioned in the Shu King" -- the title of an article he submitted to the 1971 Le Muséon: Revue d'Études Orientales. His

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[1]Michael Loewe, "The Han View of Comets," Bulletin of the Museum of Far Eastern Antiquities, 52 (1980), 3, 4, 13, 14.

discussion is organised in terms of: "1. Chinese archaic chronology"; "2. The word *djyoen*"; "3. Exegesis of ancient recitatives"; "4. Stars and seasons"; "5. Dating the calendar rules"; "6. Restoring genuine recitatives"; "7. Proper use of the calendar"; "8. Doubts of former commentators"; "9. An eclipse brought about by mismanagement"; "10. Rendering archaic sounds"; "11. Full contexts"; "12. Star charts".

One tends to overlook conference papers -- which generally are short on in-depth analyses. But Hartner's (1975) paper for the 14th International Congress of the History of Science "on Shang-Yin eclipses, on the calendar and on the chronology, finally, on religious and social conditions of the earliest historic Chinese dynasty" is not to be missed.[1] Not only is it a corrective to former opinions, particularly those of Tung Tso-pin, Ch'en Meng-chia, and Dubs regarding early records of eclipses and the chronology of Shang, it represents unmistakably the sensitivities of a scholar who is as much at home with sinological concerns while examining oracle bone inscriptions as with interpreting astronomical data. Above all, evidence, materials, and assessments are presented and described concretely by tracing in detail the author's own reconstruction and search process. Some of Hartner's final views on eclipse observations from oracle bones and on establishing significant dates in Shang's history were expressed in L'astronomia all'alba della civiltà cinese (1977). Once again, much can be learnt from the author's incisive discussion and clarification of the problems involved, a reflection of his sinological as well as scientific acumen.

Amidst the apparent confidence in accurately dating historically important events in China's remote past using contemporaneous astronomical records, Keightley, like Cullen, sounded a note of caution to warn all and sundry. Aimed specifically at one of the conclusions drawn by Muller and Stephenson in their article "The Accelerations of the Earth and Moon from Early Astronomical Observations" regarding a solar eclipse from Shang inscriptions, Keightley's paper in the 1977 History of Science articulates some of his worries

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[1]Willy Hartner, "Some [*hsin wen*] about Shang-Yin," in Proceedings. . . 14th International Congress of the History of Science, Tokyo / Kyoto, 1974 (Tokyo: Science Council of Japan, 1974-75), vol. 4, pp. 3.

which range from the authors' success in grasping the context and contents of the text to the reasoning used in their computation.[1]

Two essays in the same issue of Monumenta Serica, one by Hartmut Walravens and the other by Alvin P. Cohen and Robert R. Newton, are directed at eclipse information from particular periods, and complement previous Western findings for the Shang, Han, Ming, and Ch'ing. Walravens' "Vorhersagen von Sonnen- und Mondfin Sternissen in mandjurischer und chinesischen Sprache" (1983) gives chronologically the details of solar eclipses (from 1669 to 1909) and lunar eclipses (from 1671 to 1909) including the texts in which they are situated. Occupying the second half of his article is "Ausgewählte mandjurische Texte" and "Übersetzung der texte". Cohen and Newton (1983) on the other hand, combed through the *T'ang hui yao*, *Chiu T'ang shu*, *Hsin T'ang shu*, *Wen hsien t'ung kao*, and *Yüan shih*, identified solar eclipses noted in the T'ang era, and performed a close dissection of the data.[2]

D. J. Schove and Ho have scrutinised Chinese notices of sunspots and aurorae in order to supplement previous Western accounts. Their first (1959) article covers 1048 to 1070 A.D., with translations from Chinese writings and comparisons with information from the same period furnished by other civilisations in order to help verify dating. The second study (1967) focuses on the fourth century. Translations are again supplied along with a diagram summarising the observations.

". . .the propitious combination of social and environmental conditions in China which led to the recording of historical observa-

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[1]Paul M. Muller, and F. Richard Stephenson, "The Accelerations of the Earth and Moon from Early Astronomical Observations," in Growth, Rhythms and the History of the Earth's Rotation, ed. D. Rosenberg, and S. K. Runcorn (London: Wiley, [1975]), pp. 489-534.

[2]This extended study is arranged topically into: "1. Introduction"; "2. Statements of Right Ascension"; "3. Analysis of the values of Right Ascension"; "4. Eclipses that were predicted but not seen"; "5. Recorded eclipses that were not observable"; "6. Observable eclipses that were not recorded"; "7. Eclipses with special remarks"; "8. Records that specify magnitude or visibility"; "9. The places of observation"; "10. Eclipses with the hour given"; "11. Discussion".

tions of sunspots and aurorae which is the subject of this essay."[1] Given such an opening statement, one anticipates a critical discourse. But J. Roger Bray's (1974) three-page essay on sunspots and aurorae is in fact a rather breezy and informal piece that contains such amusing remarks as: "A spotted deity was unthinkable, or perhaps worse than unthinkable, vulgar, rather like believing the ~~diety~~ deity had acne."[2]

Continuing their endeavour to give new prominence to East Asian astronomical materials, Clark and Stephenson (1978) compiled an analytic catalogue of pre-telescopic sunspot records from 28 B.C. to A.D. 1604 based on Chinese and Korean dynastic histories, in which "the historical data are used to investigate major excursions in solar activity during the past two millenia."[3] While such catalogues can no doubt serve important functions, we should also take heed of Cullen's reminder in his "Was there a Maunder minimum?" (1980) that traditional Chinese evidence must be handled and applied with due care. His short commmunication alerts fellow researchers to the fact that before any final conclusion regarding this period of apparently scanty sunpsot observations can be reached, we must search through a vast body of Chinese sources of varying nature and not put our trust overly in official documents.

Finally, two works on a kind of astronomical phenomena that had unique significance for the Chinese in early and medieaval times, but which may be unfamiliar to Western readers: "cloud" and "vapours". In A. F. P. Hulsewé's words, they "were mostly observed in the sky, close to the sun and the other heavenly bodies (although one reads very little about the latter), but also close to the surface of the earth. These phenomena are the *ch'i*, the cloud-vapours (sometimes

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[1]J. Roger Bray, "The Modern Use of Historical Chinese Solar Observations," in For Dirk Struik, (Dordrecht: Reidel, 1974), pp. 143.

[2]ibid.

[3]David H. Clark, and F. Richard Stephenson, "An Interpretation of the Pre-Telescopic Sunspot Records from the Orient," Quarterly Journal of the Royal Astronomical Society, 19 (1978), 387. The article is divided into: "Introduction"; "2. The historical records"; "The completeness of the historical sample"; "4. Protracted Minima"; "5. Comparison with the C history"; "6. Conclusion".

called emanations), visible signs and as such different from the "ethers" -- evidently invisible forces -- about which Professor Bodde has written"; and there were "no less than twelve vapour-watchers" within the Director of Astrology, functioning in much the same way as "star-watchers."[1] Material on instances and records of this activity especially in the Han period -- taken mainly from the Han shu and Shih chi -- were translated and discussed. Ho's (1985a) study on these signs in the sky and earth was prompted by his interest in a 10th century "arcane astrological handbook intended for military use" -- the Chan yun ch'i shu.[2] His account probes into the concept and practice of "reading military movements through the observations of clouds (*yun*) and vapours (*qi*)" as revealed in the handbook.[3]

5.5 ASTRONOMICAL INSTRUMENTS; SPHERICAL ASTRONOMY

In his "Les instruments astronomiques des chinois au temps des Han" published in 1938/39, Maspero notes that, "les études dont l'astronomie chinoise ancienne a été l'objet dans ces dernières années ont surtout cherché à déterminer l'étendue des connaissances astronomiques, ainsi que les théories relatives au système du monde, et à en faire l'histoire, plutôt qu'à en reconstituer les conditions techniques; en ce qui concerne les instruments d'observation en particulier, l'intérêt des savants s'est assez peu porté sur eux."[4] Compared to 19th and early 20th century Western writings on, for example, eclipse records or astronomical chronology, those on astronomical instruments were indeed far fewer, and the number of individuals involved was also much smaller.

The study Gaubil completed in 1734 on ancient Chinese gnomons and observations of sun-shadow lengths was published by Laplace in

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[1]A. F. P. Hulsewé, "Watching the Vapours: An Ancient Chinese Technique of Prognostication," Nachrichten der Gesellschaft für natur- und völkerkunde Ostasiens, 125 (1979), 40.

[2]Ho Peng Yoke, "A Long Lost Astrological Work: The Dunhuang MS of the *Zhan Yunqi Shu*," Journal of Asian History, 19 (1985), 2.

[3]Ho, "A Long Lost," 3.

[4]Henri Maspero, "Les instruments astronomiques des chinois au temps des Han," Mélanges Chinoises et Bouddhiques, 6 (1938-39), 183.

1809 as "Des solstices et des ombres méridiennes du gnomon observés à la Chine. . .". To complement Gaubil's work, Laplace wrote "Mémoire sur la diminution de l'obliquité de l'écliptique, qui resulte des observations anciennes" (1811) which makes serious use of Chinese initiatives as well as those from other civilisations. Their calculations were questioned by Needham, who argued that, "all these computations involve so many uncertainties -- the date, the place, the height of the gnomon, and the nature of the units of length -- that the high figure obtained by Gaubil and Laplace gave a fallacious appearance of precision."[1]

Among the few 19th and 20th century Western scholars who made noticeable attempts at puzzling out the famous instruments made by Kuo Shou-ching in the 13th century (e.g. the armillary sphere, simplified instrument, lofty gnomon) was Wylie. His presentation for the Congrès International des Orientalistes (1878) traces their history, significance, and workings, supported by comments and translations from Chinese texts such as the Yüan shih and Ch'ou jen chüan. J. L. E. Dreyer also sought to acquaint Western scholars with these instruments; his short account appeared in the 1877/83 Proceedings of the Royal Irish Academy.

Traditional Chinese sundials prompted only one special study in the 20th century. A stone sundial of 3rd century B.C. discovered in Honan in 1932 was described and its astronomical importance assessed by Williams C. White and P. M. Millman in 1938.

One of the classics on Chinese astronomical instruments (as well as on Chinese astronomy in general): Maspero's "Les instruments astronomiques des chinois au temps des Han", can be found in his Mélanges Chinoises et Bouddhiques (1938/39). Besides being remarkably well-documented, supplying a comprehensive and critical history of early Chinese astronomical instruments over the course of seven neatly laid out sections, this unique contribution also has the virtue, in Needham's opinion, of setting an example of "how the subject of Chinese astronomy should be treated."[2] Needham's own inquiries into gnomons, armillary spheres, sundials, and clepsydra

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[1]Science and Civilisation in China, vol. 3, pp. 290-91.

[2]Science and Civilisation in China, vol. 3, pp. 182.

types drew heavily from Maspero's findings, though (as all conscientious researchers should) he also cautioned that when dealing with armillary spheres, "in spite of his [i.e. Maspero's] great, and deserved, authority, one cannot assume that all his conclusions are reliable."[1] Another piece by Maspero on Chinese astronomical instruments was published posthumously in 1951. This chronological portrayal treats the origin and early phases of the instruments up to the 4th century.

Another scholar whose works are often cited in the section on astronomical instruments in Science and Civilisation in China vol. 3 is Henri Michel. Beginning with "Les jades astronomiques chinois: une hypothèse sur leur usage" in the 1947 Bulletin des Musées Royaux d'Art et d'Histoire, Michel issued a series of studies in the late 1940s, '50s and early '60s that has as their main subject a kind of jade discs which Michel contended were astronomical instruments.[2] Michel -- following the suggestion of Wu Ta-ch'eng and others -- called these objects *hsüan chi*, a term that soon gained general acceptance; (they were sometimes also called *pi*). To present his case that these were "circumpolar constellation templates" to be used together with sighting-tubes (*yü heng*), time and again the age and the way in which these objects were supposedly employed were rationalised and illustrated, calling into service Chinese documentary sources as well as opinions from Chinese and Western scholars such as É. Biot and Berthold Laufer. Michel's theses were not challenged until the early 1980s when Cullen and Anne S. L. Farrar heaped scathing criticisms upon them, and Bradley Schaefer remarked candidly and simply that "it is unfortunate that Michel's very beautiful theory is not true."[3]

When Michel first made his claim, he had at least one supporter. To complement Michel's essay in the 1948/51 Mélanges Chinois et

[1]Science and Civilisation in China, vol. 3, pp. 342.

[2]These works appeared in journals as diverse as Communications de l'Académie de Marine [Brussels] (1949), Popular Astronomy (1950b), and Oriental Art (1950). There is also a twenty-page monograph from 1959.

[3]Bradley Schaefer, "Chinese 'Astronomical' Jade Disks: The *pi*," Archaeoastronomy, 6 (1983), 101.

Bouddhiques Van Esbroeck submitted to the same issue two essays on the *hsüan chi*. The content of "Commentaires étymographiques sur les jades astronomiques" is exactly that described in the title, and the author's intention is to confirm the astronomical role and significance of these discs. "Les sept étoiles directrices" is a short communication summarising Van Esbroeck's own reading of a statement crucial to understanding what *hsüan chi* in fact refers to.[1]

Before moving on to other studies from the 1950s, a two-page communication from M. Destombes should be reported. His "Les observations astronomiques des chinois au Lin-yi" (1947) furnishes evidence of Chinese experience in observing shadow lengths in the 4th century using a gnomon.

Astronomical instruments from the Yuan dynasty received another round of close scrutiny in the 1950s, first by Hartner, then by Needham. Hartner's (1950) essay concentrates on seven terms and names given to instruments built in China probably by a Persian astronomer at the request of Kublai Khan and which were noted in the *Yüan shih*. In unravelling the terms Hartner improved our conception of the functions and value of these instruments as well as the complex inter-relationship between Chinese and Arabic astronomy during this period. In Needham's (1955) paper the emphasis is placed on the "simplified instrument" and equatorial mounting. The claim is made that, "the 'Simplified Instrument', essentially identical with the equatorial mounting of modern telescopes, was Kuo Shou-ching's modification of the earlier mediaeval Arabic and European instrument known as the torquetum. It was called 'simplified' because the ecliptic components had been removed, in accordance with the system of equatorial co-ordinates, classically Chinese, and adopted generally in the West after the time of Tycho Brahe."[2]

Besides Gaubil and Laplace, Hartner had also dwelt on measurements of the obliquity of the ecliptic provided by early Chinese astronomers. In a paper written in 1954 he confronted specifically

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[1]We have met with this statement from the *Yao tien* once already, in Cullen's "Some Further Points on the *shih*".

[2]Joseph Needham, "The Peking Observatory in A.D. 1280 and the Development of the Equatorial Mounting," Vistas in Astronomy, 1 (1955), 67.

those figures in the Hou Han shu, which he compared with calculations from Ptolemy.

Pooling their many and varied skills, established scholars Arthur Beer, Ho, Lu Gwei-djen, Needham, E. G. Pulleyblank, and G. I. Thompson focused on an account of the T'ang meridian survey in the Chiu T'ang shu. Their solidly researched study from 1961 is of great value to those interested in Chinese spherical astronomy, mathematics, and metrology. In addition to the first-rate, richly-annotated translation, relevant literature was appraised, problems and concerns regarding computation meticulously analysed, and the significance of the survey assessed.[1]

Finally, two works from the 1980s which are critical of Michel's scholarship and interpretations. Cullen and Farrer's (1983) account attacks Michel's (and others') speculation and explication regarding certain jade discs (called *hsüan chi*) which Michel tried desperately to prove were circumpolar constellation templates, arguing persuasively that these discs in fact had no connection at all with astronomy, and proposed that they be referred to by "purely descriptive terms 'flange trilobate disc' or simply 'trilobate disc.'"[2] Armed with sinological expertise, archaeological and literary evidence, the authors begin by systematically demolishing Michel's theories and laying bare a number of his errors and flaws.[3] They then seek "to analyse the individual stylistic features of the CFT [i.e. classic flanged tribolate], to examine their origin in stone and jade forms and to trace their subsequent evolution and assembly."[4] Schaefer, a physicist, approached the issue via a

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[1]For instance, that those Chinese involved with the survey "envisaged the earth's sphericity": Beer et al., "An 8th-century Meridian Line: I-Hsing's Chain of Gnomons and the Pre-history of the Metric System," Vistas in Astronomy, 4 (1961) 3.

[2]Christopher Cullen, and Anne S. L. Farrer, "On the Term *hsüan chi* and the Flanged Trilobate Discs," Bulletin of the School of Oriental and African Studies, 46 (1983), 76.

[3]For example, that Michel mistakenly relied on and misunderstood statements made by others, not least regarding the term *hsüan-chi*; that "he is unwilling to emend or omit passages when this serves to strengthen his argument": Cullen and Farrer, "On the Term," 62.

[4]Cullen and Farrer, "On the Term *hsüan chi*," 66.

totally different avenue. By using a computer programme that could search for possible sets of key stars of any epoch and then trying to match these stars to the indentations around the edge of the discs, Schaefer also reached the conclusion that these jade discs were not astronomical instruments since "Michel's key stars do not accurately fit the indentations on the *pi*."[1]

5.6 BIBLIOGRAPHICAL WORKS

Not a few titles treated in the above sections relied heavily on or made dedicated use of written Chinese sources, often providing useful bibliographic guidance to these materials. Temptations to prepare special bibliographic aids, however, were realised on few occasions. Of the many 19th and 20th century Western publications on Chinese traditional astronomy, only two were devoted expressly to reviewing and introducing writings on the subject.

Modern Scholarship on the History of Chinese Astronomy by Ho was published in 1977. Its first part offers a summary of 19th and 20th century Chinese, Japanese and Western historiographic trends, while the main body is a bibliography of Chinese, Japanese, and Western-language works mostly from the 19th and 20th centuries (up to 1976) alphabetically-arranged by author. It is hard to gauge the intention of the work as neither a strategy aimed at achieving comprehensive coverage nor one that would facilitate the critical selection and analysis of titles is evident. Moreover, at times the overview comes across as a narrative dotted with issues that the author feels strongly about or has been personally involved with, occupying more space in the historical account than their role would generally warrant.[2] We will take a close look at its bibliography section in *5.10: II. Specialised Bibliographic Sources*. Suffice to say here, one wishes that the bibliography could deliver more than it does. As

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[1]Schaefer, "Chinese 'Astronomical' Jade Disks," 100.

[2]For instance, different positions taken by Needham and the Japanese scholars Yabuuchi Kiyoshi and Nakayama Shigeru towards the function and historical importance of the Chinese calendar (*see* pp. 8-10) or Ho's own research on comets and novae (*see* pp. 14).

such the work should more fairly be viewed as a potpourri of reflections and observations accompanied by an extended list of titles selected from a personal collection rather than a guide that furnishes the reader with a balanced and complete picture. But once this is accepted, we can then appreciate this contribution on its own terms for what it is. For one, it affords a rare glimpse into some private anecdotes from one of the most prominent 20th century interpreters of traditional Chinese science. And given that there is not much else to fall back on, Ho's project can serve as the basis for subsequent work, heighten bibliographic concern, and inspire others to work on serious bibliographic aids which the field deserves and demands.

The other bibliographically oriented work is a notice from 1981 by Sivin "to inform readers of ARCHAEOASTRONOMY about the flood of important publications now appearing in the Chinese and Japanese languages."[1] Approximately sixty titles have been chosen, including books, articles, and essay collections (with separate entries for relevant papers).[2] "For the sake of concision and timeliness, important publications are simply listed, with essential bibliographical information but without characters; the titles of articles are given in translated form only. When titles do not indicate contents, brief descriptions are added."[3] There are also some critical remarks.

5.7 CONCLUSION

Writing in the late 1950s, Needham observed that, "one can readily see that everything which has been done in the West, from Gaubil to Saussure, has only touched on the fringe of the subject."[4]

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[1]Nathan Sivin, "Some Important Publications on Early Chinese Astronomy from China and Japan, 1978-1980," Archaeoastronomy 4 (1981), 26.

[2]Two books are in Japanese. Also listed are eight articles in English.

[3]Sivin, "Some Important Publications," 27.

[4]Science and Civilisation in China, vol. 3, pp. 209.

And in an article published in 1994, Jean-Claude Martzloff made the following passing comment regarding the "rudimentary character of what we know of the history of Chinese traditional astronomy": "Although much valuable work has been published on observational astronomy (catalogues of stars, novae, comets, etc.) not much is known of the computational aspect of Chinese predictive astronomy: the very important problems of the reconstruction of Chinese techniques of eclipse prediction and of the comparison of the results so obtained with the recomputations of past eclipses using modern astronomical theory still awaits investigation."[1] This may indeed reflect a sentiment shared by other scholars active in the field today, and can be a piece of disheartening news for to judge by the amount of rhetoric the subject has prompted over the past two centuries, the subject did not lack students or advocates, and the attainment of a more advanced level of understanding should perhaps have been expected. There is also no shortage of written as well as archaoelogical material waiting to be assessed.[2] But to say simply that work has been done does not necessarily mean that it has been done correctly or in the best possible manner or that there is little room for improvement and adjustment. Bear in mind, also, that traditional Chinese astronomy was a very complex activity involving "a number of strands -- the observational, the computational, the cosmological, the divinatory, the metaphysical, the mythological, the ritual -- emerging gradually, each at its own pace."[3]

So, what are we to make of all the two hundred forty or so studies that consumed the energy of a number of learned scholars and

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[1]Jean-Claude Martzloff, "Space and Time in Chinese Astronomy," Chinese Science, 11 (1993/94), 67.

[2]". . .the Chinese astronomical literature, though much more confused, scattered and fragmentary than that on mathematics, is probably rather larger, even apart from all losses. It is only equalled by the botanical-zoological-pharmaceutical literature, and only surpassed by the medical writings": Science and Civilisation in China, vol. 3, pp. 209. And, "Chinese astronomy is verbose. We do not wonder why astronomers in 100 B.C. or A.D. 1280 moved off in new directions; they tell us in detail": Nathan Sivin, "Science and Medicine in Imperial China: The State of the Field," Journal of Asian Studies, 47 (1988), 61.

[3]Sivin, "Science and Medicine in Imperial China," 63.

aspiring students over the decades? Did they generate more heat than light and not substantially expand our store of knowledge? Were the offerings too limited in scope and ambition or were they misguided? Were they once considered reliable and informative, but have within the last generation or two become hopelessly outdated?. It would be presumptious of me to claim that I am in a position to proffer answers to these questions, but summarising the patterns of research might provide some helpful orientations.

Chronology, the age and beginnings of Chinese explorations and knowledge of the heavens were deemed issues of great significance to the few Western scholars that studied the history of Chinese astronomy in the early half of the 19th century. A generation later, extracting records of eclipses (and other celestial events) from Chinese historical sources and the compilation of catalogues preoccupied those interested in the subject. They were also concerned with astronomical chronology and the *hsiu* system, and dabbled in various other areas (e.g. movement of the planets, calendars). At a time when most aspects of traditional Chinese science only had a handful of preliminary accounts to show, research into astronomy-related themes already gained considerable recognition by the end of the 19th century.

A few contributors continued to labour on Chinese records of eclipses, new stars, sunspots, etc. in the opening decades of the 20th century, but the spotlight was undoubtedly cast on de Saussure's life-long research into the fundamental and distinctive characteristics of Chinese astronomy, particularly the *hsiu* system, its origins and antiquity, and issues such as early Chinese cosmological theories.

The second quarter of the present century, which witnessed the publication of seminal works by Maspero, Eberhard, Chatley, Hartner as well as an array of writings from others, was an exciting and fertile period. New topics (e.g. cosmology, the Su-chou astronomical chart, astronomical instruments) were probed, and general works covering multiple areas were written, but Chinese observations of the planets, sun and moon, the *hsiu*, and astronomical chronology remained high on the list of priorities.

With the arrival of Science and Civilisation in China vol. 3, Ho's The Astronomical Chapters of the *Chin Shu*, Sivin's "Cosmos and Computation in Early Chinese Mathematical Astronomy" in the 1950s and '60s, and such works as Bielenstein's "An Interpretation of the Portents in the *Tsien-Han-shu*", it became more and more apparent that the direction of historical study was gradually shifting: although some old questions were still being asked (e.g. by Reck concerning eclipse information), answers were sought from less familiar quarters or supplemented with less conventional treatments by certain researchers. Above all, there arose an unprecedented enthusiasm to tackle and employ Chinese observational data of comets and novae.[1] In addition, Michel opened up the problem of astronomical jade discs.

Comets and novae continued to enjoy reasonable popularity well into the third quarter of the 20th century. Eclipse predictions and observations were also alive and attended to. Attempts were occasionally made to broaden the scope of inquiry and experiment with alternative methodologies, to extend and create new possibilities and dimensions. Consider, for instance, the different ways in which the *shih* was studied and interpreted, the fresh and stimulating inquiries by Teboul and Maeyama, and the bibliographic work by Ho.

Very often it is questionable wisdom to fault others for not taking paths that they had no intention of following or that led to places they do not wish to go. However, it is equally important that one be honest regarding past limitations and prejudices, even though in truth no one was fully conscious of them at the time. A brief summary of such limitations may include the following points.

First, given the size of the body of material, the aspects examined and the manner in which they are handled are not as broad and diverse as one might expect. Instead, there are areas of concentration, battlefields, and highly visible issues that were repeatedly studied and debated.[2]

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[1]But the assumption should not be made that interests in these categories of materials were unheard of before this period.

[2]For example, although much on the astronomical clockwork can be learned from the pioneering work done by Needham, Combridge, and others in their historical studies on horological and mechanical engineering, Chinese astronomical instruments -- whether singly or as a sub-field of Chinese astronomy -- have not been cultivated vigorously by Western scholars.

A related characteristic is the focus on specific episodes, periods, and texts, on filling in details, while considerably less energy was expanded on painting a broad picture or preparing comprehensive maps and overviews.

Third, searches for ever more Chinese observational data, whether concerning sunspots, comets, or eclipses, have long been regarded as an appropriate and valuable access to the history of Chinese astronomy, and were still conducted arduously well into the third quarter of the 20th century. The resulting studies concentrate on and emphasize the availability -- and in some instances, the accuracy -- of these historical records. Above all, they frequently seek directly or indirectly to relate the Chinese observations to modern Western systems of knowledge and astronomical events. These accounts are generally rich in textual or archaeological evidence and convincing in their demonstration of the immense historical value of the Chinese materials. However, more often than not, they pay little attention to the light the records can shed on the nature, functions, aims and evolvement of the Chinese astronomical tradition itself, on the actual techniques used in making observations, in computation and prediction; and further, on the scientific and cultural environment that helped generate those activities.[1]

This concern with chronicling could have stemmed largely from and been motivated by several considerations and perceptions of the Chinese records: (1) the earnest desire to demonstrate that the Chinese had long recognised, identified and registered various happenings in the heavens, often anticipating similar efforts and discoveries in the West; (2) to date historical events and periods in China's past by appealing to identifiable astronomical phenomena in Chinese sources; (3) and to make use of Chinese data to improve our understanding of world history and astronomy. This tacit assumption

[1]Asking, for instance, such questions as why, under what circumstances, and how were they compiled and maintained, what were the political, administrative, social and economic imperatives, the intellectual, philosophical and popular ideas and beliefs at work, existing scientific and technological knowledge (e.g. in mathematics and building technology), and above all, what was the relative importance of each set of elements and how did they all gel and interweave, ebb and flow in this multifaceted scientific enterprise which collectively is known now as traditional Chinese astronomy.

and agreement that all skills and activities are to be assessed according to modern Western scientific norms and procedures might have been responsible for the general lack of interest in providing an interpretative framework in which to make sense of and measure traditional Chinese creativity, knowledge and contributions on their own terms, in rendering it as an overriding objective to be systematically and critically pursued. It simply might not have crossed the minds of many that there could be other precepts and standards. Moreover, the confidence with which the Chinese recordings were presented might have misled one into assuming that the interpretation and selection of sources should not present too much problem, and not giving the proper Chinese contexts to ground these recordings further encouraged unsuspecting readers to accept all the data at face value.

Perhaps the time has come for us to ask ourselves the question whether we should let these and only these motivations and aims guide and influence research and writing on China's traditional astronomy.

5.8 PARTICIPATING COUNTRIES AND INDIVIDUALS

The field no doubt benefited enormously from the work of certain key figures who stood out by virtue of the frequency and / or originality of their publications. But traditional Chinese astronomy also attracted a number of other writers who contributed in perhaps a less significant manner. Thus, in the 19th century, although J. B. Biot and his son Édouard, Williams, Wylie, Edkins, Kühnert, and Schlegel were among the chief advocates, interests in the subject were shown unmistakably by Laplace, Abel-Rémusat, Kingsmill, Chalmers, Parker, etc. And in the present century, while de Saussure, Maspero, Eberhard, Chatley, Hartner, Dubs, Michel, Needham, Ho, Cullen, Sivin, Maeyama, Stephenson, and Teboul all pursued this area of study actively and laboured hard to produce the major works we spoke of above, it would not be fair to leave unrecognised contributions from, for instance, Rufus, Duyvendak, Lundmark, Rickett, Clark, Kiang, Harper, and Kalinowski.

The 19th century boasted a colourful crowd of participants. Pioneers in Oriental and Sinological studies were involved in greater or lesser degrees, names such as Abel-Rémusat, Édouard Biot, Wylie, Russell, Edkins, and Chavannes. The vast majority of them worked in China, some as missionaries (e.g. Wylie, Edkins, Pratt), others as government representatives (e.g. Davis was Governor of Hong Kong, Chavannes was an attaché at the French Legation in Peking, Hosie was in the China Consular Service), and in the case of Russell, a professor at T'ung-wen College. In addition there were scientists and astronomers such as Laplace, J. B. Biot, Williams, and von Oppolzer.

Continuing this trend, researchers from the first half of the 20th century included Sinologists with broad interests; one can give as examples Maspero, Eberhard, Dubs, and Erkes. There were also those from other fields: Chatley -- keenly interested in many areas of Chinese science and technology -- was an engineer by profession, de Saussure was originally a navigator, Lundmark worked at the Lick Observatory at Mount Hamilton, White was Keeper of the Far Eastern Collection at the Royal Ontario Museum, and Hartner left behind a trove of original works on various aspects in the history of Western as well as Chinese science.[1]

In the latter half of the 20th century, in addition to the participation from scholars in the main Chinese studies camp (e.g. Rickett, Keightley, Loewe, Porter) there was serious input from those trained in Western science and astronomy.[2] Above all, substantial efforts from Chinese historians of science (e.g. Needham, Ho, Sivin, Cullen) were critical to the advancement of the study of Chinese astronomy in the West.[3]

In the 19th century, French and British involvement was substantial, and they were largely responsible for determining the direction the field took during this period. These two countries conti-

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[1]Even Oort -- the famous Dutch astronomer who discovered comets -- expressed a passing interest.

[2]e.g. Michel was an engineer, Kiang worked at the Dunsink Observatory in Dublin, Clark at the Royal Greenwich Observatory, and Mullard Space Science Laboratory, University College London, Stephenson at the Department of Geophysics and Planetary Physics, School of Physics, University of Newcastle upon Tyne.

[3]Among other historians of science with publications in traditional Chinese astronomy were Goldstein from the Department of History of Science and Medicine at Yale University, and Maeyama at Frankfurt University's Institut für Geschichte der Naturwissenschaften.

nued to maintain a steady interest in the subject throughout the 20th century, but from the 1950s and '60s on, scholars from the U.S. displayed a strong presence, supplying a significant portion of the historical studies on Chinese astronomy.[1] Research from Germany, communicated chiefly through the works of Schlegel, Eberhard, Hartner, and Maeyama, was important.

And it would be a gross oversight not to point out that initiatives taken by individuals from other countries were impressive, including those by de Saussure and Hulsewé (Switzerland), Kühnert (Austria), Michel (Belgium), Duyvendak (the Netherlands), White and Millman (Canada), Ho (Malaysia and later Australia and Hong Kong), Bray (New Zealand), Bausani and Chessa (Italy).

5.9 FORMS OF PUBLICATION

Journals encountered most frequently in this chapter are those from the Chinese / Asian studies field. Chosen regularly in the second half of the past and throughout the present century -- mainly though not exclusively by those with a background in Sinology -- they are mostly mainstream titles such as the Journal of the Royal Asiatic Society, Harvard Journal of Asiatic Studies, Asia Major, Bulletin of the Museum of Far Eastern Antiquities, Oriens Extremus, Cina. Each periodical typically carried between one to three articles, except for the following titles: (1) China Review, with a series of short discussions and communications in the 1880s; (2) Journal of the North China Branch of the Royal Asiatic Society, which issued nine studies from 1866 to 1936 written by Wylie, Hosie, Kingsmill, Dubs, and Chatley; (3) Journal Asiatique, which was responsible for nine articles by de Saussure; (4) Monumenta Serica, which featured three articles in the 1930s and '40s, and two in the 1980s; (5) and above all, T'oung Pao which, in addition to providing fourteen of de Saussure's essays, published studies by Kühnert, Maspero, Duyvendak, Hartner, Sivin, and others over the course of the 20th century.

Periodicals on astronomy were also used fairly often. Connaissance des Tems (sub-titled "ou des mouvemens célestes, à l'usage des

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[1]Before 1950, the only contribution from the U.S. was that by Lundmark.

astronomes et des navigateurs") supplied works by Gaubil, Laplace, and Édouard Biot in the early part of the 19th century, while Monthly Notices of the Royal Astronomical Society presented nine accounts between 1855 and 1909. Among titles from the first half of the present century were Popular Astronomy, Journal of the Royal Astronomical Society of Canada, Publications of the Astronomical Society of the Pacific. Over twenty articles were published in astronomy periodicals in the post-1950 period (compared to over thirty in Chinese / Asian studies journals). The Quarterly Journal of the Royal Astronomical Society distributed four papers (between 1962 and 1979) and Archaeoastronomy three (between 1981 and 1983), but other titles were also represented.[1] Note that in spite of the large quantity of works in *5.3 Pole, equator and hsiu; star names and catalogues; calendrical and planetary astronomy*, only four accounts appeared in this type of journal, reminding one of variations in the journals used even among aspects within a single subject.[2]

Though obviously far from dominant, science as well as history of science journals played their modest part in the 20th century.[3] Once in a while one would come across other types of journals; for instance, Journal des Savants (1819, 1839, 1861), Baessler Archiv (1933), Past and Present (1980), but the range and number was surprisingly small.

The ten or so collective works and festscriften with articles on the Chinese astronomical tradition belong mainly to the Chinese /

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[1]Including, for example, The Observatory, Sky and Telescope, and Vistas in Astronomy.

[2]i.e. three in the Monthly Notices of the Royal Astronomical Society by Williams, Hind and Knobel respectively from 1855 to 1909, and one by Schafer in the 1977 Journal for the British Astronomical Association.

[3]Science journals include: Monatsberichte der Deutsche Akademie der Wissenschaften zu Berlin (1880), Revue Générale des Sciences Pures et Appliquées (1907), Physics Bulletin (1970), Philosophical Transactions of the Royal Society of London (A. Mathematical and Physical Sciences (1974), Nature (1936) (1969) (1979). History of science journal include: Bollettino de Bibliografia e di Storia delle Scienze Matematiche e Fisiche [Boncompagni's] (1868), Archives des Sciences Physiques et Naturelles (1907, 1919, 1923), Archives Internationales d'Histoire des Sciences (1976), History of Science (1977), Isis (1950), Chinese Science (1983).

Asian studies area.[1] Maeyama's 1977 work in Prismata: Naturwissenschaftsgeschichtliche Studien; festschrift für Willy Hartner, and Sivin's report in the 1979 Astronomy in China: A Trip Report of the American Astronomy Delegation are the only exceptions. There is also a limited number of conference papers.[2]

Eleven works were published in the form of monographs. Written in English, German, or French, and issued in the 19th as well as 20th century, they deal with different aspects of Chinese astronomy.

5.10 BIBLIOGRAPHIC PROVISION AND CONTROL

A. GENERAL BIBLIOGRAPHIES FOR CHINESE / ASIAN STUDIES AND THE HISTORY OF SCIENCE

(a) Henri Cordier, Bibliotheca Sinica. . . (1904-08); (1922-24):

The subject of astronomy is served primarily by "Sciences mathématiques" in the section "XII. Sciences et Arts".[3] For essays from the Monthly Notices and Memoirs of the Royal Astronomical Society, Journal des Savants, and Philosophical Magazine and other non-Chinese / Asian studies periodicals and works this bibliography should not be relied upon; but it offers access and control for those from material in the Chinese / Asian sphere, providing information on accounts in the China Review, Journal Asiatique, A Dictionary of the Chinese Language. . ., etc.

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[1]For instance, Morrison's A Dictionary of the Chinese Language. . . (1819), Études historique: mélanges posthumes sur les religions et l'histoire de la Chine (1951), Chinese Thought and Institutions (1957).

[2]The only four being contributions to the Congrès International des Orientalistes (1878), the International Congress for the History of Science (1975, 1959, 1975), the International Conference on Supernovae (1974), and the International Conference of Orientalists in Japan (1981).

[3]Kühnert's "Das Kalenderwesen bei den Chinesen" as well as "Der chinesischen Kalendar nach Yao's Grundlagen und die wahrscheinlich allmähliche Entwicklung und Vervollkommung desselben" are in "X. History - Chronologie"; Hosie's article on sunspots is in "V. Climat et Météorologie"; Abel-Rémusat's account on aereolites is in "VI. Histoire Naturelle - Géologie et Minéralogie".

(b) John Lust, Index Sinicus. . . , 1920-55 (1964):

Though not comprehensive, this index functions well as a source for papers from journals on Chinese and Asian studies, including that by Woitsch (in Das Licht des Ostens) which no other bibliographic guide indexed.[1] However, it lists only several (out of approximately two dozen) articles in other types of periodicals. In addition to "XVIII. Science and Technology - c. Astronomy and Calendar", other sections should be checked for relevant titles.[2]

(c) ISIS Cumulative Bibliography, 1913-65; 1966-75; 1976-85:

In this bibliography, the divisions under which the majority of titles on Chinese astronomy fall are: "F Astronomy"; "FP Stars and star clusters"; "FU Cosmology"; "FV Astronomical chronology"; "FW Calendar". Of Michel's nine articles on astronomical jade published between 1947 and 1962 ISIS entered all but the ones in Oriental Art and Mélanges Chinois et Bouddhiques. It is tempting to seize upon this instance as an example of ISIS' inadequacy in supplying items in Chinese / Asian studies journals. Certain works from this category of periodicals and essay collections were indeed omitted.[3] But one is just as obliged to recognise that a number of such titles did make their way into the bibliographies.[4]

With regard to articles from history of science, science, and astronomy journals, and also periodicals of a broad nature, ISIS is

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[1]The following titles somehow escaped Lust's notice: Hartner's contributions to Frühling und Herbst des Lü Bu-We and *Li Gi*, das Buch der Sitte des älteren und jungeren Dai, Eberhard's articles in the 1939 Orientalische Literatur-Zeitung and 1940 Monumenta Serica, Dubs' accounts in the 1951 and 1953 T'oung Pao.

[2]e.g. "III. History - b. History by Period" for several of de Saussure's studies, and "XVI. Archaeology and Fine Arts - e. Epigraphy" for Hopkins' "Sunlight and Moonshine".

[3]e.g. Asiatic Review (1938), T'oung Pao (1960), Early China (1979, 1981).

[4]e.g. Harvard Journal of Asiatic Studies (1936), Silver Jubilee Volume of the Zinbun-Kagaku-Kenkyūsyo (1954), Asien: tradition und Fortschritt (1971), Bulletin de l'École Française d'Extrême Orient (1983).

generally helpful.[1] Nevertheless, some important accounts, in particular earlier ones, failed to receive attention.[2] Except for the 1970 reprint of twenty of Eberhard's works and Lavier's Uranologie chinoise, all monographs on the subject published in the present century are listed.

(d) Bibliography of Asian Studies, 1936- :

This bibliography had the potential to be an excellent candidate to perform bibliographic control duties for our subject: so far as articles published since the late 1930s in Chinese / Asian studies journals and festschriften are concerned, oversights are relatively uncommon, and with the exception of Historical Supernovae and Uranologie chinoise, all other monographs -- including Hartner's account prepared for the Accademia nazionale dei Lincei -- were noted.[3]

But conscientious seekers of bibliographic information on material related to Asia would no doubt have realised over the decades that the Bibliography of Asian Studies must be supplemented. Even though it mentions Cullen's article in Past and Present, Ho's in Physics Bulletin, and Schafer's in Chinese Science, it does not per-

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[1]Relevant studies published in the 1920s up till the '80s in such periodicals and festchriften as the Revue Général des Sciences Pures et Appliquées, Osiris, Occasional Notes of the Royal Astronomical Society, Vistas in Astronomy, Ciel et Terre, Physics Bulletin, Prismata: Naturwissenschaftsgeschichteliche Studien; festschrift für Willy Hartner, Archaeoastronomy, Journal of the British Interplanetary Society, Past and Present are all listed. Chochod's "La notion du temps et le calendrier dans l'ancienne Chine" (Mecure de France) can only be located in this bibliography.

[2]e.g. Lundmark's "Suspected New Stars Recorded in Old Chronicles, and among Recent Meridian Observations" (1921 Publications of the Astronomical Society of the Pacific), de Saussure's "Origine babylonienne de l'astronomie chinoise" (1923 Archives des Sciences Physiques et Naturelles), Eberhard's "Das astronomische Weltbild im alten China" (1936 Naturwissenschaften), Needham's "Astronomy in Classical China" (1962 Quarterly Journal of the Royal Astronomical Society), Sivin's "History of Astronomy" (1979 Astronomy in China: A Trip Report of the American Astronomy Delegation), Stephenson's "Chinese Roots of Modern Astronomy" (1980 New Scientist), Cullen's "Was there a Maunder Minimum?" (1980 Nature).

[3]Omissions include, for example, studies by Duyvendak (1942 T'oung Pao), Van Esbroeck (1971 Le Muséon: Revue d'Étude Orientales), Paper (1974 Chinese Culture), Teboul (1981 Transactions of the International Conference of Orientalists in Japan), Ho (1985 Journal of Asian History).

form well for works in journals other than those from the Chinese / Asian field. Above all, the serious drawback and handicap posed by titles being placed routinely under subject headings other than "Science and Technology" simply cannot be ignored.[1]

(e) Bulletin Signalétique, 1947- :

This index is weak as a bibliographical source for articles on traditional Chinese astronomy from Chinese / Asian studies periodicals. The inclusion of studies from this group of journals -- even major titles such as Monumenta Serica, Oriens Extremus, T'oung Pao or Bulletin de l'École Françaies d'Éxtrême Orient -- was the exception rather than the rule. However, there are surprises such as Van Esbroeck's "The So-called Eclipse in the *Shu-King*" in the 1971 Le Muséon: Revue d'Études Orientale.

Articles in astronomy, history of science, and general science journals, on the other hand, are much better served.[2] Nevertheless, Paar, Ho and Parsons' study on the Crab Nebula (1972 Vistas in Astronomy) and Stephenson's essay on the Chinese roots of modern astronomy (1980 New Scientist) were overlooked as were Clark and Stephenson's "An Interpretation of the Pre-telescopic Sunspot Records from the Orient" and Cullen's "Can We Find the Star of Bethlehem in Far Eastern Records?" published in the 1978 and 1979 Quarterly

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[1]e.g. **(1)** Rickett's "An Early Chinese Calendar Chart: *Kuan-tzu*, III, 8 (*Yu kuan*)"; Walravens' "Vorhersagen von Sonnen- und Mondfin sternissen in mandjurischen und chinesischen Sprache"; Cohen and Newton's "Solar Eclipses Recorded in China during the Tarng Dynasty" in **"History"**. **(2)** Dubs' "The Date of the Shang Period"; Bielenstein's "An Interpretation of the Portents in the *Tsien-Han-shu*"; Michel's "Astronomical Jades" in **"General"**. **(3)** Eberhard's "Das astronomische Weltbild im alten China"; Hopkins' "Sunlight and Moonshine" in **"History and the Humanities"**. **(4)** Reck's "Materialen zur Naturbeobachtung der Chinesen und Koreaner im 10-14 Jahrhundert" in **"General and Miscellaneous"**. **(5)** Eberhard's "The Political Function of Astronomy and Astronomers in Han China" in **"Politics and Government"**. **(6)** Hulsewé's "Watching the Vapours: An Ancient Chinese Technique of Prognostication"; Kalinowski's "Les instruments astro-calendriques des Han et la methode *liu ren*" in **"Philosophy and Religion"**.

[2]For instance, one can find in the index articles from Philosophical Transactions of the Royal Society of London (A. Mathematical and Physical Sciences) (1974), Archives des Sciences Physiques et Naturelles (1975), History of Science (1977), Archaeoastronomy (1981, 1982, 1983).

Journal of the Royal Astronomical Society respectively. As always, the most efficient way to retrieve titles is through the annual subject index under "Chine". Alternatively, one can look under "II. Sciences et Techniques Physiques - C. Astronomie".

(f) Revue Bibliographique de Sinologie, 1955-70; 1983- :

Studies on Chinese astronomy have been placed consistently under the "Histoire des Sciences" section. The review began in 1955, but Western scholarly interest in this subject area was at a relatively low ebb in the 1950s and '60s. Publication was suspended between 1971 and 1982 -- a decade during which the West paid considerable attention to Chinese traditional astronomy.[1]

Nevertheless, during those years that the Revue was active, nearly all relevant articles from Chinese / Asian studies periodicals were reviewed.[2] The bibliography's coverage of astronomy, history of science, and general science periodicals is much less adequate. As to monographs, only The Astronomical Chapters of *Chin Shu* and Les premières théories planétaires chinoises were selected.

(g) Tōyōgaku Bunken Ruimoku, 1963-:

Its special section "Astronomy and Calendar" provides good information on studies in Chinese astronomy from Chinese / Asian journals.[3] As with the Bibliography of Asian Studies, one has to turn elsewhere for writings published in other types of journals. As for Western monographs that appeared between 1963 and 1985, this Japanese index failed to include the ones by Ho, Eberhard, Hartner, and Lavier.

II. SPECIALISED BIBLIOGRAPHIC SOURCES

Two special compilations have played a significant role in the

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[1]Three books, for instance, were issued in 1977.

[2]Yet oddly enough, although Cohen and Newton's article in the 1981/83 Monumenta Serica received an entry, Walravens' from the same volume did not. Similarly, it lists Ho's paper in the 1985 Journal of Asian History, but not his other one in the 1969 volume of the same journal.

[3]For a period of over twenty years (i.e. from 1963 to 1985) only items from the 1969 Journal of Asian History, 1971 Le Muséon: Revue d'Études Orientale, 1979 Cina, 1980 Journal of Oriental Studies, and 1982 Bulletin de l'École Françaies d'Éxtrême Orient were left out.

bibliographic control of Western literature on traditional Chinese astronomy: "Bibliography C" in Science and Civilisation in China. Vol. 3: Mathematics and the Sciences of the Heavens and the Earth (1959), and Modern Scholarship on the History of Chinese Astronomy by Ho (1977).

Science and Civilisation in China vol. 3's "Bibliography C: Books and journal articles in Western languages" provides approximately a hundred titles devoted primarily to traditional Chinese astronomy, including books, articles from all kinds of journals, essays from festscriften, etc. from the 18th, 19th, and 20th centuries (up till 1957). For older works, this bibliography is remarkably thorough.[1] Ever since its appearance over three decades ago it has been regarded as indispensable for those patient enough to pluck out relevant entries on astronomy among fifty-nine pages of titles in small print on a kaleidoscope of topics.

Elsewhere we have spoken of Modern Scholarship on the History of Chinese Astronomy's introductory section and overall contribution. Here we will concentrate more single-mindedly on its bibliographic function and whether it is fair to regard it as a comprehensive and / or critical aid to Western material that the field would very much have welcomed in 1977 (and still lacks now).

First, a few words on the bibliography's basic features. Anyone with a copy of this guide would have available at his finger-tips the bibliographic information of almost two hundred and fifty Western-language, eighty Chinese, and seven Japanese studies, all of which are related to a greater or lesser extent to Chinese astronomy. Chinese and Japanese titles carry English translation, and charac-

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[1]Nevertheless, some of the less important titles are not given. For example, most of the short exchanges in China Review in the 1880s; Woitsch's "Die Astronomie der Chinesen"; Lübke's Der Himmel der Chinesen; Sowerby's "Astronomy in Ancient China"; several papers by Eberhard (e.g. "Sternkunde und Weltbild im alten China", "Der Beginn der Dschou-Zeit: Ein Beitrag zur Geistesgeschichte der Han--Zeit", "Sinologische Bemerkungen zu den türkischen Kalenderfragmenten"); Chatley's "Further Notes on Ancient Chinese Astronomy" and his "Chinese Planetary Observations"; Chochod's "La notion du temps et le calendrier dans l'ancienne Chine".

ters are placed conveniently next to romanisations.[1] Almost all titles bear a 19th or 20th century publication date.[2] Entries are organised alphabetically by author, and under each author, in reverse chronological order.

In a review of the work, Thatcher E. Deane indicated three advantages Ho's bibliography has over that in Science and Civilisation in China vol. 3, namely, "more portable and affordable", "conveniently isolates bibliography for Chinese astronomy", and "gives full journal titles, at least in romanization, instead of countless abbreviations."[3] Ho indeed deserves a round of applause for providing an alternative to Needham's bibliographic listing.[4]

It is therefore regrettable and disappointing to find the work marred by some serious shortcomings. It was criticized by Deane for its omission of major titles, its lack of annotation, and its "editorial inconsistency" (which he considered "obtrusive").[5] He gave as examples three important Western and two Chinese titles which Ho ignored, and warned that there might be more. There indeed are more. Ho's compilation was probably based on "Bibliography C" in Science and Civilisation in China vol. 3, judging from the editorial errors it carried over, and its giving only the beginning page number after the Science and Civilisation in China fashion for most of the entries published before 1959. Yet over ten Western-language titles listed in Science and Civilisation in China vol. 3 -- including some seminal

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[1]But curiously, only romanisations are supplied for Chinese and Japanese journal titles.

[2] The earliest item listed is "Annotations breves in antiquissimam observationem astronomicam scilicet notabilem illam conjunctionem planetarum quae sub Chuen-Hio, Sinarum Imperatore, facta perhibetur" by C. Kirch in the 1727 Miscellanea Berolinesia ad Incrementum Scientiarum, and the latest is R. R. C. de Crespigny's Portents of Protest in the Later Han Dynasty from 1976.

[3]Thatcher E. Deane, rev. of Modern Scholarship on the History of Chinese Astronomy by Ho Peng Yoke, in Chinese Science, 5 (1982), 44,

[4]Note, however, that as the work is in a series of "Occasional Papers" from the Australian National University's Faculty of Asian Studies, one cannot rule out possible difficulties in acquiring or locating a library which owns a copy of the monograph.

[5]Deane, rev. of Modern Scholarship, 43.

works in the field -- received no entry.[1] A further dozen or so studies between 1959 and 1976 failed to make their appearance.[2] As Deane remarked, "if these omissions were deliberate, the reader is left to guess the reason, since the introduction gives no criteria for the selection of items."[3] The bibliography is also spoilt by misprints and careless editing. Examples abound; some inconsequential, and others quite arresting: incorrect or lack of date of publication and / or journal page numbers, entries under the same author not strictly according to reverse chronological order, absence of English translation in some Chinese and Japanese titles, and typographic errors.[4] Moreover, these bibliographic flaws are not compensated by the provision of subject access or annotations -- major assets to any bibliography. Given the availability of other sources (e.g. the ISIS cumulative bibliographies) to cross-check and acquire titles, it is not unreasonable for users to expect the compilation to have done more bibliographically than it does.

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[1]e.g. Biot's "Précis de l'histoire de l'astronomie chinoise", Chatley's "Ancient Chinese Astronomy", Eberhard's "Chinesische Volkskalender und buddhistisches Tripitaka", Dubs' "The Date of the Shang Period".

[2]e.g. Needham's "The Peking Observatory in A.D. 1280 and the Development of the Equatorial Mounting", Michel's "Le plus ancien instrument d'astronomie, le *pi*", Cullen's "A Chinese Eratosthenes of the Flat Earth: A Study of a Fragment of Cosmology in *Huai Nan Tzu*", Maeyama's "On the Astronomical Data of Ancient China (ca. -100 -- +200): A Numerical Analysis".

[3]Deane, rev. of Modern Scholarship, 43.

[4]e.g. Abel-Remusat's "Catalogue des bolides et des aerolithes observées à la Chine et dans les pays voisins, tirés des ouvrages chinois" was published in 1825 -- not "1925" as given, and Wylie's "Notes of the Opinions of the Chinese with regard to Eclipses" in 1866 -- not "1966"; one finds "1,000 B.A." in Dubs' "Canon of Lunar Eclipses for Anyang and China, 1400 B.C. to 1,000 A.D."; the first page of Hosie's "Sun-Spots and Sun-Shadows Observed in China, B.C. 28 to A.D. 1617" should be 91 -- not "51"; Kühnert's "Über die von den Chinesen 'Te-sing' oder Tugendgestirn genannte Himmelserscheinung" was published in no. 110 -- not "100" -- of the Sitzungsberichte der mathematisch-naturwissenschaften Klasse der kaiserlichen Akademie der Wissenschaften [Wien]; two of Kühnert's contributions are in the wrong chronological order; Tasaka Kodo's "Seiyo rekiho no Tozen to kaikai rekijo no unmei" does not carry an English translation.

III. CONCLUSION

None of the bibliographic aids mentioned has managed to provide near comprehensive coverage for the years that it covers. Furthermore, there are works not registered by any of them.[1] Nevertheless, on the whole, the level of bibliographic control cannot in fairness be labelled as dismal in the sense that by checking different bibliographies diligently and regularly, someone from the 20th century -- especially after the 1950s -- can keep abreast of a decent amount of new publications and compile a good preliminary working list.[2]

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[1] e.g. Sivin's "History of Astronomy" in Astronomy in China: a Trip Report of the American Astronomy Delegation (1979), Stephenson's "Chinese Roots of Modern Astronomy" (1980 New Scientist), Cullen's "Was there a Maunder Minimum?" (1980 Nature), Lavier's Uranologie chinoise (1985).

[2] But the need to consult more than one or two sources cannot be over-emphasized. As the examples given above have demonstrated, each bibliography leaves out studies even in journals from subject fields to which it is dedicated, and some publications can only be located in a particular index.

CHAPTER 6 : EARTH SCIENCES

Drawing the perimeter for this chapter is not easy. The first complication arises from the use of the term "geography", which sometimes can be used interchangeably with the term "earth sciences". There is an intriguing ambiguity in the traditional Chinese conception of "*ti li*" -- commonly translated as "geography". Moreover, those writings that are known generically as Chinese geographical texts and treatises (e.g. the chapter *Yü Kung* in *Shu ching*, the *Shan hai ching*, and local gazetteers) typically cover an amazing array of topics of extremely diverse nature.[1] Science and Civilisation in China vol. 3 lists six sub-divisions under "Geographical classics and treatises", but they include a hotch-potch of literature and texts.[2] Rémy Mathieu, when commenting on the principal classes of writings of ancient Chinese geographers, also did not spell out the definition for "traités de géographie", and only gave examples of these treatises.[3] A scholar who did articulate and explain the confusions with terminology and concepts admirably was Kazataka Unno. His article "The Geographical Thought of the Chinese People: With special reference to Ideas of Terrestrial Features" also traces the changes in the classification of books that are supposed to deal with *ti li*.[4]

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[1]For further discussions on the nature of these geography works, *see*, for example, Chen Cheng-siang, Geographical Evaluation of the Chinese *fang-ch'ih*, and Otto Mänchen-Helfen, "The Later Books of the *Shan-Hai-King*".

[2]The six categories are: "(1) Ancient writings and official histories"; "(2) Anthropological geographies"; "(3) Descriptions of southern regions and foreign countries"; "(4) Hydrographic books and descriptions of the coast"; "(5) Local topographies"; "(6) Geographical encyclopaedias".

[3]The four classes mentioned in his "Fonctions et moyens de la géographie dans la Chine ancienne" are: "la toponymie"; "les traités de geographie"; "les calculs géodesiques"; "la cartographie".

[4]In the section "The Double Sense of Ti-li" Unno informs us that, ". . . the same word *ti-li* came to be used in category headings for works of different content. As mentioned earlier, *ti-li* as a term means none other than the true state of things on earth; but which aspect of the true state of things will be perceived is a question to be decided by the orientation of the interests of the

The term "geography", then, is much too broad and loose for our purpose, encompassing many topics from human geography, economic geography, regional customs, to travels and explorations. More appropriate is "earth sciences", a term and concept that is more focused, and which indicates more clearly a close association with the sciences and technologies. And it is with this distinction in mind that the term "earth sciences" is chosen as the chapter title and the following two categories of literature excluded from our discussion. First, works concerned with travels and voyages made within and outside China or with discoveries and explorations of foreign lands.[1] Second, studies of place names, including such issues as origins, identification, and changes.[2] So have studies such as Benjamin A. Elman's "Geographic Research in the Ming-Ch'ing Period".[3]

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term's user. When Pan Ku or Chia Tan used the word *Ti-li chih*, they undoubtedly had in mind a description of the land to be utilized as material for political and military operations; whereas for the geomancer, there is no question but that *ti-li* was the very appearance of the land, as a means of deciding the sites of house or graves. . . . In any event, it must be concluded that the concept of *ti-li* in Chinese popular society was ambiguous and vague, and that the meaning of the word was different in its administrative and popular usage": Kazataka Unno, "The Geographical Thought of the Chinese People: With special reference to Ideas of Terrestrial Features," The Memoirs of the Tōyō Bunko, 41 (1983), 86-87.

[1]For example: W. F. Mayers, "Chinese Explorations of the Indian Ocean during the 15th Century"; A. C. Moule, "Hang-chou to Shang-tu, A.D. 1276"; Paul Pelliot, "Notes additionelles sur Tcheng Huo et sur ses voyages"; Kenneth Ch'en, "*Hai-Lu*: Fore-runner of Chinese Travel Accounts of Western Countries"; J. J. L. Duyvendak, China's Discovery of Africa; *Ying-yai sheng-lan*: "The Overall Survey of the Ocean's Shores"; Translated from the Chinese Text edited by Feng Ch'eng-chun, with Introduction, Notes and Appendices by J. V. C. Mills.

[2]For example: E. Chavannes, "Documents historiques et géographiques relatifs à Lichiang"; Gabriel Ferrand, "Le K'ouen-Louen et les anciennes navigations interocéaniques dans les mers du sud"; M. C. Hagnenauer, "Le Lieou-k'ieou kuou du Souei chou était-il Formose?"; Louis Hambis, "Survivance de toponymes l'époque mongole en Haute Asie"; D. D. Leslie and K. H. J. Gardiner, "Chinese Knowledge of Western Asia during the Han"; Herbert Franke, "Nichtchinesische Ortsnamen in Quellgebiet des Huang-Ho nach der aufzeichnungen der Expedition unter Qubilai 1281".

[3]Elman's article is a fine example of a work on geography rather than earth sciences. Although this paper summarises the development of cartography in China from the Han maps to the Jesuit maps of the 18th century, much attention is paid to such themes as the importance

The other thorny issue concerns cartography. J. V. Mills commented in 1954 that "the development of extant Chinese maps may conveniently be studied in three periods. In the first period, A.D. 801 to 1584, the maps were purely Chinese compositions. . . . In the second period, 1584 to 1842, Jesuit influence was pre-dominant. Father Ricci's world-map of 1584, based on European models, for the first time indicated the meridians of the sphere. Chinese cartography now pursued two different courses: on the one hand the maps of the K'ang Hsi Emperor (1717-21) and the map of Li Chao-Lo (1832) were constructed on scientific principles, while the world-map of Huang Ch'ien-Jên (1767) and the map of the empire composed by Chu Hsi-Ling (1819) were fanciful misrepresentations in the Chinese style. In the third period, after 1842, scientific principles gradually triumphed. The opening of China effected a major revolution in Chinese cartography. . . ."[1] While the inclusion of writings on the "first period" and the exclusion of those typical of the "third period" is fairly obvious, taking into account the "second period" is more open to debate. Cartography in China after the arrival of the Jesuits in the 16th century has been extensively studied. It is, for instance, treated with erudition and enthusiasm in Science and Civilisation in China vol. 3 under the heading of "The coming of Renaissance carto-

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of gazetteers as vehicles for "collection and recording materials on historical geography", geography and military strategy, the knowledge of foreign nations, the *k'ao cheng* movement and geography during the 17th century: Benjamin A. Elman, "Geographic Research in the Ming-Ch'ing Period," Monumenta Serica, 35 (1981/83), 4. Elman argues in his conclusion that, "relying on systematic gathering of materials that they would then critically scrutinize and in some cases even quantify, Ch'ing scholars combined evidential research methods with data collection and organization. As research pushed forward in the seventeenth century, geography became a key discipline. Despite the internal turn of this research away from concern with foreign lands, achievements in geographical knowledge during this period were most evident in the areas of military defense and historical and descriptive geography": Elman, "Geographic Research," 17.

[1]J. V. Mills, "Chinese Coastal Maps," Imago Mundi, 11 (1954), 152. Note that Mills wrote this paper before the Han maps, which put the date of the earliest extant Chinese maps back to the second century B.C., were discovered.

graphy to China".[1] Based on Needham's review, it appears that works that discuss maps drawn with the help of scientific principles brought by the Jesuits are not concerned with distinctively Chinese cartographic concepts, techniques and traditions. They are therefore not represented in this chapter.[2] Studies that seek primarily to

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[1]"In 1583 Matteo Ricci. . . was asked by Chinese scholarly friends, especially Wang Phan, to prepare for them a map of the world. This was the beginning of his famous world-map (*Khun Yü Wan Kuo Chhüan Thu*) of 1602. . . . Ricci's map has been carefully analysed by Baddeley and Heawood, while the text on it has been fully translated by L. Giles and Goodrich. There has been much discussion as to Ricci's Chinese sources, and his influence on subsequent Chinese cartography has been described by Chhen Kuan-Shêng and Hummel. To Bernard-Maître we owe an exhaustive discussion on all aspects of Chinese geography in the +17th and +18th centuries, which, however, belongs to the history of science in general rather than to that of the characteristic Chinese contributions. Subsequently the art and science of map-making was cultivated by several of the Jesuits - Saniasi's 'Ricci-type' map of +1648 has been described by Mills, and Verbiest's stereographic projection map of +1680 by Ahlenius. . . . Great geographical and cartographic activity took place in the Khang-Hsi reign-period (+1662 to + 1722). . . . an elaborate programme of work has led to the Khang-Hsi Jesuit Atlas, the *Huang Yü Chhüan Lan Thu*, which has been reproduced and exhaustively studied by Fuchs. The original idea seems to have been that of Jean François Gerbillon. . . . The Jesuit who bore the chief responsibility was Jean-Baptiste Régis. . .; among his assistant were Joachim Bouvet. . . and Pierre Jartoux. . ., together with Chinese scholars such as Ho Kuo-Tung. . . . The history of this period would have to deal, not only with the bringing of Renaissance cartography to China, but also with the advances made by Western geographers in knowledge of Asia which the new access to Chinese sources permitted. . . . Meanwhile the stream of Chinese geographical scholarship continued. In the +17th century fine contributions were made such as the *Thien Hsia Chün Kuo Li Ping Shu* (Merits and Drawbacks of all the Countries in the World) by Ku Yen-Wu. The following century produced a very great work, the Chhien-Lung Atlas of China. This was based on Jesuit surveys carried out between 1756 and 1759. . . . Much of the surveying was done by Felix da Rocha. . . and Joseph d'Espinha. . ., while Michel Benoist. . . worked on the cartography at Peking. A good 'Geography of the Empire' (*Chhien-Lung Fu Thing Chou Hsien Chih*) appeared in +1787, and a "Historical Geography of the Sixteen Kingdoms' (i.e. +5th century) (*Shih Liu Kuo Chiang Yü Chih*) in +1798, both by Hung Liang-Chi. But all this lies outside the scope of the present book": Science and Civilisation in China vol. 3, pp. 583-86.

[2]For example: J. F. Baddeley, "Father Matteo Ricci's Chinese World Maps, 1584-1608"; Lionel Giles, "Translations from the World Map of Father Ricci"; Henri Bernard-Maître, "Les étapes de la cartographie scientifique pour la Chine et les pays voisins (depuis le XVIe jusqu'à la fin du XVIIIe siècle)"; Walter Fuchs, Die Jesuiten-Atlas der Kanghsi Zeit; China und die Aussenlaender; B. Szczesniak,

describe and solve problems associated with the various editions of maps rather than the cartographic content of the maps themselves are also excluded.[1]

6.1 GENERAL WORKS

Eduard Erkes' "Das Weltbild des *Huai-nan-tze*" (1917) gives a meticulous translation of Book / Chapter 4 of Huai nan tzu -- a complex early text with valuable information on various aspects and notions concerning the earth's surface. The article addresses more than one area of the earth sciences in that Erkes' commentaries furnish important clues to different elements in early Chinese perception and understanding of the earth's relief features, the stones and mineral substances found in the earth's crust, etc.

But on the whole, Western historians preferred to pay piecemeal attention to traditional Chinese approaches to the earth sciences and rarely attempted broad characterisations that encompass several subfields.

The only general history available to us is that supplied by various sections in Science and Civilisation in China vol. 3: "21. Meteorology"; "22. Geography and cartography"; "23. Geology"; "24. Seismology"; "25. Mineralogy". Published in 1959, certain parts are obviously in need of up-dating in the light of new discoveries and re-orientations. Nevertheless, Needham's study still remains the only Western work that embraces almost every branch of the earth sciences, and is thus an irreplaceable source of information and

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"The Description and Map of Kansu by Giovanni Battista Maeoletti de Seviavalle"; H. M. Wallis, and E. D. Grinstead, "A Chinese Terrestrial Globe, 1623".

[1]Walter Fuchs had devoted considerable attention in the 1930s and '40s to the Ming / Mongol atlas. Scholarly and thorough as his studies are, utilising Chinese, Japanese, and Western materials, they are nevertheless directed at scrutinising and tracing the evolution of the numerous editions of this atlas scattered in Chinese historical sources and in collections round the world (as well as the references made to them by different scholars) rather than at comparing the map's features in different versions, and the ways in which they were drawn.

reference. Section 21, which is subsumed under "The Sciences of the Heavens" department together with sections on astronomy, includes: "(a) Introduction"; "(b) Climate in general"; "(c) Temperature"; "(d) Precipitation"; "(e) Rainbows; parhelia and spectres"; "(f) Wind and the atmosphere"; "(g) Thunder and lightning"; "(h) The aurora borealis"; "(i) Sea tides". Sections 22 to 25 are grouped together as "The Sciences of the Earth" and occupy a total of 183 pages. Within Section 22, "(b) Geographic classics and treatises" is further broken down into six major categories, while "(d) Quantitative cartography in East and West" receives considerable attention, with the historical evolution in China examined in close relation with that in the West.[1] Aspects and themes explored in all sections are characterised by frequent reference to a kalaidoscope of Chinese historical records and literature, aimed chiefly at demonstrating and documenting the richness of Chinese traditional knowledge in the earth sciences -- a hallmark of the Science and Civilisation in China series.

In D. C. Twitchett's opinion, "the section on geography and cartography is. . . extremely interesting."[2] He found it "difficult, however, to accept Dr. Needham's suggestion (p. 576) that Shen Kua's use of 'the twenty-four directions' refers to compass bearings, although he knew of the magnetic compass. The further hypothesis that Shen's *Shou-ling t'u* was something like a Portolan chart seems pure fantasy."[3] He also commented in some detail on surveying techniques, especially with regard to their use at the government and local levels, and how that was affected by "the methods of communica-

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[1]"(2) Scientific cartography; the interrupted European tradition" and "(3) Religious cosmography in Europe" deal exclusively with the situation in Europe. Other topics and issues explored in this sub-section include: "(4) The role of the navigators"; "(5) Scientific cartography" (which surveys the scene from the Ch'in and Han period down to Yuan and Ming); "(6) Chinese sailing charts"; "(7) The role of the Arabs"; "(8) Religious cosmography in East Asia".

[2]D. C. Twitchett, rev. of Science and Civilisation in China vol. 3, in Bulletin of the School of Oriental and African Studies, 25 (1962), 187.

[3]ibid.

tion of new knowledge in traditional China."[1] However, other reviewers of vol. 3 (e.g. Bodde, Loewe, Sivin) gave only passing remarks to sections on the earth sciences, and very few words indeed were said of topics not related to cartography. They preferred instead to concentrate on mathematics, astronomy, and the volume's overall message and general approach.[2]

6.2 METEOROLOGY

Needham remarked in 1959 that he knew "nothing in any Western language on the history of meteorology in China except the paper of Chu Kho-chen which is very brief. Nor is there any monograph in Chinese specifically devoted to the subject."[3] This is indeed the case if one takes that to mean surveys of a comprehensive nature that span the centuries and treat all areas of meteorology. Western works on individual aspects are, however, available.

In his two articles in Journal Asiatique -- one on temperature (1840) and the other on climate (1849), Édouard Biot seeks to provide evidence of early Chinese efforts at understanding activities in the earth's atmosphere as well as to contribute fresh data to the historical study of climatic changes in the world. Information was taken from Chinese sources, especially compilations such as the 13th century *Wen hsien t'ung k'ao*. His short essay "Note sur un phénomène de mirage indique par quelque textes chinois" (1848) supplies, as the title indicates, Chinese views of the phenomena.

A. Hosie, inspired by the tabular forms of Indian famine lists, published in 1878 a chronological list of droughts in China from 620 to 1643 according to the *T'u shu chi ch'eng*. A similar but much shorter list on floods, also by Hosie, appeared in the 1879 China Review. Though no analysis or commentary accompanies these registers, they display an awareness of the abundance of Chinese meteoro-

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[1]Twitchett, rev. of Science and Civilisation in China vol. 3, 188.

