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Foundation Yellow Fever Research Institute at Yaba, Lagos,
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A research enclave in 1940s Nigeria : the Rockefeller Foundation Yellow Fever Research Institute at Yaba, Lagos, 1943-49

Over the last 30 years or so, sub-Saharan Africa has been the site of extensive biomedical research and interventions by 'global health' institutions. Though there are multiple definitions of 'global health', in general this term refers to a combination of initiatives launched in the post-World War 11 period (but particularly since the 1980s) by actors based outside of the continent, including large philanthropic foundations, international health organisations, bilateral agencies and public-private partnerships. Alongside these initiatives there has now emerged a considerable literature in medical and social anthropology, science and technology studies and history analysing the impact of these initiatives.¹ Whilst acknowledging the very real advances in health outcomes that recent global health investments have made, much of this work is highly critical of the modes of operation of global health institutions – their relative lack of accountability, their technocratic and experimental foci, their biosecurity agendas and (in some accounts) implication in the construction of forms of 'biopower'. Many scholars see 'global health' as operating in a kind of 'state of exception', exercising a form of semi-privatised governmentality that lies outside the control of African states and their citizens, creating 'parastates' and islands of medical research and surveillance in the context of growing health inequalities and crumbling public health systems.²

There is some disagreement in this literature on the question of continuity or discontinuity between the workings of 'global health' and the institutions of colonial and international health that preceded it. As some philanthropic foundations increasingly operate with larger budgets than that of the World Health Organisation, it can be argued that we are in a new era of privatised global health, producing "new biopolitical forms" in Africa and a "new vital politics".³ Others point to greater continuity in international health interventions in Africa in the post World War 11 period, or beyond into the late colonial and inter-war periods.⁴ ⁵ The current power and influence of global health foundations, such as the Bill and Melinda Gates Foundation, also has roots that

go much deeper than that of the late twentieth century, as a number of authors have pointed out.⁶ There is a tension in this recent literature between a critique of global health practices as remote, technocratic and experimental, and a parallel critique of its interventions as excessively intrusive, especially in the area of sexual health, and engaged in the construction of new forms of citizenship and subjectivity. Guillaume Lachenal describes the work of the scientific community of ‘virus hunters’ in Africa as a form of ‘medical nihilism’ characterised by a mixture of scientific hubris and non-intervention (or the ‘intervention of non-intervention’) in the context of failing public health systems.⁷ The unfolding of the 2015 West African Ebola epidemic came as a reminder of how sophisticated international medical research on viruses in Africa coexists with catastrophically under-resourced public health facilities.

In the light of this literature on global health in Africa, this paper examines the history of the Yellow Fever Research Institute at Yaba, near Lagos in Nigeria in the 1940s. It is largely based on the documentation produced by the Rockefeller-funded personnel, supplemented by British Colonial Office papers, and is inevitably limited by that. No doubt there is a much fuller story to be told by historians of science in Nigeria.⁸ Though largely funded by the Rockefeller Foundation, the YFRI at Yaba was nevertheless formed by a collaboration with the British colonial authorities, employing British as well as American scientists. I argue that the YFRI demonstrated many of the characteristics of the international research enclave as described by scholars of present-day global health in Africa. Like them, I also argue that the laboratory that formed the heart of this enclave was far from being hermetically sealed – it formed part of a larger experimental field in which technologies were tried out and tested. I am not arguing that the YFRI was in any way typical of scientific or medical research in Africa at the time, but it is a striking precursor to recent examples. Though the scientists of the YFRI were central to a wartime programme of vaccine development and supply to Allied troops, for the most part they regarded West Africa as a site for pure research into viruses and were largely disengaged from the pressing needs of public health, which they regarded as the responsibility of the colonial authorities. Scientifically ambitious, sophisticated and very well

funded, the YFRI scientists embarked on a programme of research that took them from laboratory to the 'field' and thus, inevitably, into a highly unequal engagement with Nigerian (and other West African) communities.

By and large this story does not resonate with that told by Helen Tilley of late colonial scientists engaging self-critically with African realities.⁹ It is in part a story of post-war scientific optimism and of ambition, but the ambition related more to 'pure' research than it did to public health applications. The Rockefeller scientists were optimistic that their research in Africa would result in a significant advance in knowledge of the yellow fever virus, particularly in its endemic form, and to some extent this ambition was fulfilled. Their work in Africa was at the cutting edge of virology and they could claim to have discovered much about virus behaviour that is still relevant today, as recent discussions of the Zika virus have shown.¹⁰ This knowledge had the potential to inform attempts to control the spread of viral disease globally.¹¹ During and after World War 11 this may have been given added urgency by biosecurity concerns, particularly over the use of viral agents as biological weapons. Rarely did they attempt to justify their investment in terms of African public health. Indeed, as Heather Bell argued in her pioneering work on yellow fever in eastern Africa, it would have been difficult for them to do so since yellow fever did not appear to be the most pressing of medical issues for the colonial authorities in Africa, though they may well have underestimated its impact.¹² Critically, though an effective and largely safe vaccine had been available since 1937, the British colonial authorities (unlike the French) did not attempt any major vaccination campaign in West Africa in this period, except when an epidemic occurred, viewing this as impractical and expensive.¹³ The Rockefeller scientists may have been privately critical of this inertia, but by this time the International Health Division of the Rockefeller Foundation had largely withdrawn from public health, making the story of their African involvement very different from those in Central and South America.¹⁴ Whilst they urged the British to increase their investment in medical research in West Africa, and occasionally warned of the danger of a resurgence of yellow fever epidemics, they did not actively advocate for the health of African colonial subjects.

West Africa in the history of yellow fever research

The history of yellow fever in the Americas in the late nineteenth and early twentieth centuries is, with good reason, a mainstay of history of medicine textbooks. Epidemics of this incurable vector-borne viral disease, probably originating in Africa and assumed to have been carried to the New World in slave trading ships, periodically devastated non-immune populations in the Americas until the early twentieth century. Yellow fever was a major danger to trade and settlement in the Americas (and, to a lesser extent, Europe) in the eighteenth and nineteenth centuries; it was implicated in the Haitian revolution and threatened to destabilise projects of imperialism in Central and South America. The discovery of the mosquito vector responsible for urban yellow fever epidemics (*aedes aegypti*) and the implementation of highly effective environmental and sanitation measures form part of a narrative of disease 'conquest' in which American science and scientists typically play heroic roles.¹⁵ The late nineteenth century advances in the control of yellow fever were, without a doubt, impressive, notwithstanding the fact that the commonly told account neglected to relate the whole story and, in particular, sidelined the input of non-American actors.¹⁶

As vector control proved effective and urban epidemics receded in the Americas, so yellow fever appeared to be a less immediate threat there, and total eradication seemed plausible through control of the insect vector responsible for those epidemics, *aedes aegypti*. But the early twentieth century was also a time of increasing colonisation of many parts of the world by imperial powers and agents of international capitalism. With the development of faster transport links (notably air travel) the possibility that endemic yellow fever might 'jump' from one continent to another, causing devastating epidemics, especially in Asia, was the source of increasing anxiety on the part of European imperial powers and the United States after the First World War.¹⁷ It was at this point that the Rockefeller Foundation began its major investment in yellow fever research and control. The coastal regions of West Africa had suffered from large-scale urban

epidemics of yellow fever in the late nineteenth century and the early years of the twentieth century, Europeans appeared particularly vulnerable and mortality rates amongst colonisers were disconcertingly high.¹⁸ From 1916-1949 expenditure on research on yellow fever in Africa carried out by the International Health Division of the Foundation amounted to around one and a quarter million dollars, but this was only a fraction of a global expenditure of nearly \$14m.¹⁹ Much of this investment was made in Central and South America.²⁰ Nevertheless, the Foundation's West African yellow fever research in the 1920s and 1930s was highly significant scientifically and achieved considerable fame.

From 1925 until 1934, the Foundation, in collaboration with the British colonial authorities funded the West Africa Yellow Fever Commission with a laboratory in Yaba, near Lagos.²¹ As Marisa Chambers has argued, though the Foundation initially announced an interest in control work similar to that carried out in Central and South America, this failed to materialise and it soon became clear that West Africa would be the site of research, not public health intervention.²² This was in line with a more general shift away from public health to research within the International Health Division of the Foundation, as described by Farley.²³ But it also reflects the largely impoverished colonial context of West Africa and prevailing attitudes towards Africans.²⁴

As a scientific body, the Commission achieved fame, for both good and bad reasons. In 1927 its scientists had made a major advance when they identified a susceptible animal that could be used for experimentation – the rhesus monkey. From this point they developed the crucially important 'protection test', a method which allowed them to identify individuals who had been exposed to yellow fever in the past and had developed immunity. The test involved injecting a person's serum along with the live virus into a rhesus monkey. If the monkey survived, this demonstrated the 'protective' qualities of the human serum; if it died, then it was assumed that the serum conveyed no immunity.²⁵ By 1931 it had been shown by Max Theiler that this method could be used on mice, and that the virus could then be passed directly from mouse to mouse using intracerebral

injections. This discovery greatly expanded the applicability of the protection test but also opened up numerous other experimental avenues. Ultimately it enabled Theiler to produce a vaccine made possible by a Ghanaian named 'Asibi' whose blood had been taken by a member of the Commission, Alexander Mahaffy.²⁶ But the research had also taken its toll on the community of yellow fever scientists. The Commission's laboratories had been shown to be mismanaged. A total of six scientists died as a result of accidental infections, and though this was glossed in terms of heroic sacrifice, it was also a story of hubris, especially on the part of one its more famous members, Hideyo Noguchi, who stubbornly adhered to his mistaken theory of a bacterial agent beyond the point at which this appeared plausible.²⁷

