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THE PARADOXICAL TEXT 'ON THE HEART'

PART I

by

I. M. LONIE*

‘ἐν τῇ αἰσθησει ὁ κρῖσις’—Aristotle

THE TREATISE IN Vol. IX, pp. 80–93 of Littré's edition of the Hippocratic Corpus, *De Corde*¹ is one of the most attractive in that collection, despite the wretched state of its text. It is a real pleasure, after reading some Hippocratic treatises, to come upon something which we can instantly recognize as scientific exposition of a familiar kind. It is attractive in its manner of presentation: there is a remarkable absence of that egotistic style, ‘Ich-Stil’, so characteristic of some fifth-century scientific writing. The author is no sophist or iatrosophist, calling us into hushed and reverent attention with some high-faluting piece of bombast. Contrast the beginning of *De Genitura* (VII, 470L.): ‘Law governs all things’, with the matter of fact tone of *De Corde*: ‘In shape, the heart is like a pyramid’. This tone is maintained until the equally quiet conclusion: ‘that is what I have to say concerning the heart’. The author does not obtrude himself. He does not leave us with the impression, so frequently derived from Hippocratic writings, that we have heard a spectacular oration from a sophist, justly confident of his reputation but concerned also to maintain that reputation. The tone is quiet and businesslike: there is the lecturer, there before him is the subject of his lecture, the heart in its anatomy, and thus he gets on with it. His personality is absorbed by his subject, and what pride is there is not personal pride, but an entirely altruistic pride in the handiwork of the Craftsman who made the heart. He is a pious man.

We are engaged by the manner—but also by the matter. Despite great difficulties in interpretation of particular passages, we receive a clear and distinct impression of the author's anatomical subject, the heart. It is precisely this clarity, so unlike the anatomical essays of other works in the Collection, that stimulates us to investigate those passages where the outline seems to have been lost, or the details have become blurred

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¹ Bibliographical note:

1. D. Joannes Nardius, *Noctes Geniales*, Bologna, 1655, pp. 685–748.
2. M. Wellmann, *Fragmente der Sizilischen Ärzte*, Berlin, 1901, pp. 97–107.
3. E. Mühsam, *Janus*, 1910, 15, 797–833.
4. F. C. Unger, ‘Liber Hippocraticus περὶ καρδίας’, *Mnemosyne*, 1923, 51, 1–101.
5. P. Diepgen, *Klin. Woch.*, 1937, 1820ff.
6. P. Kapferer, *Hippokrates*, 1938, 251ff.
7. H. Diller, *Arch. Ges. Med.*, 1938, 31, 201–18.
8. F. R. Hurlbutt, jr., *Bull. Hist. Med.*, 1939, 7, 1104–13.
9. J. Bidez, and G. Leboucq, *Revue des Études Grecques*, 1944, 57, 7ff.
10. Karl-Hans Abel, *Hermes*, 1958, 86, 192–219; cf. *Gesnerus*, 1958, 15, 71–105 (references will be to the pages in *Gesnerus*).
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and indistinct, whether through textual corruption or failure in the author's own knowledge. We have the feeling that such investigation will not be a waste of time.

But the *De Corde* is a puzzling work. There is the question of date. Since Littré made his pronouncement that *De Corde*, being one of those works which recognizes the heart as the beginning point of the blood vessels, must be post-Aristotelian, the guarded observation 'of uncertain date' has echoed up and down the footnotes of articles and books. After Littré, the work has become attached, through Wellmann, to Diocles and the 'Sicilian school', and has perhaps shared, in the minds of scholars, something of the temporal vicissitudes suffered by Diocles. The uncertainty has become even more uncertain.

Littré's grounds for a post-Aristotelian date were no good grounds,² and the putative bond between *De Corde* and Diocles may turn out to be no more than putative. About the date we may still feel uncertain, and there is good reason, as I hope to show, for expressing ourselves with caution, but I suspect that many scholars feel instinctively that this is a late work, perhaps very late.³ Within the last fifteen years, apart from feelings, some solid evidence towards a later dating has been forthcoming. Karl-Hans Abel has offered lexical and grammatical grounds for at least a third-century B.C. date, and these have been generally approved, while Professor Kudlien has with all due caution given reasons which make it at least not absurd to connect *De Corde* with Posidonius and the Pneumatic School. Such developments can only be welcome to those who have an 'instinctive' feeling that the work is late. Yet it must at the same time be admitted that the evidence, whether considered piecemeal or cumulatively, would carry small conviction to anyone who was obstinately disposed to argue for an early date, or at least against a late one. This is the fate of most evidence for dating Hippocratic texts: it will not stand up to the kind of treatment it receives (and often, it must be admitted, invites). For example, nothing could be more impressive than the kind of linguistic evidence offered by Abel, yet it could, theoretically at any rate, be argued that quite early writers might show traces of 'late' language: the *De Corde* might even be cited as a case in point! In fact, evidence for dating, whether drawn from the language of a treatise or from its material content, usually has a persuasive function: it is like the evidence one uses in literary or artistic criticism to define more accurately one's feelings about a work of literature or art, or to support a particular interpretation of that work. This does not mean that it is not 'objective' evidence: on the contrary. But it does mean that it is part of a 'case', that the evidence advanced cannot hope to be more than circumstantial. This is recognized by those who advance it, but not always recognized by those who criticize it. The only real answer to such criticism is, as it is with a poem or a work of art, to take one's opponent, gently and persuasively, deeper into the matter. Who knows, we may end by agreeing with him. But in any case we may hope to have deepened our understanding on the way.

Let me take, for a starting point, the use in ch. 11 of *De Corde* of the strange word PHOTOEIDÉS 'light-like', 'luciform', 'luminous'. The left chamber of the heart, he

² E. Littré, *Oeuvres d'Hippocrate*, Vol. I, 382ff.; cf. 220.

³ As Hermann Conring in the seventeenth century put it curtly: 'liber de corde . . . neutiquam ab Hippocrate profectus, sed longe est recentior, uti alias ostenditur' (*De Sanguinis Generatione et Motu Naturali*, 2nd ed., 1646, p. 283). Kuehlewein thought the author was post-Aristotelian and Stoic (see R. Fuchs in Neuburger-Pagel, I, p. 225).

says, is 'nourished by a luminous substance (PHŌTOEIDEI PERIOUSIÊI) refined from the blood (sc. in the right chamber)'. Now if one were simply concerned with hard and fast evidence, one would note this, along with other examples, as a late word, as Abel has done.⁴ It is not however just a question of lexical lateness, for so far as the form of the word is concerned, there is no reason why such a word should not have been used at any time in the fifth century. But 'photoeidés' is a resonant word, it is full of vibrations immediately apparent to anyone whose philosophic ear is attuned to neo-Platonism and its precursors.

The word first occurs in connexion with Heraclides of Pontus. Heraclides, so we are told in the doxography, 'defined the soul as luciform (PHŌTOEIDÊ)'.⁵ Heraclides, that strange combination of philosopher, scientist and popular journalist, was an associate both of Plato and Aristotle. He also had associations with the Pythagoreans, yet he seems to owe more to Plato than to Pythagoras; indeed he was one of the chief creators of the legend of a Platonizing Pythagoras: he looks forward to neo-Pythagoreanism and neo-Platonism, rather than back. Whether he himself used the word we cannot tell: it seems likely enough. In any case, he said that the origin and the true home of the soul was in the Milky Way, from which it descends to terrestrial life, and whither it returns, an idea which reappears in the mystical vision of Scipio which Cicero placed at the end of the *De Re Publica*. Here we are already on the shores of neo-Platonism, with its elaborate theory of the descent of the soul, and the astral body (OCHĒMA) of the soul, a body which is formed of light. The word next appears in a fragment quoted by Sextus Empiricus from the Stoic philosopher Posidonius:⁶ it is by its affinity with light (PHŌTOEIDOUS), said Posidonius in explaining the Timaeus of Plato, that our sight can perceive the light, an idea which is repeated, with the use of the same word, by Plotinus.⁷ In Galen too the word appears in a context evidently Posidonian (Galen, *de Placitis* p. 641 Müller; cf. K. Reinhardt, *Kosmos und Sympathie*, Munich, 1926, p. 188 ff.) where although applied to vision, it is related to the idea that the soul itself is 'luminous and aetherial'. 'Lichtsymbolik', both in Plato and in its later developments is a vast theme which cannot be explored here: for present purposes it is enough merely to mention that for Plato the eye and its sight is an analogy of the intellect and its intellection, the one illuminated by the light of the sun, as the other is made possible by the Form of the Good, in whose light only all things are made intelligible. When Heraclides called the soul 'luciform' he was no doubt thinking of the soul's *intellectual* qualities; and this is certainly the case in an allegorical passage of Plutarch, 'On Isis and Osiris' 77, 382C: 'the garment of Osiris has no chiaroscuro nor variegation, but its luminous character (TO PHŌTOEIDES) is one and uniform: for the first principle is untempered, and unmixed is that which is primary and intelligible (NOËTON)'. In 'On the Heart', we remember, it is the GNŌMĒ or *intellect* which dwells in the left heart and is fed by a luciform exhalation.

Light and its associations form a powerful mystique. How far back this mystique goes it is difficult to say. Certainly to Plato; perhaps to certain Pythagoreans before him. A Pythagorean in the fifth century might have used the word, so might Plato, and it is probable that Heraclides of Pontus, Plato's mystical pupil, did use it in the

⁴ cf. *Gesnerus*, 1958, 15, 74.

⁶ Sextus, *adv. Math.* 7.93.

⁵ Aetius IV, 3, 6 = Fr. 98A Wehrli.

⁷ 4, 4.24 and 5, 5.7.

fourth century. The word, and the way in which it is applied to the soul or intellect does not so much help to date the treatise, as place it in a particular philosophical tendency. To me the clearest reverberation of the word comes back from Posidonius and the strange combination of science and cosmos worship so well described by A. D. Nock (JRS 49 (1959) 1-16) which is characteristic of the first century B.C.⁸ But there are other, and earlier, reverberations as well. At the moment I merely wish to point out the striking quality of the word: it cannot be simply included as one among others in a list of 'late' words. It is a striking index of 'style', scientific or philosophic.

Still keeping to this point of style, let me turn for a moment to the actual content of 'On the Heart', its anatomical subject. It is, we are inclined to say, 'surprisingly accurate'. 'Surprising', precisely because we read it as a part of the Hippocratic Collection, and are therefore struck by the difference from other works in that Collection. Contrast it, for example, with the description of the blood vessels in *Ep. II, 4, 1 = Nat. Oss. 10*—a good contrast, because in the latter passage the author is being as careful in his observation and as honest in his record of it as he can be.⁹ But we sympathize with his disadvantages as much as we admire the results of his observation. The author of 'On the Heart', by contrast, presents us with a description of an organ which we can recognize—it is like moving from a medieval pictorial anatomical representation to a Renaissance representation. It is all so much clearer, so much more precise, so much more 'life-like'. It is perhaps a better piece of anatomy than anything even in Aristotle: certainly it is as good. Now there are two distinct points here. One is the simple one that anatomy no doubt becomes easier the more one practises it, and the more one learns from teachers who have had the opportunity to practise it. There is no doubt a historical progress in the craftsmanship of anatomy, just as there is in the craftsmanship of drawing. But perhaps more important than this is the point of motive: the writer of 'On the Heart' may have more motive for observing and describing accurately than a writer in the fifth century. Certainly both pre-Socratics and Hippocratics dissected: Alcmaeon, for example, made a remarkably subtle anatomy of the eye, or so we are told. Yet the recorded results of these anatomies—the most elaborate, as well as the most familiar, is Diogenes' vascular anatomy—leave us in some doubts about their quality. It is almost as if they were, not so much unable to observe with precise detail, but uninterested in precise detail. Once again it is a question of two different styles in science. One factor that would go a long way to explain the difference is the interest which the writer of 'On the Heart' takes in the relation between form and function: an interest prompted by his teleological outlook.

In ch. 9 he makes the following observation: 'It is for this reason, I say, that while inspiration into the left cavity [sc. of the heart] is effected through veins, into the right cavity it is effected through an artery: for vessels which are soft [i.e. the veins] have more attractive power, being more capable of distention'. (The author's assumption is that the left heart, fed from the lung by the pulmonary veins, is hotter than the right, and therefore requires more cooling from the lung.) The observed difference (probably not original to him: the point will be discussed below) between vein and artery prompts

⁸ The Posidonian reverberations are noted by Kudlien, *op. cit.*, p. 425, n.2. and ff.