[2]Could it be that fewer scholars were interested in the earth sciences? Or was it that these sections ruffled fewer feathers?

[3]Science and Civilisation in China, vol. 3, pp. 462.

logical records.

In the 1920s, two British Sinologists, Herbert A. Giles and A. C. Moule examined traditional Chinese understanding of the bore and tidal theory. Giles (1921) approached the subject by focusing on a particular character's usage and the phenomena associated with the word. Moule (1923), on the other hand, translated and summarised a variety of passages which describe and which can serve to illuminate Chinese ideas on the cause of the bore on the Ch'ien T'ang River.[1]

In a paper for the 20th Congress of Orientalists and published in the 1939 Le Muséon; Revue d'Études Orientales, B. Belpaire throws light on some traditional notions regarding thunder by drawing on T'ang folklore (e.g. that in the novel *Feng shen yen i*). His study, a large portion of which consists of translations, is divided into: "I. Composition sur le 'Peuple du tonnerre' (Lei Min)"; "II. Tchang-Keou"; "III. Li Joung"; "IV. Le sanctuaire de Lei Kong"; "V. Le Remède du tonnerre"; "V. La Hache du tonnerre".

Works from the 1940s ranged from Karl August Wittfogel's multi-faceted study of meteorological records inscribed on Shang oracle bones, Yao Shan-yu's analysis of materials on floods and droughts, to a review by D. Justin Schove on data on precipitations presented in secondary Western literature.

Wittfogel's (1940) in-depth inquiry, based on over 14,500 pieces of oracle bone from sixteen collections, covers a number of different issues: "Climatic change in human times"; "Meteorologic content of the inscriptions"; "The calendar and seasons of Shang"; "Origin and method of investigation"; "The rainfall data"; "Analysis of the meteorological table"; "Structure of the meteorological table"; "The agricultural year"; "The political year"; "A 'little' calendar of Shang"; "The fossil bones of Shang". There are also three appendices on sources used in tables of the meteorological year, the agricultural year, and the political year respectively.

Armed with evidence derived from collected works such as the *T'u*

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[1]Appendix I gives the Chinese text of the more important passages; Appendix II is a translation of extracts from the *T'ang kuo shih pu*; Appendix III lists about twenty modern Western accounts of the bore.

shu chi ch'eng Yao observes in his "The Chronological and Seasonal Distribution of Floods and Droughts in Chinese History 206 B.C. - A.D. 1911" (1942) that, "local differences caused by local topographical and climatic factors do exist, nevertheless the maximum period of floods usually occurs one or two months after the period of maximum rainfall, whereas the maximum drought season approximately coincides with the months of maximum rainfall."[1] Yao offered additional comments in two later articles, one of which focuses on provincial distribution in the same period. In the other (1944), he articulates more openly on the nature of the entries and their significance in reflecting Chinese attitudes towards floods and droughts.[2]

By collating and interpreting information in various studies in Western languages written by researchers in China and the West -- for instance those by the eminent Chinese authority on meteorology Chu Coching, by Hosie, and by Yao (whose work forms "an excellent base from which more detailed investigations can be made") -- Schove presented a summary of "Chinese rainness through the centuries" in the

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[1]Yao Shan-yu, "The Chronological and Seasonal Distribution of Floods and Droughts in Chinese History 206 B.C. - A.D. 1911," Harvard Journal of Asiatic Studies, 6 (1942), 312.

[2]". . .we not only can see how trustworthy our flood and drought data are, but also can obtain a clearer idea as to how adequate some of, if not all, the materials in the *T'u-shu chi-ch'eng* really are. . . . The fact that these records of floods and droughts are not based on scientific observations made with rain gauges and other scientific instruments should always be remembered. Floods and droughts were therefore not measured in terms of absolute quantities of rainfall, but rather according to the material damage and suffering they caused to the people. . . . Furthermore, our historians' supply of information was necessarily limited by the technical facilities of the time. . . . Since the historians naturally could record only what they could learn, the areas surrounding the capitals and the important economic areas thus attracted disproportionate attention. . . . Moreover, since the occurrences of floods and droughts often brought about tax exemption of the region thus affected, it is conceivable that local officialdom might be strongly tempted either to exaggerate the seriousness of such calamities or even to fabricate stories about them. . . . Yet one of the most important motives which brought into existence these records is the alleged supernatural significance that was attached to them": Yao Shan-yu, "Flood and Drought Data in the *T'u-shu chi-ch'eng* and the *Ch'ing shih kao*," Harvard Journal of Asiatic Studies, 8 (1944), 214, 216-17.

1949 Meteorological Magazine.[1]

There were six articles on meteorology published between 1959 and 1962, and five contributors (i.e. the Ho Peng Yoke / Needham / Lu Gwei-djen team; John S. Major; and Wang Pao-kuan). Although the topics explored and supporting evidence employed in these accounts are quite different, they share common objectives and orientations, which in turn are similar to those exhibited in past studies.[2]

Utilising information obtained from the *Chin shu*, Ho and Needham (1959) described the methods by which ancient Chinese astronomers identified and recorded solar haloes and parhelia. They successfully demonstrated that "by the early +7th century the official Chinese astronomers of the Imperial Bureau of Astronomy had not only observed nearly all the component parts of the solar halo and parhelia complex, but had given them specific names."[3] (Note that there are also studies on sunspots and aurorae in *Chapter 4: Astronomy.*) And by appealing to a host of textual evidence from Han poems to the *Pen ts'ao kang mu*, Needham and Lu (1961) claimed that for the Chinese, it already seemed common knowledge before second century B.C. that snowflakes are six-sided, whereas in the West, their hexagonal nature was only recognised in 1591.

Our understanding of the perception of the atmosphere during Han times was enlarged by an original study from Major (1979) on "some problems of the nomenclature of winds and directions encountered in HNT [Huan Nan Zi] and certain other closely associated texts."[4] By examining "the names of the eight winds and eight directions, their

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[1]D. Justin Schove, "Chinese Rainness through the Centuries," Meteorological Magazine, 78 (1949), 16.

[2]Major's article is an exception.

[3]Ho Ping-yü, and Joseph Needham, "Ancient Chinese Observations of Solar Haloes and Parhelia," Weather, 14 (1959), 131-32.

[4]John S. Major, "Notes on the Nomenclature of Winds and Directions in the Early Han," T'oung Pao, 65 (1979), 66. Major captured the overriding importance of the work by observing that, "the doctrines incorporated in HNT represent one of the final steps in the development of Chinese cosmology anterior to Tung Chung-shu's grand synthesis of natural and social philosophy, political theory, and public policy that established the ruling ideology of Confucian government for the remainder of the Han and beyond": Major, "Notes on the Nomenclature," 80.

symbolic connotations, their correlations with the seasons, and the definition of social and political activities appropriate to each", Major argues that "although the nomenclature of winds in early Han was still somewhat confused, . . . the confusion was rapidly diminishing as the manifold correlations of Han cosmology were becoming standardized."[1]

Wang's "Meteorological Records from Ancient Chronicles of China" (1979) presents relevant data registered in Chu shu chi nien, Shih chih, and Ch'ien Han shu. His "On the Relationship between Winter Thunder and the Climatic Change in China in the Past 2200 years" (1980), like his other studies, is chiefly concerned with culling material from Chinese documents. And "Unusual Lightning Events in Ancient Chinese Literature" (co-authored with Chu Jan-hwa) (1982) gives a semi-popular account of the phenomena.

6.3 GEOLOGY; PALAEONTOLOGY

In addition to an interest in early Chinese meteorological records, Biot was also curious about traditional Chinese observations, descriptions and theories related to geological formations, in particular mountains and rivers.[2] His three accounts in Journal Asiatique (1840a, 1840b, 1843) on this subject contain mainly pertinent references in selected Chinese historical records.[3]

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[1]ibid.

[2]He also wrote two articles on earthquakes, which are addressed in section *6.4 Seismology*.

[3]For instance, in "Études sur les montagnes et les cavernes de la Chine d'après les geographies chinoises", Biot explains that, "les compilations de géographie chinois, telles que le *Thai-thsing-y-thoung-tchi*, et l'Abrége de la géographie des Ming, le *Kouang-yu-ki*, présentent, dans la description de chaque province, une section speciale, ou les montagnes et les rivières de chaque département ou district sont citées avec les particularités remarquables qui s'y rattachent. Dans cette section, appeleé *Chan-tchuen* <<montagnes et cours d'eau>> on trouve dans détails plus ou moins circonstanciés sur la forme des montagnes et de leur roches, sur leurs cavernes et fissurer, sur les souvenirs, traditionnels de la localité, sur le cours des rivières, sur l'étendue des lacs. . . .": Édouard Biot, "Études sur les montagnes et les cavernes de la Chine d'après les geographies chinoises," Journal Asiatique, 3rd ser., 10 (1840), 273-74. The article is divided into sections such as "Blocs isolés ou

Were there indications that the Chinese had knowledge in the area now called palaeontology? L. Carrington Goodrich (1942) once called attention to the *Chu tzu yü lu* which apparently mentions fossil fish. Richard C. Rudolph (1946) supplemented this with references taken from an important Chinese work from 1927 which gives the earliest reference to fossil fish as that in *Shui ching chu* from the late 5th and early 6th century.[1]

6.4 SEISMOLOGY

Again it was Biot who alerted 19th century scholars to Chinese registers of earthquakes. However, his "Sur la cause probable des anciens déluge, rapportés dans les annales historiques des chinois; sur les tremblements de terre, affaissements et soulèvements de montagnes, observés en Chine, depuis les temps anciens jusqu' à nos jours" (1839) does not give exact citations. These are supplied in another article (1840) which presents roughly two dozens instances of earthquakes from 234 B.C. to A.D. 1818 recorded in Book 301 of *Wen hsien t'ung k'ao* and other material. Biot also attempted to provide modern scientific explanations for these occurrences.

The only two 20th century works on traditional Chinese seismological understanding and experience were both directed at Chang Heng's famous seismoscope. Moule (1924) translated the familiar passage in *Hou Han shu* on the working of this instrument, with annotations by Pelliot. The other work is a definitive study by André Wegener Sleeswyk and Nathan Sivin published in the 1983 Chinese Science. By adopting an innovative interpretation of the *Hou Han shu* text and taking into consideration previous Chinese attempts at reconstructing the instrument as well as recent archaeological discoveries, the authors have shown that "by following the language of the text exactly and conforming to the limits of techniques feasible in the Western Han period, one can construct a seismoscope of requisite

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erratiques"; "Indication de terrains primitifs"; "Stalactites"; "Observations générales sur les noms des montagnes".

[1]The Chinese book is Chang Hung-chao's Lapidarium Sinicum, an insightful review of which by Paul Demiéville is mentioned below in *6.5 Mineralogy*.

sensitivity."[1] The paper contains the following sections: "The text"; "Interpretation of the text" (divided into "The 'general pillar' and the 'wind-observing earthquake instrument'", "The 'dragon triggers'", "The earthquake record"); "Reconstruction (divided into "The pendulum", "The dragon triggers"); "The seismoscope in Europe".

6.5 MINERALOGY[2]

A. Pfizmaier's "Beiträge zur Geschichte der Edelsteine und des Goldes" (1868) is mentioned in the mineralogy section of Science and Civilisation in China vol. 3. [I have not seen this title].[3] And at least two late 19th century Western scholars were conscious of the fact that the Chinese had long possessed considerable interest in minerals. If not, F. de Mély would not have written Les lapidaires chinois (1896) and M. Berthelot (1896) not reviewed it in great detail. de Mély's book -- the first volume of his Les lapidaires de l'antiquité et du Moyen Age -- is a translation of the mineralogy part (i.e. chapters 59, 60 and 61) of a Japanese edition of *San ts'ai t'u hui*. It begins with an extended introduction, followed by the translation, which is accompanied by two hundred pages of explana-

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[1]They have made it clear that, "no attempt to reconstruct the mechanism from the brief description in its inventor's biography has fully followed the specifications found there. In particular, although the extreme sensitivity of the device is emphasized, no modern reconstruction has been capable of detecting tremors too weak to be noticed without any mechanical help at all. This essay considers the mechanical principles that would make high sensitivity possible within the conditions imposed by the text. . . . It also incorporates for the first time in a Western language recent archeological discoveries that bear on mechanical and aesthetic aspects of the seismoscope": André Wegener Sleeswyk, and Nathan Sivin, "Dragons and Toads: The Chinese Seismoscope of A.D. 132," Chinese Science, 6 (1983), 3.

[2]See also *Chapter 8: Alchemy*, in particular *8.4 Early Chemistry*, which contains, for instance, Edward H. Schafer's works on lead pigments, realgar, and orpiment.

[3]". . .the portions of the *Thai-Phing Yü Lan* translated by Pfizmaier. . . is anecdotal and of no value except as an index of the dates at which various terms were in use": Science and Civilisation in China, vol. 3, pp. 646. And again, "Pfizmaier translated a chapter of the *Thai-Phing Yü Lan* encyclopaedia (+980) on gems": Science and Civilisation in China, vol. 3, pp. 669.

tory notes. There are two indices: "Identifications" (arranged alphabetically by romanised name of the mineral, with French translation and references to Western works that mention the substance); "Table" (contains in one sequence "les noms de matières", "les titres bibliographiques", "les noms de lieux et de peuples", and "les noms de personnes").[1] Also included is the full Chinese text.

Berthelot outlines his twenty-page review essay in the 1896 Journal des Savants of de Mély's work as follows: "Je présenterai d'abord quelques observations sur la valeur historique et sur le caractère des témoignages que l'on peut en tirer, relativement à la science chinoise. Ensuite je passerai brièvement en revue le traité chinois, j'en comparerai les faits, les doctrines et les préjugés à ceux des minéralogistes de l'antiquité gréco-latine et du moyen âge, et j'essaierai d'y rechercher, avec l'aide de M. de Mély, la trace des emprunts, avoués, inconscients ou déguisés, qui ont pu être faits par les Chinois en ce domaine, comme en tant d'autres, à la science occidentale, depuis le moyen âge jusqu'à nos jours."[2]

Yet another 19th century researcher had written about Chinese views of minerals. Alexander Wylie (1897), in his posthumously published article, gives descriptions of and references to asbestos in various Chinese treatises, sometimes in his own words and sometimes in the form of translations or paraphrases. This undertaking was regarded by Laufer in 1915 as "a most scholarly study. . . which contains an almost complete array of Chinese sources relative to the subject."[3] However, Laufer also stated that "the present state of science. . . has permitted me to go far beyond the results which Wylie was able to reach a generation ago. Wylie merely noted in the most general way that the accounts of the Chinese corroborate the statements of ancient classical writers, mainly emphasizing the point that the Chinese, in the same manner as the ancients, mention handkerchiefs or napkins woven from asbestos. No attempt, however, was

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[1]F. de Mély, Les lapidaires chinois (Paris: Leroux, 1896), pp. 265.

[2]M. Berthelot, "[Review of Les lapidaires chinois, by F. de Mély]," Journal des Savants, (1896), 576.

[3]Berthold Laufer, "Asbestos and Salamander: An Essay in Chinese and Hellenistic Folk-lore," T'oung Pao, 16 (1915), 299.

made by him to explain all the curious lore that was lavishly accumulated on top of this subject. . . . Further, Wylie's representation of the matter suffers from various defects. It is not well arranged in chronological or any other order, and the sources are not sifted critically. Moreover, as admitted by himself, he did not succeed in identifying most of the geographical terms to be found in the Chinese texts."[1] Laufer's own effort to "unravel the curious traditions entertained by the Chinese regarding this marvellous production of nature, and to correlate their notions of it with the corresponding thoughts of the ancients, the Syrians and Arabs, and of mediaeval Europe" resulted in a substantial study occupying almost eighty pages in the 1915 T'oung Pao.[2]

Laufer extended the same exhaustive search for available primary and secondary literature to his studies on amber (1906), turquois (1913), and diamond (1915). Readers are informed of terms used to designate the substances, their distribution, and above all, how they had been viewed and used.[3] As a museum curator specialising in anthropology and ethnology, Laufer favoured a comparative approach, but in these works his emphasis was on China and influences it might or might not have received. Thus, for instance, he "extracted everything worthy of note regarding amber that is to be found in the Chinese cyclopedias and in other historical and geographical Chinese works."[4]

Another study from the first quarter of the 20th century which is densely packed with references and fruits of painstaking research is Demiéville's in-depth and critical review (1924) of Chang Hung-

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[1]Laufer, "Asbestos and Salamander," 300.

[2]Laufer, "Asbestos and Salamander," 229.

[3]For example, The Diamond: A Study in Chinese and Hellenistic Folklore contains the following sections: "Introduction"; "Legend of the diamond valley"; "Indestructibility of the diamond"; "Diamond and lead"; "The diamond-point"; "Diamond and gold"; "The term *Kun-wu*"; "Toxicology of the diamond"; "Imitation diamonds"; "Acquaintance of the ancients with the diamond"; "Cut diamonds"; "Acquaintance of the Chinese with the diamond"; "Stones of nocturnal luminosity"; "Phosphorescence of precious stones".

[4]Laufer, "Historical Jottings on Amber in Asia," Memoirs of the American Anthropological Association, 1 (1906), 217.

chao's Lapidarium Sinicum -- a Chinese book (with an English table of contents) published in 1921 on rocks, minerals, fossils, and metals recorded in Chinese treatises and literature.

Edward H. Schafer seems to have been the lone scholar in the second half of the 20th century engaged in systematic research and publication of studies devoted to traditional Chinese understanding of minerals. From the 1950s to '70s, Schafer undertook extensive exploration into traditional Chinese knowledge, lore, appreciation, and usage of mica (1955), the so-called "Thirteen Nation-stabilizing Treasures" (e.g. yellow and white jade, moonstone) (1965), and the gemstone *lang kan* (1978). Delving deep into legends, the classics, an assortment of literary genres as well as archaeological findings, he uncovered a fascinating range of notions and ideas associated with the minerals. Aspects considered in these accounts include origins and changes in names and expressions, beliefs and folklores, distribution, employment and working of the minerals, and determination of the substances in modern scientific terms.[1] Schafer's rich

[1]The following extracts taken from "The Transcendent Vitamin: Efflorescence of *lang-kan*" can serve well to illustrate the variety of issues covered: "The earliest texts in which it occurs, texts of the late Chou and the Han periods, give us a better idea of the world of *lang-kan* than of the identity of *lang-kan*. . . . the documentation for the *lang-kan* tree of K'un-lun is the most abundant. . . . Despite these elfin affinities, the belief persisted that there was an actual mineral, born within mundane rocks, to which the name *lang-kan* could reasonably be applied. The earliest such record is in the "Tribute of Yu" section of the *Shu ching*. . . . During this H'an-T'ang interval the evidence points clearly to the use of *lang-kan* as a gem, and a valuable gem at that. . . . It was predictable that the association between *lang-kan* and the beauties of an idealized natural world would overflow into (literally) colorful (non-literal) metaphor. These tended to fall into two classes: images of crystalline splendor exemplified in forms of water and ice, and even more importantly, images of vegetative glory. . . . In T'ang times uncertainty gave way to certainty: the mysterious blue-green gem-trees did in fact exist, and in the domain of T'ang itself. . . . This new development in the natural history of *lang-kan* creates a certain problem. What kind of coral was it? While it hardly seems possible that we can ever be certain about the "true" identity of ancient *lang-kan* -- if it ever had a unique identity -- it must be admitted that the candidate of at least two modern authorities is by far the most plausible one: it was malachite. . . . *Lang-kan* -- malachite or not -- was an ingredient of Taoist elixirs during the Six Dynasties period, as T'ao Hung-ching made plain . . . . The scripture, which calls the elixir "efflorescence of *lang-kan*" may be very old indeed, as Strickmann suggests, possibly antedating even T'ao Hung-ching's

research findings and nuanced observations should prove useful to scholars of several disciplines.

6.6 CARTOGRAPHY; TOPOGRAPHICAL SITING

Little interest in traditional Chinese cartographic principles and activities was expressed in the 19th century. There was one account by J. Klaproth on the cartographic features of the *Kuang yü t'u* and other early Chinese maps in the 1823 Asiatic Journal and Monthly Register for British and Foreign India, China and Australia. Another was written by G. Pauthier (1836). He translated and commented on a passage in a text from the Wei period which, according to him, could give clues to Chinese views of the shape of the earth.[1]

E. Chavannes' widely-cited "Les deux plus anciens spécimens de la cartographie chinoise" (1903) has been called a "fundamental paper

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classic account of the preparation. The text describes a basic mix of fourteen reagents, for which the cabalistic names are given and explained by glosses consisting of their ordinary mineralogical synonyms. . . . Presumably this elixir was actually concocted many times in the course of the medieval centuries. . . . It seems probable that the end product would be a 'flint' glass -- that is, glass with a high lead conctent, the glass of ceramic glazes, artificial jewelry, and the like. The ingredients essential to such an outcome, about 20 to 40 per cent silica and about 50 to 80 per cent lead oxide, are both abundantly present in the mix. Usually a small amount or potash, soda, or alumina is desirable; they are present here, if only in traces, and in any case the niter would act as a flux. A typical flint glass softens at only 630^0 , no great problem with simple equipment. Presumably the copper would add a blusih tint, which might account for the charming classical name of *lang-kan*": Edward H. Schafer, "The Transcendent Vitamin: Efflorescence of *lang-kan*," Chinese Science, 3 (1978), 27-38.

[1]In his opinion, "si le principe de *l'aplatissement des pôles de la terre* est consacré dans le texte, il ne l'est aucunement dans les proportions véritables, puisqu'ici elles seraient dans le rapport de quatre-vingt-un à quartre-vingt-dix, tandis que, dans la réalité, elles sont à peu près comme trois cent à trois cent un; en outre, comme je l'ai déjà fait observer auilleurs, on ne sait pas si, dans le texte, on considère la terre comme un *sphéroide*, ou seulement comme une *surface plane*. J'ajouterai seulement que, par *l'intérieur des quatre mers*, les Chinois entendent quelquefois leur empire; mais c'est plus généralement le *monde, toute la terre*, qu'ils veulent désigner par cette expression, parce qu'ils se figurent *la terre* enveloppée par *quatre mers*": G. Pauthier, "Connaissance de l'aplatissement des pôles de la terre chez les anciens chinois," Journal Asiatique, 3rd ser., 1 (1836), 293-94.

in which he [Chavannes] sketched the growth of accurate mapping in China."[1] This study begins with an introduction to the background of the stone steles in the Confucian temple in Su-chou where the maps were inscribed, followed by a translation of the text. In the second half of this ground-breaking survey Chavannes informs us that, "les deux cartes gravées en 1137 sont le résultat d'un longue évolution scientifique et supposent de nombreux travaux antérieurs. Nous nous proposons de rassembler et de discuter ici les plus importants des renseignements qu'on peut trouver sur ces monuments aujourd'hui disparus de l'ancienne cartographie chinoise."[2] Included is an addendum by Pelliot.[3]

G. Vacca gave an outline of some aspects of Chinese traditional map-making in an article published in 1911. It is divided into: "I. Una carta della Cina del 1247 A.D."; "II. Sui metodi di construzione P'ei Hsiu (224 - 271 A.D.)"; "III. Sui rapporti tra la cartografia Cinese e quella Europea".

It was in the 1920s with A. Herrmann's intensive inquiries that Western research interest and access to the history of Chinese cartography was opened up.

Herrmann's "Die ältesten chinesischen Karten von Zentral- und Westasien" (1920) deals with maps on Central and Western Asia from the Han, Wei and Sui period which he reconstructed. His "Die Westländer in der chinesischen Kartographie" (1922) -- published in a massive collection edited by Sven Hedin -- was hailed by Pelliot as "le grand travail sur la cartographie chinoise."[4] The study is organised into fourteen sections, each with numerous sub-sections, copious footnotes and references. Over the space of several hundred

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[1]Science and Civilisation in China, vol. 3, pp. 526.

[2]E. Chavannes, "Les deux plus anciens spécimens de la cartographie chinoise," Bulletin de l'École Française de l'Extrême-Orient, 3 (1903), 236.

[3]Slight modification and revision to this seminal study can be found in the author's L'instruction d'un futur empereur de Chine en 1193 (Paris: Ernest Leroux, 1913), chapter 1: "La carte geographique", pp. 23-31.

[4]P. Pelliot, "Note sur la carte des pays du nord-ouest dans le *King Che Ta Tien*," T'oung Pao, 25 (1927), 98.

pages, Herrmann meticulously charts the history of Chinese cartography through the ages from "II. Die Urzeit" and "III. Die Wen-Wang-Karte" to "XIII. Andere Karten aus dem Zeitalter der Mandschudynastie" and "XIV. Das ende der Kartographie der Westländer".[1] "Die älteste chinesischen Weltkarten" (1924) is on the work of the 3rd century cartographer Pei Hsiu -- often regarded as the founder and father of Chinese cartography -- and of others from early times.

Articles from three other individuals were published in the 1920s. In the 1921/22 Geographer Teacher can be found a short essay by Florence C. Miller which describes the essential features and characteristics of early Chinese maps and includes comparisons with those from the Mediterranean. Probably written for students, this brief introduction is unique in that it was the only account from the 1920s to '50s period not based on original research and Chinese sources. In a paper read in an afternoon meeting of the Royal Geographical Society Soothill (1927) gave a summary of the development of early Chinese cartography and expounded in detail two stone-engraved maps "discovered in the Forest of Tablets at Hsianfu, the capital of Shensi province" -- "especially with regard to their origin and period" -- which Hosie first brought to light.[2] The third piece was a short note from Pelliot (1927) on a map of the northeast found in the *Ching shih ta tien*, supplied as an addendum to Herrmann's "Die Westländer in der chinesischen Kartographie".

In publishing "Sailing Directions of Chinese Voyages" (1938), Duyvendak hoped to draw readers' attention to a late 14th, early 15th century manuscript which he came across in the Bodleian Library at Oxford. On it are set forth detailed directions for navigating in

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[1]"I. Einführung in die Chinesische Kartographie" is of special interest. Some of the topics analysed include: "1. Die Kosmographischen Grundlagen"; "2. Die Grundzüge der chinesischen karte - (a) Der Kartenentwurf (b) Der Karteninhalt (c) Die Vorzüge der chinesischen Karte"; "3. Das Vorliegende Kartenmaterial -- (a) Frühere Bearbeitungen (b) Die Verteilung des Kartenmaterials".

[2]W. E. Soothill, "The Two Oldest Maps of China Extant," Geographical Journal, 69 (1927), 533, 538.

the southern sea.[1] In another article (1939), a picture (or rather, a map) related to a battle between the Chinese and the Hsiung Nu in Sogdinia in 35 B.C. prompted Duyvendak and Homer H. Dubs to comment on early map-making skills of the Chinese. (Much of the observations are in fact that of Dubs', but quoted by Duyvendak.) The early 17th century sailing charts from the _Wu pei chih_ have been studied by W. Z. Mulder (1942) from a navigator's perspective. His article discusses sailing and compass directions and places on the charts, how they should be interpreted and their accuracy. With Mulder's account, we reach the final work on cartography from the first half of the 20th century.

A quiet interlude followed. The most conspicuous effort made in the 1950s and '60s at elucidating traditional Chinese cartography was Mills' "Chinese coastal maps" (1954) which we have referred to in the opening paragraphs. It contains a useful overview of the evolution of the Chinese cartographic tradition and the systematic description of twelve coastal maps from c. 1422 to 1884.[2] Moreover, bibliographic information on relevant Western literature is generously provided. Herbert Franke's short communication in the 1957 Geschichte in Wissenschaft und Unterricht also furnishes a succinct characterisation of the major stages in China's cartographic activities and Western writings on the subject. So does Hans Keller's (1968) brief account in the Swiss journal on geography and ethnography Geographica Helvetica, which begins with the earliest time and ends with the coming of the Jesuits.[3]

The 1970s witnessed a substantial increase in interest and

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[1]The manuscript was identified in 1982 by T'ien Ju-k'ang as the _Tu hai fang ch'eng_ in his "The First Printed Chinese Rutter -- *Duhai Fangcheng*".

[2]"I. The Mao K'un Map: c. 1422"; "II. The *Kuang Yü T'u* Map: c. 1555"; "III. T'an Chiu-Ch'ou's Map: c. 1560"; "IV. The *Ch'ou Hai T'u Pien* Map: 1562"; "V. Ch'ên Lun-Ch'iung's Map: 1730"; "VI. The Bagrow Map c. 1731"; "VII. The *Hsin San I* Map: c. 1773"; "VIII. The Staunton Map: c. 1793"; "IX. The Gough Map: c. 1840"; "X. The Edwards Map: c. 1840"; "The *Hai Chiang* Map: c. 1840"; "XII. Wêng Ta-Chêng's Map: 1884"

[3]There was another article from the 1960s -- that on siting by Andrew March; it is discussed below together with Bennett's studies on the same subject.

output, with no less than fourteen articles and ten contributors. Their themes can be summarised as follows: (i) coastal maps and sailing charts (1970 Chang, 1971 Schwarz, 1979 Mills); (ii) general introductions to Chinese maps (1972 Knight, 1975 Nelson); (iii) a special type of local map (1977 Chang); (iv) a Ming map in the Bibliothèque Nationale in Paris which Marcel Destombes brought to light (1974, 1976, 1977 Destombes); (v) the spectacular Han maps dating from the 2nd century B.C. unearthed in 1973 in the Ma-wang-tui Han tombs (1978 Bulling, 1978 Hsu, 1979 Chang); (vi) topographical siting (1968 March, 1978a, 1978b Bennett).

Coastal maps and sailing directions continued to receive attention. Chang Kuei-shang (1970) has "chosen to examine three of the oldest Chinese maps relating to Africa and the Indian Ocean and to assess their significance in the large perspective of the history of geographical thought and cartography."[1] Characteristics of Chinese coastal maps from the mediaeval period to the 19th century were once again considered and described, this time by Rainier Schwarz in a paper for the 1971 Deutsche Akademie der Wissenschaften zu Berlin. Instituts für Orientforschung. Mitteilungen. Mills, well-acquainted with the coastline of Malaysia, explained sailing directions used by navigators journeying to the Malaysian Peninsula around 1500 in a special study from 1979.

One encounters more general introductory accounts on cartography than on any other subject in the traditional Chinese science field. Intended for non-specialists and largely factual and narrative rather than interpretative, they highlight major episodes, categories, and specimens. We have already mentioned several such accounts. There are two more, both written by staff members of national libraries. In his sketch, Thomas Knight (1972) of the National Library of Australia points out to the general reader that, "long before Western cartography was brought to her shores by Matteo Ricci, Ferdinand Verbiest and others, China had been making wide use of maps, the product of a flourishing indigenous and, to the Western world, little known system of cartography. There were maps for military purposes, for trade and pilgrimages, as well as cadastral and strategic maps.

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[1]Chang Kuei-sheng, "Africa and the Indian Ocean in Chinese Maps of the 14th and 15th centuries," Imago Mundi, 24 (1970), 21.

Special scrolls were made for rivers, and tax collectors were supplied with atlases showing where grain received in payment of taxes was stored."[1] The second work, by Howard Nelson (1974) of the British Library, is a well-considered and informative study which delivers more than one normally expects from a general portrayal. It covers the Han maps, earliest references to maps in China, the work of Pei Hsiu, Ricci's maps and Jesuit influence, and also "a few examples where map-making, or perhaps topography, touches on the art of the Chinese painter."[2] Fourteen illustrations add to the appeal of this article.

Concentrating on a particular type of map (i.e. "thematic maps, maps constructed mainly by local authorities in imperial times for various administrative, water control, and military purposes") and on a particular collection (i.e. the collection of rare Oriental maps in the Library of Congress), Chang Sen-dou (1977) reviewed them in terms of "1. Map orientation"; "2. Coloring"; "3. Symbolization"; "4. Ideological distortion".[3]

A hitherto unknown map signed by Wang P'an and dated 1594 in the "Manuscrits chinois de la Salle Orientale" section of the Bibliothèque Nationale in Paris was discovered in 1973 by Destombes who wrote three special papers on it in the 1970s and one in 1983. The contents and information given in these articles are essentially the same: features and characteristics of the map are recounted in detail, careful comparisons with maps from the same as well as former periods are made, and the map's significance within the Chinese map-making tradition analysed (e.g. its relation to maps drawn after the fashion of the Jesuits, and to extant Chinese cartographic and

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[1]Thomas Knight, "Early Chinese Maps," Hemisphere, 16.3 (1972), 35.

[2]Howard Nelson, "Maps from Old Cathay," Geographical Magazine, 47 (1975), 710.

[3]Chang Sen-dou, "Some Observations on the Cartographic Nature of Chinese Thematic Maps," In Chine ancienne: Actes du Congrès International des Orientalistes, Paris, 1973; section organisée par Michel Soymié (Paris: L'Asiathéque, 1977), pp. 25-26.

nautical maps made before the 17th century).[1]

The truly extraordinary discovery of several maps drawn on silk fabrics from the Han tombs at Ma-wang-tui -- which pushed the date of the oldest extant Chinese map back for over 1,000 years -- generated three Western studies on early Chinese cartographic efforts. The admirably readable paper by Mei-ling Hsu (1968) contains six sections: "The topographic map"; "The military map"; "Technological background of the Han maps"; "A reassessment of the history of Chinese cartography -- analytical and descriptive traditions"; and "Conclusion". The author not only captured the unique elements of two of these maps in a nutshell, but also furnished the necessary background information for placing them in historical perspective and for a proper interpretation and evaluation of the cartographic activities involved.[2] It should prove to be a useful guide especially for those not familiar with Chinese cartography. In contrast, A. Gutkind Bulling's "Ancient Chinese Maps: Two Maps Discovered in a Han Dynasty Tomb from the Second Century B.C." (1978) which appeared in Expedition (Columbia University's museum magazine for archaeology and anthropology) is a brief report that is much more limited in scope and substance. Chang has also assessed the Han maps in considerable

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[1]Destombes arrived at the conclusion that, "there are only two types of Chinese maps which are independent of one another: the one on which China is square based on the Chinese tradition, and is that of Wang P'an of 1594, and other inscribed on an oval grid imported from Europe, those of Ricci of 1600 and 1602. A mixed type represented by the map of Liang Chou must be later than 1603": "Wang P'an, Liang Chou et Matteo Ricci: essai sur la cartographie chinoise de 1593 à 1603," in Actes du IIIe Colloque International de Sinologie: Appréciation par l'Europe de la tradition chinoise à partir du XVIIe siècle, Chantilly, 1980 (Paris: Les Belles Lettres, 1983), pp. 47.

[2]The objective of the paper is laid out succinctly: "The Chinese restored and reported on two of the maps, one topographic and the other military. The published reports deal with the restoration procedures, map content and accuracy, and the history of the mapped area. This paper interprets these basic materials from a cartographic point of view and synthesizes the many verbal descriptions of the maps. The Han maps have brought to the surface much new information, and there is a need to reassess certain aspects of the history of Chinese cartography. The paper defines two traditions in premodern Chinese cartography, one descriptive and one analytical, and draws attention to the parallel development of these two traditions": Mei-ling Hsu, "The Han Maps and Early Chinese Cartography," Annals of the Association of American Geographers, 68 (1978), 45.

detail. In his 1979 article he maintains that ". . .the two restored maps [i.e. a garrison map and a relief map] merit serious investigation on the information they yield on China's cartographic skills and geographical concepts at such an early date, as well as on the strategic position of the State of Ch'ang-sha, the last surviving princely state in early Han China."[1] His study, therefore, treats not only cartographic concerns, but also contemporary political events and situation.[2]

We come finally to an aspect or a type of topographical science that is unique to the Chinese tradition, namely, "topographical siting" (to borrow Bennett's term). It involves concepts, methods, and objectives that have no equivalent in Western science, even though its major concern is the surveying and examination of the lay of the land, the different terrestrial features, and the prevailing topographical conditions.[3] Topographical siting has often been referred to as and confused with "geomancy", a topic that has engaged the interest of writers of popular literature on Chinese culture as well as professional academics. Their understanding of the fundamental concepts that govern the principles and goals of this Chinese acti-

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[1]Chang Kuei-sheng, "The Han Maps: New Light on Cartography," Imago Mundi, 31 (1979), 9.

[2]In Chang's opinion, "from a historical point of view, the two restored Han maps provide strong evidence for the conclusion that, with its elaborate road system in conjunction with the network of waterways, the State of Ch'ang-sha was able to maintain a strong defensive posture vis-a-vis the hostile kingdom of Nan Yüeh to the south. With the smooth and gradual integration of Ch'ang-sha into Han Empire, it became eventually possible for Han Wu Ti to unify the entire deep south without too much effort": Chang, "The Han Maps," 14. He further asserts that, "as one marvels at the sophisticated techniques of surveying and mapping involved in the production of the Han maps, one cannot help but be perplexed by the lack of significant progress in cartographic techniques during subsequent centuries. . . . In the final analysis, the prolonged stagnation in the later centuries, characterized by the paucity in innovative advances and the failure to perpetuate some of the skills already well developed by the early Han, can only be explained by the truism that history does not always march in an upward curve in any part of the world": Chang, "The Han Maps," 14-15.

[3]Hence works on topographical siting are included in this section rather than regarded as studies on philosophy and concepts of traditional Chinese science.

vity seems, however, far from accurate.[1] Informed Western studies on topographical siting, setting it within the proper context and orientation are rare. Andrew L. March begins his essay "An Appreciation of Chinese Geomancy" (1968) by taking us through the writings of Western scholars on the subject, pointing out problems in the way the concept has been understood. Then follows discussions on how the site is chosen, the origin and development of the theory and practice, and "the geomancy of burial". In two papers published in 1978, Bennett articulates in detail and comments critically on the intricate techniques being applied when choosing a site -- which can vary considerably according to land form and other considerations -- paying special attention to the underlying cosmological and sociological constructs and guiding principles.[2]

As the 1970s drew to an end, so did the flurry of activity that enlivened the decade. The five years between 1980 and 1985 saw only

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[1]Bennett has clarified the situation by explaining that "'Geomancy,' according to the Oxford English Dictionary, is 'The art of divination by means of signs derived from the earth, as by the figure assumed by a handful of earth thrown down upon some surface. . . . Hence, usually, divination by means of lines or figures formed by jotting down on paper a number of dots at random.' Geomancy, defined in this way, has not been practiced in China, and has nothing to do with locating sites for human dwellings. Whatever reasons early visitors to China had for calling the Chinese practice 'geomancy,' they were neither using the English word correctly nor translating a Chinese word. . . . The major difficulty in finding a suitable English designation is that there is no Occidental counterpart to the Chinese practice. The latter is based on a view of relationships between aspects of nature that does not appear in Western naturalistic traditions. . . . I suggest that 'topographical siting' or 'siting' is a neutral English designation which does not do harm to the Chinese concept, and at the same time captures one essential feature of the science. The word 'site' refers to the discrete areas of space known as *chai* in which, according to the Chinese system, houses and tombs are to be placed": Steven J. Bennett, "Patterns of the Sky and Earth: A Chinese Science of Applied Cosmology," Chinese Science, 3 (1978), 1-2.

One can also consult Kazutaka Unno's "The Geographical Thought of the Chinese People: With special reference to Ideas of Terrestrial Features" in which the term "*feng shui*" is discussed, and issues such as the earth as "dragon" and the association of the earth's surface with concepts in traditional Chinese medicine are highlighted.

[2]"Patterns of the Sky and Earth: A Chinese Science of Applied Cosmology", for example, contains the following four sections: "Approaches to siting"; "General philosophical assumptions behind siting theory"; "Energetics"; "On land forms".

two publications that pursued traditional Chinese map-making principles and efforts. One was Destombes' "Wang P'an, Liang Chou et Matteo Ricci: essai sur la cartographie chinoise de 1593 à 1603" (1983) to which reference has already been made.

The other was "The Five Phases, Magic Squares, and Schematic Cosmography" (1984) by Major, which deciphers and amplifies Chapter 4 of _Huai nan tzu_, "The Treatise on Topography". This provocative and richly textured study also carries a broader aim, which is to suggest that "schematic cosmography, embodied in the 3x3 grid and certain closely related figures, seems to have permeated the thinking of the Chinese of the Warring States and Han periods. Philosophers of Tsou Yen's naturalist school were able to use that cosmography to manipulate *yin* and *yang* and the Five Phases to achieve an integrated, intellecutally satisfying, and in a special sense even scientific view of the cosmos."[1] Among early representations of "the grid figure" and disposition towards orderly arrangement were the well-known simple magic square diagrams *Lo shu* and *Ho t'u* as well as for instance, "Mencius's well-field idealization of land tenure and land taxation", urban planning, and above all, the bronze "TLV mirrors" from the Han period.[2]

6.7 CONCLUSION

Commenting in 1988 on recent scholarship on the Chinese scientific and medical traditions, Sivin observed that, "work on physical studies has not gone beyond an occasional study of a text."[3] New publications and attempts at unravelling traditional Chinese understanding in the field of earth sciences were indeed scarce. Of the seventy-eight titles discussed above, only seventeen were published

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[1]John S. Major, "The Five Phases, Magic Squares, and Schematic Cosmography," in _Explorations in Early Chinese Cosmology; Papers presented at the Workshop on Classical Chinese Thought held at Harvard University, August 1976_, ed. Henry Rosemont, jr. (Chico, Calif.: Scholars P, 1984), pp. 159.

[2]Major, "Five Phases," pp. 152.

[3]Nathan Sivin, "Science and Medicine in Imperial China: The State of the Field," _Journal of Asian Studies_, 47 (1988), 60.

in the 1970s (including fourteen on cartography) and five between 1980 and 1985 (including two on cartography). One of the major consequences of this is that one often has to be content with research done over a quarter or half a century ago. Updates and reassessments are therefore urgently needed. A case in point is seismology: Sleeswky and Sivin's 1983 study gave the topic a new dimension by re-interpretating documentary sources and utilising new research methodology and advancements in technology.

Secondly, the heavy presence of and reliance on Chinese textual material (and archaeological discoveries in some post-1950 works) is unmistakable. This is understable as the need to identify and bring to light the widely-scattered evidence must be satisfied. Some studies looked upon this task as an end in itself. In the majority of cases, however, authors sought to draw lessons from the material they unearthed, in particular, the accuracy of the Chinese accounts and / or their value to present-day scientific research.[1] To do so, they judged traditional Chinese activities against modern scientific knowledge and disciplinary boundaries and viewed them within the larger global framework, say of world climatology or the general history of cartography.

But there surely are other ways of interpreting and understanding the Chinese records. For instance, we can study them primarily within the context of beliefs, reasoning, and circumstances that prevailed in political, socio-economic, intellectual, and religious domains at the time. The observations, practices and theories from early and mediaeval China can be assessed according to the needs of the Chinese themselves then, and to the physical resources and technical skills available to them.[2] Needless to say, these

[1]This applies especially to Chinese observations that pre-dated or can supplement Western ones.

[2]Indeed, the great merit of a recent collective project on cartography in traditional Islamic and South Asian societies is said to lie in its succees in achieving a delicate balance: the ability to "situate non-Western mapping traditions in their own social and epistemological settings" while not "become so overconscious of non-Western sensibilities that histories are not written at all": David N. Livingstone, rev. of The History of Cartography, vol. 2, book 1: Cartography in the Traditional Islamic and South Asian Societies, ed. J. B. Harley, and David Woodward (Chicago: Chicago UP, 1992) in Isis,

considerations and goals affect not only the reading, but the selection of material and evidence as well. Schafer, Major, Sleeswyk and Sivin were among the few individuals who have shown an interest in conducting research along these perspectives.

The common approach taken towards a given topic (e.g. bores, asbestos, snow crystals, coastal maps) has been chronological or one defined largely according to a particular period. In contrast, issue-oriented studies (e.g. articles by Bennett and to some extent Laufer's investigations of minerals) or works that made use of strategies from various disciplines (e.g. that by Sleeswky and Sivin) were less typical.

Within cartography, general introductory accounts were attempted on no less than half a dozen occasions. As already mentioned, this genre was rarely seen in other areas and sub-fields, both within the earth sciences and in Western literature on traditional Chinese science in general.[1] The overall tendency, however, was to concentrate on specific aspects rather than to encompass multiple themes or the entire branch of earth sciences. This resulted in an uneven coverage and also a lack of wide frameworks for broad discussions, comparisons and syntheses.

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84 (1993), pp. 777-78. This is quite a feat as Livingstone explains: ". . .the revisionist impulse to which the entire project is committed so enlarges the scope of what constitutes cartographic representation that critics might well raise questions about the coherence of writing a history of cartography for societies that did not even possess the label *map*. Mercifully, J. B. Harley and David Woodward did not succumb to the stultifying consequences of such methodological queries as to the natural suture lines in cartographic history, or to the crippling effects of an excessive postcolonial deconstructionism": Livingstone, rev. of The History of Cartography, pp. 778.

[1]But note that most general portrayals of traditional Chinese cartography supply the barest outline and highlight only the most prominent features and maps. They are far from thorough and contain little or no critical evaluations. Afterall, they were not written with the specialist in mind.

6.8 PARTICIPATING COUNTRIES AND INDIVIDUALS

One should begin this sub-section by recognising the extensive involvement of Sinologists and Orientalists in the pre-1950 period, including figures of renown in the world of Sinology; for example, Klaproth, Pauthier, Biot, Wylie, Erkes, Vacca, Chavannes, Soothill, Moule, and Demiéville. Scholars specialising in Chinese studies (e.g. Schafer, Major, Bennett), though far fewer in number than previously, continued to express a keen interest in the second half of the 20th century. This might explain the preoccupation with Chinese sources mentioned earlier.

Nevertheless, contributions were made by a number of other individuals, characterised by their diverse professional training and careers; for instance, de Mély and Berthelot (historians of science and chemistry), Laufer (anthropologist and curator at the Field Museum of Natural History in Chicago), Hosie (official in the China Consular Service), Schove (schoolmaster at St. David's College in Berkenham, Kent), Mills (formerly Puisne Judge of the Straits Settlements), Hsu, Chang Kuei-sheng and Wang (academics with advanced degrees in geography), Sleeswyk (Professor of Applied Physics in the Laboratorium voor Algemene Natuurkunde at the University of Groningen), Knight (Map Curator at the National Library of Australia), Needham, Lu, Ho, and Sivin (historians of Chinese science).

In considering French scholarship, the 19th and the first quarter of the 20th century was the most important period with publications by Biot, de Mély, Chavannes, Demiéville, and others on different topics and themes. Several researchers from the U.K. were engaged in the study of the subject in the late 19th and early 20th century (e.g. Hosie, Wylie, Giles, Soothill). While French interest dwindled in later years and the country was represented chiefly through Destombes' work in the 1970s, efforts from British scholars continued, with writings from Moule, Mills, Needham, Schove, Nelson, etc.

The Chinese cartographic tradition was well acknowledged and appreciated by Herrmann in the 1920s, and there were works from other German scholars such as Klaproth and Franke. And Erkes study of the *Huai nan tzu* should not be forgotten. Nevertheless, Germany's overall participation was rather limited.

The meticulously researched papers by Laufer will always be remembered as works that have enriched our understanding in traditional Chinese approaches to minerals, and so will the incomparable essays by Schafer. American contributions were by no means confined to literature from these two scholars. Other researchers from that country included, among a host of others, Wittfogel, Yao, Goodrich, and Rudolph in the 1940s, Hsu, Bennett, March, Chang, and Wang in the 1970s and '80s.

One should also mention several researchers from other countries; for example, Vacca from Italy, Duyvendak and Sleeswyk from the Netherlands.

6.9 FORMS OF PUBLICATION

Journals in this chapter fall comfortably into two main categories: Chinese / Asian studies, and geography.

The first group was much larger in terms of both the number of journals and the number of articles involved. Of particular significance were T'oung Pao (with nine articles on different aspects of the subject published between 1915 and 1979) and Journal Asiatique (with seven essays -- one from Pauthier in 1836, five from Biot in the 1840s, and one from Destombes in 1974) Other well-established Chinese / Asian studies journals were also chosen routinely (e.g. Harvard Journal of Asiatic Review (1942, 1944), Journal of the American Oriental Society (1965), Ostasiatische Zeitschrift (1917, 1920, 1924), Bulletin de l'École Française de l'Extrême-Orient (1903, 1924).

Geography journals included specialist titles such as Weather, Climatic Change and Imago Mundi as well as more general ones such as Revista geografica Italiana, Annals of the American Geographers, Geograhical Journal and Geographical Magazine. The majority of papers in geography journals were published in recent decades, but there were also several works from the first half of the present century. Unlike Chinese / Asian studies periodicals -- which were frequently responsible for two or three articles -- Imago Mundi (1954, 1970, 1979) was the only geography journal that supplied more than one paper on the subject.

Three studies can be found in Chinese Science, but history of science and other types of periodicals (e.g. Memoirs of the American Anthropological Association, Journal des Savants, Boston University Journal) played a relatively minor role in publishing literature devoted to the history of Chinese understanding in the earth sciences.

Three studies appeared in conference proceedings and the same number as parts of larger works.[1] Three works were presented in book-form.

6.10 BIBLIOGRAPHIC PROVISION AND CONTROL

I. GENERAL BIBLIOGRAPHIES FOR CHINESE / ASIAN STUDIES AND THE HISTORY OF SCIENCE

(a) Henri Cordier, Bibliotheca Sinica. . . (1904-08); (1922-24):

Titles relevant to earth sciences are listed under "II. Géographie" or "V. Climat et Méteorologie" or "VI. Histoire Naturelle - Géologie et minérologie". With the exception of Klaproth's paper in the 1823 Asiatic Journal and Monthly Register for British and Foreign India, China and Australia, Cordier recorded all sixteen titles published in the 19th century. Also indexed in the Supplement under "Industries diverses - Divers" is Laufer's study on asbestos from 1915.

(b) John Lust, Index Sinicus. . . , 1920-55 (1964):

Over a quarter of the studies discussed in this chapter were published in the years covered by this index, and a large majority of them are listed, including several from non-Chinese / Asian studies journals.[2] Although most of the works are under sub-divisions of "II. Geography - b. Historical geography and early travels" (e.g. "I. General", "II. Asia", "V. Maps"), some titles are hidden elsewhere.[3] "XVIII. Science and Technology - e. Geology" also carries a few rele-

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[1]All these collective works are China / Asia-related.

[2]e.g. Miller's article in Geographical Teacher, Mills's "Chinese Coastal Maps" in Imago Mundi.

[3]e.g. Wittfogel's "Meteorological Records from the Divination Inscriptions of Shang" in "II. Geography - c. Modern geography - v) Climate", Belpaire's "Le folklore de la foudre en Chine sous la dynastie des T'ang" in "IX. Sociology - d. Folklore".

vant articles.[1]

(c) ISIS Cumulative Bibliography, 1913-65; 1966-75; 1976-85:

One can find roughly a third of all the relevant publications in part "4 China" or "39 Far East" under various classes directly related to earth sciences -- "FZ Earth sciences", "G Meteorology", "GG Geology" (especially sub-divisions "GO Seismology and vulcanology" and "GT Mineralogy"), "GV Geomorphology; Physiography", "H Geography" (especially sub-divisions "Cartography), "HU Paleontology".[2]

It is heartening to learn that almost half of these indexed titles were derived from journals and collections on Chinese / Asian studies.[3] And to find that it supplies Bennett's essay in Boston University Journal (1978), his other article in Chinese Science (1978), and Keller's in Geographica Helvetica (1968) -- none of which is indexed in other general bibliographies. Nevertheless, one is slightly disappointed that accounts published in certain geography journals are not reported.[4]

(d) Bibliography of Asian Studies, 1936- :

Even though a little over half of the literature of interest to us was published between the 1930s and '80s, the majority in Chinese / Asian studies journals, Bibliography of Asian Studies has delivered

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[1]i.e. Moule's "An Ancient Seismometer", Schafer's "Notes on Mica in Mediaeval China", and Rudolph's "Early Chinese References to Fossil Fish".

[2]Note that Bennett's "Patterns of the Sky and Earth: A Chinese Science of Applied Cosmology" is under "FU Cosmology", while Schafer's "The Transcendent Vitamin: Efflorescence of *lang-kan*" is in "RS Pharmaco-mineralogy".

[3]e.g. Le Muséon; Revue d'Études Orientales (1939), Harvard Journal of Asiatic Studies (1942, 1944), Journal of the American Oriental Society (1965), Actes du IIIe Colloque International de Sinologie (1983).

[4]e.g. Rivista Geografica Italiana (1911), Geographical Review (1940), Navigation (1976), Bulletin of the American Meteorological Society (1979).

only a third of that number.[1] On the other hand, its efforts have yielded a few studies not found elsewhere.[2] Some of the entries, such as the two articles by Yao, are not in the "Science, technology and medicine" section.[3]

(e) Bulletin Signaletique 522, 1947- :

Eight special historical accounts on Chinese contributions to the earth sciences are supplied, ranging from Ho and Needham's in Weather, Destombes' in Journal Asiatique, Nelson's in Geographical Magazine, Bulling's in Expedition, Major's in T'oung Pao, to Schwarz's "Chinesische Küstenkarten" in Deutsche Akademie der Wissenschaften zu Berlin. Instituts für Orientforschung. Mitteilungen (the last of which does not appear in other general bibliographies). These titles are mostly located in "Science and Techniques de la terre - Géographie - Cartographie" (under "Orient et Extrême-Orient" or "Antiquité").[4] All of them can be retrieved by looking up the subject index under "Chine".

(f) Revue Bibliographie de Sinologie, 1955-70; 1983- :

Of the thirteen titles published between 1955 and 1970, and between 1983 and 1985, eight of them were reviewed, including two articles in Weather. There is a dedicated section for the history of science, technology and medicine, but not all our titles are found there.[5]

(g) Tōyōgaku Bunken Ruimoku, 1963-:

This index does little for those seeking information on earth sciences: it lists less than half a dozen studies treated in this

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[1]Titles in T'oung Pao (1942, 1955), Boston University Journal (1978), and Imago Mundi (1979) are among the missing ones.

[2]e.g. articles in Hemisphere (1972), Chine ancienne: Actes du Congrès International des Orientalistes, Paris, 1973; section organisée par Michel Soymié (1977), Explorations in Early Chinese Cosmology (1984).

[3]e.g. Yao's essays are under "History and the humanities", and Major's contribution in "Philosophy and Religion".

[4]Major's "Notes on the Nomenclature of Winds and Directions in the Early Han" is in "Science and Techniques de la terre - Météorologie - Vents".

[5]"An Appreciation of Chinese Geomancy", for example, is placed under "Philosophie et religion".

chapter.[1]

II. SPECIALISED BIBLIOGRAPHIC SOURCES

The closest one can get to a special bibliographic guide devoted to the earth sciences is "Bibliography C: Books and journal articles in Western languages" in Science and Civilisation in China vol. 3. Within its hundreds of titles are nearly forty that we have discussed above. Not only does that represent over 90% of all the literature published between 1832 and 1957, but it also contains important works not indexed elsewhere.[2]

III. CONCLUSION

Broadly speaking then, no single bibliographic aid has been wholly successful in supplying users conveniently with 19th and 20th century Western literature on traditional Chinese understanding and activities associated with the earth sciences. The Science and Civilisation in China bibliography is clearly the best place to begin (if the laborious sifting is no objection). Publications -- both before and after 1958 -- not provided by this bibliography have to be extracted piecemeal from various sources.[3] Moreover, one should bear in mind that not all works are given in Needham's listing or in the general bibliographies.[4]

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[1]e.g. Schafer's "The Origin of an Era" in Journal of the American Oriental Society (in "I. History - 3. China"), March's "An Appreciation of Chinese Geomancy" in Journal of Asian Studies (in "XIV. "Ethnogeography - 3. Manners and Customs"), Sleeswky and Sivin's "Dragons and Toads: The Chinese Seismoscope of A.D. 132" in Chinese Science (in "9. Science - 5. Other Physical Sciences and Technology").

[2]e.g. Klaproth's "On the Geographical and Statistical Atlas of China, entitled '*Kwang Yu Thoo*', and on Chinese Maps in General", Chavannes' "Les deux plus anciens spécimens de la cartographie chinoise", Laufer's "Historical Jottings on Amber in Asia", Herrmann's "Die Westländer in der chinesischen Kartographie", Franke's "Chinesische Landkarten".

[3]For instance, one has to consult Bibliotheca Sinica for four of Biot's articles, and the Bibliography of Asian Studies for Major's "The Five Phases, Magic Squares, and Schematic Cosmography".

[4]e.g. Destombes' article in Navigation (1976), Wang's in Bulletin of the American Meteorological Society (1979), Mills' in Archipel; Interdisciplinary Studies on the Malay World (1979).

CHAPTER 7 : PHYSICS

This chapter covers Western works concerned with traditional Chinese understanding in several areas now generally classified under the head of physics: measurement and metrology; optics; acoustics; magnetism. More so here than in other chapters, these and other modern scientific terms and concepts should be interpreted as nothing more than convenient guides. As Needham remarked on the first page of Science and Civilisation in China's physics volume, "one can hardly speak of a developed science of physics" in pre-modern China.[1] Nathan Sivin, Hans Ågren, and Christopher Cullen have also indicated that such modern designations are not appropriate.[2]

7.1 GENERAL WORKS

In Science and Civilisation in China. Vol. 4 Physics and Physical Technology, Part 1: Physics (1962) -- the only publication discussed in this section -- over 80% of its text is devoted to the following four areas: "(c) Mass, mensuration, statics and hydrostatics"; "(g) Light (Optics)"; "(h) Sound (Acoustics)"; and "(i)

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[1]Science and Civilisation in China, vol. 4 pt. 1, pp. 1. Nevertheless, that volume is organised along the line of Western physics.

[2]*See* Nathan Sivin, "Science and Medicine in Imperial China: The State of the Field" (mentioned in *Chapter 1: Introduction*); Nathan Sivin, "Introduction" (mentioned in *Chapter 3: Traditional Chinese Science -- Fundamental Concepts; Philosophy; Social and Cultural Relations*); Hans Ågren, "Chinese Science" (mentioned in *Chapter 3: Traditional Chinese Science -- Fundamental Concepts; Philosophy; Social and Cultural Relations*); Christopher Cullen, "Science and Medicine in China" (mentioned in *Chapter 2: Traditional Chinese Science -- General Works*).

For instance, in Sivin's (as well as Cullen's) categorisation of traditional Chinese science, "physical studies" is a sub-field under "Quantitative Sciences". They "applied the concepts of natural philosophy to particular instances of change and interaction. They were closer in style to Stoic physics than to the Aristotelian or the dominant components of the European tradition": Nathan Sivin, "Introduction," in Science and Technology in East Asia, ed. Nathan Sivin (New York: Science History Publications, 1977), pp. xiii. "Mathematical harmonics", on the other hand, belongs to "Qualitative Sciences".

Magnetism and electricity". The reason for this is not difficult to fathom. We are informed by Needham and his collaborators that, "three branches of physics were well developed among them [i.e. the scientific minds of pre-Renaissance China], optics (Section 26g), acoustics (26h), and magnetism (26i)."[1] Nevertheless, other aspects -- "(b) Waves and particles"; "(d) The study of motion (Dynamics)"; "(e) Surface phenomena"; "(f) Heat and combustion" -- are also treated. There are very few Western studies devoted to these topics; these other sections can therefore give one a rare opportunity to acquire a more comprehensive understanding of early and mediaeval Chinese approaches to elements with close connections to concerns in modern physics. Indeed, on the whole, Western researchers have given so little thought and consideration to the whole physics department that no matter how one reacts to Needham's reading of the material assembled, the entire volume deserves praise for its systematic organisation of widely-scattered Chinese sources and for bringing obscure issues to light. Criticisms were nevertheless raised, some constructive, others less so, but little damage was done to the work's overall reputation.[2]

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[1] Science and Civilisation in China, vol. 4 pt. 1, pp. xiii.

[2] **(1)** ". . .our authors seem to slight, possibly unintentionally, the treasures and the work of the scholars on Taiwan. In the section on music, for example, mention should be made not only of the Shang ocarinas preserved in Chengchou and Peking, but also of those in the museum of the Academia Sinica at Nankang. The magnificent set of bells, excavated at Hui-hsien, housed in the same museum, also deserves notice. A work of this kind should be all-inclusive": **L. Carrington Goodrich**, rev. of Science and Civilisation in China, vol. 4 pt. 1, in Journal of the American Oriental Society, 82 (1962), 458. **(2)** "Without a good deal of further evidence, for example, this reviewer finds it hard to accept the thesis that chess, traditionally accepted as being of Indian origin, was in actual fact intially developed in China and thence passed to India, from which it again returned to China": **Derk Bodde**, rev. of Science and Civilisation in China, vol. 4 pt. 1, in Pacific Affairs, 36 (1963), 298. He also commented on a negative reception towards Needham's work: ". . .the possible criticism that many of the book's topics are trivia having only a tangential relationship to 'science' as such. An extreme form of this criticism has been expressed by J. Arol Simpson of the U.S. Bureau of Standards, in his recent review of the book (see *Physics Today*, vol. 16, april 1963, p. 68) in which he writes: << . .the book is less than a success because ancient China had no physics to study. . . . We will never understand the civilization and science of China if we consider, as the author does, Taoist geomancy to be 'pseudo-

7.2 MEASUREMENT AND METROLOGY

When confronting the subject of metrology and the standardisation of measurement in ancient and mediaeval China, the approach taken by most Western scholars was to establish and compare length and weight measures from different historical periods.

The essay by John Chalmers (1884) aims at demonstrating that "the Chinese *Ch'ih* has been gradually increasing in length for the last two thousand years" and that it had gone through numerous variations.[1] Written as well as material evidence are offered.

Six accounts on length and weight measures of varying scope and scholarly sophistication were published in the first half of the 20th century.

By examining closely two silk strips found in the desert west of Tun-huang and making detailed comparisons with relevant specimens, Aurel Stein notes in his "Central-Asian Relics of China's Ancient Silk Trade" (1920) that "we are thus justified in concluding that the standard width for silk, as established during the Han times, remained the same also under the Ch'in dynasty. The dimension of the Chinese inch, on the other hand, had been altered considerably in

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science.'>> To the reviewer this statement suggests an unhistorical and nonhumanist view of life to be found today not only among many members of the lay public but also among quite a few highly qualified scientists. One would like to ask Dr. Simpson whether he would similarly deny the relevance of astrology and alchemy to the study of the history of Western astronomy and chemistry and, if so, where and how he would have the historian of ideas draw the line between what is 'science' and what is 'psuedo-' or 'proto-science'": Bodde, rev. of Science and Civilisation in China, vol. 4 pt. 1, 298-99. **(3)** "Where lexicographic analysis forms such an important part of the study, the scholar must be constantly on guard. . . . Then again, the author's enthusiasm for his subject sometimes leads him to somewhat forced inferences -- a wistful look at certain points in the cultural history under analysis that do not quite come up to his expectations, perhaps. One thinks of the paragraphs dealing with sound as vibration, in which Needham quotes Tung Chung-shu (second century B.C.) and Liu Chih (third century A.D.) as both having made statements describing the movement of concentric wave-rings, adding that these two men therefore bracket Vitruvius in time. The fact is that neither of these writers had made specific reference to *sound waves* -- while Vitruvius had": **E-Tu Zen Sun**, rev. of Science and Civilisation in China, vol. 4 pt. 1, in Technology and Culture, 5 (1964), 91.

[1]John Chalmers, "The Chinese *Ch'ih* Measure," China Review, 13 (1884/85), 334.

this later period. . . ."[1]

Evan Morgan's (1923) short essay quotes a passage translated by A. C. Moule which indicates that tonnage was determined either "by the linear method" or "by weight" in ancient China.[2] He also relates the popular story of measuring the weight of an elephant by putting it on a boat and later weighing the stones piecemeal.

Conclusions drawn by Pierre Daudin in his "L'unité de longueur dans l'antiquité chinoise" (1938) may not be entirely new.[3] Nevertheless, he offered his own translations and commented on relevant extracts from textual and other sources. The article contains four sections: "Pied en cuivre de la période Kien-Tch'ou des Han (76-84)"; "Pied des Tsin"; "Pied pour tissus des 'San-Se' des Song"; "Autres données sur la longueur des pieds".

John C. Ferguson explained in a short article published in 1937 that by appealing to a passage in the *Sung shih*, he reached the conclusion that a measure he obtained from a Chinese dealer was from the Hui Tsung period and "may be considered to be nine inches of the Sung dynasty foot measure."[4] In a more elaborate study, Ferguson (1941) reviews an interesting array of material on the Chinese foot measure, including archaeological discoveries, Chinese documentary sources and secondary literature on the subject. He begins with an assessment of Ma Heng's *Sui shu lü li chih shih wu teng ch'ih* from

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[1]Aurel Stein, "Central-Asian Relics of China's Ancient Silk Trade," T'oung Pao, 20 (1920), 141.

[2]Evan Morgan, "How Tonnage was Measured in Ancient China," Journal of the North China Branch of the Royal Asiatic Society, 54 (1923), 228.

[3]For instance, "les anciennes unités de longueur et de poids variaient avec les dynasties. . . . il existait une corrélation entre la musique et les mesures de longueur. . . . Toutes ces données sont intéressantes à connaitre avant d'aborder l'étude des mesures de longueur dans l'antiquité chinoise, qui. . . ont été sous les Tsin, les Han et les Song d'une extrême complexité. Une remarque s'impose, en guise de conclusion à cette étude: c'est qu'au cours des siècles, les pieds linéaires ont toujours augmenté de longueur": Pierre Daudin, "L'unité de longueur dans l'antiquité chinoise," Bulletin de la Société des Études Indochinoises de Saigon, new ser., 13.2 (1938), 145, 147.

[4]John C. Ferguson, "Jade Foot Measure," T'ien-Hsia Monthly, 4 (1937), 392.

1932 (which he translated in 1933) and an evaluation of the significance of a bronze foot measure discovered by Bishop W. C. White in graves in Ho-nan in the early 1930s, subsequently identified (by Ma) as "the Chou Dynasty Foot Measure mentioned in the *Sui Dynasty History* as the first item of the first of the fifteen classes."[1] Next he discusses "the relation between a foot measure and the length of the bamboo tube from which the absolute pitch of tones was chosen" and describes two measures in his own collection.[2] The article also assesses two Chinese works published in 1915 and 1936 on mensuration by Wu Ta-ch'eng and by Luo Fu-i respectively, and comments on six ivory measures presented by the Japanese Empress to the temple Shōsōin in 746 A.D.

In reply to George Sarton's question "Were the ancient Chinese weights and measures related to musical instruments?" (1947) -- which was prompted by a remark from Percival Lowell on such a correlation -- James R. Ware suggested the chapter on musical tubes and the calendar in *Ch'ien Han shu* as the source Lowell had in mind, though there could be problems with Lowell's interpretation of the text.

Relatively little concern for traditional Chinese metrological standards was displayed during the second half of the 20th century. There were nevertheless three articles, and the observations they made could have implications for the study of other subject areas.

In his "Sumerian Weight-Standard in Chinese Metrology during the Former Han Dynasty (206 B.C. - A.D. 23)", A. E. Berriman maintains that there is evidence to show that Mina N, a Babylonian stone weight (British Museum number 91005) is present "(as a multiple) in Chinese metrology during the Former Han Dynasty", and that the evidence "is to be found in Professor Homer H. Dubs' translation of Pan Ku's

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[1]John C. Ferguson, "Chinese Foot Measure," Monumenta Serica, 6 (1941), 364.

[2]Ferguson, "Chinese Foot Measure," 366. His measures are: "a bronze measure excavated at Shou-chou in Anhui province. Its length is 0.225 metre. . . . and a Jade Foot Measure. . . excavated in Honan province . . . . It is marked for nine inches each of which is divided into tenths": Ferguson, "Chinese Foot Measure," 368.

history of that Dynasty."[1]

Michael Loewe's essay (1961) seeks to unravel the different standards used for measuring the capacity and weight of grains during the Han period as well as the actual practice adopted at the time. A broad range of sources was canvassed for this purpose: dynastic histories, mathematical works such as the *Chiu chang suan shu*, archaeological findings, and secondary studies in Chinese, Japanese and Western languages.

Friedemann Freund's "Mass und Messen im 8. Jahrhundert ein modernes Kapitel aus der altchinesischen Wissenschaft" in the 1972 Waage focuses on the employment of astronomical units to determine terrestrial distances in 8th century China, made possible as a result of the large-scale meridian survey carried out by I-hsing. The accuracy of the methods used and the principles on which the effort was based are considered in modern scientific terms.

7.3 OPTICS; "MAGIC MIRRORS"

Works seeking to explain the optical phenomenon produced by ancient Chinese mirrors of unequal curvature which can reflect on the polished surface the designs on their backs -- often called "magic mirrors" -- come closest to qualifying as historical studies on the knowledge attained by the Chinese in the area of light and optics.[2]

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[1]A. E. Berriman, "Sumerian Weight-Standard in Chinese Metrology during the Former Han Dynasty (206 B.C. - A.D. 23)," Revue d'Assyriologie et d'Archéologie Orientale, (1958), 203.

[2]Note that some papers and interpretations are based on JAPANESE magic mirrors. For instance, Science and Civilisation in China vol. 4 pt. 1 makes little distinction between the Chinese and the Japanese mirrors. Nor did Ayrton and Perry, who referred to a Chinese text from the 13th century even though their research was carried out in Japan using local specimens.