The Commission withdrew in 1934. The discovery of endemic, or 'jungle' yellow fever in Brazil in 1932 had radically changed the picture of yellow fever epidemiology. The prospect of total eradication receded with the recognition that there might be large areas of the tropics and sub-tropics where yellow fever was endemic, amongst human populations, other mammalian populations, or both, and that more than one insect vector might be implicated. As Nancy Stepan argues, by the mid-1930s the Rockefeller scientists had abandoned the dream of yellow fever eradication, which ten years earlier had seemed to be within reach. Total eradication was impossible without destroying the forest habitats and animals which acted as reservoirs of the endemic variety of the disease. On the other hand the possibility of species eradication of the urban vector, *aedes aegypti*, combined with the use of a new and safer vaccine from 1937 implied that the disease might be effectively controlled and major epidemics averted.²⁸ Scientific interest in 'jungle' or 'sylvatic' yellow fever, its animal reservoirs and vectors, led the Foundation back to Africa, but this time to Uganda where, in 1936, it opened (collaboratively with the British colonial authorities) a Yellow Fever Research Institute at Entebbe and pursued both laboratory and field-based research in forest areas.²⁹

In 1943, spurred on in part by the perceived danger of the resurgence of epidemic yellow fever in West Africa as a result of the movement of non-immune Allied personnel, the Rockefeller scientists were back at Yaba in Lagos establishing an ambitious research programme collaboratively with the colonial government which lasted until late 1948 and continued in a reduced form beyond that.³⁰ This was a wartime initiative, framed by the global conflict. The Yellow Fever Research Institute at Yaba had three stated aims. Firstly, it would conduct research into yellow fever in West Africa “in order to determine whether the jungle version of the disease discovered several years ago in South America has a counterpart in West Africa”. Secondly, its laboratory would serve as a distribution centre for yellow fever vaccine to troops and “settlements”(for which read, non-African settlements) in West Africa. Thirdly, it would “provide British government units with a consultative service on problems of yellow fever control.”³¹ Links between the Yaba and Entebbe laboratories were strong, with personnel and material moving constantly between the two and beyond to the central laboratory in New York and to fellow Rockefeller scientists in Central and South America. There was also an uneasy collaboration with the French, whose Pasteur Institute at Dakar developed its own highly ambitious and sometimes controversial programme in French African territories.³²

Porous laboratories: the YFRI at Yaba as a colonial scientific enclave

The YFRI at Yaba resembled a classic colonial scientific enclave, but it had some peculiar characteristics. Firstly, it was much more generously funded than most equivalent British colonial institutions, and secondly it was an American-run institution within a British colonial setting. Like many enclaves of today’s global medical research, it was an island of technological ambition, set within a wider context of medical deprivation.³³ However, the use of sophisticated equipment coexisted with the most basic of techniques, and did not free the scientists from a heavy dependence on the labour of their Nigerian employees. By the late 1940s the compound included a new animal house and laboratory, the latter home to a hoard of expensive imported equipment. The housing for its senior scientists was elaborate; there was a tennis court, carefully tended rose gardens and plenty

of motor vehicles.³⁴ Not all American 'wives' flourished at Yaba, and war-time travel restrictions made the journey to and from the United States unpredictable, so this was a predominantly male environment, as Bugher's more private correspondence with his colleagues reveals.³⁵ Despite their enclave-like qualities, African spaces of scientific research were and are not pristine experimental spaces. Yaba was no exception. On the one hand, the documentary record emphasises its apparent isolation from the everyday realities of late-colonial Lagos. On the other hand, it was clearly a very porous space, dependent on a constant supply of imported materials, the labour of a large staff of Nigerian personnel and the provision of blood and other biological material from its surrounding communities and environment. The transgression of the laboratory space was constantly in evidence. As Robert Kohler has argued, the "placenessness" of the laboratory was always a cultural convention.³⁶

Given the unfortunate earlier history of errors, accidental infections and deaths, when the Rockefeller scientists returned to Yaba in 1943 it must have seemed incumbent on them to demonstrate that they could run a laboratory in Africa safely and responsibly. This task fell largely on the man who in 1943 was appointed Director of the Yellow Fever Research Institute at Yaba, Dr John Bugher.³⁷ Bugher, born in Indiana in 1901, had taught bacteriology and pathology at the University of Michigan before joining the Foundation's field staff in 1937. He had worked extensively on 'jungle' yellow fever in Colombia before transferring to Lagos.³⁸ Arriving in Nigeria, Bugher was introduced to key British colonial officials by the director of the Entebbe institute, Alexander Mahaffy.³⁹ He then embarked on a fact-finding tour of West Africa, publicising the Rockefeller's yellow fever programme.

One of Bugher's first tasks was to set up an efficient mouse colony, vital to the work of the laboratory that he was re-establishing. When the Commission scientists had packed their bags in 1934, they had left behind them the vestiges of a mouse colony, which had been haphazardly maintained by colonial personnel. The mice now exhibited an unacceptably high degree of variability in terms of their susceptibility. Housing and feeding the mice adequately was vital

to their use as experimental and breeding animals, and preoccupied Bugher in the first couple of years. The mice also required imported wheat germ and oats for their diet. Refrigeration was required for the mouse supplies and ceiling fans were needed for the mice themselves. Caring for the mice was largely the task of Nigerian employees. These men (and, briefly it seems, one woman) were listed in the YFRI's annual reports by name as 'Animal attendants', a title which was certainly an improvement on the earlier references to 'mouse boys', but which nevertheless understated their role.⁴⁰ Aside from the mundane but exacting tasks of feeding the mice and keeping them healthy, these attendants (as the photographic evidence makes clear) also performed the skilled operations including injecting mice brains. When some of these attendants joined a one-day strike of public workers in 1945 (the only mention of Nigerian political activity in the Rockefeller archive of the YFRI at a time of considerable political ferment), two of the wives of American scientists, Mrs Bugher and Mrs Jones, were drafted in to 'save' the colony.⁴¹ Then as now, scientific research carried out by external agencies in Africa depended heavily on the skills and commitment of local workers, who were rarely accorded the status of scientists themselves.⁴²

The relentless routine of the mouse colony was absolutely central to the work of the Institutes, both at Yaba and its twin establishment in Entebbe. It was exacting work. Not only were mice employed in epidemiological work (the "protection tests") but mice titrations were also used to ensure the quality of the vaccine which the Institute was responsible for distributing in the region to Allied troops, and for the development of a new scratch vaccine.⁴³ What this actually meant in terms of laboratory practice can be glimpsed from John Bugher's report for 1948 in which he described the processes in detail: the incubation and injection of chicken embryos with viral material, the removal and grinding of embryos in a homogeniser, the pipetting into glass containers, before culturing and titration. This was a process repeated, but with additional elements, to test the 'combined vaccine' using sheep lymph. Once produced in the laboratory, these vaccines were tested on both animal and humans subjects and their blood samples analysed in the Yaba laboratory.⁴⁴

Yellow fever epidemiology demanded work on all aspects of the disease cycle. In addition to the mouse colony, and the laboratory for vaccine development and protection tests, Yaba maintained an animal house and mosquito colonies. Though the employment of expatriat 'wives' was to become a source of friction between John Bugher and the local colonial authorities, who were under pressure to train more Nigerian staff, Mrs Marjorie Taylor, the wife of a British science schoolteacher working in Lagos, was for some time employed as a zoologist and took over the supervision of the animal experiments. Primatology, as Donna Haraway has argued, is a highly gendered and racialised science.⁴⁵ By the late 1940s, photographs of animals began to feature in the Yaba annual reports. In 1947 report a full-front portrait of 'Lulu' a captive chimpanzee occupied pride of place.⁴⁶ Lulu was apparently one of Yaba's favourite residents and was frequently photographed in the arms of Mrs Taylor.

In their mosquito studies, the Rockefeller scientists at Yaba combined the use of highly sophisticated equipment with the most basic of labour-intensive techniques. The photographic archive for yellow fever in Africa, including that for Yaba, is littered with pictures of men (both African and white men) in shorts sitting and staring intently at the bare skin of their legs. The captions read 'Catching mosquitoes'.⁴⁷ Mosquito catching also took place on a larger scale at field sites, as I describe in the next section. Since the discovery that yellow fever could be transmitted by mosquito vectors other than *aedes aegypti*, the study of the habits of a range of species, including their habitats, their flying and feeding habits and their interactions with human and other animal hosts, was an essential part of the African yellow fever research. The mosquito research took place both in the field and in the laboratory. One of John Bugher's aims was to be able to transmit the yellow fever virus from mosquito to mosquito without intermediary or use of monkeys. Colonies of mosquitoes were created in the laboratory and forcibly fed with suspensions of the virus derived from guinea pig blood. To ascertain whether the mosquitoes had successfully infected each other mice were injected intracerebrally with titrated mosquito.⁴⁸ Nigerian assistants worked on the mosquito colonies under the supervision of the entomologist .

If much of the laboratory work was necessarily mundane, Bugher's enthusiasm for the latest technologies ensured that this was combined with cutting-edge methods entailing the importation of expensive equipment. Bugher introduced to Yaba two sets of new techniques to aid the study of mosquito vectors. The first was the use of radioactive isotopes to mark and track mosquitoes in the field, which I discuss in the next section. The second was the use of sound equipment in the laboratory. On leave in the United States Bugher had made contact with Dr Kahn of Cornell University who had devised a system whereby mosquitoes could be observed and their distinctive sounds recorded "without the observer intruding his presence". In 1948 he imported a soundproof chamber, within which a mosquito cage was suspended along with a microphone in a cable and recording equipment. Climatic conditions within the chamber could be manipulated to mimic real environmental circumstances. This was a case of bringing the environment into the laboratory and the obverse of the 'experimental hut' described by Ann H Kelly in her work on present-day malaria studies in Africa.⁴⁹ The sound system recorded a range of mosquito sounds, from the fluttering of their wings to the mating sounds of male and female, enabling a detailed study of behaviour in captivity.

The work of the yellow fever scientists was both myopic and expansive, a point also made by Heather Bell in her research on Sudan.⁵⁰ At times their single-minded and technocratic pursuit of the hidden 'secrets' of the yellow fever virus appears extreme and frankly bizarre. But the nature of yellow fever epidemiology also constantly drove them beyond the laboratory to a more wide-ranging appreciation of environment and ecology.⁵¹ The scientists knew that field-based research was key to any significant advances they might make. The central 'puzzle' of yellow fever in Africa centred on its endemic form – so-called 'jungle fever'. Both in South America and in the Entebbe institute (established in 1936), Rockefeller-funded researchers had elaborated techniques to study yellow fever transmission in forest areas and amongst rural populations. The Entebbe-based scientists (led by Alexander Mahaffy, formerly of the West African Commission, and now famous for his role in the identification of the Zika virus), responding initially to an outbreak of unknown fever amongst road

workers in the Bwamba area, had set up a semi-permanent field station there, where they conducted exhaustive entomological, zoological and epidemiological research. Soon after establishing their laboratory and animal facilities, the Yaba scientists also began field research and were searching for a field site equivalent to that at Bwamba.