⁹ Cf. V, 124, 1: 'where they go from there, I have not yet been able to observe' and 'so far as I can judge', *ib.* 13 and 17.

him to ask the question 'what difference in function does this anatomical difference suggest?' But obviously, it can work the other way as well: preconceptions about difference in function might well dispose him to a more particular examination of those parts which he believes serve that function. Now one of the glories of Greek science (or proto-science) is its use of observation. But there is a great difference—I would say a difference in 'style'—between, say, the observation of the hatching chick in ch. 29 of the treatise (late fifth or early fourth century) 'On the Nature of the Child', which that author uses to support his theories about embryonic development, and the observation implied in ch. 9 of 'On the Heart'. Certainly the observation in 'On the Nature of the Child' is more striking *historically*, for we think of its repetition by Aristotle, Coiter, Fabricius, Harvey, and von Baier. But it is a different matter when we consider that observation from the point of view of the kind of questions the author was asking, and the way in which he actually *used* the observations to answer those questions. This again is a problem which cannot be explored here: but I would like to suggest that a comparison of the two instances—in the end so very different—of 'observation' might lead us to the conclusion that the tyranny of the final cause in Plato and Aristotle was on the whole a benevolent tyranny—and not least in the matter of scientific observation.¹⁰ For the moment, however, my general point is that the dominance of the final cause is surely one, and an important one, of the considerations which explain the remarkable improvement in Greek anatomy from the fifth to the fourth and third centuries.

Thus the implied question in ch. 9 of 'On the Heart' may be, like the word PHŌTOEIDĒS, one of those points, those pieces of 'evidence', which constitute our instinctive feeling for the lateness of the treatise. But perhaps we can explore this matter of veins and arteries further. The author takes for granted a distinction between veins and arteries, and uses it as the basis for a question about function. In the context of Greek medicine the distinction between veins and arteries may be anatomical—to do with structure, composition, size—or it may be physiological—are there differences between vessels in respect of what they carry and/or in their movement?—or it may be both. It is a convenient textbook formula to say that 'Praxagoras was the first to distinguish between veins and arteries', although we may be uneasily prompted to add 'to distinguish clearly'. But Praxagoras was the first only in the sense—an important one however—that he wove into the fabric of a coherent system certain distinctions both anatomical and physiological that had been observed long before his time. The veins carried blood and the arteries pneuma. This physiological distinction had evidently been noticed as early as Alcmaeon, who referred to 'blood-carrying veins' (HAIMORHOOI PHLEBES);¹¹ presumably Alcmaeon had noticed that in slaughtered animals some vessels are empty of blood, others are not. The word ARTERIA for artery, which appears later, embodied this distinction, for it was a catachrestic extension of the ordinary use of the word, meaning 'trachea'.¹² Thus a physiological distinction between vein and artery, in the sense that veins carry blood,

¹⁰ Consider Harvey in this respect: see Walter Pagel, *The Biological Ideas of William Harvey*, 1967, pp. 41 and *passim*.

¹¹ Diels-Kranz, *Fragmente der Vorsokratiker* I, 214, 18.

¹² Indeed, even for Erasistratus the arteries may still have had an anatomical connexion with the trachea. cf. *de Usu Partium* VI, 12, trans. May, p. 308, n.58.

arteries pneuma (or pneuma and blood), is early. When the author of 'On Joints' 45, in the late fifth century, refers to 'the communications of veins and arteries' (PHLEBŌN KAI ARTĒRIŌN KOINŌNIAI) (IV, 190, 7 Littré), this is the distinction he has in mind, since he speaks of 'blood-carrying veins' in IV, 324, 12 and V, 372, 13.¹³ But there may be also an anatomical distinction as early as the fifth century. There certainly was in the fourth: Aristotle (HA3.3, 513A20) refers to the vessel 'which some call aorta through having observed even in dead bodies its sinewy (NEURŌDES) part'. It is in any case hard to believe that some anatomical distinction was not noticed earlier than Aristotle. Aristotle himself, however, does not give the appearance of thinking it important, although he does adopt the term 'aorta'. So far as we can tell, it was not until Herophilus that the anatomical distinction was made precise: the walls of the arteries = walls of veins $\times$ 6 (Galen III, 445K.); also, he said, the arteries do not collapse at death (VIII, 747K.). Puzzled evidently by the structure of the pulmonary artery, he gave it the historic name of 'arterial vein' (PHLEPS ARTĒRIŌDĒS). The assumption implied by this nomenclature is that all vessels originating in the right heart must be veins, while all those which originate in the left must be arteries.

We are fortunate enough to know the reason for Herophilus' change of name, and to be able to infer something of the background of that change. Rufus of Ephesus tells us (p. 162 Daremberg) that Herophilus believed that in the lung, vein and artery exchange their character, 'for there the veins are strong and approximate in their nature to arteries, while the arteries are weak and approximate in their nature to veins'.¹⁴ But the crucial passage is Galen 'On Anatomical Procedures', VII, 4 (II, 596 ff. K; p. 175 ff. Singer). 'It is easy', says Galen, 'to discern the arteries throughout the body by their pulsation and by their continuity with the great artery. But it is impossible to discern by the senses the pulsation of these in the lungs . . . In spite of this one might guess at [their nature] from their continuity with the left ventricle of the heart'. That is to say, Galen assumes two criteria for the recognition of an artery (i) its pulsation and (ii) *its continuity with the left ventricle*. But from what he goes on to say, it is clear that this assumption was not peculiar to him. After describing the divergent views of the Erasistrateans and the Herophileans (both of whom hold that the arteries in the lungs pulse) on the cause of pulsation, Galen continues 'But unless its movement be clearly distinguished you should not call a vessel an artery, whether it spring from the left ventricle or the right, *whatever some of the anatomists may say*'. From this we learn that, for Galen, pulsation is the primary criterion, but that for some it was origin in the right or left ventricle. Then, after a passage of anatomical investigation, he concludes 'It would be best, as I said, to distinguish these vessels by the presence or absence of a pulse. But as that is not clearly discernible by the senses, their names should be given from their communication with the two ventricles, with a qualification from their substance . . . By substance, the vessel springing from the right ventricle of the heart is an artery, that from the left a vein. Conversely, by function, that from the left is an artery, that from the right a vein'. Hence the name 'arterial vein' for the pulmonary artery, and 'venous artery' for the pulmonary vein(s).

¹³ See C. Friedrich, *Hippokratische Untersuchungen*, Berlin, 1899, p. 66ff., where the whole question is discussed.

¹⁴ For the anatomical facts, cf. Rauber-Kopsch, *Lehrbuch der Anatomie*, 10th ed., Abt. 3., p. 269 (Leipzig, 1914).

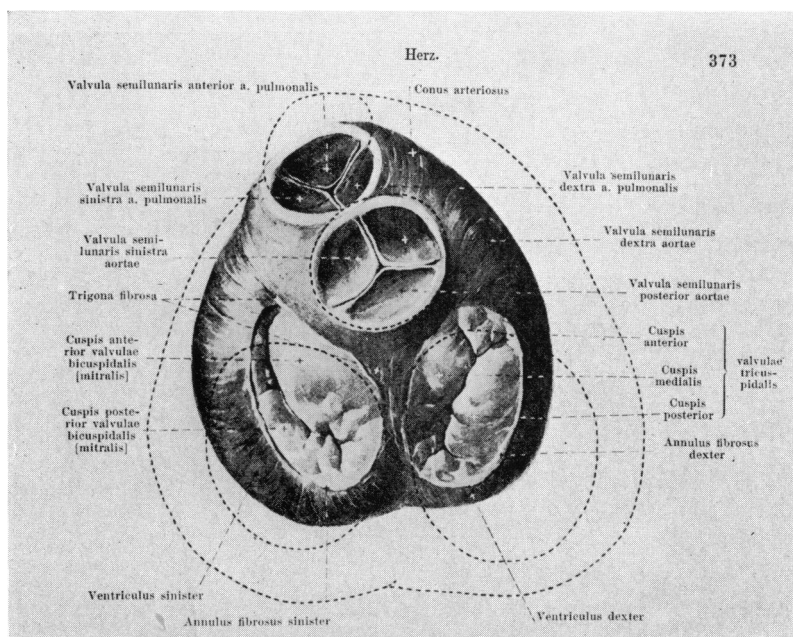


Figure 1

The four valves of the heart as illustrated in *Handatlas der Anatomie des Menschen*, Leipzig, 1913, Vol. II, p. 373, fig. 414.

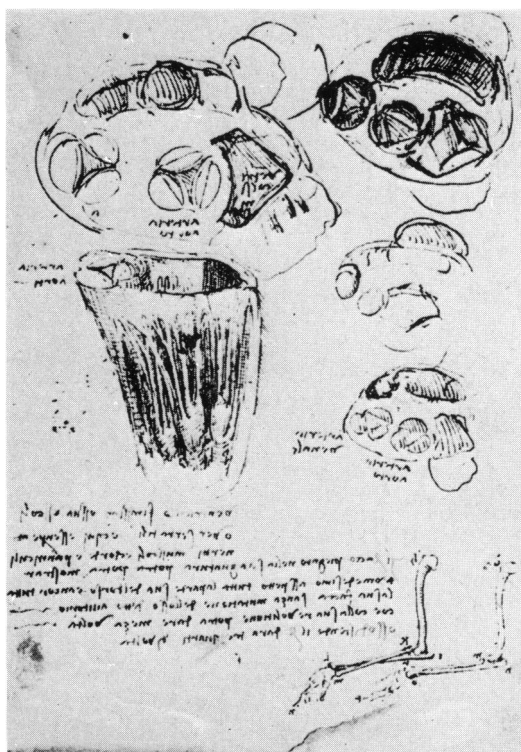


Figure 2

The four valves of the heart as drawn by Leonardo da Vinci.

The Paradoxical Text 'On the Heart'

What comes from the right ventricle must, appearances notwithstanding, be a vein, and what comes from the left, an artery.¹⁵ Such is Galen's reasoning and such, we may infer, was Herophilus'. For otherwise, he would have explained the appearance by calling the pulmonary artery the venous artery, and the pulmonary vein an arterial vein. But he did just the opposite. But what was the background to Herophilus' name-giving? Was it taken for granted by other anatomists contemporary with and prior to Herophilus that the pulmonary artery was an artery? If so, this must have been on anatomical grounds. And yet it seems to have been Herophilus who was the first to investigate closely the anatomical differences between vein and artery—and the recognition of the arterial character of the pulmonary artery required more than superficial observation. Or did they on the contrary assume that the pulmonary artery was a vein on the grounds that it issued from the right heart, so that Herophilus' change in nomenclature was a change in stress: 'vein, yes, but a vein of an *arterial* character'? On the whole, this seems the more likely supposition.¹⁶

All this, however, is as nothing to the author of 'On the Heart'. For him, there is no question but that the pulmonary artery is an artery. Thus he disposes of a degree of anatomical knowledge, and an acuteness in detailed anatomical observation, that one would not expect before Herophilus. And yet he ignores altogether the Herophilean nomenclature which, it seems, became standard almost immediately (evidently Erasistratus accepted it) and was to remain standard. A strange state of affairs.¹⁷

The author of 'On the Heart' can take the anatomical distinction for granted, although he is not concerned about the physiological distinction: for him the arteries carry blood (see ch. 11 ad fin.), and he says nothing about their pulsation. He is not aware of, or not concerned with, the form in which Praxagoras expressed the difference between veins and arteries, nor with Herophilus's name for the pulmonary artery. Veins differ from arteries because veins are 'soft' or 'yielding', and hence have a greater attractive power. Since the left heart requires more cooling than the right, for which too much cooling would be bad, the arrangement of vessels here, in view of their anatomical structure, is excellently designed to achieve this purpose. He thus performs a relatively sophisticated intellectual manoeuvre, without pomp or circumstance. Admittedly the manoeuvre is no more sophisticated than many which

¹⁵ If we concentrate on this point alone, we might be disposed to place *De Corde* before Praxagoras. We could argue, that is, that the assumption that all vessels arising from the right heart are veins and all those from the left are arteries must be part and parcel of Praxagoras' distinction between veins and arteries, namely that veins carry blood and arteries *pneuma* (the distinction being prompted by the observation that in dissection both the left ventricle and the arteries are empty of blood). Both Herophilus and Erasistratus felt bound to preserve this assumption about the origin of veins and arteries, Herophilus by a sleight of nomenclature, and Erasistratus by a sleight of anatomy (cf. Galen, *De Usu Part.*, 6.12, III, 465 K, (p. 308 May)). It may then be argued that since *De Corde* shows no awareness of this tyranny, it was written at a time when there was some awareness of an anatomical distinction between veins and arteries, but before Praxagoras' presumed association of the distinction with the right and left heart. This piece of reasoning would also fall into line with Fredrich's view (*Hippokratische Untersuchungen*, 1899, p. 77.) that *De Corde* represents a transitional stage between Praxagoras and the older Hippocratic writers who held that the arteries (as well as the veins) contain blood: for *De Corde*, although the arteries contain blood, the left heart does not. The schematism is pleasing, despite the questions which it, and all such arguments, inevitably begs. The reader must decide for himself what weight it has against the other considerations which I adduce.