Japanese mirrors, however, as pointed out by Julia K. Murray and Suzanne E. Cahill in a study from 1987, are different from Chinese ones. "For the past thousand years, writers have periodically investigated a rare type of ancient Chinese mirror. . . . In English these mirrors have been called "light-penetration mirrors", "diaphanous mirrors," and "magic mirrors," the last term being the most familiar and memorable. The name "magic mirror" is also applied to a group of 19th-century Japanese mirrors that exhibit a superficially similar phenomenon. However, the optical properties of the image reflected by a Japanese magic mirror differ from those of a Han magic

These mirrors had roused considerable curiosity and inspired a series of spirited discussions in the 19th century chiefly among French and British scientists. Much of this exchange came in the form of short notices and communications. These accounts are alike in their underlying nature and intention: almost all of them seek to employ modern optical theories to determine how the Chinese might have achieved the effect and / or report laboratory experiments to produce mirrors with the same properties as those in the Chinese ones.[1] Publications that contain greater details or received more attention at the time include the following:

(1) 1832 David Brewster: The optical phenomenon was interpreted simply as a case of the pattern being drawn on the surface of the mirror.

(2) 1832 James Prinsep: ". . .the deception is entirely produced by irregularities on the surface, which are rendered the less perceptible to the eye, because the surface is convex instead of being plane."[2]

(3) 1847 Stanislas Julien: In contrast to other studies, extracts from the *Ko chih ching yüan* were translated. Julien also described a Chinese magic mirror owned by the Marquis de La Grange.

(4) 1847 Séguier: His opinion was unique in that, as Needham said, "all the physicists agreed that the effects must be due to minute differences in the degree of curvature of the convex polished surface, except Séguier. . . who thought that they were produced by some kind of compression."[3]

(5) 1847 Person: ". . .la surface réfléchissante était plane vis-à-vis ces figures, et convexe vis-à-vis le reste. Les rayons réfléchis

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mirror; and the two types of mirror were not made by the same process": Julia K. Murray and Suzanne E. Cahill, "Recent Advances in Understanding the Mystery of Ancient Chinese 'Magic Mirrors': A Brief Summary of Chinese Analytical and Experimental Studies," Chinese Science, 8 (1987), 1.

[1]Reviews and summaries of these discussions are available in Science and Civilisation in China, vol. 4 pt. 1, pp. 95-97, in the article by Ayrton and Perry, and in that by Bertin.

[2]James Prinsep, "Note on the Magic Mirrors of Japan," Journal of the Asiatic Society of Bengal, 1 (1832), 244.

[3]Science and Civilisation in China, vol. 4 pt. 1, pp. 96.

sur les parties convexes divergent et ne donnent qu'une image affaible; au contraire, les rayons réfléchis sur les parties planes gardent leur parellélisme et donnent une image dont l'intensité tranche sur le reste."[1]

(6) 1853 M. Maillard: Unequal curvature was given as a possible explanation.

(7) 1877 James Parnell: The point was made that the surface of the mirror was partly convex.

(8) 1878 W. E. Ayrton and J. Perry: This thorough study begins with an overview of European writings on the subject, followed by a detailed account of their own experiments and an analysis of their conclusion, which is divided into five sections: "Explanations"; "Composition used in making mirrors"; "Moulds for mirrors"; "Curving the surface"; "Polishing". Their experiments convinced them that they had "strong reasons for favouring the 'inequality of curvature' theory".[2]

(9) 1880a, 1880b M. Govi[3]: The author's primary aim was to report his experiments "to make all mirrors with designs embossed on the back show the effect, by heating."[4]

(10) 1881 A. Bertin: Efforts at producing magic mirrors in collaboration with J. Duboscq "using powerful pressure from behind the mirror" were described.[5] In addition, Bertin surveyed at some length various theories proposed earlier in the 19th century.[6]

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[1]Person, "Observations faites sur des miroirs chinois dits *miroirs magiques*," Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences [Paris], 24 (1847), 1110.

[2]:W. E. Aryton and J. Perry, "The Magic Mirror of Japan, I," Proceedings of the Royal Society, 28 (1878), 139. The French version of this account appeared in the 1880 Annales de Chimie et de Physique.

[3]These papers were first presented to the Academy in Turin in 1864 and 1866 respectively.

[4]Science and Civilisation in China, vol. 4 pt. 1, pp. 96.

[5]Science and Civilisation in China, vol. 4 pt. 1, pp. 97.

[6]The paper consists of six sections: "I. Introduction"; "II. Histoire des miroirs magiques"; "III. Théorie des miroirs magiques: 1. Théorie chinoise, 2. Théorie de Brewster, 3. Théorie de Séguier, 4. Théorie de Person" [also includes discussions on papers by Ayrton

By the 20th century, this once vigorous interest in the optical effect produced by magic mirrors died down almost completely.[1] Instead, the three remaining studies on optics deal respectively with burning lenses, two "optick artists" from Chiang-su, and knowledge of optics in the *Mo ching*.

Berthold Laufer's "Optical Lenses: Burning Lenses in India and China" (1915) delineates the technical features, use, and manufacture of burning lenses in China (and other parts of Asia) as well as addresses the question of their origins and the process of their transmission in Asia. Laufer argues that, "China, despite the opposite contention of some enthusiasts, has not the shadow of a claim to their invention, but, on the contrary, admits her debt to Lo-ch'a and Champa; that means, to India."[2]

"The Optick Artists of Chiangsu" by Needham and Lu Gwei-djen (1967) attempts to throw light on Chinese optical knowledge in the 17th century by analysing the short biographies of Po Yü and Sun Yün-ch'iu in the Chiang-su local gazatteers. Passages were translated, the lives, careers, and sources of the skills of these two individuals traced (in particular the possibility of Western influence), and the pieces of equipments mentioned in the biographies given careful consideration.

It is difficult to think of a major recent contribution to traditional Chinese understanding in areas now considered part of physics other than A. C. Graham and Nathan Sivin's "A Systematic Approach to Mohist Optics" (1973). It stands out as an exemplary

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and Perry, and by Maillard]; "IV. Confirmation de la théorie de Person"; "V. Production artificielle des miroirs magiques par MM. Bertin et Duboscq"; "VI. Effets magiques exceptionnels".

[1]A special section on this topic can be found in Science and Civilisation in China vol. 4 pt. 1, but it occupies only three pages.

[2]Berthold Laufer, "Optical Lenses: Burning Lenses in India and China," T'oung Pao, 16 (1915), 225. This extensive study is divided into: "Fire-production by means of optical lenses among the ancients"; "Burning-lenses in the Middle Ages and among the Arabs"; "Refutation of the theories that the ancient Chinese were acquainted with burning-lenses"; "Burning-lenses not a Chinese invention. Deficient knowledge"; "Huo-tsi not a burning-lense, but mica"; "Liu-li and lang-kan, not burning-lenses"; "Introduction of burning-lenses into China"; "Burning-lenses in India and Siam"; "Ice-lenses".

study on which writings on the history of Chinese science can be modelled. Its three opening sections -- "The Mohist Canon"; "The Canons and the explanations"; "Problems of comprehension and translation" -- not only help provide a deeper appreciation of this cardinal work, but also establish a set of guidelines for approaching Chinese texts.[1] Furthermore, the manner in which the eight optical propositions were translated has demonstrated how illuminating and fruitful translations can be: for each proposition, the Chinese text is presented (with appropriate adjustments), followed by the translation of the proposition in the Canons and the corresponding Explanation, with critical commentaries offered in the sections "Textual notes" and "Physical interpretation". Two appendices -- "Other propositions which have been said to concern optics" and "Shen Kua on the inversion of the shadow" -- are also included as well as an impressive "Bibliography" not found in other studies discussed in this chapter.[2]

7.4 ACOUSTICS; MUSICAL SOUNDS AND MATHEMATICAL HARMONICS

20th century Western scholarly investigations into early Chinese acoustical ideas, knowledge and skills were carried out largely within the framework and sphere of musical sounds and mathematical harmonics.

One can start with several articles from the 1950s and '60s by Fritz A. Kuttner. Among his early projects were ones which involved

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[1]The authors have made clear that "to arrive at a clear determination of what one can hope to comprehend given the present state of Mo-ching studies, and of what must be left for some unanticipated breakthrough, several methodological principles must be applied simultaneously", and "our goal in pooling our efforts in this translation has been to apply all these standards for the first time": A. C. Graham, and Nathan Sivin, "A Systematic Approach to Mohist Optics," in Chinese Science: Explorations of an Ancient Tradition, ed. Nakayama Shigeru, and Nathan Sivin (Cambridge, Mass.: MIT P, 1973), pp. 111, 113.

[2]The bibliography is divided into "Classical texts" and "Commentaries, studies, and reference works", the latter consisting of Chinese, Japanese and Western titles on the Mohist Canons (with Chinese characters, and English translation of titles where appropriate).

the tuning and suspension techniques of sonorous jade objects. His article for the 1953 Artibus Asiae claims that the ancient Chinese flat jade disks called *pi* and other possibly sonorous jades were tuned to a preconceived musical pitch. He further argues that their sole function was acoustical, and that the techniques employed were identical to those developed for the Shang bronze bells. In another paper Kuttner (1959) maintained that after subjecting to close scrutiny eighteen sonorous stones from tombs in Lo-yang (sealed in the middle of the 6th century B.C.) now kept at the Royal Ontario Museum in Toronto, he was convinced that "the Chinese knew and used both the 'Pythagorean' and natural systems of intonation about 550 B.C. or earlier, especially for the major third which is represented in both intonations among our lithophones."[1]

Kuttner (1965) has also given thought to the seemingly mysterious origin of the names for the twelve *lü*.[2] In his opinion, they "are in fact expressions of acoustical facts or observations, and that musicological interpretation can lead to satisfactory explanation."[3] His findings were apparently controversial.[4] The twelve *lü*

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[1]Fritz A. Kuttner, "A 'Pythagorean' Tone-System in China -- Antedating the Early Greek Achievements by Several Centuries," in Bericht über den Siebenten Internationalen Musikwissenschaftlichen Kongress, Cologne, 1958 (Kassel: Bärenreiter, 1959), pp. 176.

[2]"The twelve pitches appear to have mythological or even mystical names whose meaning has vexed scholars in various disciplines and countries for quite some time. Sinologists, archeologists, linguists, and philologists have repeatedly tried to explain the hidden connotations of the Lü names, but so far without success. Even Joseph Needham, backed by his enormous scientific and linguistic resources, gave up without really trying": Fritz A. Kuttner, "A Musicological Interpretation of the Twelve *Lü* in China's Traditional Tone System," Ethnomusicology, 9 (1965), 22.

[3]ibid. He summarises his reasoning as follows: "(*) the construction of a complex tone system calls for considerable mathematical and acoustical skills; thus the existence of such a system in any civilization is a priori evidence of corresponding scientific or technological knowledge; (*) the ancient Chinese had a particular knack for combining eminently practical or factual observations with abstruse mythological ideas; (*) the science and technology of music was in the hands of privileged guilds or clans who kept their trade secrets closely guarded; thus intentional mystification of the layman by the choice of the terminology is highly plausible, while at the same time the technical terms had to convey important information to the initiated": ibid.

were also explored by Walter Kaufmann, but through a very different channel. His 1969 essay seeks to explain mathematically Liu An's (i.e. Huai-nan Tzu's) measurement of the twelve pitch-pipes, or rather, why Liu chose certain numbers in his calculation.

The theoretical calculation of the equally tempered scale and its discovery by Chu Tsai-yü in the 16th century -- "the crowning achievement of China's two millennia of acoustical experiment and research" -- was a new theme taken up by four of the six studies published between 1975 and 1980.[1]

Kuttner was again involved. He (1975a) contends that "the 749-method of temperament calculation originated with Prince Chu Tsai-yü in 1584, inspired by a calculation recorded in the Chin Shu, from figures created by Hsün Hsü prior to 289. There did not exist any attempt of tempering, with or without the divisor 749, in China at the time of Huai Nan Tzu, in or before 123 B.C. Any ascription of the 749-method to him is due to an intentional mystification by Prince Chu Tsai-yü, or to writers copying this mystification from Chu's work. The first documented temperament in China dates from c. 430-440 and is the work of Ho Ch'êng-t'ien."[2] His other essay from the same year (1975b) is organised around the life and work of Chu, especially his discovery of the theory vis à vis that by the Flemish

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[4]In a footnote, Kuttner himself informed us that his "article is a detailed version of a paper read at the 173rd annual meeting of the American Oriental Society (A.O.S.). . . on March 28, 1963. The paper was submitted to the Journal, A.O.S., for publication but was rejected by the Editor on the grounds that it failed to offer philological argument or proof. We mention this circumstance because it is characteristic of certain attitudes in Oriental studies where even convincing physical evidence may be considered as "guess work" in the absence of literary evidence or philological reasoning. Similar attitudes, unfortunately, are occasionally found in musicological circles as well, with the result that philological "evidence" is sometimes offered in contradiction to known physical or acoustical fact. It seems necessary to relegate strictly philological musicology to its proper place whenever it is found out of bounds": Kuttner, "A Musicological Interpretation," 37.

[1]Science and Civilisation in China, vol. 4 pt. 1, pp. 224.

[2]Fritz A. Kuttner, "The 749-Temperament of Huai Nan Tzu," Asian Music, 6 (1975), 100.

scientist and engineer Simon Stevin around the same time.[1]

Ernest G. McClain wrote in 1979: "Between the first century B.C. and the 5th century A.D., certain aspects of Chinese tuning theory were more than a thousand years ahead of similar developments in the West. The cycle of fifths was studied to the limit of 60 and then 360 tones, and arithmetic approximations to equal temperament were developed. The simplicity and accuracy of Chinese methods, not fully appreciated in the East, have been hidden from the West by the language barrier."[2] To better understand and appreciate the Chinese technique, McClain offered "a complete translation of the 60-division tuning of Ching Fang (-78 to -37) together with an analysis of his procedure."[3]

A Critical Study of Chu Tsai-yü's Contribution to the Theory of Equal Temperament in Chinese Music (1980) was originally a B.Litt. thesis Robinson wrote in 1951 for the University of Oxford. To bring

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[1]Kuttner's view differs significantly from that held by Robinson who co-authored the acoustics section with Needham in Science and Civilisation in China vol. 4 pt. 1: "It is with regret that these pages bring me into conflict with some of Robinson's views": Fritz A. Kuttner, "Prince Chu Tsai-yü's Life and Work: A Re-Evaluation of his Contribution to Equal Temperament Theory," Ethnomusicology, 19 (1975), 201.

In Kuttner's opinion, Chu "presented a highly precise, simple and ingenious method for arithmetic calculation of equal-temperament monochords in 1584. Stevin offered a mathematical definition of equal temperament plus a somewhat less precise computation of the corresponding numerical values in 1585 or later. . . . It seems pointless to attempt a qualitative evaluation of the two solutions with a view to label one or the other as superior. Both authors proceeded within the framework of their own cultural traditions and created perfect solutions consistent with their different scientific surroundings. Neither Chu nor Stevin can be recognized as "inventors" of equal temperament, for the following reasons. In China the problem of such tempered tuning had been known for many centuries as in Europe. Stevin's definition and calculation was not needed in Europe where practical tunings with satisfactory approximations to good tempering had been known and used for almost a hundred years before his work. In Chinese musical practice equal temperament was neither needed nor desired before or after Chu's publications, thus unfortunately making his achievement irrelevant for his nation": Kuttner, "Prince Chu Tsai-yü's," 200.

[2]Ernest C. McClain, "Chinese Cyclic Tunings in Late Antiquity," Ethnomusicology, 23 (1979), 205.

[3]McClain, "Chinese Cyclic Tunings," 225.

it up-to-date, Needham contributed a preface while Erich F. W. Altwein furnished supplementary notes; in addition, a bibliography incorporating more recent titles was attached. The monograph contains ten chapters: "Part I. Introduction"; "Part II. Tuning methods (a) Just intonation (b) The cycle of fifth"; "Part III. The alleged influence of Pythagoras in Chinese music"; "Part IV. A possible origin of the metric cycle"; "Part V. From just intonation and the cycle of fifths to equal temperament (a) The orthodox pitch-pipes theory (b) The theory of microtonic division (c) The theory of modified notes (d) The theory of equal temperament"; "Part VI. Chu Tsai-yü's contribution to musicology"; "Part VII. The nature of the "*kuan*" or ancient flute"; "Part VIII. Facts and figures concerning the pitch-pipes"; "Part IX. Blowing the pitch-pipes"; "Part X. Conclusions".

The remarkable discovery of a set of sixty-four 5th century B.C. bronze bells in the tombs of Marquis Tseng in China in 1977-78 prompted two accounts, both published in 1985.

In [Joseph] Cheng-Yih Chen's words, "a detailed comparison between the measured and theoretical frequency ratio. . . made in terms of the harmonic progressions in both pentatonic and heptatonic patterns. . . support the theoretical findings that the Chou musicians had in their possession a versatile chromatic scale."[1]

The bells' technological and musicological significance was assessed in some detail by McClain (1985). His study traces the archaeological background and discusses the following issues: "Ancient Chinese bell designs"; "The control of pitch and timbre"; "Zeng relative pitch names"; "The one-hundred thirty tones"; "The small bells in the top row"; "Musical implications of the Chinese scale";

[1][Joseph] Cheng-Yih Chen, "A Study of Harmonic Progressions in the Unearthed Bronze Set-Bells of the 5th Century B.C.," in 17th International Congress of History of Science, Berkeley, 1985. Abstracts of Papers presented in Scientific Sections (Berkeley, Calif.: Office for History of Science & Technology, U of California, 1985), vol. 1, Tb. In his paper, Chen also mentions that "the oldest extant Chinese record on a quantitative procedure for the generation of harmonic progressions is found in the 'Kuan Tzu'. . . compiled in the -4th century", and that "in the 'Lü-Shih Ch'un-Ch'iu. . . of -239, the up-and-down principle is extended to the generation of a set of twelve tones": ibid.

"Evidence for an 'absolute' pitch system"; "Evidence for frequency determination"; "The Zeng bells as an acoustical tonometer". Also included is an appraisal of the historical and cultural implications of the discovery.

7.5 MAGNETISM; MAGNETIC COMPASS

Western writings on ancient and mediaeval Chinese notions and observations regarding the directive property of the magnet and the associated practical applications have assumed the form of charting, documenting and clarifying the origins and use of the magnetic compass through the centuries.

Historical accounts on the magnetic compass in China were published in the 1830s and '40s. J. Klaproth's Lettre à M. le Baron A. de Humboldt sur l'invention de la boussole (1834), cited in nearly all later literature on the subject, was regarded by Needham as "perhaps the most remarkable work which has ever been devoted to the magnetic compass by a Western scholar. . .; many of his conclusions still stand today."[1] Textual sources in Chinese, Greek, Latin, Arabic, and other languages were mined for references pertaining to the properties of the magnet, the declination of the magnetic needle and its use for navigation. These were analysed from the philological point of view, and above all considered with the aim of establishing and elucidating the chronological layers involved in the development and transmission of the magnetic compass in China and elsewhere. However, Needham also pointed out that, "but like all other nineteenth-century discussions, it was vitiated by the failure. . . to distinguish between the 'south-pointing carriage' and the magnetic compass proper."[2] This confusion had coloured and muddled not only 19th century inquiries, but even those from the early 20th century.[3] An anonymous article in English paraphrasing the gist of

[1] Science and Civilisation in China, vol. 4 pt. 1, pp. 244.

[2] ibid.

[3] It is important to bear in mind the distinction between the development of the magnetic compass and the south-pointing carriage / chariot as the latter involved chiefly skills in mechanical technology and engineering.

Klaproth's treatise can be found in the 1834 Asiatic Journal.

Additional Chinese material on the magnetic compass (and aurora borealis) -- extracted for instance from the *Wen hsien t'ung k'ao* -- was furnished by Édouard Biot in 1844. Alexander Wylie (1859) also offered his opinion on the subject, citing Chinese documentary evidence that could indicate the observation (though perhaps not complete understanding) of the declination of the magnetic needle by the Chinese since the early periods. A two-page article by W. F. Mayers -- "The Mariner's Compass in China" -- appeared in the 1870 Notes and Queries on China and Japan. [I have not seen this title].

Accounts from the late 19th century clustered round the years 1889 to 1891. Joseph Edkins (1889) suggested that the compass was first used by the Chinese in 1130 B.C., but his interpretation did not take into account the difference between the compass and the south-pointing chariot. J. Chalmers took a firm position on the subject, and began his 1890 essay with the following comments: "'I am asked 1. Where is the magnetic compass first mentioned' '2. When and by whom is it supposed to have been invented?' '3. What was its oldest form and first use?' Having long observed the intense desire the Chinese have to appropriate to themselves the invention of all sorts of things; and having once or twice already exposed the hollowness of their claims. . . , I feel inclined to pity them when their long acknowledged claim to the early possession of the mariner's compass is called in question. Why should we seek to deprive those patriotic champions, who contend so bravely for the intellectual honour of their own country, of their last hope? Still the claims of truth are greatest; and truth will no doubt triumph sooner or later anyhow. So I give the facts, leaving others to judge."[1] However, the anonymous author quoted in the article "Is the Mariner's Compass a Chinese Invention?" in the 1891 Nature held rather different views: "The credit of the discovery, both of the polarity of a magnetized needle and its suitability for use by mariners at sea must. . . be given to the Chinese. It was China also that has the credit of having first noticed that any iron needle may be polarised by rubbing

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[1]J. Chalmers, "China and the Magnetic Compass," China Review, 19 (1891), 52.

it with a magnet."[1] The article also mentions the use of the compass for geomancy, the connection with astronomy, and the transmission to Europe via Arabs. For his "Die Sage vom Kompass in China" (1891) A. Schück's adopted the atypical approach of summarising ideas and findings presented by various 18th and 19th century European scholars (mainly French and Italian) on the development of the magnetic compass in China.

Four studies in different languages -- Italian, English, German, and French -- were published in the first quarter of the 20th century. Timoteo Bertelli's historical research on magnetism led him to China. In an article (1903) that addresses the role of the ancient Chinese, he refers to works by Klaproth, Julien, Carlo Puini, etc., and to passages in the *Meng ch'i pi t'an* and other Chinese texts.[2] In "Origin of the Mariner's Compass in China" (1906) Frederich Hirth outlines the historical development of the magnetic compass (and south-pointing carriage) in early and mediaeval China. Various landmarks are presented in a chronological chart which begins with "B.C. 2704-2594. The invention of the 'south-pointing chariot' ascribed to the legendary Emperor Huang-ti according to the Ku-kinchu (4th cent. A.D.)" and ends with "A.D. 1115. The magnetic needle is described in detail and its deviation mentioned in the Pön-ts'au-yen-i, where no allusion is made to its use on board ship."[3] Schück's other contribution -- "Zur Entwicklung der Einteilungen der

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[1]"Is the Mariner's Compass a Chinese Invention?," Nature, 44 (1891), 309.

[2]He opens his essay with these remarks: "Riguardo alle primitive conoscenze dei Cinesi intorno alle proprietà dell'ago magnetico, VI è sempre stata nei diversi autori che ne hanno scitto dal secolo XVII sino ai nostri giorni, una doppia opposta corrente, come più volte ho dovuto notare, cioè di quelli che intorno a ciò hanno negato tutto ai Cinesi, e di altri invece che hanno troppo ecceduto nell'attribuir loro cognizioni che realmente non ebbero. In qualche recente mio lavoro ho dovuto combattere alcuni dei primi, mentre al presente in questa *Nota* debbo pure far ciò riguardo ad altri della seconda categoria, benchè con molto ritardo, prevalendomi ora soltanto della recente occasione che ho avuto di dover di nuovo parlare della bussola": Timoteo Bertelli, "Se da alcuni documenti si possa dedurre l'antica conoscenza della 'Declinazione magnetica' presso i Cinesi," Bollettino della Società Geografia Italiana, (Mar 1903), 178.

[3]Friedrich Hirth, "Origin of the Mariner's Compass in China," Monist, 16 (1906), 328-30.

chinesischen Schiffs - und der 'Gaukler' Bussole" (1917) -- is a short sketch also based on secondary Western material. Léopold de Saussure's treatise (1923), on the other hand, is an extensive account accompanied by copious footnotes. It confronts multiple aspects and issues associated with early Chinese knowledge and observations in magnetic directivity and declination, and the subsequent application of the magnetic needle to navigation. Special attention is paid to transmissions across cultures.[1]

Henri Michel's brief article in the 1950 Communications de l'Académie de Marine de Belgique is the last account treated in this section that still confuses the magnetic compass with the south-pointing carriage.[2]

In his discussions on Chinese understanding of magnetism and the use of the magnetic compass Li Shu-hua cautiously moved the south-pointing carriage out of the way. However, his historical reconstructions from the 1950s share with earlier literature a dominant interest in establishing dates and primacy. "L'origine de la boussole" (1954a) is divided into two parts: the first, subtitled "I. Le char montre-sud" deals exclusively with the south-pointing carriage; the second, "II. Aiment et boussole" is on the magnetic compass. A slightly different version of his interpretations appeared in the 1956 Tsing Hua Journal of Chinese Studies. It is separated into: "Introduction"; "I. History of the south-pointing carriage"; "II. Interior arrangement of the south-pointing carriage"; "III. Lodestone and its attractive force"; "Magnetic needle"; "V. Application of the

[1]Topics discussed include: "La division chinoise de l'univers"; "La division cosmologique de l'horizon"; "La rose azimutale des Chinois"; "Invention de la boussole en Chine"; "Le montre-sud"; "Le 'char montre-sud'"; "L'aiguille aimantée et son récipient"; "Découverte de la déclination magnétique"; "Application de la boussole à la géomancie"; "La division de l'horizon en degrés"; "Application de l'aiguille aimantée à la navigation"; "Les procédés d'aimantation"; "Inductions et présomptions"; "La rose azimutale des Arabes"; "Les renseignments de Prinsep"; "Origine de la rose sidérale".

[2]Michel also takes note of the evolution of the magnetic compass outside China.

magnetic needle to navigation"; "Conclusion".[1] Li argues much along the same line in his "Première mention de l'application de la boussole à la navigation" (1954b): "On connait mal, d'après les textes chinois consultés jusqu'ici, l'époque ou l'aiguille aimantée commença d'être utilisée pour la navigation. Klaproth pense que les Chinois se servaient probablement de la boussole dans leurs navigations sur l'Océan Indien, sous les T'ang, au 7ème et 8ème siècle. Mais l'examen des relations de voyage que nous ont laissées les pélerins bouddhistes ne confirment pas cette induction. On n'y voit aucune allusion à l'aiguille aimantée. La première mention de l'application de la boussole à navigation se trouve dans le *P'ing-chou-k'o-t'an*, ouvrage composé sous les Sung, dans les premières années du 12ème siècle, par Chu Yü. . . ."[2]

"After a century and a half of historical, archaeological and sinological work on the history of man's knowledge of magnetic phenomena, the moment seems ripe for a re-consideration of the

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[1]The following chronology is given in the conclusion: "Ancient Chinese authors themselves often confused the compass with the south-pointing carriage. . . . Beginning with the third century and during the next thousand years, the south-pointing carriage was often mentioned in the annals of the various dynasties as well as in many other works. . . . In the third century B. C., the attraction of iron by a lodestone was known in China. In the first century A.D. the attraction of a sewing needle by a lodestone was noticed, and very probably the polarity of the magnet was also discovered at the same time. It is in the Sung literature that the first texts on the magnetic needle are found. The work in which the magnetic needle is first mentioned was written by Shen Kuo between 1086 and 1093. The needle was magnetized by being rubbed with a lodestone. It was also Shen Kua who first made known to us the declination of the magnetic needle. . . . As for the first mention of the use of the mariner's compass in navigation, it is found in a work by Chu Yü which mostly records the events occurred in the very beginning of the twelfth century, between 1101 and 1103. The application of the magnetic needle to navigation was first made by Chinese sailors on Chinese sea-going ships. This certainly occurred a long time before Chu Yü referred to it in his book. . . . The magnetic needle was mentioned for the first time in European literature about a hundred years later than in Chinese literature. . . . Many facts lead us to believe that the compass was introduced to Europe from China by the Arabs": Li Shu-hua, "The South-Pointing Carriage and the Mariner's Compass," Tsing Hua Journal of Chinese Studies, 1.1 (1956), 108-09.

[2]Li Shu-hua, "Première mention de l'application de la boussole à la navigation," Oriens Extremus, 1 (1954), 6.

evidence and a summary of the 'state of play' at the present time."[1] So Needham observed. Needham himself prepared and presented this timely and much-needed review at the Congrès International de l'Histoire des Découvertes in Lisbonne in 1960. The paper, broader in scope than its title "The Chinese Contribution to the Development of the Mariner's Compass" suggests, is a distillation of Needham's thoughts and findings on various issues related to the subject.[2] Probing systematically into a multitude of early and mediaeval Chinese writings, Needham provided a critical overview of the discovery of magnetic directivity by the Chinese and the intricate evolutionary process by which the mariner's compass came into being. He also lay bare the difference between the invention of the south-pointing carriage and that of the magnetic needle.[3]

Two short articles can be found in the 1963 and the 1967 Forschungen und Fortschritte. Authors Hans-Günther Körber (1963) and Rainer Schwarz (1967) inspected specimens of traditional Chinese magnetic compasses held in Germany and outlined opinions expressed by Chinese and Western researchers in the 19th and 20th century on Chinese knowledge and experience concerning magnetism.

In 1967 Peter J. Smith and Needham demonstrated the validity of a dozen or so Chinese records of observations of magnetic declination

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[1]Joseph Needham, "The Chinese Contribution to the Development of the Mariner's Compass," Scientia, 96 (1961), 225.

[2]It was first published in Scientia (1961), then in French in Navigation (1974).

[3]According to Needham, the development in China can be divided into three distinct periods: "First, textual evidence of unimpeachable quality from Chinese sources is available from the end of the +10 century onwards. . . . Then at the other end of the choronological scale, archaeological evidence indicates that at least from the +1st century onwards, Chinese star-clerks and magicians were using a spoon-shaped object made of lodestone, rotating on the highly polished bronze plate of a diviner's board, and coming to rest, when joggled, in the north-south direction. Between these two periods there is almost a millennium from which we have only indirect statements and hints of various kinds. . . . Finally it is clear that although the magnetic compass was probably used in China for geomancy (especially the siting of houses and tombs) for many centuries before it was employed in navigation, Chinese sailors had a priority of at least one century and more likely two or three over their Western nautical counterparts": ibid.

from 720 to 1829. These observations -- obtained from Chinese texts -- were tabulated and their declination values were subjected to scientific scrutiny.

Dennis Grafflin also appealed to modern science to help interpret traditional Chinese activities. His note in the 1985 Journal of the American Oriental Society challenges a particular remark made in Science and Civilisation in China vol. 4 pt. 1 regarding geomagnetism.[1]

7.6 CONCLUSION

In his assessment of the historical significance of classical Chinese physics and physical thought, Needham made it plain that "though physics has often been regarded as the fundamental science, it was a branch of natural knowledge in which Chinese traditional culture was never strong."[2] Needham also observed in the introductory section of the Science and Civilisation in China physics volume that "the literature gives us very little help. The sinologists have done nothing. . . . Occidental historians of physics have been mainly occupied with post-Renaissance physics, less so with that of the Middle Ages, and perhaps still less so with antiquity. None of them has taken into account any Chinese contributions."[3] This being the case, it stands to reason that secondary literature devoted to this area of study would be modest in number and diversity.[4]

Nevertheless, magnetism and magic mirrors were treated seriously by three prominent early Western students and interpreters of Chinese scientific traditions: Klaproth, Biot, and Julien. Magic mirrors also drew the attention of several others in the first half of the

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[1]"A consideration of early Ming imperial construction, in light of our current understanding of geomagnetism, suggests caution in drawing sweeping conclusions about the geomagnetic component in geomancy": Dennis Grafflin, "Geomantic Cliché and Geomagnetic Puzzle," Journal of the American Oriental Society, 105 (1985), 315.

[2]Science and Civilisation in China, vol. 4 pt. 1, pp. 1.

[3]Science and Civilisation in China, vol. 4 pt. 1, pp. 2.

[4]The bibliography for this chapter is, however, *not* the smallest; it contains a handful of entries *more* than that for biology.

19th century. These two topics remained the only two areas of interest before the end of the past century.[1]

As already mentioned, magic mirrors dropped out of the picture with the coming of the 20th century, and the only contributions before 1985 in the optics area were Laufer's work on burning lenses from 1915, Needham and Lu's account in 1967 on Chiang-su optick artists, and Graham and Sivin's study of Mohist optics in 1973. Magnetism managed to generate more inquiries: four were published between 1903 and 1923, and ten between 1950 and 1985. These included a few in-depth ones from de Saussure, Li, and Needham, but there were also short articles. The first half of the 20th century was instead characterised by a new interest in measurement and metrology, while the period from 1950 to 1985 that in acoustics, musical sounds and mathematical harmonics.

Researchers have generally structured their works chronologically or focused on specific periods. But there were notable exceptions, for instance, writings on magic mirrors, Ferguson's "Chinese Foot Measure", and Graham and Sivin's "A Systematic Approach to Mohist Optics". Chinese documentary sources and sometimes archaeological findings, and museum specimens were often studied and used as evidence. And developments in other cultures were important concerns.

The primary aim of the majority of publications has been that of determining Chinese precedence and / or interpreting and explaining Chinese activities in the language of modern science.[2] However, a handful of more recent studies have taken a more "contextual" approach, taking into account prevailing circumstances and historical

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[1]Note that although the number of investigators and publications increased during the second half of the 19th century, nearly all articles on the magnetic compass and half of those on magic mirrors were less than four pages.

[2]Thus, answers to questions such as the following were sought: "What is the present-day scientific explanation for the phenomenon caused by magic mirrors?", "What were the methods used by the Chinese in their search for a mathematical solution to the equally tempered scale?", "When did the Chinese first observe and record magnetic directivity and use the magnetic compass to aid navigation?".

implications of the discoveries and ideas within China itself.[1] Pre-1950 accounts on measurement and metrology do not fit neatly into the above categories: their authors were mainly interested in identifying what standards were used at what time, but not why, for what particular purpose, or how the Chinese viewed metrology.

In view of Needham's comments regarding the nature of the subject, traditional Chinese approaches to issues central to modern physics may not be an area that lends itself readily to a wide range of research topics and possibilities. There are, nevertheless, indications that one need not limit oneself to those topics and sources pursued in the past (e.g. magnetic compass, equal temperament). For instance, scholars have yet to critically confront Mohist writings, mentioned regularly in Science and Civilisation in China vol. 4 pt. 1, and which Graham and Sivin's study has shown to be deserving of much deeper exploration. Chinese efforts to determine terrestrial length measures according to astronomical units during the 8th century and the progress made in the development of the metric system received only scant attention. Explanations of the optical phenomenon produced by magic mirrors offered by the Chinese themselves (e.g. by Shen Kua in the 13th century) were only mentioned in passing. Early references to the magnetic needle need to be studied more attentively.[2]

Above all, the field lacks discussions dedicated to analysing the underlying ideas and conditions -- scientific and otherwise -- that informed and influenced particular Chinese responses to various physical phenomena and ways they exploited their knowledge in practical applications.

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[1]e.g. studies by Loewe, by Needham and Lu, and by Graham and Sivin.

[2]While discussing the magnetic needle in the T'ang period and earlier, Needham remarked that, "it is much to be wished that some scholars would thoroughly examine the early geomantic texts so that literary evidence could be compared with internal evidence of a scientific nature, and approximate datings established. Another research which should be undertaken is the systematic examination of Sung and Thang encyclopaedias and dictionaries for references to the lodestone and the magnetic needle": Science and Civilisation in China, vol. 4 pt. 1, pp. 256.

7.7 PARTICIPATING COUNTRIES AND INDIVIDUALS

Contributors from the U.K. were involved in all four major areas discussed above and were active in the 19th century (e.g. Brewster, Wylie, Chalmers), the early-mid 20th century (e.g. Stein, Ferguson) as well as in more recent decades (e.g. Needham, Loewe, Graham). Interests from France were expressed chiefly in essays on magic mirrors written in the 19th century by such scholars as Biot, Julien, Maillard, and Bertin, while those from Germany in works concerning the magnetic compass written by Klaproth, Schück, Körber, and Schwarz.[1] American researchers were especially visible in the latter half of the 20th century, being responsible for all but one publication on acoustics as well as various studies on other topics.[2]

Even with a relatively small group of contributors, it is important to recognise the participation of individuals outside Britain, France, Germany, and America; for example, Govi and Bertelli from Italy, de Saussure from Switzerland, and Michel from Belgium.

Orientalists and Sinologists (e.g. Klaproth, Wylie, Julien, Hirth, Loewe, Graham) commented from time to time on traditional Chinese understanding in the field of physics. A significant body of research was also carried out by professionals whose main specialties lay elsewhere -- in most cases in physics and chemistry (e.g. Ayrton and Perry were associated with the Imperial College of Engineering in Japan, Li with the Department of Chemistry at Columbia University, Smith with the U.S. Geological Survey, and Cheng with the Physics Department at University of California, San Diego) or in musicology (e.g. Kuttner, Kaufmann, and McClain).

7.8 FORMS OF PUBLICATION

Chinese / Asian studies journals emerged as important vehicles

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[1]There was also a French article on measurement by Daudin, and a German one by Freund.

[2]Among earlier writings from that country were those by Laufer and Hirth from the 1900s and 1910s.

here, publishing a third of the articles in this chapter.[1] General science journals as well as periodicals focusing on particular science disciplines also took part on a number of occasions throughout the 19th and 20th centuries.[2] In addition, there were history of science journals and essay collections.[3] And diversity in the type of periodicals involved does not end here; consider, for instance, the following titles: Monist (1906), Journal of Social and Biological Structure (1985), Communications de l'Académie de Marine de Belgique (1950).

Three works were published in book-form: Lettre à M. le Baron A. de Humboldt sur l'invention de la boussole, Science and Civilisation in China vol. 4 pt. 1, and A Critical Study of Chu Tsai-yü's Contribution to the Theory of Equal Temperament in Chinese Music.

7.9 BIBLIOGRAPHIC PROVISION AND CONTROL

I. GENERAL BIBLIOGRAPHIES FOR CHINESE / ASIAN STUDIES AND THE HISTORY OF SCIENCE:

(a) Henri Cordier, Bibliotheca Sinica. . . (1904-08); (1922-24):

Listed are titles on the magnetic compass from 1834 to 1917 (under "Sciences et arts - Boussole"), and half of the papers on magic mirrors under "Industries diverses - miroirs magiques" or "Sciences morales et philosophiques" in the Supplement.[4]

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[1] e.g. Journal of the Asiatic Society of Bengal (1832), China Review (1885, 1890, 1891), Bulletin de la Société des Études Indochinoises de Saigon (1938), Monumenta Serica (1941), T'oung Pao (1915, 1920, 1961), Artibus Asiae (1953), Tsing Hua Journal of Chinese Studies (1956), Revue d'Assyriologie et d'Archéologie Orientale (1958).

[2] e.g. Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences (1844, 1847 -- three articles, 1853), Annales de Chimie et de Physique (1880 -- four articles, 1881), Scientia (1961), Proceedings of the Royal Microscopical Society (1967).

[3] e.g. Mitteilungen zur Geschichte der Medizin und der Naturwissenschaften (1917), Archives des Sciences Physiques et Naturelles (1923), Chinese Science: Explorations of an Ancient Tradition (1973).

[4] Curiously, articles by Person (1847) and Maillard (1853) in Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences, and Bertin's 1881 account in Annales de Chimie et de Physique (1881) were not recorded even though other papers from these two journals

(b) John Lust, Index Sinicus. . . , 1920-55 (1964):

Eleven articles were published between 1920 and 1955, and nine were indexed: under "XVIII. Science and technology - b. Mathematics and metrology" (Daudin, Morgan, and two works by Ferguson), "XVIII. Science and technology - c. Astronomy and calendar" (Li's articles in Isis and Oriens Extremus), "XIV. Sinkiang - c. Sinkiang description and travel" (Stein), and "XVI. Archaeology and Fine Arts - f. Art - ix. Jades" (Kuttner's paper in Artibus Asiae).[1]

(c) ISIS Cumulative Bibliography, 1913-65; 1966-75; 1976-85:

Approximately one-fifth of all studies treated in this chapter can be found in this bibliography, scattered in several sections: "4C Physics", "4Axm Science - Metrology", and "4GLxp Geology - Geomagnetism; electrical and radiation phenomena".[2] More than a few of these titles are not indexed by other bibliographic aids; as such ISIS is an important resource.[3]

Several early articles from Chinese / Asian studies journals also found their way into the bibliography.[4] But for obvious reasons, Isis is not a good source for titles on acoustics in music journals.

(d) Bibliography of Asian Studies, 1936- :

Half of the publications in this chapter appeared after 1936,

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appear in the bibliography.

[1]The index makes no mention of articles in Isis, Archives des Sciences Physiques et Naturelles, and Communications de l'Académie de Marine de Belgique.

[2]Articles by Michel and by de Saussure are housed in the volume for Western science.

[3]e.g. Friedemann's "Mass und Messen im 8. Jahrhundert ein modernes Kapitel aus der altchinesischen Wissenschaft" in Waage; Needham and Lu's "The Optick Artists of Chiangsu" in Proceedings of the Royal Microscopical Society; Schück's "Zur Entwicklung der Einteilungen der chinesischen Schiffs - und der 'Gaukler' Bussole" in Mitteilungen zur Geschichte der Medizin und der Naturwissenschaften; Needham's "The Chinese Contribution to the Development of the Mariner's Compass" in Scientia; McClains' "The Bronze Chime Bells of the Marquis of Zeng: Babylonian Biophysics in Ancient China" in Journal of Social and Biological Structure.

[4]i.e. those by Stein (1920) and by Laufer (1915) in T'oung Pao, and by Ferguson (1941) in Monumenta Serica.

and the bibliographic details of half of them are available from this bibliography. Listed are articles in Ethnomusicology and certain items from Chinese / Asian studies serials.[1]

It is the only source for Robinson's book, two of Kuttner's papers (1965 and 1975) and McClain's article from 1979, but one has to look for them under the "Music" section.[2]

(e) Bulletin Signalétique, 1947- :

Two titles are indexed: Needham's "La contribution chinoise à la réalisation du compas de marine" published in 1974 in the French journal Navigation (under "Navigation - Instruments"), and Chen's 1985 contribution to the 17th International Congress of the History of Sciences (under "Mécanique. Acoustique - Acoustique - Musique"), both of which are not recorded elsewhere.

(f) Revue Bibliographique de Sinologie, 1955-70; 1983- :

Of the dozen or so articles published during the years the bibliography was active, two were reviewed: Li Shu-hua's "The South--Pointing Carriage and the Mariner's Compass" in Tsing Hua Journal of Chinese Studies and Loewe's "The Measurement of Grain during the Han Period" in T'oung Pao. They were taken note of along with Science and Civilisation in China vol. 4 pt. 1.

(g) Toyogaku Bunken Ruimoku, 1963-:

Science and Civilisation in China vol. 4 pt. 1 is listed in the "Science" section for books (under "General"), and Grafflin's "Geomantic Cliché and Geomagnetic Puzzle" in that for articles (under "Science - Astronomy and Calendar").[3]

II. SPECIALISED BIBLIOGRAPHIC SOURCES

The only compilation devoted specifically to our subject is Science and Civilisation in China vol. 4 pt. 1's "Bibliography C: Books and Journal Articles in Western Languages", which includes

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[1]Also Körber's and Schwarz's accounts in Forschungen und Fortschritte.

[2]However, the bibliography gives no information on Kuttner's paper in Bericht über den Siebenten Internationalen Musikwissenschaftlichen Kongress, Cologne, 1958, and Kaufmann's essay in Essays in Ethnomusicology; A Birthday Offering for Lee Hye-ku.

[3]No other general bibliography recorded Grafflin's essay in the Journal of the American Oriental Society -- most likely because it appeared in the journal's "Brief Communications" section.

nearly all studies published before 1960, and hence of decided bibliographic importance.[1]

III. CONCLUSION

It is generally a good habit to check as many resources as time and patience permits, and this practice is recommended here once again for as we have seen, each bibliography yields one or more title not available from other guides. Moreover, subject retrieval is problematic and searching under more than one section is necessary. Thus, while one may be thankful that collectively the bibliographies have reported all but three works, the bibliographic control given to the subject area as a whole is not entirely satisfactory.[2]

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[1]Among titles not listed are papers on metrology by Chalmers, and Stein, and articles on the compass by Parker, and Bertelli.

[2]The three works are: Chalmer's "The Chinese *ch'ih* Measure" in China Review (1885), Kuttner's "A 'Pythagorean' Tone-System in China -- Antedating the Early Greek Achievements by Several Centuries" in Bericht über den Siebenten Internationalen Musikwissenschaftlichen Kongress, Cologne, 1958 (1959), and Kaufmann's "The Mathematical Determination of the Twelve *Lü* as Performed by Prince Liu-An in his *Huai-nan Tzu* (Second Century B.C." in Essays in Ethnomusicology; A Birthday Offering for Lee Hye-ku (1969).

CHAPTER 8 : ALCHEMY; EARLY CHEMISTRY

8.1 ALCHEMY

It was not uncommon for 19th century Western scholars to dismiss as hollow and second-rate traditional Chinese views and ideas concerning the natural world. However, not all Western works from that era looked upon past Chinese efforts to understand, come to terms with and utilise elements in their physical surroundings with absolute disdain. The studies by Joseph Edkins and William A. P. Martin on Chinese alchemy, for instance, are good examples.

Edkins' "Phases in the Development of Tauism" (read before the China Branch of the Royal Asiatic Society and published in the Society's 1855 transactions) still commands interest. Taoist writings were translated and the following topics addressed: the close relation between Taoism and alchemy, the link between early alchemy in China and other civilisations, the physiological processes involved, and the importance of the treatise *Pao p'u tzu*. Another account by Edkins -- "On Early Tauist Alchemy" -- appeared in the Miscellany or Companion to the Shanghai Almanack for 1857. [I have not seen this title]. In a paper delivered to the American Oriental Society, Martin compares the goals and purposes of alchemists in China with those in the West, suggests an indigenous and very early origin for Chinese alchemy, and gives the translation of several passages taken from Chinese alchemical texts. The abstract was published in 1868 and the full version in 1879. Moreover, questions identified and raised in these accounts were asked repeatedly in later writings and remained important in various 20th century forays and expeditions into the land of Chinese alchemy.[1]

Literature from the closing years of the 19th and opening

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[1]As Needham informed us at the beginning of his reconnaissance of secondary sources on Chinese alchemy in Science and Civilisation in China vol. 5 pt. 2, "the gist of the matter was already contained in the seminal paper of Edkins on Taoism, written in 1855, . . . and the same can be said of the memoirs of Martin. . .:" Joseph Needham, and Lu Gwei-djen, Science and Civilisation in China. Vol. 5 Chemical and Chemical Technology, Part 2: Spagyrical Discovery and Invention: Magisteries of Gold and Immortality (Cambridge: Cambridge UP, 1974), pp. 2.

decades of the 20th century was written by a motley group of individuals who viewed and characterised the subject in very different ways. On the one hand, there were articles by T. Hiordthal (1909) and by H. J. Holgen (1917). These "two otherwise little-known chemical scholars," so Needham told us, "drawing on sinologists such as Chavannes, de Harlez, Wylie and Pelliot, and even learning some Chinese themselves in order to worry out a few paragraphs of the *Pao Phu Tzu* book with the help of friends, wrote two or three remarkably good papers. They knew about Li Shao-Chün and Liu An and Wei Po-Yang, . . . and they even knew of the distinction between *wai tan* and *nei tan* though they did not quite understand it."[1] Herbert Chatley's 1913 paper, read to the Alchemical Society, also earned credit from Needham, who considered it "brief too, but as well informed as could be expected of a Western engineer then resident in China."[2] Then there were semi-popular pieces. Selections from Chinese works related to different facets of Chinese alchemical thoughts and processes made by H. P. Blavatsky, the founder of Lucifer (subtitled "A theosophical magazine designed to bring to light the hidden things of darkness") were published posthumously in 1896.[3] F. Hadland Davis' (1913) (1915) accounts mention ancient China's "elixir of life", how it was made, what its effects were, the Chinese conception of gold as well as teachings of Confucius and Lao Tzu, a poem by Pai Chü-i, and stories of adepts. Prompted by Davis' article in the 1913 The Academy, H. Stanley Redgrove (1913), then Acting President of the Alchemical Society, asked readers to ponder on the question of similarity in the origins of European and Chinese alchemy, especially with regard to the role played by mysticism.

A body of Western studies began to cumulate in the second quarter of the 20th century. They were generally inspired by the same circle of Chinese texts, alchemists, and general concerns. Moreover, everyone was still groping for clues and searching for

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[1] Science and Civilisation in China, vol. 5 pt. 2, pp. 4.

[2] Science and Civilisation in China, vol. 5 pt. 2, pp. 3.

[3] The eleven passages (e.g. "The secret of immortality"; "The chief elements of alchemy"; "The elixir"; "Outline of the process"; "An alchemist") were said to be taken from "Lu-Zien"; "Tun-Tsze"; "Rao Shang Tze"; etc.

parts that might help piece together the story. Some of the works can still be read with profit today, others not, and most of them are much better at mapping out and drawing attention to problems in understanding Chinese alchemical theories, objectives, practice and techniques than in dissecting and expounding them in an incisive and informed way.

Let us begin with publications that involve mostly translations. The quality is uneven; nevertheless, they made important Chinese texts on alchemy available to Western readers in a tolerable form and supplied glimpses into the characteristics and shaping of the Chinese alchemical tradition.

No survey of Western historiography on Chinese alchemy can ignore the contribution made by Tenney L. Davis who, together with his Chinese research assistants at the Massachusetts Institute of Technology, published over thirty studies of varying length and usefulness on the subject in the 1930s and '40s.[1] Of various Chinese texts they rendered into English, the following three are particularly noteworthy. First, the translation in 1932 by Wu Lu-Ch'iang and Davis of the *Chou i ts'an t'ung ch'i* from the early second

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[1]In assessing the merits of these works, Needham underscored two concerns: First, "in all their work his group could never overcome one fundamental handicap, their failure to realise that Chinese 'alchemy' consists of two parts, practical laboratory alchemy. . . , i.e. *wai tan*, and physiological alchemy, i.e. *nei tan*. . . . Since a very similar technical terminology was used for both, it is always necessary to take the hint, often by nuances more subtle than the Davis group could appreciate": Science and Civilisation in China, vol. 5 pt. 2, pp. 6-7. Second, "nevertheless, the translations of Tenney Davis' group are not to be under-valued or ignored, for no sinologist, however learned, can substitute for the man who has spent years working at the laboratory bench": Science and Civilisation in China, vol. 5 pt. 2, pp. 7.

Nathan Sivin, on the other hand, had this to say: "all the books studied were understood, or misunderstood, as milestones on the road toward modern chemistry. Despite these limitations and the resulting problems in Davis' interpretations, his publications ensured at least passing mention of China in general writings on alchemy. In addition to their impact on alchemy, Davis translations were among the more important sources in Mircea Eliade's pathbreaking *The Forge and the Crucible* of 1956. . . . Davis' main influence was, of course, upon chemical historians. They in turn found Eliade's argument too inconsequential to cite, much less to rebut": Nathan Sivin, "Research on the History of Chinese Alchemy," in Alchemy Revisited, ed. Z. R. W. M. von Martels (Leiden: E. J. Brill, 1990), pp. 8.

century B.C. -- a work that had generated many Chinese commentaries through the centuries. Preceding the translation is an introduction with background information on the author Wei Po-yang, the important role of *yin yang* and *wu hsing* in Chinese alchemical thought, the Taoist origin of Chinese alchemy, and its early practitioners. Commentaries and explanation of technical terms are offered in the "Notes" section. Second, their "An Ancient Chinese Alchemical Classic: Ko Hung on the Gold Medicine and on the Yellow and the White. . ." (1935), which is a translation of chapters 4 and 16 of one of the most prominent and well-known alchemical texts, the *Pao p'u tzu nei p'ien*. A synopsis and table of content is included, and in their discussion, Wu and Davis have suggested the possible connection between the Chinese word "*hsien*" and the Arabic "djinn".[1] Third, in 1941 Davis and Ch'en Kuo-fu translated chapters 8 and 11 of *Pao p'u tzu nei p'ien* and gave a summary of other chapters.

Other translations and outlines prepared by the Davis group include the following:

(1) Selected passages from the *Chou i ts'an t'ung ch'i* (given in the article "The Pill of Immortality" by Wu and Davis 1931b).

(2) The chapter on the Gold Medicine in *Pao p'u tzu nei p'ien* (Davis and Wu 1936a).[2]

(3) An alchemical poem by Kao Hsiang-hsien (Davis and Chao 1939a).[3]

(4) Alchemical poems and essays by Chang Po-tuan (Davis and Chao 1939b, 1940b, 1940d).[4]

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[1]Extracts of this article can be found in "Ko Hung on the Yellow and the White" in the 1936 Journal of Chemical Education.

[2]"This chapter "deals primarily with the preparation and effects of various medicines of immortality, while that on the Yellow and the White treats especially of transmutation": Tenney L. Davis, and Wu Lu-Ch'iang, "Ko Hung on the Gold Medicine," Journal of Chemical Education, 13 (1936), 103.

[3]They chose this poem because of its similarity to an essay in the *Wu chen p'ien* written not later than 1333 A.D. on how to compound mercury and lead.

[4]In "Chang Po-tuan of T'ien T'ai, his *Wu Chen P'ien*, Essay on the Understanding of the Truth: A Contribution to the Study of Chinese Alchemy", the translation is preceded by a review of the theory embodied in Chang's essay and the possibility of a link between Chinese alchemy and Alexandrian chemistry, biographical

(5) A list of contents of the 15th century encyclopaedia of alchemy *Chin tan cheng li ta ch'üan* (Davis and Chao 1940a).

(6) "A brief survey of the several parts" of a work attributed to Chang Po-tuan, the title of which Davis and Chao translated as "The Secret of Compounding Internal *tan* of the Golden Treasure from the Secret Papers in the Clear Jade Box of *Ch'ing Hua*" (Davis and Chao 1940c).[1]

William H. Barnes' "Possible References to Chinese Alchemy in the Fourth or Third Century B.C." (1935b) identifies and invites comments on several passages from *Chuang tzu* and *Lieh tzu* which may have alchemical connections. In 1937, Fung Chia-loh and H. Bruce Collier presented a quick run down of opinions regarding the origins of Chinese alchemy and translated part of the *Tan fang ching yüan* in order to "give an idea of the content of one of the more practical alchemical treatises of later date, to point out some of the difficulties involved, and to stimulate interest in the problems."[2] The *Pao p'u tzu nei p'ien* also received attention from Eugene Fiefel, who made its chapters 1-3, 5, and 9 available in English in the 1941, 1944, and 1946 Monumenta Serica, accompanied by occasional brief annotations.[3] Compared to Wu and Davis' translation of the same treatise, Needham considered the Feifel version "better sinologically perhaps but lacking the chemical insight which Davis was able to give."[4] Based on a passage in a Sung Taoist treatise, Roy C. Spooner and C. H. Wang (1948) described an alchemical recipe known as

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material of Chang from *Lieh hsien ch'üan chüan* and local gazetteers, and a register of editions and prefaces of the essay.

[1]Tenney L. Davis, and Chao Yün-ts'ung, "The Secret Papers in the Jade Box of Ch'ing Hua," Proceedings of the American Academy of Arts and Sciences, 73 (1940), 385.

[2]Fung Chia-Loh, and H. Bruce Collier, "A Sung Dynasty Alchemical Treatise: 'Outline of Alchemical Prescriptions' by Tu-ku T'ao," Journal of the West China Border Research Society, 9 (1937), 291.

[3]Chinese texts of the different editions used are given in the first article. Also offered is a short introduction to these editions and a list of eighteen titles -- five Western, three Japanese, and ten Chinese. But no mention was made of Davis' work or any study specifically on Chinese alchemy.

[4]Science and Civilisation in China, vol. 5 pt. 2, pp. 6.

the "Divine Nine Turn Tan Sha Method" in some detail as well as explained its background and the terminology and principles involved. Sivin apparently thought little of this contribution.[1]

Of the other studies published between 1925 and 1949, the following are more substantive:

(1) Obed Simon Johnson's A Study of Chinese Alchemy (1928) began life as a doctoral dissertation for the University of California, Berkeley. Divided into six chapters (i.e. "Taoism", "The changing concept of early Taoist teaching", "The alchemy of prolonging life", "The alchemy of transmuting metals", "Later development of Chinese alchemy", "Alchemy East and West"), this first Western monograph devoted solely to Chinese alchemy was criticised mercilessly by Berthold Laufer on almost every count.[2] Chatley also found grave limitations with Johnson's book and some of his reasoning less than convincing.[3] Needham, however, was more forgiving and had something

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[1]"Since the translators were working under conditions which precluded a reconnaissance of the alchemical literature, this version is highly unsatisfactory": Nathan Sivin, Chinese Alchemy: Preliminary Studies (Cambridge, Mass.: Harvard UP, 1968), pp. 323.

[2]In Laufer's opinion, Johnson's book "lacks depth, viewpoint, method and criticism. It hardly contains any new facts, no clear exposition of Chinese alchemy, a heavy excess baggage of irrelevant matter, and a strong dose of unsound speculation. The first two chapters on Taoism and the changing concept of early Taoist teaching bear no direct relation to the subject. . . . The most disconcerting blunder of the book. . . is the intimation that the Chinese alchemist's object in transmuting base metals into gold was dictated by a desire for riches and for a life of comfort and ease. . . . Modern sinological science is entirely foreign to the author. Nothing is said about the alchemy of India and its relation to that of China. . . . The bibliography offers a great surprise. It gives titles of numerous works which contain nothing about alchemy, while important treatises on the subject are omitted": Berthold Laufer, rev. of A Study of Chinese Alchemy by Obed Simon Johnson, in Isis, 12 (1929), 330-32. The harsh criticism might have stemmed partly from Laufer's own belief that "alchemy, in fact, is an entirely foreign element in Chinese thought and suddenly shoots up in the second century B.C. under the emperor Wu when China was actually flooded by an invasion of influences rushing on from the West": Laufer, rev. of A Study of Chinese Alchemy, 330-31.

[3]For instance, Johnson "makes no reference to the Hermetic literature, which is usually regarded as the fountain-head of European alchemical tradition and is perhaps no lightly to be dismissed in this connection. . . . A great deal of valuable and interesting information from Chinese sources has been collected by Dr. Johnson,

positive to say about Johnson's book, although not exactly giving credit to his scholarship.[1] "Primary sources" lists twenty-three Chinese titles (dynastic histories, classics, compendiums, etc.) with annotations. "Secondary sources", as Laufer pointed out, indeed contains some odd entries and few titles directly relevant to Chinese alchemy.[2]

(2) On unravelling the mystery of the roots of alchemical theories and practices in China, Arthur Waley's paper in the 1930 Bulletin of the School of Oriental Studies is probably a more stimulating and valuable guide.[3] Waley begins with a passage on alchemy in the *Han shu* and the story of Ch'eng Wei from the *Hsin lun*, and moves on to examine the nature and significance of the *Chou i ts'an t'ung ch'i* and *Pao p'u tzu nei p'ien*. The study concludes with an analysis of

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but some of it is badly assimilated. Certainly as to Taoist doctrine and terms used in Taoistic Alchemy, there are some misleading statements. . . . On p. 78 chin tan is given as one of three terms 'denoting exclusively the preparation for the transmuting of metals.' This is certainly incorrect. . . . the sublimation of the body is supposed to depend, inter alia, on the obtaining of certain occult secrets, but never is there any interest in the transmutation of metals; the fact is far otherwise. On the whole, one cannot acquit the author of superficiality in this treatment of a very interesting if futile subject": Herbert Chatley, rev. of A Study of Chinese Alchemy by Obed Simon Johnson, in Journal of the North China Branch of the Royal Asiatic Society, 59 (1928), 288-92.

[1]"After Johnson things were never quite the sane. His work directly stimulated Arthur Waley in England to make several contributions which raised the subject to a previously unattained level of scholarship. It also obliged the great synthesisers to take China seriously": Science and Civilisation in China, vol. 5 pt. 2, pp. 6.

[2]For example: J. S. Brewer, Opera quaedam hactenus inedita; Encyclopaedia Britannica; F. Paulsen, Introduction to Philosophy.

[3]Sivin's annotation for this title in his "Introductory Bibliography" reads as follows: "An erudite and still useful attempt to get at the beginnings of Chinese alchemy and to assess the possibility of foreign influence. The only flaw of any consequence is Waley's suggestion (due to ignorance of technical language) that the earliest extant treatise, the *Chou i ts'an t'ung ch'i* is not at all concerned with chemical operations. An equally influential but very poorly informed attack on the same problems has been made by Homer H. Dubs. . . .": Nathan Sivin, "Bibliography of Traditional Chinese Science: Introductory Books and Articles in Western Languages," in Chinese Science: Explorations of an Ancient Tradition, ed. Nathan Sivin (Cambridge, Mass.: MIT P, 1973), pp. 302.

the following themes: "Alchemy from the fifth to the tenth century"; "The antiquity of alchemy in China"; "Connection with alchemy elsewhere".

(3) Davis' "The Dualistic Cosmogony of *Huai-nan-tzu* and its Relations to the Background of Chinese and of European Alchemy" (1936) embodies original thinking and reveals the extent of early-mid 20th century Western perceptions of Chinese alchemy. In this essay, Davis appeals to passages on *yin yang* in the *Huai nan hung lieh chieh* and stresses similarities its dualistic principles and concepts had with that in the Emerald Table of Hermes Trismagistos (which was influential in Egypt and Mesopotamia).[1]

(4) In 1940 Roy C. Spooner took some of the most well-known Chinese alchemical writings and compared them with European alchemical texts, acknowledging that Johnson's book was "the source for much of my material."[2] Of interest are observations Spooner made regarding the study of Chinese alchemy in the West and an outline of the work done by Edkins, Martin, Davis, etc.

(5) For a special number of the Ciba Symposium devoted to Chinese alchemy, William Jerome Wilson (1940) wrote a series of short essays on the subject, each focusing on a single topic: background, early ideas, biographies of early alchemists, later developments, relations with other countries, etc. The most useful is the bibliography which registers almost all the relevant titles published in the 1920s and

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[1]He reasons that, "while we do not find in the writings of Wei Po-yang any clear-cut dualistic doctrine of chemistry, we do find an account of the alchemical process based directly upon Yin-Yang. The ancient doctrine of the Two Contraries was evidently imported into China where a mystical idea-system gave practical people strong motives for seeking an immortality which was not promised by their religion. Here it seems to have furnished a general scientific background upon which alchemy sprang up, an alchemy identical in theory and practice with the later alchemy of mediaeval Europe. The facts confirm the opinion that alchemy came to Europe from China, probably through the agency of the Arabs in the eighth or ninth century, and that it there mingled with the purely chemical tradition of Alexandria to make up the body of information and practice, knowledge and speculation, which was the alchemy and chemistry of mediaeval Europe": Tenney L. Davis, "The Dualistic Cosmogony of *Huai-nan-tzu* and its Relations to the Background of Chinese and of European Alchemy," Isis, 25 (1936), 340.

[2]Roy C. Spooner, "Chinese Alchemy," Journal of the West China Border Research Society, ser. A, 12 (1940), 85.

'30s (plus a few earlier ones). According to Needham, Davis' translations "formed the pièce de resistance" for Wilson's "influential compilation."[1]

(6) Homer H. Dubs' essay in the 1947 volume of Isis embraces some bold remarks and conclusions concerning the beginnings of Chinese alchemy which have generally been regarded as ill-founded and misguided by other scholars.[2]

Like the longer works, some of the shorter accounts and sketches from the 1920s, '30s, and '40s did not generate new information. Others, however, demonstrated significant thinking on the subject. The latter can be said of a series of communications by the eminent historian of chemistry J. R. Partington in Nature (1927a, 1927b, 1931, 1935, Read and Partington 1927). His chief message was that it was far from certain that Chinese alchemy had Arabic roots (as proposed by René Berthelot and Edmund O. von Lippmann) and that the question of dates remained open. He appealed to China experts to give assistance and encouraged the careful reading of Chinese texts and translations.

The desire to know and learn more was echoed in Davis' first article on Chinese alchemy, co-authored with Wu Lu-ch'iang and published in the 1930 Scientific Monthly. It brings up issues such

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[1]Science and Civilisation in China, vol. 5 pt. 2, pp. 7.

[2]Sivin contended that "Dubs' argument. . . is quite irrelevant to the history of Chinese alchemy. His definition, which includes all successful counterfeiting or falsification of gold regardless of motive, and excludes concern with both the chemical principles of change and with the arts of immortality except when accompanied by goldmaking, would have been inconceivable to any alchemist, and rules out all but a small fraction of the alchemical corpus": Nathan Sivin, "On the Reconstruction of Chinese Alchemy," Japanese Studies in the History of Science, 6 (1961), 71.

Needham was also struck by Dubs' handling of the issue: "The usual unawareness of the explanatory power of sociological distinctions, such as could take into account the effects of class barriers in many societies of the past, was perhaps one reason for the failure of the most elaborate theory about the development of Chinese alchemy so far put forward, that advanced by Dubs in two learned memoirs. Although the sinological scholarship which he applied to the problem was on a much higher level than that of any previous writers on the subject, except perhaps Waley, his presentation was shot through with faults of reasoning, historical implausibilities, and misinterpretations of evidence": Science and Civilisation in China, vol. 5 pt. 2, pp. 47.

as Chinese alchemy's Taoist background, the role played by the concepts of *yin yang* and *wu hsing*, the alchemists and their writings, and concludes that "Chinese alchemy is a broad and largely unexplored field of study. The present paper scarcely scratches the surface of it. But it shows the sort of thing that will be found in it, and, we hope, makes clear the necessity for more detailed studies in this important chapter of the history of chemistry."[1] Davis' other short papers were published in a variety of journals, but they carry similar themes.[2]

We have already come across expressions and names such as "extreme age", "Elixir of Life" being "the principal objects of alchemy", Ko Hung, *Chou i ts'an t'ung ch'i*, *Pao p'u tzu nei p'ien*. They surface yet again in a work by E. J. Holmyard in the 1932 Aryan Path. This paper also contains a familiar comment: "a major problem for the future is to gauge the relationship of Chinese alchemy with that of Alexandria, Islam and Western Europe. That there are striking similarities is obvious upon even a casual glance, but whether these similarities are due to coincidence or to direct affiliation is a mystery that has yet to be solved."[3]

The title of Barnes "Chinese Influence on Western Alchemy" (1935a) signals to us that, like his contemporaries, Barnes was also

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[1]Tenney L. Davis, and Wu Lu-ch'iang, "Chinese Alchemy," Scientific Monthly, 31 (1930), 235.

[2]For instance, "The Advice of Wei Po-Yang to the Worker in Alchemy" (1931a) which he wrote jointly with Wu, is tucked away in The Nucleus (a periodical published by the Northeastern section of the American Chemical Society). [I have not seen this title]. "Stories of Early Chinese Alchemists: First to Practice the Art" (1935) is in Tech Engineering News from the MIT graduate school. Another article (1938) appeared in Isis; it gives further expression to the hypothesis developed in his essay on the dualistic cosmogony of *Huai nan tzu* by pointing out that "the identity of Chinese and European alchemical theory is now found in old Chinese pictures which represent symbolically what is obviously the same theory as the European pictures": Tenney L. Davis, "Pictorial Representations of Alchemical Theory," Isis, 28 (1938), 83. And "The Chinese Beginnings of Alchemy" (1943) in Endeavour combines his views on the derivation of Western alchemy from China by way of India and Islam with introductions to Chinese alchemical treatises and stories.

[3]Eric J. Holmyard, "Alchemy in China," Aryan Path, 3 (1932), 746-47, 749-50.

interested in origins and transmissions.[1]

Contributions from the late 1950s and the '60s lent a new character and trend to Western scholarly pursuit of the Chinese alchemical tradition. Translations and textual studies, accompanied regularly by extensive and critical commentaries, were done with great care and set against a much broader context. Familiar issues and concerns heard often in past discussions were given wide-ranging analysis and subjected to close scrutiny. Several inquiries concentrating on specific topics also emerged. Initiatives as well as influential and sophisticated research carried out by three chief interpreters of traditional Chinese science in mid-late 20th century: Joseph Needham, Ho Peng Yoke, and Nathan Sivin, have made this development possible, they being responsible for all but three of the twelve studies published between 1957 and 1969. But before reviewing their publications, one must pause and take a close look at three other serious expositions.

In an incisive and insightful essay in the 1960 Bulletin de la Société d'Acupuncture Max Kaltenmark calls into question views expressed by Dubs in his "Beginnings of Alchemy"; he also sheds light on the principles that guided the Chinese alchemists and the ultimate purpose of their chemical manipulations by emphasizing that "l'alchimie chinoise se distingue dès le début par une nette liaison avec la recherche de l'immortalité, la recherche de longue vie qui caractérise surtout les sectes taoistes, qui remonte à de vieilles croyances populaires."[2] Undaunted, in 1961 Dubs once again expounded

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[1]"Chinese alchemy was concerned primarily with the twin pursuits of immortality and transmutation. . . . It is interesting to speculate on the reception in Alexandria which might have been accorded to marvellous tales of immortality and transmutation. . . . the apparent completeness of Prof [A. J.] Hopkins' picture does not automatically preclude the possibility that reports of Chinese alchemy may have had some influence on the origin of the Egyptian art. Whether such an influence is considered to be 'improbable' or 'probable', present data still appeared to indicate it is 'possible'": William H. Barnes, "Chinese Influence on Western Alchemy," Nature, 135 (1935), 824-25.