Blood, mosquitoes and the creation of the 'field'

The 'field' for the Yaba scientists was in fact a set of overlapping scientific spaces. Firstly there was the 'field' of research into the past and current extent of yellow fever infection in West Africa. Secondly, there was the 'field' of experimentation with new vaccines, and thirdly there was the 'field' of ecosystems. Endemic 'jungle yellow fever' was presumed to exist in West Africa, but its existence had yet to be proven. Establishing this would necessitate a combination of animal studies including immunity studies similar to those carried out on human populations, and susceptibility studies involving the trapping of animals and attempting to infect them with yellow fever virus. Insect studies in the field would also be essential to understand the range of mosquito vectors involved and their relationship to both human and other mammal populations. The studies of the behaviour of yellow fever virus in laboratory mosquitoes needed to be correlated with field-based evidence for transmission. Mosquitoes, it was apparent, behaved differently in captivity.⁵²

Building on the earlier work of the Commission, the scientists set about mapping the distribution of yellow fever in West Africa. Though thought to be extensively present, the virus was also infuriatingly elusive. The colonial medical authorities had been instructed to report any suspicious outbreak of disease to the Institute, but everyone was well aware that reporting alone would never be sufficient. The second method, which had been employed effectively (but not uncontroversially) by Rockefeller researchers in Central and South America, and experimented with in Uganda and the Belgian Congo, was viscerotomy⁵³. Viscerotomy entailed the extraction and testing of liver tissue from 'fresh' corpses. Bugher regarded it as essential for accumulating knowledge on the

current incidence of yellow fever, but there had been earlier attempts to set up a viscerotomy service in West Africa, which appear to have failed.⁵⁴ The obstacle, Bugher discovered from talking to British officials and to Alexander Mahaffy who had been part of the earlier Commission, was “not native resentment”, but “administrative”, that is, finding out about deaths before burials had taken place.⁵⁵ It seems that in Nigeria this theory was put to the test again only briefly in 1944. In collaboration with the government, fourteen experimental viscerotomy posts were established around the country. The Rockefeller scientists reported that local medical officers were “sceptical but cooperative”. No reports of major “native resistance” reached the Rockefeller scientists and at the end of the experiment they concluded that it was indeed the lack of close administrative supervision of deaths that made the use of viscerotomy impractical.⁵⁶

If viscerotomy was impracticable, this was apparently not the case with the “protection test” which became the central tool of yellow fever epidemiological research and, along with vaccine trials, entailed the creation of experimental communities. The creation of such communities and the ethics of bioscientific experimentation are central themes in recent literature on global health in Africa. These sites have been described as “states of exception” in which the scientists (especially those involved in large drug trials) are often very far removed from clinical engagements. These characteristics have in turn been linked to the privatisation of previously publicly-run services in Africa over the last few decades and to the dominance of vertical, disease-specific research.⁵⁷

The area around Yaba had been an experimental site for the yellow fever researchers on and off since the mid-1920s.⁵⁸ As soon as the laboratory reopened in 1943 they began collecting blood from local schoolchildren and testing it for immunity. Samples from children were especially valuable for the “protection tests” since through them the scientists could date recent outbreaks (or “passages” as they sometimes put it) of the disease. This practice was extended to other parts of West Africa, in an attempt to generate a map of yellow fever incidence and immunity. As John Bugher explained, particular attention

was given to children under the age of 15, as this enabled them to track recent possible outbreaks of yellow fever, and also ensured continuity with earlier studies of yellow fever in Nigeria.⁵⁹ Some of the samples were obtained directly from schoolchildren at Lagos School Clinic, and others were provided “through the kindness” of medical officers in Ilorin and Jos Plateau.

The scientists did not spend much time worrying about the ethics of these procedures, though they did sometimes place the word ‘volunteer’ in inverted commas in their correspondence. They were privately critical of what they regarded as the excessive caution of British colonial officials when it came to experimentation on African subjects. In the area of vaccine development they regarded themselves as manifestly more responsible than the French, whose mass vaccination programme in French West Africa had been criticised as unsafe.⁶⁰ They prided themselves on their safety record. However, as John Farley has pointed out, the occurrence in 1942 of jaundice outbreaks amongst Allied troops resulting from yellow fever vaccination had come as a “slap in the face” for the Health Division of the Rockefeller Foundation and produced a degree of caution all round.⁶¹ There is no evidence from the Yaba archive of any major iatrogenic incident, though this cannot be completely ruled out.⁶² Unlike the sleeping sickness vaccine programme in Cameroon described by Lachenal, the Rockefeller scientists in West Africa did not administer a useless vaccine to large numbers of people under dangerous conditions, and neither did they work with an explicitly racial theory of disease.⁶³ Nevertheless, the research relied, implicitly and sometimes explicitly, on a degree of coercion which most of us would find unacceptable. Undoubtedly some people gave blood willingly, but children and leprosy patients had little choice but to cooperate. Others did so on the instructions of local chiefly authorities, who in turn took instructions from the British colonial authorities.⁶⁴

The ‘field’ was also a field of entomology, which once again relied on the considerable input of Nigerian labour. In 1945, the British entomologist, P.F. Mattingly, who was seconded from the colonial medical service, began a detailed study of mosquito species, their habits and distribution at a field station on the

Ogun river. Using a technique perfected by his colleagues in Uganda, particularly the indefatigable Alexander Haddow⁶⁵, Mattingly had erected a series of platforms at different heights on which were stationed trained Nigerian assistants working in pairs, whose job it was to catch mosquitoes. Over 30,000 mosquitoes were caught, composed of more than 50 species and their biting cycles and vertical distributions studied.⁶⁶ As these figures indicate, this was a remarkably labour-intensive and exacting enterprise.

The labour intensity of mosquito catching was, however, combined at Yaba with the most innovative and cutting-edge of techniques. Around the same time as he had become aware of Kahn's 'mosquito sound' studies, Bugher also heard of the possibility of using radioactive isotopes to mark mosquitoes and track them in the field. This technique would allow for more accurate mosquito tracking, though it did not do away with the laborious task of catching them.⁶⁷ In 1947, having sought advice whilst on leave in the United States, Bugher, backed by his colleagues in New York, set about obtaining permission to import the radioactive material from the United States and to have it transported, along with a Geiger counter, safely to Nigeria. He then began a series of experiments in the marking of mosquito larvae in the laboratory at Yaba, followed by further experiments releasing the mosquitoes in the field.⁶⁸

The Ogbomosho Epidemic : a 'natural experiment'

The Yaba-based researchers were saved by an epidemic, which acted for them as a 'natural experiment'. The absence of active clinical cases amongst Africans had been a major impediment to their work. Yellow fever in West Africa, as in Uganda, was a kind of 'present absence', its 'passages' through populations could be seen through the protection tests, but actual cases remained elusive. In April 1946 came the news that a Syrian trader, Mr S Shaar, hospitalised in Lagos, had been suffering from yellow fever. An interview with Shaar revealed that he had most likely been infected in Ogbomosho (now Ogbomoso), a densely populated city of about 100,000 people in southwest Nigeria around thirty miles from the railway connecting Ibadan and Ilorin. Ogbomosho was not unknown to the

earlier generation of Rockefeller scientists conducting work on urban yellow fever. Henry Hanson's diary mentions a visit there in 1927.⁶⁹ Further research was carried out in the town in the early 1930s, and in 1937 there had been two European cases of yellow fever reported from there.⁷⁰

At Yaba this news was greeted with excitement and Bugher immediately went into action preparing a major case-finding and research expedition, equipping a mobile laboratory, including a few boxes of mice. The expedition team included Bugher himself who would work in the clinical and epidemiological studies with Drs Hahn and Macnamara; the entomologist (Mattingly), the zoologist (Marjorie Taylor), and Mr J.E Knight who would supervise the laboratory work. Mrs Knight was placed in charge of organising and supervising the practicalities of the expedition and its camp. Twenty unnamed African staff also took part in the expedition, including Bugher's cook, two chauffeurs, a carpenter, eight 'mosquito boys', four 'animal boys', four animal trappers, one laboratory assistant, two house stewards and one laundryman.⁷¹ Bugher's plan was to study all aspects of yellow fever epidemiology in Ogbomosho, but the primary aim was to identify actual cases in Africans and isolate strains of the virus from them.

Ogbomosho was described a "native city". It had no resident British administrator and was run through the native authority system typical of British rule – by a chief, who oversaw around one hundred village headmen. The majority of the city's densely packed population were agriculturalists who moved constantly between the city and their fields, within a radius of around fifteen miles and also engaged very actively in trade (as Mr Shaar's presence there had indicated). Bugher estimated that if you took this mobility into account, the population potentially affected by an outbreak of disease in the town was very much larger than the estimated population of 100,000 – more like a million people. Despite its size, Ogbomosho had no government medical officer, but it was home to a leprosy asylum (which still exists) and a Baptist Mission Hospital.⁷² As was immediately apparent to the team, the environmental conditions in the city were highly conducive to mosquito-borne diseases. The population took its water supply from a small reservoir, greatly depleted owing

to a recent drought, and stored it in water pots in the compounds. There was also a dyeing industry in the city, and the dye pits acted as breeding grounds for mosquitoes. The mosquito implicated in urban yellow fever, *aedes aegypti*, was everywhere. Unsurprisingly, malaria was common. Indeed, before any cases of yellow fever were found, it was apparent that a malaria epidemic was in full swing.