¹⁶ For an entirely different approach to Herophilus' nomenclature, see J. Pagel, *Einführung in die Geschichte der Medizin*, p. 89.

¹⁷ Abel, op. cit. (*Gesnerus*) p. 88, n. 121 also suggests that *De Corde* is making use of Herophilus' investigations. But what is puzzling is that the author does not adopt Herophilus' nomenclature.

one finds in Aristotle. Admittedly, teleological explanations of human anatomy are as old as Diogenes of Apollonia, or whoever the passage 'de hominis fabrica' in Xenophon *Memorabilia* 4, 1. depends on.¹⁸ Admittedly, anatomical distinctions between vein and artery were probably observed as early as the fifth century. All these things can be admitted, for they do not affect the essential point, which is one of style. To refer to the literary analogy again: there is all the difference in the world between a great originaive poet who forms a new style, and his epigoni, those lesser men who can see well enough, once the way has been shown them, how to apply such a style—who can turn out quite respectable heroic couplets without thinking very much about it. The difference lies in the degree to which the later writer—or scientist—can take things for granted, while the originaive genius has to invent and make his tools for himself before he can use them.

DE CORDE AND THE 'CLASSICAL' PICTURE OF THE HEART

I referred earlier, thinking of the analogy of draughtmanship, to the author's 'life-like' portrait of the heart. If we were to picture mentally the heart as it is in Aristotle, as it is in Galen, and as it is in *De Corde*, and set these pictures side by side, then we would immediately see, without the intervening confusion of words, that the portrait of the heart in *De Corde* resembles the portrait in Galen far more than it does the portrait in Aristotle. It would be a striking demonstration. For the portrait of the heart as painted by Galen of course became the classical portrait, the basis from which all scientific investigation of the heart in the sixteenth and seventeenth centuries proceeded. Now Galen's portrait was in part a classic formulation of the ideas of his predecessors, notably Herophilus and Erasistratus, and the Pneumatic School, though we cannot now tell precisely how much he owes to his predecessors and how much depends on his own research. Once the anatomical lines had been laid down, as they certainly were by Herophilus and Erasistratus, any further work must have been in the direction of a greater precision of detail, of debate upon this or that anatomical or physiological point, rather than the outright rejection of an old model and the assumption of a new one. The direction was of course maintained by the existence of the heart itself, a palpable anatomical object—yet, before the Alexandrians, so inadequately and carelessly described. For this reason certain discoveries, once made, were irreversible: for example the greater thickness of the left heart (noted already by Aristotle)¹⁹ or the existence of the four valves, discovered, so Galen says, by Erasistratus.

The difference between Aristotle's heart and Galen's heart may be outlined very briefly, even childishly. For Aristotle the heart consists of three chambers, and it gives rise to two significant vessels, the vena cava and the aorta. Nothing is said about valves. For Galen the heart has two chambers, and four significant vessels, the 'arterial vein' (pulmonary artery), the 'venous artery' (pulmonary vein or veins, considered for practical purposes as one), the vena cava and the aorta. Each of these four vessels has valves on its entrance: the semilunar valves on aorta and pulmonary artery, the bicuspid and tricuspid valves on pulmonary vein and vena cava respectively. A simple and coherent picture, with a pleasing symmetry.

¹⁸ Teleology will be discussed below.

¹⁹ *De Partibus Animalium* 3.4, 665B34, 'the centre of the heart'. I am of course assuming that the central chamber of Aristotle's three-chambered heart corresponds to our left ventricle. On this see below.

The Paradoxical Text 'On the Heart'

Between this classical picture and the picture given in 'On the Heart' there are some resemblances and some differences. These will be explored further below, but first it is necessary to establish as far as possible, what the picture in 'On the Heart' is. The crucial passage is in ch. 7, where unfortunately the text is corrupt and, where not corrupt, ambiguous. A literal translation of the main manuscript might be 'Their [sc. the two chambers] orifices are not open [or 'exposed'] unless one cuts off the heart (1) of the ears (2) and of the heart, the head. If one cuts them off, there will appear also a pair of orifices upon the two ventricles (3). For the thick vein, running up out of one, leads astray the sight if it is cut (4). These are the springs of man's nature, and these the rivers throughout the body with which is watered the mortal frame . . .'.

(1) The editors (Littré and Unger) propose words meaning 'top' or 'tip'. This is a necessary and acceptable change, and I propose to adopt it without further discussion.

(2) 'Ears' are the auricles. The question is, what does the author mean by auricles? Unger argues that he includes in them the atria, and in this he seems to me to be right, since (i) if only the auricles are removed, nothing bearing any resemblance to what the author describes in the remainder of the chapter would be revealed; (ii) in ch. 10, the 'sinews' in the chambers of the heart—i.e. the atrio-ventricular valves—are described as 'beginnings of the aortas' (ARCHAI TĒISIN AORTĒISIN), which suggests that the atria are not regarded as existing separately; (iii) the 'ears' are described in ch. 8 as 'having cavities' (SĒRANGŌDEA); (iv) the atria are not elsewhere mentioned; (v) Erasistratus and Galen regarded auricles and atria (or part thereof) as one.²⁰

(3) This is the crux. For the words may mean either four or two orifices: i.e. the same ambiguity exists in the Greek as it does in English when we say 'a pair' without adding, in what follows, the word 'each'.²¹ The only way of deciding the matter is by deciding first what anatomical operation the author has in mind. For if the base of the heart is completely removed, then of course what will be revealed will be only the orifices of the two ventricles. But what he says (apparently), is 'if the *tips* of the ears are cut off'—that is to say, a *partial* removal of the atria. In that case, he may mean not the total removal of the base, but the removal of the atria and the aorta and pulmonary artery in such a way as to expose the mitral, tricuspid and the semilunar valves. One might then well say that 'a pair of openings for [each of] the two chambers are revealed'.²² So at any rate Nardi understood the passage,²³ followed by Unger p.81, who refers to the very clear picture of the four orifices in Rauber-Kopsch, *Lehrbuch der Anatomie*, III, p. 247, fig. 199.²⁴

(4) We do not know what the 'thick [or broad] vein' is. Nardi assumed it to be the

²⁰ This point will be discussed below.

²¹ See Abel, op. cit., p. 99, with reference to Diller.

²² Taking of course the preposition EPI in a distributive, rather than a local sense.

²³ D. Joannes Nardius, *Noctes Geniales*, Bologna, 1655, p. 708: 'Ubi vero praesequeris, in unaquaque apparebunt duo oscula, in sinistro quidem arteriae venalis, quae ex pulmone in cor procedit, et aortae, quae ex corde in universum corpus excurrit. In dextro caute procedendum: nam si cavam sequeris, visum fallit, ubi vero caput ventriculi et aurem, ut diximus, excideris, duo meatus fient in propatulo, primus quidem, atque maior a cava vena ad ventricululum ipsum; alter vero minor a ventriculo ad pulmonem, quem constituit vena arteriosa'.

²⁴ Pictures are sometimes better than arguments; cf. the very similar representation in *Handatlas der Anatomie des Menschen*, Leipzig, 1913, Vol. II, p. 373, fig. 419, reproduced in this paper as fig. 1 and the much less satisfactory picture in *Gray's Anatomy*, 32nd ed., p. 714 (reproduced from Quain).

I am informed by Dr. K. D. Keele that the section is an easy one, which would be made almost

vena cava; Unger argued that it was; Littré assumed it to be the aorta or the pulmonary artery; Abel, *op. cit.*, p. 87, takes it to be the pulmonary artery, with reference to Rauber-Kopsch, I, 536 ff. But since the author distinguishes in ch. 9 quite definitely between artery and vein (PHLEPS), I suppose that when he says 'vein' (PHLEPS) here he means vein. However, the meaning of the sentence, as an explanation of the previous sentence, is quite obscure, whatever be the vessel which the author meant. I would propose the following translation, which involves the addition of a negative to the text: 'For the fact that the thick vein runs up from one chamber deceives our eye, *unless* we dissect'. The point is that 'to sight', before dissection, the vena cava appears to be two veins (superior and inferior) which would suggest that there should be five main entrances, not four, to the heart; but dissection shows, in the author's opinion, that it is really one vein, whose common stock he takes to be the right atrium. That is how, apparently, the relation between the vena cava and the heart was seen by Aristotle, for whom the right atrium²⁵ is simply a broadening out of the vena cava in its vertical course, much as a river may broaden out into a lake (*Historia Animalium* 3.3, 513B1 ff.), while Erasistratus too regarded the right atrium as part of the vena cava, with the tricuspid valve at its orifice (Galen V, 548 K).

It would, no doubt, be better not to emend, but in this case all that is involved is the supplement of a negative—and anyone, whether Greek textual scholar or English proofreader, knows how easily a negative may disappear. I suggest, then, the following translation for the whole passage: 'The orifices of the cavities are not exposed until one cuts off the tops of the ears. Once they are cut off, a pair of orifices for each of the two chambers is revealed. For the fact that the thick vein runs up from only one chamber escapes our notice, *unless* we dissect.'

Two chambers, four entrances—if not, as in Galen, four main vessels (for the author speaks of the pulmonary veins in the plural). But that is, as we shall see, immaterial, for it is on the four entrances, STOMATA, that Galen insists. And the valves, yet to be discussed, the features for which the treatise 'On the Heart' is deservedly celebrated. That is the classical portrait of the heart: in Galen—and in 'On the Heart'. Since we are still talking of impressions, of 'feelings', to which we are trying to give an objective value by an examination of the facts, let me say this at once: I find it altogether difficult to conceive that this portrait of the heart, which corresponds at least in its outlines to the classical portrait in Galen, should have been made before the work of Herophilus and Erasistratus. It seems to belong quite clearly in that sector of light which beams out, as from a lighthouse, from its apex in third-century Alexandria, broadening out to include the Pneumatic School and Galen, towards, eventually, the European Renaissance, and leaving behind it in obscurity the dubious reefs and shoals of fifth-century science.

But the valves of the heart? To these we must now turn.

inevitably in due course by any anatomist dissecting the heart, and that it was made, apparently in this way, and illustrated by Leonardo da Vinci—who had no presuppositions about what he might find. See the facsimile in the 'Quaderni', IV, 14 Recto, or 19118 in Sir Kenneth Clark's Windsor Catalogue (see fig. 2).

²⁵ The words in Aristotle can hardly mean anything else. Cf. Hermann Conring, *De Sanguinis Generatione et Motu Naturali*, 2nd ed., 1646, p. 283: 'Quae omnia commodum sensum vix habent nisi auriculam dextram ventriculi dextram partem feceris'. I owe the reference to Dr. W. Pagel.

The Paradoxical Text 'On the Heart'

THE VALVES IN 'ON THE HEART' AND HEROPHILUS.

Aristotle did not know of the valves; Erasistratus demonstrated them anatomically and gave a physical explanation of their function; now since on the one hand, the discovery was universally attributed to Erasistratus according to Galen, and since on the other Galen evidently knew the *De Corde*,²⁶ Galen at least must have assumed that *De Corde* was subsequent to Erasistratus' discovery. So runs the argument (Abel op. cit. pp. 82–83).