[2]Max Kaltenmark, "L'alchimie en chine," Bulletin de la Société d'Acupuncture no. 37 (1960), 22. Kaltenmark, for instance, makes the following observations: "L'alchimie conçue comme transmutation du cinabre en or ou du mercure en or, est ainsi attestée à partir du IVe siécle. Mais les idées de base sont plus anciennes, comme l'idée

his thesis on the derivation of the word "alchemy" from the Chinese word for gold and on the interconnections in the origins of Chinese, Arabic, and Alexandrian alchemy.[1] The first complete translation of *Pao p'u tzu nei p'ien* was published in 1966, prepared by James R. Ware. Reviewers all agreed that while some of Ware's renderings were unconvincing and preliminary, the translation, as Needham put it, "gives broadly the right sense throughout, and will lead no one astray as long as a certain caution is borne in mind."[2] Most significantly, it made a very difficult and important Chinese alchemical text accessible to Western readers. The book is divided into twenty chapters, with annotations and an introduction.

The first group of writings from Needham, Ho, and Sivin was a trio of articles from 1959 written jointly by Ho and Needham. Three different themes and approaches were explored. The purpose of "Theories of Categories in Early Mediaeval Chinese Alchemy" (1959) is twofold: to offer a full translation of the T'ang treatise *Ts'an t'ung ch'i wu hsiang lei pi yao* and its Sung commentary, and to examine critically the "conscious body of theory" in this text which "strongly indicates a derivation from the philosophical ideas of a

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populaire des transmutations naturelles (genre hirondelle-huitre). Surtout, it faut tenir compte de la vieille expérience chinoise de la métallurgie. Les métallurgistes admirables des Yin qui arrivaient par des moyens empiriques à fabriquer des ustensiles de bronze parfaits avaient une expérience précise des alliages des métaux. Cette expérience technique a certainement influencé les recherches alchimiques. L'influence ne s'est pas exercée que sur la pratique, mais aussi sur les idées, car les anciens forgerons chinois avient une mythologie, des croyances en rapport avec une conception de la nature, de l'univers. . . . cette idée était essentielle dans les idées chinoises en général, et aussi dans leurs conceptions techniques et alchimiques": Kaltenmark, "L'alchimie," 27.

[1]Repeating a remark we have already made: Dubs' conceptual approach and findings were rejected by Sivin who considered them to be "a regression from the level of understanding attained much earlier by Tenney L. Davis": Sivin, "On the Reconstruction," 70.

[2]Joseph Needham, rev. of Alchemy, Medicine, Religion in the China of A.D. 320: The *Nei P'ien* of Ko Hung (Pao-p'u tzu) by James R. Ware, in Technology and Culture, 10 (1969), 91.

famous Han scholar and thinker, Tung Chung-shu (179 to 104 B.C.)."[1] Another alchemical text Ho and Needham translated (together with Ts'ao T'ien-ch'in) was the *San shih liu shui fa*, a collection of recipes that involves aqueous solutions from the Han and later periods found in the *Tao tsang*. The article is organised into "I.Introduction"; "II. Date of the text"; "III. Translation and annotations"; "IV. Discussion". It also includes a bibliography with forty-four items. A fascinating issue in Chinese alchemy is that of elixir poisoning. Ho and Needham (1959) have documented and catalogued different cases of elixir poisoning and their effects as well as traced the responses and measures taken to minimise or prevent these harmful effects. Their account starts with stories and passages taken from various sources about emperors and high officials that were involved.[2] The authors then trace the literature on elixir poisoning (e.g. in memorials and medical writings), warnings against the use of poisonous substances in elixirs (e.g. from Li Shih-chen), and possible explanations for different kinds of poisoning from mercury, lead and arsenic. Careful consideration is given to ways in which the alchemists themselves dealt with the problem up till the Ming dynasty, by which time "alchemy in China had gone into a profound decline, leaving the victory to the pharmaceutical naturalists, who fulminated against elixirs of any kind whatsoever."[3]

A series of studies by Sivin from 1967 to 1969 represented the next major step in steadily setting out a new framework for appreci-

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[1]Ho Ping-yü, and Joseph Needham, "Theories of Categories in Early Mediaeval Chinese Alchemy," Journal of the Warburg and Courtauld Institutes, 22 (1959), 173, 188.

[2]Including, for instance, some of the oldest examples found in the *Chan kuo tse* and the biography of the famous physician Shun-yü I, the Chin emperor Ai Ti, the T'ang emperor Wu Tsung, Liang Wu Ti, and the poet Su Tung-po.

[3]Ho Ping-yü, and Joseph Needham, "Elixir Poisoning in Mediaeval China," Janus, 48 (1959), 336. ". . .the Chinese alchemists may be divided, broadly speaking, into two different schools. The first ignored the poison danger altogether and considered the symptoms supervening after taking elixirs to be quite normal and even essential. The second recognised the poisonous nature of some of the constituents and tried to neutralise it in one way or another, or else to use only substances which were harmless": Ho and Needham, "Elixir Poisoning," 330.

ating the complex subject of Chinese alchemy -- its theories, objectives, operations, results, and riddles that lace its attending literature. "On the Reconstruction of Chinese Alchemy" (1967) gives an impressive -- and one of the earliest -- critique and explication of the methodological, conceptual, and textual problems and pitfalls in approaching and interpretating Chinese alchemy. An introductory section captures the unique characteristics of the Chinese scientific traditions, and within this context, Sivin develops his provocative arguments in support of a particular set of priorities for the study of Chinese alchemy: "Initial conditions"; "Preliminary operations"; "Internal problems"; "Origins"; "Aims"; "Theories"; "Operations and equipments"; "Products and their evaluation"; "External problems".

The publication of Sivin's Chinese Alchemy; Preliminary Studies in 1968 was a cause for celebration -- and not simply because of the remarkably high standard of scholarship applied to the critical study and translation of the *Tan ching yao chüeh*, a possibly T'ang alchemical work attributed to Sun Ssu-mo.[1] Four other features in this work as pointed out by reviewers are particularly worthy of praise. Firstly, it is "primarily a demonstration of how to find one's way around in alchemical literature, and it leaves one with the confidence that at last someone has got his bearings, can distinguish what is known from what is not yet known, and judges by firm standards."[2] Secondly, a "galaxy of appendixes serves the needs of historians of science and sinologists."[3] The ten appendices range from highly specialised ones such as "B. 'Apothecaries' measure' in the T'ang period" and "D. Directions for preparing the reaction vessel and lute as given in *Ch'ien chin fang*", less specialised ones such as "C. Comparison of elixir names in Sun Ssu-mo's lists with those in other sources" and "E. Table of dates concerned with the

[1]This text gives numerous recipes and describes methods for the chemical processes involved in preparing elixirs of immortality as well as directions for making apparatus.

[2]A. C. Graham, rev. of Chinese Alchemy; Preliminary Studies by Nathan Sivin, in Bulletin of the School of Oriental and African Studies, 33 (1970), 227.

[3]Michael Loewe, rev. of Chinese Alchemy; Preliminary Studies by Nathan Sivin, in History of Science, 9 (1970/71), 93.

life of Sun Ssu-mo", to ones of general interest such as "I. On understanding the language of early Chinese chemistry and pathology: A bibliographical essay" and "J. Published translations of Chinese alchemical treatises". Thirdly, Sivin prepared the ground for his annotated translation with three painstakingly researched sections: "I. On the reconstruction of ancient Chinese alchemy"; "II. *Tan Ching Yao Chueh*: The tradition and the book"; "III. The biography of Sun Ssu-mo: A historiographic inquiry". Fourthly, Sivin himself followed some of the procedures described in Sun's text in a modern laboratory and utilised the results of his experiments in the commentary.

Sivin's "Chinese Alchemy as a Science" (1968b) focuses on the recurring temptation of researchers to assess the Chinese alchemical tradition from the standpoint of modern chemistry, and why, in his opinion, this is irrelevant and unproductive. Particular emphasis is laid on the futility and meaninglessness in grafting European notions and projecting Western preconceptions onto Chinese ones as well as on the complexities in the objectives and assumptions embedded in Chinese alchemy. His short essay in the 1969 Isis was prompted by a review by Pierre Huard and Wong Ming of Ware's Alchemy, Medicine, Religion in the China of A.D. 320: The *Nei P'ien* of Ko Hung (Pao-p'u tzu) in the same journal in the previous year which raises certain points that Sivin thought should be straightened out and clarified, especially the dates of Ko Hung.

One more publication before we move on to the 1970s: a study by Ho from 1968 on the stones and minerals used for alchemical purposes as given in Chinese pharmacopoeias, for example the *Shen nung pen ts'ao ching*, *Pen ts'ao ching chi chu*, *Cheng lei pen ts'ao*, and *Pen ts'ao kang mu*. These stones and minerals are categorised into six groups according to the Periodic Table.[1] Under each substance is given the different names it was known by, the Chinese treatises that mention it, its use and method of preparation. Of special interest is a list of twenty-seven technical terms used in alchemical experiments.

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[1]Group I: sodium compounds, potassium compounds, copper and its compounds, silver, gold; Group II: calcium compounds, mercury and its compounds; Group IV: chalcedony, lead and its compounds; Group V: ammonium chloride, compounds of arsenic; Group VI: sulphur; Group VII: iron and its compounds.

Rarely does one come across a branch of the Chinese scientific traditions showered with such dedicated attention within a single decade as alchemy in the 1970s. A total of twenty-two articles as well as two volumes of Science and Civilisation in China that deal specifically with alchemy arrived one after another between 1970 and 1979 with a uniformly high standard and an interesting array of themes. But just as astonishing is the actual number of contributors: seven of these studies came from Needham and another seven from Ho and his collaborators. In this corpus of literature, old concerns and controversies were constantly revisited and reassessed, in particular problems connected with the beginnings and evolution of alchemy in China and other cultures, the goals of the alchemists, the leading theories and ideas, the dating, provenance, language and interpretation of Taoist alchemical texts.

The link and similarity between alchemy in early China and that belonging to Indian, Arabic and Hellenistic traditions was reconstructed and given eloquent treatment in several of Needham's articles. In "Artisans et alchemistes en Chine et dans le monde Hellenistique" (presented as a Rapkine Lecture at the Institut Pasteur in Paris and published in the 1970 La Pensée), for instance, Needham concludes that, "tout ce qui concerne l'origine de l'alchimie dans le monde hellénistique, peut-être aussi dans la Chine ancienne et dans l'Inde, devient compréhensible dès lors qu'on abandonne cette idée fixe des premiers historiens de la chimie, à savoir que le artisans et les alchimistes constituaient un groupe homogène. Il convient d'aborder le problème d'un point de vue de sociologue. De cette méthode nous avons précédemment fourni l'esquisse à plusieurs reprises, notamment en mettant en lumière la différence radicale qui séparait ces deux classes sociales: les artisans travailleurs du métal et les philosophes dilettantes."[1] In The Refiner's Fire (1971) -- his J. D. Bernal lecture delivered at Birkbeck College -- Needham endeavours to convince the audience of the central idea that, "everything that happened in the Hellenistic world about the origin of

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[1]Joseph Needham, "Artisans et alchemistes en Chine et dans le monde Hellenistique," trans. Hubert Condamine, La Pensée: Revue du Rationalisme Moderne, Arts, Sciences, Philosophie, no. 152 (1970), 24.

aurifaction and not only there but in China earlier and in India perhaps later as well, can be understood if we give up the idée fixe of the pioneer historians of chemistry that the artisans and the 'alchmists' were the same people. What is needed is a sociological approach. . . namely that there was a radical difference of social class between the artisan metal workers and the dilenttänte philosophers."[1] He introduces the terms "aurifaction", "aurifiction", and "macrobiotics", argues for "the existence of two quite distinguishable groups in Hellenistic Egypt, the technical artisans of aurifiction and the mystical philosophers of aurifaction", quotes textual sources in support of the antiquity of cupellation in China and inquires into the case of Ko Hung regarding transformation and cupellation.[2]

Yet another attempt made by Needham to get inside the different assumptions and cultural milieu that lay behind and governed the idea of immortality, the search for elixirs, and the rise of chemical medicine in East and West can be found in an essay published in three different journals.[3] Here, Needham sets the stage of his argument by again explaining the terms "aurifiction", "aurifaction", "macrobiotic" and the three distinct roots out of which ancient Chinese alchemy arose. He then demonstrates that "in spite of an impression sometimes found, there is almost nothing about elixirs or macrobiogens in the documents of the Hellenistic proto-chemists", charts "particularly the passage westwards of Chinese alchemical theory and practice", clarifies the origin of the names for elixir in different languages, gives a number of direct quotations from Arabic sources on the elixir, highlights "one very important theme of Arabic alchemy which seems never before to have been set properly in the context of elixir doctrine. . . . the so-called Science of Generation (*Ilm al-Takwin*), concerned with the artificial asexual *in vitro* generation of plants, animals and even men, as well as with the production of ores

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[1]Joseph Needham, <u>The Refiner's Fire: The Enigma of Alchemy in East and West</u> (London: Birkbeck College, 1971), pp. 30.

[2]Needham, <u>The Refiner's Fire</u>, pp. 9.

[3]In <u>Acta Medicae Historiae Patavina</u> (1972/73), <u>Journal of the Chinese University of Hong Kong</u> (1974), and <u>Organon</u> (1975).

and minerals in Nature and in the laboratory, including the generation of the noble metals from the base", confirms that "if. . . there was a passage of the elixir idea from the Arabic alchemists to the Latins, reaching full acceptance by them, according to their lights, in the time of Roger Bacon; then it might be expected that similar macrobiotic hopes would have become known in Byzantine culture a couple of centuries earlier", and finally relates the above observations to the formation of the elixir idea in the Latin West as well as to the contributions made by medical hygienists and iatro-chemists during the Scientific Revolution -- regarded by Needham as the precursors of modern chemical medicine.[1]

What metals did the Chinese alchemists have available to them? How did they make use of these metals for their alchemical pursuits and purposes? "Metals and Alchemists in Ancient China" (1976) -- extracted with slight modifications from Science and Civilisation in China vol. 5 pt. 2's "The metallurgical-chemical background; identifications of alchemical processes" -- supplies the necessary metallurgical background to these questions.

His "Category Theories in Chinese and Western Alchemy" (1979) is a formidable essay that does not lend itself to effortless reading in one sitting except for those few who can glide as smoothly over the broad and intricate arena as does the author.[2] In full command of

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[1]Joseph Needham, "The Elixir Concept and Chemical Medicine in East and West," Journal of the Chinese University of Hong Kong, 2 (1974), 247, 250, 255, 256, 259.

[2]It begins with the following comments: "About the interaction of substances and things there existed in ancient and medieval China a coherent body of doctrine springing from philosophical ideas first apparent in the writings of the famous Han scholar and thinker, Tung Chung-Shu (-179 to -104). In this world-order every thing and being belonged to a category *(lei)*, and events took place by mutual resonance between entities in the same category. These classical theories took shape at the very general conceptual level of Yin and Yang and the Five Elements, so that they could be applied to the whole range of man's experience of natural transformations and natural phenomena; and their extension led to an early form of what after the Scientific Revolution were to become theories of chemical affinity": Joseph Needham, "Category Theories in Chinese and Western Alchemy," Epeteris Epistemonikon Ereunon, 9 (1979), 21.

And it concludes with these thoughts: "The point to be emphasised here is that while Greek thought moved away from those ancient ideas towards concepts of mechanical causation foreshadowing the and always careful to cite relevant primary and secondary sources, Needham deftly juxtaposes and interweaves concepts in early and mediaeval Chinese philosophical thought, Chinese alchemy, and the shaping of Western chemistry. Among the themes brought forward for discussion are: the ideas of Tung Chung-shu; ancient and mediaeval Chinese writings on category theories; "ideas of groups, classes, categories and affinities. . . found embryonically within the writings of the Hellenistic proto-chemists"; "the lore of sympathies and antipathies apart from the stimulus which it gave to affinity theory in chemistry"; "the oldest application of the theory of categories in alchemy" as seen in the *Chou i ts'an t'ung ch'i* and *Ts'an t'ung ch'i wu hsiang lei pi yao;* and the question "is there any representative in modern chemical theroy of the doctrine 'that things of similar category go together?'"[1]

For a lightning tour of the supremely broad canvas covered in the four alchemy and early chemistry volumes of Science and Civilisation in China and to get acquainted with some of the most important vocabulary and reasoning employed there, the lecture Needham gave at the Quincentenary Celebrations of Uppsala University in 1977 may be a helpful start. It delineates concisely terms such as "*nei tan*", "*wai tan*", "aurifiction", "aurifaction", "macrobiotics", and "comparative macrobiotics".[2] It also communicates in a fairly uncomplicated and

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complete break of the Scientific Revolution, Chinese thought developed their organic aspect, visualising the universe as a hierarchy of parts and wholes suffused by a harmony of internal necessities. In this development the Chinese alchemists participated according to their lights, though their contributions to chemical discovery and invention, certainly not less than those of other civilisations, remained until the end of a typically pre-Renaissance character. Yet after all, the dimensional analysis of current scientific concepts is showing how again and again in many different fields the two thought-patterns 'unlikes attract', and 'birds of a feather flock together', underlie the most recondite and sophisticated theories. Perhaps, as categories of thought itself, they always will": Needham, "Category Theories," 46.

[1]Needham, "Category Theories," 31, 32, 36, 43.

[2]For instance, "the Greek or Western one [i.e. tradition] had only aurification and aurifaction. The macrobiotic idea, the idea of an elixir of life, or youth or perpetual longevity, immortality, arose only in China": Joseph Needham, "Alchemy and Early Chemistry in China," in The Frontiers of Human Knowledge: Lectures held at the

accessible manner what the Chinese alchemists actually made (e.g. arsenical copper, the discovery of stannic sulphide), distinctive features in Chinese alchemy (e.g. governmental support, involvement of women), underlying theoretical assumptions (e.g. the great importance of "the concept of time-controlling substances"), apparatus, three different kinds of distillation, and the discovery of strong alcohol.[1]

With few exceptions Ho (and his collaborators) preferred to concentrate on specific topics when writing about Chinese alchemy in the 1970s, favouring the delivery of keen insights to areas with well-defined and sharply-drawn perimeters. Topics and aspects they explored include the following:

(1) 1971 Ho -- the place of alchemy during the Ming dynasty: its advocates, the support from emperors, documentary information from that period (e.g. those by Li Shih-chen, Sung Ying-hsing, and in novels).

(2) 1972 Ho -- the significance of the "Book of Changes" in shaping the historical contours of Chinese alchemy and traditional Chinese science in general: Originally a Edward H. Hume Lecture presented at Yale University, this essay tackles the subject chronologically after a careful consideration of hexagrams, starting with Wei Po-yang and *Chou i ts'an t'ung ch'i*, and proceeding to the 4th to 9th century (when "the absence of the use of the system of the *Book of Changes* is also significant among the writings of these alchemists"), then to the 9th to the 13th century (with "a problem of obscurity in style, and once again, we see that the system of the *Book of Changes* comes into play"), and finally to the Ming dynasty (a period in which "the obscurity of the text" remained very much in evident).[2]

Quincentenary Celebrations of Uppsala University, 1977, ed. Torgny T. Segerstedt (Stockholm: Almquist & Wiksell, 1978), pp. 173.

[1]Needham, "Alchemy and Early Chemistry," pp. 177.

[2]Ho Peng Yoke, "The System of the Book of Changes and Chinese Science," Japanese Studies in the History of Science, 11 (1972), 35, 38. The discourse concludes with the following observation: "If they [i.e. many other branches of Chinese indigenous science] were fully satisfied with an explanation they could find from the system of the *Book of Changes* they would not go further to look for mathematical formulations and

(3) 1972 Ho, Goh and Lim -- an investigation into Lu Yu's "alchemical beliefs and activities as a step towards the understanding of the sociological impact of alchemy on the literati in Sung China"[1]: To accomplish this objective, "about twenty of Lu Yu's poems are selected, translated and rendered into verse in order to illustrate the feelings of the poet on alchemy and the Taoist belief that the span of human life could be extended indefinitely."[2]

(4) 1973 Ho -- early and mediaeval Chinese alchemists' quest for "perpetual youth": Different facets of this activity are addressed, including the first manifestations and subsequent development of their search for an elixir of life, the method of sublimation used by many in their experimental processes, how an elixir was prepared, the Chinese theory of category, the consequences of taking elixirs, how the conception of material immortality originated and why it managed to survive for a long period in China.[3]

(5) 1973 Ho, Lim, and Morsingh -- the study of *Shun yang lü chen jen yao shih chih*. The translators have increased our store and knowledge of Western translations of Chinese alchemical texts in different ways; firstly, by choosing a text that deals with elixir plants rather than one on metals and minerals which are more typical and exist in far greater numbers, and secondly, by recounting the detective work they have done to establish the possible date and author of the text. The translation is amply annotated.

(6) 1974 Ho, Goh, and Parker -- fifteen poems by Pai Chü-i on immortality, the search for elixirs and the effects of these substances, translated with critical commentaries.[4]

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experimental verifications in their scientific studies. Looking at the system of the *Book of Changes* in this light, one may regard it as one of the inhibiting factors in the development of scientific ideas in China": Ho, "The System," 38.

[1]Ho Peng Yoke, Goh Thean Chye and Beda Lim, Lu Yu, The Poet-Alchemist (Canberra: Australian National UP, 1972), pp. 3.

[2]ibid.

[3]Opening the essay is a quick sketch of the background of Western and Chinese research on alchemy.

[4]Also discussed is the possibility that another famous T'ang poet Han Yü might have consumed elixir in his old age.

(7) 1975 Ho -- evidence, as seen in the core principles and technical terms used in alchemical recipes and medical prescriptions, suggests that in China, alchemy and medicine "have come from the same roots", contrary to "the development in Europe where alchemy and medicine were two distinct disciplines for many centuries."[1]
(8) 1979 Ho -- the formidable and critical problem of dating Taoist alchemical literature. Based chiefly on his own vast experience and expertise in handling this task, Ho has offered specialists and non-specialists a practical and almost step-by-step guide to tackling authorship, biographies of authors, provenance, textual transmission and other related questions and concerns. Numerous examples, hints, and clues illustrate the intricacies and possible methods to unlock the mysteries of alchemical texts in Taoist writings.[2]

Efforts made by other scholars in this decade were equally notable. In fact, a unique feature in Western historical research on Chinese alchemy in the 1970s (as well as early-mid'80s) is that almost all the published views on the subject are worth a second if not third reading.

Mircea Eliade's "Alchemy and Science in China; Review of *Chinese Alchemy: Preliminary Studies* by Nathan Sivin" (1970) has done much to broaden and sharpen our appreciation of the significance of China's alchemical tradition in the history of world chemistry.[3]

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[1]Ho Peng Yoke, "Chinese Alchemical and Medical Prescriptions; A Preliminary Study," in Proceedings. . . 14th International Congress of the History of Science, Tokyo / Kyoto, 1974 (Tokyo: Science Council of Japan, 1975), vol. 3, pp. 298.

[2]The preface gives a brief summary of attempts made by Western and East Asian scholars to come to grips with Taoist literature. The main "Methodology" section considers "Use of bibliographies"; "Personal names"; "Textual comparisons"; "'Taboo words'"; "Reign titles"; "Geographical names"; "Technical names"; "Linguistic method". The monograph ends with a short conclusion and a bibliography of over thirty Western, a dozen or so Chinese, and several Japanese titles.

[3]The following thoughts deserve special attention: (1) "Most probably, the obstacles to a correct understanding of Chinese alchemy must be sought mainly in the Western, limited and rigidly conditioned, historiographic consciousness. There is no doubt that Chinese alchemy *is* a science; it applies a systematic framework to chemical operations, employs concrete measures, and resorts to laboratory experiences": Mircea Eliade, "Alchemy and Science in China; Review of *Chinese Alchemy: Preliminary Studies* by Nathan

The main thesis in Sivin's "Chinese Alchemy and the Manipulation of Time" (1976) is that the activities, motivations and aims of the Chinese alchemists "were not in any significant sense chemical", that in the ultimate analysis, one has to recognise that "in China the operative alchemy of the laboratory, no less than the physiological and introspective disciplines that borrowed its language and symbols, was a form for self-cultivation, a means toward transcendence", that "the content, tone and balance of the evidence strongly suggest that the dominant goal of Chinese alchemy was contemplative, and even ecstatic."[1] Comments are also made in passing to the similarity between Chinese and Hellenist alchemical thought.[2]

Placing and interpreting alchemy and the perception of the human body in early and mediaeval China in a patently important, but until recently poorly understood, context is Lu Gwei-djen's "The Inner Elixir (*Nei Tan*): Chinese Physiological Alchemy" (1973). In Lu's opinion, ". . .if the Western companion of metallurgical-chemical alchemy was psychological, its Chinese companion (*nei tan*) was essen-

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Sivin", History of Religions, 10 (1970), 179. (2) ". . . the similarity between the Taoist hermits and alchemists, on the one hand, and the Indian Tantric hermits and Hathayogic adepts, on the other hand, is too striking not to raise the problem of historical relations": Eliade, "Alchemy," 181. (3) "The investigations of Needham and Sivin of traditional Chinese science have a general methodological significance. Such studies contribute to the understanding of that stage in the history of the human mind when scientific knowledge had a holistic structure, and no art or technique was intelligible without its cosmological, ethical, and 'existential' presuppositions or implications": Eliade, "Alchemy," 181-82.

[1]Nathan Sivin, "Chinese Alchemy and the Manipulation of Time," Isis, 67 (1976), 513, 524-25. Sivin contends that this becomes evident once we have accepted that the alchemists' concepts of temporal change, that the elixirs they strove for and the chemical operations they constructed (for instance in the case of fire phasing -- "the gradual increase and decrease of fire intensity by using precisely weighed increments of fuel") "was not model-making for its own sake, nor was it the pursuit of chemical knowledge for its own sake, nor even an alternative way of doing natural philosophy": Sivin, "Chinese Alchemy," 518, 522.

[2]Sivin maintains that, "in the great metaphysical and religious significance given to alchemical processes the Chinese art was remarkably similar to that of the Hellenistic tradition, although the dominant metaphors were constructed out of very different worldviews and beliefs": Sivin, "Chinese Alchemy," 524.

tially physiological. The Chinese adept of the 'inner elixir' did not seek psycho-analytic peace and integration directly, he believed that by doing things with one's own body a physiological medicine of longevity and even immortality (material immortality, for no other was conceivable) could be prepared within it. Thus there opens out before us the whole field of Taoist physiology, a proto-science not exactly the physiology of the physicians down through the centuries, but not very far different from it. No greater mistake could be made than to analogize *nei tan* with the 'spiritual alchemy' of the West; it was physiological through and through."[1] To explicate and shed light on this peculiar concept, Lu directs one's attention to passages in Chinese treatises on classical philosophy, Taoist alchemical works, Chinese medical writings, etc. from early times to the 16th century. And to reveal the significance of and guide the reader through these sources insightful commentaries and background information are also furnished.

In "Sur la chemie en Chine, d'après Joseph Needham" (1977) François Hominal provides a short and convenient summary and analysis of the differences in Needham's and Sivin's orientations and interpretations towards and assumptions concerning the history of science and the definition of alchemy, ending with the observation that "l'alchimie chinoise est le confluent de trois recherches: a) une investigation des procédés métallurgiques et chimiques d'aurifiction et d'aurification qui s'est développée, en Chine et ailleurs, à partir d'une proto-métallurgie; b) une recherche botanique et pharmaceutique de plantes macrobiotiques, elle aussi très répandue; c) enfin, la mise au point de substances inorganiques employées en thérapie."[2]

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[1]Lu Gwei-djen, "The Inner Elixir (*Nei Tan*): Chinese Physiological Alchemy," in Changing Perspectives in the History of Science: Essays in honour of Joseph Needham, ed. Mikuláš Teich, and Robert Young (London: Heinemann, 1973), pp. 69-70.

[2]François Hominal, "Sur la chemie en Chine, d'après Joseph Needham," Revue d'Histoire des Sciences, 30 (1977), 260. For instance, with regard to the history of science, Hominal notes that, "Needham ne craint pas d'affirmer son parti pris en faveur de l'unité humaine et de la continuité du progrès de la connaissance. . . . Pour Nathan Sivin, l'histoire des sciences ne peut se limiter à rechercher dans le passé ce qui joue un rôle dans notre science à

Convinced that "the study of China's alchemical tradition can provide considerable insight into early Chinese medical theory, pharmaco-therapeutic practice and psychosomatic concepts", and that "Chinese alchemy is a complex blending of philosophical, cosmological, physiological and natural scientific thought", John J. Kao (1977) sketched "some important aspects of Chinese alchemical research and theory" in a short piece based chiefly on secondary Western accounts on Chinese alchemy.[1]

A decade separated the publication of the first (1974) and the last (1983) volume on alchemy in the *Science and Civilisation in China* series.[2] Together, they constitute the most comprehensive and systematic study hitherto undertaken in the West on the subject; and needless to say, the information, concepts, hypotheses, and conclusions they put forth defy summary. Very briefly, vol. 5 pt. 2 *Spagyrical Discovery and Invention: Magisteries of Gold and Immortality* (1974) provides the necessary preliminaries and background for the comprehension of the subject as well as for the other three volumes. Vol. 5 pt. 3 *Spagyrical Discovery and Invention: Historical Survey, from Cinnabar Elixirs to Synthetic Insulin* (1976) is a historical survey, organised chronologically. It begins with the earliest phases in the Chou dynasty, and the story is brought down to the coming of modern chemistry in the 18th and 19th centuries. Vol. 5 pt. 4 *Spagyrical Discovery and Invention: Theories and Gifts* (1980) is devoted to three specific aspects: laboratory apparatus and equipments; the theoretical background of elixir alchemy; a comparative survey of the development of alchemy in China and other cultures

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nous; elle doit se préoccuper de toute pensée abstraite sur la nature": Hominal, "Sur la chemie," 257. As for the definition of alchemy, Hominal comments that, "J. N. tente d'en donner une définition qui permette de comparer les pratiques diverses rencontrées dans des aires culturelles différentes. . . . Nathan Sivin, pour sa part, donne de l'alchimie une définition qui permet de maintenir la dénomination d'<alchimistes> aux praticiens hellénistiques": Hominal, "Sur la chemie," 258-59.

[1]John J. Kao, "Chinese Alchemy: Confluence and Transformation," *Comparative Medicine: East and West*, 5 (1977), 233.

[2]They fall under the general division of "Chemistry and chemical technology" within the series.

(especially in the Hellenistic and Arabic worlds).[1] Vol. 5 pt. 5 Spagyrical Discovery and Invention: Physiological Alchemy concentrates solely on the area of physiological alchemy or *nei tan*.[2]

While the content of vol. 5 pt. 3, vol. 5 pt. 4, and vol. 5 pt. 5 may be gleaned easily enough by perusing the headings for the respective sub-sections and further divisions, that of vol. 5 pt. 2 requires a little elaboration. "(a) Introduction: the historical literature" offers a two-page introduction to primary Chinese sources and a review of Western studies on the subject from the 19th century to the 1960s, often indicating their scholarly value and their influence on historians of chemistry in the West.[3] Main topics examined under sub-section "(b) Concepts, terminology and definition" include the key terms and concepts of "aurifiction", "aurifaction", and "macrobiotics"; ideas of afterlife in various cultures and Chinese concepts of immortality; substances used in ~~incences~~ incenses and the significance of incense-burners; and a table setting out meticulously the nomenclature of chemical substances and minerals as seen in Chinese alchemical works. "(c) The metallurgical-chemical background; identifications of alchemical processes" expounds methodically and exhaustively on the different techniques and procedures employed by Chinese alchemists for making artificial gold and silver.

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[1] There are four sub-sections: "(f) Laboratory apparatus and equipment"; "(g) Reactions in aqueous medium"; "(h) The theoretical background of elixir alchemy [with Nathan Sivin]"; "(i) Comparative survey".

[2] This volume contains two sub-sections: "(j) The outer and the inner macrobiogens; the elixir and the enchymoma"; "(k) The enchymoma in the test-tube; medieval preparations of urinary steroid and protein hormones".

[3] Needham was particularly emphatic when commenting on the handling of Chinese alchemy by E. O. Von Lippmann ("the greatest and most learned historian of chemistry in the early twentieth century"): "The regrettable fact of the matter is that with no personal knowledge of the Chinese language, no awareness that the *Tao Tsang* even existed, no use of the dynastic histories or the pharmaceutical natural histories, and no consciousness of archaeological and ethnographic data, it was painfully presumptuous to entitle a dozen pages "Chimie und Alchemie in China'": Science and Civilisation in China, vol. 5 pt. 2, pp. 4.

"(d) The physiological background; verifications of the efficacy of elixirs" introduces and underscores the physiological character of Chinese alchemy as well as comments on the alchemists' knowledge and perception of elixir poisoning.

Reviews often offer excellent guides to themes that figure most prominently in the study under review and issues that are most controversial. In this instance, reviews on the first of the alchemy volumes are especially worth noting. The rise and development of Chinese interest in alchemical pursuits (in particular the role of Taoism and the question of sociological elements) and the handling of Western alchemy caught most reviewers' attention. They were, above all, capitivated by the concepts of "aurifiction", "aurifaction" and "macrobiotics" -- not surprising, since these are theories on which much of Needham's interpretation of Chinese alchemy hangs and based on which his historical account is structured. However, as with other volumes of Science and Civilisation in China, the more critical reviewers did not react to the work in the same manner, a sign, perhaps, that the ideas articulated by Needham were truly thought-provoking and original.[1] Praise, nevertheless, was given by all

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[1]**(1)** In **Sivin's** opinion, "Needham's use of his three concepts leaves some doubt in my mind whether their value will hold up through the continued critical study that will form a secure understanding of the Great Work; they provide a most useful guide to certain important aspects of Chinese alchemy and at the same time obscure others. Furthermore, a critical look at the literature -- even at Needham's own selection of evidence -- makes a considerable amount of qualification necessary. . . . Needham's approach to the role of Taoism remains remarkably unsociological. . . . One never learns where the Taoism that is said to have shaped alchemy. . . was located and how it operated in Chinese society": Nathan Sivin, rev. of Science and Civilisation in China, vol. 5 pt. 2, in American Historical Review, 82 (1977), 1042-43. **(2) Robert P. ~~Maultauf~~** Multhauf would like to learn more about "the significance of Needham's social classes", which "is far from clear": Robert Maulthauf, rev. of Science and Civilisation in China, vol. 5 pt. 2, in Ambix, 22 (1975), 219-20. For instance, "alchemy was particularly associated with the Taoists. To which of these classes did they belong? . . . I doubt that anyone would deny that there was, in China as elsewhere, a radical difference of social class between artisan metal-workers and dilettante philosophers, but I finish this book full of uncertainty as to what this has to do with the history of Taoism or of Chinese alchemy": ~~Maulthauf~~ Multhauf, rev. of Science and Civilisation in China, vol. 5 pt. 2, 220. **(3) Derk Bodde** concentrated on the "three basic intellectual factors. . . posited as primarily responsible for the early development of alchemy in China" and other ideological issues: Derk Bodde, rev. of Science and Civili-

regarding the comprehensive treatment of the subject, while concern was expressed over the amount of details given, and over the time lapse between volumes.

Moving on to the 1980s, one encounters a collection of studies with diverse themes and intentions. Sivin's "Discovery of Spagyrical Invention" (1981) was prompted by the publication of Science and Civilisation in China vol. 5 pt. 3. The section headed "Difficulties" stresses problems unique to the study of Chinese alchemy.[1] "Accomplishments" deepens one's appreciation of Needham's scholarship and mission.[2] "Alternative views of alchemical history" deals with areas which could benefit from further research.[3] "Obfuscation as a historical force" focuses on Needham's tendency to characterise "whole periods of alchemical history by greater or lesser clarity of exposition": Sivin himself prefers to have one "ask how secret a secret name can be that occurs in text after text with the same meaning over a period of five hundred years or more."[4] Finally, in "Translation, documentation, and production", compliments are given

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sation in China, vol. 5 pt. 2, in Journal of Asian Studies, 35 (1976), 489. **(4)** For his review, **Micheal Loewe** chose to contrast Needham's views towards "science, nature, and the human intellect" and "the relationship between religion, science, and nature" with those held by Seyyed Hossein Nasr: Michael Loewe, rev. of Science and Civilisation in China, vol. 5 pt. 2, in Bulletin of the School of Oriental and African Studies, 38 (1975), 659. He also commented on "the attitude of the Chinese to death and the powers of the dead": Loewe, rev. of Science and Civilisation in China, vol. 5 pt. 2, 660.

[1]For instance, having to "disentangle the chemical from the transcendental", "reconstructing a temporal order of development in a tradition founded on the notion that it had no development", and dating Taoist alchemical texts: Nathan Sivin, "Discovery of Spagyrical Invention," Harvard Journal of Asiatic Studies, 41 (1981), 223.

[2]For instance, it explains why this volume "typifies the qualities that have made Needham the only scholar of pre-nineteenth-century China who is exerting a perceptible influence on the broader trends of contemporary thought", why "what Needham finds mainly significant about alchemy is therefore its protochemical aspect rather than, say, its ritual or its recourse to remarkable notions of Godhead and spiritual perfection": Sivin, "Discovery," 225.

[3]For example, understanding the *Chou i ts'an t'ung ch'i*, clarifying the confusion between what should be regarded as legendary and what is proper alchemical history.

[4]Sivin, "Discovery," 232.

to translations of Chinese sources and the "design and physical form of the book", while frustrations are expressed towards the treatment of Japanese materials, the inclusion of over 200 pages of texts from vol. 5 pt. 2, and the incredibly long time it takes to produce one volume of Science and Civilisation in China.[1]

One of the lectures given by Needham in the Second Series of Ch'ien Mu Lectures at New Asia College, The Chinese University of Hong Kong in 1981 is titled "Comparative Macrobiotics". In it, Needham weaves an engaging story that touches upon a host of topics on alchemy, including characteristics and differences in the Chinese, Arabic and Western alchemical traditions, episodes in the history of alchemy, possibilities of influence between Arabic and Chinese alchemical thought and theories, especially the concept of longevity and immortality.

The task of systematically explaining from the point of view of modern chemistry the formulae, manipulations and techniques used by Chinese alchemists in their laboratory was given special prominence in two papers by Anthony R. Butler and his collaborators. The first (1980) is concerned with a 6th century method on solubilisation of cinnabar. The authors explain that the required impurity in the nitre was chloride ion (which occurs in natural deposits), and that to speed up reaction in acqueous 8% acetic acid (i.e. vinegar) within the time specified in the method (i.e. thirty days), the Chinese alchemists concentrated vinegar by freezing. The second article (1983) takes a close look at two totally different recipes employed by Chinese and Western alchemists in the production of tin sulphide (also known as mosaic gold as it has the appearance of gold). The Chinese recipe was taken from *Pao p'u tzu nei p'ien*, while the "oldest known European account is in an anonymous, untitled manuscript of the 14th century catalogued as *De arte illuminande* in the Biblioteca Nazionale in Naples."[2]

For her doctoral thesis for the University of Paris, Farzeen Baldrian-Hussein translated a Sung alchemical treatise, the Ling pao

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[1]Sivin, "Discovery," 234.

[2]Anthony R. Butler, et al., "Mosaic Gold in Europe and China," Chemistry in Britain, 19 (1983), 132.

pi fa. Published as Procédés secrets du joyau magique: traité d'alchimie taoiste du XIe siècle (1984), it is more than another routine translation. To begin with, the choice of the particular text is significant.[1] Second, this monograph was a welcome addition to historians of Chinese alchemy as they began to acknowledge the overriding importance of *nei tan* (physiological alchemy in Needham's terminology, internal alchemy in Sivin's), an element which lies at the heart of Chinese alchemy, but which has been poorly understood in the West. Third, in order to cope with the text and the subject matter, Baldrian-Hussein successfully synthesized a considerable body of complex material, the results of which are presented in her three opening chapters: "I. L'alchimie intérieure: Remarques générales. Définitions"; "II. Les Textes et leur choix"; "III. Les Méthodes Tchong-Lu".[2]

For another study of *nei tan*, Baldrian-Hussein (1985) chose as her subject of inquiry "Spring in the Garden by the River Ch'in", a short poem from the Sung dynasty. According to Baldrian-Hussein, "the poem comprises numerous allusions to *nei-tan* techniques found in other texts ascribed to Lü Tung-pin and his legendary master Chung-li Chüan."[3] Moreover, this poem was very popular in the 12th cen-

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[1]As Kaltenmark stresses in the preface to the book: "Le *Ling-pao pi fa* traduit par Madame Baldrian-Hussein traite de cette alchimie très particulière ou l'installation des appareils de laboratoire et la manipulation des ingrédients <<chimiques>> se font tous à l'intérieur du corps de l'adepte. Tout cela au moyen d'un travail surtout mental: l'oeuvre alchimique consiste ici en une série compliquée d'exercices de concentration spirituelle, de respiration contrôlée, de visualisations. La principale difficulté de ce genre de traités d'alchimie intérieure réside dans la nomenclature, en partie empruntée à l'alchimie opératoire, mais avec des sens différents et, parmi les textes de *nei-tan* eux-même mot change de valeur au cours des opérations, à mesure que le travail alchimique progresse": Farzeen Baldrian-Hussein, Procédés secrets du joyau magique: traité d'alchimie taoiste du XIe siècle (Paris: Les Deux Océans, 1984), pp. 10.

[2]This monograph is one of the few Western works rated by Sivin as "important studies of Chinese alchemy" in the list of references for his article on research on the history of Chinese alchemy: Sivin, "Research on the History," pp. 17.

[3]Farzeen Baldrian-Hussein, "Yüeh-yang and Lü Tung-pin's *Ch'in-yüan ch'un*: A Sung Alchemical Poem," in Religion und Philosophie in Ostasien: Festschrift für Hans Steininger zum 65. Geburststag, ed.

tury, and its title served as the name of a melody as well. The first half of the article seeks to determine the author of the poem, the exact date of its first appearance, its transmission, the origin of the tune and other issues related to the writing of the poem. It is then translated in full, with critical annotations and explanations "drawn upon interesting interpretations from various commentaries."[1] As we have seen, those that worked on Chinese alchemy often turned to Taoist sources, but few made reference to contemporary tales and anecdotes as Baldrian-Hussein did in order to help reconstruct the historic milieu under which a work was written.

Appearing in the same festschrift as Baldrian-Hussein's contribution is another article on Chinese alchemy. Mention the novel Hsi yu chi (with its celebrated "monkey" character) and the Chinese literary -- rather than alchemical -- tradition springs to mind. However, Catherine Despeux's "Les lectures alchimiques du *Hsi-yu chi*" (1985) has shown convincingly that this great novel has considerable relevance for scholars in Chinese alchemy as well. Despeux begins her essay by alerting one to the fact that "le même titre [i.e. Hsi yu chi] étant porté par un ouvrage écrit par un disciple de Ch'iu Ch'ang-ch'un, éminent Taoiste des Yüan, une confusion naquit entre les deux, si bien que des Taoistes, non seulement clamèrent que le roman était l'oeuvre de Ch'iu Ch'ang-ch'un, mais encore s'ingénièrent à écrire des commentaires interprétant le roman comme une quête alchimique, une description des transmutations psychophysiologiques ayant lieu dans le corps tout au long du cheminement."[2] "Conclusion" sums up the author's thesis and presents ideas for further study.[3] There are three other sections, all with abundant documen-

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Gert Naundorf, Karl-Heinz Pohl, and Hans-Hermann Schmidt (Würzburg: Königshausen und Neumann, 1985), pp. 25.

[1]ibid.

[2]Catherine Despeux, "Les lectures alchimiques du *Hsi-yu chi*," in Religion und Philosophie in Ostasien: Festschrift für Hans Steininger zum 65. Geburststag, ed. Gert Naundorf, Karl-Heinz Pohl, and Hans-Hermann Schmidt (Würzburg: Königshausen und Neumann, 1985), pp. 61.

[3]"Il est clair que l'auteur du roman a utilisé délibérément le symbolisme alchimique. Dès le premier chapitre, le singe est placé sous le signe de l'éveil (*wu*), terme qui entre dans la composition de

tation and commentaries.[1]

By drawing attention to a popular poem and a celebrated novel, Baldrian-Hussein and Despeux have illustrated just how varied the sources for studying Chinese alchemy can be.

The *Shih yao erh ya* was considered by Needham to be "the single greatest lexicographic effort of this kind [i.e. works especially devoted to the iatro-chemistry of the inorganic world], . . . a synonymic dictionary of minerals and chemical substances mostly with medical uses, finished in +806."[2] Fabrizio Pregadio's privately published An Index to *Shih Yao Erh Ya*: A Chinese 'Lexicon alchemiae' of A.D. 806 (1985), as the title indicates, is a straightforward list of Chinese names and synonyms found in this lexicon giving their Western equivalents.[3]

Such a large proportion of accounts was sensitive to the relationship between Chinese and Western alchemy that it is not surprising that the final work discussed in this section is one which proposes a way of reconciling different opinions in the debate. In his paper for the 16th International Congress of the History of Science held in 1981 and in an amended version published in 1985 H. J. Sheppard submits an answer to the question, "What, then, is the common thread linking the so-called alchemical practices of China and the West?": "In the opinion of the writer much time and effort have been wasted by protagonists of Chinese and Western alchemy in claiming that their, and no other, was true alchemy. The question can

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son prénom Wu-k'ung, et l'on nous annonce que son ambition est de jouir de l'immortalité. Les termes employés et les poèmes sur la quête spirituelle et alchimique montrent que Wu Ch'eng-en connaissait fort bien l'alchimie intérieure et la littérature qui s'y rapporte": Despeux, "Les lectures," pp. 71.

[1] "Les deux *Hsi-yu chi* et l'attribution du roman à Ch'iu"; "Les commentaires alchimiques du roman"; "Les lectures alchimiques" (subdivided into "1) Les principaux personnages", "2) Interprétation alchimique des chapitres").

[2] Science and Civilisation in China, vol. 5 pt. 2, pp. 158.

[3] Pregadio also mentioned various editions of the Chinese text and supplied a bibliography of Chinese and Western works.

only be settled by the formulation of a definition of alchemy which expresses those elements which are common to the practices of both East and West. . . . For those practices which are generally regarded as alchemical the following definition is proposed: 'Alchemy is the art of liberating parts of the Cosmos from temporal existence and achieving perfection which, for metals is gold, and for man, longevity; then immortality and, finally, redemption. Material perfection was sought through the action of a preparation (Philosophers' Stone for metals; Elixir of Life for human), while spiritual ennoblement resulted from some form of inner revelation or enlightenment (*gnosis*, for example, in the West)'. Such a definition, it is suggested, is applicable in a general way to every one of the world's major alchemical traditions. Its use may make unnecessary the continued effort to prove that only one tradition was genuine alchemy from the start. . . ."[1] Sheppard's paper also recapitulates the current situation with scholarship on Chinese alchemy and reviews briefly the peculiarities in the theory and practice of Chinese and Western alchemy in three sections: "Myths: metals and maturity"; "Longevity and immortality: the Chinese tradition"; "Metallurgy and transmutation: the Western tradition".[2]

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[1]H. J. Sheppard, "Chinese and Western Alchemy: The Link through Definition," Ambix, 32 (1985), 188. Sheppard's suggestion has been regarded by Sivin as one of two "broadly informed attempts to define alchemy in a way that holds for all the great world traditions"; the other is Needham's whose "blend of chemical technique and self-deception contrasts with Sheppard's emphasis on a spiritual process": Sivin, "Research on the History," pp. 4-5.

However, Sivin also argued that, "both of these definitions are flawed, because in important Chinese sources the perfected material is not metallic; cinnabar is as important as gold. Needham's definition is particularly flawed because his dichotomy of alchemical naiveté and artisanal sophistication -- intended to reflect what he considers a key social distinction -- is not consistently reflected in Chinese sources": Sivin, "Research on the History," pp. 4. According to Sivin, Needham's and Sheppard's definitions nevertheless remained unchallenged, "so low is the vitality of the history of alchemy" in the mid-late 1980s: ibid.

[2]"It has been suggested that Western, i.e. European, alchemy arose out of knowledge transmitted to Spain by the Arabs in the tenth century A.D. and translated into Latin two hundred years later. However, it remains a fact that later indigenous European alchemical works, as well as those supplied by Islam, display basic theories and symbolism which originated in Hellenistic Egypt; apart from the

8.2 BIOGRAPHICAL WORKS ON ALCHEMISTS

Lives of half a dozen Chinese alchemists -- Ko Hung, T'ao Hung-ching, Chang Tao-ling, Shih Hsing-lin, Hsüeh Tao-kuang, Shang-yang Tzu -- were considered by Forke, Davis, Spooner, and Barnes in short articles published in the 1930s and '40s. These brief and unadorned biographical accounts consist mainly of translations or summaries of relevant passages. For instance, Davis turned to appropriate sections in the *Lieh hsien ch'üan chüan* for his portrayals of Tao and of Ko, and to biographies in the *Shen hsi t'ung chih* and some of their own poems for his articles on Shih and Hsüeh; Barnes based his sketch on T'ao on a Chinese paper which contains information derived from dynastic histories.

Distinctive elements in the individual's ideas, the place he occupied within the Chinese alchemical tradition, and conditions under which he operated were alluded to in passing in a few instances.[1] But limited evidence and analysis were offered. A possi-

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concept of elixir in its Islamic form, there is no evidence of the borrowing of Chinese terms or theories. This would seem to indicate that the two schools, East and West, arose independently out of a primordial urge towards the same goal. . .": Sheppard, "Chinese and Western Alchemy," 181.

[1]For example, in his article on Chang, Spooner concludes that, "in view of the preceding, it would appear that Chang Tao Ling was not an alchemist, nor was he noted for his knowledge of chemical methods that could be used to obtain the Elixir. Rather he seems to be the representative of the wu group of magicians and wizards or Fang Shih. . . . As such he probably possessed the belief in the Elixir of Life, but the method to be used to obtain it would not depend on essentially chemical knowledge or practices. Hence he cannot be called an alchemist. Nor has definite proof been found to show that there was any definite connection between alchemy and the Taoist religion at the time of the latter's inception": Roy C. Spooner, "Chang Tao Ling, the First Taoist Pope," Journal of Chemical Education, 15 (1938), 507.

In Davis and Ch'en's article, readers are told that Shang-yang Tzu caught their attention because of "the remarkable picture and diagram. . . which illustrate the *Chin tan ta yao* and which appear to prove briefly, conclusively, and in a manner as direct as words could do, that the essential doctrine of Chinese alchemy is the same as that of the alchemy of Europe": Tenney L. Davis, and Ch'en Kuo-fu, "Shang-yang Tzu, Taoist Writer and Commentator on Alchemy," Harvard Journal of Asiatic Studies, 7 (1942), 126. The two illustrations in question are: "The interaction of the Figure and the Thing for the preparation of the pill of immortality. Cf Tao-tsang 738.3.66" and "A Diagram of the medicine laboratory of Tzu-yang. Cf Tao-tsang ble exception is Forke's "Ko Hung der Philosoph und Alchimist" (1932). As the title indicates, the study displays an interest in Ko's philosophical concepts and beliefs in addition to his alchemical practices.

By contrast, the only two biographically-oriented studies from the second half of the 20th century are more substantial, and significantly richer in that they take into serious account their subjects' motivations and other broader concerns.

Ho and Lim have investigated the life, official duties, alchemical interest and knowledge, and fragments of writings of a lesser-known member of the Sung literati, Ts'ui Fang, "an example of a junior civil servant who acquired and practised the art of experimental alchemy."[1] In their paper (1972), emphasis is laid on determining the significance of the elixir formulae and compositions in Ts'ui's work (especially connections with medical prescriptions) and on revealing that "there were many government officials, who themselves were acquainted with operative alchemy and some of whom even did the experiments themselves."[2]

The other biographical work -- a path-breaking and persuasive inquiry -- was written by Michel Strickmann (1979), who saw the study of elements in Chinese society as the best way to attain a firm grip on Taoist alchemy.[3] His in-depth and critical documentation and evaluation of the life and ideas of T'ao Hung-ching starts with alchemy in the Mao Shan Revelations and concludes with "Alchemy in a Taoist context" in which the following issues are articulated: "History and Taoist definitions: The way of the celestial master"; "The southern occult tradition"; "Structure: Toward an astroal-

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738.3.8a".

[1]Ho Peng Yoke, and Beda Lim, "Ts'ui Fang, a Forgotten 11th Century Chinese Alchemist," Japanese Studies in the History of Science, 11 (1972), 12.

[2]ibid.

[3]Sivin refers to this work -- and other writings by Strickmann -- with respect on various occasions in his "Research on the History of Chinese Alchemy".

chemy"; "Eschatology and destiny".[1]

8.3 ALCHEMICAL APPARATUS AND EQUIPMENT

It is curious that the subject of alchemical apparatus and equipments had motivated little research from Western scholars. There were only two special publications dedicated to this topic from the 1930s and one published in 1959. Barnes' two articles were based on a Chinese article on alchemy that appeared in 1933. There are nine parts to his "<The Apparatus, Preparations and Methods of Ancient Chinese Alchemists> by Y. Y. Ts'ao: A Review" (1934): "an introduction and a general history of Chinese alchemy"; "the fundamental requirements for the location of alchemical apparatus"; "specifications for the platform employed to support the alchemical oven"; "descriptions of the alchemical ovens"; "two kinds of crucibles or containers"; "distillation and distilling apparatus"; "the operation of grinding"; "sublimation"; "formulas and procedures for compounding the mud, plaster, or earth for sealing the crucibles, and in certain cases, for insulation purposes to prevent the ingredients in the reaction vessel from heating too rapidly".[2] His second paper (1936) focuses on the diagrams given in the Chinese work.

The crucial and unique contribution to the study of this topic before the publication of Science and Civilisation in China vol. 5 pt. 4 was "The Laboratory Equipment of the Early Medieval Chinese Alchemists" (1959), an elaborate and masterly survey by Ho and Need-

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[1]Strickmann argues forcefully that, "context and intention were everything and must be determined in each individual case. After our efforts to recover the alchemy of T'ao Hung-ching, it should be clear that there is only one way to flesh out the bare bones of the texts. The crucial social and personal factors, must be rediscovered and correlated with the pronouncements of scripture. Neither religion nor technology can be adequately studied in isolation. Our efforts to elucidate both Taoism and the Taoist arts must be firmly grounded within the study of Chinese society": Michel Strickmann, "On the Alchemy of T'ao Hung-ching," in Facets of Taoism: Essays in Chinese Religion, ed. Holmes Welch, and A. Seidel (New Haven: Yale UP, 1979), pp. 192.

[2]William H. Barnes, "<The Apparatus, Preparations and Methods of Ancient Chinese Alchemists> by Y. Y. Ts'ao: A Review," Journal of Chemical Education, 11 (1934), 656-58.

ham. After an introductory section, the authors guide us through their sources, "which include more than twenty different alchemical texts, all from the Tao Tsang", laid out in a list "giving where possible the names of their authors, the dates when they were written and also their numbers in the standard catalogues."[1] The main portion of the study is organised according to eight different types of alchemical equipments, apparatus, and accessories, and contains fifty-four illustrations.[2] The bibliography that follows has forty-four items (mainly Western). Ho and Needham express in their concluding sentence the hope that "enough has been said about the Chinese equipment to dispel the impression given by some older authorities, who without any access to original texts, could write, e.g. 'They (the Chinese) possessed neither characteristic chemical methods of their own, nor any apparatus originating in their own culture.'"[3]

8.4 EARLY CHEMISTRY

Authors of publications discussed above all sought to better comprehend Chinese alchemy, but it is fairly obvious that a number of them treated the subject as a department or a part of the whole Chinese experience in the field categorised today as chemistry.[4]

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[1]Ho, Ping-Yü, and Joseph Needham, "The Laboratory Equipment of the Early Medieval Chinese Alchemists," Ambix, 7 (1959), 60.

[2]These categories are: "1. The laboratory bench"; "2. The stoves *lu* and *tso*"; "3. The reaction-vessels *ting* (tripod, container, cauldron) and *kuei* (box, casing, container); "4. The closed reaction-vessels or bowls *shen-shih* (magical reaction-chamber) and *yao-fu* (vessel composed of two crucible-like bowls placed mouth to mouth); "5. Steaming apparatus, water-baths, condensation vessels and cooling jackets"; "6. Sublimation apparatus"; "7. Distillation and extraction apparatus" (further divided into: "i. Destillatio per descensum", "ii. East Asian types of still", "iii. The evolution of the still", "iv. The stills of the Chinese alchemists", "v. The geographical distribution of still types"); "8. Accessories".

[3]Ho and Needham, "The Laboratory Equipment," 115. The quotation concerned was taken from Edmund O. Von Lippmann, Entstehung und Ausbreitung der Alchemie. . . (Berlin: Springer, 1919), vol. 1, pp. 456.

[4]After all, how else was one supposed to study Chinese alchemy if not by exploring its chemical aspects and techniques with the help of concepts and vocabulary derived from modern chemistry. Remember that

Such an approach, however, was often not articulated openly. Those responsible for studies addressed in the present section, however, expressed an unmistakable interest in different types of knowledge and activities related to chemistry and chemical technology -- not just alchemical ideas, practices and literature. They made reference to the use of minerals, metals and other chemical substances by alchemists as well as in manufacturing and chemical technologies, and occasionally in areas of health and medicine. There were also several works that focus on distillation.[1]

Of the four studies from the 19th century, the most interesting is probably Jules Klaproth's "Sur les connaissances chimiques des chinois dans le VIIIe siècle" (1810). Klaproth brought to light, translated passages from, and discussed a supposedly T'ang manuscript on oxygen and on metals. However, the alleged title of the work (*P'ing lung jen*), date of composition (A.D. 756), and author (a certain Mao Hua), are all rather mysterious as they cannot be traced or verified. F. Porter Smith's "Chinese Chemical Manufacturers" (1870) is typical of a kind of literature on traditional Chinese science from that era which seizes selected passages from Chinese documents and interprets them according to modes of understanding current in Western science. The "Chinese chemical manufacturers" considered by Smith include those who practiced alchemy, made gunpowder, and used metallic substances as materia medica. Edkins' (1877) paper concentrates on distillation which, according to him, "is entirely unknown in Chinese antiquity."[2] Instead, "philology brings the praise or blame of first making, and naming distilled liquids back to the Arabs from whom the art spread both into China

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it was only in recent decades that some scholars began to launch serious and constructive challenges to the long-time practice of addressing traditional Chinese science primarily from the perspective of Western science.

[1]Works in the mineralogy section in *Chapter 6: Earth Sciences* also give information on what the authors saw as Chinese contributions to the field of pre-modern chemistry. But needless to say, studies on ceramic technology, metallurgy, gunpowder, pharmaceutics and medicine lie off our course.

[2]Joseph Edkins, "Distillation in China," China Review, 6 (1877), 211.

and into Europe in the 13th century."[1] In a lengthy account from 1895 M. F. de Mély describes how various minerals and metals were used not only in alchemical but also other kinds of activities involving chemical processes, drawing evidence from Chinese sources.

The handful of accounts from the first half of the 20th bore no appreciable difference in orientation from those of the previous century. Starting with *Pao p'u tzu*, John Antenorid's "Die Kenntnisse der Chinesen in der Chemie" (1902) runs through roughly chronologically how the Chinese utilised quick-silver, iron, etc. for metallugical, medical and other purposes. Holgen supplemented his "Iets over de chineesche Alchemie" with "Iets uit de Geschiedenis van de chineesche mineralogie en chemische technologie" -- also published in the 1917 Chemisch Weekblad. Von Lippmann, who gave no credit to the Chinese in his masterpiece on the history of chemistry, referred to Berthold Laufer's acclaimed "Sino-Iranica. . ." and the well-known Chinese pharmacopoeia *Pen ts'ao kang mu* in a brief essay from 1923 on Chinese contributions to the history of chemistry.[2] M. Muccioli published in the 1926 Archivio di Storia della Scienza a rejoinder to Klaproth's paper, arguing against his claims. Referring to Li Ch'iao-p'ing's The Chemical Arts of Old China, Maurice Daumas named a host of Chinese achievements in his "La naissance et le développement de la chimie en Chine" (1949).[3]

Readers today may find these pieces from the 19th and first half of the 20th century too uncritical and simplistic to be convincing as studies of traditional Chinese knowledge and skills in the preparation and use of minerals, metals and chemical compounds in alchemical, technological and medical procedures. Furthermore, little thought was given to the resources available at the time and to the functions of and circumstances motivating these activities. However,

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[1]Edkins, "Distillation," 212.

[2]Berthold Laufer, "Sino-Iranica: Chinese Contributions to the History of Civilization in Ancient Iran; with special reference to the History of Cultivated Plants and Products," in Field Museum of Natural History. Anthropològical Series 25.3 (Chicago: Field Museum of Natural History, 1919), pp. 185-630.

[3]Li Ch'iao-p'ing, The Chemical Arts of Old China (Easton, Penn.: Journal of Chemical Education, 1948).

these publications should not left out of our chronicle: they add to our understanding of the general development of Western interest in traditional Chinese science especially with regard to the manner in which the issue in hand was conceptualised and characterised.

Inquiries from the second half of the 20th century were generally much more informed and mindful of the need to clarify and document claims.

Schramm's "Über der Chemie im alten China" (1963), however, is more akin to earlier works in that the author compiled his inventory of Chinese contributions mainly by skimming over Chinese treatises and secondary Western literature, offering little by way of critical assessments.[1]

On the other hand, Edward H. Schafer's "Orpiment and Realgar in Chinese Technology and Tradition" (1955) and "The Early Use of Lead Pigments and Cosmetics in China" (1956) make use of a wide variety of carefully selected literary as well as archaeological evidence. The first paper charts the mining of realgar and orpiment and their use as pigments, medical remedies, alchemical ingredients, explosives, and talismans. The second article delineates in great detail the manufacture and application of lead and lead oxides (e.g. massicot, minium, ceruse, litharge) by alchemists, painters as well as for cosmetics and a number of other purposes in ancient China.

Further observations and comments on the Chinese manuscript mentioned by Klaproth on oxygen and metals were given by Needham in 1972. The title of his article, "A Chinese Puzzle: Eighth or Eighteen?" is yet another indication of Needham's attachment to the issue of transmission and priorities.[2]

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[1]Schramm touched on ceramics, metallurgy, the role of *wu hsing* and *yin yang*, alchemy, pharmaceutics, gunpowder, and paper.

[2]In the opening paragraph, he remarks that, "as is well known, the Jesuit Mission of the seventeenth century played a great role in transmitting to China the newly developed modern sciences of mathematics, astronomy and physics. In the eighteenth century, however, for various reasons, they did almost nothing to pass on the new chemistry. Yet there is a strange story to tell about one possible attempt to put the discovery of oxygen into Chinese. At the same time it confronts us with one of the most singular literary puzzles which has presented itself in the whole course of our studies on the history of science in China": Joseph Needham, "A Chinese Puzzle: Eighth or Eighteenth?" in <u>Science, Medicine and Society in the Renaissance</u>, ed.

Valuable factual information as well as historical perspectives on distillation -- a subject rarely pursued by Western scholars -- can be found in two publications from the 1970s. The objective of Lu Gwei-djen, Joseph and Dorothy Needham's lengthy essay "The Coming of Ardent Water" (1972) is to "discover, if we can, who first became familiar with the taste and smell of strong distilled alcohol, and where this was."[1] Their findings are presented in four sections (i.e. "i. The Salernitian quintessence"; "ii. Ming naturalists and Thang 'burnt wine'"; "iii. Liang 'frozen-out' wine"; "iv. From icy mountain to torrid still") and accompanied by a six-page bibliography in small print. The second paper, "L'alchimie en Chine; pratique et théorie" (1975) by Needham is, in spite of its title, chiefly concerned with distillation of alcohol from ancient to mediaeval times. The last part of the article touches on the concept of *yin* and *yang*. As with most of Needham's contributions, chronology and the establishment of priorities are extremely important considerations.

Also on distillation is H. G. Thurm's "*Shao chiu*: vom ausgefrorenen bis zum gebrannten Wein". Published in 1978 in Alkoholindustrie, this short article comments briefly on how different mediaeval Chinese writers and texts treated the subject of distillation and wine-making.[2] Thurm also introduces opinions of several Western scholars on the subject.

8.5 CONCLUSION

To recount the story of Western writing on Chinese alchemy faithfully, works from the 19th century should not be forgotten. Neither would it be fair to strike off the record those short accounts from the first quarter of the 20th century. In Sivin's opinion, however, "consciousness of the Chinese alchemical tradition in the West began with the publications of Tenney L. Davis. . . who from

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Allen G. Debus (New York: Science History, 1972), vol. 2, pp. 251.

[1]Lu Gwei-djen, J. Needham, and D. Needham, "The Coming of Ardent Water," Ambix, 19.2 (1972), 69.

[2]Chinese treatises mentioned include: *Hsin hsiu pen ts'ao*, *Pen ts'ao kang mu*, *Po wu chih*, *Shih liao pen ts'ao*, *Shen nung pen ts'ao ching*, *T'ang kuo shih pu*, *Yin shan cheng yao*.

1930 to the mid-1940's collaborated with Chinese graduate students and others to translate a series of readily available alchemical classics."[1] Davis and some individuals from the 1920s and '30s thought it necessary to stress the importance of learning more about the subject as well as the West's limited understanding of it. Their words did not fall on deaf ears. As Sivin explained, "a broader *problematique* that set the agenda for alchemy was provided by Joseph Needham in general writings on science from the 1940's on, in monographic essays on alchemy beginning in 1950, and in the four volumes devoted to this topic. . . published between 1974 and 1983."[2] There were, of course, other contributors in this period, from Feifel, Spooner, Dubs, Ware, Ho, to Sivin himself.

This sounds encouraging. But according to Sivin, the subject was in fact in steady decline from the 1980s on. He informed us in a 1989 review of current scholarship on traditional Chinese science that far from being the centre of historical attention as it had been in the 1960s and '70s, "alchemy is now little studied worldwide; where once historically minded chemists were fascinated by it, the growing prestige of scholarship on twentieth-century chemistry has encouraged them to explore their own time."[3] In a later (i.e 1990) essay on research on the history of Chinese alchemy, he has this to say: ". . .despite the increasing number of [Asian] scholars exploring the literature, the outcome continues to be claims about ancient anticipations of modern chemistry. Superficial claims are freely made, since the search for Chinese priorities encourages them, and freely voided, since closer examination tends to reveal that alchemists and modern chemists have little in common. In Europe, where the trajectories of technical history, religious studies, and philological Sinology manage to traverse the alchemical literature without encountering each other, the most frequent product still tends to be annotated translation. I detect no sign of new frameworks of understanding that will be adequate to the many dimensions of the sub-

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[1]Sivin, "Research in the History," pp. 8.

[2]Sivin, "Research in the History," pp. 9.

[3]Nathan Sivin, "Science and Medicine in Imperial China: The State of the Field," Journal of Asian Studies, 47 (1988), 60.

ject."[1] In fact, he begins the essay by pronouncing that the "history of alchemy is, if not dead, at least moribund."[2] Included in his paper are also reasons for this sad state of affairs and suggestions "to vivify the study of Chinese alchemy."[3] It is instructive to compare these recommendations with topics and concerns that were attended to regularly in the period we are concerned with (i.e. from 1800 to 1985).

Sivin divided his proposals into two categories. Under "Means and ends" there are four main elements to note:

(1) "Stop assuming that the ends of alchemy were chemical, and ignoring evidence to the contrary. The Chinese documents suggest, as do those of Hellenistic alchemy, that chemical knowledge, usually in small concentrations, was only a means. The goals were more spiritual than cognitive or utilitarian. The most obvious way to proceed involves attention to what alchemists themselves have to say about what they were doing and thinking."[4] The goals and objectives of alchemists were not ignored in past literature. Waley, Dubs, Kaltenmark, Needham, and Sivin were among those who offered their perspectives on the issue. However, it cannot be denied that not enough effort went into listening objectively and systematically to the practitioners' themselves. Few works have made their words and relating them to the speakers' own actions and ideas the prime concern. Moreover, "spiritual" ends were rarely considered.

(2) "Attempts to excavate clear modern principles out of the teeming synonyms, metaphors, and secret names in alchemical writing are misdirected. The purpose of alchemical obscurity was not 'mystifications to addle the uninitiated' but a maximum of symbolic allusion

[1]Sivin, "Research on the History," pp. 12-13.

[2]Sivin, "Research on the History," pp. 4.

[3]Sivin, "Research on the History," pp. 13. He especially urges researchers to concentrate on the following questions: "Who did alchemy, how practitioners were associated and why, what their quest signified to them, and what their own goals were; how aspects of this picture changed, and for what reasons": ibid.

[4]ibid.

packed into every utterance."[1] Plagued by numerous problems with Chinese alchemical literature ranging from dating, authorship, to technical language, a number of studies have indeed directed their attention towards the comprehension of specific alchemical texts. Unfortunately, the methods and strategies frequently adopted were based heavily on or designed to detect modern chemical knowledge and skills.

(3) "An alternative hypothesis, namely that alchemists on the whole took their techniques and apparatus from craftsmen and physicians, deserves to be explored. That entails, of course, looking beyond the alchemical literature."[2] This important aspect was not addressed in the body of work we discussed.

(4) "An adequate understanding of alchemy is unlikely to come from either the history of chemistry or the history of religion pursued separately as disciplinary specialists."[3] When perusing pre-1985 Western publications on traditional Chinese science, one seldom encounters the use of sound and effective inter-disciplinary approaches. Alchemy is not an exception.

Sivin's second category, "Mental and social activity", contains two important points.

(1) "There is little save legends to satisfy curiosity about who the alchemists were. . . . Until this mystery is unravelled, the history of alchemy will remain afloat, unrooted in the web of activity that we call Chinese society."[4] It is plain that biographically-oriented works were severly lacking.

(2) "The character of alchemical practice is shaped by time, place, circumstances and interests, and. . . it is possible in given cases to learn what they were."[5] Few studies mentioned in this chapter were structured by the authors' recognition of and need to explore this central element.

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[1]Sivin, "Research on the History," pp. 13-14.