Earlier yellow fever scientists had often remarked that when the disease attacked Africans its effects were often mild and transient and indistinguishable from other fevers. The Rockefeller scientists did not subscribe to the view (which had long been associated with the Atlantic slavery) that Africans were immune to the disease.⁷³ Though they very occasionally speculated on genetic adaptation, their methods, particularly the 'protection test', were based on the assumption that African populations were susceptible to yellow fever infection. The results of these 'protection' surveys, which showed that in some specific geographical areas (and certainly not everywhere), a significant proportion of the population could have been infected in the past and survived, appeared to demonstrate that mortality rates for Africans were indeed lower than they appeared to be for non-Africans. But they were cautious in interpreting these results, noting that most deaths went unrecorded, and that disease surveillance was extremely rudimentary. Indeed, as Jennifer Tappan has argued, the maps of immunity could also be read as maps of susceptibility, demonstrating that in some areas rates of protection against the disease were very low.⁷⁴ However, when compared to the widespread effects of malaria, and with high mortality from other infectious diseases (including smallpox, cerebrospinal meningitis, and later, polio), the immediate threat posed by yellow fever to African populations appeared to some British medical officers to be minimal. The Ogbomosho epidemic presented an opportunity for the Rockefeller scientists to demonstrate that the threat of urban epidemics, such as had been experienced in the coast in earlier decades, was still real.

The immediate reaction of the Ogbomosho population and its leadership was frankly sceptical. Bugher reported that "Early in the investigation it became

apparent that the native inhabitants did not know that there was an epidemic among them, nor were they interested".⁷⁵ Part of this "lack of interest" might be explained by suspicion of the scientists' motives. Their arrival in a cavalcade with their mobile laboratory had entailed large-scale 'bleedings' and was followed by an increased presence of the colonial authorities who set about instituting emergency measures, including DDT spraying, emptying water pots and preventing movement in and out of the town. Bugher's team initially found some difficult identifying cases – the epidemic was proceeding unnoticed. Eventually, with the cooperation of schoolteachers they worked backwards from pupil absentee records, visiting sick schoolchildren (or those who had recovered) in their homes and taking blood samples from them and from family members. Daily visits were made to suspected yellow fever cases and severely ill people were taken to the Baptist Mission Hospital, where autopsies were also performed. Eventually, 75 cases were positively identified by blood tests, including nine deaths, though Bugher later estimated that the overall mortality rate was probably less than 1%. Bugher believed that in all there might have been as many as 5,000 cases altogether, but observations seemed to confirm that yellow fever was a "milder disease" in Africans, and that in some cases none of the classical signs of yellow fever were present. Bugher concluded that yellow fever in Africa is "an acute febrile disease distinguished by its high variability and high proportion of mild cases....convalescence is typically rapid and complete, especially among children."⁷⁶ The epidemic had provided a unique research opportunity. Thirty-four strains of the virus had been isolated from patients and immunological studies conducted on primates. The virus had also been extracted from *aedes aegypti* mosquitoes and from monkeys hunted in the region. Detailed patient case histories had been collected. Liver samples had been taken for analysis at Yaba. Over 60,000 people were vaccinated against the disease and in subsequent years extensive vaccine trials were carried out in Ogbomosho, including on the semi-captive population of leprosy patients in the Ogbomosho asylum.⁷⁷

Ogbomosho had constituted one kind of experimental setting. The identification of the epidemic had allowed Bugher and his colleagues to examine the various

aspects of urban yellow fever epidemiology in real time, in contrast to the 'protection tests' which were a constant and tantalising reminder that they had missed previous outbreaks. Furthermore, the strains isolated from the Ogbomosho patients could be used in the ongoing work of vaccine development. With its relatively low mortality rate, Ogbomosho could hardly be called a 'classic' case of an urban yellow fever epidemic as described in the tropical diseases textbooks. Nevertheless, its epidemiology appears to have been relatively straightforward. The more complex epidemiology of 'jungle yellow fever' was still incompletely understood. For this, another kind of experimental fieldwork space was called for. If it did not exist, it had to be created.⁷⁸

Manufacturing a yellow fever outbreak: the Kumba experiment

From the beginning of his time as Director of the Yellow Fever Research Institute at Yaba, John Bugher had been pushing an idea that he knew to be controversial. He drew on the lessons of his colleagues in Uganda. Though they appeared to have found an ideal location for the study of 'jungle' yellow fever in the Bwamba forest, the work was long and painstaking and had produced only one human case in six years of intensive research. Writing in his diary during a visit to Entebbe in 1945, Bugher argued that in order to advance the research a forest site should be identified in West Africa into which the yellow fever virus could be artificially introduced into the non-human mammal population and its subsequent spread monitored. This would allow a 'shortcut' to understanding the entire cycle of sylvan yellow fever, an experiment that could be completed in weeks rather than the years that seemed to be required in natural circumstances. There was one obvious possible objection to this plan. The scientists would be introducing yellow fever to an area and to a human population that had quite possibly never experienced it before and the "administration would be horrified at the prospect of turning yellow fever loose under any circumstances."⁷⁹ Bugher planned, however, to control those "circumstances" as far as possible. They would identify an isolated area of low population density where human mobility could be easily monitored and they would vaccinate the entire population before introducing the virus into the forest canopy through caged rhesus monkeys. In fact, this protective measure

also had an experimental dimension as Bugher intended to use the opportunity to test a new scratch vaccine grown in chick embryos under field conditions.

After exploring possible sites in Nigeria and elsewhere, eventually a location was found for such an experiment in the British Cameroons. The requirements for such an experiment were exacting. The area had to be forested and to harbour an abundant animal and insect (especially mosquito) population; it should have a low human population density and be relatively isolated from travel routes. Kumba, in southwestern Cameroon, is a town (now a major trading hub) on the edge of a forested extinct volcano. The Rockefeller team selected a site near the volcano, with a population of around 4,000 people. Initial 'protection' surveys indicated that previous exposure to yellow fever was low (around 10%) and therefore that a mass vaccination programme, using the new 17D scratch vaccine, would have to take place in advance of the experiment. Against possible objections that the team was introducing yellow fever into an area that had previously had little or no experience of it, Bugher could argue that since there was proof, from an earlier survey, of yellow fever infection in "the general area" amongst the monkey population, "nothing new was being introduced which was not already in the region".⁸⁰

In December 1947 preparations for the field study began. A van, jeep and Dr Bugher's car were shipped to Victoria (the port of British Cameroon) in advance of the arrival of the staff (which included Nigerian personnel) by air and road. The equipment list was extensive, including material for taking blood samples and for separating sera; sealed ampoules for the latter; materials for the preparation of skins and skulls; entomological collecting supplies; microscopes and slides, stains, a portable dry heat steriliser, a small autoclave, hand centrifuges and pressure filters for the monkey sera, plus tents and supplies. In June, having settled on a site within the Kumba crater, the team began by vaccinating the entire population within a five mile radius after pre-inoculation samples had been taken from a sub-group of 200 people. A laboratory was set up in a shed at the local hospital, an electric plant installed to run the refrigerator. The five rhesus monkeys and 600 mice arrived by sea and were trucked up to the

site. One of the monkeys was inoculated with a Nigerian strain of yellow fever (but not without some difficulty) and placed on a platform hoisted into the forest canopy. The monkey was bled daily to ensure that it was still infected with the virus. After a couple of weeks, the next stage of the experiment began. Mosquitoes were to be collected in the area, ground down and inoculated into mice. Subsequently, a sample of local monkeys would be shot to ascertain whether any of them had been infected.

The fieldwork did not go smoothly. The first inoculated rhesus monkey placed in the forest canopy failed to fall sick and had to be replaced by a second one which appeared to have been highly infectious before dying. But as the entomological work began, a significant and unanticipated problem arose – the scarcity of mosquitoes. Bugher and his colleagues concluded that they needed many more mosquito catchers under these circumstances and made an arrangement with the local Catholic Mission School for fifty volunteer schoolboys (all vaccinated) to help with the night catches. Even with this apparently enthusiastic assistance only nine specimens of *A. Africanus* (the mosquito thought to be implicated in transmission in this area) were recovered from a total of 701 man-hours of catching. These were ground down and inoculated into mice, but no trace of yellow fever virus was found. Animal trapping was continued and twenty monkeys were shot around the lake, but ultimately it became clear that the experiment had failed to infect the animal population. Bugher concluded that this was due to the peculiarity of the mosquito population in the Kumba area. More positively, the programme of vaccination using the new vaccine had yielded an immunisation rate of 92.3%, with no adverse clinical reactions.⁸¹

It was deeply ironic that, in a region plagued by mosquito-borne disease, in this experimental setting the mosquitoes refused to cooperate. In a later publication, Bugher used the failed Cameroonian field experiment to reflect on the complexity of 'jungle' yellow fever epidemiology and on scientific methods.⁸² In his correspondence with the Foundation he remarked that "A lot of hard work went into that experiment – one thing we learned was that so-called

bacteriological warfare is not so easy.”⁸³ He would have reason to reconsider these words.

African Virus Research and the Cold War

In 1949 the Rockefeller Foundation withdrew its scientists from the Yellow Fever Virus Research Institute at Yaba and handed the facility over to the British colonial authorities. In theory, the Institute had always been a joint enterprise, but the Americans had long complained that the British contribution was inadequate, and that British bureaucracy was cumbersome. The colonial authorities in Nigeria seemed, to the Americans, to be paralysed by anxieties associated with decolonisation. Bugher complained that it was no longer possible to recruit British women (including wives of local colonial officials) to certain roles without first demonstrating that there were no Nigerians suitable for these posts.⁸⁴ More generally, the Rockefeller Foundation appeared to have concluded that their ambitious field research programme on yellow fever in Africa and South America at Yaba had run its course.⁸⁵ The Yaba scientists could certainly claim that their vaccine research had made a major contribution to the development of a safe and effective vaccine. The extensive ‘protection’ test surveys appeared to confirm that yellow fever was active as a human disease in parts of West Africa, and that there was more than one variant of ‘jungle’ yellow fever in Africa. Ogbomoshó had also demonstrated that urban yellow fever was still a threat. Indeed, in his rather belated plea to the Americans to stay at Yaba, the British Colonial Secretary, Arthur Creech-Jones cited the Ogbomoshó epidemic.⁸⁶ However, the relatively low mortality rate made it hard to argue that yellow fever was a priority in terms of African health.⁸⁷ The extensive and expensive research on ‘jungle’ yellow fever seemed to have resulted in the conclusion that this variety of yellow fever was much less common in West Africa than it was in South America, and, though there was always a danger of yellow fever spreading from forest reservoirs to human populations, that had been mitigated by the development of the vaccine. As the Annual report of the International Health Division of the Foundation put it in 1950, “... it is not a dead foe; it is only a dormant one. The price of freedom from yellow fever is constant

vigilance.”⁸⁸ The fact that the British colonial authorities never implemented a widespread vaccination programme was, of course, a major weakness.