The matter is, however, more complicated. How many valves did the author recognize? The question has prompted some thoughtful debate, and the votes are unevenly divided between those who hold that he recognized all four valves, the atrio-ventricular as well as the semi-lunar,²⁷ and those who hold that he recognized only the semi-lunar.²⁸ The most comprehensive discussion is also the most recent, by Abel, who in effect defends Kapferer's translation and interpretation. According to Abel, the author means by the membranes (HUMENES, IX, 86, 13) *all* the valves, of which first the 'cobweb-like' atrio-ventriculars are described (86, 14–17), then the semi-lunars (86, 17–88, 3). The genitive in the sentence beginning in 86, 17 'There is a pair of them . . .' refers to the membranes, i.e. the valves which are the subject of the whole chapter; not to the 'aortas', the subject of the preceding sentence; the pair which is meant, however, are the semi-lunars, which are described in two linked relative clauses. The whole sentence means something of this kind: 'Now among these membranes, there is a pair, which are contrived like doors, three membranes to each [but to what does the feminine HEKASTÊI refer, if we agree with Abel that the preceding AUTŌN refers not to the 'aortas', but to the membranes?] rounded at their edges like a semi-circle, and which by meeting together close in a wonderful fashion the openings, the limit of the aortas.'

The text is undoubtedly corrupt, and Abel has given it more satisfactory treatment than it has received hitherto. And yet even if we accept his interpretation, it will not in the end make very much difference. The general sense of the chapter, as Abel himself says, is clear enough: the author (i) begins with the wonderful workmanship of the membranes of the heart, (86, 13–14), then (ii) describes (14–17) either all the membranes or a particular set of them (namely the atrio-ventriculars); then (iii) goes on (86, 17 ff.) to describe the semilunars. No-one doubts that it is the semilunar valves which are described in the third section. What is disputed is the content of the second section; to what anatomical facts do these words refer: 'There are membranes in the chambers, and fibres as well [adopting Unger's emendation ALLAI INES for the ALLOI TINES of the manuscripts] in the chambers of the heart, spread out like cobwebs, surrounding the orifices on all sides and emplanting filaments into the solid walls of the heart. In my opinion these serve as the guy-ropes and stays of the heart and its vessels, and as beginnings for the aortas.?' The decision is doubtless one for the anatomist who is also a philologist, that 'rara avis et vix in terris reperta'.²⁹ The layman, after much earnest

²⁶ The experiment with the pig is described by Galen V, 719K, in very similar language to that of *De Corde* 2.

²⁷ Unger, p. 92; Bidez-Leboucq, p. 33; Kapferer in his translation and in *Hippokrates*, 1938, p. 251ff; and Abel, op. cit., p. 97ff.

²⁸ P. Diepgen, *Klin. Woch.*, 1937, 1820ff; H. Diller, *Arch. Ges. Med.*, 1938, 31, 207.

²⁹ But is he so rare? Or rather, would we really achieve by the long-wished-for conjunction of these qualifications, as by the advent of a philosopher king, that ideal State in the history of Greek medicine in which there shall be no more disputes?

consultation of anatomical textbooks, discussion with qualified anatomists, and some practical dissection on his own part, may form the opinion that the author can only mean the chordae tendineae and muscoli papillares, and perhaps the trabeculae carnae. And the author could hardly have recognized these, without also recognizing the tricuspid and mitral valves which form a part of this complex. That at any rate seems to be the line of reasoning adopted by those who think that the author recognizes the atrio-ventricular valves. It is not for the layman to say whether it is sound. Notice that in this line of reasoning the philological problems are little more than a side issue, for these problems do not centre round the meanings of the words INES ('fibres') TONOI ('stays') HUMENES ('membranes') and ARACHNAI ('cobwebs'), but around the connexions of sentences, in particular the connexion between the second and third sections of the chapter. The connexion suggested by Abel, which gives the meaning 'among these (several) membranes there are two (in particular)', is certainly helpful, but it is hardly essential. But not only is the philological line of argument misdirected; the anatomical line of argument is misdirected too. For supposing that it is wrong, that the author does not recognize the chordae etc. Then, whatever else may follow, it is at least certain that he recognizes only two valves, the semi-lunar. But supposing that it is right, and supposing also that the philological arguments are right—that is, that the author recognizes the atrio-ventriculæ *and* (the philological argument) includes them in the 'work of craftsmanship, most worthy of description', which the whole chapter is about, then the atrio-ventriculæ must be worthy of description because, like the semi-lunars, they have a function. What is that function? *It is not the function of valves.* The author speaks instead of their service as 'guy-ropes' (TONOI). Neither here nor anywhere else do we hear of any other valves, functioning as valves, than the semi-lunars. So that even if we do allow the arguments of the layman anatomist, and admit that the author recognized the atrio-ventricular valves, we cannot then conclude that he recognized them as valves. We shall see later, when we come to Erasistratus, just how important that qualification is. In other words, scholars have been treating the question 'did the author see the atrio-ventricular valves?' as if it were the question 'did he see that the atrio-ventricular valves were valves?', which it is not.

The consideration of two points should make this quite clear. In the first place, recognition of the chordae etc. does not carry with it the recognition of the atrio-ventricular valves *as such*. For the truth of this statement we can appeal to evidence supplied by Aristotle. For Aristotle too (and, as we shall see, Herophilus) recognized sinews in the cavities of the heart, without recognizing the atrio-ventricular valves (HA 1.17, 496A13). In another passage he mentions these sinews again, and connects them with the anatomical structure of the aorta: the heart, he says, is the point of origin for the sinews (NEURA) as well as the blood vessels, 'for the heart has sinews within itself in the largest of its three chambers, and the aorta is a sinew-like vein' (HA 3.5, 515A28ff.). This is curiously like the remark in 'On the Heart' that the sinews are the 'beginning points of the aortas' (ARCHAI TŌN AORTŌN), a remark difficult to understand unless it means what Aristotle means. However that may be, it is certainly the case that recognition of the sinews did not carry with it recognition of the atrio-ventricular valves for Aristotle, and it therefore need not have done so

for the author of 'On the Heart'.

The second consideration concerns the structure of 'On the Heart'. Whether or not the treatise originally formed part of a larger writing, it is certainly, so far as it is concerned with the heart, self-contained. It is evidently designed to lead up to the climax of the three concluding chapters, which describe together the 'membranes of the heart', 'a piece of craftsmanship most worthy of description' (ch. 10) and which then describe separately their function, first for the aorta (ch. 11), and then for the pulmonary artery (ch. 12). This structure reflects the pious tendency of the whole work. If the author had been able to strengthen his case by assigning a similarly admirable function to the atrio-ventricular valves, he would surely have done so. Presumably then he knew of no such function—and was not acquainted with Erasistratus, who evidently did. Or perhaps he was acquainted with Erasistratus, but did not believe him.

To suppose that 'On the Heart' recognized only two of the valves, while Erasistratus recognized all four, would again fit into a neat historical schema, in which 'On the Heart' would be prior to Erasistratus.

Galen attributes the discovery of the valves—all four of them—unambiguously to Erasistratus, quoting (V, 548–550K.) something like Erasistratus' own words on the subject. Although, he says, there were some of Erasistratus' contemporaries who doubted the existence of the valves, anyone who does so now is distinctly antique (ARCHAIOS)—except, evidently, that miscreant Asclepiades, for whom worse terms are reserved. Asclepiades denied their existence, calling as his witness that excellent anatomist Herophilus who (said Asclepiades) had never observed them in all his many dissections (Galen I, 109K). But perhaps more reliable than Galen's report of Asclepiades' report on Herophilus, is another remark of Galen's in *de Placitis* 1.10 (V, 206K). Here Galen is answering the question, what did Aristotle mean by saying that the heart has a multitude of 'nerves' (PLĒTHOS NEURŌN)? He suggests that the philosopher was referring to what Herophilus called 'nervelike tendons' (DIAPHUSEIS NEURŌDEIS), but calling them outright, not 'nerve-like', but 'nerves'. These, Galen goes on, are the ends of the membranes on the orifices of the heart, 'about which membranes Erasistratus wrote precisely (AKRIBŌS), but Herophilus carelessly (AMELŌS)'. By them, says Galen, the membranes are united and bound to the heart. Clearly these are the atrio-ventricular valves; clearly, too, Herophilus did not describe their function satisfactorily, perhaps did not recognize them as valves at all. We do not know in what sense Herophilus described them 'carelessly', but it is at least certain that Galen's remarks are confined to the atrio-ventricular valves; about the semilunar valves he says nothing in this passage. What he says about Herophilus might be applied equally to 'On the Heart' which, as we have seen, does indeed describe the atrio-ventricular valves, but describes them AMELŌS, 'without sufficient attention'—in the sense that it does not describe them *as* valves, does not describe their function.

Does 'On the Heart' reflect an Herophilean 'stage' in the description of the heart—a stage in which the semilunar valves are recognized as valves, but not yet the atrio-ventricular valves? It need hardly be said that we cannot attribute knowledge of the semilunars to Herophilus on the strength of a negative statement about his knowledge

of the atrio-ventriculars. There is also the consideration that Galen elsewhere seems to attribute the discovery of all the valves to Erasistratus. All the same, the possibility is worth suggesting: there might be a sense in which Galen could justifiably attribute the discovery to Erasistratus, even though the semilunars had been recognized, and recognized as valves, prior to Erasistratus' 'discovery'. Whether there might be such a sense may be discussed later. For the moment, the obvious question is what else the author of 'On the Heart' might have in common with Herophilus.

The belief of the author that the arteries as well as the veins contain blood has already been mentioned. The aorta, he says, 'is not lacking in blood', although the left ventricle is. It seems to be generally accepted that Herophilus in distinction from his teacher Praxagoras and from Erasistratus, held that there is blood in the arteries. There is some doubt, however, about the evidence. Susemihl, *Geschichte der Literatur der Alexandrerzeit*, Vol. I, p. 792 and n. 92, quotes Galen IV, 731K. So too does Fuchs in Neuberger-Pagel I, p. 288, then Gossen in RE VIII, 1, col. 1106.³⁰ G. Sarton, *Introduction to the History of Science*, Vol. I, p. 159, says the same, no doubt relying on Gossen; and F. Steckerl, *The Fragments of Praxagoras of Cos*, p. 35, mentions both the Galen passage and Gossen, as if he had some doubts on the matter. And well he might: for when we look at the Galen passage we find that if we interpret it as meaning that Herophilus was one of those who held that the arteries contain blood, we must also interpret it as meaning the same for Praxagoras, who is mentioned along with Herophilus.³¹ However, we can find something a little more reliable in the passage from Anonymus Londinensis 28.47ff. (cited by Fuchs, though in connexion with a different point): Herophilus held (like the author of the Papyrus himself, but unlike Erasistratus) that nutriment (TROPHE) is absorbed into the arteries as well as into the veins, although the author does not share his view that the absorption is greater for the arteries than it is for the veins. This may remind us of 'On the Heart', for which the aorta is 'laden with nutriment inappropriate for the ruling principle' (TROPHE OUKH HEGEMONIKE).³²

We may grant then, on the basis of the passage in the Anonymus, that Herophilus, unlike Praxagoras and Erasistratus, held that some blood is contained in the arteries as well as in the veins, and that in this he resembles the author of 'On the Heart'. But

³⁰ Gossen also mentions IV, 171K, but I can find nothing relevant here.

³¹ Cf. L. G. Wilson, *Bull. Hist. Med.*, 1959, 33, p. 296, n. 18.

³² The function of the aortic valve is not quite certain. The manuscripts read: 'so that the contents of the artery do not retard [check, hold back, ANAKOKHEI] the food which is in a tempest [ZALE], it [? the right chamber] closes off the path towards itself'. Littré translates 'l'aliment qui est en fluctuation'; Unger, 'alimentum . . . vehementer motum'. But ZALE, which means a rain-squall or shower of hail, is a much stronger word than 'vehementer motum', and it is besides altogether inappropriate to describe the exhalation of 'pure and luminous substance' which the sun-like heat of the left chamber draws from the right. ZALE, if it is correct (one would suspect SALOI, the tossing movement of a rough sea, especially since ANAKOKHEI may contain a nautical metaphor) must surely apply to the confused movement of the 'nutriment inappropriate for the ruling principle (TROPHE OUKH HEGEMONIKE)' contained in the artery, not to the contents of the left chamber, the seat of intellect. The passage might well have been written in reminiscence of Plato, *Timaeus* 42E-44C, in which Timaeus describes the confusion caused in the motions of the rational soul by the influx and efflux of nutriment. (TROPHE 43B and 44B) when the soul is first found in the body. The peculiar idea that the rational soul has a motion of its own which may be disturbed by the movement of nutriment (cf. also *Tim.* 76A and 86E) is common to both passages, and Plato in fact uses the word ZALE in 43c. Translate: 'so that the contents of the artery in its squall (EN ZALE EONTA) does not retard . . .'. The change from EON to EONTA is quite easy, and a rainy squall or hail storm might well be said to 'retard' the attraction by the sun of nutriment from the earth.

