

Macrocosm, Microcosm and the Circulation of the Blood: Bruno and Harvey.

Giordano Bruno consistently asserted that the blood flows rapidly in a circle. Being generous to Bruno, we might see these remarks as the first clear statement of the rapid circulation of the blood. As Bruno made them well before the work of Harvey, we might give him at least some of the credit for the discovery of the circulation. However, being less generous to Bruno, we might see his comments as nothing more than speculation employing a macrocosm/ microcosm analogy, with little to do with Harvey's scientific discovery. As we shall see, matters are not as clear cut as these positions might suggest, and the aim of this paper is to steer a course between these two extremes. One thing Bruno and Harvey have in common is a strong reliance on a macrocosm/ microcosm analogy between the human body and the earth's weather cycle to support their views on the circulation.

I

Firstly some background on the blood system in humans. The generally accepted view in the sixteenth century was due to Galen. There were two separate blood systems and the blood did not circulate, but was gradually consumed by the body. One system was based on the liver, where 'nutritive' blood was generated. This blood was then carried slowly through the veins to the rest of the body, some (but not all) passing through the right side of the heart to the lungs. This blood was consumed by the body, and did not return to the liver or pass through the lungs. The second system, based on the heart and the lungs, carried 'vivified' blood from the lungs via the arteries and the left side of the heart to the body.¹ Effectively, these were two separate systems carrying different types of blood in different vessels. Some nutritive blood was believed to seep through small pores in the septum, the muscular wall separating the right and left sides of the heart, in order to replenish the vivified blood consumed by the body, but this was the only significant connection between the two systems.

It is by no means obvious that the blood circulates rapidly around the body in a single system. There are two different types of blood (oxygenated and deoxygenated) which have noticeably different colours (bright red and purple). There are significant differences between arteries and veins (artery walls are much thicker, and the arteries carry a pulse). It is not clear given the technology of the sixteenth century how arteries and veins are linked together (capillaries being observable only under a microscope). These facts might well lead one to believe there to be two separate blood systems. There are three considerable problems in arguing for a unitary circulation against this background. Firstly, how can it be that there are two types of blood within the one system? There needs to be a means by which one type of blood can be converted into the other and vice versa, and this needs to be happening continually. Secondly, how does blood get from the arteries to the veins? Thirdly, how does blood pass through the lungs, which now take the full flow of the blood? If one argues that the circulation of the blood is rapid, then these problems become more acute. Substantial amounts of blood must pass swiftly through the link between arteries and veins and through the lungs. The process of the interconversion of the two blood types also has to be highly efficient and continual.

One significant advance made during the Renaissance, which it is quite likely that Bruno was aware of, was the postulation of what is known as the lesser circulation by Colombo.² Here blood is thought to pass from the right side of the heart through the pulmonary artery to the lungs, and then return via the pulmonary vein to the left side of the heart. Blood is still thought to be produced by the liver and consumed by the body, so here we have one open ended system instead of Galen's two, or the single closed system of the full circulation. While this idea was suggested in the Renaissance, it was far from being universally accepted.

II

What does Bruno have to say on the circulation of the blood? Without doubt the most encouraging comment is the following, from *De Rerum Principiis*:

"The blood and other humours are in continuous and most rapid circulation."³

So too we are told that the blood from the heart:

"Goes out to the whole of the body and comes back from the latter to the heart, as from the centre to the circumference and from the circumference to the centre, proceeding so as to make a sphere."⁴

Furthermore we are told of:

"The blood which in the animal body moves in a circle."⁵

In *De Immenso et Innumerabilibus*, Bruno also tells us that:

"In our bodies, the blood and other humours in virtue of spirit run around and run back,⁶ as with the whole world, with stars and with the earth."⁷