[2]Sivin, "Research on the History," pp. 14.

[3]ibid.

[4]ibid.

[5]Sivin, "Research on the History," pp. 15.

Finally, mention must be made of a theme that had preoccupied a number of Western scholars, but which Sivin's article does not dwell on, namely, comparing developments in China with those in other cultures in order to shed light on issues of influence and transmission. This concern held a key place in Western historiography on Chinese alchemy and was raised repeatedly, from Martin's paper in 1879, Davis' 1936 essay on the dualistic cosmogony of *Huai nan tzu*, to Needham's contributions and Sheppard's studies in the 1970s and '80s.

8.6 PARTICIPATING COUNTRIES AND INDIVIDUALS

In spite of the fact that this chapter contains over a hundred and twenty titles, surprisingly few individuals were involved. But if the respectability of a field of study is in direct proportion to the level of participation of eminent scholars, then the standing enjoyed by Chinese alchemy was indeed high. It has profited from a number of major inquiries by Needham, Ho, and Sivin -- all distinguished Chinese historians of science -- while some of the other contributors were authorities in their respective subject areas (e.g. Partington in the history of chemistry, Kaltenmark and Strickmann in Taoism, Eliade in anthropology).

Another feature to take note of is that the subject of Chinese alchemy and early chemistry has been diligently pursued by professors in chemistry and biochemistry (e.g. Davis at MIT, Barnes at McGill University, Spooner and Collier at West China Union University, Butler at The University, St. Andrews.)

Works were also written regularly by those whose expertise resided primarily in the field of Oriental or Sinological study (e.g. Klaproth, Edkins, Johnson, Waley, Muccioli, Dubs, Ware, Strickmann, Baldrian-Hussein) and most were significant contributions in one way or another.

It was to scholars in Britain and America that one turned for the majority of pre-1985 publications. Britain was represented chiefly by Edkins, Chatley, Waley, and Partington before the 1930s, Dubs, Needham, Lu, and Sheppard after that period. On the American side were Johnson, Davis, Wilson, Spooner, etc. in the 1920s, '30s and '40s, Shafer, Ware, Sivin, Eliade, Kao, etc. in the 1950s, '60s and '70s. Though rather limited in the past, several researchers from France (e.g. Kaltenmark, Hominal, Balrian-Hussein, Despeux) have paid serious attention to the subject in recent decades. German interests were shown in works by Klaproth, von Lippmann, Shramm, and Thurm, but Germany's overall role was relatively minor.

Scholarship would have suffered greatly had it not been for the dedicated effort made by Ho (at the University of Malaya, and later at Griffith University in Australia) and his collaborators. Barnes and Collier from Canada, Hiordthal from Norway, Holgen from the Netherlands, and Pregadio from Italy had also raised the question of Chinese knowledge in the areas of alchemy and early chemistry.

8.7 FORMS OF PUBLICATION

The two most important groups of journals that carried articles on alchemy and early chemistry in the first as well as second half of the 20th century were periodicals for Chinese / Asian studies and for the history of science. Monumenta Serica and Harvard Journal of Asiatic Studies each published three essays on the subject, and Journal of the West China Border Research Society two. Other Chinese / Asian studies journals (e.g. China Review, Papers on Far Eastern History, Chung Chi Journal) were each responsible for one study. The situation was different with history of science and history of chemistry journals (e.g. Japanese Studies on the History of Science, Revue d'Histoire des Sciences). Ambix, published by the Society for the History of Alchemy and Chemistry in Great Britain and concerned exclusively with the history of chemistry, featured six articles between 1946 and 1985 specifically on China, while Isis, the official journal of the History of Science Society in America, contributed eight essays between 1932 and 1976.[1]

The rest of the articles were distributed among three different categories of material. (1) Festschriften, collective works and

[1]Authors for the Ambix articles (e.g. Barnes, Ho, Needham, Lu, Sheppard) worked in Britain, while those that chose Isis (e.g. Wu, Davis, Spooner, Sivin) lived in the U.S. Dubs, who taught in America before his invitation to become Chinese Professor at Oxford, had one article in Ambix and one in Isis.

conference proceedings on various subjects, from lectures held at the quincentenary celebrations of Uppsala University, the Ch'ien Mu lectures at the Chinese University of Hong Kong, conferences on the history of science, to collections on Taoism, Chinese religion, and archaeology. (2) Chemistry journals such as Chemisch Weekblad, Chemistry in Britain, Chemistry in Canada and especially Journal of Chemical Education (with eight articles in the 1930s from Davis, Wu, Spooner, Chao, and Barnes). (3) A broad and interesting array of journals from various disciplines and fields of study; titles include: Nature (which provided the venue for exchanges in the 1920s and '30s), Proceedings of the American Academy of Arts and Science (with eight articles from Davis and his collaborators), Endeavour, History of Religions, Epeteris, [Nova Acta] Leopoldina, Bulletin de la Société d'Acupuncture, Mémoires de l'Academie Impériale des Sciences de St. Petersbourg, Annales; Économies, Sociétés, Civilisations, The Quest, Aryan Path, Journal of the Warburg and Courtauld Institutes, Alkohol-industrie. It is unusual for a large percentage of studies to appear in journals not primarily associated with the field concerned.

Finally, emphasis should be laid on the twelve book-length works: four (i.e. ones by Johnson, Ware, Sivin, and Baldrian-Hussein) originated as doctoral theses, four are volumes in Science and Civilisation in China, two were written by Ho, one by Needham, and one by Pregadio.

8.8 BIBLIOGRAPHIC PROVISION AND CONTROL

I. GENERAL BIBLIOGRAPHIES FOR CHINESE / ASIAN STUDIES AND THE HISTORY OF SCIENCE:

(a) Henri Cordier, Bibliotheca Sinica. . . (1904-08); (1922-24):

In the sub-division "Alchimie" under "Sciences Médicales" within "XII. Sciences et Arts", two titles are listed: de Mély's "L'alchimie chez les chinois et l'alchimie grecque" and the abstract of the paper Martin read before the American Oriental Society.[1] Edkins' three essays (published in Transactions of the China Branch of the Royal

[1]But not the extended version in China Review.

Asiatic Society, Miscellany or Companion to the Shanghai Almanack for 1857, and China Review) cannot be found in science-related sections.[1] The same is true for Smith's account in the Journal of the North China Branch of the Royal Asiatic Society. In the supplementary volume, Hiordthal's contribution (published in a history of chemistry festschrift -- Beiträge aus der Geschichte der Chemie dem gedächtnis von Georg W. A. Kahlbaum), is under "XII. Sciences et Arts - Ouvrages divers".

(b) John Lust, Index Sinicus. . . , 1920-55 (1964):

Almost fifty articles appeared between 1920 and 1955, and half of them are available from Lust's index. In reviewing the types of journals to which the indexed articles belong, it is found that approximately six of them fall within the Chinese / Asian studies category.[2] The rest comes from the chemistry or the history of science fields.[3] Thus Lust's index does occasionally extend beyond periodicals concerned primarily with China and Asia.[4] With the exception of Feifel's translations of the *Pao p'u tzu* and Davis and Ch'en article on Shang-yang Tzu (placed under "XII. Religion - (d) Taoism") all relevant titles are kept in the "XVIII. Science and Technology - (d) Chemistry" section.

(c) ISIS Cumulative Bibliography, 1913-65; 1966-75; 1976-85:

Listing almost two-thirds of the material published between 1913 and 1985, this bibliography offers a decent coverage of the literature from this chapter. It is particularly good at supplying articles from history of science and history of chemistry journals,

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[1]But since the bibliography pays particular attention to journals concerned with Chinese studies, it is possible that they are located elsewhere -- a good example of the difficulty with subject retrieval.

[2]e.g. Bulletin of the School of Oriental Studies, Aryan Path, Journal of the West China Border Research Society, Monumenta Serica, Harvard Journal of Asiatic Studies.

[3]e.g. Isis, Ciba Symposium, Archivio di Storia della Scienza, Ambix.

[4]Among articles not registered are ones in Nature, Proceedings of the American Academy of Arts and Sciences, Journal of Chemical Education, Scientific Monthly, Technology Review, Endeavour, and Chemistry in Canada.

indexing all but one of the twenty-three essays from these two types of serial publications.[1] Of the eleven essays published in festschriften and collective works, ISIS is the only general bibliographic source that has analysed the ones from non-Chinese / Asian fields.[2]

One is slightly less enthusiastic with ISIS' coverage of chemistry and general science journals. Nearly half of the articles in these two categories of periodicals have been left out, although all eight titles in the Proceedings of the American Academy of Arts and Sciences were entered.[3]

A moderate number of articles in Chinese / Asian studies, humanities, and social sciences journals also found their way into the bibliography.[4] As for works in book form, those by Ho, Goh, and Lim (1974), by Ho (1979), and by Pregadio (1985) are not listed.

It should be mentioned that the way in which the recorded titles are grouped and classified may render them difficult to retrieve. A number of studies do not appear in the alchemy section under China [i.e. 4] or Asia [i.e. 39].[5]

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[1]Chatley's article in the 1931 Journal of the Alchemical Society was omitted.

[2]i.e. The Frontiers of Human Knowledge, Changing Perspectives in the History of Science, To Illustrate the Monuments: Essays on Archaeology presented to Stuart Piggott, and Science, Medicine and Society in the Renaissance.

[3]For example, the following articles failed to gain entry: three articles in Journal of Chemical Education from the 1930s, Collier's paper in Chemistry in Canada (1952), Kaltenmark's in Bulletin de la Société d'Acupuncture (1960), Butler, Glidewell and Needham's in Journal of Chemical Research (1980).

[4]e.g. Harvard Journal of Asiatic Studies (Davis 1942), T'oung Pao (Schafer 1956), Monumenta Serica (Feifel 1941, 1944, 1946), Transactions of the International Conference of Orientalists in Japan (Sivin 1968), History of Religions (Eliade 1970), La Pensée: Revue du Rationalisme Moderne, Arts, Sciences, Philosophie (Needham 1970).

[5]For instance, Ho and Needham's "Elixir Poisoning in Mediaeval China" is in "4Q Pathology"; Ho's "The System of the Book of Changes and Chinese Science" is in "39 FU Cosmology"; Davis' "Pictorial Representations of Alchemical Theory", Dubs' "The Origin of Alchemy", and Needham's The Refiner's Fire: The Enigma of Alchemy in East and West are in the main subject (i.e. non-civilisation specific) portion

(d) Bibliography of Asian Studies, 1936- :

The early volumes [i.e. the Bulletin of Far Eastern Bibliography] indexed retrospectively a fair number of works published before 1936 (e.g. those by Chatley, Waley, Davis). But nearly two thirds of the post-1940 literature are missing, including articles not only from science, history of science, and chemistry journals (e.g. 1943 Endeavour, 1980 Journal of Chemical Research, 1959 Janus, 1959, 1961, 1985 Ambix), but surprisingly from Chinese / Asian studies journals as well (e.g. 1941, 1944, 1946 Monumenta Serica, 1973 Papers on Far Eastern History, 1974 Journal of the Chinese University of Hong Kong). Also omitted are Ware's Alchemy, Medicine, Religion in the China of A.D. 320 (1966), Ho, Goh and Lim's Lu Yu, The Poet-Alchemist (1974), Ho's On the Dating of Taoist Alchemcal Texts (1979), and Pregadio's An Index to *Shih Yao Erh Ya* (1985).[1]

Nevertheless, one must give the Bibliography of Asian Studies credit for providing unique information on Strickmann's "On the Alchemy of T'ao Hung-ching" (under "China - Science and Technology"), Baldrian-Hussein's "Yüeh-yang and Lü Tung-pin's *Ch'in-yüan ch'un*: A Sung Alchemical Poem" (under "China - Literature - Poetry") and Procédés secrets du joyau magique: traité d'alchimie taoiste du XIe siècle (under "China - Philosophy & Religion - Taoism), and Despeux's "Les lectures alchimiques du *Hsi-yu chi*" (under "China - Literature - Poetry).

(e) Bulletin Signalétique, 1947- :

A dozen or so titles discussed in this chapter were recorded -- mainly from history of science journals (e.g. 1963 [Nova Acta] Leopoldina, 1969 Isis, 1972 Japanese Studies on the History of Science, 1977 Revue d'Histoire des Sciences) and conference proceedings of the International Congress of the History of Science. Thus Bulletin Signaletique 522 cannot be considered an adequate

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of the bibliography under "DY Alchemy". Above all, almost twenty works are situated in the section for "Personalities" under the name of the alchemists (e.g. Wei Po-yang, Ko Hung, Chang Po-tuan).

[1]It is curious that Sivin's article in the 1967 Japanese Studies in the History of Science is mentioned, but not the one by Ho and Lim in the 1972 volume of the same journal, and that some papers from Ambix are listed (e.g. Dubs' from 1961, Ts'ao, Ho, and Needham's from 1959, Ho and Needham's from 1959), but not others.

bibliographic aid. However, Needham's articles in the 1973 Acta Medicae Historiae Patavina and 1975 Organon, and Ho's paper in the Proceedings of the 14th International Congress of the History of Science, Tokyo / Kyoto, 1974 can only be found in this index.

Within the broad category of "Sciences et techniques physiques" is the division "J. Chimie", which includes the sub-division "01. Alchimie". In spite of the provision of a dedicated section for alchemy, checking relevant terms under "Chine" in the annual subject index still provides a more thorough and expeditious access to works on alchemy and early chemistry.

(f) Revue Bibliographique de Sinologie, 1955-70; 1983- :

Only six out of the twenty-four titles published in the period covered by this annual index were reviewed, namely, the books by Ware (1966) and by Sivin (1968), one article in the Journal of the Warburg and Courtauld Institutes (1959), one in T'oung Pao (1956), and three in Ambix (two from 1959, one from 1961).

(g) Tōyōgaku Bunken Ruimoku, 1963-:

Its contribution is restricted to the four volumes of Science and Civilisation in China, Sivin's book and his article in the 1976 Isis, Ho paper in Chung Chi Journal (all under "IX. Science"), Ware's book (under "VII. Religion - 3. Taoism"), and Ho, Goh and Parker's paper (under "X. Literature - 3. Verse & Prose).

II. SPECIALISED BIBLIOGRAPHIC SOURCES

As always, Science and Civilisation in China's "Bibliography C: Books and Journal Articles in Western Languages" is an impressive tool, but one which demands considerable patience to use. For material before 1974, the bibliography in vol. 5 pt. 5 provides an almost comprehensive coverage.[1] A quick inspection reveals that only half a dozen short pre-1935 accounts (e.g. Edkins' essay in Miscellany or Companion to the Shanghai Almanack for 1857 and F. H. Davis' accounts in The Academy), Kaltenmark's work in Bulletin de la Société d'Acupunctur, and Schramm's article in [Nova Acta] Leopoldina are not there. Note that even though the volume was published in 1983, studies after 1975 are not included.

"Bibliography of Chinese Alchemy" in Wilson's "Alchemy in China"

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[1]Vol. 5 pt. 5 supplies all the relevant items entered in the earlier volumes.

in the 1940 Ciba Symposium is also helpful. Apart from a few items, the thirty-five entries in this bibliography are concerned primarily with Chinese alchemy. Arranged alphabetically by author, it makes accessible bibliographically a number of works published before 1940.[1]

Section "A51 China and Japan" (in part A "Alchemical Text") and section "B51 China and Japan" (in part B "Works about Alchemy: Countries") in Alan Pritchard's Alchemy: A Bibliography of English Language Writings (London: Routledge & Kegan Paul, and The Library Association, 1980) is beyond doubt an excellent resource for anyone interested in collecting bibliographic information on Western material related to Chinese alchemy.[2] Its coverage is excellent: it contains nearly all English-language works -- which make up the vast bulk of Western writings on Chinese alchemy -- expressly concerned with the subject as well as a number of titles tangential to it up to 1975.[3] Martin's "On the Study of Alchemy in China" is the only pre-1975 work treated in this chapter that failed to secure a place in the bibliography. It is accurate: Pritchard had personally examined almost all items. Access is easy: entries are grouped conveniently in two special sections ("A Alchemical Texts - A51 China and Japan"; "B Works About Alchemy: Countries - B51 China and Japan").[4] In A51 arrangement is broadly alphabetical by romanised Chinese title or author, and in B51 alphabetical by author. There is also an exten-

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[1]Accounts by Hiordthal, Holgen, Davis and Wu (1930), Holmyard, Spooner (1938), and Partington are not listed.

[2]Alan Pritchard, Alchemy: A Bibliography of English Language Writings (London: Routledge & Kegan Paul, and The Library Association, 1980).

[3]It even supplies a handful of early titles -- probably of minor significance and interest -- but nevertheless not registered by Science and Civilisation in China or the general bibliographies (e.g. Edkins' "On Early Tauist Alchemy", F. Hadland Davis' "The Elixir of Life in Ancient China", Tenney L. Davis' "Stories of Early Chinese Alchemists: First to Practice the Art").

[4]Three works are, however, housed in "C Works About Alchemy: Subjects - C0 Alchemy -- general": Davis' "Pictorial Representations of Alchemical Theory", Needham's The Refiner's Fire: The Enigma of Alchemy in East and West, and his "The Elixir Concept and Chemical Medicine in East and West".

sive index of "all personal names occurring in the bibliography (ie authors, printers, publishers, editors, and persons written about), together with subjects" in one sequence.[1] Regarded as "an extremely valuable work which will place every historian of alchemy in his debt", the bibliography itself is readily available in libraries.[2]

III. CONCLUSION

Needless to say, those in search of literature not in English or published after the mid-1970s have to turn to guides other than Pritchard's for assistance. Moreover, his bibliography does not treat any theme or work on early chemistry. But taking it as a primary source and expanding it with titles from elsewhere -- especially ISIS -- an excellent list can be generated.[3]

On the whole, bibliographic control for publications on alchemy and early chemistry is excellent, particularly for pre-1975 publications.

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[1]Pritchard, Alchemy, pp. 407.

[2]H. J. Sheppard, rev. of Alchemy: A Bibliography of English Language Writings by Alan Pritchard, in Ambix, 28 (1981), 57.

[3]The following titles are not mentioned in the general or special bibliographies: Thurm's "*Shao chiu*: vom ausgefrorenen bis zum gebrannten Wein" in Alkohol-industrie (1978), Needham's "Category Theories in Chinese and Western Alchemy: A Contribution to the History of the Idea of Chemical Affinity" in Epeteris Epistemonikon Ereunon (1979), and Pregadio's An Index to *Shih Yao Erh Ya*: A Chinese 'Lexicon alchemiae' of A.D. 806 (1985).

CHAPTER 9 : BIOLOGY

No one can dispute the fact that the Chinese have a long and impressive tradition of registering and systematising their relationships, observations, and perceptions towards plants and animals in one form or another. However, readers should be alerted to the fact that it may not be appropriate to measure and judge such traditional knowledge and experience by applying modern scientific rules and criteria.[1] Thus as Needham said, ". . .there are certain branches of botanical science which are not to be anticipated in an account of Chinese botany. The first essential is to have some historical perspective, and not to expect post-Renaissance developments in traditional Chinese science. For example, no decisive advance in the understanding of plant nutrition and assimilation could be contemplated before the rise of pneumatic chemistry in the +18 century. . . ."[2] The Chinese also did not necessarily communicate their under-

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[1]The following exposition from the opening pages of Science and Civilisation in China vol. 6 pt. 1 (the first botany volume), which delineates the nature and characteristics of this body of Chinese knowledge, is instructive: "Even at the time of the pre-Socratic philosophers there were men who investigated and spoke about plants, whether the timber-trees. . . or the medicinal plants. . . . The names and ideas of some of these writers have been preserved in the works of Theophrastus of Eresus (-371 to -287). . . . To his pair of long discursive books, . . . there is no parallel in the Chinese literature. . . . Nevertheless that does not mean that the Chinese naturalists of Warring States, Chhin and Han times were not talking at length about very similar things, for this can be demonstrated by a study of the technical terms which their lexicographers have fully preserved for us. Thus the foundations of the sciences were laid by Greeks and Chinese at the two ends of the Old World at about the same time. Though the true manner of plant nutrition, and the true meaning of the flower, remained unknown to all of them, they made a beginning of vegetative organography, the distinctions between the many different sorts of parts of plants, they initiated anthology and carpology, the study of flowers and fructifications, and above all they began the elaboration of that basic essential of botany, the accurate phytographic language. It is in these early times also that we find the first beginnings of the natural classification of plants": Needham, Joseph; with the collaboration of Lu Gwei-djen, and a special contribution by Huang Hsing-tsung, Science and Civilisation in China. Vol. 6 Biology and Biological Technology, Part 1: Botany (Cambridge: Cambridge UP, 1986), pp. 2.

[2]Science and Civilisation in China, vol. 6 pt. 1, pp. 13.

standing of plants and animals through channels and means with which we are most familiar. Moreover, in early and mediaeval times, ideas and practices in areas which we now label separately as pharmacology, materia medica, agricultural science and technology, economic botany, horticulture, animal husbandry, botanical sciences, zoology, were all closely tied to one another.[1]

Western scholars, on their part, have taken steps over the past centuries to uncover, describe and organise this vast store of information which the Chinese accumulated. These Western studies can be seen, very roughly, as falling into three broad categories, although they share many common denominators and elements, and draw from the same major documentary sources. First, predictably, there is an enormous body of material which concentrates on the Chinese use of plants for medicinal and therapeutic purposes.[2] Second, we have at our disposal publications which take aim chiefly at the cultivation and production of crop plants such as rice and millet, of vegetable, fruit or garden plants, or at the domestication, keeping and breeding of animals and their employment in service of man. These two groups of writings -- focusing as they fundamentally are on human utilisation, control and manipulation of plant and animal resources and their practical value -- belong more to the domains of medicine, and of agricultural science and technology respectively, and are therefore not included here.[3] The third cluster is made up of a relatively small but important collection of works that are concerned not only with exploring the curative and medicinal value of plants

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[1]Indeed, Nathan Sivin reminded us forcefully that, "in the classical period biology did not exist as a distinct discipline. The bulk of Chinese biological knowledge is preserved in the great pharmacopoeias (since practically every substance was used in one or another function in Chinese prescriptions) or in agricultural works; with some exceptions, Chinese biological thought is inextricable from general philosophy": Nathan Sivin, "Bibliography of Traditional Chinese Science: Introductory Books and Articles in Western Languages," in Chinese Science: Explorations of an Ancient Tradition, ed. Nathan Sivin (Cambridge, Mass.: MIT P, 1973), pp. 308-09.

[2]Also the use of animal, mineral, and human substances.

[3]Similarly, accounts concerning traditional Chinese views and knowledge of the health of the human body and diseases that affect it are considered as scholarship on medical sciences.

and animals, or their roles in the development of China's agricultural tradition. Authors of these studies are also interested in other aspects and activities associated with Chinese historical approaches to plant and animal life; for instance, their awareness of a species' varieties, physical characteristics, life cycle, behaviour, distribution, ecology, etc. However, these Western accounts -- most of which are discussed in this chapter -- often do not handle their subject matter in the same manner a present-day textbook or research work on biology, botany or zoology would; instead they may contain an array of material on traditional customs, notions, and lore related to the plants and animals under consideration. As some authors put it, their studies were conceived as cultural histories of the chosen plants or animals.[1]

The problem with classification and with terms for chapter and division headings rears its thorny head again in this, as in other, chapters. "Natural history" is a potential candidate, but the definitions given to it as well as the facets and areas it covers are too many and too varied to be of practical help.[2] Relevant classes and terms in the ISIS classification scheme are: "J Biology"; "K Botany"; "L Zoology".[3] Bulletin Signalétique has the following arrangement under the "Biologie" division (which is within the larger "Sciences et techniques de la vie"): "Paléontologie. Evolution. Génétique"; "Botanique"; "Zoologie".[4] In Science and Civilisation in

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[1].One may therefore question whether these publications are aimed primarily at promoting discussion and providing information on traditional Chinese understanding in the spheres of botany and zoology. Should they be viewed, for instance, as inquiries that belong to the ethnology and ethnography domains instead? This is open to speculation and debate, but the important point to bear in mind here is that the main subject of inquiry in these works is the plants or animals themselves rather than say, certain belief systems.

[2]Moreover, so far as the present thesis is concerned, some of these areas and sub-divisions are better subsumed under other chapters: for example, mineralogy under the chapter on earth sciences.

[3]"HY Natural History" (to be sub-divided by region) comes before "J" while "M Sciences of Man" follows "LZ".

[4]Sub-divisions under these three classes vary, but are generally a combination of periods (e.g. "XVII siècle") and subjects (e.g. "Insectes").

China, section 38 is "Botany" and 39 is "Zoology".[1] After considering the way in which these systems handle the titles and topics treated here, the following arrangement and terminolgy is adopted: "9.1. Evolution; Environment"; "9.2 Botany"; "9.3 Zoology"; "9.4 Bibliographical Works".[2] Keep in mind, nevertheless, the cautionary note in the opening paragraphs regarding the nature of traditional Chinese experience and concepts in areas pertaining to plants and animals, and the Western vocabulary as merely a means to make the subject matter of the works under discussion readily comprehensible.

In addition to those already mentioned, there are other types of publications that are off the boundary of this bibliographical study.[3] These include accounts whose main goals and intentions are: (1) To give modern scientific designations and identifications to plants and animals mentioned by the Chinese.[4] (2) To investigate

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[1]Followed by "40 Biochemical Technology (Nutrition and Fermentation)", and "41 Agriculture, Animal Husbandry, and Fisheries".

[2]Note that we include soil science but not horticulture. Science and Civilisation in China and ISIS differ in their placement of these two subjects. In the former, "Horticulture and its techniques" (which includes biological pest control) is located in "38 Botany", but in ISIS "SC Plant cultivation and horticulture" is subsumed under "SA Agriculture". As for soil science, it again falls within the area of botany in Science and Civilisation in China (in "38b The setting: China's plant geography"), but as part of agriculture in ISIS (as "SB Soil science; agricultural physics and chemistry").

[3]These topics and issues are comparable to what Science and Civilisation in China vol. 6 pt. 1 claims it "will not be trying to do", which can be summarised as follows: (1) "it will not be a study of the Chinese and East Asian flora; that can only be done by professional botanists"; (2) "it will not be a systematic survey of the origin of cultivated plants in East Asia and elsewhere in the tradition established by Auguste de Candolle"; (3) it will not "always track down the oldest mentions of particular plant species in Chinese literature"; (4) "it will not give a perfect account of the transmissions of cultivated plants to and from the Chinese culture-area such as Laufer attempted in his unique 'Sino-Iranica', or Schafer in his fascinating work on Thang exotica": Science and Civilisation in China, vol. 6 pt. 1, pp. 11.

[4]e.g. Edward H. Schafer, "Rosewood, Dragon's Blood, and Lac"; Bernard E. Read, Famine Foods listed in the *Chiu Huang Pen Ts'ao*, giving their Identity, Nutritional Values and Notes on their Preparation.

their presence in 19th and 20th century China.[1] (3) To trace the origins and routes of their migration.[2] (4) To analyse philologically the names given to plants and animals.[3] (5) To study how plants and animals have been portrayed in art.[4] (6) To characterise extant editions or scrutinise the lineage and transmission of particular Chinese treatises on plants or animals.[5] As noted in *Chapter 1: Introduction*, we include here relevant studies by Emil Bretschneider (1833-1901) who received his medical training at the University of Dorpat, worked as a physician at the Russian Legation in Peking from 1866 to 1883, and died in St. Petersburg.

9.1 EVOLUTION; ENVIRONMENT

It may be argued that one cannot talk intelligently and legitimately of the presence and development of such modern scientific concepts as heredity, evolution, spontaneous generation, and conservation of the natural environment in the early and mediaeval Chinese world. Nevertheless, a few Western scholars have inquired into historical Chinese understanding and attitudes that are loosely related to these issues.

In "Early Chinese Ideas on Heredity" (1953) Donald Leslie directs his attention towards philosophers and philosophical works from the Chou and Han times. Wang Ch'ung's Lun heng in particular is examined in some detail, and passages relevant to the following five concerns translated and commented upon: the spontaneity of nature; species; man's endowment; human nature; likeness to parents. A

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[1]e.g. O. von Moellendorff, "The Vertebrata of the Province of Chihli, with Notes on Chinese Zoological Nomenclature"; E. D. Merrill, and E. H. Walker, A Bibliography of Eastern Asiatic Botany.

[2]e.g. H. W. Glidden, "The Lemon in Asia and Europe".

[3]e.g. Gabriel Ferrand, "Le nom de la girafe dans le *Ying-yai cheng-lan*".

[4]e.g. Arther de Carle Sowerby, Nature in Chinese Art; Bo Gyllensvärd, "A Botanical Excursion in the Kempe Collection".

[5]e.g. Tsien Tsuen-hsuin, "On Dating the Edition of the *Chü Lu* at Cambridge University"; Ma Tai-loi, "The Authenticity of the *Nan-fang ts'ao-mu chuang*".

second article from Leslie -- written jointly with Needham in 1955 -- has the specific objective of illustrating through a series of examples taken from various Chinese philosophical treatises that "early Chinese views on evolution, as revealed by leading scholars between the third century B.C. and the fourteenth century A.D., show considerable attention to modes of development: organic development, metamorphosis, zoological transformation, repeated evolution, and speciation. . ."; moreover, "comparable ideas in India during the same period suggest interesting relations in Asian biological thought which deserve much further consideration."[1]

For an account on notions and experience related to the conservation of plants, animals and their environment in mediaeval China, one has to turn to a paper Edward H. Schafer's delivered at the 10th International Congress of the History of Sciences held in 1962, with a more detailed version titled "The Conservation of Nature under the T'ang Dynasty" in the 1962 Journal of the Economic and Social History of the Orient. It is the author's conviction that "the study of the history of man's knowledge of plants and animals is all the more necessary in that it has been neglected in favor of the study of the development of tools."[2] Hence, in his paper "on attitudes towards the preservation of living things and their habitat in medieval China", he "hopes to redress the balance of interest, if only slightly, in favor of man's direct involvement with the natural world, and away from the study of artifacts preserved in museums."[3] "I. Motivations" considers "some cultural factors which seem to have influenced policy relating to the conservation of nature", grouped topically

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[1]Joseph Needham, and Donald Leslie, "Ancient and Medieval Chinese Thought on Evolution," Bulletin of the National Institute of Sciences of India, 7 (1955), 1. The essay is broken down into: "1. Introduction"; "2. Hsun Chhing (3rd cent. B.C.), Tai Chih (13th cent. A.D.), and the 'Ladder of Souls'"; "3. Chuang Chou (4th cent. B.C.) and Zoological Transformations"; "4. Wang Chhung (1st cent. A.D.) and Species"; "5. Cheng Ching-Wang (12th cent. A.D.) and Metamorphosis"; "6. Wu Lin-Chhuan (14th cent. A.D.) and Repeated Evolution"; "7. Chu Hsi (12th cent. A.D.) and Organic Development"; and "Conclusion".

[2]Edward H. Schafer, "The Conservation of Nature under the T'ang Dynasty," Journal of the Economic and Social History of the Orient, 5 (1962), 279.

[3]ibid.

into: "A. Religion"; "B. Historical monuments"; "C. Royal preserves"; "D. Almanacs and rural wisdom"; "E. Urban influence"; "F. Esthetic ideals"; "G. Scientific Aims".[1] "II. Results" reviews "some of the particular measures undertaken to make policy effective", divided into: "A. Water"; "B. Field and forest"; "C. Animals"; "D. Soils and minerals".[2]

9.2 BOTANY

It has to be admitted that some 19th and early 20th century studies on the Chinese scientific traditions can do little for the newcomer to the field. Although they may be important from the historiographic point of view and contributed meaningfully to the existing store of knowledge at the time of their first publication, their outdated and limited data, concepts, and approaches often render them unappealing and unhelpful to readers in the late 20th century. A notable exception is the pioneering research by Bretschneider, whose writings can still command interest and be consulted profitably by students and specialists alike. His "On the Study and Value of Chinese Botanical Works, with Notes on the History of Plants and Geographical Botany from Chinese Sources" appeared in installments in the 1870/71 Chinese Recorder and also as a separate monograph. Even as late as the 1980s the comment was made that, "it is safe to say that since that time no Western scholar has written better on the history of Chinese botany, none half so well."[3] The work is in fact made up of several parts of varying length, each with its own theme.[4] It begins with an introduction to the manner in

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[1]ibid. It is interesting that "G. Scientific aims" consists only of a single sentence: "The desire to preserve conditions of life, for such scientific purposes as the study of the habits and habitats of living creatures, or to gain other sorts of knowledge as a motive for conservation measures, did not, it seems, exist for the men of T'ang": Schafer, "The Conservation," 293.

[2]Schafer, "The Conservation," 279.

[3]Science and Civilisation in China, vol. 6 pt. 1, pp. 20.

[4]Two general points Bretschneider made in his preface is worth noting: (1) "living in the Chinese Metropolis five years, I was encouraged by the favourable conditions in which I found myself, to

which plants are classified in the *Pen ts'ao kang mu*, and to the major Chinese botanical treatises. After that is an extended section on field crops and garden plants, more specifically, "on the antiquity of their cultivation in China" based principally on the *Pen ts'ao kang mu*.[1] (In addition to the botanical description of each plant, remarks are made on its names, origins, distribution, the family to which it belongs, as well as how it had been cultivated and employed.) This is followed by brief references to Western accounts and characterisations of traditional Chinese botany. The aim of the next section, in the author's words, is "to complete my notes on Chinese botanical works and to illustrate my critique of them", giving "some specimens of Chinese descriptions of plants chiefly from the Pen-ts'ao, and I shall choose for this purpose the Chinese account of Palm trees. . . ."[2] An "Addenda", a "List of Chinese works, quoted in foregoing notes", eight woodcuts, and a two-page "Preface to the study and value of Chinese botanical works" complete the study. Bretschneider was not uncritical of the botanical know-

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make some inquiries into Chinese plants and to venture on the publication of these notes on Chinese Botany. Every body will admit, I think, that some questions regarding Chinese plants can be more easily decided by men, living in China, by direct observation and information taken directly from the natives, -- than in Europe by eminent savants, who have not been in China and must base their views, for the most part upon accounts given by travellers, which are not always exempt from errors, and upon translations from Chinese works, made by sinologues, who know little or nothing about Botany. I beg therefore to be excused if I have attempted sometimes to contradict some views of well known scholars": Emil Bretschneider, "On the Study and Value of Chinese Botanical Works, with Notes on the History of Plants and Geographical Botany from Chinese Sources," Chinese Recorder, 3 (1870/71), 293.

(2) "as my notes have been written for Sinologues as well for Botanists, I have endeavoured to be intelligible to both and especially to the latter, by explanations of the Chinese characters, which occur therein. I would take advantage of this opportunity to observe, that Chinese names of plants should not be considered from the same point of view as names in other oriental languages, which can be transcribed easily and unmistakably by our letters": ibid.

[1]Bretschneider, "On the Study," 173. Bretschneider found this group of plants worth studying for "although much has been written in Europe on Chinese agriculture, no details are to be found on the cereals cultivated by the Chinese": ibid.

[2]Bretschneider, "On the Study," 244.

ledge of the Chinese and his views were not always well-informed. Evaluations of his opinions are given in Science and Civilisation in China vol. 6 pt. 1, and in the eminent Chinese botanist Shih Sheng-han's partial Chinese translation (published in 1935).[1]

Bretschneider is however best remembered for his magnum opus: Botanicon Sinicum: Notes on Chinese Botany from Native and Western Sources" (1881-95). Vol. 1 is concerned primarily with supplying sources and background information.[2] Vol. 2 "The botany of the Chinese classics" is devoted to "I. Plants mentioned in the *Rh ya*", and "II. Plants mentioned in the *Shi king*, the *Shu king*, the *Li ki*, the *Chou li* and other Chinese classical works". Vol. 3 "Botanical investigations into the materia medica of the ancient Chinese" consists of one main chapter: "Medicinal plants of the *Shen nung pen ts'ao king* and the *Pie lu*".[3] One need not go far in search of reasons why copies of Bretschneider's treatise are not sitting on bookshelves gathering dust, and why Sivin regarded it as "still the leading source on Chinese botany in a Western language."[4] Firstly, even after sifting away data (e.g. the Latin binomials) that are no longer of practical use and very much out-of-date due to the age of the work and various limitations faced by Bretschneider at the time of his research in China, the admirable homework the author did in collecting source material of historical significance is still impressive in terms of both range and sheer numbers; he also systematically enumerated and provided bibliographic details for these

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[1]*See especially* Science and Civilisation in China, vol. 6, pt. 1, pp. 21-23.

[2]It is divided into: "I. Contribution towards a history of the development of botanical knowledge among Eastern Asiatic nations"; "II. On the scientific determination of the plants mentioned in Chinese books"; "III. Alphabetical list of Chinese works; Index of Chinese authors"; "Appendix: Celebrated mountains of China".

[3]In addition, there are three appendices: "Chinese geographical names"; "Alphabetical index of Chinese names of plants"; "Alphabetical index of genus names of plants".

[4]Nathan Sivin, "An Introductory Bibliography of Traditional Chinese Science: Books and Articles in Western Languages," in Chinese Science: Explorations of an Ancient Tradition, ed. Nakayama Shigeru, and Nathan Sivin (Cambridge, Mass.: MIT P, 1973), pp. 309.

writings.[1] Secondly, various lists and indices supply additional information and facilitate usage.[2] Botanicon Sinicum thus provides readers from the 19th as well as the late 20th centuries with indispensable starting points and references, a strong sense of the richness of Chinese materials, and ample stimulus for future studies.

Before leaving the 19th century, August Pfizmaier's three articles in the Sitzungsberichte der philosophie-historie Klasse der kaiserlichen Akademie der Wissenschaften from the 1870s should be mentioned. Running between sixty to ninety pages each, these are straightforward translations of some of the chapters in the 10th century encyclopaedia *T'ai ping yü lan* on various types of trees and fruits, done without interpretive commentaries or bibliographical references. Even though the one-dimensional and uncritical treatment may jeopardise these works' scholarly value, they deserve a mark on the historiographical map: they represent one category of early Western writing on traditional Chinese science.

Next on our agenda are works from the 1920s, '30s, and '40s. The main objective of the authors was to assemble written materials from different times in China's history on specific families of plants. Seen from today's perspective, such an approach appears monotonous and pedestrian, but at the time of their publication, these works had the merit of conveying the infrequently heard message that Chinese historical involvement with plants should not be dis-

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[1]For example, in vol. 1, the entry for each plant is accompanied by Chinese characters, romanisation, references to relevant Chinese works, and modern botanical designation. In the same volume, supporting information is provided in sections such as "4. Early acquaintance of the Chinese with Indian and West Asiatic plants". And relevant Chinese as well as Western works are listed in various places: (1) vol. 1, Chapter I's first three sections (i.e. "1. Chinese literature on materia medica and botany", "2. Chinese works on agriculture", "3. Chinese geographical works containing botanical information"); (2) vol. 1, Chapter III "Alphabetical list of Chinese works and authors"; (3) vol. 2, "Introduction"; (4) vol. 2, "Notes on Chinese, Japanese and European works consulted"; (5) vol. 3, "Introduction"; (6) vol. 3, "Titles of some Chinese, Japanese and European books quoted in my researches by abbreviated references".

[2]For example, in vol. 1, following the "Alphabetical list of Chinese works" is an index of the authors of these works; vol. 2 has an "Index of Chinese names referred to in the Botanicon Sinicum" as well as one for European names" (both prepared by Dr. E. Faber).

missed summarily.

Henri Imbert wrote a handful of accounts in 1921 and 1922 on traditional Chinese views of particular plants and animals, including Le nélombo d'Orient (Lotus); fleur sacrée des bouddhistes (1922a) and La Pivoine, reine des fleurs en Chine (1922b). [I have not seen these titles].

Among Michael J. Hagerty's contributions to the field of traditional Chinese science and technology were two translations: that of the first Chinese treatise on oranges, the 12th century *Chü lu* (in the 1923 T'oung Pao); and of the first Chinese monograph dedicated to bamboos, the 5th century *Chu p'u* (in the 1940 Harvard Journal of Asiatic Studies). Both translations are annotated and include anxillary material to help better illuminate the Chinese texts.[1]

In his account on the lemon in China and elsewhere Laufer (1934) argues that, "it was heretofore supposed that the lemon is of recent origin in China, introduced by 'foreigners'. It will be shown that this conception of the matter is erroneous and that Chinese acquaintance with the lemon dates from the middle of the 12th century under the Sung dynasty."[2] He develops this thesis by reviewing firstly, the way the lemon had been treated in several Western botanical treatises (e.g. F. Porter Smith's Contribution towards the Materia Medica etc. of China from 1871), and secondly, the earliest references to and descriptions of the fruit in Chinese records. Various names used in China in historic times are then examined and compared to those given by people from other parts of Asia. One also finds translations of extracts associated with how the lemon had been employed and grown, etc., a discussion of the Chinese nomenclature of the lemon, and a quick glance at the cultivation of lemon in China in

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[1]The study on bamboos, for instance, begins with these sections: "Wang Mo's note concerning Tai K'ai-chih and his *Chu-p'u*"; "Chung Hung's remarks concerning Tai K'ai-chih"; "Description of *Chu-p'u* in the *Ssu-k'u ch'üan-shu tsung-mu*"; "Bibliography" (which lists editions and modern reprints of the Chinese treatise as well as thirty secondary works). The article on the *Chü lu* includes a seven-page introduction by Paul Pelliot.

[2]Berthold Laufer, "The Lemon in China and Elsewhere," Journal of the American Oriental Society, 54 (1934), 143.

the 19th century.[1]

To supplement a conference paper delivered by Laufer in 1907 on when, where and by whom the peanut or groundnut was introduced into China, L. Carrington Goodrich (1937) presented critical translations of eight passages from the 18th century compilation *Pen ts'ao kang mu shih i* on the knowledge and cultivation of the plant. He also gave three notices taken from other sources.[2]

"A strange word, which is unpronounceable and probably ought never to have existed," but which "will always be the generic name of this beautiful and interesting tree."[3] The name in question is *Ginkgo biloba*, first given to the tree in 1771 by Linneaus in his Mantissa Plantarum Altera. Intrigued by the name, A. C. Moule (1937) charted the history of the tree, paying special attention to Chinese connections and Chinese descriptions (e.g. in poems, dictionaries, botanical treatises). Passages from such works as the *Pen ts'ao kang mu* were translated. Twelve years after the publication of this study, Moule (1949) translated parts of yet another text on the *Ginkgo biloba* -- the 17th century treatise *Ju nan p'u shih*; comments relating to his previous essay were also made.[4]

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[1]The last six pages of the study deals with issues of the lemon outside China.

[2]The final notice is rather amusing and is a fine example of some of the lighter moments in studying the history of Chinese science. Goodrich's translation reads as follows: "It is fitting to close with the last will and testament of Chin Sheng-t'an. . . , famous for his comments on the *Three Kingdoms*, the *Western Chamber*, the *Chin p'ing mei*, and the *Water Marshes*, who was sentenced to death in 1662 at the age of thirty-five along with many other scholars of the Soochow area. He wrote just before his execution, 'Decapitation is most painful (and deplorable) and now I have been sentenced to face it. Don't forget, my son, that peanuts and dried bean curd make a good combination. It has the taste of the best ham'": L. Carrington Goodrich, "Early Notices of the Peanut in China," Monumenta Serica, 2 (1936/37), 408-09.

[3]A. C. Moule, "The Name *Ginkgo biloba* and Other Names of the Tree," T'oung Pao, 33 (1937), 204.

[4]"Of this book [i.e. the *Ju nan p'u shih*]. . . I could hear of no copy in England, Paris, or Leiden. But when the T'oung Pao reached America, Dr. A. W. Hummel most kindly sent me photostats of the text to the passage on the ginkgo from a copy of the book in the Library of Congress": A. C. Moule, "*Ginkgo biloba* or *yin hsing*," Asia Major, 1 (1949), 16. These three pages of Chinese text were repro-

We have seen that in order to ascertain and adequately appreciate the botanical knowledge the Chinese acquired in the past, Hagerty, Laufer, and Moule set out to track down and render into English references to these plants in different kinds of Chinese documents. Philip K. Reynolds and Mrs. C. Y. Fang also kept to a similar course in their study of the banana. The first half of "The Banana in Chinese Literature" (1940) identifies poems and treatises (e.g. _I wu chih_, _Nan fang ts'ao mu ch'uang_, _Kuang tung hsin yü_) in which the tree is mentioned, lists the names and designations used, suggests the time of the introduction of the fruit into China and its distribution and transplantation to different parts of the country, describes the types of banana, and reconstructs chronologically the cultivation of the fruit from around 100 A.D. to the 17th century. The second half of the essay is taken up by a translation of pertinent sections in the _Pen ts'ao kang mu_.

The focus of researchers in the first half of the 20th century was on textual sources and single classes or families of plant. Although Chinese writings remained of utmost importance, none of the post-1950 Western works addressed a specific kind of plant. Of the five publications that appeared between 1954 and 1981, four were the results of Needham's (and Lu Gwei-djen's) labour, and one was written by Li Hui-lin.

In publishing his "Prospection géobotanique en Chine médiévale" (1954), Needham afforded interested scholars a rare chance to marvel at a hitherto unexplored area in traditional Chinese science. To help readers make the best sense of soil science and geo-botany as understood and practised in mediaeval China, Needham translated and commented on excerpts from Chinese treatises (e.g. _Kuan tzu_, _Pen ts'ao shih i_) relevant to this branch of knowledge; in addition, he brought into the discussion developments on pedology in the West in the past as well as in modern times.[1] Twenty-seven years later,

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duced to go with the translation.

[1]The following thought is offered in the conclusion: ". . .nous en avons assez dit pour montrer que ces observations, faites par des Chinois médiévaux, précédèrent un vaste champ de la science moderne. Il est curieux qu'Agricola dise très peu de choses des plantes comme indicatrices de minerais. Il serait intéressant de connaitre davantage les idées européennes médiévales (s'il y en avait vraiment) dans

Needham (1981) wrote another article on a closely related topic. This time, he and co-author Lu Gwei-djen focused on the ancient text *Yü Kung*. He writes in the "Abstract": "The *Yü Kung* is a geographical survey of China dating from about the -5th. cent. containing *inter alia* descriptions of local soils and the associated vegetation. It is thus probably the oldest document on soil science in the world. This paper translates the relevant passages of the *Yü Kung* and attempts to identify the technical pedological terms within the framework of soil classification in modern China. It ends with a brief comparison between ancient Chinese and Roman soil science."[1]

On two further occasions Needham again drew attention to important topics in the history of Chinese plant sciences that might otherwise have escaped notice. "The Esculentist Movement in Medieval Chinese Botany: Studies on Wild (Emergency) Food Plants" (1968) is essentially an examination of the early 15th century treatise *Chiu huang pen ts'ao* and its author Chu Hsiao, including its significance and the related setting. The essay begins with well-researched information on Chu and the circumstances under which he wrote the work. The issue of nomenclature is then confronted: "how did Chu Hsiao choose the names for the hundreds of plants 'new to science' which he recorded?"[2] And to illustrate and reveal the significance

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ce domaine. En attendant les Chinois eux-mêmes méconnaissent l'acuité de leurs ancêtres. Ainsi dans la mise au point des méthodes modernes de prospection de P'AN TCHOUNG-SIANG, excellente par ailleurs, ces techniques géobotaniques sont mentionnées comme si elles étaient purement d'origine moderne occidentale. Il serait intéressant de faire un examen de la littérature chinoise à la lumière des connaissances actuelles sur les plantes reconnues pour être significatives. Aucune d'elles en effet, mentionnées ci-devant, ne sont parmi celles que mentionnent les textes, mais l'identification de ces dernières est peut-être trop incertaine pour avoir une signification. Réciproquement, il serait intéressant d'examiner sur les bases des méthodes modernes quelques-unes des plantes que les Chinois semblent avoir utilisées": Joseph Needham, "Prospection géobotanique en Chine médiévale," Journal d'Agriculture Tropicale et de Botanique Appliquée, 1 (1954), 147.

[1]Joseph Needham, and Lu Gwei-djen, "Chinese Geo-Botany *in statu nascendi*," Journal d'Agriculture Traditionnelle et de Botanique Appliquée, 28 (1981), 200.

[2]Joseph Needham, and Lu Gwei-djen, "The Esculentist Movement in Medieval Chinese Botany: Studies on Wild (Emergency) Food Plants," Archives Internationales d'Histoire des Sciences, 21 (1968), 232.

of Chu's knowledge and method, his descriptions for the plants belonging respectively to the *Companulaceae*, *Asclepiadaceae*, and *Alismataceae* are given a close inspection. The rest of the study is devoted to assessing firstly, the connection Chu and his treatise had with the Jews of K'ai-feng; secondly, the *Chiu huang pen ts'ao*'s influence on botanical works on wild plants in the next couple of centuries (e.g. on the *Yeh ts'ai p'u*, the *Ju ts'ao p'ien*, the *Yeh ts'ai po lu*); and thirdly, the implications of Chu's undertaking on the Chinese scientific tradition in the Ming dynasty.[1]

The other subject raised by Needham was that of the historical development of botanical taxonomy in Chinese culture -- an intricate and major area of study that deserves in-depth investigations. He gave it a quick summary treatment in a brief conference paper in 1971 and provided ideas that were not so much conclusive as exploratory. Hints and clues to questions such as the following were suggested: "At what period did Chinese scholars interested in plants and animals begin to classify them in a dendritic or hierachical manner? . . . More especially when did three levels of groups or classes and sub-classes appear?"[2]

According to Needham, the *Nan fang ts'ao mu chuang* "is assuredly a text of weight and importance for the history of Chinese botany, but its evaluation is not an entirely simple matter. . . ."[3] Li Hui-lin has undertaken a comprehensive study of this supposedly early 4th century botanical work on plants in southern China and neighbouring areas commonly attributed to Chi Han (also transliterated as Hsi

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[1]"Whether or not because the most suitable and relatively common wild food plants had now all been mustered, the movement began to peter out towards the middle of the 17th century. . . . The thought which remains with us, however, is that to anyone who designates the Ming period as one of decline or 'stagnancy' in Chinese scientific endeavour, one can answer that it saw almost the whole on this great and unprecedented effort to extend the realm of botany from plants believed to be of pharmaceutical value to include all those which were useful for the diet of man": Needham and Lu, "The Esculentist Movement," 247-48.

[2]Joseph Needham, "The Development of Botanical Taxonomy in Chinese Culture," in 12e Congrès International d'Histoire des Sciences, Paris, 1968. Actes (Paris: Blanchard, 1971), vol. 8, pp. 127.

[3]Science and Civilisation in China, vol. 6 pt. 1, pp. 447.

Han). The final product, published in 1979, presented for the first time the translation of the entire text into a Western-language. Commentaries (together with thirty-nine botanical illustrations) are given along the way for the benefit of Sinologists as well as botanists. They identify the plants and place them in both historical and modern contexts; they also delineate associated records and traditional Chinese botanical experience. Preceding the translation is a thirty-page "Introduction" consisting of "1. Historical and geographical background"; "2. Chi Han, the author and his work"; "3. Ethnobotanical notes" (divided into "A. Economic botany of the Yüeh people" and "B. Origin of cultivated plants"); "4. Bibliographical notes". The Chinese text from which the translation was made and an appendix of geographical names used by Chi Han complete the monograph.[1]

9.3 ZOOLOGY

By and large, even though their degree of sophistication (in terms of reflecting serious scholarship and supplying useful data and insights) varied considerably, 19th and 20th century animal-related studies were alike in their general frame of reference and intention.

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[1]Scholars have long been puzzled by the treatise's authenticity. Being sensitive to this issue and the problems involved, Li has made considerable effort to address it, but it appears that the final word on the authenticity of the work has yet to be said.

Li writes in his conclusion to the section "Chi Han, the author and the work": "All these seem to indicate the originality and early derivation of Chi Han's work. Although we cannot rule out the possibility of interpolations and cannot verify the authenticity of most of the contents, we can be reasonably sure that the text, as it has come down to us in its present form since the late Sung period, represents on the whole a historically trustworthy account of the plants treated therein as they appeared in the southern regions around the third and fourth centuries A.D.": Li Hui-lin, *Nan-fang ts'ao-mu chuang*: A Fourth Century Flora of Southeast Asia (Hong Kong: Chinese UP, 1979), pp. 13. However, later in "Bibliographical notes", where the different editions and the views of Chinese scholars from the Sung period down to the present day are traced and assessed, an element of reservation seems to have crept in. Here, Li tells us that, "the question of the authenticity of the present text of Chi Han's work cannot be readily determined with certainty": Li, *Nan-fang*, pp. 29. Also singled out for discussion are theories and interpretations proposed by various individuals (e.g. those from Ma Ta-loi, which Li did not seem to favour.)

They deployed similar investigative mechanisms and progressed along more or less the same track.[1]

First, two publications from the 1870s. Pfizmaier's "Denkwürdigkeiten von den Insecten China's" (1874), a lengthy article that stretches to almost eighty pages, searches painstakingly through Chinese texts for pertinent remarks associated with insects on much the same order as his other works on trees and fruits. W. F. Mayers' (1878) essay on the mammoth or the huge *Elephas primigenius* in Chinese records discusses the description of the animal in the _Shen i ching_ -- "the ancient work to which the first notions concerning the mammoth may be clearly traced" -- and in "two disquisitions upon natural science" made by the Emperor K'ang-hsi in the early 18th century.[2] Also considered is the origin of the different names given to the mammoth.

In a one-page anonymous article in the 1882/83 _Nature_, traditional Chinese explanation of the behaviour and activities of certain animals -- mainly those of birds, which can supposedly transform into other species -- is discredited as "scientific heresies".[3]

Of the nearly twenty contributions from the early half of the 20th century, three of them dealt with the rhinoceros. "History of the Rhinoceros", published in 1914 as part of an inquiry into defen-

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[1]One unfortunate aspect of this is that the following account appears at times monotonous and repetitive.

[2]W. F. Mayers, "The Mammoth in Chinese Records," _China Review_, 6 (1878), 274-75.

[3]"Like most common fallacies, those current in China. . . are derived from ancient authorities, but, unfortunately, in the case of the Chinese, whose respect for everything that is old is supreme, this antiquity only entails upon them the more unquestioning faith. They are, therefore, perfectly content to believe that the disappearance of quails in autumn is sufficiently accounted for by the assumption that at that time of year they are transformed into moles, and that in spring they succeed in reappearing again in beaks and feathers. . . . Another generally accepted belief is based on what Max Müller calls a disease of language. At the opening of spring, hawks are said to become pigeons, and at midsummer to be reconverted to their original shapes. . . . Much in the same way has arisen the legend that in late autumn certain small birds go into the sea and become crustaceae. . . . A resemblance in outward form, or even in disposition, is enough to give rise to a belief that the animals are interchangeable": "Scientific Heresies in China," _Nature_, 27 (1882/-83), 342.

sive armour (which in turn is a section in an elaborate work on Chinese clay figures), was one of Laufer's earlier investigations into the history of plants and animals in Chinese and other non-Western cultures. It aims to treat as completely as possible the question of what exactly the animals referred to as "*ssu*" and "*hsi*" were.[1] This is accomplished in the space of a hundred pages, accompanied by an abundance of references to written and archaeological sources originating from different ancient cultures as well as twenty-four illustrations, (but no Chinese characters).[2]

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[1]Hides from these two animals were often used to make armour in early times.

[2]After a review of the opinions on the matter expressed by scholars such as Édouard Biot, E. Chavannes, Bretschneider, and in particular Herbert A. Giles, the author takes up at great length the theme of how the Chinese illustrations of the animals (on which Giles' arguments supposedly lie) were arrived at, turning over every piece of historical data he could lay his hands on. For instance, in order to understand the particular way these Chinese illustrations came about and were drawn, and to explain the distinctive characteristics of these illustrations, the author appeals to ancient Chinese sources (e.g. *Shuo wen*, *Erh ya*) as well as makes comparisons to drawings and descriptions of the rhinoceros in Western classical texts as well as old Indian and Tibetan works.

Two topics are then dealt with relatively briefly: "a most interesting psychological parallel to the representations of the rhinoceros in China is formed by the ostrich"; and the rhinoceros in ancient Chinese artifacts: Berthold Laufer, "History of the Rhinoceros," in his Chinese Clay Figures: Part I, Prolegomena on the History of Defensive Armor (Chicago: Field Museum of Natural History, 1914), pp. 124.

The next twenty pages are devoted to Chinese written accounts on the animals taken from the 5th to 16th centuries (e.g. the *Pen ts'ao kang mu*, *Pen ts'ao shih i*). Laufer is then in a position to elaborate on the hypothesis that within this period, the two Chinese characters in question "invariably referred to the rhinoceros, that the two species of the single-horned and two-horned animal were recognized, that their geographical distribution was perfectly and correctly known, and that the main characteristics of the animal were seized upon": Laufer, "History of the Rhinoceros," pp. 153.

A "reconstructive history of the rhinoceros in the historical era" in China follows, starting with the *Shih ching* and *Shu ching*, proceeding to the time of Ssu-ma ch'ien, and down to the T'ang and Sung: Laufer, "History of the Rhinoceros," pp. 159. After this, the author examines drinking cups as well as other objects made out of horns from rhinoceros and bovine animals for he was convinced that "the product yielded by an animal, and the manner of their utilization, allow also conclusive evidence in regard to the nature of the animal itself": Laufer, "History of the Rhinoceros," pp. 166.

To conclude the discussion, Laufer begins the final paragraph

"Les rhinocéros de la Chine et de l'Indochine d'après de anciens textes" (1921) by Henri Imbert is more limited in its coverage. As the title indicates, it focuses on early Chinese texts. The translated extracts pertain mainly to the application of the words "*ssu*" and "*hsi*" to designate the animal, and to the description and utilisation of the rhinoceros horn (e.g. as medicine). Carl Whiting Bishop was also perplexed by the problem and confusion caused by the two Chinese characters "*ssu*" and "*hsi*" -- both of which in his opinion, "refer to large beasts bearing horns."[1] But his curiosity led him to evidence of a different sort. His (1933) article on the rhinoceros and the wild ox as known to the Chinese in the Han and earlier periods compares information on the distribution of wild bovine animals in historic times, remains from excavations, inscriptions in Shang oracle bones and tortoise shells, Chinese classics, and the use of the skin and horn of these animals.

Of all the members of the animal world, two insects -- the cicada and the cricket -- held particularly prominent positions in traditional Chinese culture, and had been associated with a wide variety of activities and beliefs. In an article for the 1919 Revue Archéologique G. Geiseler tells the story of the cicada seen through the eyes of the Chinese over the centuries, grouping traditional Chinese fascination with the insect topically into: "moeurs de la cigale"; "la cigale indicatrice du solstice d'été"; "les cinq vertus de la cigale"; "pureté de la cigale dans le taoisme"; "Nan-yu ou jade de la bouche du mort"; "la cigale dans l'art culinaire et l'art de guérir"; "éloge de la cigale par Kouo pou"; "essai littéraire par Tchoan yuan"; "essai sur la han tchan par Tsi Lou-yun"; "essai littéraire"; "capture des cigales"; "métamorphose"; "essai sur la han tchan". Less structured and detailed is Le grillon et la cigale en Chine (1921) by Imbert, a slim palm-sized booklet published by La "Politique de Pekin". It is a grab-bag of references to the two

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with the following statement: "Finally, the memorable passage in the *Chou li* from which we started. . . regarding the manufacture of hide armor, is sufficient evidence in itself that the hide in question is only that of the rhinoceros": Laufer, "History of the Rhinoceros," pp. 172.

[1]Carl Whiting Bishop, "Rhinoceros and Wild Ox in Ancient China," China Journal of Science and Arts, 18 (1933), 322.

insects derived from Chinese sources which the author chanced to come across, for instance, those in the *Li chi*, *Shih ching*, *pen ts'ao* literature, poems, folklore, and Taoist writings.

It was left to Laufer to come up with an account that was regarded by Hartmut Walravens as "Arbeit ist bis heute das Standardwerk zur Kulturgeschichte der chinesischen Grillen."[1] The title Insect-Musicians and Cricket Champions of China (1927) was chosen for good reasons: the study devotes much of its space to scrutinising every aspect and small detail associated with cricket fights and to the "singing" or chirping of crickets. Other elements in the relationship the Chinese had with crickets and evidence of their extensive involvement with the insect are also revealed and discussed, once again through calling into service a wealth of source materials.

Gaines Kan-chih Liu was another specialist who had written on the cicada, and his important contribution from 1950 will be treated when we reach the second half of the 20th century. Here, mention should be made to a short essay he wrote in 1939 for a journal published by the Cambridge Entomological Club in Massachusetts. The purpose of his "Some Extracts from the History of Entomology in China" (1939) was to supplement three Western treatises on entomology with historical material drawn from Chinese texts.

In addition to rhinoceroses, crickets, and cicadas, monkeys and apes were the subject of yet another pamphlet by Imbert -- Les grandes singes connus des anciens chinois (1922). [I have not seen this title].

The paper Moule composed in 1925 to document the way in which the Chinese in early and middle ages learned about and took to animals not indigenous to China was intended to "bring together passages from Chinese books, some of which have been translated before in a different context, illustrating them by reproductions of woodcuts which are unfamiliar and of great interest."[2] These "fo-

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[1]Hartmut Walravens, "Zoologische illustration in China und Japan," in Die Zoologische Buchillustration: ihre bibliographie und geschichte, ed. Claus Nissen (Stuttgart: Anton Hiersemann, 1976), vol. 2, pp. 418.

[2]A. C. Moule, "Some Foreign Birds and Beasts in Chinese Books," Journal of the Royal Asiatic Society, (1925), 247.

reign" animals included the ostrich (with "the longest record in China"), zebra, giraffe, hornbill, lion, etc., and the passages translated were culled from literature such as the *Shih chi*, *Ying ya sheng lan*, *Ming shih*, *Shan hai ching*, *I yü ch'in shou t'u*.[1] Moule's interest in historical Chinese records related to the plant and animal world was not restricted to those on foreign animals or the *Ginkgo biloba*. The goldfish was also perceived by Moule as a subject worthy of study. "The plan" in his lengthy (1949) article on the goldfish "is to begin with a preface about *The Book of Vermilion Fish* and its author, to be followed by a long introduction which gives, first, versions of what some Chinese authors have written about gold fish from the 11th century to the 17th; secondly, translates and extracts from a few European authors of the 17th and 18th centuries; and thirdly, some personal reminiscences of gold fish in China sixty years ago. Finally comes the attempted version of the book itself."[2] This annotated translation of the 16th century *Chu sha yu p'u* is accompanied by an appendix "Kin-yu ou Poisson Doré, Dorade de Chine" -- an 18th century French manuscript in the Library of the French Academy.

As with his other works, textual sources tapped by Laufer in his (1925) account on the giant salamander -- referred to by the early Chinese as the "tree-climbing fish" -- are diverse. In this case, he starts with the earliest notice of the reptile, namely that in the *Shu chih*, the "exact date of which is not known, but which must be an ancient work, as it is frequently quoted in the Ts'i min yao shu, a book on agriculture of the fifth and sixth century."[3]

ISIS Cumulative Bibliography 1913-65 has registered under "LZ - Mammalogy" another work from the 1920s -- a decade with a significant volume of Western interest in traditional Chinese understanding in botanical and zoological subjects -- namely, J. Krumbiegel's "Säugetierkenntnisse im ältesten China" in the 1928 Zeitschrift für

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[1]ibid.

[2]A. C. Moule, "A Version of the Book of Vermilion Fish," T'oung Pao, 39 (1950), 1.

[3]Berthold Laufer, "The Tree-Climbing Fish," China Journal of Science and Arts, 3 (1925), 35.

Säugetierkunde. [I have not seen this title].

Eduard Erkes' "Das Pferd im alten China" (1940) was conceived as a "sinologischen Forschung zur Verfügung stehenden Hilfsmitteln über Entstehung, Entwicklung und Bedeutung der Pferdezucht im alten China ermitteln lässt, zusammenhängend darzustellen."[1] Five other works he penned on pigs (1942), birds (1942), dogs (1944), bees (1948), and sheep (1954) respectively in early Chinese culture also share more or less the same objective.[2] For this series of articles, Erkes assembled a dense package of historical material, including quotations from Chinese classics, dictionaries and other compilations, references to the animals concerned in proverbs, metaphors, myths, and folklore, the different names by which they were known, and archaeological finds.

To demonstrate that "early Chinese naturalists, in common with their Western colleagues, believed in the existence of the jumar", and that "the Chinese mind has been conditioned from very early times to the possibility of unrestricted interbreeding", Rudolph chose the jumar -- "the supposed offspring of a cross between the horse and the cow" -- as the subject of an article for the 1949 Isis.[3] Several Chinese accounts which could provide evidence of the "far eastern belief -- and disbelief -- in this imaginary animal" were identified.[4]

Writers responsible for publications from the second half of the 20th century operated within basically the same framework as that for earlier works in so far as aims and purposes were concerned. Never-

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[1]Eduard Erkes, "Das Pferd im alten China," T'oung Pao, 36 (1940), 26.

[2]Their length, however, varies considerably, from over thirty-five pages on horses and dogs, to two pages on bees.

[3]Richard C. Rudolph, "The Jumar in China," Isis, 40 (1949), 35.

[4]ibid. This includes the *Pen ts'ao kang mu* which contains "the most enlightening source on the Chinese attitude toward crossbreeding and hybrid sterility"; the *Yü p'ien* which is "the oldest source noted that contains a definition of the jumar"; the *Pao p'u tzu* where "belief and disbelief are combined" in one of the passages; "a folktale still current in China" that explains "the sterility of the hybrid mule"; and the *Ch'i min yao shu* which "is very matter of fact and practical in its observation on the mule's sterility": Rudolph, "The Jumar," 36-37.

theless, in most cases, the scope and breadth of their documentation and of the aspects they treated were more extensive.

An excellent case in point is Liu's "Cicadas in Chinese Culture (including the Silver-Fish)" (1950). This treatise, which takes up over a hundred and twenty pages, carries a number of sections and sub-sections. "I. Cicadidae" is divided into: "A. Biological tettigology in China"; "B. Economic tettigology in China"; "C. Aesthetic tettigology in China".[1] "II. Fulgoridae" has one division -- "The crimson lady". "III. Aphididae" is divided into: "1. The nut-gall aphis"; "2. The bamboo aphis"; "3. The peach aphis"; "4. The bean aphis"; "5. The cabbage aphis"; "6. The tree aphis"; "7. the tao-shi-chu aphis". "IV. Coccidae" is divided into "1. The tse-kwang coccid"; "2. The white-wax coccid". After "V. Conclusions" comes "VI. Silver-fish" which "is included here for the sake of convenience" as the silver-fish actually "forms a group by itself".[2] Liu -- an entomologist trained at Harvard -- cautioned the reader that his classification "represents our modern conception of the relation of insects and should be understood as such only."[3] He was also keen to point out that "with our modern standards. . . not all these references can be considered as of equal value: some are good and some bad."[4]

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[1]**"A. Biological tettigology in China"** consists of: "1. Morphology"; "2. The sound-producing organ"; "3. Classification"; "4. Cicadas in Chinese literature"; "5. The life history of cicadas"; "6. The feeding habits of cicadas"; "7. Distribution"; "8. Cicadas and other organisms"; "9. The aquatic environment of cicadas". **"B. Economic tettigology in China"** contains: "1. Cicadas as food"; "2. Cicadas in ginger picking"; "3. Cicadas for entertainment"; "4. Cicadas as drugs"; "5. Methods of collection". **"C. Aesthetic tettigology in China"** is broken down into: "1. Cicadas in decoration"; "2. The sound of cicadas"; "3. Cicadas in allegory"; "4. Cicadas in poetry"; "5. Cicadas in painting"; "6. Cicadas in love-making"; "7. Cicadas as money-makers"; "8. Cicadas and the cryptic leaf"; "9. Cicadas in augury"; "10. Cicadas in mythology"; "11. The festive cicadas".

[2]Gaines Kan-chih Liu, "Cicadas in Chinese Culture (including the Silver-Fish)," Osiris, 9 (1950), 277.

[3]ibid.

[4]Liu, "Cicadas," 278. He further emphasized that, "historically speaking, the bad ones are just as instructive as the good ones. At least, their authors were just as honest in what they wrote as we

To anyone wishing to fathom the nature and staggering range of traditional Chinese knowledge, experience, beliefs and attitudes associated with the camel, elaphure, and parrot, Schafer's three studies should provide ample leads as well as specifics. As usual, Schafer displayed an enviable knowledge as well as control of an array of material of varied texture. "The Camel in China down to the Mongol Dynasty" (1950) is separated into: "I. Introduction"; "II. Philological"; "III. Paleontological"; "IV. Historical"; "V. Place-names and landmarks"; "Nicknames and sobriquets"; "VII. Metaphor and proverb"; "VIII. Folklore and tales"; "IX. Bright camels and purple camels"; "X. Poetry"; "XI. Art (literary notices)"; "XII. Bronze camels"; "XIII. Art (extant)"; "XIV. Practicalities"; "XV. Cousins". "Cultural History of the Elaphure" (1956) is organised in similar fashion: "Introduction"; "Linguistic identity and history"; "Distribution"; "Hunts and parks"; "Practical uses" (sub-divided into: "A. Food", "B. Medicine", "C. Miscellaneous"); "Folklore"; "Appendix I: The Chu"; "Appendix II: Stag-tails". His "Parrots in Medieval China" (1959) is much shorter, but no less informative. We are first told about parrots that were "native" to China, and then about "exotic" parrots: how they were depicted in literature, where they came from, the different varieties, how they were used.[1] The last few pages are packed with all sorts of material, including the role of the parrot in Chinese thought and sundry parrot stories.[2]

Bruno Belpaire's "La zoologie en Chine au IXe siècle" (1956) stands in sharp contrast to Schafer's contributions. It contains the basic translation of six paragraphs from a T'ang compilation which "contient au livre VI chapitre 4 une série de notes sur des faits

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are today, and hence the bad ones will tend to show that even so-called scientific truth is not necessarily final": ibid.