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when we go on to read in the Anonymus Herophilus' reasons for the greater absorption of the arteries, we find a considerable difference between the two. The arteries, according to Herophilus, contract and expand in pulsation, while the veins do not, and it is pressure of this expansion and contraction which causes more absorption into the arteries than into the veins. Now this is precisely the opposite of the reason for which the author of 'On the Heart' explains the cooling of the left heart from the lung through veins, and the cooling of the right heart through an artery. Here it is the *veins* which have the greater attractive power, because they are softer and more yielding. It is true that Herophilus regarded the pulmonary vein(s) as an artery, but as we have seen, there is no trace of this view, or of Herophilus' nomenclature, in 'On the Heart'. On this point then it seems impossible to reconcile the author's views with those of Herophilus, although—it is one of the 'paradoxes' of the work—'On the Heart' seems at the same time to presuppose the investigations into vascular anatomy performed by Herophilus. Nor is there any trace in 'On the Heart' of the theory of pulsation (SPHUGMOS), which was so significant for Herophilus, and described by him with such loving elaboration. On the contrary: while Herophilus distinguished between 'pulsation' (SPHUGMOS) and 'palpitation' (PALMOS), and confined the first to the heart and arteries (Rufus of Ephesus, p. 231 Daremberg; Galen VIII, 716K), the author of 'On the Heart' describes the movement of the heart as a 'leaping' (HALMA).³³

A further point of divergence is the seat of the intelligence, which Herophilus (like Erasistratus) placed in the ventricles of the brain, while the author of 'On the Heart' places it in the left chamber of the heart. This of course is no mere detail, since Herophilus's views on this matter are connected with his researches into the nervous system, for which he was celebrated.

Thus we have to remove 'On the Heart' a little from the sphere of Herophilus. There is certainly no close connexion between their views. But in order to fit 'On the Heart' into a strict historical schema, in which Herophilus succeeded in describing only two valves and their function, while Erasistratus, Herophilus's contemporary, only a little later described all four, we would require, if not evidence of a master and pupil relationship between Herophilus and the author of 'On the Heart', at least evidence of a relatively close relation in doctrine. There is no such evidence.

[*To be concluded.*]

³³ Possibly also in ch. 1, where the MSS. read THALLETAI, 'flourishes', but Schneider, followed by Littré and Unger, conjectured HALLETAI, 'leap'. Van der Linden suggested PALLETAI, 'palpitate'—which would make the difference from Herophilus even more striking.

THE PARADOXICAL TEXT 'ON THE HEART'

PART II

by

I. M. LONIE

‘ἐν τῇ αἰσθήσει ἡ κρίσις’—Aristotle*

ERASISTRATUS AND THE VALVES

Erasistratus described all four valves, ‘On the Heart’ describes only two. Is ‘On the Heart’ using the discovery which Galen emphatically attributes to Erasistratus, and to no-one else, but using it only in part? This question prompts a further one: what was the real nature of Erasistratus’ discovery?

References to Erasistratus on the valves are scattered throughout the corpus of Galen’s works, and Galen, it is salutary to remember, was not writing history but defining his own views and defending them against rival views. Polemic is of the essence of Galen’s mode of exposition, and in this he was a true Greek. We may at times suspect his accuracy, and in any case the removal, intact and undistorted, of a particular doctrine from among the complicated tissues of Galenic controversy is an operation which requires some care. Thus the locus classicus on Erasistratus’ discovery of the valves occurs in *de Placitis* 6.6 (V, 549K), and the context of this passage is Galen’s development and defence of his own view that not the heart, as Aristotle and Erasistratus said, but the liver is the ARCHĒ or starting point of the veins. The context is further complicated by the fact that Galen opposes his own view not only to that of Aristotle and Erasistratus but to that of certain followers of Erasistratus who appear to have ‘developed’ Erasistratus’ views on the function of the liver in line with Aristotelian doctrine. This view, according to Galen, assumes a flow of material from the right heart down the vena cava. But this, he says, contradicts the celebrated discovery of their own master Erasistratus, for the tricuspid valve on (as both Erasistratus and Galen regarded it) the vena cava prevents any backward flow of material from the right heart into the vena cava. Thus from Galen’s point of view it is the atrio-ventricular valves which are important, and more particularly the right atrio-ventricular valve; and it is the function of these that he stresses. In view of the passage cited earlier, where Galen seems to say that it was these, atrio-ventricular, valves that Herophilus described ‘carelessly’, and Erasistratus ‘precisely’, we might be disposed to argue that it was these valves which it was Erasistratus’ peculiar glory to have discovered, rather than the semilunar valves. In another passage too Galen seems to stress the atrio-ventricular valves (*Nat. Fac.* 2, 1, II, 77K): ‘not even Erasistratus wishes any other part [sc. than the lung] to be nourished from the heart, because of the implantation of the membranes (DIA TĒN TŌN HUMENŌN EPIPHUSIN, i.e. the tricuspid valve which prevents any backward flow into the vena cava).’

Such a possibility³⁴ should not be immediately rejected: it may be a means of discerning the true arrangement of the historical facts, if any confirmatory evidence can

* The Editor regrets the typographical errors in this quotation in Part I.

³⁴ It was canvassed by Wellmann, *Fragmente der Sikelischen Ärzten*, p. 106.

be found. Nevertheless, in the passage from the *De Placitis* Galen, despite the fact that his main interest is in the atrio-ventricular valves, does give full measure to Erasistratus' description of the other two as well. We had better look at the whole passage, a golden fragment among the miserable ruins of Alexandrian medicine.

The phenomenon is described by Erasistratus in his work 'On Fevers', how membranes adhere to the orifices of the vessels which the heart employs in the service of introducing and expelling its material. Some have had the effrontery to deny the existence of these membranes, saying that Erasistratus invented them for the sake of establishing his doctrine.³⁵ But knowledge of them is by now so general among physicians, that anyone who did not know about them would be regarded as antediluvian. There are upon the orifice of the vena cava three membranes which are very similar in their arrangement to cusps—which I suppose is why some followers of Erasistratus gave them the name 'tricuspid'. But on the venous artery (as I call the branching vessel which goes from the left cavity of the heart into the lung) the membranes, while very similar in shape, are unequal in number. For to this orifice alone, only two membranes adhere. Of the other two orifices, each has three membranes, all of them sigmoid (i.e. semilunar). Now as Erasistratus says in explaining the phenomenon, of the two orifices one expels blood into the lung, the other, pneuma into the whole living creature. These membranes, as he thinks, perform a reciprocal service to the heart, by alternating at the appropriate times—those which adhere to the vessels which introduce material being carried in an inward direction, and tripped up by the entering material, falling back into the cavities of the heart and, by opening their orifices, giving an unimpeded passage to what the heart draws in. For, he says, material does not rush in of its own impetus, as it might into some lifeless cistern, but it is the heart itself which by dilating, like the blacksmith's bellows, draws in material and fills itself in diastole. But those membranes which, we said, lie on the vessels which expel material, are considered by Erasistratus to behave in the opposite way. For they incline from within in an outwards direction, being tripped by the material passing out, and so opening the orifices at the time when the heart distributes its material. But at every other time the orifices are tightly closed, forbidding any material which has been emitted to return. In the same way (he says that) the membranes upon the vessels which introduce material, close the orifices when the heart contracts, not allowing what the heart has attracted to escape back again. (*De Placitis* 6.6, V, 548–550K).

Erasistratus had been a pupil of the peripatetic philosopher Strato of Lampsacus, a hard-headed mechanist who stripped the Aristotelian nature of her divine attributes and left her as a mechanical force operating 'by weights and movements'.³⁶ In her reduced state, she looks something like the ANANKĒ or mechanical necessity of the atomists, but unlike ANANKĒ, Stratonian nature has a purpose, and Strato was a teleologist. But the similarity to Democritus serves to remind us of a mechanical strain in earlier Greek medicine, in particular as it appears in the author of the treatises 'On Generation', 'On the Nature of the Child' and 'On Diseases 4'.³⁷ This author loves to construct models, such as the model in ch. 39 of three vessels connected at their bases with pipes so that, as fluid is poured into one vessel, the level in the others rises. This particular model represents the relation between the four main organs or reservoirs in the body which intercommunicate the humours. It is not a mere decorative tour de force, for it is evident that the author finds a real help, both in his embryology and his physiology, in such a mechanical way of visualizing processes. It is a demonstration model, to make the process clearer to the reader, but it also has a certain

³⁵ As Abel (op. cit., p. 82) points out, this remark of Galen's, if true, shows that the valves were not generally known, if known at all, before Erasistratus—otherwise the slander has no point.

³⁶ Cicero, *Academica* II, 38, 121 = Fr. 32 Wehrli.

³⁷ Littré, Vol. VII, pp. 470ff. and, recently edited with French translation by R. Joly, in the Budé series. A text, translation, and commentary is being prepared by G. Baader and I. M. Lonie for the series 'Ars Medica'. On the content of the treatises see especially O. Regenbogen, *Quell. Stud. Ges. Math.*, 1929/30, 1, 131–82 and G. E. R. Lloyd, *Polarity and Analogy* passim.

heuristic value for the author himself. The same is true of the model he uses to illustrate the process of articulation in the embryo: 'Suppose you were to tie a bladder on to the end of a pipe, and insert through the pipe earth, sand, and fine filings of lead. Now pour in water, and blow through the pipe. First of all the ingredients will be thoroughly mixed up with the water, but after you have blown for a time, the lead will move towards the lead, the sand towards the sand, and the earth towards the earth. Now allow the ingredients to dry out and examine them by cutting around the bladder: you will find that like ingredients have gone to join like. Now the seed or rather the flesh is separated into members by precisely the same process, with like going to join like'.³⁸

But there is one feature which these two models, and the others used by the author, have in common, a feature worth considering for it gives us an insight into the development of ancient science. The apparatuses whose construction the author describes are not *useful* pieces of apparatus. They are gratuitous, ad hoc, serving no purpose independent of the author's own. The author thinks in terms of mechanistic processes but he does not, if the distinction is allowed, think in terms of machines—of apparatus simple or intricate, with each part in a logical relation to every other part, and all arranged in a logical hierarchy of which the particular purpose of the machine is at the summit. There is evidently mechanism and mechanism in Greek science—of mechanical process on the one hand and functional machine on the other.

Erasistratus' conception of the heart is of the latter kind: it is that of a functional machine, in which part and function cannot be separated from each other and considered in isolation.³⁹ The four valves, the two kinds of material (blood and pneuma) are so to speak enfolded and included in the action of the heart: it is a unitary conception.

Erasistratus himself, to judge from the passage in Galen, compared the action of the heart to that of the blacksmith's bellows, which was no doubt the most familiar form of pumping device in the ancient world.⁴⁰ But the heart as Erasistratus conceived it is in fact a two-stroke (i.e. combined suction- and force-) pump with double action (since it is designed to move two different fluids, blood and pneuma, simultaneously).

A pump, with two alternating sets of valves, is described by Philo of Byzantium (third or second century B.C.).⁴¹ It is a simple fire-engine pump, or the kind that used to be employed for pumping ships. In order to keep up a constant jet of water the pump has two cylinders whose intake and output alternate.

The similarity between this pump and Erasistratus' heart is that each has two sets of valves. Otherwise the differences are considerable: the heart is not a piston pump,

³⁸ *De Natura Pueri* ch. 17 (VII, p. 498 Littré). For the explanation of this model, in its relation to what it is meant to illustrate, and in its Democritean affiliations, see C. Müller, *Gleiches zum Gleichen*, Wiesbaden 1965, 115–22.

³⁹ Cf. the remarks of L. G. Wilson, op. cit. (n. 31), p. 297.