Bruno quite specifically asks why the blood moves continually in this manner.⁸ His answer comes by way of a macrocosm/ microcosm analogy. What explains the ebb and flow of tides, winds, rain, springs coming from and going into the earth?⁹ According to Bruno, who rejects several other answers as unsatisfactory,¹⁰ it is what Plato called soul and is defined as the number which moves itself in a circle.¹¹ Similarly with the human body, it is the natural circular motion of soul which is the reason for the circulation of the blood. In *De Monade, Numero et Figura*, Bruno is keen to emphasise the heart as centre of the microcosm, from which the vital spirits go out to the whole of the body.¹² The Platonic and neoplatonic ideas of soul, world soul and the perfection of circular motion I take to be reasonably well known. As soul is intelligent it will always act for the best, and so will execute the best sort of motion as well as it can.¹³ The origins of macrocosm/ microcosm analogy also go back to Plato. In the *Timaeus* especially, we find the foundation of much neoplatonic thinking on this matter. The cosmos, having been brought into being by a well meaning craftsman with only the best in mind,¹⁴ is a living, intelligent, ensouled entity. The heavenly bodies, which similarly are alive, intelligent and ensouled and execute (combinations of) regular circular motion, are the visible manifestation of the intelligent life of the cosmos. Just as the cosmos has mental revolutions, so do human beings, and the *Timaeus* tells us that:

"God devised and gave to us vision in order that we might observe the rational revolutions of the heavens and use them against the revolutions of thought that are in us, which are like them, though those are clear and ours confused, and by learning thoroughly and partaking in calculations correct according to nature, by imitation of the entirely unwandering revolutions of God we might stabilise the wandering revolutions in ourselves."¹⁵

Bound up in this is the standard Platonic moral injunction that we strive to become as much like god as possible. Humans should also imitate the cosmos to maintain good health. The *Timaeus* tells us that the cosmos has a rocking motion, and as the cosmos keeps itself in motion in order to sustain its own good order, so should humans take a moderate amount of exercise in order to sustain their good order (which equates with their good health).¹⁶ Indeed, we can also find a macrocosm/ microcosm analogy directly to do with the blood in Plato. Just as the cosmos confines and agitates the particles within it, so does the human body confine and agitate the blood.¹⁷ There is little doubt that Bruno goes beyond what Plato says. Plato does not specifically mention the circulation of the blood or the speed of its circulation, and it would be hard to extract such ideas from the *Timaeus*, even though many of the ingredients are there.¹⁸ The macrocosm/ microcosm analogy also became more refined and was common in many types of thought in the Renaissance. The lesser world was thought to be structured in a similar way, or to function in a similar way to the greater world. Typically there was harmony and/ or sympathy between the greater and lesser worlds, and spirit might operate as a mediating factor between world soul and matter. Bruno's use of the macrocosm/ microcosm analogy employs these ideas and is more sophisticated than anything to be found directly in Plato's *Timaeus*.

III

While Bruno may make a clear statement of the idea that the blood circulates and does so rapidly, there would immediately appear to be several lines of criticism. This idea would appear to be the result of speculation using the macrocosm/ microcosm analogy rather than the product of observation and experiment. Certainly there is nothing here in the way of quantified observation and argument, which is supposed to mark out Harvey's work. Bruno also seems to believe that the blood is in some way alive, or imbued with soul, and makes no use of the mechanical analogy of the heart as a pump which is supposedly of so much importance for Harvey.

There are though some important similarities between Harvey and Bruno. Harvey too makes considerable use of the macrocosm/ microcosm analogy, with the heart at the centre of

the microcosm and the circulation of the blood likened to the earth's weather cycle.¹⁹ The motion of the blood, he says:

"We may call circular, after the same manner that *Aristotle* says that the rain and the air do imitate the motion of the superior bodies. For the earth being wet, evaporates by the heat of the Sun, and the vapours being rais'd aloft are condens'd and descend in showers, and wet the ground, and by this means here are generated, likewise, tempests, and the beginnings of meteors, from the circular motion of the Sun, and his approach and removal... So the heart is the beginning of life, the Sun of the Microcosm, as proportionably the Sun deserves to be call'd the heart of the world, by whose vertue, and pulsation, the blood is mov'd, perfected, made vegetable, and is defended from corruption and mattering; and this familiar household-god doth his duty to the whole body, by nourishing, cherishing, and vegetating, being the foundation of life, and author of all."²⁰

While Harvey makes use of Aristotle on the weather cycle, it is important to note that Aristotle himself did not make use of the macrocosm/ microcosm analogy here or elsewhere. Harvey also uses the analogy of the circle and its central point in relation to the heart. In his lectures on anatomy he says that:

"The heart... is the principle part [of the body] for it occupies the principle place as at the centre of a circle."²¹

Harvey, it has been held, broke with Aristotle in his use of quantitative experiment and mechanical analogies. However, Harvey's argument that more blood is transmitted by the heart in a short time than the blood vessels can contain or the ingested food can supply is supported by (and only in fact requires) some very rough estimates.²² So we find a series of estimates for the volume of the ventricle and the pulse rate in humans and some other mammals, and the proportion of this volume expelled per pulse.²³ There is nothing here that Aristotle would object to, and nothing to suggest that Harvey would follow Galileo in saying that the book of nature is written in the language of geometry or mathematics (indeed Bruno may be stronger on this idea than Harvey). Moreover, there is an interesting passage in the *Meteorologica* where Aristotle argues against the idea that the rivers are supplied with water by great underground reservoirs which fill up in the winter and then gradually deplete during the summer. He then argues that:

'It is clear that, if anyone should wish to make the calculation of the amount of water flowing in a day and picture the reservoir, he will see that it would have to be as great as the size of the earth or not fall far short of it to receive all the water flowing in a year.'²⁴

Structurally this argument is similar to Harvey's, and Harvey would have been well acquainted with the *Meteorologica* as it is here that Aristotle discusses the circular nature of the weather cycle. Harvey also refers to the Vena Cava as the 'headspring, the cellar and cistern of the blood' in *De Motu Cordis (DMC) V*, and in general argues that if there were not a circulation, the veins would rapidly empty.

It has also been held that Harvey broke with Aristotle and was in tune with the positive developments of the seventeenth century in his use of mechanical analogies when discussing the heart and the circulation. Harvey gives greater prominence to the macrocosm/ microcosm analogy, and did not in fact liken the heart to a pump, but to a pair of water bellows, and did so only in his lecture notes. He says that:

'From the structure of the heart it is clear that the blood is constantly carried through the lungs in to the aorta as by two clacks of a water bellows to raise water.'²⁵

A water bellows has significant differences from an orthodox pump and is significantly less of a mechanical analogy than might be suggested by a direct analogy with a pump. Is there anything which breaks with Aristotle here? Aristotle likens not only the lungs but also the heart to a pair of forge bellows:

'It is necessary to regard the structure of this organ [the lung] as very similar to the sort of bellows used in a forge, for both lung and heart take this form.'²⁶

Harvey also believed the blood to be in some way alive. We can find him saying that:

"Seeing therefore that blood acts above the powers of the elements and is endowed with such notable virtues and is also the instrument of the omnipotent Creator, no man can sufficiently extol its admirable and divine faculties. In it the soul first and principally resides, and that not the vegetative soul only, but the sensitive and the motive also."²⁷

That Harvey was heavily influenced by Aristotle is well known, as is much of the evidence for this view. The early Aristotelian influence in Padua,²⁸ the idea of the heart as the key organ, the approach to embryology, the centrality of the heart in research, the comparisons with other animals, and the dispute with Descartes over mechanism have all been seen as evidence of Harvey the Aristotelian. Harvey, like Bruno on this matter does not make a radical break with ancient ideas. Rather, both make use of and develop ancient ideas. There are several issues then where we find that if we are to be critical of Bruno, then we must also be critical of Harvey.

IV

Both Bruno and Harvey seek a purpose for the circulation of the blood, and neither find mechanical causation an adequate explanation for the circulation.²⁹ After his comment that the blood moves rapidly in a circle, Bruno goes on to say that the motion of the blood continually preserves life.³⁰ The peripatetics, he says, put forward confused reasons and indeed no explanation at all when they say these things happen 'by nature'. The circulation cannot be explained either in terms of natural instinct, necessity of fate, providence of God, nature of the living or condition of the soul.³¹ What then does keep the blood in motion? Bruno says that:

"Now we must consider in particular what in the greater world ascends and recedes, what is it that makes the sea flow and flow back, springs bubble up, to emerge from the bowels of the earth and disappear again, what makes warm things freely ascend, moist and solid ones descend, and winds flare up from all regions?"³²

He goes on by saying:

"It is not possible to explain this in terms of vapours, humours and the like, which move these things, for what moves these humours and vapours?"³³