The failure of the Kumba experiment was a disappointment to Bugher. Virus research, however, was still a hot topic, and the knowledge gained from the extensive African research was important to the wider field. In 1949 Bugher wound down the laboratory at Yaba, handing its facilities over to the colonial authorities and moved to a position in the International Health Division laboratories at the Rockefeller Institute in New York where he would continue to investigate ‘new viruses’.⁸⁹ He took 200 mice with him. However this was far from being a final ending of Rockefeller involvement in yellow fever research in West Africa, as Thomas P. Monath has shown.⁹⁰

In Bugher’s papers an undated document, authored by him and entitled ‘A Wartime Scientific Programme for the International Health Division’ refers to the circumstances of the “resurgence” of “open warfare”, presumably alluding to the outbreak of the Korean War in June 1950, and the new role this implied for the IHD.⁹¹ The threat of biological warfare utilising viruses amongst other agents had been raised in the Second World War when the Japanese used toxins in their Chinese campaigns. A US biological warfare programme began in 1941 and expanded after the war.⁹² Bugher advocated a programme that would be both of “immediate military value in either defense or offense”, and of “lasting value to science”. Specifically, he suggested that the programme concentrate on research into virus and rickettsial diseases (including yellow fever), and an evaluation of the potential of a range of viruses for “effective employment” in biological warfare. The potential relevance of the Foundation’s earlier Africa-based research was clear in this document, including the reference to the importance of establishing the natural vectors of significant viruses and the use of radioactive tagging.⁹³

By 1950, Bugher’s expertise in the use of isotopes (and possibly his viral research) also came to the attention of Shields Warren, the Director of the Division of Biology and Medicine at the US Atomic Energy Commission. In

December 1950, Shields Warren wrote to the Director of the IHD, George Strode, to say that the Atomic Energy Commission required Bugher's expertise and asked if Bugher could be released from IHD employment for at least two years to work as Deputy Director of the Division of Biology and Medicine. Strode initially resisted, arguing (somewhat disingenuously) that it did not appear to him that Bugher had expertise appropriate for this role, and that his virus research made him virtually irreplaceable to the IHD.⁹⁴ Presumably Bugher was keen to assume this new position. Strode relented and in March 1951 Bugher moved to be Deputy Director of the Division of Biology and Medicine at the AEC, becoming its Director in 1952.

This was a period in the United States of heightened anxiety about biological warfare and even before taking over the role at Atomic Energy Commission, Bugher had addressed Civilian Protection Groups on 'General Considerations on the use of Infectious agents as Weapons'.⁹⁵ Bugher argued that the objective of using such a weapon would not necessarily be that of "wholesale destruction" and "mass slaughter", since this might result in the victor being left with the burden of a "paralysed" enemy. The real potential of biological weapons lay in their ability to "incapacitate the enemy temporarily" and to "induce the enemy to expend essential energy and war potential in useless activity."

As Bugher had discovered in the Cameroons, yellow fever was not the easiest disease to weaponise. In a 2005 Roundtable, yellow fever expert Thomas Monath claimed that "we did weaponise yellow fever in the United States", but that the programme had not gone far.⁹⁶ In the AEC Bugher worked on testing fission and thermonuclear devices and became an expert on the biological consequences of fallout. He ended his career as Director of the Nuclear Center of the University of Puerto Rico, from 1960-1969.⁹⁷

Yellow Fever Resurgent

While researchers in Africa in the 1930s and 1940s were frequently exasperated by a lack of clinical cases to study, the following decades saw major epidemics in

both East and West Africa, including Nigeria. In 1950-1952 there were a reported 12,000 cases in Onitsha Province and another epidemic on Jos Plateau caused 500-600 deaths. By the mid 1950s, scientists from the Yaba institute, now run by the British colonial authorities, had built up a more complex picture of the pattern of endemicity and susceptibility to epidemics in different parts of Nigeria, and the different vectors involved. In the rain forest belt of South and Southwest Nigeria, where villages were interspersed with forest, they found that the disease was endemic in both human and monkey populations, and that over 70% of the population had become immune by the age of ten years. However, epidemics did occur in towns (including Ogbomoshó) which were in the 'transitional belt' between forest and savannah. In densely populated Eastern Nigeria, where most of the forest had disappeared, human populations were largely non-immune and epidemics occurred, though the mortality rates experienced during these events varied markedly. In Northern Nigeria, where the disease was neither endemic nor epizootic, epidemics occurred rarely and could usually be traced to an infected traveller entering the region from the south.⁹⁸

The 1960s saw further major outbreaks in Africa, including a devastating epidemic in Ethiopia with an estimated 30,000 deaths. In 1969 there was a region-wide epidemic across West Africa. The ending of the mass compulsory vaccination scheme in the former French colonies of West Africa made large populations vulnerable and resulted in a resurgence of epidemic disease in these regions. During an attempt to control one such epidemic in Senegal in 1965, a major iatrogenic outbreak of post-vaccinal encephalitis occurred.⁹⁹

Despite its formal withdrawal from Yaba, the Rockefeller Foundation remained heavily involved in research in Africa into yellow fever and related viruses, amongst which are West Nile Fever and Zika, both of which have demonstrated a capacity to travel and transform in new environments. Climate change raises the possibility of further global spread. As in the 1940s, the major impetus for African arbovirus research comes more from global biosecurity concerns than it does from a desire to protect the health of African populations. However, yellow fever itself is now regarded as a major 'resurgent' epidemic disease in Africa,

where around 90% of reported cases occur.¹⁰⁰ Belatedly, immunization, which has been so widely used (and enforced) to prevent the global spread of yellow fever, is now being applied to African populations. Since 2000 there has been a major effort on behalf of international health organisations and African governments to extend yellow fever vaccination across the continent and between 2006 and 2012, 69 million people received the vaccination.¹⁰¹

If Bugher and his Rockefeller colleagues had made a minimal impact on the public health of either West or Eastern Africa, they could claim some role in creating a lasting postcolonial research interest in virology in these regions. In Nigeria the Rockefeller Foundation contributed to the establishment of the Virus Research Laboratory at Ibadan in 1963, now part of the University of Ibadan, and in Uganda the Uganda Virus Research Institute succeeded the East African Virus Institute, itself a successor of the Rockefeller's Entebbe Yellow Fever Research Institute. Tragically, the emergence of HIV/AIDS in sub-Saharan Africa as a devastating disease and the recent global spread of Zika virus have both highlighted the importance of virus research in African locations and have contributed to the continuing international interest in viruses of African origin. The legacy of the work of Bugher and his colleagues in terms of research and medical priorities is not easily summarised. On the one hand, their technocratic enthusiasm and ambitions as international researchers led to them to produce the kinds of research enclaves that we see on the continent today – financed by international agencies, self-contained and with minimal impact on the health of surrounding populations. On the other hand, their multi-faceted research into yellow fever had clearly demonstrated the complexity of viral disease and the necessity to understand all of its human, animal and environmental aspects. Perhaps this contributed to a scepticism on the question of eradication which, as Nancy Stepan has argued, was typical of approaches to malaria control in Africa even at the height of enthusiasm elsewhere for DDT.¹⁰² Without a better financed and run public health service and economic and social development, research was unlikely to be translated into effective practice, as Bugher and his colleagues well knew when they advocated for wider vaccine coverage. The virus itself was an unlikely candidate for eradication.

¹ Tamara Giles-Vernick and James L.A. Webb Jr, (eds), *Global Health in Africa* (Athens, Ohio: Ohio University Press, 2013); P. Wenzel Geissler and Catherine Molyneux (eds), *Evidence, Ethos and Experiment: the Anthropology and History of Medical Research in Africa* (Berghan Books, 2011); P. Wenzel Geissler, Richard Rottenburg and Julia Zenker (eds), *Rethinking Biomedicine and Governance in Africa* (Bielefeld: Verlag Transcript, 2012); Guillaume Lachenal, *Le médicament qui devait sauver l'Afrique: un scandale pharmaceutique aux colonies* (Paris: La Découverte, 2014); Julie Livingston, *Improvising Medicine: an African Oncology Ward in an Emerging Cancer Epidemic* (Durham, NC: Duke University Press, 2012); Ruth J. Prince and Catherine Molyneux (eds), *Making and Unmaking Public Health in Africa: Ethnographic and Historical Perspectives* (Athens Ohio: Ohio University Press, 2014); Ann H. Kelly and P. Wenzel Geissler (eds), *The Value of Transnational Research: Labour, Participation and Care* (Abingdon: Routledge, 2012); P. Wenzel Geissler (ed), *Para States and Medical Science: Making Global Health in Postcolonial Africa* (Durham: Duke University Press, 2014); Joanna Tayloe Crane, *Scrambling for Africa: AIDS, Expertise and the Rise of American Global Health Science* (Ithaca: Cornell University Press, 2014); Meilissa Graboyes, *The Experiment Must Count: Medical Research and Ethics in East Africa, 1940-2014* (Athens Ohio: Ohio University Press, 2015). For a critical history of global health, including the Africa, see Randall M. Packard, *A History of Global Health: Interventions into the Lives of Other Peoples* (Baltimore: Johns Hopkins University Press, 2016).