⁴⁰ The same comparison is applied to the auricles in 'On the Heart', ch. 8. It seems to be a quite common comparison: we find it in Aristotle, *De Respiratione*, 480A20, and several times in Galen (e.g. VIII, 703K; III, 483K). It may have been used by the Pneumatic School: Kudlien, op. cit., p. 427, notes its occurrence in Gregory of Nyssa, *De Opificio Hominis*, Migne, *Patres Graeci* XLIV, col. 245, where it is applied to the heart—a passage perhaps influenced by Posidonius.

⁴¹ The description is most easily accessible in Hero of Alexandria, *Pneumatics* I, 28, translated in W. R. Cohen and J. E. Drabkin, *A Source Book in Greek Science*, 1948, pp. 329–31, with two illustrations. Cf. also Singer, Holmyard etc., *A History of Technology*, II, p. 634, and for a discussion see A. G. Drachmann, *The Mechanical Technology of Greek and Roman Antiquity*, 1963, pp. 155–57.

and collapsible bellows are a better analogy to its action of diastole and systole. Moreover the pump described in Hero alternates—this indeed is its TELOS—in order to keep up a constant jet of water, whereas the heart of course sends out its material in pulses. Thirdly, the pump moves one material only, water, whereas the heart moves two, blood and pneuma. The differences are perhaps greater than the similarities. Yet both are the index of a particular way of thinking—of seeing things in terms of a definite series of events, designed to achieve a particular end. The pump in Hero, and Erasistratus' four-valved heart, recognizably come from the same world—and from the same period.⁴² The heart in Erasistratus is conceived as a machine: it is mechanistic, in the second of the two senses suggested above.

From this point of view, it hardly matters whether Erasistratus discovered the semilunar valves as well as the atrio-ventricular valves (which as valves he certainly did discover), or whether they were known before him. If they were known before him, he 'rediscovered' them, in the sense that he brought them into his unitary conception of the action of the heart, and showed that they, along with the atrio-ventriculars, have an essential and equal role in that action. Their function cannot be considered in isolation. It is thus after all the idea of *action* that is predominant in Erasistratus' picture of the heart, while anatomical structure is subordinate to this idea. But the idea of action is simply Aristotle's ENERGEIA—and it is moving to see how, in Erasistratus, conception of the heart, those two strains of mechanism and teleology which Plato in the Laws (X, 889Aff.) so sharply and inimically opposed, are united at last in marriage, under the fairest auspices.

It was this anatomico-physiological conception that was the real nature of Erasistratus' discovery—the question I posed at the beginning of this section. Some or all of its elements, anatomical and physiological, may have existed before him, although probably not, as we have seen, the recognition of the atrio-ventricular valves as valves.⁴³ But once this discovery, in this sense, had been made, was it reversible? It could certainly be rejected outright—and as we have seen, some of Erasistratus' contemporaries did so,⁴⁴ as did Asclepiades later on.⁴⁵ But could it be retained in part, and rejected in part? It seems unlikely: not only would such a partial acceptance make nonsense of Erasistratus' unitary conception, but it would involve the loss of a splendid opportunity for teleological moralizing—such as that in which the author of 'On the Heart' indulges. We must nevertheless entertain the possibility—for it is a curious fact that neither the Stoics nor the Stoic-influenced Pneumatic school nor the Church Fathers who echo the Stoic theme *de fabrica hominis* ever specifically mention the

⁴² Erasistratus might well have seen this pump, since it was originally invented by the practical genius Ctesibius, who probably lived in Alexandria in the reign of Ptolemy II (283–247) and was therefore a contemporary and fellow-citizen of Erasistratus. For the relations between Hero, Philo, and Ctesibius see now H. B. Gottschalk, *Strato of Lampsacus: Some Texts* (Proc. Leeds Philosophical and Literary Society, Literary and Historical Section, Vol. XI, 1965, pp. 95–82), pp. 133ff.; and A. G. Drachmann, *Ktesibios, Philon and Heron*, Acta Historica scientiarum naturalium et medicinarum, Vol. 4, Copenhagen, 1948.

For a similar problem in connexion with William Harvey, see Walter Pagel, *op. cit.*, pp. 212–13 and n. 14, especially with reference to C. Webster in *Bull. Hist. Med.*, 1965, 39, pp. 508–17.

⁴³ It is significant in this respect that they were first named, not by Erasistratus himself but by his successors.

⁴⁴ Cf. Galen V, 548K., quoted above.

⁴⁵ Galen I, 109K.

valves. Yet they were not averse from such detail: the function of the epiglottis features prominently in Cicero's rhetorical treatment of the theme.⁴⁶ Yet it is also probable that the Stoics and Pneumatics 'knew' of, or rather accepted, the valves and their function. For Galen, who says that most physicians of his time took them for granted, would certainly have mentioned the Pneumatic school, if they had been an exception; and acceptance by the Stoics can I think be inferred from Cicero, *De Natura Deorum* 2.138 with Gregory of Nyssa, *De Opificio Hominis* ch. 30, *Patres Graeci* XLIV, col. 240ff. Migne.⁴⁷ Cicero says: 'nam quae spiritu in pulmones anima ducitur, ea calescit primum ipso ab spiritu, deinde contagione pulmonum, ex eaque pars redditur respirando, pars concipitur cordis parte quadam, quem ventriculum cordis appellant, cui similis alter adiunctus est, in quem sanguis a iecore per venam illam cavam influit; eoque modo ex his partibus et sanguis per venas in omne corpus diffunditur et spiritus per artus.' And Gregory of Nyssa: 'The heart is contained in the middle of the lung, and in perpetual motion, in which it imitates the action of fire, which moves eternally, it attracts, like bellows in foundries, material from the lung placed alongside it, filling its own cavities as it dilates, and fanning what is fiery in itself, it breathes it out into the adjoining arteries. And it never ceases from doing this: in dilation, attracting from outside into its cavities, and in compression, distributing material from itself into the arteries' (op. cit. col. 245C).

What is significant in both passages if they are combined is the movement of diastole and systole (implied in Cicero, and mentioned explicitly in Gregory), by which blood on the one hand, and pneuma on the other, is alternately attracted into the heart and distributed from the heart to the body. This could hardly be visualized without the assumption of valves—which are in any case implicit in the comparison of the heart's action to that of bellows.

The lack of any specific mention of the valves in later sources is odd, but we cannot assume that they were discarded, either wholly or in part, except by Asclepiades and the Methodists. Indeed the evidence, such as it is, points rather in the opposite direction. We may assume that Erasistratus' 'discovery', in the sense defined above, remained unreversed.

The conception of 'On the Heart', where there are only two valves, and no 'action' of diastole and systole, is quite different from that of Erasistratus. But it must be admitted that the details of its physiology are quite indistinct and uncertain. Although there is no account such as Erasistratus gave of diastole and systole, the author does speak of the heart as 'leaping' (chapters 1 and 8), and gives a striking observation of the difference in movement between the 'ears' and the heart as a whole: 'you can see the heart jumping as a whole, while the ears inflate and collapse with a movement of their own' (ch. 8). Significant too is the description of the heart as 'a very strong muscle' (ch. 4). What the function of its musculature is we are not told. Evidently it has nothing to do with the passage of air between the heart and the lungs, in which the author is primarily interested, for it is the 'ears' which 'handle' (KHEIROUTAI) the

⁴⁶ *De Natura Deorum* 2.163: probably from Posidonius, who was interested in the epiglottis from this point of view: cf. Scholiast on Homer, II.22.325 and Reinhardt, RE XXII, 1, 708ff.

⁴⁷ It is Kudlien, op. cit., p. 426, who makes the suggestion that Gregory may be used to clarify points left obscure by Cicero, on the hypothesis that both are directly or indirectly making use of Posidonius. I think this hypothesis is well grounded.

breathing from the lung into the heart (ch. 8). But the question of the heart's musculature and its function involves a cluster of problems.

According to the interpretation of the anatomy in ch. 7 given previously, the 'ears' whose partial removal exposes the four orifices must include the atria as well as the auricles proper. Hence the author can describe them as 'cavernous' (SĒRANGŌDEA) and can compare them to the blacksmith's bellows. The right atrium is also regarded as the terminal section of the vena cava, and presumably, by an obvious analogy, the left atrium of the pulmonary veins.

This was the view shared by Galen with Erasistratus, whose view of the relation between the auricles and the heart was contrary to that of Herophilus: 'If anyone, like Herophilus, regards [the auricles] as part of the heart, he has increased the number of the orifices, and in this he will appear to be at variance with Erasistratus and myself, who have said that there are four orifices in all' (Galen II 624K; cf. Wellmann *RE* s.v. Erasistratus 340, 68). The number of orifices would be increased because the vena cava would then be regarded as having two orifices, with four for the pulmonary veins, which Galen regards as one.⁴⁸ This supposition is part of the standard, 'classical', picture of the heart with its two chambers and four orifices (there is, says Galen *de Placitis* 6.6 (V, 551K) no 'fifth opening'), which can thus be brought back to Erasistratus—and is found in 'On the Heart'.

In the *De Usu Partium* 6.15 (III, 481 K) Galen has something to say of the function of the atria regarded as part of the vessels: 'It seems to me that when the heart exerts its full powers of attraction, it would actually tear a vessel to pieces if our Creator had not in this instance too contrived a protection against such an accident by placing outside each opening that admits material another separate cavity like a storehouse for nutriment, so that the vessel may not be in danger of rupturing when at times the heart attracts suddenly and violently and the vessel alone, because it is so narrow, cannot furnish abundantly all that the heart demands . . . Thus the auricles of the heart were not formed in vain, though no good sense was used in naming them . . .' (trans. May, pp. 316–17).

We have of course no reason to suppose that this was also Erasistratus' explanation, although it would be quite in accordance with his views. But it does help to bring into focus a problem both in the text of 'On the Heart' ch. 8, and in the physiology of the treatise. The received text reads '(the craftsman) seeing that the organ would be a solid thing, owing to the density [?] of its material [text uncertain], and in consequence entirely attractive, equipped it with bellows, as blacksmiths do their furnaces, by means of which to control [or 'manage'] its respiration'. Unger changed the reading, by supplying a negative, to 'and in consequence not at all attractive'. His reason for doing so is in the following chapter, where it is what is 'soft' or 'yielding' (MALAKON), not what is hard or solid, that has the greater attractive power—this is the reason, says the author, why the left heart breathes through veins, instead of through an artery like the right heart. Unger's change has much to recommend it. Without it, there is a contradiction between the two chapters, and the transitional phrase at the

⁴⁸ Cf. *De Usu Partium* 6.7 (III, 436K) and May, p. 292, n. 28; *de Placitis* 6.6 (V, 548), where Erasistratus is represented as speaking of the (one) orifice of the (one) vena cava; *De Usu Partium* 6.20 (III, 507K), where Galen speaks of the *foramen ovale* in the embryonic heart as 'opening the [pulmonary artery] into the great artery and the [pulmonary vein] into the vena cava'.

beginning of ch. 9, 'for this reason' (DIA TOUTO), loses its significance. Yet Galen's 'powerfully attractive heart', to whose force the atria serve as moderators, does tempt us to leave the text as it stands, with a query against it. The purpose of the auricles in 'On the Heart' would then be to control the draught rather than to create it; and to describe the heart as 'entirely attractive' would give some purpose to its powerful musculature, which at present it lacks. What does the heart do with its muscles? It provides blood for the lung, we are told, and this is presumably by pumping—but does it attract blood, or at least potentially sanguineous material, from the vena cava? And does it, from the left ventricle, send out that luminous substance to the rest of the body? Presumably it does, since it is equipped with a unidirectional valve on the aorta. We begin to suspect that the author has left half the story untold—which is not the same as saying that he has told all he knows. It is the same situation as we have found several times before: clear and surprisingly sophisticated detail on the one hand, suggesting a well-developed background of anatomy and physiology, and an elusive vagueness on the other—like, perhaps, a badly remembered lesson.

In points of detail there is both agreement and disagreement with Erasistratus. Unlike Erasistratus, he regards the arteries as containing blood, and he situates the intellect in the heart, whereas Erasistratus located it in the membranes of the brain. On the other hand, the reason he gives that the left heart is fed from the lung through veins, because of their greater attractive power, implies the principle 'horror vacui' (PROS TO KENOUMENON AKOLOUTHIA) of which Erasistratus made such systematic use.⁴⁹

The point on which the author of 'On the Heart' most obviously deviates from Erasistratus is his insistence that ingested fluid, or a portion thereof, passes into the lung, a belief which he demonstrates by slaughtering a thirsty pig who has been given dyed water to drink (ch. 2). The view that the trachea is the normal passage, and the lung the normal receptacle, for *all* fluids, was held by Philistion and subsequently to, and perhaps in dependence upon, Philistion, by Plato.⁵⁰ The function of the fluid which reaches the lung in this way is to cool the heat of the heart.