Instead of these sorts of explanations, what we must look for to explain these things, both in the body and in the world, is what:

"Plato in truth called it soul, and defined as number which moves itself in a circle."³⁴

The life force in the body flows out from the heart to whole of the body and back again. Blood in the body and water in the weather cycle do not move by themselves, but move because of spirit.³⁵ If we separate blood from the body, then

"The blood, which in the bodies of animals moves in a circle... outside the body is immobile, torpid and liable to putrefy, and ought no longer to be called blood."³⁶

Similarly,

"Water outside of its proper place, outside springs and rivers, putrefies, and plants torn from the earth cease to flourish, and die, as do limbs severed from bodies."³⁷

For Bruno then, any materialist or mechanistic explanation of either the weather cycle or the circulation of the blood will be inadequate, as will any 'peripatetic' explanation. After comments on the macrocosm/ microcosm relation and the perfection of the blood quoted above, Harvey famously says that:

"But we shall speak more conveniently of these in the speculation of the final cause of this motion."³⁸

Harvey is also scathing about materialism and mechanistic explanations in physiology in *De Generatione*:

"They that argue thus, assigning only a material cause, deducing the cause of natural things from an involuntary and causal occurrence of the elements, or from the several dispositions or contriving of atoms, do not reach that which is chiefly concerned in the operations of nature, and in the generation and nutrition of animals, namely the divine agent, and God of nature, whose operations are guided with the highest artifice, providence, and wisdom, and do all tend to some certain end, and are all produced, for some certain good." ³⁹

It is notable here that Harvey is willing to accept a generally Aristotelian explanation of the circulation of the blood and the weather cycle, albeit with a Christian God in the key teleological role. Bruno is quite specific in rejecting 'peripatetic' explanations of the motion of the blood and of water in the weather cycle, preferring a more immanent spirit in both the macrocosm and the microcosm to produce the circular motions of blood and water.

V

Having looked at the considerable similarities between Bruno and Harvey, we must now turn to the dissimilarities. Although we may rightly be sceptical about how far Harvey's experiments on flow rates represent a radical new departure on the question of quantification, Harvey does produce a wealth of empirical support for the circulation thesis in addition to the flow rate experiments. There are experiments to show the impermeability of the septum, experiments with ligatures to demonstrate the direction of blood flow in arteries and veins, and to demonstrate that there must be connection between arteries and veins. There is also important work on the exact nature of the heart beat, and comparative work on other species.

Equally importantly though, Harvey is concerned with making the circulation hypothesis work in detail. Here we come back to the three problems for the circulation thesis mentioned in section I, about the links between the arteries and the veins, the interconversion of the two types of blood within one system, problems which are intensified if the blood is thought to circulate rapidly. Harvey makes important use of macrocosm/ microcosm analogy in relation to the weather cycle and the circulation. He recognises that there are two types of blood, venous and arterial:

'This contains blood rawish, unprofitable, and now made unfit for nutrition, the other blood digested, perfect and alimentative.'⁴⁰

The weather cycle for Aristotle has the qualitative and cyclical changes of water into air by evaporation and air into water by condensation. Harvey specifically links this to the functions of the circulation of the blood, and this forms the main body of the critical chapter eight of *DMC*. He develops the comparison between heart and sun by saying that:

'So in all likelihood it comes to pass in the body, that all the parts are nourished, cherished, and quickened with blood, which is warm, perfect, vaporous, full of spirit, and, that I may so say, alimentative; in the parts the blood is refrigerated, coagulated, and made as it were barren, from thence it returns to the heart, as to the fountain or dwelling house of the body, to recover its perfection, and there again by naturall heat, powerfull and vehement, it is melted and is dispens'd again through the body from thence, being fraught with spirits, as with balsam, and that all the things do depend upon the motional pulsation of the heart.'⁴¹

So as the sun provides heat for the macrocosm, so does the heart for the microcosm. That is significant as the sun's heat generates the key change in the weather cycle, the evaporation of water. In terms of Aristotle's element theory that is the change from cold, wet water to hot, wet air. The heart similarly creates the key change in the circulation in converting one type of blood into the other, and does so by its 'powerfull and vehement' natural heat. With the weather cycle the contrary conversion is a cooling, and the heart 'melts' the blood while the parts coagulate it. Finally, the sun is the cause of all change in the terrestrial realm.⁴² For Harvey all things depend on the motion of the heart.⁴³