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- ² Geissler (ed), *Para States*; Richard Rottenburg, 'Social and public experiments and new figurations of science and politics in postcolonial Africa', *Postcolonial Studies*, 12,4 (2009), 423-440.
- ³ P.Wenzel Geissler, 'Introduction: a Life Science in its African Para-State', in Geissler (ed), *Para States*, 1-47
- ⁴ Sabine Clarke documents the rise of 'technocratic' British colonial scientific research in the post World War 11 period: S.A. Clarke, 'Technocratic Imperial State?: The Colonial Office and Scientific Research, 1940-1960', *Twentieth Century British History*, 18, 4 (2007), 453-480. See also Richard Keller, 'Geographies of Power and Legacies of Mistrust: Colonial Medicine in the Global Present', *Historical Geography*, 34 (2006), 26-48.
- ⁵ John Manton, 'Trialing Drugs, Creating Publics: Medical Research, Leprosy Control and the Construction of a Public Sphere in post-1945 Nigeria' in Geissler (ed), *Para States*, 78-103.
- ⁶ William H. Schneider (ed), *Rockefeller Philanthropy and Modern Biomedicine: International Initiatives from World War 1 to the Cold War* (Bloomington: Indiana University Press, 2002); Benjamin Page and David Valore (eds), *Philanthropic Foundations and the Globalisation of Scientific Medicine and Public Health* (University Press of America, 2007); John Farley, *To Cast Out Disease: a History of the International Health Division of the Rockefeller Foundation* (Oxford: Oxford University Press, 2004); Nancy Leys Stepan, *Eradication: Ridding the World of Diseases Forever?* (London: Reaktion Books, 2011).
- ⁷ Guillaume Lachenal, 'Lessons in medical nihilism: virus hunters, neoliberalism and the AIDS crisis in Cameroon', in Geissler (ed), *Para States*, 103-142.
- ⁸ On the latter see Gloria Thomas-Emeagwali (ed), 1992, *The Historical Development of Science and Technology in Nigeria* (Lampeter: Edwin Mellen Press).
- ⁹ Helen Tilley, *Africa as a Living Laboratory: Empire, Development and Scientific Knowledge* (Chicago: Chicago University Press, 2011).
- ¹⁰ Zika is, like yellow fever, a Flavivirus and its discovery in 1947 is attributed to the Rockefeller-funded researchers of the Yellow Fever Research Institute in Entebbe, Uganda.
- ¹¹ George K. Strode (ed), 1951, *Yellow Fever* (New York: McGraw Hill); Kavita Sivaramakrishnan, 2016, 'Extremely Far, Incredibly Close: Yellow Fever, Quarantine and the Jet Age in India' in Alison Bashford (ed), *Quarantine: Local and Global Histories* (London: Palgrave Macmillan), 154-173.
- ¹² Heather Bell, 1999, *Frontiers of Medicine in the Anglo-Egyptian Sudan, 1899-1940* (Oxford: Clarendon Press). See Jennifer Tappan for a different view: Jennifer Tappan, 'Endemic Yellow Fever and Immunization in Sub-Saharan Africa', Rockefeller Archive Center, Research Report, 2014: <http://www.rockarach.org/publications/resrep/tappan.pdf>.
- ¹³ Jennifer Tappan, 'Endemic Yellow Fever and Immunization in Sub-Saharan Africa'; Marissa Joanne Chambers, 'Responses to Yellow Fever in British West Africa, 1900-1948' PhD, University of Liverpool, 2000, 255.
- ¹⁴ There is an extensive literature on the role of the International Health Division of the Rockefeller Foundation in the history of public health in Central and South America, including work on yellow fever. See Marcos Cueto, 'Sanitation from above: Yellow Fever and Foreign Intervention in Peru, 1919-22', *The Hispanic*

American Historical Review, 72 (1992), 1-22; Marcos Cueto and Steven Palmer, *Medicine and Public Health in Latin America* (Cambridge: CUP, 2015); Armando Solorzano, 'Sowing the Seeds of Neo-Imperialism: the Rockefeller Foundation's Yellow Fever Campaign in Mexico', *International Journal of Health Services*, xxii, 3 (1992), 529-54; Ilana Lowy, 2001, *Virus, Moustique et Modernite: la fièvre jaune au Bresil* (Paris: Archives d'Histoire Contemporaine); Ilana Lowy, 'What/who should be controlled: opposition to yellow fever campaigns in Brazil', in Bridie Andrews and Andrew Cunningham (eds), *Western Medicine as Contested Knowledge* (Manchester: Manchester University Press, 1997); Paola Mejia Rodriguez, 'Of mice, vaccines and men: the Rockefeller Foundation yellow fever programme in Columbia, 1932-48', *Dynamis*, 24 (2004), 119-55.

¹⁵ John R. Pierce and Jim Writer, 2005, *Yellow Jack: How Yellow Fever Ravaged America and Walter Reed Discovered its Deadly Secrets* (London: John Wiley and Son). On the eradication narrative see Nancy Leys Stepan, 2011, *Eradication: Ridding the World of Diseases Forever?* (London: Reaktion Books,).

¹⁶ Francois Delaporte, (trans. Arthur Goldhammer), 1991, *The History of Yellow Fever: an Essay in the Birth of Tropical Medicine*, (Cambridge Mass.: MIT Press),

¹⁷ In 1951 George K. Strode, Director of the International Health Division of the Rockefeller Foundation summarised the Foundation's work on yellow fever and explained the perceived security threat it posed, whilst conceding that the disease had not, so far, spread to India: George K. Strode (ed), *Yellow Fever*, 1951 (New York: McGraw Hill); Heather Bell, 1999, *Frontiers of Medicine in the Anglo-Egyptian Sudan, 1899-1940* (Oxford, Clarendon Press), chapter 6; Kavita Sivaramakrishnan, 2016, 'Extremely Far, Incredibly Close: Yellow Fever, Quarantine and the Jet Age in India'.

¹⁸ On the consequences for urban planning and public health in French West Africa see Kalala J. Ngalamulume, 'Keeping the City Totally Clean: Yellow Fever and the Politics of Prevention in Colonial St Louis-Du-Senegal, 1850-1914', *Journal of African History*, 45 (2004), 182-202; Christian Strother, "'A danger which more or less threatens us all": Yellow Fever and the politics of disease control in Senegal, 1890-1914', *Journal of Colonialism and Colonial History*, 15, 2 (2014) DOI: 10.1353/cch.2014.0034.

¹⁹ This was however only a fraction of global expenditure of nearly \$14m. George K Strode ed., *Yellow Fever* (New York: McGraw Hill, 1951).

²⁰ Farley, *To Cast Out Disease*, Chapter 6; Marcos Cueto, "The cycles of eradication: The Rockefeller Foundation and Latin American public health, 1918-1940" in P. Weindling (ed), *International health Organisations and Movements, 1918-1939* (Cambridge: Cambridge University Press, 1995), 222-243; Stepan, *Eradication*, 77-97.

²¹ Marisa Joanne Chambers has provided a detailed account of the work of the Commission, focusing on the role of the British colonial authorities and their relations with the Rockefeller Foundation: Marisa Joanne Chambers, 'Responses to Yellow Fever in British West Africa, 1900-1948', PhD, University of Liverpool, 2000; see also Farley, *To Cast Out Disease*, Chapter 6.

²² Chambers, 'Responses', p82.

²³ Farley, *To Cast Out Disease*, Chapter 10.

²⁴ West Africa (Nigeria)- Yellow Fever Annual Report, 1931, Folder 2662, Box 215, Subseries 495 O, Series 3 Routine Reports, RG 5, International Health/Board

Division, FA 115, Rockefeller Foundation records (hereafter RF), Rockefeller Archive Center (hereafter RAC).

²⁵ Henry Beeuwkes, J.H. Bauer and A.F. Mahaffy, 'Yellow Fever Endemicity in West Africa with Special Reference to Protection Tests', *American Journal of Tropical Medicine*, 10 (1930), 305-33.

²⁶ The history of yellow fever vaccine development is a subject in its own right, which I am unable to deal with fully in this paper. See Farley, *To Cast Out Disease*, chapter 11; Strode (ed), *Yellow Fever*; Thomas P. Monath, 'Yellow Fever' in Andrew W. Arenstein, *Vaccines: a Biography* (New York: Springer, 2009), 159-191.

²⁷ See the revealing biography of one of these victims, Theodore Brevard Hayne : Charles S. Bryan, *A Most Satisfactory Man: The Story of Theodore Brevard Hayne, Last Martyr of Yellow Fever* (Charleston S.C: Waring Library Society, 1996).

²⁸ Farley, *To Cast Out Disease*, Chapter 6; Stepan, *Eradication*, 79-90.

²⁹ Bell, *Frontiers of Medicine*, Chapter 6; Julia R. Cumiskey, 'Placing Global Science in Africa: International Networks, Local Places and Virus Research in Uganda, 1936-2012' Rockefeller Archive Center, Research Report, 2013; Jennifer Tappan, 'Endemic Yellow Fever and Immunization in Sub-Saharan Africa', Rockefeller Archive Center, Research Report, 2014.

³⁰ National Archives, London (TNA), CO 859/64/4: Medical, Infectious Diseases: Yellow Fever Control in Africa, Lagos Laboratory, 1942-43.

³¹ "The Return to West Africa", 1943, f 17, Box 3, Subseries 495 0 West Africa Region, Yellow Fever, Series 494 West Africa Region, RG 1.1 Projects (FA 115), RF, RAC.

³² Myron Echenberg, "For Their Own Good": The Pasteur Institute of Dakar and the Quest for an Anti-Yellow Fever Vaccine in French Colonial Africa' in *Les Conquêtes de la Médecine Moderne en Afrique*, ed. Jean-Paul Bado (Paris, Karthala, 2006), 53-69.

³³ P.Wenzel Geissler, 'What future remains? Remembering an African Place of Science' in Geissler (ed), *Para States*, 142-179; J. Fairhead, M. Leach and M. Small, 'Where Techno-Science meets Poverty: medical research and the economy of blood in Gambia, West Africa', *Social Science and Medicine*, 63, 4 (2006), 1109-1120; Garboyes, *The Experiment Must Continue*.

³⁴ John Bugher was a keen amateur film-maker. Views of the Yaba compound, as well as the work of the laboratory, can be seen in his collection of audio-visual material: YFRI Nigeria, Box 1, DVD AV840, Series 7, Audio-Visual Material, John Bugher Papers (FA 027), RF, RAC.