The view that is represented in 'On the Heart' differs significantly from the view stated by Plato. While in Plato *all* the fluid swallowed passes down the trachea into the lungs—the passage in *Timaeus*, 91A leaves no doubt about this—in 'On the Heart' it is only a portion, and that a very small one, which passes down the trachea. The reason given is the 'precise fit' of the epiglottis. Moreover, although the author retains the cooling function of this liquid, it does not cool by remaining in the lungs but by being filtered out and gathering round the heart itself, inside the pericardium, as the pericardial fluid. We cannot then equate *tout court*, as has sometimes been done, the view of 'On the Heart' and of Plato, and regard both as the view of the Sicilian school of medicine.

⁴⁹ There is even perhaps a coincidence in vocabulary: the word DEXAMENE, properly meaning a tank or cistern, is used by the author of 'On the Heart' to refer to the right ventricle. It was evidently used in reference to the heart by Erasistratus, in the passage quoted above from Galen, *De Placitis*: "the heart" says Erasistratus "is no lifeless receptacle (DEXAMENE)". Galen himself may be echoing Erasistratus in another passage, *De Usu Part.* 6. 11 (III, 461K), where he describes the right chamber of the heart as a DEXAMENE. This is a frail point of course; but the word is not particularly common. It was used however by Democritus—of the blood vessels (B135).

⁵⁰ For Philistion, see Plutarch, *Quaest. Conviv.* 7. 1, 699A; for Plato, see *Timaeus* 70C; 91A; and in general F. Kudlien, *Der Beginn des medizinischen Denkens bei den Griechen*, 1967, p. 88ff.

The Paradoxical Text 'On the Heart'

The view as it appears in Plato was disputed both before and after Plato's time. It was disputed before Plato⁵¹ in *Diseases* 4 ch. 56, where the author proudly enumerates seven arguments from observation (HISTORIA) against the view (and then adds another one for luck); and after Plato by Aristotle ('On the Parts of Animals' 3.3, 664B3ff.) and by Erasistratus (whose arguments are recorded in Plutarch op. cit.). Some of the arguments used in *Diseases* 4 reappear in a recognizable form, both in Aristotle and in Erasistratus. One of these arguments is the function of the epiglottis, which has evidently not yet acquired its name in *Diseases* 4 (nor, in fact, anywhere in the Hippocratic Collection apart from 'On the Heart'), where it is described as '(a covering) like a leaf of ivy', but which is named in Aristotle. Aristotle gives an accurate description of the epiglottis and its function, and as one might expect, it is for him a valuable illustration of the purposiveness of nature (as it was to become for the Stoics: see above).

Now the recognition of the existence and function of the epiglottis was not decisive against Plato's view, or at least a modified version of that view, for it was defended by Dexippus 'the Hippocratic' as Plutarch op. cit. calls him,⁵² who recognized the epiglottis, but reformulated the theory and stated that only a small portion of liquid enters the lung. Dexippus' words as reported by Plutarch have a curious resemblance to those of 'On the Heart'. The function of the epiglottis is 'to filter through the drink gently and in small quantities so that it does not force back and disturb the breath by rushing in in a mass' (Cf. 'On the Heart', ch. 2: 'Since the liquid flows through the crevice in small quantities it does not obstruct the ascent of the air'). It also performs, as in 'On the Heart', the service of moistening the trachea.

It is this reformulated view, depending upon the recognition of the epiglottis, which we have in 'On the Heart', and to it, the author has added the demonstration with the pig, not mentioned in Plutarch. To claim that it is post-Platonic is not to stretch the evidence beyond toleration, for surely Plato (or his source) would not have disregarded the opportunities, exploited by Aristotle and the Stoics, for making a teleological point of the epiglottis. Indeed, according to Plutarch, Erasistratus criticized him sharply for this omission, one altogether inappropriate in a philosopher who 'sought after the final cause of each part of the body'. The formulation given by Dexippus—and used in 'On the Heart'—shows how this might be done without sacrificing the essence of the view that liquids pass into the lung.

Once again, the evidence points to a degree of relatively late development in 'On the Heart'—and once again, it serves to detach the author from any historically identifiable personality or doctrine. For Erasistratus, who knew about the epiglottis, did not himself adopt the modified view of Dexippus—he is rather opposed by Plutarch to Dexippus.

By adopting this modified, and therefore later, view, the author of 'On the Heart' gets, so to speak, two 'final causes' for the price of one. This brings us to the question of—

Teleology.

The most striking single feature of 'On the Heart' is its teleology. Not only are

⁵¹ I ask indulgence for the assumption that '*Diseases* 4' is pre-Platonic or at least pre-*Timaeus*, although I think this will be readily granted.

⁵² The name in Plutarch is Dioxippus: for the identification with Dexippus see Wellmann in *RE* V, 294.

particular details in the anatomy of the heart provided with a functional⁵³ explanation, but the whole structure of the work is designed to lead up to the explanation of the working of the semilunar valves which, as we shall see, the author regards as 'a masterpiece of Nature's craftsmanship'. The treatise, in structure, is a pietistic sermon on such craftsmanship as it is revealed in the workings of the heart. But perhaps more significant than this is the degree to which the author has absorbed a functional approach to anatomy and physiology—the extent to which he takes such functional (and, in the context of Greek science, teleological) explanations for granted. Thus in his discussion of the pulmonary artery and the pulmonary veins he assumes that an observed anatomical difference requires an explanation in terms of function—an assumption which in earlier Greek science is exceedingly rare. Teleological moralizing may be, and often is, a mere rhetorical flourish; but a functional, and teleological approach of the order which we have here is no mere adventitious decoration which might be learned overnight.

In ch. 1. the pericardial fluid exists 'for this purpose, that the heart might leap in safety (TOUTOU HENEKA, HOKÖS . . .)'. This resembles Plato's *Timaeus*, where the fluid-filled lung is both a cushion for the heart to bounce against, and a cooling system for the heart: a further function which the author goes on to apply to the pericardial fluid. The fluid, he says, resembles urine, 'so that you would think the heart was moving in a bladder', and he goes on to describe the heart—it has an odd sound—as 'lapping up' the fluid from the lung and 'urinating it out'.⁵⁴ Thus the Platonic functions are retained, but the anatomy is different. We remember that Aristotle criticized Plato for describing the lung as a cushion (PA 3.6, 669A14ff.: he does not care to mention that Plato also said that it was for cooling the heart). Perhaps the author remembered it too and ascribed this function to the pericardial fluid instead.

The notion of the protection of organs is a common trait in passages of Greek science which have a teleological approach: vide the *Timaeus*.⁵⁵ It occurs again in

⁵³ The explanation of the structure of an organ by reference to its function is not of course the same as a teleological explanation, which is anthropomorphic, explaining such structure by reference to the 'purpose' of some divinity or conscious power. Indeed, a functional explanation is logically quite compatible with a mechanistic approach to nature, and may even be an inevitable consequence of such an approach (cf. what was said above about the two senses of mechanism in Greek science). Nevertheless, it is an accident of the way in which Greek science developed, from Plato through Aristotle and the Stoics to Galen, that such functional approaches are always implicitly, and often explicitly, teleological. In Plato's *Timaeus* for example, while a particular explanation might, considered in isolation, be regarded as simply functional, the whole approach of the dialogue, in which everything in the visible world is a result of the craftsmanship of the DEMIOURGOS or of his ministers, can leave us in no doubt that particular explanations as well as being functional imply an anthropomorphically conceived 'purpose'. What is true of the *Timaeus* is also true of the whole Galenic corpus. It is true of 'On the Heart' as well: the reference to the 'expert craftsman' in chapter 8 implies a similarly teleological approach in passages of functional explanation where such a power is not explicitly mentioned. It was of course theoretically possible, in any Greek writer, for a functional approach to divest itself of the teleological swaddling which was the legacy of Plato. But I am not aware of any case, apart from the rather doubtful one of Strato of Lampsacus, in which this was in fact done. For practical purposes, in the history of Greek science functional explanations are synonymous with teleological explanations.

⁵⁴ See Unger's text and discussion: he retains the DIOUREEI of the manuscripts, which Littré after Schneider changed to DIORROI. The metaphors are rugged—a reason for retaining them. There is, perhaps, an implicit comparison to the embryo cushioned in the amniotic fluid, which was sometimes identified with urine. The strange accumulation of participles with LAPTOUSA are explained by Kudlien op. cit. p. 425 n.1. as glosses, with reference to Hesychius. He is undoubtedly right.

⁵⁵ SOTERIA and BOËTHEIA, 'salvation' and 'succour' are key words here: cf. W. Theiler, *Teleologische Naturbetrachtung*, p. 75. The author uses TIMORIE in ch. 3.

chapter 6, where the thick or massive construction of the left heart is 'for the purpose of protection against the strength of the hot'. The same observation, and a similar explanation, is applied by Aristotle to the middle of his three chambers, which is presumably the left ventricle.⁵⁶ The care taken by nature that parts should receive neither more nor less cold and heat than is good for them is implicit in what the author says about the lung in ch. 6, which 'keeps in check the intemperance of the hot', and about the pulmonary vascular system in the three culminating chapters of the work. The function of the air is generally described as a 'service' or even 'cure' (THERAPEIA) in ch. 3.

A feature of teleological explanations are 'Technikvergleichen', parts of the body being compared, in respect of form and function together, to familiar instruments or utensils. In 'On the Heart' the gullet is like a funnel (KHŌNOS) (ch. 2), the left chamber is like a 'mortar' (ch. 5, HOLMOS)—or should we say, a crucible?⁵⁷ And the auricles, 'the instruments (ORGANA) with which nature captures the air', are compared to the bellows on blacksmiths' furnaces. Similarly in ch. 10 the *musculi papillares* (evidently) are called TONOI: the word is fairly general, but seems here to mean 'guy-ropes' or 'stays'.⁵⁸

Thus the short treatise is saturated in teleology: almost every chapter shows some sign of this feature. But the culmination is in chapters 10, 11 and 12—'the unseen'⁵⁹ membranes of the heart, a work of craftsmanship (ERGON) altogether worthy of description (AXIAPĒGĒTOTATON). That 'worthy of description' may make us pause for a moment. We might sense the tones of the rhetorician, elegantly embroidering upon a TOPOS or set theme. We might suspect the genuineness of his interest: is the anatomy of the heart an end in itself, or merely an occasion for rhetorical display? But the detail is against it: the thorough and personal knowledge of the anatomy of the heart. Rhetoricians do not usually care to be so specific—or to dirty their hands. Indeed, it was a reflection on dirtying one's hands in the zoology laboratory that inspired Aristotle to one of his noblest passages (*On the Parts of Animals* 1.5). Thus the rhetorical touch will be of no use to us in locating the work. But we note in AXIAPĒGĒTOTATON a strand which connects the author on the one hand with Aristotle, and on the other with the more Posidonian passages of Cicero and later writers, down to the Church Fathers.

It would be a hazardous proceeding to attempt to date a work by the presence of teleology in it, and still more hazardous to posit several quite distinct varieties of

⁵⁶ But in Aristotle (*PA* 3.4, 665B) the purpose is 'to guard the source of heat'. Possibly the corresponding passage in 'On the Heart' should be translated similarly. Yet 'strength' (ISKHUS) seems to suggest a potentially deleterious force, particularly since the author has just described the corrosive effect of heat on the chambers.

⁵⁷ Littré takes this to refer to the whole heart. But the author is still speaking of the left chamber and does not return to the heart as a whole until the next chapter, which begins with the words 'both (sc. chambers) are rough inside . . .' (So too Diller interprets the passage op. cit., p. 208). Besides, the author is describing the inside rather than the outside shape—the heart 'is hollowed out inside like a mortar in shape'—and a mortar does not have two compartments.

⁵⁸ Used of the torsion straps of siege engines in Philo's *Belopoeica*. Is this an example of a 'mechanistic' approach? Cf. what was said above about Erasistratus' conception of the heart as a machine.