There is also the question of what happens between arteries and veins in the absence of direct evidence of the capillaries, and a problem about the passage of blood through the lungs, each problem being made acute by Harvey's estimation of the quantity of blood flowing through the heart. The weather cycle presents an analogous difficulty, in that while rivers, evaporation and rainfall may be evident, it is less clear how the rainfall becomes rivers. Aristotle hypothesises that the mountains act like a sponge, and that gradually water collects together and emerges as rivulets which then form the rivers.⁴⁴ In *DMC* chapter seven, where Harvey is

talking of the passage of the blood through the 'streyner of the lungs', his leading example is that:

'It is well enough known that this may be, and that there is nothing which can hinder, if we consider which way the water, passing through the substance of the earth doth procreate Rivulets and Fountains.'⁴⁵

Only after this does Harvey give the examples of sweat passing through the skin and urine through the kidneys. The latter are weaker examples as they will not support a great enough volume of liquid passing.

It is also important that Harvey has an account of the heart and arteries which will allow for the rapid circulation of the blood. Galen believed the expansion of the heart to be its active stroke, such that it attracted blood into itself. The compressive stroke was a relaxation, so that blood was not expelled from the heart with any great force. As the active stroke of the heart and the pulse occurred at different times, Galen believed that the pulse was due to the arteries rather than the heart, and that the arteries attracted blood into themselves. Galen's account of the heart and arteries will thus support the slow movement of the blood required by his conception of the blood systems. Harvey worked hard to come to an account of the heart with compression/ expulsion as its active phase which would support a rapid motion of the blood which would suit the circulation thesis.

Harvey then is concerned to ensure that the circulation hypothesis works at a detailed and practical level. Bruno's primary interest in these matters is with soul and the macrocosm/ microcosm relation between the human soul and the world soul. It is sufficient for him to relate the soul to the blood and have both executing some form of circular motion. On the issue of the circulation of the blood at least, Bruno argues his case employing some neoplatonic ideas and with reference to Plato himself.⁴⁶ Harvey on the other hand was a neoaristotelian interested in completing a programme of research in anatomy and physiology which he felt only the subjects of the heart and the blood were left to complete.⁴⁷ So while Bruno is concerned with the blood and the other humours⁴⁸ in relation to the soul, Harvey is more concerned with the detailed structure of the heart and blood vessels and the question of the flow of the blood. While both reject materialist and mechanical explanations of the circulation, Bruno rejects some specifically Aristotelian explanations,⁴⁹ where Harvey does not. Bruno also has a more Platonic notion of teleology, good behaviour and good structure being imposed on nature by soul, where Harvey has the more Aristotelian notion of good behaviour and structure being inherent in nature. It is interesting to note, that contrary to the views of some commentators, that neither the rapid circulation of the blood nor the circulation of the blood conceived as a microcosm of a macrocosmic weather system are specifically Aristotelian ideas but could also be formulated employing neoplatonic ideas.

VI

Is it possible that there was some link between Bruno and Harvey, such that Bruno's views may have influenced Harvey? Harvey never mentions or alludes to Bruno, although it must be said we have only a small proportion of Harvey's papers and little idea of the contents of his library as his house was ransacked by Parliamentary troops. One possible route for influence may have been the group of scholars associated with the Earl of Northumberland, who were known to have been acquainted with the works of Bruno, and Walter Warner in particular.⁵⁰ The evidence here is fairly thin and unreliable though, and at most would indicate that if Warner had arrived at the idea of the circulation independently and prior to Harvey, that the contact between them was fairly minimal with no direct discussion of Bruno's ideas.⁵¹

Another possible route may have been through Harvey's association with Robert Fludd. It is now recognised that the reason for the acceptance of Harvey's work in some quarters was that it fitted well with certain ideas from the magical tradition prevalent at the time. I would agree with French that there is a great temptation to believe that because Harvey made so momentous a discovery he had a superior, and perhaps scientific, method.⁵² This, in my view, has led to an overestimation of the role of quantification and mechanical analogy for Harvey, and, in the past, an underestimation of the role of Aristotelian ideas. It has also, I suggest, led to an underestimation of the possible role of the magical tradition in the formulation of Harvey's circulation thesis. Fludd argues for a circular motion of the earth's weather system, a circular motion of the blood and a macrocosm/ microcosm relation between the two. He then says that:

"This seems to confirm exactly the sentiments and opinions of that most learned man William Harvey, a most skilful doctor of medicine, most clear in matters of anatomy, and indeed

most well versed in the profound mysteries of philosophy, a most cherished friend of mine and most faithful to the college."⁵³

It is notable that Fludd continues by saying that Harvey argued for the circulation:

"With reasons produced from the treasury of philosophy as well as many experimental demonstrations."⁵⁴

Fludd is explicit about both the circulation of the blood and an alchemical interpretation of the circulation. The process of heating, cooling and perfecting is seen as an alchemical process similar to that of the distillations of the alchemists, and Fludd is keen on a broad interpretation of alchemy as something involving far more than the transmutation of lead into gold. If we look then to Harvey, it is interesting to examine the language in which the circulation thesis is expressed. The blood is heated and in general perfected and made useful, alimentative and fit for nutrition by the heart while in the body it is cooled, refrigerated, coagulated, and made barren, and the distinction between the two types of blood is that venous blood is rawish, unprofitable, and unfit for nutrition, while arterial blood is digested and perfect. The word that Harvey uses in the Latin version of *De Motu Cordis* for the circulation, *circulatio*, commonly uses by alchemists for the process of distillation. Certainly the alchemical interpretation of Harvey was significant in the acceptance of the circulation thesis in some quarters. Waleus tells us that:

"Blood circulates for the sake of its perfection. By virtue of its continuous movement it is attenuated. It warms up and becomes rarefied in the heart, and subsequently condensed and as it were more concentrated in the outer parts of the body. For none of its parts is warmer than the heart and none cooler than the surface. Hence a kind of circulation operates, not unlike that by means of which chemists utterly refine and perfect their spirits."⁵⁵

It is also interesting to note that in his lectures on anatomy, Harvey compares the functioning of the lung to that of the alembic, a favourite piece of apparatus among alchemists.⁵⁶ Fludd was often present at Harvey's dissections,⁵⁷ so it is quite possible that Fludd had some influence on Harvey.⁵⁸

Whether Bruno was influential in the formation of Fludd's views is another matter though. Fludd does not refer to Bruno in relation to these matters, and it is highly unlikely that he would have seen Bruno's *De Rerum Principiis*. Bruno's work may have contributed to a culture where ideas like the circulation of the blood as a microcosm in relation to the circulation of the weather cycle as a macrocosm could be formulated, but we have no direct evidence of an influence on either Harvey or Fludd.

VII

It would be wrong to draw a sharp and watertight distinction between the supposed speculation of Bruno and the supposed new science of Harvey.⁵⁹ The situation is considerably more complex, and there are many significant similarities between them on key issues. As I have attempted to show, both make important use of the macrocosm/ microcosm analogy. So too both seek a purpose of the circulation, both are disparaging about certain types of causation, both consider the blood to be in some sense alive or ensouled and both are influenced by the natural magic tradition. Neither formulate mechanical models of the body, both believing mechanical explanation to be inappropriate for both the circulation of the blood and the weather cycle.

Having said that, there are also some important dissimilarities. The most fundamental is that while Bruno sought a correspondence between nature of soul in the macrocosm and soul in the microcosm, Harvey was more interested in the detailed functioning of the heart and the circulation of the blood. Harvey produced the empirical evidence and used the macrocosm/ microcosm analogy to solve problems with the circulation thesis that Bruno seems to have been unaware of. Effectively, it is Harvey who made the circulation thesis into a viable proposition, wherever the idea for the circulation emanated from.⁶⁰

¹ For Galen the veins are those vessels which carry nutritive blood and the arteries are those which carry vivified blood (whether they carry blood to or from the heart). So he terms our pulmonary artery (which carries blood from the heart to the lungs) the artery-like vein and our pulmonary vein (which carries blood from the lungs to the heart) the vein-like artery. See Galen, On the Functions of Parts of the Human Body, Book VI, and On the Natural Faculties, Book III.