³⁵ Though generally reserved and proper in his correspondence with the Foundation, Bugher's papers also contain jokey letters from his colleagues, replete with sexual innuendo and some dubious poetry: Correspondence, 1945-48, f 7, Box 1, Subseries 1, Series 1, John Bugher Papers FA 027, RF, RAC.

³⁶ Robert E. Kohler, 'Labscapes: Naturalizing the Lab', *History of Science*, 40, 4 (2002), 473-501. Bruno Latour and Steve Woolgar, 1979, *Laboratory Life: the Social Construction of Scientific Facts* (Beverly Hills, Sage Publications); Hans-Jorg Rheinberger, 1997, *Towards a History of Epistemic Things: Synthesising Proteins in the Test Tube* (Stanford: Stanford University Press).

³⁷ Biographical file, John C. Bugher, f40, Box 1, FA 485, RF, RAC.

³⁸ The process of re-establishing the Yaba compound and negotiating with the British colonial authorities can be followed in John Bugher's officer's diary, Alexander Mahaffy's diary, and their correspondence with the Foundation: John C. Bugher Officer's Diary, Box 55, RG 12 (FA 391), RF, RAC; John C Bugher diary entries in John C. Bugher papers, f10, Box 1, Subseries 1, Series 1, Box 1, FA 027, RF, RAC; Alexander Mahaffy diary entries, Alexander Mahaffy Officer's Diary, Box 274, RG 12 (FA391), RF, RAC.

³⁹ Mahaffy was Director of the Yellow Fever Research Institute in Entebbe and a key figure in the history of yellow fever research.

⁴⁰ The pioneering sleeping sickness researcher, Louise Pearce, was funded by the Rockefeller Foundation to investigate the disease in the Belgian Congo in the early 1920s. In her papers she describes the trials of establishing an experimental mouse colony and the work of the "mouse boys". The latter were frequently accused of stealing the animal food for their own consumption. Louise Pearce papers, FA 188, RF, RAC.

⁴¹ West Africa (Nigeria) Yellow Fever Annual Report for 1945, f 2667, Box 216, Subseries 3 495.0, Series 3, RG 5 (FA115), RF, RAC.

⁴² P. Wenzel Geissler, 'Parasite Lost: Remembering Modern Times with Kenyan Government Medical Scientists' in Geissler P. Wenzel and Catherine Molyneux (eds) 2011, *Evidence, Ethos and Experiment: the Anthropology and History of Medical Research in Africa*, Oxford: Berghahn, 297-333; G. Lachenal, 'The Intimate Rules of the French Coopération: Morality, Race and the Postcolonial Division of Scientific Work at the Pasteur Institute of Cameroon', in Geissler, Molyneux (eds), 2011, *Evidence, Ethos and Experiment*, 373-403; Johanna Tayloe Crane, 2013, *Scrambling for Africa: AIDS, Expertise and the Rise of American Global Health Science*, Cornell University Press.

⁴³ John Bugher to Andrew Warren, December 11, 1943, f 17, Box 3, Subseries 495.0 West Africa Region, Yellow Fever, Series 495, RG1.1 (FA 386), Projects, RF, RAC.

⁴⁴ West Africa (Nigeria) Yellow Fever Annual Report for 1948, f 2670, Box 216, Subseries 495.0, Series 3, RG 5 (FA 115), RF, RAC.

⁴⁵ Donna J. Haraway, *Primate Visions: Gender, Race and Nature in the World of Modern Science* (New York: Routledge, 1989).

⁴⁶ West Africa (Nigeria) Yellow Fever Annual Report for 1947, f2669, Box 216, S, Subseries 495.0, Series 3, RG 5 (FA 115), RF, RAC.

⁴⁷ Melissa Garboyes also describes the process of mosquito catching on the skin using suction tubes in East Africa : Garboyes, *The Experiment Must Continue*, 33-34.

⁴⁸ West Africa (Nigeria), Yellow Fever Annual Report for 1945, f 2667, Box 216, Subseries 495.0 Series 3, RG 5 (FA 115), RF, RAC.

⁴⁹ Ann H. Kelly, 'The Experimental Hut: hosting vectors', *Journal of the Royal Anthropological Institute*, 18 (2012), 145-160.

⁵⁰ Heather Bell, 1999, *Frontiers of Medicine in the Anglo-Egyptian Sudan, 1899-1940* (Oxford: Clarendon Press), 190

⁵¹ This is a point also made by Tilley in her examination of late-colonial science in Africa : Tilley, *African Laboratory*.

⁵² John Bugher to Andrew Warren, 11 December 1943, f 17, Box 3, 495.0, RG 1.1., RF, RAC.

⁵³ A viscerotomy service had been introduced in the Bwamba area of Uganda in 1937. At the end of two years, 127 specimens had been taken, but none showed yellow fever: f59, Box 6, Series 1, Subseries 1, John Bugher papers (FA027), RF, RAC. On viscerotomies in Belgian Congo see Kenneth Smithburn's correspondence: f103, 1940 Stanleyville, Box 11, Series 2 Diaries, Kenneth Smithburn Papers (FA 040), RAC. On resistance to viscerotomies in Brazil in the inter-war period see Marcos Cueto, 'The cycles of eradication: the Rockefeller Foundation and Latin American public health, 1918-1940' in Paul Wiending (ed), 1995, *International Health Organisations and Movements, 1918-1949* (Cambridge: CUP), p.233.

⁵⁴ Frederick Russell (Director of the IHD) writing to Henry Beeuwkes (West Africa Yellow Fever Commission) in 1933 encouraged him to set up a viscerotomy service in Nigeria, pointing to its success in Brazil and arguing that it could substitute for autopsies and would be invaluable to the medical service: Russell to Beeuwkes, 10 March 1933, f 12, Box 2, Subseries 495.0, Series 495, RG.1.1 (FA386), RF, RAC.

⁵⁵ John Bugher diary entries for 1943, Box 55, RG 12 (FA291) RF, RAC. See also Richard Hahn's diaries, 18 November 1943, Box 191, RG 12 (FA392) RF, RAC.

⁵⁶ West Africa (Nigeria), Yellow Fever Annual Report for 1945, f2667, Box 216, Subseries 495.0, Series 3, RG5 (FA115), RF, RAC.; Richard Hahn diary entry 18 November 1943, Box 191, RG 12 (FA392), Box 191, RF, RAC.

⁵⁷ P.Wenzel Geissler, 2015, 'Introduction', in Geissler (ed) *Para-States and Medical Science*, 1-47; Ann Kelly, 'The Territory of Medical Research: Experimentation in Africa's smallest state', in Geissler (ed), *Para-States and Medical Science*, 303-333; Melissa Graboyes, 2015, *The Experiment Must Continue: Medical Research and Ethics in East Africa, 1940-2014* (Athens OH: Ohio University Press); Rottenburg, 'Social and Public Experiments'; Geissler and Molyneux (eds), 2011, *Ethos and Experiment*.

⁵⁸ See the West African Commission correspondence from the 1930s: 'Lagos Letter' from Henry Beeuwkes to Frederick Russell, 20 February 1931, referring to sending sera from blood collected from local children: f 10, Box 2, Subseries 495.0, Series 495, RG 1.1 (FA386), RF RAC; Andrew Sawyer to Henry Beeuwkes, 14 September 1932, with techniques for collecting blood from very young children: f 11, Box 2, Subseries 495.0, Series 495, RG 1.1 (FA386), RF, RAC.

⁵⁹ West Africa (Nigeria), Yellow Fever, YFRI, Semi-Annual Report for 1945, Box 216, Subseries 3: 495.0, Series 3, RG 5 (FA115), RF, RAC.

⁶⁰ However, Myron Echenberg argues that the "aggressive application" of the French vaccine by French colonial officials "saved more lives than did the much more passive British colonial approach to yellow fever": Myron Echenberg, "For Their Own Good": The Pasteur Institute of Dakar and the Quest for an Anti Yellow Fever Vaccine in French Colonial Africa, 1924-60' in *Les Conquêtes de la Médecine Moderne en Afrique*, ed Jean-Paul Bado (Paris, Karthala, 2006), 53-69.

⁶¹ John Farley, 2004, *To Cast Out Disease: a History of the International Health Division of the Rockefeller Foundation (1913-1951)*, (Oxford: Oxford University Press), 179.

⁶² For a major example of this see Anne-Marie Moulin, 'Defenceless Bodies and Violent Attitudes in a Global World: Blood Iatrogenesis and Hepatitis C

Transmission in Egypt' in Giles-Vernick and Webb (eds), 2013, *Global Health in Africa*, 138-159.

⁶³ Lachenal, *Le Médicament*. The Rockefeller scientists did believe that Africans generally experienced yellow fever as a 'mild' disease and this was almost certainly an over-generalisation. However, they did not subscribe to theories of racially inherited susceptibility or resistance.

⁶⁴ For an examination of similar practices in East Africa and their local meanings see Graboyes, *The Experiment Must Continue*, 75-76.

⁶⁵ "His ability to turn bush children into good mosquito catching machines is astonishing", John Bugher to Andrew Sawyer, late June 1944, f 17, Box 3, Subseries 495.0, Series 495, RG 1.1 (FA386), RF, RAC. Entomologists working for the earlier West Africa Yellow Fever Commission had also employed the method of "night catches with human bait" perfected by Theodore Haynes, another scientist who died of yellow fever in the course of his research: Charles S. Bryan, *A Most Satisfactory Man: The Story of Theodore Brevard Haynes, Last Martyr of Yellow Fever*, (Spartanburg SC: Reprint Company Publishers, 1996, p92).

⁶⁶ Leonard Bruce-Chwatt, f2, Box 1, Series 1, John Bugher papers, FA 027, RAC.

⁶⁷ On mosquito trapping and sampling techniques see M.W. Service, *Mosquito Ecology: Field Sampling Methods*, Second Edition, (Dordrecht: Springer, 1993); Kohler, *Landscapes and Labscapes*, 2002; A.H. Kelly, 'The experimental hut: hosting vectors', *Journal of the Royal Anthropological Institute*, 18 (1), 2012, 145-160. On recent techniques, including genetic modification of mosquitoes see Ann H. Kelly and Javier Lezaun, 'The Wild Indoors: Room-Spaces of Scientific Inquiry' (unpublished paper).