[1]e.g. the exotic ones were sent as "presents from potentates to the Chinese court": Edward H. Schafer, "Parrots in Medieval China," in Studia Serica Bernhard Karlgren Dedicata, ed. Soren Egerod, and Else Glahn (Copenhagen: Munksgaard, 1959), pp. 278.

[2]e.g. "parrot flesh were eaten by the natives of the southern coastal provinces [because] parakeets chanced to be abundant", and "the belief that stroking a parrot's feathers made one liable to a mortal disease goes back to the third century at least, probably much further": Schafer, "Parrots," pp. 278-79.

curieux se rapportant à la zoologie et à la botanique."[1] Each paragraph is concerned with a different animal: "les gibbons roux"; "les lézards"; "la branche des papillons"; "les chauves-souris rouges"; "les poissons de la grotte du lait"; "L'aile en eventail de l'echassier dit <<mere des moustiques>>". Brief remarks precede the translations.

The great scope of Robert H. Van Gulik's The Gibbon in China: An Essay in Chinese Animal Lore (1967) and its careful and extensive use of evidence reminds one of works by Laufer and Schafer. It embraces Chinese sources (often accompanied by thoughtful scholarly commentaries) on the gibbon from the Shang when this primate was used as motifs in bronzes and oracle bones, through the Han and T'ang periods which produced an assortment of literature related to gibbons, down to Sung, Yuan and Ming when they were given pictorial representations and featured in paintings. The book is organised chronologically, with a fascinating introductory chapter "describing gibbons and their habits as I came to know them during many years of daily association", and a tape recording of "musical calls of gibbon" which are of interest because they "play an important role in Chinese literature".[2] There is also an appendix on gibbons in Japan.

Finally, G. Pilleri's "The Chinese River Dolphin (*Lipotes vexillifer*) in Poetry, Literature and Legend" (1979) is yet another account that conforms to the blueprint adopted by most scholars in their treatment of traditional Chinese observations and perceptions of animals: it translates Chinese writings on the river dolphin including excerpts from the *Erh ya* (its chapter 16 "Commentary on Fish" is apparently "the oldest existing reference to the river dolphin"), *Pen ts'ao shih i* (in which "under the heading <<dolphin>> comes a series of quotations showing the different names which are used for the animal"), *San ts'ai t'u hui*, Sung poems, local gazet-

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[1]Bruno Belpairé, "La zoologie en Chine au IXe siècle," Reflets du Monde, no. 8 (1956), 41.

[2]Robert. H. Van Gulik, The Gibbon in China: An Essay in Chinese Animal Lore (Leiden: E. J. Brill, 1967), preface.

teers, and folk legends about river dolphins.[1] The circumstances that led to the writing of this article were, however, somewhat unusual: it was prompted by what the author perceived as "the precarious situation of *Lipotes* today -- the result of over 2,000 years of exterminating" by the Chinese.[2]

9.4 BIBLIOGRAPHICAL WORKS

Although Bretschneider did not speak primarily as a bibliographer in Botanicon Sinicum, the organisation and description of documentary sources is one of the most important aspects of his study. Yet it motivated few bibliographically-oriented works that could update its inventory or challenge its approach to the subject.

Among the handful of 20th century Western scholars who addressed the topic of traditional Chinese botanical knowledge bibliographically were Liou-Ho and Claudius Roux. In 1927 they published Aperçu bibliographique sur les anciens traités chinois de botanique, d'agriculture, de sericulture et de fungiculture. It is arranged as follows: "Introduction"; "I. Anciens traités de botanique" (divided into: "A. Les Pen-tsao", "B. Traités divers de botanique", "C. Le Tche-wou-ming-che-tou-kao"); "II. Anciens traités d'agriculture" (divided into: "1. Le Keng-tchi-thou-chi", "2. Traités divers d'agriculture"); "III. Estampes, peintures et manuels artistiques"; "IV. Anciens traités ou procédés de fungiculture"; "V. Conclusions"; "VI. Bibliographie"; "VII. Titres en caractères chinois". This treatise belongs to the kind of bibliographic work that fills no major gap in the bibliographical literature on the subject concerned: they are not intended to offer comprehensive coverage and bring to light new information; neither are they aimed at scoring with radically different interpretations or evaluations of the titles

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[1]G. Pilleri, "The Chinese River Dolphin (*Lipotes vexillifer*) in Poetry, Literature and Legend," in Investigations on Cetacea, ed. G. Pilleri (Berne: Hirnanatomisches Institut der Universität, 1979), vol. X, pp. 336.

[2]Pilleri, "The Chinese River Dolphin," pp. 348.

listed.[1] Nevertheless, they occasionally provide nuggets of information that may come in handy.[2] Liou-Ho and Roux (1926) also delivered a short paper for the 50e session of the Association Français pour l'Avancement des Sciences, which simply introduces without criticism and analysis how different plants are described in key *pen ts'ao* works, and the authors and content of these Chinese accounts.

Richard C. Rudolph's (1966) article on illustrated botanical works in China and Japan originated as a lecture for a conference on bibliography and natural history held in Kansas. This relatively brief, but informative and highly readable account should give someone unfamiliar with traditional Chinese writings on plant sciences a good start in acquainting himself with these materials and the appropriate way to approach them.[3] In characterising and portraying these works, Rudolph makes a conscious effort to apprise his audience of the treatises' dates and editions, historic setting, compilers, unique features and significance (especially with regard to their illustrations), and similarities or differences they have

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[1]As Georges Métailié remarked: "Beaucoup plus modeste, cette bibliographie complète néanmoins la précédente [i.e. Bretschneider's Botanicon Sinicum], localisant certains des livres dans les grandes bibliothèques d'Europe et des Etats-Unis": Georges Métailié, "Bibliographie indicative concernant la botanique et l'ethnobotanique de la Chine (ancienne et contemporaine)," Journal d'Agriculture Traditionelle et de Botanique Appliquée, 28 (1981), 354.

[2]In Aperçu bibliographique sur les anciens traités chinois de botanique, d'agriculture, de sericulture et de fungiculture, for instance, its "VI. Bibliographie" (also called "Index des sources et références") offers ninety-one titles, mainly French, with several in English and German.

[3]These treatises include *Shen nung pen ts'ao* -- "traditionally regarded as the oldest Herbal in China"; *Nan fang ts'ao mu ch'uang* -- "the earliest original and complete botanical treatise still in existence"; *T'ang pen ts'ao* -- "the earliest medical botany still existing in any degree of completeness"; *Chü lu* and *Li chih p'u* -- "the most outstanding works in the field of agricultural history"; general works such as *Cheng lei pen ts'ao* and *Pen ts'ao kang mu*; *Chiu huang pen ts'ao* -- "probably the most original compilation of its kind, not only in China, but anywhere"; *Chih wu ming shih t'u k'ao*" -- "the greatest of the pre-modern Chinese botanies": Richard C. Rudolph, "Illustrated Botanical Works in China and Japan," in Bibliography and Natural History; Essays presented at a Conference convened in June 1964 by Thomas R. Buckman (Lawrence, Kansas: U of Kansas Libraries, 1966), pp. 104-05, 107, 109.

with texts from the West. Also welcomed are the opening remarks in which Rudolph refers to several major Western and Chinese secondary sources, explains the term "*pen-ts'ao*", and comments on "the earliest known Chinese illustrations from nature."[1]

Métailié's "Bibliographie indicative concernant la botanique et l'ethnobotanique de la Chine (ancienne et contemporaine)" (1981) is a selective and annotated list of primary and secondary literature on botanical knowledge in China's past and present, with forty-seven Chinese, thirty-one Western and seven Japanese titles. The purpose of this bibliography and its selection guidelines are stated succinctly: "Dans ce travail qui ne prétend pas à l'exhaustivité, je me suis efforcé de signaler tous les textes (livres ou articles) qui me paraissent nécessaires ou simplement utiles à quiconque désire aborder le sujet. La liste de titres présente certainement des lacunes: elles peuvent être comblées en consultant les bibliographies signalées. Ainsi lorsqu'une publication récente peut en remplacer une plus ancienne difficilement assessible, cette dernière n'est pas citée. . . ."[2] The bibliography is divided into two main parts: "I. Chine ancienne" and "II. Chine contemporaine". Each item is furnished with full bibliographic information, including Chinese / Japanese characters and French translation of non-Western titles. Almost all entries carry annotations which indicate the content and arrangement of the works and sometimes their usefulness and scholarly value. A rather unusual feature of this bibliographic listing should be brought up for discussion. Even though the total number of entries is by no means great, there are many narrow divisions and sub-divisions.[3] One may wonder whether such detailed classification

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[1]Rudolph, "Illustrated Botanical Works," pp. 104.

[2]Métailié, "Bibliographie," 354.

[3]"I. **Chinese ancienne**" is divided into: "**1.1. Bibliographies**" -- not clear what the system of organisation is for the three Chinese, one Japanese, and five Western titles. "**1.2. Les sources chinoises**" -- sixteen Chinese and three Western titles listed; arrangement explained as follows: "Renvoyant pour des recherches détaillées au contenu des bibliographies de la liste précédente, je ne citerai que les principaux textes, par ordre chronologique et en mélangeant les genres". "**1.3. Etudes sur la botanique chinoise**" -- three Chinese and five Western titles arranged alphabetically by author. Then follows four un-numbered sub-sections. The first sub-section

is necessary. It is not essential in that even with far fewer divisions and much broader subjects, the bibliography is perfectly acceptable and convenient to use. The complexity of all the subdivisions and sub-sub-divisions can be confusing and bewildering at first glance. On the other hand, carving the body of literature under consideration into thin slices does have its benefits: a work's main area of concern can be pinned down more quickly and precisely, thus making it easier for the user to decide its suitability for his own study; the fine partitions also create room which allows the compiler to easily insert comments on and alert users to different aspects, themes, and special types of material involved in the study of the subject under consideration.

A Western work on zoological understanding in traditional China devoted solely to bibliographic matters did not surface until the 1970s. While Rudolph's "Illustrated Botanical Works in China and Japan" was published in a volume on bibliography and natural history, Hartmut Walravens' "Zoologische illustration in China und Japan" (1976) appeared in the compilation Die Zoologische Buchillustration: ihre bibliographie und geschichte. Three-quarters of the study -- which is in the form of an essay rather than a straightforward list of titles -- deals with China. It opens with a section on Western

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("Ci-dessous sont indiquées une série de références concernant plus specifiquement l'histoire des plantes") lists one Western title. The second sub-section ("Les références suivantes forment un ensemble de textes complémentaires sur l'histoire des plantes cultivées en Chine") lists two Chinese, two Japanese, and four Western titles alphabetically by author. The third sub-section ("Dans les ouvrages suivants une partie est consacrée à l'histoire des plantes chinoises") lists one Chinese and four Western titles. The fourth sub-section ("Sur l'histoire des decouvertes botaniques") lists two Western titles.

"**II. Chine contemporaine**" is divided into: "**2.1. Bibliographies**" -- two Western titles. "**2.2. Dictionnaires**" -- two Chinese titles. "**2.3. Flores, etc.**" -- sub-divided into "2.3.1. Etude sur la végétation" with one Chinese title; "2.3.2. Flores générales" with five Chinese and one Japanese title; "2.3.3. Flores régionales" with a note referring to a series of Chinese works, but no title listed; "2.3.4. Flores ou catalogues spécialisés" further separated into "2.3.4.1. Plantes médicinales" with five Chinese and two Western titles, "2.3.4.2. Plantes alimentaires" with four Chinese, two Japanese, and one Western titles, "2.3.4.3. Autres plantes d'intérêt économique" with five Chinese titles, "2.3.4.4. Ouvrages non specifiquement consacrés à Chine mais très utiles" with one Japanese and two Western titles.

scholarship, separated into seven categories: "1. Allgemeine Bibliographien"; "2. Einzelne Tiere"; "3. Malerei"; "4. Farbholzschnitte und Farbdrucke"; "5. Abklatsche"; "6. Symbolische Darstellungen"; "7. Populäre Kunst".[1] The main portion of the bibliographic guide is taken up by "Chinesische Quellen". These Chinese textual sources are classified into: "A. Enzyklopädien"; "B. Die pharmakologische literatur"; "C. Medizinisches"; "D. Landwirtschaftliche literatur"; "E. Geographisches"; "F. Ethnographisches"; "G. Sonstige werke"; "H. Zoologisches Wörterbuch"; "I. Chinesische einflüsse in Europa". A total of twenty-six Chinese titles are given (plus three Western publications in section I). Each of them carries data on the author, the time it was written or compiled, its various editions, and other writings to which it is related. Depending on the history and significance of the work, some remarks can be quite detailed.[2] In addition, the portion in a treatise that bears upon zoology is often indicated; references to Western accounts are also made occasion-

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[1]"**1. Allgemeine Bibliographien**" contains very general bibliographies (e.g. Index Sinicus; Bibliography of Asian Studies; library catalogues of the School of Oriental and African Studies, and of the East Asiatic Library at the University of California, Berkeley; E. D. Merrill, and E. H. Walker, A Bibliography of Eastern Asiatic Botany. "**2. Einzelne Tiere**" is directly related to the publications discussed here. Under each of the twenty animals (e.g. "Allgemeines"; "Fische"; "Kamel"; " Katze"; "Krabben"; "Vögel"; "Zikaden; Grillen") is listed (generally one or two) special Western studies devoted to it. For "**3. Malerei**", "**4. Farbholzschnitte und Farbdrucke**", "**5. Abklatsche**", "**6. Symbolische Darstellungen**", and "**7. Populäre Kunst**", Walravens gives a few titles for each of these categories, pointing out relevant sections in the works. Among items listed are: Friedrich Hirth, Scraps from a Collector's Note Book; being Notes on some Chinese Painters of the Present Dynasty (Leiden: E. J. Brill, 1905) in "3. Malerei"; Roger Goepper, Blumen aus dem Senfkorngarten (Munich: Hirmer, 1960) in "4. Farbholzschnitte und Farbdrucke"; Gerhard Pommeranz-Liedtke, Die Weisheit der Kunst: Chinesische Steinabreibungen ([Leipzig]: Insel-Verlag, 1963) in "5. Abklatsche"; C. A. S. Williams, Encyclopedia of Chinese Symbolism and Art Motifs (Shanghai: Kelly & Walsh, 1932) in "6. Symbolische Darstellungen"; Wolfgang Bauer, Das Bild in der Weissage-Literatur China (Munich: Moos, 1973) in "7. Populäre Kunst".

[2]e.g. "Ausgaben des *Pen-ts'so kang mu*" occupies three pages, and is divided into four columns: "Jahr"; "Ort"; "Hrsg./Verlag"; "Bermerkungen" (which includes information such as "Vorh. in Library of Congress"; "Mit Ch'i-ching pa-mo k'ao, Mo-chüeh k'ao-cheng, P'in-hu mo-hsüeh"; "Typendruck nach d. Ausg. 1930").

ally.[1] The first question that comes to mind regarding this bibliographic guide is that it is not immediately obvious as to the person best placed to use it or the kind of reader it is meant to serve. Let us consider the types of potential users:-

(1) Those who work in areas closely associated with the Chinese scientific traditions and who are acquainted with the Chinese treatises mentioned in "Chinesische Quellen": They may find the section on Western material helpful.[2] As for Chinese sources, they may appreciate the information on specific references to animals, but less concerned with general remarks on editions, contents, etc. of which they are probably cognizant. The bibliography may therefore have some appeal to this group of specialists, but perhaps not in a significant way.

(2) Those that have little contact with Chinese history or with areas in Chinese studies (e.g. historians of Western science): It should not be surprising to find readers falling under this category bewildered and frustrated by the numerous Chinese names and terms which often appear in romanised form without translation, by the comments on Chinese treatises (which seem to contain too much and too little information at the same time), and even by the range of material covered in the section on Western studies.[3] One can argue that since these users do not read Chinese, they may not want to pursue these primary sources anyway and would be content with picking up a few Western works. It is unfortunate that Walraven's guide has not made the task of quarrying bibliographic information on Chinese writings easy for them because judging from the nature of the book of which it is a part, this is the kind of users that is most likely to come across the bibliography.

(3) Those that specialise in or have some familiarity with Sinology,

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[1]e.g., works by Bernard E. Read, Robert H. Van Gulik, Ulrich Unschuld.

[2]Titles in "1. Allgemeine Bibliographien" and even "2. Einzelne Tiere" may already be known to them, but they may welcome suggestions regarding other research areas outlined in parts 3, 4, 5, 6, and 7.

[3]Too much in the sense of too many names and dates all piled on top of each other, and too little in the way of explaining these works and their significance, of guidance as to which editions are important, etc.

but are not specifically informed about Chinese history of science (e.g. scholars in Chinese literature or intellectual history): They should not have any problem with romanised titles and terms. With the information provided, they can evaluate the importance of the various texts and editions as well as make full use of all the bibliographic details given to track down the items. In addition, they would find the Western publications in "2. Einzelne Tiere" worth noting, and also be ready to explore titles in 3, 4, 5, 6, which they may have come across in other contexts.

9.5 CONCLUSION

So what study trends and areas of interest does this collection of literature covering the period 1870 to 1981 reveal?

The last quarter of the 19th century had more than a smatter of Western writings to offer. Both Pfizmaier and Bretschneider had bequeathed us material on the subject, but as we have seen, the end results of their dedicated labour could not have been more different. It was the period between 1920 and 1950 that Western scholarly attention to both plant and animal-related topics was at its most visible. While the number of publications remained steady for zoological themes as one moved on to the 1950s, botanical works experienced a sudden drop. Interests buoyed up in the plant department in the 1960s and '70s, but inquiries into the history of Chinese involvement with members of the animal kingdom have been sliding downhill since the 1960s. For a short time in the 1950s and early '60s, several studies took aim at areas in the biological sciences other than those directly related to botany or zoology.

The great majority of those who pursued Chinese understanding of animals selected vertebrates. And among these, mammals were the most popular, especially hoofed mammals or ungulates, with only one or two studies devoted to carnivora, primates, and cetacea. Other vertebrates treated were reptiles, birds, and fishes. The few accounts on invertebrates were all concerned with insects. Works on particular plant families concentrated on fruits (banana, orange, lemon, peanut) and trees (*Gingko biloba*, bamboos).

There were about two dozen publications on animals, and roughly the same number for plants. Other similarities can be detected. After all, some contributors (e.g. Pfizmaier, Moule, Laufer, Schafer) had spent time over both botanical and zoological topics. The more ambitious researchers from both camps entered into discussions on issues such as names, nomenclature, classification, description of appearance, behaviour, habitat and life cycles, economic, pharmaceutical and other practical use, artistic representation and symbolic meaning, often employing a host of sources.[1] Others limited their contributions to that of providing mainly translations or paraphrases of exerpts. Whatever the scale and comprehensiveness, whether derived from one treatise or numerous sources, the faithful delivery of references to the plants and animals in question remained a high priority and prime concern. This is especially true of studies concerned with the animal world. Nevertheless, some scholars such as Schafer and Li were more conscious of associated background information and stages of development, and had sought to provide more than a mere assembly of translated passages or an inventory of available details.

Yet differences must also be recognised. Authors of plant studies issued during the second half of the 20th century (notably Needham's) tried to move away from species by species investigations. Another distinction is that all-encompassing cultural histories were favoured more by those involved with animals.

Only on several occasions were attempts to register or describe botanical or zoological literature and records (Chinese and / or Western) undertaken.[2]

Finally, we must once again emphasize the bid taken by a few scholars -- Leslie, Schafer, and Needham -- to explore unfamiliar

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[1]e.g. dictionaries, *pen ts'ao* literature, the classics, poems, legends, folklore, paintings, archaeological evidence.

[2]Some interesting questions and speculations can be raised. For instance, with the vast store of *pen ts'ao* literature, the history of Chinese botany is well suited to investigation by bibliographically-oriented means. Can it be that Bretschneider's compilations have been so dependable and valuable that even after all these decades no one felt the need or inclination to produce further listings or bibliographic aids? On the other hand, why did no one follow in Bretschneider footsteps and turn his method of study into a regular practice?

grounds with new tools.[1]

What then are the deficits? Is it the poor standard of scholarship? As over fifteen studies came from the pen of such learned scholars as Bretschneider, Laufer, Schafer, Needham, not to mention noteworthy publications by Liu, Rudolph, Li, Van Gulik, and Métailié, this charge can hardly be levied. Is it the limited sources used in the studies? Considerable attention has been paid to primary textual materials. Appeals were also been made occasionally to paintings, artifacts, and archaeological remains. Is it the overall paucity of publication? One may be surprised to find over fifty titles listed: most would think that there is not much more than Bretschneider's Botanicon Sinicum.[2]

What the sophisticated reader really misses can be summarised as follows. First and foremost, one looks for in-depth analysis and critical interpretations that take the exercise of collation and narration further. This involves translating raw data (in some cases so carefully garnered and described) into coherent and sustained discussions that systematically assess and explain the relevant Chinese experience in the light of traditional Chinese world view and in the context of Chinese historical experience and concepts concerning nature and its plant and animal occupants.[3] Moreover, the field suffers from a serious shortage of dedicated attempts at integrating findings and drawing parallels that cut across the boundaries circum-

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[1]Their ventures into the background of Chinese ideas and activities related to heredity, the environment, botanical taxonomy and geo-botany etc. have opened up important questions and vistas, but neither these specific themes nor the method of investigation suggested by these works were succeeded by further experimentations.

[2]Nevertheless, it should be noted that the bibliography for this chapter carries the least number of items.

[3]In other words, the writings collectively have sent the message that a great deal can be gained by patiently combing through Chinese sources, and some provocative ideas and interesting possibilities have been presented. But we are left to interpret the meaning of the words as best we can on our own. We are not provided with a clear picture of how these particular activities, observations, and beliefs came about, what specifically were the underlying motivations and elements that shaped the perceptions and responses, and how everything fits within the broader framework of traditional Chinese scientific understanding.

scribing particular species, records, or issues.[1] There is also a need for reinforcement of opinions, of on-going debates, and of studies that complement each other.

9.6 PARTICIPATING COUNTRIES AND INDIVIDUALS

A significant portion of Western writings on traditional Chinese understanding in areas we now term biology came from those with a scholarly background in Chinese studies.[2] Valuable efforts were also made by individuals trained in the sciences.[3]

Erkes taught at Universität Leipzig, Schafer at the University of California, Berkeley, and Rudolph at the University of California, Los Angeles, but not everyone pursued a teaching career.[4]

Scholars from America were active in botanical as well as zoological domains throughout the 20th century, beginning with Laufer, Goodrich, and Hagerty, followed by Liu, Reynolds, Rudolph,

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[1]Science and Civilisation in China, which is always an excellent source for such purpose, had not come to the rescue before 1985. Part of the botany section was published in 1986. Vol. 6 pt. 1 contains the following sub-sections: "(a) Introduction"; "(b) The setting; China's plant geography"; "(c) Botanical linguistics"; "(d) The literature and its content"; "(e) Plants and insects in man's service". However, there is as yet no indication as to when the remainder -- which covers the important themes of "Treatises on traditional botany; and the development of classification"; "The development of plant description and illustration"; "Chinese knowledge of the life of plants"; "Horticulture and its techniques"; "The influence of Chinese flora and botany on modern plant science" -- is to appear.

[2]e.g. Pfizmaier, Moule, Leslie, Schafer, Erkes, and Rudolph.

[3]e.g. Liu was an entomologist at the Biological Laboratory at Harvard University, Li was a botanist at the Morris Arboretum and the University of Pennsylvania, and Pilleri came from the Brain Anatomy Institute at the University of Berne in Switzerland.

[4]For instance, Bretscheider was a physician, Laufer was Curator of Anthropology in the Field Museum of Natural History in Chicago, Hagerty was the official Chinese translator in the Bureau of Plant Industry at the U.S. Department of Agriculture, Belpaire was "secrétaire à l'Institut belge des hautes études chinois", Van Gulik was a diplomat from the Netherlands (as well as creator of the "Judge Dee" character in mystery novels), and Métailié is a researcher at the Laboratoire d'Ethnobiologie-Biogéographie in Paris.

Schafer, and in recent decades by Li. Teams from the U.K. (e.g. Moule, Leslie, and especially Needham and Lu), Germany (e.g. Erkes, Walravens), and France (e.g. Imbert, Liou-Ho and Roux, Métailié), though smaller, all contributed to the shaping of the field at one time or another. Not to be overlooked are individuals from other countries (e.g. Pfizmaier, Bretschneider, Van Gulik, Pilleri).

9.7 FORMS OF PUBLICATION

One cannot survey the Western publications discussed above without becoming aware of how regularly articles appeared in Chinese / Asian studies journals. Over a dozen such journals were involved.[1] T'oung Pao in particular published six essays on both botanical and zoological topics from 1923 to 1949. Not surprisingly, specialists in Chinese studies (e.g. Moule, and Erkes) tended to choose periodicals in their own field.

The share taken by journals and essay collections from the history of science field was smaller, but most of the articles they carried were serious inquiries.[2] Likewise, although only a few specialist journals and collective works from the biology, botany or zoology departments featured historical studies on China, Journal d'Agriculture Traditionelle et de Botanique Appliquée supplied two original accounts fom Needham on geo-botany (1954, 1981) and the bibliography by Métailié (1981).

As in most other cases, the role played by periodicals from disciplines outside the immediate spheres treated in the chapter

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[1]e.g. Revue Indochinoise (1921), Journal of the American Oriental Society (1934), Asiatische Studien (1953), Monumenta Serica (1937, 1942), Harvard Journal of Asiatic Studies (1940, 1948).

[2]Consider, for instance, Liu's survey of the cicada in Osiris (1950), and Needham and Lu's investigation into wild food plants in Archives Internationales d'Histoire des Sciences (1968). One can also add the papers by Schafer and by Needham in two meetings of the International Congress of the History of Science (1964) (1971), that by Rudolph in the conference on bibliography and natural history (1966), and by Walravens in Die Zoologische Buchillustration (1976).

concerned was small, but should not be ignored.[1] Five works were issued as pamphlets and three as monographs.

9.8 BIBLIOGRAPHIC PROVISION AND CONTROL

I. GENERAL BIBLIOGRAPHIES FOR CHINESE / ASIAN STUDIES AND THE HISTORY OF SCIENCE:

(a) Henri Cordier, Bibliotheca Sinica. . . (1904-08); (1922-24):

Studies by Bretschneider and translations by Pfizmaier can be found in this bibliography. Cordier placed the two articles on trees in "Agriculture; économique rurale; acclimation" under "XII. Sciences et arts", and the other titles either in "Botanique" or "Zoologie" under "VI. Histoire naturelle".

(b) John Lust, Index Sinicus. . . , 1920-55 (1964):

An exceptionally large number of articles were published within the thirty-five years covered by the index. Equally remarkable is the percentage of these studies registered by Lust: only five articles are not there, all from journals in science fields.[2] (But accounts in Isis, Osiris, Forschungen und Fortschritte are listed.) The majority of essays appear in sub-sections "f. Botany" or "g. Biology" under "XVIII. Science and technology". Exceptions are the five papers from Erkes.[3]

(c) ISIS Cumulative Bibliography, 1913-65; 1966-75; 1976-85:

A fairly large proportion of works appeared in Chinese / Asian studies journals and collections; one is therefore pleasantly surprised to find nearly half of these titles in the cumulative biblio-

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[1]e.g. Revue Archéologique (1919), Bulletin of the National Institute of Sciences of India (1955), Reflets du Monde (1956).

[2]e.g. the article by Needham in Journal d'Agriculture Tropicale et de Botanique Appliquée, that by Liu in Psyche.

[3]Four are considered to be studies on folklore. ("The Hund im alten China" is also listed in "XVII. Music and Sports" under "d. Sports, Games"). "Vogelzucht im alten China" is in "XI. Sociology - c. Social Customs and Dress - I. General".

graphies.[1] The provision of bibliographic information from this category of material is, however, inconsistent.[2]

The listing of studies from history of science journals is less erratic; in fact all titles from these journals are included. Moreover, ISIS is the only bibliographic source with information on articles by Gieseler (1919 Revue Archéologique), Krumbiegel (1928 Zeitschrift für Säugetierkunde), and Liu (1939 Psyche); also, Laufer's "History of the Rhinoceros" appears as a separate item. However, Walravens' bibliographic study and Rudolph's essay on botanical treatises are not listed individually. Other major studies omitted include Liou-Ho and Roux's Aperçu bibliographique sur les anciens traités chinois de botanique, d'agriculture, de sericulture et de fungiculture (1927), Needham and Leslie's study on evolution in the Bulletin of the National Institute of Sciences of India (1955), and Métailié's bibliography in Journal d'Agriculture Traditionelle et de Botanique (1981).

A concern that needs emphasizing is that almost half of the recorded titles are NOT located in "K Botany" or in "L Zoology".[3]

(d) Bibliography of Asian Studies, 1936- :

In assessing the role the Bibliography of Asian Studies plays in providing bibliographic control for the literature discussed in this chapter, there are several features about which something must be

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[1]e.g. Journal of the Economic and Social History of the Orient (1962), T'oung Pao (1923, 1937, 1940, 1942, 1944), Harvard Journal of Asiatic Studies (1940, 1948), Studia Serica Bernhard Karlgren Dedicata (1959).

[2]For instance, Schafer's essays on the camel and on the elaphure in the 1950 and 1956 Sinologica are not there; Moule's first article on the *Gingko biloba* in the 1937 T'oung Pao was indexed, but not his second in the 1949 Asia Major.

[3]e.g. "The Lemon in China and Elsewhere" is in "SM Fruit cultivation" (which comes under "Cultivated plants in general; economic botany" in "Agriculture"); "Han Yen-chih's *Chü lu*: Monograph on the Oranges of Wen-chou, Chekiang" is in "SG fibre plants" (which also comes under "Cultivated plants in general; economic botany"); "Das Pferd im alten China is in "SPP Horses and other equines" (which comes under "Animal husbandry" in "Agriculture"). Incidentally, the translation by Hagerty cannot be found under Hagerty's name in the Author Index since only the Chinese author of the treatise (i.e. Han Yen-chih) was taken into account in the indexing process.

said. First, the vast majority of articles published in Chinese / Asian studies journals since 1941 are listed.[1] Second, five essays in history of science or science journals received entries including the works by Liu on cicadas (1950), by Rudolph on illustrated botanical works (1966), and by Métailié on botanical sources (1981). Third, only Belpaire's "La zoologie en Chine au IXe siècle" in the 1956 Reflets du Monde (not reported in other general bibliographies) is situated under "China - Science, Technology, Medicine, Public Health". An astonishingly high percentage of works indexed are kept under "China - General" (a "catch-all" category).[2] Scattered in other sections are such works as "The Conservation of Nature under the T'ang Dynasty" (in "China - History - T'ang to Ming"), "Illustrated Botanical Works in China and Japan" (in "Far East - Bibliography, books and libraries"), "Bibliographie indicative concernant la botanique et l'ethnobotanique de la Chine (ancienne et contemporaine)" (in "China - Economics - Bibliography"). One finds it difficult to fathom the reason for such an arrangement, and even harder to take advantage of and profit from this bibliographic aid.

(e) Bulletin Signalétique, 1947- :

Of the nine accounts from science or history of science periodicals published after 1947, five were noted.[3]

(f) Revue Bibliographique de Sinologie, 1955-70; 1983- :

Three works on evolution and environment, two on botany, and four on zoology were published between 1955 and 1970. Of these, the review can supply information on three by Schafer (1956 Sinologica,

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[1]Among titles overlooked are four articles by Erkes (1940, 1942, 1944 T'oung Pao and 1942 Monumenta Serica), Schafer's "Cultural History of the Elaphure" (1956 Sinologica), and Li's book (1979).

[2]e.g. "A Version of the Book of Vermilion Fish", "The Camel in China down to the Mongol Dynasty", "Parrots in Medieval China", The Gibbon in China: An Essay in Chinese Animal Lore.

[3]i.e. those by Schafer in the Proceedings of the 10th International Congress of the History of Science, Ithaca, 1962 (1964), by Needham and Lu in Archives Internationales d'Histoire des Sciences (1968), by Needham in the Actes du XIIe Congrès International d'Histoire des Sciences, Paris, 1968 (1971), by Métailié and by Needham and Lu in Journal d'Agriculture Traditionelle et de Botanique Appliquée (1981). Li's monograph was also listed as one of its review appeared in Annals of Science.

1962 Journal of the Economic and Social History of the Orient, 1959 Studia Serica Bernhard Karlgren Dedicata). The article on the elaphure from Sinologica somehow escaped the notice of both the Bibliography of Asian Studies and ISIS (as well as other bibliographies). The Revue Bibliographique de Sinologie is thus the only place where bibliographic details of this contribution from a well-established Chinese scholarly journal appears.

(g) Toyogaku Bunken Ruimoku, 1963-:

Only a small portion of studies appeared after the index came into existence, two of which are listed (i.e. the books by Van Gulik and by Li).

II. SPECIALISED BIBLIOGRAPHIC SOURCES

Only one special aid is of significant use for our purpose.[1] Although not targeted specifically at readers in search of Western literature on traditional Chinese knowledge of animals, Walravens' "Zoologische illustration in China und Japan" can offer them assistance. "2. Einzelne Tiere" contains half of the publications treated in the present chapter and other Western works of interest are given in that as well as later sections.

III. CONCLUSION

None of the general bibliographic tools can be recommended unreservedly, although Index Sinicus and the ISIS cumulative bibliography are undoubtedly good starting points.[2] Nevertheless, other

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[1]Métailié's "Bibliographie indicative concernant la botanique et l'ethnobotanique de la Chine (ancienne et contemporaine)" is not an appropriate source for obtaining bibliographic information on 19th and 20th century Western studies on traditional Chinese botany. Found there are only Botanicon Sinicum -- listed in two separate sections (in "1.1. Bibliographies", and in "1.3. Études sur la botanique chinoise") -- and Li's *Nan-fang ts'ao-mu chuang*: A Fourth Century Flora of Southeast Asia (in "1.2. Les source chinoise"). However, it offers other Western titles which, though not primarily devoted to the historical study of plant science in China, contain useful material on the subject.

We cannot take into account Science and Civilisation in China vol. 6 pt. 1 as our survey extends only to 1985 and the volume was published in 1986. All we can say here is that its "Bibliography C: Books and journal articles in Western languages" lives up once again to its reputation.

[2]The absence of subject access for topics discussed in this chapter renders the value of the Bibliography of Asian Studies questionable in spite of the number of titles it recorded.

bibliographies of a general nature should be checked as each covers different types of material and periods. Additional assistance can be sought from Walravens' guide for zoology.[1] But even a careful inspection of these bibliographic aids would not net Pilleri's article on the Chinese river dolphin, and more importantly, Walravens' bibliography.

Finally, attention must be drawn once again to the issue of subject retrieval. Even within a single bibliography titles are scattered in various sections, and subject access is often difficult. This is largely due to the nature of the studies under consideration: they can be looked upon as writings on plant and animal sciences, on agricultural sciences, on folklore, etc., depending on the preference, leaning and emphasis of a particular classification system and bibliographic guide.

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[1]And Science and Civilisation in China vol. 6 pt. 1 for botany.

CHAPTER 10 : CONCLUSION

The present chapter can be viewed as consisting of one central portion, followed by two supplementary sections. By combining, comparing, and contrasting interests and publications in the eight broad disciplines treated individually in chapters two to nine, subdivisions 10.1 to 10.11 aim at providing a final summary and general review. This overview also creates a frame of reference which allows the development trends and characteristics of the writing in each area to be seen in better perspective. In accordance with the rest of the study, the emphasis remains that of describing and illustrating past activities, though they are occasionally subjected to sharp analysis or sweeping generalisations.[1]

The function of the penultimate section (*10.12 Lessons We have Learnt; The Road Ahead*) is very different. Not being a scholar of Chinese science, I am in no position to make definitive diagnosis, prescribe treatment or pronounce judgement of any sort regarding the future health and prospect of the field. But as the heading of that section makes clear, I believe that there are plainly lessons to be learnt from our review that can help enhance the field and plan future directions. These suggestions, laid out in ten different compartments, often contain critical assessments.

Finally, as this bibliographic survey was prompted in part by my own work experience in a library that specialises in Chinese history of science, technology and medicine, I hope I can be excused by concluding the study with some personal (and admittedly less than objective) reflections and perceptions.

10.1 1800-1849 -- STUDY TRENDS; PARTICIPATING COUNTRIES AND INDIVIDUALS; FORMS OF PUBLICATION

One of the few individuals from the early half of the 19th

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[1]Summarising and making generalisations are always dangerous, not to say meaningless, if one is insensitive to the primary objective of such exercises, namely, to seek clues and parallels, and to draw possible connections in order to identify patterns.

century that offered the Western scholarly community glimpses of the vast unexplored terrain of traditional Chinese science was the German Orientalist J. Klaproth.[1] His "Sur les connaissances chimiques des chinois dans le VIIIe siècle" from 1810 is one of the earliest publications treated in this thesis; he also wrote "On the Geographical and Statistical Atlas of China, entitled *Kwang Yu Thoo*, and on Chinese Maps in General" (1832) as well as Lettre à M. le Baron A. de Humboldt sur l'invention de la boussole (1834).

Also represented in this half-century were publications on magic mirrors -- products of French and British interests in the 1830s and '40s. But the area which received the most attention was astronomy. Gaubil's "Des solstices et des ombres méridiennes du gnomon, observés a la Chine" and his "Observations chinoises; dépuis l'an 147 avant J. C., envoyées par le P. Gaubil en novembre 1749" were issued by Laplace in 1809 and 1810 respectively. J. B. Biot's celebrated review of Ideler's book appeared in the 1839 Journal des Savants, and among the pioneering works on the Chinese astronomical traditions were catalogues of comets and meteors by his son Édouard Biot -- a Sinologist and determined student and advocate of past Chinese contributions to the sciences and technologies. In addition to historical Chinese astronomical records, É. Biot sought consciously, in a series of articles published mostly in Journal Asiatique between 1835 and 1849, to expose Western scholars to early and mediaeval scientific and technological skills, mathematical knowledge, and understanding in meteorology, geology, and seismology. Much of Biot's effort was directed towards the search for and translation of references to the topics concerned in Chinese treatises and compilations.

Nearly all studies of this vintage were published in learned and academically-oriented journals, including several from national scholarly bodies of renown.[2] Most of these journals were concerned

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[1]Klaproth held a Professorship of Chinese in Berlin, one of two such positions in Germany at the time; see T. H. Barrett, Singular Listlessness: A Short History of Chinese Books and British Scholars (London, Wellsweep, 1989), pp. 73.

[2]e.g. Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences [Paris], Philosophical Transactions of the Royal Society, Memoirs of the Royal Astronomical Society, Mémoires de l'Académie

either with scientific matters or with topics related to China / Asia. There were also a few periodicals that deal with broad areas of human knowledge.[1] Except for Connaissance des Tems, locating these journals should not present much difficulty to researchers from our generation. This, however, cannot be said of the only two publications that did not take the form of journal articles: Klaproth's Lettre à M. le Baron A. de Humboldt sur l'invention de la boussole, and Reeves' "Chinese Names of Stars and Constellations Collected at the Request of the Author of this Dictionary" in Morrison's A Dictionary of the Chinese Language. . ..

10.2 1850-1899 -- STUDY TRENDS

China's astronomical past continued to engage the interest of a number of Western researchers in the latter half of the 19th century, giving rise to a host of studies on the *hsiu* system, astronomical chronology, calendars, and above all to the assembly of catalogues on eclipse observations.[2] It is important, however, to recognise that these were not the only accounts on traditional Chinese science composed during this era. Curiosity in other scientific domains explored by the Chinese yielded a dozen or so items each on mathematics, on the magic mirror, on alchemy and early chemistry, as well as a handful of articles on the magnetic compass, on botanical and zoological topics, and of a general nature.

One of two prominent features exhibited by the literature that emanated from the second half of the 19th century was the serious preoccupation with the issue of origins and emergence, and the repeated comparison of Chinese practices and ideas with those of other cultures. The other dominant strain that linked the diverse

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Impériale des Sciences de St. Petersbourg, Journal of the Asiatic Society of Bengal.

[1]e.g. Journal des Savants, Philosophical Magazine.

[2]Seminal works include: J. B. Biot's "Précis de l'histoire de l'astronomie chinoise", Schlegel's *Sing Chin Khao Youen*; Uranographie chinoise, ou preuves directes que l'astronomie primitive est originaire de la Chine. . ., and catalogues of eclipses by Williams from the 1860s and '70s.

contributions was the continued devotion to unearthing and extracting relevant material from Chinese textual sources, with the resulting summaries or translations often taking up the better part of an account.[1]

Though much of the scholarship from this era is now considered seriously flawed, a few truly earnest and rigorous attempts have resulted in "classics" that are still included in the "must read" list in their respective areas.[2] No matter how one judges these works, when reading and evaluating them, it is best that they be viewed against the light of other Western publications of the same age on China, and also of Western notions and practical measures taken towards the study of that country in those days.[3]

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[1]On several occasions, other approaches towards the comprehension of traditional Chinese science were also pursued, as seen, for instance, in works on magic mirrors and in the French and German translations of Wylie's "Jottings on the Science of the Chinese; Arithmetic".

[2]e.g. Julien and Champion's Industries anciennes et modernes de l'empire chinois, d'après des notices traduites du chinois. . ., Edkins' "Phases in the Development of Tauism", Martin's "Alchemy in China", Wylie's "Jottings on the Science of the Chinese; Arithmetic", studies on indeterminate analysis by Mattheisen, de Mély's Les lapidaires chinois, and most notably Bretschneider's "On the Study and Value of Chinese Botanical Works, with Notes on the History of Plants and Geographical Botany from Chinese Sources", and his "Botanicon Sinicum: Notes on Chinese Botany from Native and Western Sources".

[3]Reconstructing study trends and comparing writings treated in the present survey with those in the larger fields to which they belong are undoubtedly intriguing -- and the answers important. Unfortunately, it also involves straying far and deep into little-studied or controversial spheres if meaningful responses are to be prepared. To avoid veering off our course, I have therefore to be content with merely suggesting elements to consider, and in supplying titles that bear on these issues in *Appendices: (i) Works Consulted.*

Consider, for instance, the following comments: Not "all Western writing on Far Eastern history [from the 19th century] has been worthless. Much of it has been useful, some of it very good indeed; but for the most part it has been valuable as a means of introducing the subject to the Western reader, rather than in the stricter sense of making 'a new contribution to knowledge'. . . . Far Eastern history was not a subject worth serious study. It was left to the men who went there -- and few of them could avoid being either complacent or patronizing about it": E. G. Pulleyblank, and W. G.

10.3 1850-1899 -- PARTICIPATING COUNTRIES AND INDIVIDUALS

As with a fair number of 19th century Westerners who wrote about China's past and present, Wylie and Edkins did not restrict their research efforts and attention to a special cluster of literature, themes or activities. But unlike others, they delved deep into various topics connected with the history of Chinese observations and understanding in the realm of science and produced several seminal accounts in these areas.[1] Yet it was not solely on account of their endeavour that contributions from the U.K. stood out. Material related to astronomy from such researchers as Williams, Russell, Hosie, Kingsmill, Chalmers, and Parker made up a significant portion of historical writing on Chinese science in this period. In addition, their fellow countrymen expressed an interest in other topics (e.g. magic mirrors).

Astronomy also fascinated the French, but they spent time on other branches of Chinese science as well. Thus, while publications

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Beasley, "Introduction," in Historians of China and Japan, ed. E. G. Pulleyblank, and W. G. Beasley (London: Oxford UP, 1961), pp. 21.

For a splendid account of the development of Chinese studies in Britain (and other Western countries) from the earliest days to the present, especially with regard to institutional aspects -- government support and funding, establishment of professorships, building library collections and resources -- and the personalities involved, *see* Barrett's Singular Listlessness: A Short History of Chinese Books and British Scholars.

One learns, for example, from Barrett of the following developments in the mid-late 19th century: "The late Victorian and Edwardian eras saw the establishment of further chairs at other universities and the expansion of Britain's Chinese collections in a number of public and private libraries. Government service rather than missionary endeavour now became the principle incentive in bringing about expansion, but it is also possible to see continuities between these two phases of growth. . . . His [i.e. James Legge's] eventual installation at Oxford as Professor of Chinese in 1876, though it marked in some ways a new era in British sinology. . . also showed a marked continuity with the past. For it was still not the university which saw any need of a Professor of Chinese; rather Legge's friends clubbed together to provide for the Chair. . . . By way of comparison it may be noted that even Belgium had installed a sinologist in a university chair some years before this": Barrett, Singular Listlessness, pp. 75-76.

[1]Aspects of traditional Chinese science discussed by Wylie include mathematics, astronomy, mineralogy, and the magnetic compass; and that by Edkins include astronomy, alchemy, mathematics, and distillation.

by Gaubil and Sédillot on astronomy were noteworthy, so were accounts by de Mély (mineralogy, early chemistry), Berthelot (mineralogy), and by other French scholars on the abacus and on magic mirrors.

Germany's involvement -- on a smaller scale than that of the British and French at this stage -- consisted primarily of the pursuit of astronomical themes, and of studies by Mattheisen in mathematics.

Inquiries from this half-century were undertaken by a group which was quite diverse in terms of professional careers: there were physicians (e.g. MacGowan, Bretschneider), missionaries (e.g. Gaubil, Wylie, Edkins), academics (e.g. Schlegel, Russell) as well as government officials (e.g. Davis, Vissière). Some were trained in the sciences (e.g. Smith, Williams, Aryton and Perry), and others in Sinological or Oriental studies (e.g. Pauthier, Pfizmaier, Julien). A number possessed some familiarity (in varying degrees) with classical Chinese and traditional Chinese source materials. However, secondary sources and translations were relied upon on certain occasions, as in the case of studies by J. B. Biot and Laplace. But it is a highly significant fact that the vast majority of them shared a common denominator, namely, that of having gone to live and work in China.

10.4 1850-1899 -- FORMS OF PUBLICATION

Not every study from this period was published as a journal article.[1] And those that were did not all appear in Chinese / Asian studies or science periodicals. For example, there were articles on mathematics, astronomy and earth sciences in Journal des Savants, on mathematics in Bulletin de Géographie Historique et Descriptive, and on alchemy in Lucifer. Nevertheless, the vast bulk of essays could be found in these two categories of journals.

[1]e.g. three book-length studies were issued (by Julien and Champion, Schlegel, and de Mély respectively), Chalmer's essay on ancient Chinese astronomy was tucked inside Legge's The Chinese Classics. . ., and one of Mattheisen's papers on indeterminate analysis appeared in Sitzungsberichte der mathematisch-naturwissenschaftlichen Section in der 30. Versammlung deutscher Philologen und Schulmänner in Rostock, 1875.

Chinese / Asian journals had a slight edge over science periodicals in that they supplied somewhat more articles, and the latter were not involved in the *Fundamental Concepts* and *Alchemy* chapters. But in areas where interests were greatest (i.e. mathematics and astronomy), both types of journals were important vehicles. Moreover, the actual number of Chinese / Asian journals concerned was smaller as each frequently carried more than one article.

In characterising these periodicals, whether concerned with China / Asia or with scientific matters, a few common features may be mentioned. Most of them were scholarly and were not restricted to one narrow subject area (e.g. China Review, Journal Asiatique, Nature, Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences [Paris], Bollettino de Bibliografia e di Storia delle Scienze Matematiche e Fisiche).[1] They were often issued by academic institutions or learned societies (e.g. Journal of the American Oriental Society, Proceedings of the Royal Society, Bulletin de la Société Mathematique [de France]). On the whole the periodicals in both groups cannot be called obscure, though the Chinese / Asian titles may be more readily available (as they are "standard" items in any Chinese library collection of long and respectable standing), while one or two science titles such as Rivista Scientifico-industriale delle principali Scoperte ed Invenzioni fatti nelle Scienze e nelle Industrie are off the beaten track. Note also that half of the fourteen Chinese / Asian studies journals involved were published in Asia (e.g. Journal of the North China Branch of the Royal Asiatic Society, Journal of the Peking Oriental Society, Transactions of the Asiatic Society of Japan).

10.5 1900-1949 -- STUDY TRENDS

Output and historiographic trends from the first half of the 20th century bore signs that often indicate that a field of study was in transition from one phase to another: on offer was an intriguing

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[1]There were, nevertheless, several science titles that specialised in a particular branch of science (e.g. [Crelle's] Journal für die reine und angewandte Mathematik, Numismatic Chronicle, Monthly Notices of the Royal Astronomical Society, Copernicus).

blend of old and new as well as a good mixture of broad and narrow.

For one, in moving forward from the first to the second quarter of the century there was a discreet but unmistakable sense that the ground had shifted and the surroundings undergone alterations. An appraisal of the value and extent of Western contribution to the study of traditional Chinese science in the *first* quarter depends much -- though by no means exclusively -- on the grades one awards to the products of a few researchers: the large volume of mathematics papers by Van Hée and astronomy literature by de Saussure, and the handful of extensive studies by Laufer on topics related to Chinese understanding of minerals, animals and optical lenses.[1]

Though not without its own leading figures (e.g. Eberhard, Hartner, Davis), it is more difficult and dangerous to characterise and rate the historical scholarship created in the *second* quarter of the 20th century by fastening one's attention primarily on a small cluster of participants and their labour. Except for mathematics, in every major branch of the sciences, the base -- and arguably ambitions as well -- had widened. One witnessed considerably more publications, more contributors, more new Chinese sources being utilised, and more memorable inquiries in the 1930s and 40s; and the host of new topics explored during this second quarter extended from cartography, metrology, astronomical instruments, to the ensemble of studies by Forke, Tucci, Zen, Bodde, and Needham on the philosophical aspects and essence of Chinese science.

For the half-century as a whole, in seeking to reconstruct Chinese historical experiences and ideas in scientific domains, researchers sometimes aimed rather narrowly at single events or themes, but at other times cast the net over generous areas and essayed the portrayal of broad tracts. Works on plants and animals and publications on the philosophical foundations of scientific thought represented the two furthest points on this scale respectively, with the former concentrating neatly on specific species and the latter communicating sweeping remarks.

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[1]Nevertheless, the picture would not be complete and the assessment not balanced if one fails to recall the dozen or so short accounts by various individuals on alchemy as well as such works as Edmunds' "Science among the Chinese", and Herrmann's "Die Westländer in der chinesischen Kartographie".

Furthermore, those responsible for biology-related topics often had in mind particular texts or emphasized documentary sources of various sorts, while themes or problems -- say, the magnetic compass or the *ch'ih* measure -- were chosen instead as focal points by those who wrote general accounts and in studies on fundamental concepts and on physics. We have also come across chapters with a combination of issue-oriented works (e.g. on origins of Chinese alchemy, or on the explanation of a particular mathematical technique) and accounts that dwell on specific treatises or groups of records (e.g. the *Ts'an t'ung ch'i*, meteorological records in Shang oracle bones). Biographical and bibliographical treatments were attempted only on rare occasions, but the initiation of these efforts -- especially the compilation of bibliographies -- is worth noting.

Above all, origins, dating, and comparisons with similar experiences in other cultures assumed a very important dimension in the literature on alchemy, on the essential components in traditional Chinese scientific thinking, and in general works -- and to some extent in the astronomy and earth sciences repertories as well. And of the vast store of knowledge of the natural and physical world possessed by the Chinese and the experiments they conducted in the past, most frequently selected as subjects of study were those categories easily recognisable as either resembling activities cultivated and developed in Western and other civilisations (and which the Chinese might have undertaken earlier and better than anybody else) or that have always intrigued the Western mind. Thus among the more popular topics in the historiography of this period were observations of celestial phenomena, alchemical operations (in particular those that involved metals, minerals and chemical processes), certain plants, animals, and minerals known to the West, and map-making.[1]

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[1]This phenomenon was apparently consistent with other types of Western (at least American) historical writing on China from the same period. According to Paul A. Cohen, "up through World War II, American writing tended to stress those aspects of the recent Chinese past with which the West itself had been most immediately concerned: the Opium War, the Taiping uprising, . . .the missionary enterprise, Japanese aggression, and so on": Paul A. Cohen, *Discovering History in China: American Historical Writing on the Recent Chinese Past* (New York: Columbia UP, 1984), pp. 1.

Cohen goes on to articulate what he considers to be the likely explanation: "This emphasis on the more Western-related facets of

Nevertheless, in the more established areas of study such as astronomy, alchemy and mathematics, a more critical and discriminating handling of the subject matter surfaced occasionally. On the whole, however, studies from the first half of the 20th century were descriptive rather than interpretative; more often than not publications were linear accounts that strove to report, translate, and highlight episodes and statements as recorded in Chinese historical materials.

With hindsight, one may be tempted to criticize this period's contributions for their general indifference to certain key questions; for instance: what the Chinese practitioners themselves considered to be issues of weight and substance (conceptually, ideologically or practically); whether there were other activities that consumed the energies of ordinary people, government officials, and scholars; whether the treatise or topic isolated for study was but one among the many complex writings and shifting elements that figured in the Chinese scientific traditions and enterprise. Furthermore, new generations of readers may suspect that the research was motivated (consciously or unwittingly) by the authors' interest in determining whether the performances of the Chinese were achievements or failures -- or a mixture as in the case of Van Hée and de Saussure -- and that it was guided by the assumption that the pattern of traditional knowledge (scientific and otherwise) acquired and exhibited by the Chinese should best judged according to contemporary Western standards and conceptual frameworks.

These are indeed legitimate observations and must not be glossed over. It is, however, equally important that one be realistic and reasonable in one's expectations: after all, if one believes in seeking the appreciation of the experience of the Chinese and the theories they espoused on their own terms and not some foreign or later-day standards, should one not also assess these early 20th

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Chinese history was partly a consequence of the inability of most American scholars to handle Chinese sources and the inaccessibility, in any case, of important collections of these sources. It was also a result of an intellectual bias that equated *modern* with *Western* and *Western* with *important*. For many Americans of this era, even educated ones, Westernized China and modern China were indistinguishable": Cohen, Discovering History, pp. 2.

century Western publications in the light of what was customarily practised when studying other areas of Chinese culture and in the history of science in those days?[1] I share Needham's sensitivity when commenting on Forke's The World-Conception of the Chinese: Their Astronomical, Cosmological and Physico-Philosophical Speculations: "what we miss most in his book is a critical evaluation of the worth of the Chinese ideas from the standpoint of a mind trained in the natural sciences; this no one at that time was in a position to give."[2]

Of course, saying that a work belongs squarely to certain historiographical trends prevalent at the time may or may not imply that it bears reading *today*: much depends on the merits of that tradition as well as the demands of today. Whatever the case may be, as already indicated, our understanding of past scholarship stands to profit greatly from learning more about the circumstances under which the works were written.[3]

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[1]Otherwise we may run the risk of laying ourselves open to the same charge we accuse some early-mid 20th century Western scholars of levelling at practitioners of Chinese science in early times -- namely, that of criticizing others for failing to achieve a goal they did not intend, were not quite ready for, or hoped to pursue at a particular stage.

[2]Science and Civilisation in China, vol. 2, pp. 216.

[3]So far as the early-mid 20th century is concerned, a crucial question to ask is the extent to which the dramas that were rapidly unfolding in China and Japan (and indeed the whole world) throughout the first half of the 20th century influenced and altered scholarly as well as popular views towards these two East Asian countries. On the one hand, not only did political upheavals, socio-economic changes, and the accompanying shifts in international relationships took place on an unprecedented scale, they were further heightened by exciting archaeological discoveries early in the century and a growing appreciation for Chinese and Japanese art in certain segments in the West. On the other hand, the time involved, the manner in which these experiences and changes were funnelled, filtered, and absorbed by various Western communities, translated into research concepts and finally crystallised into actual publications must be complex. How did all these developments affect the study of topics (such as traditional Chinese science) which stirred the imagination of only a few or were not perceived as ones that had any practical connections and relevance? Were the influences marginal?

Another important factor to recognise is that Chinese studies in various Western countries continued to develop along different paths and manifest different characteristics. Consider the following

To sum up then, did the nature, outlook and methodological approach of the literature from the first half of the 20th century differ substantially from that of the previous century?

Broadly speaking, they did not undergo a radical transformation: it is more appropriate and helpful to consider the period as a transitional phase. The historiographical pattern woven before the mid-point of the present century still maintained visible ties with that of the late 19th century. Literature aimed at registering, cataloguing, and translating, at reckoning age and ancestry, at providing a sense of the dominant traits of various branches of

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comments from Barrett: ". . .Britain's Chinese collections on the eve of the First World War presented a sorry contrast to those of France. The Bibliothèque Nationale in 1913 possessed not only the most complete collection of Chinese books outside the Far East but also a worthwhile published catalogue of its holdings -- in Pelliot's judgement the first serious catalogue in Europe. And not only that: at a time when Giles and Backhouse represented the best that British sinology had to offer, a generation of French scholars were making use of these library resources in Paris to give French such a commanding lead in the academic study of China that in some areas their achievements have not been bettered even today. . . . At the start of this century only France possessed any lengthy tradition of professional scholarship in Chinese studies, but other nations of continental Europe soon established schools of sinology which vied with that of Paris in their commitment to the highest academic standards. Otto Franke (1862-1949) in Germany and J.J.L. Duyvendak (1889-1954) in the Netherlands did pass some of the earlier days of their careers in consular services, but by the end of the ~~Frist~~ First World War were both full time scholars; Bernhard Karlgren (1889-1978) in Sweden appears to have enjoyed this status throughout. By contrast, Britain was still appointing superannuated old China hands, when its universities bothered to make any appointments at all. . . . The origins of Chinese studies in the United States may, like our own, be traced back into the nineteenth century, but almost from the start very marked differences from the pattern of development in this country became apparent. . . . By the Second World War Chicago and Pennsylvania had joined the select group of American universities [i.e. Harvard, Yale, Berkeley, Columbia] with full programmes in Chinese studies. . . and some American professional sinologists. . . had already found posts in these institutions. But it was Europe, especially France and Holland, which set the standards, and it was to men like Pelliot that the promoters of American sinology turned for advice on librarianship in particular. Academics with a missionary background. . . might also be found in American universities at this time, but hardly dominated the scene to the same extent as in Britain": Barrett, Singular Listlessness, pp. 89-91, 93, 96. Were these differences reflected in the way French, British and American scholars tackled themes in traditional Chinese science? Bear in mind that not only Sinologists studied the subject.

scientific experience, and at applying traditional Chinese knowledge to enhance the store of contemporary scientific information still flourished. Nevertheless, while threads from former times were often eagerly taken up by a number of new investigators, it should also be recognised that horizons were beginning to widen, interesting questions were opened up, treatments and tactics were more varied, the advantages of re-examining old concerns in a less conventional light was subtly acknowledged, and the distant rumbling of a new impetus could be dimly heard.

10.6 1900-1949 -- PARTICIPATING COUNTRIES AND INDIVIDUALS

It is worth beginning our country review by highlighting two key elements: first, the invaluable contributions made by Dutch, Italian, Belgian, and other researchers outside Britain, France, Germany, and America.[1] In the first half of the 20th century, these other studies were of such importance that failure to record them or to accord them full recognition would be unpardonable. Several names stood out: de Saussure from Switzerland, who illuminated a corner of Chinese traditional astronomy which had hitherto been shrouded in darkness; the Japanese mathematician Mikami whose The Development of Mathematics in China and Japan shaped Western understanding of the history of Chinese mathematics for over a generation; Van Hée, the Dutch Jesuit, who also made intense efforts in the field of mathematics. Another scholar from the Netherlands, the Sinologist Duyvendak, studied aspects of astronomy and the earth sciences. Literature from Italy on various disciplines, written by Vacca, Tucci, Loria, Bertilli, and Muccioli, also played a part in the evolution of Western scholarly interest in traditional Chinese science. So did works by Kühnert (from Austria), by Barnes on alchemy and by Rufus on astronomy (both from Canada), and by Michel (from Belgium) on the contro-

[1]In the "Participating Countries and Individuals" section of each chapter, generally only scholarship from these four countries receives dedicated treatment, though studies from elsewhere are always mentioned and given due credit. This is not because British, French, German, and American works are regarded as more deserving; it is due more to the simple fact that collectively, these publications were ones that regularly supplied the bulk and coherence.

versial *hsüan chi*.

The second distinctive development was the greatly expanded activities from the U.S. As though trying to make up for past neglect, American contributions were evident in almost every main branch of Chinese science. Consider, for instance, the works of Bodde (general works), Smith (mathematics), Lundmark (astronomy), Hirth (earth sciences), Yao (earth sciences), Hagerty and Reynolds (plants), Laufer (various), and Goodrich (various). Alchemy was particularly well served by the American contingent, with accounts by Johnson, Davis, and Wilson. Nevertheless, impressive as their publications were in both quality and quantity, initiatives made by American scholars did not eclipse those from other countries.

Research efforts from the U.K. remained strong and fairly varied, beginning with studies by Stein (physics), Partington (alchemy), Giles (earth sciences), Soothill (earth sciences), Chatley (general works, astronomy, alchemy), and continued by discussions from Moule (earth sciences, biology), Waley (alchemy), Dubs (astronomy, alchemy), Schove (astronomy), and Needham (general works).[1]

Support given by the Germans in this period was not inconsiderable. The majority of their works dealt with astronomy, and was written by Eberhard, Hartner, etc. Among other German contributors were Forke (fundamental concepts), Erkes (earth sciences, biology), Herrmann (earth sciences), von Lippmann, Hiordthal (alchemy and early chemistry).

Maspero's treatises on Chinese astronomy were unparalleled; articles by Pelliot and Demiéville -- awe-inspiring names to students of Sinology -- were featured; and French interest in Chinese understanding of plants was displayed in such work as Liou-Ho and Roux's Aperçu bibliographique sur les anciens traités chinois de botanique, d'agriculture, de sericulture et de fungiculture. But compared to their involvement in the previous century and to the attention paid to the subject by their British and American counterparts, the role assumed by French scholars in this half-century was less robust.

Interests in this half-century were generated by persons whose

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[1]Dubs, "a missionary scholar of wide experience and varied attainments", was an American who took the chair in Chinese at Oxford in 1947: Barrett, Singular Listlessness, pp. 104.

professional background was different from that possessed by those operating chiefly during the latter part of the 19th-century -- but not entirely so. One still encountered a small band that spent a significant amount of time in China (e.g. Smith, Ferguson, Chatley, and Van Hée).[1] But in contrast to the former situation, here researchers frequently held academically-related positions; most had teaching responsibilities in universities, including several who taught in China (e.g. Edmunds, Barnes).[2] Those specialising in Sinological or Asian matters had an important part to play.[3] And alongside the Sinologists were a fair number of individuals with a background in the sciences.[4] But as with former times, the picture was anything but plain and simple black-and-white. Coming immediately to mind are individuals with careers outside academe (e.g. Hommel, Hagerty, Van Hée, Chatley) or who did not pursue research primarily in Sinology or the sciences (e.g. de Saussure, Stein).

Our curiosity in the disciplines in which the authors were trained and their professions stems partly from the suspicion that the information could throw light on differences in approaches or the selection of topics. In the period under consideration it did not appear that there were two or three distinct camps, each pitched at opposite corners of the field; for instance, with the Sinological experts preoccupied solely with textual exegesis, and the scientists busy with rendering the scientific content of mathematical or alchemical techniques into the language of modern science. Features and frames of reference characteristic and prevalent in the historiography of this era had advocates in all parties.

Nevertheless, as suggested in the appropriate chapters, some

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[1]According to Pulleyblank and Beasley, those that did *not* reside in China were "more conscious than their predecessors of being 'academic', a gain in the quality of detachment which may well be balanced by a loss in that of human experience": Pulleyblank and Beasley, "Introduction," pp. 22.

[2]But Laufer and White were museum curators, and Schove was a school master.

[3]e.g. Moule, Eberhard, Dubs.

[4]Among the scientists were the prominent historians of chemistry Partington and Von Lippmann.

individuals might have viewed the issues and topics from particular vantage points partly as a result of their specialisation and professional interests (e.g. de Saussure, Van Hée, Davis). Moreover, alchemy and early chemistry was the favourite choice among those with a chemistry background.[1]

10.7 1900-1949 -- FORMS OF PUBLICATION

To understand the types of periodicals in which the articles from this half-century were published, it is helpful to recall that Sinologists and scientists were the most prominent contributors, and that the first group out-numbered the second by a narrow margin. These circumstances probably explain the heavy concentration of journals belonging to either the Chinese / Asian studies field or science disciplines.

But factors leading to the publication of an article in one but not another journal are complex.[2] Hence when questioned about the relative importance of these two categories of periodicals, it is not possible to offer conclusive answers:

(1) Only in alchemy did science periodicals gain a lead over Chinese / Asian studies journals; in all other chapters the latter were chosen more or equally often.

(2) Science periodicals were not selected in *General Works*, and only once each in *Physics* and *Fundamental Concepts.*

(3) On the whole, slightly more Sinologists published their works in non-Chinese periodicals than scientists in Chinese journals.[3] One

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[1]This is not to say that Sinologists did not also write on alchemy, or few scientists wrote on other aspects of Chinese science.

[2]The process is often the result of a combination of an author's preference and place of work, publication policies of journals, deadlines, sheer convenience, and other variables not necessarily within one's control.

[3]For instance, on the Sinologists side: Dubs' "The Beginnings of Alchemy" in Isis; Goodrich's notes on the use of abacus in Isis; Duyvendak's "Further Data bearing on the Identification of the Crab Nebula with the Supernova of 1054 A.D." in Publications of the Astronomical Society of the Pacific; Eberhard's "Das astronomische Weltbild im alten China" in Naturwissenschaften; Rudolph's "The Jumar in China" in Isis.

would have taken this to mean that Chinese / Asian journals appeared less, not more, regularly -- but this was not the case.
(4) Studies by Van Hée and de Saussure can be found in Chinese journals (mainly T'oung Pao), but also in science as well as history of science periodicals.

The number of Chinese / Asian studies journals used in this period rose considerably, and only four from the previous half-century re-appeared.[1] But certain past characteristics also apply here. First, the recurrence of the same title in a single or multiple chapters. T'oung Pao was by far the most popular, with nine articles in *Mathematics*, twenty in *Astronomy*, six in *Earth Sciences*, two in *Physics*, and three in *Biology*. Other titles frequently encountered include: Monumenta Serica, Harvard Journal of Asiatic Studies, Journal of the North China Branch of the Royal Asiatic Society, and China Journal of Science and Arts. Second, most were academically-oriented, with a focus primarily on textual or other types of scholarly research (e.g. Asia Major, Bulletin de l'École Française d'Extrême-Orient, Ostasiatische Zeitschrift, Bulletin of the Museum of Far Eastern Antiquities). Third, they are generally well-known titles that no one then or now should experience too much difficulty in verifying or locating.[2]

Science periodicals, on the other hand, exhibited more diversity -- partly because of the simple reason that the total number and kinds of science journals on the market have always been much greater. Repeatedly chosen were titles devoted to a particular discipline or concern (e.g. Bibliotheca Mathematica, Journal of the Royal

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As for the scientists: Chatley's papers on astronomy appeared in four different Chinese journals; Fung and Collier's "A Sung Dynasty Alchemical Treatise: 'Outline of Alchemical Prescriptions' by Tu-ku T'ao", and Spooner's "Chinese Alchemy" both in Journal of the West China Border Research Society; Davis and Ch'en's "Shang-yang Tzu, Taoist Writer and Commentator on Alchemy" in Harvard Journal of Asiatic Studies.

[1]The four being: Journal of the North China Branch of the Royal Asiatic Society, Journal of the American Oriental Society, Journal Asiatique, and T'oung Pao.

[2]Possible exceptions are: Geist des Osten and Revue Indochinoise.

Astronomical Society of Canada, Meteorological Journal, Journal of Chemical Education), but those with broader bearings also had a small share (e.g. Revue des Questions Scientifiques, Scientific Monthly, Association Français pour l'Avancement des Sciences. Comptes Rendus. . .). It was rare for articles on diverse subject areas to surface in a single science periodical, although within a given chapter one journal might have delivered several papers.[1] As to be expected, academic and scholarly journals were very much favoured (e.g. Sitzungsberichte der philosophie-historie Klasse der preussischen Akademie der Wissenschaften, Bollettino della Società Geografia Italiana), but also present were a few titles that appealed to a wider audience (e.g. Geographical Teacher, Popular Astronomy). Relatively obscure titles such as Zeitschrift für Säugetierkunde and Nucleus reared their heads several times.

More exciting, perhaps, was the involvement of history of science journals, which began to claim a place in all chapters. Isis was of singular importance among the dozen or so titles.[2] Archives Internationales d'Histoire des Sciences (which superceded Archeion and Archivo di Storia della Scienza) was also chosen on a number of occasions.[3]

In spite of the preponderance of the above groups of periodicals (i.e. Chinese / Asian, science, and history of science), this was by no means the whole story: to tell it in full requires taking serious note of three other elements. First, a small number of articles appeared in periodicals that extended from Quaderni di Sintesi, Archiv für Geschichte der Philosophie, to Proceedings of the American Academy of Arts and Sciences, Forschungen und Fortschritte, Bulletin

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[1]Nature published short communications in astronomy and alchemy, and Popular Science Monthly had an article on fundamental concepts and one on mathematics.

[2]Isis carried thirteen articles and notes relating to four different branches of traditional Chinese science during the first half of the 20th century, including six on alchemy by Wu, Davis, Spooner, and Dubs.

[3]Other history of science periodicals ranged from Archives des Sciences Physiques et Naturelles, Quellen und Studien zur Geschichte der Mathematik (B. Astronomie und Physik) to Journal of the Alchemical Society.

des Musées Royaux d'Art et d'Histoire, Mercure de France, and Revue Archéologique.