- ² The lesser circulation was also proposed by Ibn al-Nafis in the thirteenth century and Servetus in the sixteenth, though Servetus' work was suppressed by the church. It is thought that the three discoveries were independent. Colombo's work was reasonably well known and debated. See Ibn al-Nafis, A Thirteenth-Century Manuscript on Blood, in M. Graubard, Circulation and Respiration, The Evolution of an Idea, Harcourt, New York 1964, Michael Servetus, Christianismi Restitutio, Vienna 1555, Book V, Realdo Colombo De Re Anatomica, Venice 1559, Book VII.
- ³ Bruno, *De Rerum Princip.*, BOL 521.28 ff. [my translation]. Cf. 524.7 ff. esp. 9-10 and 524.22-25.
- ⁴ *De Rerum Princ.* 524.7-10 [my translation].
- ⁵ *De Rerum Princ.* 524.23-24 [my translation].
- ⁶ Runs around in a circle, perhaps ? The Latin is *circumcursant et recursant*.
- ⁷ *De Immenso* 6/VIII, BOL 185 [my translation].
- ⁸ See *De Rerum Princ.* 522.11-12.
- ⁹ See *De Rerum Princ.* 522.13 ff.
- ¹⁰ See *De Rerum Princ.* 522.13 ff.
- ¹¹ See *De Rerum Princ.* 523.4-5.
- ¹² See *De Monade*, BOL 347. For other comments in Bruno, see W. Pagel, William Harvey's Biological Ideas, New York, Karger, 1967 pp. 106-108.
- ¹³ On these matters see *Laws* 893b-899d.
- ¹⁴ See *Timaeus* 28a-29d. Note that the cosmos for Plato is organised from a chaos, not created *ex nihilo*.
- ¹⁵ See *Timaeus* 47a ff. [my translation].
- ¹⁶ See *Timaeus* 88de.
- ¹⁷ See *Timaeus* 81ab.
- ¹⁸ It is important to note though that Plato, unlike Bruno and indeed Harvey does not associate the blood with soul, and in the *Phaedo* quite specifically denies that we think with the blood (or air or fire), possibly in reply to some presocratic speculation (see *Phaedo* 96b).
- ¹⁹ Harvey also considered the hen's egg to be a microcosm, see Disputations touching the generation of animals trans. G. Whitteridge, Oxford, Blackwell Scientific, 1981 (*DGA*) p. 51.
- ²⁰ The anatomical exercises of Dr. William Harvey : De motu cordis 1628 London, The Nonesuch Press, 1928 (*DMC*) Ch. 8. See Aristotle *De Generatione et Corruptione* II/10, *De Anima* 415b3-8, *De Mundo* 399a20-35 for the Aristotelian background here. For Aristotle it is the sun that is the cause of the weather cycle - this is in the very strong Aristotelian sense of being both efficient and final cause - see *Meteorologica* 346b20 ff. In the Preface to the King which precedes *DMC*, he also brings the king into the analogy: "*The Heart of creature is the foundation of life, the Prince of all, the Sun of their Microcosm, on which all vegetation does depend, from whence all vigor and strength does flow. Likewise, the King is the foundation of his Kingdoms, and Sun of his Microcosm, the Heart of his commonwealth, from whence all power and mercy precedes.*"
- ²¹ Harvey, Anatomical lectures : Prelectiones anatomie universalis, ed. & trans. G. Whitteridge, London, E. & S. Livingstone, 1964 (*Lectures*) pp. 244-245.
- ²² See *DMC* Ch. 9.
- ²³ See *DMC* Ch. 9.
- ²⁴ Aristotle, *Meteorologica* 349b16ff [my translation].
- ²⁵ Harvey, *Lectures* p. 272.
- ²⁶ Aristotle, *De Respiratione*, 480a20-23, cf. 478a10 [my translation]. Galen also frequently likens the heart to a forge bellows.
- ²⁷ Harvey, *DGA* p. 250, cf. *DMC* p. 6, *Lectures* p. 295, p. 319.
- ²⁸ Harvey would have been exposed to Aristotelian ideas in his time as an undergraduate at Cambridge as well; see R. French, William Harvey's Natural Philosophy, Cambridge U.P., 1994, p. 51.
- ²⁹ In Bruno see e.g. *De Rerum Princ.* 525.4 ff., in Harvey see e.g. *DMC* Ch. 8.
- ³⁰ See Bruno, *De Rerum Princ.* 521.28-522.5
- ³¹ See Bruno, *De Rerum Princ.* 522.5-12.
- ³² Bruno, *De Rerum Princ.* 522.20-27 [my translation].
- ³³ Bruno, *De Rerum Princ.* 522.27-29 [my translation].
- ³⁴ Bruno, *De Rerum Princ.* 523.4 [my translation], cf. 521.25.
- ³⁵ See Bruno, *De Rerum Princ.* 524.6 ff.