⁶⁸ On the use of radioisotopes in biological and ecological science and controversies around the export of this material from the United States see Angela N. H. Creager, *Life Atomic: A History of Radioisotopes in Science and Medicine*, (Chicago: University of Chicago Press, 2013), Chapter 10. On the importation and shipment of radioactive material : f 21, Box 3, Subseries 495.0., Series 495, RG 1.1 (FA386), RF, RAC. The experiments are detailed in John Bugher papers, "Radioactive Mosquitoes", f 57, Box 6, Subseries 1, Series 1, John Bugher papers (FA 027), RAC. Series 1, Subseries 1, Box 6, f 57.

⁶⁹ Entry for April 30th, 1927:

https://exhibits.hsl.virginia.edu/hanson/files/2013/03/Hanson_diary_complete.pdf. Accessed 4 October 2015.

⁷⁰ W.B. Johnson, 'Recent advances in knowledge of Yellow Fever', *British Medical Journal*, August 13 1932: 2 (3736), 285-8; Bryan, *A Most Satisfactory Man*, p.59.

⁷¹ YFRI Yaba, Semi-Annual Report, January-June 1946, f 62, Box 6, Subseries 1, Series 1, John Bugher papers (FA 027), RF, RAC.

⁷² Ogbomoso has been an important Baptist centre since the mid nineteenth-century: I.A. Adedoyin, *The Place of Ogbomoso in the History of Nigerian Baptism* (Ibadan, Penthouse 2005).

⁷³ See S.J. Watts, 'Yellow Fever Immunities in West Africa and the Americas: a reappraisal', *Journal of Social History*, 34,4 (2001), 955-967; Kenneth K. Kiple, 'Response to Sheldon Watts, 'Yellow Fever immunities in West Africa and the Americas: a reappraisal', *Journal of Social History*, 34, 4 (2001), 969-974; S.J. Watts, 'Response to Kiple', *Journal of Social History*, 34, 4 (2001), 975-976.

⁷⁴ Tappan, 'Endemic Yellow Fever'.

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- ⁷⁵ YFRI Yaba, Semi-Annual Report, January-June 1946, f62, Box 6, Subseries 1, Series 1, John Bugher papers (FA 027), RF, RAC.
- ⁷⁶ YFRI Yaba, Semi-Annual Report, January-June 1946, f 62, Box 6, Subseries 1, Series 1, John Bugher papers (FA 027), RF, RAC.
- ⁷⁷ YFRI Yaba, Annual Report for 1946, f61, Box 6, Subseries 1, Series 1, John Bugher papers (FA 027), RF, RAC; Richard Hahn to George Strode, 4 September 1946, f 19, Box 3, Subseries 495.0, Series 495, RG 1.1 (FA386), RF, RAC.
- ⁷⁸ R.E. Kohler, *Landscapes and Labscapes: exploring the lab-field border in biology* (Chicago: Chicago University Press, 2002); Ann H. Kelly, 'The Territory of Medical Research: Experimentation in Africa's smallest state' in Geissler (ed), *Para States*, 303-333;
- ⁷⁹ John C. Bugher diary entry for 24 January to 5 February, f 1943-47, Box 55, RG 12 (FA392), RF, RAC; 'Studies in the Cameroons', f 12, Box 1, Subseries 1, Series 1, John Bugher papers (FA 027), RAC.
- ⁸⁰ 'Studies in the Cameroons', f 2669, Box 216, Subseries 3:495.0, Series 3, RG 5(FA115), RF, RAC.
- ⁸¹ 'Studies in the Cameroons', f 12, Subseries 1, Series 1, John Bugher papers (FA 027), RAC.
- ⁸² John C. Bugher, 'Jungle Yellow Fever' in *Yellow Fever: a Symposium in commemoration of Carlos Juan Finlay, 1955*, paper 8 (25-31). Accessed online at http://jdc.jefferson.edu/yellow_fever_symposium/12
- ⁸³ John Bugher to Andrew Warren, 13 October 1948, f 23, Box 3, Subseries 495.0, Series 495, RG 1.1 (FA386), RF, RAC.
- ⁸⁴ John Bugher to Alexander Mahaffy, 12 May 1947, f7, Box 1, Subseries 1, Series 1, John Bugher papers (FA 027), RAC; John Bugher to Andrew Warren, 16 March 1948, f7, Box 1, Subseries 1, Series 1, John Bugher papers (FA 027), RAC.
- ⁸⁵ Farley, *To Cast Out Disease*, chapter 16; 'International Health Division', Rockefeller Foundation, *Annual Report for 1948* (New York, 1948) <http://www.rockefellerfoundation.org/app/uploads/Annual-Report-1948.pdf>.
- ⁸⁶ Arthur Creech-Jones to George Strode, 22 December 1948, f 23, Box 3, Subseries 495.0, Series 495, RG 1.1 (FA386), RF, RAC; George Strode to Arthur Creech-Jones, 19 January 1949, f 23, Box 3, Subseries 495.0, Series 495, RG 1.1(FA386), RF, RAC.
- ⁸⁷ In 1949 Bugher summed up the work conducted at Yaba over the previous five and a half years: Yellow Fever Research Institute, Yaba, 1949, f 25, Box 1, Subseries 495.0, Series 495, RG 1.1(FA386), RF, RAC.
- ⁸⁸ The Rockefeller Foundation Annual Report for 1950, New York, 1950, p38 <https://www.rockefellerfoundation.org/app/uploads/Annual-Report-1950.pdf>
- ⁸⁹ The Institute continued under British charge and with reduced personnel : TNA, CO 927/181, Virus Research (YFRI), Nigeria, Technical Papers, Report on the YFRI, Yaba, Nigeria, for January-August 1949; TNA, CO 927/492, West African Virus Research Institute, Lagos, Nigeria, 1954-55. On virus research at IHD lab see also Farley, *To Cast out Disease*, chapter 10. Also, Harald Norlin Johnson, Virologist and Naturalist with the Rockefeller Foundation and the California Department of Public Health, an Oral History conducted in 1987 and 1988 by Sally Smith Hughes, Regional Oral History Office, The Bancroft Library,

University of California, Berkeley, 1991:

digitalassets.lib.berkeley.edu/roho/ucb/text/johnson_harald.pdf

⁹⁰ Thomas P. Monath, 'Yellow Fever: *Victor, Victoria?* Conqueror, Conquest? Epidemics and Research in the Last Fifty Years and Prospects for the Future', *American Journal of Tropical Medicine and Hygiene*, 45 (1), 1991, 1-43.

⁹¹ "A Wartime Scientific Program for the International Health Division", International Health Division Program, 1948-50, f17, Box 2, Subseries 1, Series 1, John Bugher papers (FA 027), RAC. The postwar role of the IHD had been unclear and it was eventually wound down in 1951: see Farley, *To Cast Out Disease*, chapter 16.

⁹² E. Regis, *The Biology of Doom: The History of America's Secret Germ Warfare Project* (New York, Henry Holt, 1999); G.W. Christopher, T.J. Cieslak, J.A. Pavlin and E.M. Eltzer Jr., 'Biological Warfare: a historical perspective', *JAMA*, 278 (5), Aug 6 1997:412-7.

⁹³ 'A Wartime Scientific Program for the International Health Division', International Health Division Program, 1948-50, f 17, Box 2, Subseries 1, Series 1, John Bugher papers (FA 027), RAC

⁹⁴ Shields Warren to George Strode, 20 December 1950, f 7, Box 1, Subseries 1, Series 1, John Bugher papers (FA 027), RAC; George Strode to Shields Warren, 28 Dec 1950, f7, Box 1, Subseries 1, Series 1, John Bugher papers (FA 027), RAC.

⁹⁵ 'Civilian Protection Group, 1950', f4, Box 1, Subseries 1, Series 1, John Bugher papers (FA 027), RAC; 'Medical Planning for Disasters and Civil Defense, 1950', f24, Box 1, Subseries 1, Series 1, John Bugher papers (FA 027), RAC.

⁹⁶ Roundtable Discussion on Yellow Fever, 13 September 2005, PBS, American Experience Online, <http://www.pbs.org/wgbh/amex/fever/sfeature/experts.html#q5>.

⁹⁷ Bugher was Director of the AEC's Division of Biology and Medicine from 1952 to 1955 when he returned to the Rockefeller Foundation as Director of Medical Education and Public Health. He was appointed Consultant on Nuclear Affairs for the Foundation in 1959. John Bugher, f 0, Box 1, RF Biographical files (FA 485), RF, RAC; John Wargo, *Green Intelligence: Creating Environments that Protect Human Health*, (New haven: Yale University Press, 2009), 19.

⁹⁸ TNA, CO 927/492, West Africa Virus Research Institute, Lagos, Nigeria, 1954-55, West African Council For Medical Research, Extract from Scientific Report.

⁹⁹ Monath, 'Yellow Fever: *Victor? Victoria?*', 14.

¹⁰⁰ Jarion Vainio and Felicity Cutts, *Yellow Fever*, Division of Emerging and Other Communicable Diseases Surveillance and Control (Geneva, WHO, 1998); Thomas P. Monath and Pedro F.C. Vasconcelos, 'Yellow Fever', *Journal of Clinical Virology*, 64 (2015), 160-173; J.P. Mutebi and A.D. Barrett, 'The epidemiology of yellow fever in Africa', *Microbes and Infection*, 4, 14 (November 2002), 1459-68;; Tappan, 'Endemic Yellow Fever'; P.P. Mortimer, 'Yellow Fever Resurgent', *Communicable Disease and Public Health*, 6, 2 (June 2003), 85-86; Leslie Roberts, 'Resurgence of Yellow Fever in Africa Prompts a Counterattack', *Science*, 316, No.5828 (25 May 2007), 1109.

¹⁰¹ Tappan, 'Endemic Yellow Fever'; WHO, 'The Yellow Fever Initiative: an Introduction', (WHO, Geneva, 2007).

¹⁰² Stepan, *Eradication*, 160