Second, eleven essays and papers were published in a variety of festschriften, conference proceedings, or collected works with multiple authors. It would take a library extraordinarily well-stocked in materials in different European languages in the fields of Chinese studies, history of science, and perhaps anthropology and archaeology, to supply all these works.[1]

Third, we come to studies that were not first published as articles in periodicals or collective works. Articles remained so overwhelmingly important throughout the early half of the century that it is difficult for one to attach much significance to the fact that some dozen or so works were issued in the form of monographs. Nevertheless, this was another new development that should not be left out of the record. And even here, variety was evident. Some (e.g. Bodde's China's Gifts to the West, Rufus and Tien's The Soochow Astronomical Chart, Needham's Science and Society in Ancient China) are rather slender, while others (e.g. Mikami's The Development of Mathematics in China and Japan, Johnson's A Study of Chinese Alchemy) are full-length books. And some probably can be considered of more substance than others.

10.8 1950-1985 -- STUDY TRENDS

Composing headlines for the tale of Western writing and interest in traditional Chinese science in the latter half of the 20th century should not be difficult: there were exciting changes on all fronts and no lack of heroic moments. And no headline or story can ignore the following features: (1) the spectacular growth in the

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[1]Consider, for instance, Beiträge aus der Geschichte der Chemie dem gedächtnis von Georg W. A. Kahlbaum; Scientific Japan; Past and Present; prepared in connection with the Third Pan-Pacific Science Congress, Tokyo, 1926; Manule di storia della scienza. Antichità; Reflections on Our Age; Lectures delivered at the Opening Session of UNESCO at the Sorbonne University; Chinese Clay Figures: Part I, Prolegomena on the History of Defensive Armor; Southern Tibet; Discoveries in Former Times compared with my own Researches in 1906--1908; Le Lin-Yi; sa localisation, sa contribution à la formation du Champa, et ses liens avec la Chine; Frühling und Herbst des Lü Bu-We.

number of publications on all branches of Chinese science; (2) a degree of scholarly sophistication and seriousness that had never before been displayed on such a wide scale; (3) findings, conclusions, and arguments that were strikingly at variance with those from earlier periods; (4) the impact made by Needham's contributions, in particular the Science and Civilisation in China series; (5) the emergence of a group of new investigators specialising in the history of Chinese science.

What follows is an attempt to elaborate on these generalisations and to translate them into more concrete terms.

One of the most impressive and distinctive aspects of post-1950 historiography was the sheer range and variety of topics and themes being explored, many of which were entirely new and some perhaps considered rather unconventional when they first made their appearance.[1] Various issues and concerns raised in the past were, nevertheless, not forgotten, as was evident in inquiries into records of eclipses, the magnetic compass, and the origins of Chinese alchemy.

Parallel to this substantial broadening of scope in the areas selected for investigation was an expansion and diversification in sources and types of material on which supporting evidence was based. Everywhere one turned, one was presented with new documents and references, may it be Pai Chü-i's poems or the *Hsi yu chi* in studies on alchemy, or the *Chiu huang p'en ts'ao* in botany, or the numerous hitherto untapped historical records from which observations of comets and supernovae were culled.

Heterogenity was also apparent in other ways. Some scholars preferred to work on vast canvases and encompassed an array of information or various classes of material; others chose to stay close to a well-defined path, dissecting strands, untangling snarls,

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[1]Some of the best and strongest indications could be seen in the new questions and aspects addressed in studies on the underlying concepts and general characteristics of Chinese science; there were certainly others, including whole sub-fields such as *nei tan*, acoustics, and geometry as well as single elements such as specific maps, and traditional ideas regarding evolution.

and offering focused treatments.[1]

In addition, increased attention was paid to accounting for the rationale underlying the historical developments. Besides items in the chapter on fundamental concepts, philosophy, social and cultural relations that concentrate specifically on this issue, one can point to such discussions as Elvin's "Skills and Resources in Late Traditional China", and Sivin's "Cosmos and Computation in Early Chinese Mathematical Astronomy".

Furthermore, the simple gathering and matter-of-fact translation of textual information was no longer deemed by everyone active in the field as the best or only viable way to write about Chinese scientific endeavours and ideas, although this remained the favoured approach of several investigators, especially a few who wrote on plants and animals. Even in literature in which the translation of Chinese writings is a vital component, most authors have gone to great lengths to formulate innovative means to elicit more precise meanings and to unlock hidden or subtle connotations, especially those that lurk behind technical terms.[2] Other genres as well as modes and methodologies of carrying out historical investigations were attempted and thoughtfully pursued. For instance, bibliographically-oriented works were issued by those exploring mathematics, astronomy, and plant and animal worlds. Archaeological findings were seized upon in the areas of cartography, acoustics, and cosmology. Sociological strategies were particularly prominent in works treated in *Fundamental Concepts* and in studies such as Strickmann's "On the Alchemy of T'ao Hung-ching". And in the chapter on general works we have seen various new mechanisms that were conceived in the second half of the 20th century, from accounts on study trends and informa-

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[1]Pictures painted on very large scales include the "cultural histories" of various animals by Schafer and Van Gulik. Accounts that carried the latter kind of orientation included Berriman's "Sumerian Weight-Standard in Chinese Metrology during the Former Han Dynasty (206 B.C. - A.D. 23), Cullen's "An Eighth Century Chinese Table of Tangents", and Butler, Glidewell, and Needham's "The Solubilisation of Cinnabar; Explanation of a Sixth-Century Chinese Alchemical Recipe".

[2]Graham and Sivin's "A Systematic Approach to Mohist Optics" is a good example; another is Wagner's studies on Liu Hui's commentary on the <u>Chiu chang suan shu</u>.

tion sources, directories of researchers, to the compilation of essay collections.[1]

But even after all this, we have yet to mention what was arguably the most gripping and head-turning development witnessed in this period.

Broadly speaking, Western scholars in the past either rarely offered evidence and reasoning that were persuasive, consistent and potent enough to fully convince those not in the know that various scientific operations of the Chinese should be credited with long and distinguished lineages, or they themselves did not hold entirely favourable opinions towards the Chinese. Much of that changed with a new community of researchers. Led by none other than Needham -- possibly the greatest single influence on the development of research into Chinese science worldwide in the past couple of centuries -- they regarded it as their mission to strive and prove the creativity and originality of the Chinese, especially by demonstrating that Chinese efforts antedated similar discoveries and activities in other cultures.[2] And the success these Western scholars attained in their endeavour, singly as well as collectively, was nothing less than phenomenal. To convert non-believers, every tool was employed to expose past inattentiveness and weaknesses of past arguments: new source materials, new readings and interpretations, frequently utilising a combination of Sinological expertise, mastery of modern scientific practices and ideas, and an understanding of the historical progress of Western science. In confronting the issue of Chinese

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[1]Several individual examples of innovative devices and approaches may also be mentioned: Ho's "On the Dating of Taoist Alchemical Texts" has provided assistance to so many thorny problems that every student of Chinese alchemy owes the author a debt of gratitude; Sleeswyk and Sivin's study of the seismoscope has combined new reading of the crucial passage, archaeological discoveries, and a reconstruction of the instrument; Teboul's use of computational analysis and modern mathematical equations has helped make his textual research and translations more compelling and lucid.

[2]Consider, not only Science and Civilisation in China, the writings of Needham, and the many publications by Ho on numerous topics, but also, for example, studies by Wang Ling and Lam on mathematics, by Stephenson on astronomy, down to the three general books for laymen, and the article by McClain with the eye-catching title of "Babylonian Biophysics in Ancient China" published as recently as 1985.

priorities, ancestry and influences, never before had so many researchers been so formidably equipped. It cannot be denied that these carefully crafted and determined efforts played a critical -- though not exclusive -- role in catapulting Chinese history of science into an area of study that became increasingly systematic, recognisable, and respected.

At the same time, another momentous development was afoot, especially towards the third quarter of the century, that paradoxically experimented with moving away from this preoccupation with precusors and antecedents. Serious consideration was given to the possibility of studying the history of Chinese science without plunging headlong into the "who-did-it-first" debate and taking issue with one side or the other, and without limiting inquiries to matters of contemporary interest or utility. Certain specialists began to define the problem at hand in what can be called a more "contextual" manner: they were more concerned with identifying and shedding light on elements that were regarded as important to the Chinese themselves then, in explaining Chinese activities and concepts in terms of notions and forms of knowledge about the natural world held at the time.[1] In the overall picture, those who consistently advocated these alternative goals and objectives were still in the minority. But their works -- as with most works written by those in the minority -- are just as interesting and revealing, and require just as much attention. Indeed, a case can conceivably be made that more so than those that viewed the subjects under study essentially through modern Western lenses in order to ascribe "firsts" (and therefore successes and achievements) to the Chinese or uncover useful information for scientists of our times, this smaller group of publications, by nature more innovative in its functions, perspectives, and historiographical outlook, truly heralded an attempt to break with past pat-

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[1]e.g. in *Earth Sciences*: Major's "Notes on the Nomenclature of Winds and Directions in the Early Han", Bennett's papers on topographical siting, and Schafer's "The Transcendent Vitamin: Efflorescence of *lang-kan*"; in *Alchemy*: Baldrian-Hussein's Procédés secrets du joyau magique: traité d'alchimie taoiste du XIe siècle; in *Physics*: Loewe's "The Measurement of Grain during the Han Period". The said approach was above all most forcefully and systematically articulated in essays by Sivin in *Fundamental Concepts*, and in his discourses on various subjects elsewhere.

terns.

It pays to remember, nevertheless, that the situation was a complex one. There were sub-groups and variations on the same theme, and very often it was a matter of emphasis. Histories written in this period may belong squarely to one of the two types described above, or to none, or to a combination. For example, a kind of study to be heard from occasionally was that which was critical of works portraying outstanding scientific progress made in ancient and mediaeval China, yet not so much because they sought to avoid the priority-hunting course, but rather to contend the claims of Chinese ingenuity.[1] And though the vast majority of publications are most usefully seen against the light of one or the other kind of convention and category, some of the best works are ultimately unclassifiable.[2]

The previous comments regarding the fastening of attention on first manifestations serve as a convenient entry point to our next observation, namely, that shifts in the historiographical trends and practices were perhaps not as revolutionary, complete, and absolute as they might appear at first glance.

At least in one important aspect literature from the second half of the 20th century inherited traits exhibited in earlier decades. The keen interest -- at times bordering almost on obsession -- in precedents, ancestry and influences in post-1950 works was so obvious that though an author's motivations and intentions in conducting a study were not always advertised and stated openly, it could not escape anyone's notice that this element, so patently embedded in earlier writing, not only managed to survive, but flourished. Very different channels and supporting evidence were employed, and the conclusions advanced were much more convincing, but a

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[1]Such approach was manifested in Qian's The Great Inertia: Scientific Stagnation in Traditional China, and could also be seen, for instance, in Cammann's accounts on magic squares.

[2]Libbrecht's highly praised and important Chinese Mathematics in the Thirteenth Century: The *Shu-shu chiu-chang* of Ch'in Chiu-shao, for instance, discusses origins and primacy of discovery while at the same time displaying a sensitivity towards the purpose and evolution of scientific practices or mathematical innovations based on cultural considerations and prevailing conditions.

good portion of the new generation of specialists remained attached to this familiar exercise, whether the aim was to serve the needs of modern-day scientists or to heighten the prestige of the Chinese of yester years or both.[1]

Moreover, in spite of the avalanche of material and wealth of approaches, there remained a serious shortage of broad surveys and overviews as well as general synthetic accounts, both introductory and advanced, aimed at tracing and evaluating systematically the formation, historical progress, and significance of an entire branch across a vast stretch of time or on a more ambitious level, traditional Chinese scientific activities and understanding as a whole. Biographical and institutional studies were also pitifully scarce.

One can draw other connections and affinities with the past. Textual sources still acted as focal points and prime targets for all sorts of research operations. Each branch of science continued to march at a pace that was different from the others; the fortunes each experienced remained varied, and the height they reached by 1985 was far from uniform.

Above all, one can name important elements that were left uncultivated or if given fuller consideration and exploitation, could have led to departures even more fundamental, yielded kinds of histories even more diverse, and brought about a radical re-examination of the field from its foundations. These concerns are wide-ranging, involving materials and resources, topics and themes, formats and genres, methodological tools and perspectives. As they function well as pegs on which to hang discussions on new possibilities, challenges, and apparatus, they have been incorporated into the section *"10.12 Lessons We have Learnt; The Road Ahead"*.[2]

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[1]Going hand in hand with this is the possibility that such research would face the same type of limitations and handicaps that afflicted earlier studies -- a question we have asked once already of pre-1950 publications.

[2]Another issue that is raised in that sub-section rather than here is historical writing on traditional Chinese science vis à vis that on the history of science and on China in general from the same period.

10.9 1950-1985 -- PARTICIPATING COUNTRIES AND INDIVIDUALS

American researchers can be justifiably proud of their achievement in enhancing research into Chinese science in the post-1950 period. They had a significant presence in every major discipline, though they did not totally dominate any. Their efforts were particularly intensive in the areas of astronomy, alchemy, the earth sciences, and above all, in the explication of the fundamental concepts of the Chinese scientific traditions and the social and cultural relations of Chinese science.

Published views from the U.K. were not confined to those from Needham. There were well-crafted and solidly-researched works from China specialists (e.g. Graham, Loewe, Elvin) as well as scientists (e.g. Butler, Stephenson), and from Cullen, a historian of Chinese science.

Similar observations may be made of the situation in France in that although the actual number of French researchers that have published studies specifically on traditional Chinese science was not large, one encountered important and memorable French contributions in all chapters -- with the exception of *Fundamental Concepts*, and *Physics*.[1]

The attention which German researchers such as Hartner and Maeyama paid to Chinese traditional astronomy was of great consequence to the study of the subject; German activities in the area of mathematics, generated by Vogel, Mahler, and Kogelschatz, are not to be brushed aside; Walraven's bibliographic account "Zoologische illustration in China und Japan" deserves special mention. Nevertheless, in other disciplines and sub-fields German studies had little influence, being limited only to a few short articles in each of the subjects concerned.

As with former times, scholars that worked in other countries are to be commended for augmenting major advances. Indeed, without them, the field would have suffered from a noticeable reduction in the number of publications, and above all, would have been deprived

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[1]For example, publications by Huard in *General Works*; by Martzloff in *Mathematics*; by Teboul and Kalinowsi in *Astronomy*; by Baldrian-Hussein in *Alchemy*; by Métailié in *Biology*.

of certain path-breaking research, fine studies, and accounts that addressed topics which were not previously treated. A list of these countries and some of the representatives include: Australia (Ho, Knight, Wang Ling); Belgium (Belpairé, van Esbroeck, Libbrecht); Canada (Collier, Gillon); Denmark (Wagner); Italy (where nearly ten scholars such as Muccioli, Adamo, Chessa, Pregadio, have expressed interests in astronomy, mathematics, alchemy, or general studies); the Netherlands (van Gulik, Sleeswyk); New Zealand (Bray, Hoe); Switzerland (Hulsewé, Pilleri).[1] And a "non-Western" scholar also took part: Lam from the University of Singapore.

The company of researchers that viewed the history of Chinese science as their main specialty (and whose publications expressly on this subject appeared between 1950 and 1985) was in fact surprisingly small, around a dozen or so all told. But the vibrations they generated cannot be measured merely according to the number of members in the team. They have contributed in a meaningful way to at least one sub-field in all main branches of traditional Chinese science. Their efforts were especially critical in the areas of mathematics, alchemy, fundamental concepts, and in the chapter on general works. In terms of broadness of interest and versatility, Needham reigned supreme, with Ho and Sivin not far behind.[2] And as previously mentioned, erudition and an enviable combination of knowledge in classical Chinese and the history of Chinese culture with advanced training in Western science is their hallmark.

Those whose primary scholarly interest lay in various facets of Chinese culture proved to be crucial in shaping the course of our area of concern in the post-1950 period, particularly in chapters on fundamental concepts, on astronomy, and on biology.[3] Dozens demonstrated their enthusiasm, and not a few of their publications were

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[1]Note that before joining Griffith University in the 1970s, Ho was associated with the University of Malaya.

[2]Needham's works appeared in all chapters; Ho's except in *Physics* and *Biology*; and Sivin's except in *Mathematics* and *Biology*.

[3]Their initiative in the realm of mathematics was least evident.

ground-breaking in one way or another.[1] In regard to the overall weight carried by specialists in the China field, there was therefore little deviation from the pattern that existed in the first half of the century. But apparently the training and scholarly sophistication of China experts from the second half of the 20th century -- at least for America -- was markedly different from that of their predecessors.[2]

One must not lose sight of the service rendered by those who pursued research chiefly in Western sciences: studies from Huard, Stephenson, Sleeswyk, Li Hui-lin, Butler, and Struik, for instance, should not be dismissed. Yet the overall contribution from this group was relatively limited and their general share of the field, compared with that half a century ago, was much reduced. Historians of Western science were also missed. Their interest in Chinese scientific traditions was revealed only in accounts by White, Restivo, and Benfey on fundamental concepts, by Vogel and Swetz on mathematics, and by Hartner and Maeyama on astronomy.

More than ever before, publications on the history of Chinese science were authored systematically by those with full-time careers in the academic arena or with duties that focused on research or education.[3] Although Van Gulik and Mills spent much time in Asian

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[1]Among those who have explored more than one aspect in the Chinese scientific traditions were Dubs, Schafer, Rudolph, Loewe, Walravens, and Elvin.

[2]According to Cohen, it was not until the "the two decades following World War II, building on the foundation laid by a tiny handful of trained historians who had studied in China in the 1930s, [that] a new generation of American China specialists came into being. . ."; and all that went on before that time belonged to "the amateur phase. Much of the work was in the hands of missionaries, diplomats, customs officials, and the like, people with little formal training as scholars and none as historians of China": Cohen, <u>Discovering History</u>, pp. 2. On the other hand, as will be made clear in section 10.12, Cohen also argued that the majority of Chinese historians in America active in the 1950 and '60s writing about 19th and 20th century China held orientations and attitudes similar to those a generation ago.

[3]The majority of them held teaching and research positions at colleges and universities in the West. . There were also staff members of museums and libraries (e.g. Nelson, Knight, Chang, Farrer), and of observatories (e.g. Kiang, Clark).

countries, the former as a diplomat and the latter a judge, gone were the days when traditional Chinese science was little more than side projects -- some would say the hobby -- taken up by men who went to China or other Asian countries to work in various capacities.[1]

10.10 1950-1985 -- FORMS OF PUBLICATION

An account of the forms in which publications from these three and a half decades have taken should begin with the substantial increase in the amount of material issued in book-form. This development can be viewed as a cause for celebration for books are generally more visible than journal articles in that they are more likely to appear in book reviews, indexes and bibliographies, and thus give the subject greater exposure and publicity. There were over thirty books (not counting collections of previously published articles, translations, and abridgements). Earth sciences was the only area in which no monograph was published during this period. The goals and research skills of the authors differed widely; so were the themes and scale of the books as well as their reception by critics.[2] Yet one cannot help but notice a striking feature common to almost half of the titles: they were conceived largely as translations of a Chinese text. But as everyone is well aware, translations come in a variety of hues, shapes, and forms, and it is no exception

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[1]Even Needham, who was Scientific Counsellor at the British Embassy and Director of the Sino-British Science Cooperation Office in Chungking from 1943 to 1944, did not publish works on traditional Chinese science while he was in China, though his interest in the history of Chinese science had already been kindled.

[2]Consider these titles: Silverberg's _Wonders of Ancient Chinese Science_; Libbrecht's _Scientific Thinking in Ancient China_; Kogelschatz's _Bibliographische Datem zum frühen mathematischen Schrifttum Chinas im Umfeld der 'Zehn mathematischen Klassiker' (1. Jh.v. Chr. bis 7. Jh.n. Chr.)_; Clark and Stephenson's _The Historical Supernovae_; Robinson's _A Critical Study of Chu Tsai-yü's Contribution to the Theory of Equal Temperament in Chinese Music_; Needham's _The Refiner's Fire: The Enigma of Alchemy in East and West_; Ho, Goh and Lim's _Lu Yu, The Poet-Alchemist_; and Van Gulik's _The Gibbon in China: An Essay in Chinese Animal Lore_.

here.[1] Another peculiarity was that seven works originated as doctoral dissertations -- three on mathematics, one on astronomy, and three on alchemy.[2] Though perhaps a mere coincidence, but it is telling nevertheless, to find first, that these three subject areas were also ones that have received the most intense and sustained study within the past century; and second, that all seven of them focused on a particular treatise.

The percentage of articles written for conferences and collective works also experienced a small upward leap. These contributions were featured mainly in collections from the China field.[3] Those of interest to historians of science were also important.[4] Several articles were included in collections on topics in modern science.[5] Aspects of Translation, To Illustrate the Monuments: Essays on Archaeology presented to Stuart Piggott, and Science in Contemporary China are interdisciplinary. Only a few titles (e.g. Sviluppi scientifici prospettive religiose movimenti rivoluzionari in Cina,

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[1]Again, compare these works: Sun and Sun's Sung Ying-hsing: *T'ien-kung k'ai wu*: Chinese Technology in the Seventeenth Century; Ho's The Astronomical Chapters of the *Chin Shu*; with Amendments, Full Translation and Annotations; Baldrian-Hussein's Procédés secrets du joyau magique: Traité d'alchimie taoiste du XIe siècle; Li's *Nan-fang ts'ao-mu chuang*: A Fourth Century Flora of Southeast Asia.

[2]e.g. Hoe's Les systèmes d'équations polynômes dans le *Siyuan Yujian* (1303); Ho's The Astronomical Chapters of the *Chin Shu*; with Amendments, Full Translation and Annotations; Ware's Alchemy, Medicine, Religion in the China of A.D. 320: The *Nei P'ien* of Ko Hung (Pao-p'u tzu).

[3]e.g.Études historique: mélanges posthumes sur les religions et l'histoire de la Chine; Explorations in Early Chinese Cosmology; Papers presented at the Workshop on Classical Chinese Thought held at Harvard University, August 1976; Studia Serica Bernhard Karlgren Dedicata.

[4]e.g. Histoire générale des sciences; The Voices of Time; Le matin des mathématiciens; entretiens sur l'histoire des mathématiques. Proceedings of the International Congress of the History of Science were particularly important: six papers in chapters 3 and 4, three in chapters 5 and 8, two in chapter 9, one in chapters 2 and 7; but none in the chapter on earth sciences.

[5]Supernovae and Supernovae Remnants. Proceedings of the International Conference on Supernovae held in Lecce; Italy; May 7-11; 1973.

Proceedings of the 1st Australian Conference on the History of Mathematics, Monash University, 1980, Bericht über den Siebenten Internationalen Musikwissenschaftlichen Kongress, Cologne, 1958, and Investigations on Cetacea Vol. X) may prove trying to locate.

Nevertheless, journals continued to be the most important forum for discussion and communication. The first number of Chinese Science, "an informal and irregular bulletin dedicated to the study of traditional Chinese science, technology, and medicine" created by Sivin, appeared in 1975 with a directory of individuals outside of East Asia studying this subject.[1] Over the next five issues, it was to deliver another eleven articles on Chinese science, technology and medicine.[2]

Of all the journals involved in this period, there were approximately forty that belonged to the Chinese / Asian studies field, and about the same number from various science disciplines. History of science periodicals followed with half that amount. The rest of the articles were distributed in almost thirty journals of wide-ranging nature.[3]

As the field of Chinese studies moved towards adulthood, new serial publications pursuing different aims and seeking to fill in various gaps were launched. Partly as a result of this development, papers on traditional Chinese science were found not only in journals of long standing (e.g. Harvard Journal of Asiatic Studies, Asia Major, Bulletin de l'École Française d'Extrême-Orient), but also in periodicals catering to special concerns (e.g. Journal of Chinese

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[1]Two comments on the goal and purpose of the bulletin are worth noting: "to serve as a means of communication between people all over the world who are attempting through the study of primary sources to comprehend the Chinese traditions of science, technology, and medicine. . . . It will only publish articles that would be out of place in a more general journal of the history of science or of Asian Studies, but would be of real use to workers in the field": Nathan Sivin, "Introduction," Chinese Science, 1 (1975), 1.

[2]The journal did not commit itself to a regular appearance and Number 7 was published in 1986.

[3]Once again, one must be alert to variations and irregularities. As noted in the individual chapters, while a particular group of journals was favoured by researchers writing on one branch of Chinese science, it was not selected by those studying another branch.

Philosophy, Early China, Asian Music, Journal of the Economic and Social History of the Orient) as well as occasionally in non-academic magazines (e.g. Hemisphere, Eastern Horizon). There were also less incidents of one journal acting as the carrier of multiple articles, though this phenomenon by no means disappeared. T'oung Pao no longer could claim dominion over other titles, but it remained as the journal chosen most frequently: eleven times in five subject areas.[1]

The range of Chinese / Asian studies journals used had indeed broadened, but science periodicals were far more diverse. This is hardly surprising as every scientific discipline (and often aspects within each) is served by one or more dedicated professional journal.[2] And there are obviously many more periodicals of a general nature in the science enterprise from which to choose, nine of which have published essays on traditional Chinese science within the period discussed.[3]

History of science journals had a heavy presence in *Alchemy and Early Chemistry* (with eight journals and fifteen articles), but a rather poor showing in *Physics* (with a short note in Isis). Out of over twenty such journals, only a handful is concerned with the history of specific science disciplines, but each of these was responsible for at least three articles.[4] Of the general ones, Isis (with seven papers covering five different areas) was still in the

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[1]Papers on Far Eastern History, Oriens Extremus, Journal of the American Oriental Society, Hemisphere, and Chung Chi Journal each surfaced once in three different chapters.

[2]Hence in *Mathematics* articles were published in Mathematics Teacher (four times), Mathematische Nachrichten, Mathematical Chronicle, Journal of the Association for Computing Machinery; and in *Earth Sciences*, Weather (twice), Imago Mundi (three times), Geographical Magazine, Annals of the Association of American Geographers, among others.

[3]e.g. Interdisciplinary Science Review, Nature, New Scientist, Bulletin of the National Institute of Sciences of India.

[4]e.g. Archive for History of the Exact Sciences (four articles), Historia Mathematica (seven articles), Archaeoastronomy (three articles), Ambix (five articles).

lead in terms of popularity.[1]

The humanities, arts, and social sciences were all represented in the remaining two dozen or so journals as a sampling of them reveals: Past and Present, Revue de Synthèse, La Pensée, Antaios, History of Religions, Deutsche Zeitschrift für Philosophie, Journal of the Warburg and Courtauld Institutes, Research in Sociology of Knowledge, Sciences and Art, Minerva, Annales; Économies, Sociétés, Civilisations, Journal of Social and Biological Structure, and Boston University Journal.[2]

The publication of works in a rich mix of specialist (though not obscure) journals and essay collections together with the frequent production of monographs, may well be interpreted as one of the encouraging signs that the field of traditional Chinese science has gradually made inroads into larger scholarly networks and communities.

10.11 OVERALL BIBLIOGRAPHIC PROVISION AND CONTROL

"The underlying health and long-term prospects for a field of historical study. . . must. . . be judged by the character and quantity of its research guides, bibliographies, biographical directories, and archival collections and related finding aids, as well as by the published secondary literature. The preparation of bibliographies or the carrying out of similar projects may be done by individuals, but these activities ideally are part of a larger, collective endeavor that is the concern of all scholars in the field, irrespective of their personal research interests. Activities furthering the control of access to bibliographic data or other categories of information ought to be subject to greater rationalization and organization than is the conduct of research into substantive topics

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[1]Other general history of science journals include British Journal for the History of Science, Osiris, Janus, Historia Scientiarum, and Centaurus.

[2]It is not without interest -- though neither is it unexpected -- to note that nearly half of these periodicals came from *Fundamental Concepts*.

in the field."[1]

To those truly concerned about the "underlying health and long-term prospects" of the field of traditional Chinese science, these are indeed thoughtful and judicious words. While such advice should be taken to heart when plotting the path ahead, ascertaining past activities and strengths one can build on is equally important. How effective and adequate has bibliographic control been over the past century and a half? Did it fare reasonably well in view of the circumstances under which it developed?[2] Who provided it and how was it performed? What major problems do they pose to present-day seekers of bibliographic information?

In the eight subject chapters we have already delineated and illustrated with specific examples the bibliographic treatment each branch received from various general and specialised subject bibliographies.[3]

But in order to provide more comprehensive answers to the above questions three important tasks remain to be done:

(1) Summarise the *overall* contribution to traditional Chinese science made by each of the seven general bibliographies, highlighting special practices and characteristics, and identifying problems and pitfalls one may encounter in using them.

(2) Comment on *other* retrospective bibliographies in the China and history of science fields that are not treated in the subject chap-

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[1]Clark A. Elliot, "Bibliographies, Reference Works, and Archives," Osiris, 2nd ser., vol. 1: Historical Writing on American Science, ed. Margaret W. Rossiter, and Sally Gregory Kohlstedt (Philadelphia: Department of History and Sociology of Science, U of Pennsylvania, 1985), pp. 295.

[2]After all, it must be remembered that although interest and publications related to the subject have been around for a fairly long time, before the middle of the 20th century, they were often perceived as sorties into isolated topics and individual themes, crafted by a very small band of individuals.

[3]To recapitulate, the seven general bibliographies include five on China / Asia (two retrospective and three current), and two current ones in the history of science field. These bibliographies have been singled out for individual discussion in each chapter because they are among the most well-known and readily accessible, and they have indexed a reasonable amount of titles on traditional Chinese science.

ters because of the relatively limited support they have given to traditional Chinese science.

(3) Review the combined role played by the small group of subject bibliographies specifically on an area of traditional Chinese science (e.g. mathematics, astronomy).

In handling these tasks, attention is given to coverage, access and organisation of titles, and accuracy. Coverage refers to different things, one of the most obvious being the total number of works listed. It also includes chronological span as well as consistency in supplying particular types of material.

I. GENERAL BIBLIOGRAPHIES FOR CHINESE / ASIAN STUDIES AND THE HISTORY OF SCIENCE:

(a) Henri Cordier, Bibliotheca Sinica. . . (1904-08); (1922-24):

That an individual from the opening decades of the 20th century curious about traditional Chinese systems and ways of dealing with the natural world or about opinions of the West on this subject could turn to a well-respected bibliography for guidance is not insignificant. Patience is no doubt needed when negotiating one's way round the rather peculiar subject categories, and above all to extract the tiny fraction of historical studies from science sections which often contain predominantly scientific accounts of the physical world and natural phenomena in the China region or the development of Western science in that country. Moreover, Cordier often failed to record articles in science journals.

Nevertheless, on the whole the bibliography did not do badly at indexing works from Asian / Chinese studies journals (which, as we have seen, carried the bulk of the articles on traditional Chinese science published in the 19th century) as well as monographs and offprints. Bibliographic details are also reliable. Though not as straightforward and logical as one would wish, and with certain titles buried in odd locations, some limited form of subject guidance is available.[1] Note also the listing of pre-19th century works. Thus, in any review of early activities at providing bibliographic

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[1]For instance, all titles on the magnetic compass published between 1834 and 1917 can be found under "XII. Sciences et arts - Boussole", and over twenty titles on mathematics are listed in "Mathématiques pures" and "Souan-pan" under "XII. Sciences et Arts".

access to Western literature on traditional Chinese science, Bibliotheca Sinica should have pride of place.

(b) John Lust, Index Sinicus. . . , 1920-55 (1964):

This index proved to be extremely useful for subjects with a significant number of articles published within its indexing period in journals and collective works from the China / Asia field.[1] Nevertheless, it is not exhaustive even for this category of material. Some titles from other types of periodicals are listed, and it provides a handful of works not reported by other bibliographic sources. The majority of entries that interest us are housed in the dedicated "XVIII. Science and Technology" section which carries clear and sensible sub-divisions. In addition to the Author Index Lust prepared an Index of Subjects -- a welcome bonus.

(c) ISIS Cumulative Bibliography, 1913-65; 1966-75; 1976-85:

This bibliography has been crucial in maintaining control and access of material in *all* eight subject chapters. By diligently indexing items from history of science and technology journals and essay collections, by paying careful attention to relevant papers from specialist periodicals for various science disciplines, from general science, humanities and social sciences journals, and not least, by taking note of titles from the Asian / Chinese studies area from time to time, it has amassed more titles than any other general bibliography as well as included a number of important works nobody has recorded.

ISIS's value as a powerful bibliographic tool also resides in its meticulously-crafted classification scheme. This is not the place to launch an introduction to and review of this major feat; rather, we are more concerned with its effectiveness in handling materials on Chinese science. On the whole it has done quite a good job of it: the system is comprehensive as well as flexible enough to accomodate a broad range and variety of topics and orientations.[2]

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[1]For example, it is excellent for astronomy, earth sciences, biology, but less so for mathematics, and general works.

[2]And perhaps ironically, the fact that the vast majority of pre-1985 studies themselves adopted primarily Western structures in interpreting and categorising Chinese scientific endeavours might have made it easier to house them.

China has its own section in the first cumulation within the "Civilizations and Periods" volume, and shares the space with Japan and Korea in "39 Far East" in the other two cumulations.[1] Although at times the main subject of a study as interpreted by ISIS differs from the one adopted in the present bibliographic survey, ISIS is always reasonable and consistent when assigning class numbers.[2] Assistance and guidance can also be obtained by consulting the Subject Index. Items listed -- including published material in all formats as well as the occasional doctoral dissertation -- are mostly in Western languages, but there are also some in Chinese and Japanese.[3] Western entries are unannotated except in rare cases when the content of a work is not reflected in its title. Curiously, there is no author index for the 1966-75 cumulation, which can be inconvenient, but a book review section which "contains a cumulation of all the references in the annual ISIS bibliographies" except for the years 1969, 1970, and 1971, is available.[4] And while on the matter of authors, one minor source of annoyance may be mentioned: surnames and given names have been reversed on more than a few occasions, making it impossible to retrieve the work concerned from the Author Index.[5] But otherwise, blemishes in the bibliographic information supplied have been few.

Equipped with an enviable retrieval mechanism, the ISIS Culmulative Bibliography is without question the chief and best bibliographic source for all types of literature on traditional Chinese

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[1]Note that classification numbers given to entries in the 1913-65 cumulation are far more detailed than those in the latter two cumulations, employing more frequently the "Form and Aspects Subdivisions".

[2]One must, however, remember to check different related subject divisions.

[3]These non-Western items not only bear English translations of the title, but are graced with succinct and critical annotations from Sivin in the 1966-75 and 1976-85 editions.

[4]John Neu, ISIS Cumulative Bibliography, 1966-75, vol. 1 (London: Mansell, in conjunction with the History of Science Society, 1980-85), Introduction.

[5]e.g. Ang Tian Se became "Se, Ang Tian" in the 1976-85 cumulation.

science for the period 1913 to 1985. Yet it must also be recognised that its coverage is by no means comprehensive: its inclusion of items from Asian / Chinese studies journals and collections is inconsistent; it does not list all the monographs mentioned in our subject chapters; and in several of them (e.g. *Fundamental Concepts*, *Mathematics*, *Astronomy*, *Earth Sciences*) some articles from history of science and science-related journals are missing.

(d) Bibliography of Asian Studies, 1936- :

This bibliography's excellent coverage of articles from Chinese / Asian journals, festschriften and other collective works ought to have made it the perfect complement to ISIS for bringing historical studies on Chinese science under control. Moreover, this standard resource in the Asian field can supply information on works not given elsewhere in no less than five of our chapters. And accounts in science, history of science, and other non-Asian / Chinese studies periodicals have found their way into the bibliography from time to time.[1]

Yet it is difficult to ignore major problems with subject retrieval. Subject access for the 1936 and 1937 volumes is not available; for 1938, 1939 and 1940 this can be obtained through the Subject Index at the back of each volume. For an individual seeking to assemble material on traditional Chinese science from the two subject cumulations (1941-65, 1966-70), the exercise is nothing less than a nightmare. Although a "Science, Technology, Medicine, Public Helath" section is offered within the part on China with entries in alphabetical order by author, relevant studies are routinely placed outside this section.[2] And it is neither simple nor easy even if one is willing to spend time inspecting other subject sections.[3]

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[1]Bear in mind, nevertheless, that the bibliography failed to index at least a few articles from periodicals or collective works belonging to the Asian field in each chapter, the most serious being the one for earth sciences.

[2]Only in the case of general works and publications on mathematics would a relatively small number of titles be missed by checking the "Science and Technology" section alone.

[3]There are thirty-four broad subject areas in the part for China with seven that carry sub-divisions (e.g. "History" is split into "Antiquity to Ming"; "Ch'ing"; "20th Century"). Each section,

The organisation and hierarchical structure used in the annual volumes from 1971 on has followed basically that of the cumulations, though the number of sections and sub-sections vary from issue to issue, and occasionally the sub-divisions "Bibliography", "Reference", "Sources", and "Study and Teaching" have been added.[1] For three years (1971-73), books and periodicals are kept in separate sections under each subject, and for two years (1971-72) dissertations and theses are included. Since each annual volume contains a much smaller amount of publications than that in the cumulations, the time it takes to peruse a particular sub-division (which varies from three to seven pages) from beginning to end is less exasperating. Also, since 1973, "leader dots are used [at the top of each page] as hierarchy indicators to assist the user in tracking subjects."[2] Nevertheless, serious handicaps still remain. Important studies have continued to appear under different categories.[3] And to aggravate an already rather gloomy state of affair, its indexing practice is not always consistent.[4] There is also the relatively minor source of

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whether in the first or second tier, runs between several to a dozen pages. And studies on traditional Chinese science can be found under sections ranging from "General" to "History and the Humanities".

[1]For instance, in the 1971 volume "Science and Technology" has no sub-division; in 1979, it is broken into "Environmental Studies", "Geology", "Medicine", "Nutrition", "Public Health"; in 1985 into "Environmental Studies", "Geology", "Hydraulic Engineering", "Medicine", "Nutrition", "Public Health", "Yoga and Health".

[2]Association of Asian Studies, Bibliography of Asian Studies, 1973 (Pittsburg: Association for Asian Studies, 1975), pp. xxi.

[3]This is sometimes understandable as when the item is considered as a study on a particular historical period; but at other times there is apparently little rhyme or reason to it. For example, Wagner's "Doubts concerning the Attribution of Liu Hui's Commentary on the *Chiu-chang suan-shu*" is astonishingly placed under "Library and Information Science - Manuscripts".

[4]For example: "Illustrated Botanical Works in China and Japan" is in "Far East - Bibliography, books and libraries", which seems to indicate that the essay is considered first and foremost as a bibliographic study, with the subject matter left unspecified (though botany is clearly stated in the title). On the other hand, "Bibliographie indicative concernant la botanique et l'ethnobotanique de la Chine (ancienne et contemporaine)" is in "China - Economics - Bibliography", implying that subject (i.e. economics) comes before form (i.e. bibliography).

inconvenience of not separating historical studies out from accounts of modern science, technology, and medicine in the "Science and Technology" section. Rather than doing subject searches, one can of course make use of the two author cumulations and the Author Index in the annual volumes instead.[1] All in all, life has been made rather hard for those interested in traditional Chinese science, and one has mixed feelings when it comes to measuring the Bibliography of Asian Studies' success in meeting our bibliographic needs.

(e) Bulletin Signalétique, 1947- :

First, a word of caution to those who wish to consult earlier forms of this bibliography: the name changes and metamorphoses it has undergone within the past fifty years are truly bewildering.[2] Very briefly: until 1969 when a separate and independent volume and title devoted solely to the history of science, technology and medicine (i.e. Bulletin Signalétique: 522 Histoire des Sciences et des Techniques) was created, this subject area was a section or sub-section of larger entities. And over the years these history of science sections as well as their "parents" experienced a series of expansion and combination.[3]

Why would anyone wish to consult this periodical index? What are the special benefits? The short answer is: it can provide some titles overlooked by others.[4] But farther than this, the index

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[1]In this instance, the separate author volumes in the two cumulations (not merely indexes, but proper bibliographies with full details) do have the benefit of saving the user extra trips of taking the codes along to the main bibliography for the full entry.

[2]A final and permanent identity does not appear to be forthcoming as it was given yet another title, Francis: Bulletin Signalétique 522, Histoire des Sciences et des Techniques, in 1991.

[3]Their various names are given in *Chapter 1: Introduction*. For a full and precise description of its changes of fortune, Pietro Corsi's account in his article "Guide to Bibliographical Sources," in Information Sources in the History of Science and Medicine, ed. Pietro Corsi, and Paul Weindling (London: Butterworths, 1983), is indispensable; see especially pp. 139-40, and 151.

[4]Some, but by no means all, of these items can be said to be of marginal importance. For instance, not being aware of the French version of Needham's "The Chinese Contribution to the Development of the Mariner's Compass" is probably of little consequence, but one

cannot take us.[1] Relevant accounts in history of science journals and proceedings generally managed to get indexed.[2] But articles from other categories of periodicals and collections fare rather badly though they are mentioned at random intervals.[3]

There is, however, an important lesson to be learnt from Bulletin Signalétique 522. The path of access in the quarterly issues is the classified scheme.[4] But someone conducting a retrospective search can make use of an additional means of subject access, the annual "Table Analytique des Concepts" (introduced in the 1951 volume). Later called "Table des Concepts", it enables retrieval under a number of terms and keywords. "Chine" has been chosen as a keyword from the beginning, and increasingly smaller divisions (subject, period, names, etc.) have appeared under it. Such a system has definite advantages. In the bibliography itself, the provision of separate sub-divisions by country alerts users to studies related to Chinese understanding of a particular topic. Furthermore, the presence of a detailed subject index frees the indexer from the restriction of having to assign only one subject per study. This is of great value to a field like traditional Chinese science where the available secondary literature is relatively small: being able to index aspects of lesser importance or direct users to a work that contains sections on Chinese science is immensely helpful. A third

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would want to know Libbrecht's "Indeterminate Analysis: Historical Relations between China, India, Islam and Europe".

[1]Note that since book reviews are also included, one is sometimes informed of monographs as well.

[2]Bulletin Signalétique 522 is especially good at furnishing information on abstracts and papers from the International Congress of the History of Science from recent decades.

[3]e.g. in *Fundamental Concepts*, *Astronomy*, and *Earth Sciences*.

[4]Like the title changes, the arrangement within the history of science section was also altered from time to time, reflecting the various additions and adjustments to its indexing scope and orientation. Nevertheless, it has always adopted a subject classification. Under a handful of broad categories (e.g. "Généralités", "Sciences et Techniques Mathématiques", "Sciences et Techniques de la Terre") are subject fields (e.g. "Chimie") and sub-fields (e.g. "Alchimie"), which are sometimes further broken down according to period or civilisation (e.g. "Orient et Extrême-Orient").

method of retrieval is through the annual "Tables des Auteurs".[1]

(f) Revue Bibliographique de Sinologie, 1955-70; 1983- :

This annual bibliography is best known for its unparalleled annotations and critical comments by some of the most respected authorities in the Chinese studies field from different Western countries. Its function and value for those seeking published materials in traditional Chinese science has remained largely that of a provider of these exceptional treats (which everyone should indulge in whenever possible) rather than supplying a significant volume of Western titles on the subject.[2] This is, nevertheless, a unique service. And in a few rare instances, items not reported by other general bibliographies are given.[3] In indexing periodicals, the emphasis has been put mostly on those related to Chinese / Asian studies, though occasionally works from other types of journals make an appearance.[4]

Only fifteen years (i.e. 1955-70) were covered in the original series.[5] In this series "Histoire des Sciences" forms a separate section, and a handful of issues carries sub-divisions (Généralitiés", "Sciences Exactes", "Géographie", "Techniques", and "Médecine").[6] There is an index for authors as well as an "Index des matières et des noms propres"; the latter, together with "Voir aussi" cross-references, enable retrieval of items of interest to a histo-

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[1]But one has to be wary of confusions over names. For example: Ho Peng Yoke was entered as "YU, (H.P.)" in the 1962 volume and as "PENG-YOKE, (H.)" in the 1961 volume; F. J. Swetz and Ang Tian Se as "SWEZ, (F.J.), SE (A.T.)" in the 1985 volume.

[2]Note also the listing of and priceless commentaries on Chinese and Japanese titles.

[3]e.g. Schafer's "Cultural History of the Elaphure" in the 1956 Sinologica.

[4]e.g. articles in Ambix, Weather.

[5]Each volume was at least several years behind, and the issue for publications from 1968/70 appeared in 1982.

[6]Once in a while, one comes across titles situated elsewhere (e.g. March's "An Appreciation of Chinese Geomancy" under "Philosophie et religion"). But they can located by checking the subject index.

rian of science in other sections.[1] In addition, "Periodiques Analyses" gives not only the titles of journals, but also indicates where indexed articles from these journals are located. The second series started in 1983. It differs from the first in several ways: the "Histoire des Sciences" section is organised according to periods / dynasties instead of disciplines; deliveries have been prompt; and French researchers have been largely responsible for the preparation of the commentaries.

(g) Toyogaku Bunken Ruimoku, 1963- :

This annual Japanese started in 1963 and has focused heavily on Chinese / Asian studies periodicals and collective works. As with Revue Bibliographique de Sinologie, its restricted and uneven coverage has rendered it a less than effective bibliographic instrument for controlling Western publications on traditional Chinese science. It can nevertheless claim that book review information -- always convenient to have -- are furnished.[2]

Books and articles are listed separately, and both indexes include the section "9. Science", sub-divided into "1. General", "2. Astronomy and Calendar", "3. Mathematics", "4. Medicine, Herbals and Natural History", and "5. Other Physical Sciences and Technology". But titles are frequently placed in other sections. There is also an Author's Index.[3] Chinese and Japanese works, given in the original script with no transliteration, are housed separately from ones in Western languages.

II. OTHER GENERAL BIBLIOGRAPHIES FOR CHINESE / ASIAN STUDIES AND THE HISTORY OF SCIENCE:

In addition to the seven general bibliographic sources mentioned

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[1]e.g. Schrimpf's "Bibliographie sommaire des ouvrages publiés en Chine durant la période 1950-1960 sur l'histoire du développement des sciences et des techniques chinoises" is in the "Bibliographie" section, but also indexed under "Mathématique", "Chimie", "Astronomie", etc., with a "voir aussi" note in "VII. Histoire des Sciences - I. Généralités" as well.

[2]It has also registered two papers not recorded by others: Grafflin's "Geomantic Cliché and Geomagnetic Puzzle", and Ho's "The Earliest Chinese Magic Square and Magic Squares in the Islamic World".

[3]Note that book numbers given in the Author Index of the 1983 volume do not correspond to the actual numbers in the main index.

above, there are other bibliographies of a general nature that purport to cover the entire China or history of science field or at least one major aspect of it (e.g. a key disciplinary area, a very wide time span). Some have long been regarded as "standards" or "classics", while others are relatively new arrivals. Their compilers and editors were usually either academics or librarians.[1]

Do these bibliographic guides cater to those interested in traditional Chinese science? Why have they not been discussed earlier?[2] The answer is that they have played a rather limited role, and apart from a few exceptions, they cannot be recommended with a clear conscience.

It would be false to claim that I have inspected every such bibliographic aid in all languages; note also that except for one item from 1990, the rest were published before 1986.[3] For the sake of simplicity and convenience, I have separated the examined bibliographies into four categories, and examples are given under each.[4]

(a) Bibliographies that do not list any work on traditional Chinese science:-

* Jean Olivia Lindsay, The Early History of Science, A Short Handlist ([London]: Published for the Historical Association by G. Philip, 1950): The compiler states her reason for omitting China as follows: "Any serious hand-list of works on the history of science should

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[1]e.g. Charles O. Hucker and L. Carrington Goodrich -- China specialists; Stephen G. Brush and Roy Porter -- historians of science; Yuan Tung-li -- from the Library of Congress; Norman E. Tanis -- Director of University Libraries at California State University, Northridge.

[2]Pritchard's Alchemy: A Bibliography of English Language Writings, with its superb coverage of Chinese alchemy, is the only such bibliography reviewed in the subject chapters.

[3]It is felt that a full-scale investigation is not required, and that checking a fairly large sample should serve the purpose.

[4]Even though they have been singled out for comment, it is hoped that the particular examples cited would not be interpreted as "the best" or "the worst" of the lot. There is no reason why some other bibliographies could not have functioned as examples just as effectively. For instance, the Mitteilungen zur Geschichte der Medizin und der Naturwissenschaften und Technik (1902-1941), and Comité Belge d'Histoire des Sciences' Notes Bibliographiques (1946-) can be added to the second category.

include a section on the Far East and India, but such a section has not been included in the present list because it was not likely to supply an urgent need in the case of students in this country."[1]

* Don Y. Lee, An Annotated Bibliography of Selected Works on China (Bloomington, Ind.: Eastern P, 1981): This bibliography is not properly named; its title can at best be called vague and at worst very misleading. Though the title may prompt one to suspect that science-related works are listed, the work in fact only deals with traditional Chinese collections of classics, literary works, dynastic histories, etc.

(b) Bibliographies that provide a very limited number of titles on traditional Chinese science:-

The chief problem with a number of these general bibliographies in terms of providing bibliographic information on traditional Chinese science is not so much that they have failed to make any provision for the subject as that it is not properly representated. Coverage is often very uneven: it is doubtful that certain entries are of any use while important works have been excluded.[2] There is thus a danger of giving a distorted picture, especially to those users who are enthusiastic, but have little knowledge about secondary Western sources on traditional Chinese science.[3]

Typically, between six to twelve titles on traditional Chinese science are offered, always including Science and Civilisation in China for post-1956 bibliographies, and sometimes along with an assortment of other works related to the history of Chinese technology and / or medicine, modern science in China, Chinese history and culture, etc. In some cases all titles are located in a single section, and in others they are scattered, but retrievable through the subject index.

* George Sarton, Horus: A Guide to the History of Science (New York: Ronald P, 1952): Two dozen titles are listed under "Special Cultural

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[1]Lindsay, The Early History of Science, pp. 7.

[2]And one cannot put the blame on "selection policies": there always seems to be ample room for a better selection of titles.

[3]Statements alerting unsuspecting readers to other more comprehensive sources should have minimised this risk, but these are rarely provided.

Groups - China", including works on Chinese science, technology, and medicine (e.g. a handful of science titles by de Saussure, Schlegel, Johnson, and de Mély) as well as general works and studies on Chinese history and culture (e.g. Bibliotheca Sinica, Fung Yu-lan's History of Chinese Philosophy).

* Yuan Tung-li, China in Western Literature (New Haven: Far Eastern Publications, Yale U, 1958): Less than ten of our works fall within its indexing perimeters which encompass predominantly books and monographs published from 1921 to 1957.[1]

* Charles O. Hucker, China: A Critical Bibliography (Tuscon: U of Arizona P, 1962): True to the title of his bibliography, Hucker was extremely critical in his selection of works to be included in the "Science and Technology" section, and few history of science publications lived up to his high standards.[2] Annotations are excellent.

* François Russo, Éléments de bibliographie de l'histoire des sciences et des techniques, 2nd ed. (Paris: Hermann, 1969): "Chine" does not appear in the index or table of contents, but combing through the bibliography revealed a handful of studies on the history of Chinese science and technology.[3]

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[1]Note that Imbert's Le grillon et la cigale en Chine is reported in this and no other general bibliography; this title as well as Laufer's Insect-Musicians and Cricket Champions of China and the book form of "A Version of the Book of Vermilion Fish" by Moule are all under "Natural Sciences". Forke's The World-Conception of the Chinese: Their Astronomical, Cosmological and Physico-Philosophical Speculations is in "XII. Philosophy - General Works"; Needham's Science and Society in Ancient China in "II. General Works - Civilisation and Culture"; his Human Laws and the Laws of Nature in China and the West in "VIII. Law and Legislation - General Works". Science and Civilisation in China is in "XIX. Natural Science - General Works".

[2]e.g. works by Needham, Dubs, Cammann, and Li were chosen.

[3]e.g. Science and Civilisation in China, Dawson's The Legacy of China, and Huard's "Panorama de la science chinoise et de quelques-unes de ses disciplines" are listed in "D. Ouvrages d'histoire des science, toutes époques et toutes disciplines -- 6. Ouvrages generaux par pays -- Chine" (but countries are not specified in the table of contents); Maspero's "L'astronomie chinoise avant les Han", and Michel's Méthodes astronomiques des hautes époques chinoises are listed in "C. Astronomie - 2. Tous points de vue par époques et par pays - a. Antiquité et Moyen Age"; Barde's "Recherches sur les origines arithmétique du *Yi-King*" is listed in "B. Mathematiques - 3. Par pays - k. Chine. Japon" (again countries are not specified in the

* Peter Smit, History of the Life Sciences: An Annotated Bibliography (Amsterdam: Asher, 1974): Its "Ethnographical" part contains section "6. Life and Medical Sciences in the Far East". It is further divided into "a. History of science and culture in general", "b. History of the plant and animal sciences", and "c. History of the medicinal sciences".[1]

* F. Henry Brookman, "The History of Science in the Non-Western World: An Inventarisation of Some Important Works during the 20th Century," Historia Scientiarum, 25 (1983), 93-100: This is not a general bibliography, but it displays a similar set of disturbing symptoms.[2]

* Stephen G. Brush, and Helmut E. Landsberg, The History of Geophysics and Meteorology: An Annotated Bibliography (New York: Garland, 1985): China-related titles have secured places in six different sections, and all indicated in the subject index under "Chinese science".[3]

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table of contents). Note that Mikami's The Development of Mathematics in China and Japan is under "j. Inde"!

[1]"a. History of science and culture in general" gives Forke's The World-Conception of the Chinese. . ., Li Ch'iao-p'ing's The Chemical Arts of Old China, Science and Civilisation in China, and fifteen other titles; "b. History of the plant and animal sciences" lists Bretschneider's Botanicon Sinicum, Liu's "Cicadas in Chinese Culture", Liou-Ho and Roux's Aperçu bibliographique sur les anciens traités chinois de botanique among a curious mix of twenty-six titles.

[2]The main portion of this bibliographic essay is concerned with the question, "how much has already been published on the history of science in non-Western countries?": Brookman, "The History of Science in the Non-Western World," 93. The gist of his one-page account on China is as follows: "Japanese historians of science have also written much about the history of science in China and Korea. . . . Y. Mikami, for instance. . . . Yet doubtlessly, the most influential scholar who has left his mark upon the history of science in China is Joseph Needham. . . . Apart from Needham, the persons who have published a lot about China and its surrounding areas are the Japanese historian K. Yabuuti, the American historian of science N. Sivin, and the French historian P. Huard": Brookman, "The History of Science in the Non-Western World," 96.

[3]e.g. Shorter Science and Civilisation in China vol. 2 under "A. General histories"; Science and Civilisation in China vol. 3 under "J. Seismology"; Wang's "Meteorological Records from Ancient Chronicles" under "O. Meteorology: Observations - D. Early observational

* Burghard Weiss, Wie finde ich Literatur zur Geschichte der Naturwissenschaften und Technik (Berlin: Verlag Arno Spitz, 1985): Seven works are listed in section "5.6.4.2. Geschichte der Naturwissenschaften nach Epochen und Kulturkreisen - China".[1]

* Instituto e museo di storia della scienza, Bibliografia italiana di storia della scienza, 1982- (Florence: Leo S. Olschki, 1985-): This annual bibliography has "Cina" as a subject term in its subject index, with the relevant classification numbers (not title numbers) listed underneath (e.g. "520.951 astronomie"). As this is a recent arrival and only publications in Italian (and on rare occasions in other languages written by scholars in Italy) are indexed, its assistance to seekers of pre-1986 works is understandably limited.

(c) The "long live Science and Civilisation in China" category, i.e. bibliographies that provide only this title:-[2]

If delivering a dozen of so token titles is upsetting and can skew the picture, directing users to a single work (and versions of it) with no obvious justification for it is, in my opinion, even more damaging.[3] Fortunately relatively few bibliographies fall into this category.

* Roy Porter, The Earth Sciences: An Annotated Bibliography (New York: Garland, 1983): In this compilation -- one of a well-known, often acclaimed bibliography series on the history of science and

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series (prior to 1870)"; Michel's "Notes sur l'historie de la boussole" under "U. Geomagnetism".

[1]i.e. Peter Buck, American Science and Modern China, 1876-1936; Genevieve C. Dean, Science and Technology in the Development of Modern China: An Annotated Bibliography; Hsia Nai, "Bibliography of Recent Archaeological Discoveries bearing on the History of Science and Technology" (in 1980 Chinese Science); Science and Civilisation in China; Shorter Science and Civilisation in China; Needham, Science in Traditional China: A Comparative Perspective; Needham, Wissenschaftlicher Universalismus: Über Bedeutung und Besonderheit der chinesischen Wissenschaft.

[2]Sometimes the few works derived directly from it are also listed.

[3]I would argue that this is even worse than stating in the preface that history of Chinese science is excluded altogether for readers can then search elsewhere if they so desire instead of arriving at the (mistaken) conclusion that only one or two works are available.

technology -- Science and Civilisation in China is registered in the section "5. Studies by Area - c. Other, in Alphabetical Order by Country or Continent", and entered in the index under "China, geology in".

* Peter P. Cheng, Current Books on China, 1983-88: An Annotated Bibliography (New York: Garland, 1990): This bibliography -- in the "Garland reference library of social science" series -- "is designed for an audience of non-specialists."[1] In "Chapter 20 Science and Technology", Science and Civilisation in China, Temple's The Genius of China: 3,000 Years of Science, Discovery and Invention, and the Shorter Science and Civilisation in China are supplied.[2]

(d) Bibliographies that provide a relatively greater cross-section of titles:-

Compilers of these bibliographies seemed to have a greater interest in fulfilling their share of intelligently informing users of selected works on traditional Chinese science. The total number of titles listed is still pitifully small, and veterans in the field would probably find these general bibliographic aids of minimal use. The service these reference works render to the study of traditional Chinese science lies rather in their giving a fairer representation to Western historical accounts on Chinese science. By having a somewhat more varied and sensible selection, they indirectly convey the message to those not previously exposed to the subject that this area of study is not to be dismissed or slighted.

* L. Carrington Goodrich, and H. C. Fenn, A Syllabus of the History of Chinese Civilization and Culture, 5th ed. (New York: The China Society of America, 1950): Although there is no subject index in this fifty-five page highly selective bibliographic guide (which is organised essentially by historical periods under which are subject

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[1]Cheng, Current Books on China, 1983-88, pp. ix.

[2]The annotation for Science and Civilisation in China reads: "The series demonstrates the major importance of Chinese science and technology to world history and maintains the tradition the great scholarly works of the twentieth century. It contains an authoritative survey of the literature from the earliest to modern times and an assessment of the Chinese system of classification": Cheng, Current Books on China, 1983-88, pp. 187. I sincerely hope that these statements make more sense to others than they do to me.

categories) pre-Science and Civilisation in China Western efforts to study traditional Chinese science (and technology) are acknowledged and clearly signposted.[1]

* Chang Chun-shu, Premodern China, A Bibliographical Introduction (Ann Arbor: Center for Chinese Studies, U of Michigan, 1971): The work "is designed primarily to introduce graduate students of premodern Chinese studies to all basic research tools and the current state of research in their field. It is hoped that the use of this bibliography will familiarize students with the major achievements and the most significant issues raised in Western-language sources (primarily English) before they undertake their research into Chinese and Japanese materials."[2] Science is used as a sub-division or a keyword within the bibliography's various parts and sections, which are set out in a detailed table of contents; there is no subject index.[3]

* Norman E. Tanis, David Perkins, and Justine Pinto, China in Books: A Basic Bibliography in Western Language (Greenwich, Conn., Jai P, 1979): Even though the word "basic" appears in its title, and its stated objective is to assist academic and public librarians with meeting the needs of undergraduates and students, it is a pleasant surprise to find that out of a hundred items supplied in its "Technology / Science / Medicine" section, twelve are historical studies

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[1]For example, under "The Former Han dynasty - 4. Astronomical calculations" are Maspero's "Les instruments astronomiques des chinois au temps des Han", Dubs' "Solar Eclipses during the Former Han Period", and Wen's "Observations of Halley's Comet in Chinese History"; under "The Sung - Mathematics" are Mikami's The Development of Mathematics in China and Japan (pp. 56-88), Konantz's "The Precious Mirror of the Four Elements: An Expression of the Chinese Genius", and Van Hée's "Li-yé, mathématicien chinois du XIIIe siècle".

[2]Chang, Premodern China, Preface.

[3]e.g. "Part three: A selected bibliography of Western-language works on premodern China - III. Aspects of Chinese history and civilization - 11. Science and Technology"; "Part three - VI. History by periods - 2. Early Imperial China: The Ch'in and Han Empires, 221 B.C. - A.D. 220 - G. Science and cosmological views".

which we have included in the present bibliographic survey.[1] Three other titles are given as cross-references.[2]

* Joseph W. Dauben, The History of Mathematics from Antiquity to the Present Time (New York: Garland, 1985): Traditional Chinese science is given better treatment in this bibliography than in other volumes from Garland, but that is neither on account of the fact that there is a section designated for the history of Chinese mathematics nor that it has noted many more relevant titles. The three features that set it apart from other bibliographies is firstly, the compiler has indicated the scope of his selection.[3] Secondly, helpful annotations are given.[4] Thirdly, Chinese-language works are provided.

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[1]It is refreshing to see Needham's The Grand Titration: Science and Society in East and West and Clerks and Craftsmen in China and the West, Nakayama and Sivin's Chinese Science: Explorations of an Ancient Tradition, Libbrecht's Chinese Mathematics in the Thirteenth Century, Ho's The Astronomical Chapters of the *Chin Shu*, and Sivin's "Cosmos and Computation in Early Chinese Mathematical Astronomy" (book version) given due attention. Even two Taiwan reprints: Schlegel's *Sing Chin Khao Youen*; Uranographie chinoise, and de Saussure's Les origines de l'astronomie chinoise are listed.

[2]The way these three works are classified is not without interest: Science and Civilisation in China under "General Works" (on all aspects of Chinese culture), Silverberg's Wonders of Ancient Chinese Science under "Juvenile - Non-fiction", and Ware's Alchemy, Medicine, Religion in the China of A.D. 320: The *Nei P'ien* of Ko Hung (Pao-p'u tzu) under "Religion and Philosophy, - Taoism, Lao Tzu, I-Cheng [sic], Chuang-tzu, Huai-Nen [sic] Tzu".

[3]"In this bibliography more emphasis is placed on algebra and the period most extensively covered is from the thirteenth to the early fourteenth century. There is a selection of essential works on the history of Chinese mathematics up to the Ch'ing dynasty. The recent publication are mainly monographs on important works in Chinese mathematics": Dauben, The History of Mathematics, pp. 423. Thus, listed are the books by Hoe, Lam, Libbrecht, Vogel, and Mikami, Science and Civilisation in China vol. 3, and Ho's five essays in the Dictionary of Scientific Biography. Also offered is Wang and Needham's "Horner's Method in Chinese Mathematics: Its Origins in the Root-Extraction Procedures of the Han Dynasty", Sarton's three-volume Introduction to the History of Science, and Wylie's Chinese Researches.

[4]For example, the annotation for the Sarton entry reads: "The biographical notes on Chinese mathematicians in these volumes provide useful guidance for general and research purposes. See also items 348, 469": Dauben, The History of Mathematics, pp. 425. The one for the Wylie entry is as follows: "Although this is a nineteenth-century

One last word remains to be said before we take leave of all these bibliographies, namely that this state of affairs is much to be regretted. Widely cited and readily obtainable in libraries with even the slightest interest in East Asia or the history of science, these reference aids had the opportunity to greatly improve one's bibliographic knowledge on works related to traditional Chinese science, but that was sadly passed over.

III. SPECIALISED BIBLIOGRAPHIC SOURCES

As the characteristics and performance of each special source have been described and appraised individually, only a few general comments are necessary here.

These bibliographies vary enormously in their purpose, style, comprehensiveness as well as the extent of their contribution to advancing the bibliographic provision and control of our field. A few are invaluable (e.g. "Bibliography C" in Science and Civilisation in China, Sivin's "Introductory Bibliography"), the rest dispensable.

But even on those occasions when it has been necessary to lay bare limitations and weaknesses in these bibliographic works, the purpose was not to belittle the labour put into those compilations or to exhort potential users to stay away from them. To begin with, it is not too much of an exaggeration to say that bibliographic access, provision, and control of our area of study has been in its infancy for so long that almost every current or retrospective register, listing and index compiled expressly for one or more topics on Chinese science has a part to play -- however small though it may seem -- in bolstering the existing condition. Second, not everyone follows the same route in collecting research data and literature. There is no fixed procedure or set of rules governing one's selection of material. Facilities and resources one has at one's disposal, research strategies, training, and sheer habit all affect use patterns. Features in a bibliography that cause a headache to one user can turn out to be attractive to another. The advice, therefore, is: be prepared to cast a very wide net and engage in extensive checking.

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book, the section "Jottings on the Science of the Chinese Arithmetic" still provides interesting and informative reading": ibid.

Falling squarely into the "notable" category are the bibliographies for books and journal articles in Western languages in *Science and Civilisation in China*. These bibliographies are legendary. The reputation and wide circulation of *Science and Civilisation in China* together with the sheer amount of titles listed have combined to make them so. We have already seen that in terms of their coverage of Western studies specifically on traditional Chinese science, they are outstanding. Many users would also find the inclusion of a whole galaxy of other works, however remotely related to the subjects treated in the volume concerned, educational and helpful; and it is indeed important that readers be exposed and alerted to as full a range of material as possible.[1] Another valuable feature not often lauded is the sub-sections introducing and reviewing Western studies (as well as Chinese literature) on the subject. The meticulously-prepared indices also allow one to track down references made to a work that is listed in the bibliography -- even when it appears in a footnote -- thus providing some guidance as to the content and worth of the study. On the whole, the bibliographic information provided is accurate; errors do exist, but they are thankfully few.[2] Giving only the beginning page number of articles can be slightly irritating as one often would like to know the length of a work before rushing out to get hold of a copy.

As already emphasized, in discussing bibliographic control, the ease of retrieval is one of the most important elements. And it is on this particular point (i.e. that of convenience of access to items that deal specifically with traditional Chinese science) that the *Science and Civilisation in China* bibliographies pose a practical

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[1] An incidental remark from Robert P. Multhauf in his review of *Science and Civilisation in China* vol. 5 pt. 3 confirms one's suspicion that in most cases titles given in "Bibliography C" are not directly relevant to the subject of that particular volume: "The latter ["Bibliography C"] may be the best bibliography extant of modern studies of the early history of chemistry. (It even includes seven pieces by the author of this review, few if any of which could have contributed much to the production of this book)": Robert P. Multhauf ~~Malthauf,~~ rev. of *Science and Civilisation in China* vol. 5 pt. 3, in *Ambix*, 22 (1975), 218.

[2] e.g. in vol. 3, "Oordt" is given instead of Oort, and "Biot, E. (14) is missing from "Bibliography C" although it is mentioned in the text (pp. 482) and also indexed.

problem, especially to those that have neither time nor patience. Arrangement is in one alphabetical sequence by author; consequently, one frequently has to wade through several pages of small print before one comes across a title that appears pertinent and interesting.[1]

Finally, note that bibliographic listings attached to individual publications have not been singled out for consideration. On the whole, they have not proved to be of much significance as sources of information.[2]

IV. CONCLUSION

While we bemoan the fact that most of the above bibliographies are less than satisfactory and beset with problems -- major and minor -- related to coverage, access, and accuracy, the situation could easily have been much worse. Imagine what life would be like without Index Sinicus, the ISIS Cumulative Bibliography or Science and Civilisation in China's "Bibliography C". And Pritchard has demonstrated ably in his exemplary work that traditional Chinese science need not be sacrificed or given short shrift in a bibliography with much broader orientations if we are willing to do our homework.[3] Nevertheless, no one should labour under the illusion that things have come under proper control and have been enjoying firm -- and above all, informed -- support.[4]

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[1]These comments are issued not as criticisms: it is questionable wisdom to attack a work for failing to provide something for which it has not been designed. The purpose here is to assess the role these bibliographies play in the bibliographic control process specifically in the area of traditional Chinese science.

[2]The bibliography "Books and Articles in Western Languages" in Libbrecht's Chinese Mathematics in the Thirteenth Century: A Study of the *Shu-Shu Chiu-Chang* of Ch'in Chiu-Shao is a rare exception.

[3]Information Sources in the History of Science and Medicine also includes an entire chapter on Chinese science by Cullen (which we have discussed in Chapter 2); so does the Dictionary of the History of Science with an entry on Chinese science written by Ågren (treated in Chapter 3). These sources are not mentioned here because they are not bibliographies.

[4]Suggestions for improvement are outlined in 10.12 (point number nine).

10.12 LESSONS WE HAVE LEARNT; THE ROAD AHEAD

The following "lessons" have been conceived as a set of keys with which one might try to open doors and as a list of questions which those interested in cultivating the field can attempt to answer. Cues have been taken from past practices, but the main consideration here is on possible solutions to longstanding problems and ways to enrich this area of study. This is done with an eye especially on paths its practitioners have *not* previously pursued, but which have been explored with varied enthusiasm and success by others that have recently engaged in the study of the history of science and of China recently. It is by no means comprehensive, and some suggestions may be awkward to actually implement. But the fact that some keys may not open any door does not mean that we should not try as many keys as possible.