³⁶ Bruno, *De Rerum Princ.* 524.22-25 [my translation].

³⁷ Bruno, *De Rerum Princ.* 524.25-30 [my translation].

³⁸ *DMC* Ch. 8.

³⁹ *DGA* pp. 51-52.

⁴⁰ *DMC* Ch. 8.

⁴¹ *DMC* Ch. 8.

⁴² See e.g. *Meteorologica* I/2 393a20 ff.

⁴³ Cf. The Preface to the King in *DMC*.

⁴⁴ See *Meteorologica* I/XIII 349a28 ff.

⁴⁵ *DMC* Ch. 7.

⁴⁶ Whether it is proper to consider Bruno to be a neoplatonist, or to be significantly influenced by neoplatonism on all issues is another matter. I merely point out that Bruno argues for the circulation of the blood in largely neoplatonic terms.

⁴⁷ See *DMC* Ch. 1.

⁴⁸ See *De Rerum Princ.* 521.28 and *De Immenso.* 6/VIII, p. 185

⁴⁹ See e.g. See Bruno, *De Rerum Princ.* 522.5-12. I would agree with Pagel (1967) *op. cit.* p. 104, "Bruno's primary concern in these passages is not the blood, but the spirit of life"

⁵⁰ See J. Jacquot Harriot, Hill, Warner and the New Philosophy. In Thomas Harriot: Renaissance Scientist, ed. J.W. Shirley, Oxford, Clarendon Press, 1974, pp. 107-128.

⁵¹ See Jacquot (1974) *op. cit.*

⁵² See French (1994) *op. cit.* p. 92 and note 41.

⁵³ Fludd, Pulsus seu nova et arcana pulsuum historia, e sacro fonte radicaliter extracta, nec non medicorum ethnicorum dictis & authoritae comprobata, Frankfurt 1630/1, p. 93 [my translation].

⁵⁴ Fludd (1630/1) *op. cit.* p. 93 [my translation].

⁵⁵ Waleus, De Motu Chyli et Sanguinis, in Anatomia ad sanguis circulationem reformata Hagae-Comitis 1655, p. 790, Pagel's translation.

⁵⁶ See Pagel (1967) *op. cit.* p. 192.

⁵⁷ Huffman, Robert Fludd and the End of the Renaissance, Routledge, London 1988, p. 22.

⁵⁸ I would agree with Pagel, Essay Review of Keynes' The Life of William Harvey, *Medical History* XI, 1967, p. 202, that 'The former [Fludd] was not without a possible sensitising influence on Harvey's discovery' (cf. W.H. Huffman, Robert Fludd: Essential Readings, Aquarian Press, London, 1992 p. 20). Debus thinks such an influence unlikely, but draws a much sharper distinction between the 'speculation' of Fludd and the 'experimental observation' of Harvey than I argue for here - Harvey too makes considerable and significant use of the macrocosm/ microcosm analogy. See A.G. Debus, Robert Fludd and the Circulation of the Blood, *Journal of the History of Medicine* XVI, 1961, pp. 374-393, esp. pp. 382-384 & 393, and The Synthesis of Robert Fludd (Ch. 4 vol. I *The Chemical Philosophy*, Science History Publications, New York 1977)), esp. pp. 271-276.

⁵⁹ So too the 'speculation' of others such as Fludd and Harvey.

⁶⁰ My thanks to Prof. Gatti and an anonymous reader for their helpful comments on this paper.