During the past several decades, adventurous members in the history of science profession as well as the China field have been busy experimenting with the inclusion (and exclusion) of a host of elements and ideas in their historical and other inquiries. Thus "external / internal" histories, structuralist concepts, the *Annales* movement, and Marxist interpretations, among others, have gone in and out of fashion, retired, or been resurrected in a different guise. We have witnessed debates that side with one camp or the other, heard proposals that lie somewhere in between extremes, and lived through revisionist backlashes.[1]

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[1]It cannot be stressed enough that there were substantial differences between how each country handled and reacted to these movements and approaches. For instance, Steven Shapin -- who was responsible for some of the pivotal studies on the "external / internal" issue -- remarked in 1992: "I became increasingly aware of the extent to which e/i talk appeared predominantly as an Anglo-American concern. Dutch, French and German commentators. . . pointed out some Continental resonances of these debates (e.g. the 'finalization thesis'), while generally confirming that historical and sociological studies of science in their countries were, for a variety of reasons, not nearly so obsessed with e/i as the United States and Britain": Steven Shapin, "Discipline and Bounding: The History and Sociology of Science as seen through the Externalism - Internalism Debate," History of Science, 30 (1992), 360-61.

Neither did historians of science and China specialists embrace or pay equal attention to the same conceptual frameworks. The type of historiography advocated by the *Annales* school had a number of ardent admirers among scholars in the China field, but according to

What did historians of Chinese science make of all this? After all, these new interpretations, debates, and changes in directions were hardly vague, subtle, and isolated.[1] There were some clues, but not enough loud and clear evidence to determine where most of them stood. A few individuals such as Needham, Sivin, (and Nakayama in Japan) have been more vocal than others and their writings often revealed their leanings, but in the field of traditional Chinese science at large, views on these controversies and concepts were seldom openly articulated in written form before the mid-1980s. One is therefore left wondering whether the new ideas were deemed inappropriate for investigations into traditional Chinese science and hence dismissed, or whether specialists in our subject were not sufficiently informed or conscious of the momentous movements and changes afoot.

It is not wise to jump on bandwagons and hurriedly write, say, something "contextual" simply because that happens to be the word on everybody's lips. But neither is it wise to ignore or overlook powerful and pervasive forces that are in operation around one. After all, as Sivin reminded us in his opening lecture for the Sixth International Conference on the History of Chinese Science in 1990 at Cambridge, "our work is part of a larger enterprise, namely the history of science in all places at all times."[2] Whatever one's persuasion -- whether it is a commitment to providing a perfectly

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Jean Dhombres, "although there was some investigation in the history of techniques it is surprising that the French historical school of the *Annales* devoted so little time to the history of science in its sociological form just when Lucien Febvre was continually stressing its importance. The reason was probably that interest at the time was focused more generally on the history of attitudes and economics, the field of science seeming to be too narrow, unsuited to portraying the changing spectacle of a period, in a word too elitist": Jean Dhombres, "On the Track of Ideas and Explanations down the Centuries: The History of Science Today," Impact of Science on Society, 40 (1990), 197.

[1]Rarely did a new approach surface quietly and calmly one glorious morning to the praise of all and sundry. Blood was frequently spilt and byways trodden; challenges and refinements, either open or underground, often went on for varying lengths of time even after a somewhat firm foothold was gained.

[2]Nathan Sivin, "Technical History, Philosophy, and the Social Sciences," Chinese Science, 10 (1991), 69.

faithful rendering of past scientific traditions of a given culture "as they saw it", or a general scepticism as to the benefits and validity of such reconstructions -- the new thinking and methods merit thoughtful consideration and deep discussions and should be subjected to a series of tests and trial runs by Chinese historians of science.[1]

This is indeed, in my opinion, one of the most important general lessons we have learnt in our survey. I have, therefore, drawn heavily upon study trends in the China studies and the history of science arenas prominent in the 1970s and '80s in the formulation of the first six points and have borrowed much of their vocabulary.[2] I have tried my best to avoid throwing my weight behind any particular orientation or to ask loaded questions. The only firm position that I take is to implore researchers to start reflecting on and engaging in constructive dialogues concerning these matters.

(1) The priority issue and bringing assumptions of modern science and Western culture to the historical study of Chinese science:

We have already delineated in some detail the widespread influence of these two related concepts in our above overview of study trends for different periods; here we will restrict ourselves to assessing some of the most significant consequences and implications of the long-time preoccupation with these concerns and paradigms in the writing of the history of Chinese science.

Whether a topic in traditional Chinese science would constitute a legitimate object for historical inquiry seemed to have come to rest subtly on how much it contributed to shortening or lengthening the list of Chinese achievements and "firsts". There was also the tacit assumption that it would be unrewarding to offer extensive treatment to past Chinese scientific activities that had not led to developments deemed important to us today or that were performed with

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[1]Chances are that we will take to several proposals immediately, but some we would never be persuaded to try; and there are still others that may turn out splendidly when suitable adjustments have been made.

[2]Some of the studies consulted -- historiographical accounts in particular -- are listed in *Appendices: (ii) Works Consulted.*

motivations that did not conform to those held in the present age. The chief problem with these presuppositions is that they are at odds with, and can therefore give little credit or encouragement to the following alternative interpretation: that an idea or procedure need not carry the label of "success" / "failure" or "first" / "dead end" -- judged according to modern Western standards -- before it can be considered as a suitable or an inappropriate candidate for illuminating part of the past.[1] Another source of worry is that decades of such concentration on selected features and the tacit general acknowledgement that these were aspects and themes that "really mattered" might well have put the field and our knowledge of traditional Chinese science in real danger of being identified for the large part with these areas and their cousins alone. And this perception could in turn have influenced and guided directions of research.

Rather than hastily urge researchers to abandon or denounce such attitudes, I recommend on-going, large-scale, critical, and well-informed debates not just between the few leaders, but among all workers in the field -- for it is not simply a case of "who was right and who was wrong". It is important to remember that lying at the heart of the whole matter is whether one is convinced that applying premises and categories based on our own (i.e. current Western) experience, cultural expectations, and the modern scientific system can truly enlighten us about the nature and characteristics of traditional Chinese scientific activities, ideas and structures, on what they were, how and why they occurred.[2] It also depends on the extent one subscribes to the overarching view that it is possible for cultures (or members within them) to experience, handle and organise elements in the natural world in ways that may be fundamentally and intrinsically different from one another -- and that any variation is not merely a matter of having chosen different icings on pieces of

[1]As we have recounted in a number of places, there was a persistent indifference to and lack of interest in giving due weight to theories, observations and practices that were perceived as less glamorous, useful, or sophisticated, and they were rarely investigated thoroughly and systematically.

[2]One may very well hold the differing opinion that we are better off, that historical understanding is better served by not having an axe to grind and not arguing with the past.

cultural cakes. And further, that gaining insights into these different categories of knowledge and systems, goals and attitudes, modes and methods of explanation, styles of communication, etc., is desirable in its own right.[1]

Until and unless distinctions in these basic and critical assumptions have been recognised, much confusion would be created by prescribing new moves and declaring what is in the Chinese history of science field's best interest: for what constitutes "reliable" and "accurate" history or "misleading" information to one camp may not be taken as such by another.

(2) Inter-disciplinary approaches and the adoption of a combination of methodological strategies:[2]

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[1]Opinions did seriously differ. In Cohen's Discovering History in China: American Historical Writing on the Recent Chinese Past, one Chinese historian's (i.e. Cohen's own) personal account of a battle that took place on the Chinese history front of the American contingent is offered. In it the story, and perhaps more significantly, the beauty and benefits of pursuing a "China-centered history of China" (in particular for the 19th and 20th centuries) is told eloquently. For our present purpose, the most important premise to note in the book is that the author divides studies published in the immediate post-World War II years up to the early 1980s into four categories according to their "conceptual frameworks". The following three are guilty of "introducing Western-centric distortions into our understanding of nineteenth- and twentieth-century China": (i) "impact-response" and (ii) "modernization" (both of which were characteristic of scholarship from the 1950s and '60s, but with deep roots in 19th century Western attitudes towards China; (iii) "imperialism" (which surfaced in the late 1960s as an attack on the above two approaches). The fourth is the aforementioned "China-centered history of China"; an approach which "begins with Chinese problems set in a Chinese context", it came to the rescue, so to speak, around 1970: Cohen, Discovering History, pp. 154.

Harold Dorn's The Geography of Science (Baltimore: Johns Hopkins UP, 1991), on the other hand, gives some very different perspectives. A reviewer has this to say: according to Dorn, "those who actually find the seeds of 'science' in primitive, non-Western societies are mere cultural apologists who disregard the certain differences between 'true' science and the various strands of thinking that mirror science elsewhere; he insists that we detect these seeds only because we long to find them and thereby prove that we are all equal and the same": Martin S. Kenzer, rev. of The Geography of Science by Harold Dorn, in Isis, 83 (1992), 634-35.

[2]Here, "disciplinary" is used to refer to broad fields of study and human knowledge (e.g. pure and natural sciences, social sciences, religion, philosophy, history, philology, the arts) rather than to divisions within each of these fields (e.g. branches of pure and

We have also seen that by and large methodological tools scholars wielded to delineate and interpret traditional Chinese science were rarely subjected to close scrutiny and radical updating. Though the long-trusted family of approaches (e.g. philological work, identifying evidence of first manifestations) has been of service, the time has come for a shift in strategies, not least since techniques that are less conventional are especially important -- indeed sometimes necessary -- in crafting certain kinds of studies outlined in (1) above.

There are different research methodologies one can learn from and pursue, some more suitable than others; those characteristic of the social sciences are among the most obvious, but by no means the only ones available. Sivin has named "three borders" at the forefront of history of science research: "first the border with scientific practice, then the border with history and philosophy, and then the border with the social sciences, mainly anthropology and sociology."[1] To clarify matters further, Sivin has declared that the home of the history of science is "in the humanities" and that it is *not* "an ~~authonomous~~ autonomous discipline"; the history of science field, he argued, "is defined by the application of historical methods (and insights from other fields, such as philosophy, anthropology, and the sociology of knowledge) to scientific practice and thought."[2] Cohen, however, did not sound too encouraging when he expounded some Chinese historians' success in putting social science methods into practice.[3]

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natural sciences such as mathematics, physics, chemistry; branches of social sciences such as sociology, statistics, political science).

[1]Sivin, "Technical History," 69.

[2]Nathan Sivin, "Research on the History of Chinese Alchemy," in Alchemy Revisited, ed. Z. R. W. M. von Martels (Leiden: E. J. Brill, 1990), pp. 3.

[3]"Finding the right theory. . . and integrating it effectively with the data is only one hurdle that has to be surmounted. Another is what may be called the stylistic barrier: the challenge of incorporating social science concepts into historical narrative. . . . A third hurdle, perhaps the most humbling of all, is the demand that the mastery of theories, methodologies, and strategies from a wide range of disparate disciplines (often extending beyond the social sciences to mathematics and even, in some instances, the applied

In any event, it does no one harm to learn more about the procedures and perspectives other disciplines have to offer. Mixing and matching them adroitly can very well lead to new insights and solutions of age-old puzzles.[1]

(3) The role and influence of non-scientific and non-technical elements:

One of the most far-reaching concepts and strategies developed within the history of science community in recent decades -- and one of the most fiercely contested issues among American and British historians of science -- has been that of awarding a key role to non-scientific and non-technical elements. It is argued that one should no longer be content with examining solely or chiefly the scientific methods employed and the technical results of scientific activities; "other" factors should be studied with the utmost seriousness as well. Candidates for these "other" elements (that might have exerted influences on scientific undertakings) include: that civilisation's world view and cultural assumptions (e.g. popular, classical, local) pertaining to the natural world, the intellectual, social, economic, political, religious, institutional, biographical circumstances and settings.

Likewise, in the China field, by the late 1970s, there was a general acknowledgement (though by no means total acceptance) that

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natural sciences) places on the human brain -- a brain that, if it happens to be lodged in the head of an American historian of China, has already put in years of time and effort doing battle with one, if not two, of the world's most daunting languages": Cohen, Discovering History, pp. 184.

See also G. William Skinner, "What the Study of China can do for Social Science," Journal of Asian Studies, 23 (1963), 517-22, and Maurice Freedman, "What Social Science can do for Chinese Studies," Journal of Asian Studies, 23 (1963), 523-29.

[1]One can even argue that *failure* to employ inter-disciplinary approaches can be extremely detrimental to the health of the field. For instance, in his account on the demise of the study of Chinese alchemy, Sivin wrote in his conclusion: "What has held it back has been the disciplinary blinders that have led scholars looking at it from different perspectives to ignore what they might have learned by combining viewpoints. Until the chemists and specialists in religion are willing to learn from each other, and the philologists and intellectual historians from both, there is little prospect of resolving old or new issues": Sivin, "Research on the History," pp. 16.

understanding ancient and mediaeval literary works or political events should (or at least could) involve more than sorting out the literal meaning of the words that make up a poem or determining which battle led to what government action or who the "culprit" was. The poem, the records of a battle or a particular government edict that were preserved and handed down to us were results of the interaction of a host of elements and processes within a complex network of structures, experiences and conditions, which could be subtle or overt, short-lived or long-established, local or country-wide, personal or institutional, intellectually, religiously, socially or economically related and motivated, etc.

Applications of this family of approaches and tendencies (given such labels as "contextual" or "external / internal") have been fairly widespread, and debates rather intense and polarised at times. But historians of Chinese science can start with pondering on the following propositions.

First, there are excellent reasons for examining thoroughly the technical content, procedures, and results of traditional Chinese scientific ideas and activities. The tendency in the vast majority of past Western studies to choose that as the main point of attack, including the compilation of fuller and better inventories, therefore has definite merits.

However, it is difficult to imagine that non-scientific and non-technical elements did not play a part in the genesis and evolvement of scientific writing and pursuits in traditional China; in other words, to conceive of Chinese historical interest in science as occurring in a vacuum, isolated from larger systems.[1]

Moreover, no matter how superbly translations and data collecting are done, efforts concentrating on minute technicalities, narrow problems, and detailed textual exegesis suffer from limitations inherent in such genres.

Finally, in performing technical and scientific analysis, serious problems can be caused by employing tools intended for

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[1]Indeed, the burden of proof lies with those who argue that none or very few of these factors provided reasons or settings for science-related activities. To present their case, they would have to offer compelling evidence that in Chinese science, the technical dimension alone can stand as finished history.

scientific structures built with Western reasoning. At times, devices derived from modern science can do much to clarify the workings of a traditional Chinese scientific procedure or concept. But they may not function well when applied routinely and wholesale to explain developments in the Chinese scientific traditions.

In sum, there is everything to gain by welcoming all opportunities to consider possible non-scientific influences and becoming sensitive to these connections. Treating non-scientific and non-technical aspects as integral parts of one's inquiry into traditional Chinese science can widen one's horizon considerably and enrich the field as a whole. Imagine histories that succeed in weaving together some if not all of the following: traditional Chinese scientific methods, techniques, observations, and records (i.e. what can be termed the internal content), the underpinning philosophical concepts and cultural premises, possible utilities, functions and objectives of the activities, prevailing socio-economic conditions, political climate as well as institutional factors, and biographical details of the responsible individuals. Would they not stand a far better chance of offering a more rounded account and meaningful interpretation of Chinese scientific endeavours? Would they not be at least more provocative? And we should not worry overmuch about how we label such histories -- are they "contextual" or are they "internal": like all truly ground-breaking works, they probably defy classification as works of one or another pedigree.

(4) Comparisons across subjects and topics:

When studying alchemy and astronomy, exercises comparing Chinese activities with those performed in other cultures were regularly conducted to illuminate features distinctive or not native to China. However, works that sought to compare and contrast Chinese experience in one scientific domain with another were rare. As ideas and practices might have shared similar origins, frameworks, goals, and documentary and other research sources, such inquiries can prove enormously profitable.[1] Moreover, reasoning, details, and con-

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[1]For instance, studies designed to advance what we identify today as astronomy or mineralogy may have important information and findings to offer say someone interested in mathematics or alchemy. And archaeological discoveries are likely to contain material applicable to the study of different spheres

clusions derived from branches that have received a larger share of attention can help advance research into areas with more diffused source materials and components. And drawing parallels across cultural boundaries can throw light on the issue of transmission and influence forwards and backwards, within and outside China, and reveal whether similar methods or problems were applied or solved differently in another time or another place.

(5) Sectors and elements that were less established, unified and elitist:

Established schools and traditions in the mainstream of Chinese culture (e.g. Confucianism, Taoism) are exceedingly well documented, and the attention lavished on them by Sinologists has a venerable history. It is not surprising, therefore, that past Western studies have concentrated almost exclusively on scientific activities and ideas that emanated from these sectors. In fact so little time has been spent on the efforts of alternative groups and members of "lesser" traditions or even on determining their presence (or absence) that one may be excused for assuming that there was only a single kind of system in operation. The study of contributions from elite and highly-regarded communities and individuals is perfectly legitimate. Yet it is unlikely that they represented the entire range of concepts and experience, and can provide all linkages and clues to explicating puzzling issues. By emphasizing them at the expense of "unorthodox" ideas and the work of less organised and visible groups, valuable perspectives and a chance to better appreciate the history of Chinese science is therefore sacraficed. All parties involved deserve their fair share of concern.[1]

(6) Changes and evolution:

By and large authors of studies on traditional Chinese science have shown little inclination to make the evolving character of a subject their main theme. Their works seldom highlight modifications, revisions, breaks in practices, governing principles or

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of scientific understanding.

[1]Recent interests in popular culture (e.g. little-known or localised social beliefs, practices, literature, religious sects) in the China field have demonstrated how much we can learn from such inquiries.

perceptions that occurred as knowledge and skills accumulated over time. Were the Chinese scientific traditions then a static entity, and tracing changes and fluctuations in fortunes therefore unnecessary? Was the history of Chinese science one long ascent from first manifestations to the peak followed by a steady continuous decline? Or should it instead be viewed as an ongoing process that went through periods of rise and fall, growth and decay? If so, were the ebbing and flowing of experiences and ideas, the changes from one stage to another erratic, abrupt or gradual? Were the alterations drastic or moderate? These are questions few have discussed deeply and consistently. If one recognises that traditional Chinese scientific activities possessed a more dynamic character than the one portrayed in the available Western literature, then one can begin, for instance, with identifying salient characteristics in each phase of development, and assessing the conditions and circumstances that dictated or facilitated deviations from and reversions to past patterns.[1]

Furthermore, investigating changes and evolution has the added bonus of encouraging much needed research into little-studied periods or less "impressive" phases.

(7) Broad surveys, comprehensive overviews, and general outlines:

There is a serious shortage of such kinds of publications at both introductory and advanced levels. With little attempt and interest at integrating findings on a wide scale, the field and its major sub-divisions appear more like miscellaneous collections of disparate contributions. There have been few general works that embrace a number of different areas and aspects, and whatever is

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[1]For example, in biology, botany, and zoology, this can take the form of mapping and analysing origins and variations in classification and taxonomy over an extended period of time. And for those interested in astronomy, Sivin recommended that they take the following measures among others: "The simplest way to attract more useful contributions would be to compile a chronological catalogue of astronomical capabilities. . . . It ought to be possible to set down what types of observation were being made at a given time, with what instruments, and to what precision. We might interweave with that an account of what was being computed in each period, by what means, and based on what data. We would want to specify what conceptual tools were guiding the design of Chinese models. It would not be wise to include only notions familiar in Europe": Sivin, "Science and Medicine," 65.

available is generally devoted to the so-called "greatest technological and medical discoveries and inventions", and contains little on guiding concepts and principles.[1]

One has long sought well-coordinated and meaningful surveys that trace and assess systematically and comprehensively the formation, historical progress, major episodes and documents of an entire branch or several of them across a vast stretch of time. These works can take different forms, one of which is succinct synoptic accounts and outlines that are basically narrative, retelling the history in a straightforward fashion. Far from being a genre to be disdained, this type of material is in fact notoriously difficult to craft.[2] One cannot emphasize enough that they should not be over-simplified, story-like popularisations that paint misleading and distorted portraits (in which case they can do more harm than good). They should be jargon-free, lively, balanced, and judicious, which someone without prior knowledge of the subject can readily digest, and which one can confidently recommend as a guide or textbook in introductory courses. Alternatively, broad interpretative reconstructions that steer more towards critical discussions and evaluations that cover vast tracts of traditional Chinese science across the centuries can be attempted. These would likely appeal to those with some background knowledge of the subject and students at advanced levels.

Whatever the emphasis and style, it pays to keep in mind the following: (i) It is essential that the work be supplemented or footnoted with plenty of thoughtfully chosen references that supply

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[1]It must be admitted that different sub-fields and topics are in different stages of maturity, and it can be argued that some (e.g. the study of Chinese knowledge of the animal kingdom) are still riddled with such sizable gaps that our pleas should be for detailed single case studies. But it would be cowardly to use this as an excuse for not attempting to construct broad patterns. An equally strong case can be made for the approach of first sketching the outlines and laying down the main themes and images, then filling in the details and refining sections of the foreground or background later. Stabs in the dark can be dangerous, but not all of them need be wide of the mark especially if the hypotheses and conjectures presented are intelligent. Provided that its foundation is basically sound, an edifice should still have the strength to withstand quakes and serve its purpose even if one or two of its wings that do not stand on firm ground may eventually crumble and have to be rebuilt.

[2]This might explain why one is still waiting for them.

the details and stimulate the reader to further inquiry. (ii) The account can come from the pen of an authority in the field, writing expressly for this purpose; it can also be a synthesis of findings gleaned from secondary sources. (iii) The work would be much more useful if the author draws on original research -- either his own or those of others -- accomplished in recent decades.[1]

And if all that proves to be too ambitious an undertaking, at least one can bring together those issues, landmarks, techniques, and treatises that one encounters individually in various places.

The simple idea of collecting in one book a sample of "the most representative" articles on a set of allied themes and topics -- ideally with critical introductory comments so that the papers' functions and value can be placed in perspective -- is also one that should not be dismissed.[2]

All manner of general works that take aim at integrating disparate elements, pulling various loose threads together, and bridging the gap between communicating the latest research results and thinking on specific topics and providing accessible broad synthesis are welcome. Without them, the field runs the risk of remaining as one

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[1]Peter J. Golas' savage attack on Robert Temple's The Genius of China: 3,000 Years of Science, Discovery and Invention (New York: Simon & Schuster, 1986) in his review dramatises the pressing need for up-to-date and accurate general surveys that are suitable for classroom teaching purposes. Whether Golas' criticisms are fully justified is something on which one can keep debating, but what concerns us here is his own strong conviction that the book suffers from grave deficiencies. Yet in spite of his denouncement of the work, he confessed that he has "just finished using this book as a text in my 'History of Chinese Technology' course", that "especially given the complete lack of any similar volume to be used in a course on Chinese technology, this book can be a useful tool provided the instructor is prepared to employ its materials selectively. . .": Peter J. Golas, rev. of The Genius of China: 3,000 Years of Science, Discovery and Invention by Robert Temple, in Chinese Science, 10 (1991), 68. That one had to resort to a book which one found exasperating and to have contained basic scholarly errors because there was simply no other work on the subject, is indeed a sad reflection on the state of affairs.

[2]Extremely important sections on the subject buried inside monographs that are not specifically on Chinese science can also be publicized in such collections.

which consists for the most part of vignettes.[1]

(8) Communication and cooperation across disciplinary boundaries and country borders; attracting external constituents, a broader audience, and post-graduate students:

Our survey has revealed that the training, profession, and specialisation of those that have expressed interest in the subject through their writings were quite diverse. While there will always be a number of researchers who would declare that their curiosity in traditional Chinese science is only a marginal one and they prefer to spend the better part of their energy elsewhere, their respective expertise can still be harnessed to bolster the field and to offer fresh perspectives. Cooperation will prove particularly beneficial in inquiries dealing with themes and subject matter (e.g. minerals) that involve different branches or that consist of a number of separate facets.

Paradoxically, it is precisely because traditional Chinese science is a formidable subject that more deliberate efforts at expanding the network of researchers should be made. Many are intimidated by its forbidding look and its esoteric nature, and secondary studies often serve those who are already in the field or who have some familiarity with allied areas. And yet the assistance of "outsiders" can be invaluable once they are persuaded to join us. And we must not allow ourselves to forget that scholars in what may seem unlikely fields at first glance (e.g. history of art) can be enlisted as well. Even teamwork performed by two or more scholars specialising in the history of Chinese science can add new dimensions to a particular issue, especially if they have been trained in different countries or in different departments (e.g. history, philosophy, Chinese studies).

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[1]Even in the general history of science field, at least one individual has felt the need to revive "general, synthetic surveys of the history of the natural sciences from the ancient Egyptians to Albert Einstein, or from the Tower of Babel to Niels Bohr": C. Hakfoort, "The Missing Syntheses in the Historiography of Science," History of Science, 29 (1991), 207. In his essay, Hakfoort asks and attempts to answer the following three questions: "Why are there almost no general syntheses at this moment? Should historians of science really be striving to write general syntheses? If so, what may these syntheses be like?": Hakfoort, "The Missing Syntheses," 207-08.

There are various other ways of broadening the base, attracting experts from other disciplines, and keeping new members. Once again, general surveys which present summaries of historical developments and major perspectives in a nutshell to non-specialists (which in a way we all are once off our own specialty) can be of great service, and so are attempts at preparing accounts that employ methodologies borrowed from other disciplines. Another route to try is to publish more often in widely-circulated journals or in ones read by different sets of specialist audience.[1]

Furthermore, the pooling and sharing of resources and expertise is especially needed in view of the fact that the ideal qualifications and training required for a first-rate historian of Chinese science are nothing if not stringent.[2] And it cannot be easy for a single institute of higher learning to provide all the facilities so that an individual can obtain the necessary instructions and preparations in these many different aspects within a reasonable amount of time. Hence ways must be found to ease the burdens and practical problems associated with training and recruiting post-graduate students.[3]

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[1]The reality of the matter is such that someone mildly interested in traditional Chinese science may not check the ISIS current bibliographies or the Bibliography of Asian Studies regularly for titles on the subject, but will gladly take note of an article which he comes across in a journal he peruses regularly. This may seem a minor point, but these small practical steps do have a cumulative effect over time.

[2]In discussing the possible adoption of social sciences methodologies, reference has been made to Cohen's remark concerning the many skills Chinese historians have to master. Add onto his list the need to understand ideas, processes, and vocabulary of a scientific and technical nature in Chinese as well as (pre-modern and modern) Western scientific systems, and the task appears beyond the reach of mere mortals.

Sivin also conceded that, "few historians anywhere combine mastery of the languages and their philology with ability to comprehend laboratory precedures. There are thus few potential investigators [of Chinese alchemy] among scientists or Sinologists": Sivin, "Research on the History," pp. 6.

[3]In commenting on the question, "how does one become a historian of science?" Dhombres observed that, "there is vitually no place of training for historian of science, whilst the profiles of present-day historians of science are increasingly varied": Dhombres, "On the Track of Ideas," 203.

(9) Systematic and dedicated bibliographic provision and control:

We can start with three observations, drawn from different parts of our review. First, the field has not established a habit of attending to bibliographic matters. Unlike disciplines in which lists of available materials arrive routinely at one's doorstep, bibliographies of secondary Western works devoted to traditional Chinese science are scholarly treats. Second, the extremely diverse types of journals and collective works involved make tighter and more dedicated control imperative. Third, in practice, it is not realistic to rely solely on general bibliographies in Asian studies or the history of science -- not even the annual ISIS bibliography or Bibliography of Asian Studies -- to do the job for us.

The proposal of filling up and expanding the bibliographic reservoir is not difficult to sell. After all, no one can argue against a near exhaustive bibliography for a particular branch of Chinese science or one that is critically selected and annotated, or a conflated listing of all the titles in Science and Civilisation in China "Bibliography C" (and better still, with up-dates and additions to the earlier volumes).[1]

But given the three comments with which we began our discussion, my recommendations for improving bibliographic access and control go further than simply encouraging the compilation of bibliographic lists. Firstly, to ensure the high quality of these bibliographic aids, the task of producing at least some of them should fall on the shoulders of those whose primary specialty is in the history of Chinese science, and who are also knowledgeable about bibliographic sources and sensitive to needs outside as well as within the field.

And the "first point" Jacques Roger makes in a recent study is one that "concerns the institutional status of history of science, which is generally marginal, and almost always ambiguous. Scientists, philosophers and historians, each in their respective Departments, practice the history of science, which finds no clear place in the traditional departmental divisions of the university. History of science may be everywhere or nowhere depending on the country or the university": Jacques Roger, "History of Science: Problems and Practices: History of Science(s), History of Mentalities, Micro-history," Nuncius, 8.1 (1993), 5.

[1]Bear in mind, however, that no one benefits from an exercise that is merely a case of more of the same.

Secondly, in addition to retrospective bibliographies, there should be regular conduits through which one can communicate and be made aware of new secondary literature along with unpublished research material and work in progress. A channel that one can now exploit is the EASCI, "an electronic discussion group for the history of East Asian science, technology, and medicine", formed around 1994 and administered by Sivin at the University of Pennsylvania.[1] Another is the Newsletter for the History of Chinese Science published biannually since 1991 by Huang Yi-Long in Taiwan to complement Chinese Science. It contains abstracts and bibliographic listings of mostly Chinese materials, but it apparently welcomes Western-language items as well.[2] The Needham Research Institute in Cambridge (which publishes a Newsletter periodically) can also play an active role as it is often the fortunate recipient of new books and articles sent by authors. A task these contributors to bibliographic updates can consider undertaking on a regular basis (say every three months) is to check the few on-line indices and resources (e.g. Francis, Historical Abstracts) that may contain relevant material.[3]

In order to be successful at channeling up-to-date bibliographic information to all interested parties, it is important to remember that such services (and the providers) must be widely publicized and must gain the broad support and co-operation of all affi-

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[1]One can "post a question for colleagues to answer, propose a topic for discussion, reply to an earlier query, trade information about publications and other resources. . . announce meetings and other activities": Announcement in Chinese Science, 11 (1993/94), page facing inside back cover. Of special interest is the following statement: "the Group will maintain files that subscribers can choose and download individually. Initially, these will include research aids (bibliographies, etc.) contributed by you and other members, as well as compilations of the messages sent to the list, prepared every month and kept for a year or two": ibid.

[2]According to the information given in its "Scope" section, Chinese Science itself -- now the official journal of the International Society for the History of East Asian Science, Technology, and Medicine and published annually -- does not appear to be interested in delivering bibliographies of secondary studies.

[3]For the subject of traditional Chinese science, on-line searches are generally not worth an individual's time (and expenses), but it would be good to have someone take the responsibility of checking the data bases regularly on behalf of the field.

liates of the traditional Chinese science community.

Thirdly, relating reference guides and bibliographies to scholarly requirements, teaching activities, and collection development in libraries -- a matter often neglected -- is essential. In other words, instead of being a hotch-potch of random items, bibliographies should cater to specific needs which have not been adequately served in the past, and adopt appropriate selection policies based on these needs.[1] And selection guidelines or gaps a compilation seeks to fill have to be clearly stated. Bibliographies are also to be judged according to how well their entries are organised and the search options available. This again depends on the focus of each particular bibliography and the requirements of its primary users.[2] The same consideration applies when determining the kind of Chinese concepts and terminology to use as subject terms or in the classification scheme.[3] It is my firm belief that no single bibliography can be everything to everybody. But all bibliographies must have practical use and their contents must be sensibly arranged; they should

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[1]For example, a bibliography designed for undergraduates that is dotted with out-of-print books and periodicals that are hard to locate is unacceptable. So are highly critical annotations that make frequent reference to unfamiliar vocabulary and concepts. On the other hand, such annotations add immense value to a bibliography intended for those with prior knowledge of the subject.

[2]For example, a bibliographic guide for non-specialists covering an array of topics must offer adequate subject guidance and cross-references, but not so detailed as to overwhelm and confuse them.

[3]This is an important point to stress. As Magda Whitrow observed, "[Robert] Flint believed that the classification of the sciences and the classification of books were essentially distinct. . . . [Henry E.] Bliss thought this distinction invalid. He believed that when books and documents are classified by subject matter, regarded as knowledge or as sources of knowledge, such classifications are virtually classifications of knowledge. Recently, there have been attempts at a rapproachment between philosophers of science, classificationists and taxonomists, thus bringing together the three important aspects of classification: logical, bibliographical and taxonomic": Magda Whitrow, "A Classification Scheme for the History of Science, Medicine and Technology," in Human Implications of Scientific Advance: Proceedings of the 15th International Congress of the History of Science, Edinburgh, 1977, ed. E. G. Forbes (Edinburgh: Edinburgh UP, 1978), pp. 519.

also contribute significantly to the coherent and systematic bibliographic control of the fields of study concerned.

Fourthly, hard to accomplish and easy to overlook, but can do a power of good all round are earnest attempts to ensure a balanced representation of materials on traditional Chinese science in all types of bibliographies in allied fields. In addition to alerting general history of science or Asian bibliographies to new works, this also means worrying over such matters as whether personal names are properly cited and whether their retrieval mechanisms allow Chinese science titles to be readily accessible.[1]

It is vital that individually as well as collectively, more thought and effort be put into bibliographic concerns, making it part of the research agenda and routine, and considering it as an issue that is worth serious scholarly treatment. It is a matter of considerable urgency that the relaxed, random approach be replaced by more committed, concerted, and continuous measures.

(10) The place occupied by Science and Civilisation in China:

Finally, a word on Science and Civilisation in China (and to a limited extent Needham's writings on the history of Chinese science) is called for.[2] To thoroughly describe and assess Science and Civilisation in China's contributions to fostering an awareness in and the scholarly study of Chinese science would be the subject for an essay. Here we will confine ourselves to commenting on the oft-repeated claim that Science and Civilisation in China is the only work available (or that "matters") when seeking information on the history of Chinese science, in the light of what we have learnt in our survey about publications that came before and after Science and Civilisation in China's time.[3] Why has this notion been so wide-

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[1]Again, the International Society for the History of East Asian Science, Technology, and Medicine or the Needham Research Institute may consider doing some of the monitoring.

[2]After all, has one ever participated in a conversation -- serious as well as casual -- on the history of Chinese science without bringing up Science and Civilisation in China (or Needham) in some shape or form?

[3]It must be stressed that the remarks that follow apply chiefly to the volumes of Science and Civilisation in China published within the period considered in the present study (i.e. prior to 1986). As

spread? Is it justified?

Science and Civilisation in China's overall excellence has never been disputed, and the highest praise has been lavished on it by authorities from different sectors of academe.[1]

Moreover, Science and Civilisation in China (and Needham's writings on Chinese science in general) are exceptionally powerful: to the attentive reader, it is plain that for Needham, his works were not merely academic exercises; there was a mission to be fulfilled, a crusade, that transcended that of merely seeking to meet high standards of scholarship. Such power and dedication has set them apart from publications by other specialists, and has made them immensely persuasive and memorable.

In addition, "word-of-mouth", I suspect, has a great deal to do with Science and Civilisation in China's image. Not only has the study of the history of traditional Chinese science been profoundly influenced by Science and Civilisation in China, but its title has graced the footnotes and bibliographies of such a large number of publications of different varieties that Needham and Science and Civilisation in China have become household names in the China and history of science worlds, names that come to people's minds and roll off their tongues even though they may only have a vague idea of what the series and Needham's great enterprise are all about.[2] And like all works that have become widely-acclaimed and indispensable clas-

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the Science and Civilisation in China project evolved, changes that altered significant features and aspects of the work were found necessary (e.g. delegation of the research and writing of entire volumes to collaborators; contents of footnotes were not longer indexed).

[1]Among the outstanding qualities repeatedly mentioned are the volumes' unsurpassed richness and the vast amount of information they contain; insights, originality and new revelations (especially comparisons between East and West, and illumination of points that have escaped Sinologists with inadequate training in the sciences); Needham's extraordinary erudition, enthusiasm and broad interests; the masterly bibliographies and indices; the volumes' handsome presentation.

[2]Remember also that Needham himself had become somewhat of a legendary figure, and his reputation extends far beyond that associated with the history of Chinese science, technology and medicine. It never ceases to amuse me when people mention Needham's name as though he is some mediaeval saint -- or heretic.

sics, those outside or new to the field often have the impression that their contents have been and should be simply received and adopted without weighty criticisms or perhaps even minor reservations.

But such notions are regrettable.

First, as we have seen in the above chapters, while saluting the fine qualities which the Science and Civilisation in China volumes possess, reviewers have never shied away from asking critical questions, raising serious doubts or delivering a few harsh words on particular points. Those who have patiently followed the fortunes of the series over the last forty years are, of course, keenly aware that Needham and his collaborators' provocative way of exploring and interpreting source materials coupled with their assumptions of certain fundamental views and positions (e.g. Needham's singular approach to China's role in the development of Western science and technology) have meant that almost none of the volumes managed to free itself entirely from protest or dissent in one form or another. In a word, there have always been criticisms -- mild as well as fierce.[1]

Second, for all Needham's exceptional zeal, honesty, ingenuity, and learning, starting an entire movement is too much a claim for any one person alone. Science and Civilisation in China was not fatherless: it was itself a fruit that grew out of seeds sown over the centuries. Western literature from the past played such a significant part in the tale told by Science and Civilisation in China -- positively or negatively, in spirit or content -- that without it the story would have been very different.[2] And Needham himself was always the first to take great pains to remind readers of previous work done on the subject.

Third, we have seen repeatedly the stimulation the volumes gave

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[1]On the other hand, it should also be borne in mind that the few total and full-scale condemnations (e.g. as in Qian's The Great Inertia) did not win any meaningful and consistent support.

[2]I cannot imagine or visualise a volume of Science and Civilisation in China that takes no cue from or that does not make use of other Western writing, may it be to affirm, modify or dissent diametrically from their findings and observations. This is particularly noticeable in a subject such as astronomy.

to later publications and research. These writings took various forms and styles. Some followed the outlines drawn by Science and Civilisation in China closely and faithfully: these heirs to the Science and Civilisation in China mode of studying the subject were interested primarily in filling in the foregound, adding details or giving fuller consideration to the delineation. Others, though also prompted by remarks from and encouraged by the groundwork laid in Science and Civilisation in China, substantially altered conclusions set out in it or questioned its research methodology and ideological premises (e.g. its persistent search for precusors and antecedents).[1] In one way or another, all these post-Science and Civilisation in China accounts have nicely complemented the portrait drawn by Needham and his collaborators by offering extensions, elaborations or contrasts.[2]

To help everyone arrive at a more balanced and healthy view of the place occupied by Science and Civilisation in China, all these features should be articulated and driven home more frequently and openly.

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[1]It can in fact be argued that these works came very close to instituting a separate school in the study of Chinese science.

[2]In the final analysis, after conducting this historiographic review, I would venture to argue that Science and Civilisation in China's unique contribution to the field ultimately lies in the magnitude, weight, originality, and far-reaching consequences of its controversies, challenges, tantalising ideas, broad strokes, and amassed materials. These are the qualities that have clinched its place as the most important work in the study of traditional Chinese science in the 19th and 20th centuries, and will help secure its value for decades to come -- more so than its being the last or only word, for it is neither, and Needham himself made no claim that he had provided all the answers. The minute details, particular findings, and specific hypotheses in the volumes will not all endure the test of time, but even if some of them eventually crumble, the Science and Civilisation in China volumes will still stay on bookshelves, and continue to capture the imagination and attention of staunch supporters as well as stern critics, students as well as scholars, newcomers as well as experts, who will share their sense of excitement and turn to them for inspiration and reference time and time again.

10.13 AFTERWORD

In *Chapter 1: Introduction* I have explained that the present bibliographic survey was stimulated by a curiosity in as well as the practical need to find out about Western historiography on traditional Chinese science, and spurred on by comments and anecdotes that I came across. Now, four hundred pages later, I am happy to report that I have reached my very own conclusion: that all in all, there is some very good news and some not so good news.

The excitement first. Judging by all the published views specifically on the subject, Western interests in the 19th and early-mid 20th century were not as pitiful as I had originally thought. Although on the whole the literature produced was not remarkable in terms of scholarship, it harboured a certain degree of variety and was of a moderate size. And in spite of the overall mediocrity of these earlier works, one has to concede that there were a few exceptions and respectable advocates in each generation. Above all, though different aspects of it experienced ups and downs in their respective fortunes, and undertakings to learn more about it were somewhat ad hoc and haphazard, the subject of traditional Chinese science never vanished totally out of sight. It somehow managed to survive, and with the passing of every decade since the 1950s we have seen it rise steadily in respectability and momentum. By 1985 one could look back proudly and exclaim that the study of Chinese science truly has come a very long way since the days of Biot, Edkins, Bretschneider, Wiley, Van Hée, and de Saussure. The field could boast some first-rate scholarly works and champions, research results appeared often as monographs and in distinguished journals from different disciplines, and no scholar worth his salt could persist in looking upon inquiries into traditional Chinese science with disdain. It has emerged from the shadow, and there simply is no way the clock can be turned back.

Now comes the part that, in my personal opinion, seems less good.

First, it is disturbing to find a lack of general discussion on historiographic trends among those in the West who share an interest in traditional Chinese science. What positions have scholars adopted in the past, and are they still appropriate? What are the current opportunities, problems, and priorities? As I have stressed in many places, reaching commonly accepted answers or some kind of shared consensus to these questions is not as important as being more conscious of them, facing up to them, and reviewing them regularly. Though seeds for constructive discussions were planted by a handful of pioneering works by Sivin and Nakayama, these issues were confronted on few occasions by the community's rank and file.[1]

Parochialism as well as the isolation of the field's investigators both from each other and from specialists in other disciplines is another source of worry. In my opinion, active, functional and extensive networks that welcome and assist anyone interested in the subject whatever their scholarly persuasion and background should have been formed decades ago. That such networks have the advantages of providing forums for discussion on the field's future, of facilitating greater visibility and a higher profile to its members, of fostering communication among the more seasoned workers as well as offering help to the newly arrived, should be self-evident. Not everyone will want to get deeply involved in the activities of such groups, but it is so very important to generate a sense of community amongst *all* individuals studying the subject.[2] Even today, when one

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[1]Even in the "Kyoto Symposium" held in 1987 in honour of Yabuuti Kiyoshi and organised by Nakayama (with 102 scholars from China, Japan, and Western countries), we learnt from Nakayama's report that among the fourteen papers presented, only the following three came from Western scholars: Paul Ulrich Unschuld, "Multi-paradigmatic Science vs. Revolutionary Science? Some Thoughts on the Comparative Study of European and East Asian Cognitive Dynamics"; Sivin, "Science and Medicine in Imperial China: The State of the Field"; Ho, "Trends and Prospects of Recent Chinese Research in the History of Science". According to Nakayama, "a considerable portion of the Symposium was devoted to free discussions of future strategy": Nakayama Shigeru, "Grading Chinese Science Studies: A Report on the Kyoto Symposium on Chinese Science," Chinese Science, 10 (1991), 58. I do not know the number of Western attendees, and I can only hope that there were plenty and they brought up the issue of research on the subject in the West in these discussions.

[2]In the field of the history of American science, such awareness is not hard to detect. In the special issue of Osiris devoted to historical writing on American science, the introductory chapter concludes with an appendix listing eighteen titles that "represent significant thinking about the state of the history of American science. . . written by observers and advocates of the field over the past half century. . . arranged here in chronological order to

speaks of the field of traditional Chinese science, more often than not one has in mind a research subject or a tiny circle of dedicated scholars, rather than a vibrant, well-structured and rapidly expanding community, conscious of its roots and idiosyncracies.[1]

Lastly, I discern a subtle but persistent and pervasive tendency to look upon traditional Chinese science as a subject that always needs to plead a special case, as a "marginal" area, a "second-class citizen".[2] While polite interest in some aspects of it is frequently expressed, when opportunities for incorporating traditional Chinese science into research proposals, teaching programmes or bibliographic tools present themselves, they are not readily taken up.

Why does this tendency and sentiment still persist? The reply would probably come in the form of a combination of the following propositions:

(1) With few exceptions, published studies in the field have generally not been convincing enough. One can argue that after picking over all the contributions, discarding ones that are poor or trivial in terms of scholarship or content, there are very few substantial

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suggest the changing orientation of those contributing to the subject": Margaret W. Rossiter, and Sally Gregory Kohlstedt, "Introduction," in Osiris, 2nd ser., vol. 1: Historical Writing on American Science, ed. Margaret W. Rossiter, and Sally Gregory Kohlstedt (Philadelphia: Department of History and Sociology of Science, U of Pennsylvania, 1985), pp. 15.

[1]For some time, Needham's research base and project in Cambridge has been the "mecca" towards which people have gravitated, but promoting cooperation and communication among all those interested in traditional Chinese science does not seem to rank high on the agenda of the Institute. My hopes are on the International Society for the History of East Asian Science, Technology, and Medicine, formed five years ago. It now publishes Chinese Science (its official journal), and organises the International Conference on the History of Science in East Asia (held every three years). Perhaps the Society can seriously consider "outreach" as one of its key functions. It can, for instance, take steps to make sure that its voice is heard and its members participate actively in the compilation of syllabi and bibliographies on non-Western science sponsored by the History of Science Society or the Commission on Bibliography of the International Union of the History and Philosophy of Science.

[2]This probably applies more to those outside the field, but sometimes within it as well.

pieces left.

(2) In theory as well as practice, traditional Chinese science does not and cannot have broad implications for the study of the Chinese culture or the history of science generally; thus it cannot become an integral part of these larger domains and be accepted into the fold as a full and active member.[1]

(3) Publications on traditional Chinese science are out of step with current historiographical trends, and scholars from the outside find it hard and uncomfortable to march side by side historians of Chinese science or to become more deeply involved with research on the subject.

(4) Unlike other more robust areas and disciplines within the Chinese studies or history of science fields which can stand up to a fair amount of wear-and-tear in classrooms or scholarly exchanges in journals, conference settings and the electronic mail, traditional Chinese science is considered not suitable for day-to-day consumption in much the same way that exotic fruits are fine for special occasions or for those that have developed an acquired taste for them.

(5) The subject may have suffered from poor exposure and publicity. The available scholarship and on-going research have demonstrated the value of studying Chinese science to those in touch with the field, but those outside remain largely unaware of their existence and potential. Inadequate bibliographic provision and control, the scatter of articles in journals of diverse nature and subject categories (and perhaps Chinese historians of science being a quiet lot that loathe to lobby aggressively or market their wares to external constituencies) may have contributed to this lack of proper appreciation for and information on the subject.

In other words, I had expected to see the firm acceptance and integration of the field of traditional Chinese science into the inner circles of the Chinese studies and history of science families as a full member -- not merely sitting on the fringes, waiting to be

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[1]Somehow there seems to be a sense that past Chinese scientific activities, ideas and knowledge may not be capable of providing "deep", "true", or "fundamental" historical understandings. Hence, for instance, it is only after one has learnt much in areas in the history of Western science or Chinese literature, philosophy, etc. would one dip into topics in Chinese science.

called upon for specific debates or invited into selected banquets. And I find it sad as well as sobering that this has not already happened.

This bibliographical study has been undertaken in an almost adventurous spirit, trusting that a less than perfect start is preferrable to not starting at all, and that bibliographic endeavours rarely get completed, only abandoned. The surest test of whether this concept and vision is shared by others thus lies in the willingness of readers to point out errors and continue the discussion. Therefore, allow me one final plea: read it critically, use it sensibly, improve on it, and write a sequel to it.

PART II

(i) Bibliography of Works on Traditional Chinese Science Covered in Part I (Chapter 2 - 9)

CHAPTER 2 : TRADITIONAL CHINESE SCIENCE -- GENERAL WORKS

2.1 ACCOUNTS THAT COVER MULTIPLE FIELDS AND TOPICS

[1835] **Biot, Édouard.** "Notice sur quelques procédés industriels connus en Chine au XVIe siècle." Journal Asiatique, 2nd ser., 16 (1835): 130-54.
[1860] **MacGowan, D. J.** "On the Cosmical Phenomena Observed in the Neighborhood of Shanghai, during the Past Thirteen Centuries." Journal of the North China Branch of the Royal Asiatic Society 2 (1860): 45-76.
[1869] **Julien, Stanislas, and P. Champion.** Industries anciennes et modernes de l'empire chinois, d'après des notices traduites du chinois. . .. Paris: Lacroix, 1869.
[1883] "Promise and Performance in Chinese Science." Nature 28 (1883): 417.
[1888] **Edkins, Joseph.** "A Sketch of the Growth of Science and Arts in China to the Ming Dynasty." Journal of the Peking Oriental Society 2 (1888): 142-54.
[1889] "The Priority of Chinese Inventions." Nature 40 (1889): 165-66.
[1895] "Scientific Knowledge of the Ancient Chinese." Nature 52 (1895): 622-23.
[1898] **Martin, William A. P.** "Chinese Discoveries in the Arts and Sciences." Journal of the Peking Oriental Society 4 (1898): 19-28.
[1912] **Vacca, Giovanni.** "La scienza nell'Estremo Oriente." In Atti della Società italiana per il progresso delle scienze, V Riunione, Rome, 1911. Rome: G. Bertero, 1912. pp. 3-19.
[1915] ---. "Note cinesi." Revista degli Studi Orientali 6 (1915): 131-142.
[1923] **Chatley, Herbert.** "Science in Old China." Journal of the North China Branch of the Royal Asiatic Society 54 (1923): 65-80.
[1930] **Vacca, Giovanni.** "Some Points on the History of Science in China." Journal of the North Branch of the Royal Asiatic Society 31 (1930): 10-19.
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CHAPTER 3 : TRADITIONAL CHINESE SCIENCE -- FUNDAMENTAL CONCEPTS; PHILOSOPHY; SOCIAL AND CULTURAL RELATIONS

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CHAPTER 4 : MATHEMATICS

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CHAPTER 5 : ASTRONOMY

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CHAPTER 9 : BIOLOGY

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APPENDIX

(i) Glossary

Ai Ti = Ai Di 哀帝

Chan kuo tse = Zhanguo ze 戰國策 [Records of the Warring States]

Chang Ch'iu-chien suan ching = Zhang Qiujian suanjing 張邱建算經 [Chang Ch'iu-chien's Mathematical Manual]

Chang Heng = Zhang Heng 張衡

Chang Tao-ling = Zhang Daoling 張道陵

Chao Chün-ch'ing = Zhao Junqing 趙君卿

Ch'en Meng-chia = Chen Mengjia 陳夢家

Cheng lei pen ts'ao = Zhenglei bencao 政類本草 [Reorganised Pharmacopoeia]

Ch'eng Ta-wei = Cheng Dawei 程大位

Ch'eng Wei = Cheng Wei 程偉

chi chü = jiju 積聚 [piling up of squares]

Chi (*or* Hsi) Han = Ji (*or* Xi) Han 嵇含

Ch'i min yao shu = Qimin yaoshu 齊民要術 [Important Arts for the People's Welfare]

Chia ku wen tzu yen chiu = Jiaguwenzi yanjiu 甲骨文字研究 [Researches on the Characters of the Oracle-Bones <including astronomical and calendrical data>]

chieh ch'i = jieqi 節氣 [twenty-four fortnightly periods]

Ch'ien Han shu = Qian Han shu 前漢書 [History of the Former Han Dynasty]

Chih wu ming shih t'u k'ao = Zhiwu ming shi tukao 植物名實圖考 [Treatise on the Names and Natures of Plants]; [An Illustrated Study of the Terminology and Actuality of Plants -- Sun, "Wu Ch'i-chün: Profile of a Chinese Scholar-Technologist"]

Chin shu = Jin shu 晉書 [History of the Chin Dynasty]

Ch'in Chiu-shao = Qin Jiushao 秦九韶

Ch'in Pao-tsung = Qin Baozong 錢寶琮

Ching shih ta t'ien = Jingshi dadian 經世大典 [Institutions of the Yuan Dynasty]

Ch'ing shih kao = Qingshi gao 清史稿 [Draft History of the Ch'ing Dynasty]

Chiu chang suan shu = Jiuzhang suanshu 九章算術 [Nine Chapters on the Mathematical Art]

Chiu huang pen ts'ao = Jiuhuang bencao 救荒本草 [Treatise on Wild Food Plants for Use in Emergencies]

Chiu T'ang shu = Jiu Tang shu 舊唐書 [Old History of the T'ang Dynasty <+618 to +906>]

Chou Mi = Zhou Mi 周密

Chou pei (*or* Chou pi) suan ching = Zhoubei (*or* Zhoubi) suanjing 周髀算經 [The Arithmetical Classic of the Gnomon and the Circular Paths (of Heaven)]

Chou yu = Zhou yu 周語 [Discourses on Chou -- Pankenier, "Early Chinese Positional Astronomy: The *Guoyu* Astronomical Record"]

Ch'ou jen chüan = Chouren zhuan 疇人傳 [Biographies of (Chinese) Mathematicians and Astronomers]

Chu Hsiao = Zhu Xiao 朱橚

Chu K'o-cheng = Zhu Kezheng 竺可楨

Chü lu = Zhu lu 橘錄 [The Orange Record <monograph on citrus horticulture>]

Chu p'u = Zhu pu 竹譜 [Treatise on Bamboos]

Chu Shih-chieh = Zhu Shijie 朱世傑

Chu sha yu p'u = Zhushayu pu 硃砂魚譜 [The Book of Vermilion Fish -- Moule, "A Version of the Book of Vermilion Fish"]

Chu shu chi nien = Zhushu jinian 竹書紀年 [The Bamboo Books <annals>]

Chu Tsai-yü = Zhu Zaiyu 朱載堉

Chu tzu yü lu = Zhuzi yulu 朱子語錄 [Conversations of the Philosopher Chu -- Goodrich, "Early Mentions of Fossil Fishes"]

Ch'un ch'iu = Chun qiu 春秋 [Spring and Autumn Annals]

Chung hsi suan hsüeh ta ch'eng 中西算學大成 [Compendium of Chinese and Western Mathematics -- derived from French translation by Jean-Claude Martzloff in his Recherches sur l'oeuvre mathématique de Mei Wending (1633-1721)]

Erh ya = Erh ya 爾雅 [Literary Expositor]

Feng shen yen i = Feng shen yan yi 封神演義 [Stories of the Promotions of the Martial Genii <novel>]

Hai tao suan ching = Haidao suanjing 海島算經 [Sea Island Mathematical Manual]

Han shu = Han shu *see* Ch'ien Han shu *and* Hou Han shu

Han Yü = Han Yu韓愈

Ho t'u = He tu河圖 [the 'River Diagram']

hou ch'i = houqi候氣 [watching for the ethers -- Bodde, "The Chinese Cosmic Magic known as 'Watching for the Ethers'"]

Hou Han shu = Hou Han shu後漢書 [History of the Later Han Dynasty]

hsi = xi犀 [rhinoceros; wild bovine animal]

Hsi yu chi = Hsiyu ji西遊記 [Story of a Journey to the West <novel = *Monkey*>]

Hsia-hou Yang suan ching = Hsiahou Yang suanjing 夏侯陽算經 [Hsiahou Yang's Mathematical Manual]

Hsia hsiao cheng = Xia xiao zheng夏小正 [Lesser Annuary of the Hsia Dynasty]

Hsiang chieh chiu chang suan fa = Xiangjie jiuzhang suanfa 詳解九章算法 [Detailed Analysis of the Mathematical Rules in the Nine Chapters on the Mathematical Art -- Lam, "The Geometrical Basis of the Ancient Chinese Square-Root Method"]

Hsiang chieh suan fa = Xiangjie suanfa詳解算法 [A Detailed Analysis of the Methods of Computation -- Lam, "On the Existing Fragments of Yang Hui's *Hsiang Chieh Suan Fa*"]

Hsin hsiu pen ts'ao = Xinxiu bencao新修本草 [The New (lit. Newly Improved) Pharmacopoeia]

Hsin T'ang shu = Xin Tang shu新唐書 [New History of the T'ang Dynasty]

hsiu = xiu宿 [lunar lodge, lunar mansions, "28 unequal divisions, . . . the determinative stars of which lay near the equator but were keyed to bright stars of the same right ascension in the vicinity of the celestial pole -- Sivin, "History of Astronomy"]

Hsü ku chai ch'i suan fa = Xugu zhaiqi suanfa續古摘奇算法 [Continuation of Ancient Mathematical Methods of Elucidating the Strange (Properties of Numbers)]

hsüan chi = xuan ji璿璣 [sighting-tube instrument]

Hsüeh Tao-kuang = Xue Daoguang 薛道光

hu = hu斛 [volume measure for grain]

Hu shih suan shu = Hu shi suanshu弧矢算術 [Calculations of Arcs and

Segments]

Huai nan tzu = Huainan Zi淮南子 [The Book of (the Prince of) Huai Nan <compendium of natural philosophy>]

hun t'ien = huntian渾天 [the celestial sphere]

Hun t'ien hsiang shuo = Huntian xiang shuo渾天象說[Discourse on Uranographic Models]

I Ching = Yijing易經 [The Classic of Changes; Book of Changes]

I-hsing = Yixing 一行

I wu chih = Yiwu zhi異物志 [Memoirs of Marvellous Things]

I yü ch'in shou t'u = Yiyu qinshou tu異物禽獸圖[Pictures of the Birds and Beasts of Strange Countries]

Jih yung suan fa = Riyong suanfa日用算法 [Arithmetical Methods for Daily Use]

Ju nan p'u shih = Runan pushi 汝南圃史[An Account of the Gardens of Ju-nan]

Ju ts'ao p'ien = Rucao pian茹草編[Monograph on Uncultivated Vegetables]

Juan Yüan = Ruan Yuan 阮元

kai t'ien = gaitian蓋天 [a hemispherical dome]

K'ai-feng = Kaifeng開封

k'ao cheng = kao zheng考證[evidential research]

Ko chih ching yüan = Gezhi jingyuan格致鏡原[Mirror of Scientific and Technological Origins]

Ko Hung = Ge Hong葛洪

Kuan tzu = Guanzi管子 [The Book of Master Kuan]

Kuang tung hsin yü = Guangdong xin yu 廣東新語[New Talks about Kuang-tung Province]

Kuang yü t'u = Guang yu tu廣輿圖[Enlarged Terrestrial Atlas]

Kuo Mo-jo = Guo Moruo郭沫若

Kuo Shou-ching = Guo Shoujing 郭守敬

Kuo yü = Guoyu國語[Discourses on the (ancient feudal) states]

Li chi = Li ji禮記[Record of Rites <Compiled by Tai the Younger>]

Li Chih-ch'ang = Li Zhichang 李志常

Li chih p'u = Lizhi pu荔枝譜[A Treatise on the Lichi (*Nephelium litchi*)]

Li Jui = Li Rui李銳

Li Nien (*or* Yen) = Li Nian (*or* Yan)李儼

Li Yeh = Li Yeh李冶

Liang Wu Ti = Liang Wu Di梁武帝

Lieh hsien ch'üan chüan = Liehxian chuanzhuan列仙全傳 [Complete Collection of the Biographies of the Immortals]

Ling pao pi fa = Lingbao bifa靈寶畢法 [Secret techniques of the magic jewels -- Sivin, "Science and Medicine in Imperial China: The State of the Field"]

Liu Hui = Liu Hui劉徽

liu jen = liu ren六壬 [a method of divination; *see* Kalinowski, "Les instruments astro-calendriques des Han et la methode *liu ren*"]

Liu T'an = Liu Tan劉坦

Luo Fu-i = Lo Fuyi羅福頤

Lo shu = Luo shu洛書 [the 'Lo River Writing']

lü = lu律 [semitones, pitch-pipe, regulated dance steps, pitch-measure, humming-tubes]

Lü Tung-pin = Lu Tongbin呂洞賓

Lun heng = Lun heng論衡[Discourses Weighed in the Balance]

Ma Heng = Ma Heng 馬衡

Ma-wang-tui = Mawangdui 馬王堆

Mao Hua = Mao Hua *see* <u>Science and Civilisation in China</u> vol. 5 pt. 3 for discussion of romanisation and possible Chinese characters for this name

Meng ch'i pi t'an = Mengqi bitan夢溪筆談 [Dream Pool Essays]; [Brush Talks from Dream Brook -- Sivin, "Shen Gua"]

Ming Shih = Ming Shi明史 [History of the Ming Dynasty]

Mo ching = Mo jing墨經 [The Mohist Canons]

Nan fang ts'ao mu ch'uang = Nanfang caomu zhuang南方草木狀[A Prospect of the Plants and Trees of the Southern Regions]

Nihongi日本記[Chronicle of Japan <from the earliest times to +696>]

Pai Chü-i = Bai Juyi 白居易

Pei Hsiu = Pei Xiu裴秀

pen ts'ao (literature) = bencao (literature)本草 [pandects of natural history]

Pen ts'ao ching chi chu = Bencao jing jizhu本草經集注 [Collected Commentaries on the *Classical Pharmacopoeia (of the Heavenly Husbandman)*]

Pen ts'ao kang mu = Bencao gangmu本草綱目 [The Great Pharmacopoeia; or The Pandects of Natural History]

Pen ts'ao kang mu shih i = Bencao gangmu shiyi本草綱目拾遺[Supplementary Amplifications for the Pandects of Natural History]

Pen ts'ao shih i = Bencao shiyi本草拾遺 [A Supplement for the Pharmaceutical Natural Histories]

Pai fu t'ang suan hsüeh ts'ung shu = Baiffutang suanxue congshu白芙堂算學叢書[Collected Mathematical Works of the Pai-fu Hall]

pi = bi璧 [ancient ritual object of jade]

P'ing lung jen = Pinglong ren平龍認 [Confessions of the Peaceful Dragon]

Po wu chih = Bowu zhi博物記[Notes on the Investigation of Things]

Po Yü = Bo Yu薄珏

San ts'ai t'u hui = Sancai tuhui三才圖會[Universal Encyclopaedia]

San t'ung [calendar] / san t'ung li = Santong li三統曆[Three Sequences Calendar]

Shan hai ching = Shanhai jing山海經[Classic of the Mountains and Rivers]

Shang-yang Tzu = Shangyang Zi上陽子

Shen hsi t'ung chih = Shenxi tong zhi陝西通志[General Record of Shen-hsi Province -- Davis, "Shih Hsing-lin, Disciple of Chang Po-tuan and Hsieh Tao-kuang, Disciple of Shih Hsing-lin"]

Shen i ching = Shenyi jing神異經[Book of the Spiritual and the Strange]

Shen nung pen ts'ao ching = Shennong bencao jing神農本草經[Classical Pharmacopoeia of the Heavenly Husbandman]

shih = shi式 [cosmic board, diviner's plate, diviner's board, etc.]

Shih chi = Shiji史記[Historical Records <or perhaps better: Memoirs of the Historiographer(-Royal); down to -99>]

Shih ching = Shijing詩經[Book of Odes]

Shih Hsing-lin = Shi Xinglin 石杏林

Shih liao pen ts'ao = Shiliao bencao 食療本草 [Nutritional Therapy; a Pharmaceutical Natural History]

Shih Sheng-han = Shi Shenghan 石聲漢

Shih yao erh ya = Shiyao erh ya 石藥爾雅 [The Literary Expositor of Chemical Physic; or Synonymic Dictionary of Minerals and Drugs]

Shuo wen = Shuo wen 說文 [Analytical Dictionary of Characters]

Shu chih = Shu zhi 蜀志, [Records of Sichuan -- Laufer, "The Tree-Climbing Fish"]

Shu ching = Shujing 書經 [Historical Classic]

Shu shu chiu chang = Shushu jiuzhang 數書九章 [Mathematical Treatise in Nine Chapters]

Shui ching chu = Shuijing zhu 水經注 [Commentary on the *Waterways Classic* <geographical account of rivers and canals greatly expanded>]

Sui shu lü li chih shih wu teng ch'ih = Sui shu lülizhi shiwudeng chi 隋書律志,十五等尺 [The Fifteen Different Classes of Measures as given in the Memoir on Acoustics and Calendar (by Li Shun Feng) in the *History of the Sui Dynasty*]

Shun-yü I = Shunyu Yi 淳于意

Shun yang lü chen jen yao shih chih = Shunyang luzhenren yaoshi zhi 純陽呂真人藥石製 [The Adept Lü Shun-yang (i.e. Lü Tung-pin's) Book on Preparations of Drugs and Minerals <in verses>]

Sou shen chi = soushen ji 搜神記 [Reports of Spiritual Manifestations]

ssu = si 兕 [rhinoceros; wild bovine animal]

Ssu fen li = Sifen li 四分曆 [Quarter-Remainder Calendar]

Ssu-ma Ch'ien = Sima Qian 司馬遷

Ssu yüan yü chien = Siyuan yujian 四元玉鑑 [Precious Mirror of the Four Elements]

Su Tung-po = Su Dongbo 蘇東坡

Suan ching shih shu = Suanjing shishu 算經十書 [The Ten Mathematical Manuals]

Suan fa tung tsung = Suanfa tongzong 算法統宗 [Systematic Treatise on Arithmetic]

Suan hsüeh ch'i meng = Suanxue qimeng 算學啓蒙 [Introduction to Mathematical Studies]

Sun tzu suan ching = Sunzi suanjing孫子算經 [Master Sun's Mathematical Manual]

Sung shih = Song shi宋史 [History of the Sung Dynasty]

Sung Ying-hsing = Song Yingxing 宋應星

ta yen rule / ta yen shu = dayan shu大衍[indeterminate analysis]

T'ai i = Taiyi太乙 [The 'Great Unique' star]

T'ai p'ing yü lan = Taiping yulan太平御覽[T'ai-p'ing Reign Period Imperial Encyclopaedia]

Tan ching yao chüeh = Danjing yaojue丹經要訣[Essentials of the Elixir Manuals, for Oral Transmission]; [Essential Formulas from the Alchemical Classics -- Sivin, <u>Chinese Alchemy: Preliminary Studies</u>]

T'ang hui yao = Tang huiyao唐會要 [History of the Administrative Statues of the T'ang Dynasty]

T'ang kuo shih pu = Tang guoshi bu 唐國史補[Supplement to the History of the T'ang]

T'ang pen ts'ao = Tang bencao唐本草 [The New Pharmacopoeia]

T'ang shu = Tang shu唐書 *see* Chiu T'ang shu

Tao tsang = Dao zang道藏[The Taoist Patrology]

T'ao Hung-ching = Tao Hongjing 陶弘景

ti li = di li地理[geography]

T'ien i = Tianyi天乙 [The 'Celestial Unique' star]

T'ien kung k'ai wu = Tiangong kaiwu天工開物[The Exploitation of the Works of Nature]

Tien nan k'uang ch'ang t'u lüeh = Diannan kuangchang tulueh滇南礦場圖略 [An Illustrated Summary of the Mines of Yunnan -- Sun, "Wu Ch'i-chün: Profile of a Chinese Scholar-Technologist"]

T'ien wen ch'i hsiang tsa chan = Tianwen qixiang za zhan天文氣象雜占 ["No definitive lists have yet been drawn up for the 51 textual or illustrative units found at tomb no. 3 Ma-wang-tui. . . . translated by Donald J. Harper as. . . "assorted astronomical and meteorological prognostications". . . -- Loewe, "The Han View of Comets"]

t'ien yüan = tian yuan天元 [celestial monad or celestial element -- Ho, "Chin Chiu-shao"]

Ting Ch'ü-chung = Ding Quzhong 丁取忠

Tso chüan = Zuo zhuan左傳 [Master Tso ch'iu's Enlargement of the *Ch'un Ch'iu* (*Spring and Autumn Annals*) <dealing with the period -722 to -453>]

Tsu Ch'ung-chih = Zu Chungzhi祖冲之

Tsu Keng-chih = Zu Gengzhi祖暅之

Ts'ui Fang = Cui Fang崔昉

Tu hai fang ch'eng = Duhai fangcheng渡海方程 [Mileage of Ocean Crossing]

T'u shu chi ch'eng = Tushu jicheng圖書集成 [Imperial Encyclopaedia]

Tung Tso-pin = Tong Zuobin董作賓

t'ung = tong銅 [copper or bronze]

Wang Fan = Wang Fan 王蕃

Wang P'an = Wang Pan 王泮

Wen hsien t'ung k'ao = Wenxian tongkao 文獻通考 [Comprehensive Study of (the History of) Civilisation]

Wen wu = Wenwu 文物 [Cultural Relics]

Wu Ch'i-chün = Wu Qijun 吳其濬

wu hsing = wuxing 五行 [five phases; five elements]

Wu hsing chan = Wuxing zhan 五星占 [". . .la découverte, en décembre 1973, d'un important manuscrit astrologique à *Mawangdui*. . . . Le contenu astronomique de ce manuscrit sans titre, calligraphié sur une pièce de soie, auquel on a donné le nom de *Wuxing Zhan* et qui date d'avant -- 167, a été partiellement analysé en Chine continentale. . ." -- Teboul, "Les premiers développements de l'astronomie chinoise des Royaumes Combattants au début de l'ère Chrétienne"]

Wu pei chih = Wubei zhi武備志 [Treatise on Armament Technology]

Wu Ta-ch'eng = Wu Dacheng 吳大澂

Wu Tsung = Wu Zong 武宗

Yang Hui suan fa = Yang Hui suanfa楊輝算法[Yang Hui's Methods of Computation]

Yao tien = Yao dian堯典 [The Canon of Yao]

Yeh ts'ai p'u = Yehcai pu野菜譜[Treatise on Edible Wild Plants]

Yeh ts'ai po lu = Yehcai bolu野菜博錄[Comprehensive Account of Edible Wild Plants]

Yin shan cheng yao = Yinshan zhengyao飲膳正要 [Principles of Correct Diet]

Ying ya sheng lan = yingya shenglan瀛涯勝覽[The Overall Survey of the Ocean's Shores -- Ma Huan, Ying-yai sheng-lan: 'The Overall Survey of the Ocean's Shores'; Translated from the Chinese Text. . .; with Introductory Notes. . . J. V. G. Mills]

Yü Kung = Yu Gong禹貢 [The Tribute of Yü]

Yü p'ien = Yu pian玉編 [Jade Page Dictionary]

Yüan shih = Yuan shi元史 [History of the Yuan (Mongol) Dynasty]

Yung lo ta tien = Yongle dadian永樂大典 [Great Encyclopaedia of the Yung-lo Reign-Period]

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