⁵⁹ 'Unseen' is probably not a neutral word: it has overtones of cosmos worship, and strikes a note similar to that of 'secreta naturae' in such writers as Manilius, Pliny the Elder, the author of the 'Aetna', and Seneca.

teleology, and allot them to different schools or persons. A teleological account *de fabrica corporis humani* seems to go back as far as Diogenes of Apollonia [see Theiler, op. cit., p. 6ff.]. Then there is the famous tour de force in the *Timaeus*. Plato may owe it to Philistion or in general the 'Sicilian school', but it seems more likely that his procedure was to adapt medical doctrines and to give them his own expression [see G. E. R. Lloyd, *Plato as a Natural Scientist*, JHS 88 (1968) 78–92]. The teleology may quite easily be his own, and apart from the doubtful case of Diocles, we do not know of any member of the 'Sicilian school'—i.e. Philistion—who indulged in such explanations. Nevertheless, a teleological passage at any time in the fourth century would not surprise us. But the detailed and systematic character of the teleology in 'On the Heart' suggests a later rather than an earlier date—quite apart from other considerations.

The author speaks of the auricles as being the work of an 'expert craftsman' (KHEIRONAKTOS AGATHOU) who observes (KATASKEPSAMENOS) and contrives accordingly. This is obviously reminiscent of Plato's craftsman god of the *Timaeus*, the DĒMIOURGOS. Theiler illuminatingly points out a significant difference—the result of a metaphysical development in Plato and in Aristotle—between the two philosophers in this respect. Plato's DĒMIOURGOS becomes, for Aristotle, PHUSIS, nature, who as efficient cause (ARCHĒ KINĒSEŌS) and formal cause (EIDOS) combined, is in the living thing itself [Theiler, op. cit., p. 90ff.]. We find this Aristotelian conception in ch. 8, already referred to: the auricles are 'the instruments with which nature captures the air'—followed immediately by 'the work of an expert craftsman', just as on occasion Aristotle says 'nature contrives' (PHUSIS DĒMIOURGEI *PA* 654B29; cf. Theiler, p. 89). Plato himself, on the other hand, had reservations about the word PHUSIS, and these reservations are expressed in his last work, *The Laws*.⁶⁰

The movement seems to have been towards a more immanent conception of nature, from Aristotle to the Stoics. From this point of view, 'On the Heart' may be anywhere along that line. We should perhaps put the philosopher Strato of Lampsacus in a class of his own, since his conception of nature was remarkable for its absence of any anthropomorphic feature: it is characterized in that way by the Epicurean Velleius in Cicero's dialogue *De Natura Deorum* (1.35 'Strato . . . qui omnem vim divinam in natura sitam esse censet, quae causas gignendi augendi minuendi habeat, sed careat omni et sensu et figura'. = Fr. 33 Wehrli) and made use of by the Academic Cotta in the third book of that dialogue, who no doubt gives us a more accurate impression: 'Naturae ista sunt (sc. the phenomena of cosmic sympathy and harmony) . . . naturae non artificiose ambulantis, ut ait Zeno, . . . sed omnia cientis et agitantis motibus et mutationibus suis' (3.27). These words of Cotta's seem far removed from the craftsman nature, PHUSIS KHEIRŌNAX, of 'On the Heart', which resembles

⁶⁰ Whether such a conception is present in Diocles or not, we cannot be sure. He certainly gave a teleological explanation of the cotyledons in the uterus (Fr. 27), and Soranus, who reports him speaks of 'nature' as acting 'providentially (PRONOËTIKŌS)' in this. And there is also a 'Technikvergleich' in Fr. 26. The sperm adheres to the womb because of the roughness of the latter, just as those who glue together wood or stone rasp the surfaces first. On this see Diller, RE XIX, 2, col. 2408. Certainly Diocles was a teleologist—that is clear; there is no reason why he should not have been one of the Aristotelian "variety", if we can so call it; and if he was Aristotle's pupil, it is more than likely. This may be a reason for associating 'On the Heart' with Diocles and his circle.

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rather the Stoic 'natura artificiose ambulans' referred to by Cotta. But Erasistratus, who had been a pupil of Strato, was according to Galen never tired of extolling the 'craftsmanship' and 'providence' of nature—which he too seems to have regarded as an immanent force.⁶¹ So far as the teleology of 'On the Heart' is concerned, it squares with what we are told of the teleology of Erasistratus.

The history of teleological explanation, and in particular the history of the idea of an immanent PHUSIS, are always fascinating subjects. But we should not allow them to take us too far down the centuries. It is a salutary reminder to turn back to the late fifth or early fourth century and read the famous passage in *Epidemics* 6.5, 1 (V, 314 Littré): 'Natures are the physicians of diseases. Nature herself finds out the methods . . . Nature is cultured: of herself, and without taking instruction, she does what is necessary.'⁶² Compare the craftsman of 'On the Heart', who certainly might be said to 'do what is necessary'. The idea is certainly there, ready for the taking, at the end of the fifth century.

THE NOURISHMENT OF THE LEFT HEART

'Its nutriment' says the author of the left chamber, 'is neither the solid food nor the drink which comes from the belly, but a pure and luminous substance which is refined out of the blood. It conveys this nutriment out of the neighbouring blood receptacle by transmitting its rays, deriving it from there as though from the belly and intestines . . .' (ch. 11).

However the rest of the body is fed—the author does not tell us clearly—the left chamber requires a special nutriment. This is as it should be—KATA PHUSIN—for the left chamber is the seat of the hot and of the intellect (GNÔMĒ).⁶³ Hence its greater thickness and, in comparison with the right chamber, its more corroded appearance; hence too its greater need of refrigeration from the lung. What nourishes the left chamber is not blood, but a 'pure and luminous substance' arising from blood. We may call this substance pneuma, that maid of all work in Greek philosophy and science, who appears in so many and such strange disguises.

Pneuma is universally regarded as the product of moisture and heat. For example, the author of 'On the Nature of the Child' expresses this in quite mechanistic terms: any organic substance, he says, which is heated will, provided that it is moist, produce *pneuma*, and he gives as instance leaves, green wood, legumes (ch. 12, VII, p. 486ff. Littré). For Aristotle too pneuma, despite its ultimate mystical significance, is initially a product of mechanical processes (*GA* 2.6, 742A15): given moisture and heat, pneuma follows 'by necessity' (ANANKĒ, a word which indicates the mechanical explanations so characteristic of pre-Socratic philosophy—and deplored by Plato). In Diogenes of Apollonia sperm was 'pneumatic' (Simplicius, in introducing Fr. 6; DK II, p. 62, 12); it was a foam arising from blood. There is nothing surprising about

⁶¹ See my note 33 on p. 441 of *Bull. Hist. Med.*, 1964. I am now convinced that not only the Erasistrateans, but Erasistratus himself, was a teleologist and that, whatever he may have learned from Strato, he 'anthropomorphized' nature.

⁶² For the reading adopted here, see K. Deichgräber, *Die Epidemien und das Corpus Hippocraticum*, p. 52 and n. 3.

⁶³ The GNÔMĒ . . . which rules over the rest of the soul (PSUCHĒS) ch. 10. GNOME = NOUS (intellect) would seem to be an early use. [In Aretaeus the Pneumatic, which is mentioned by Kudlien op. cit. 427, n. 2 (CMG II.2, p. 22, 26ff. H.), the word seems rather to mean, as is usual at all periods, 'powers of judgement'.] But of course there may be conscious archaism in 'On the Heart'.

the notion of pneuma arising from moisture and heat. The pneuma produced in this way may be 'vital' or 'animal' pneuma (PNEUMA ZÖTIKON), or 'soul pneuma' (PNEUMA PSUCHIKON). This may have been so for Diogenes; probably it was so for Aristotle. At least in one celebrated passage⁶⁴ he speaks of the 'pneumatization' (PNEUMATÖSIS) of blood: the blood so to speak boils up and volatilizes in the heart. In any case it seems a logical deduction from what Aristotle says elsewhere about pneuma and blood, and about the function of pneuma in the living, moving organism (though we should remember also that even the slightest evidence of such a doctrine was bound to be gratifying to later interpreters). 'Pneumatization' seems to have taken place in the middle chamber of Aristotle's three-chambered heart (*de somno et vigilia* 3.458A10ff.); however there is no chamber which contains just *pneuma*, since all three contain blood (*De Partibus Animalium* 667A1ff.). Above all, Diocles of Carystus is interesting in this matter. Diocles, it is well known, located PNEUMA PSYCHIKON in the heart, as opposed to those (Herophilus, Erasistratus, Strato and others) who located it in the brain, or some part of the brain.⁶⁵ From the heart, PNEUMA PSYCHIKON is sent throughout the body, where it gives rise to voluntary movement [Fuchs 20.550]. Diocles may even have located this pneuma more precisely in the left ventricle of the heart, although the possibility depends on an emendation by Diels [Dox. Graec. p. 304, n. 1] since in the manuscripts it is ascribed to Diogenes, not Diocles.

It is likely enough; in any case Diocles referred to 'the psychic pneuma . . . and the blood which is its next door neighbour' [Fuchs 541: TOU TAUTEI SUNOIKOU HAIMATOS]. This is so like 'the nearest blood receptacle' in 'On the Heart', that it would show a mean and grudging spirit in the matter of evidence to refuse to Diocles the belief that the right heart is for blood, and the left for pneuma. Let us show a similar generosity—it will not in the end impoverish us greatly—in the question how the pneuma originates or whence it is nourished. Wellmann, it is well known, included 'On the Heart' in his capacious net and drew it into the ambit of the Sicilian school of medicine, and those influenced by that school. In discussing the question of how Diocles conceived psychic pneuma to be nourished, he used 'On the Heart' itself as one of his pieces of evidence. We cannot of course do that, and once 'On the Heart' is removed, then the only evidence is a passage from Vindicianus 37 (who *may* represent Diocles here) that *bile* is produced from the blood 'per spirationem tenuem quam graece ἀνασπύλασιν vocamus';⁶⁶ and a passage in the *Timaeus* 86E, in which psychic disturbances are caused by an ATMIS or exhalation from bile and phlegm, which mingles with 'the motion of the soul (TÊI TÊS PSUCHÊS PHORAI)'. Thus the connexion is remote and, so far as the fourth century is concerned, (if 'On the Heart' does indeed belong there), 'On the Heart' is the only work where it is stated that psychic pneuma, in the left ventricle, is nourished by an exhalation of blood from the right.⁶⁷ Yet after all, as we have seen, there is nothing odd either in the fifth century or

⁶⁴ *De Respiratione* 479B17 ff.

⁶⁵ R. Fuchs, 'Anecdota Medica Graeca', *Rheinisches Museum*, 1894, 49, p. 540, 541, 543; Tertullian *De Anima* 15; cf. Fragment 14 Wellmann.

⁶⁶ Notice incidentally the presence of bile in the left chamber in *De Corde* ch. 11.

⁶⁷ According to Alexander Polyhistor quoted by Diogenes Laertius VIII, 30 (= Diels-Kranz I, p. 450, 20) the Pythagoreans believed that the soul is nourished from blood. But Alexander wrote in the first century B.C., and cannot be regarded as a reliable witness for early Pythagorean thought. See A. J. Festugière, *Rev. Études grec.*, 1945, 58, 1 ff. Festugière thinks (p. 49ff.) that Alexander owes his doctrines on pneuma to Diocles.

the fourth about the idea that pneuma is exhaled from blood; it is also quite possible that Diocles regarded the relation between the left and right chambers as being that which is expressed in 'On the Heart'; and we may reasonably ask rhetorically whence is psychic pneuma in Diocles (or Philistion for that matter) nourished, if not from the blood?

So far the evidence: an unsatisfactory witness, but deserving of the benefit of the doubt. We may leave Diocles for the moment, and turn to another direction: once again it is a matter of style. The left chamber, says the author, derives or rather 'pastures upon' (NEMESTHAI) the blood by 'transmitting its rays or beams' (AKTĪNAS). AKTIS means a ray or beam from any bright object, fire, or lightning or the eye, but it is above all associated with the radiance of the sun. 'O gloriously radiant sun' (AKTIS ĀELIOU) are the words with which the chorus of Thebans in the 'Antigone' greet the dawn after a night of doubt and destruction. It is a potentially reverberant word. The heat in the left chamber of the heart is like the heat and radiance of the sun; the dispenser of life to the microcosm, as the sun is to the macrocosm, but, like the sun, itself requiring nourishment. That the sun, indeed all the heavenly bodies, feeds upon 'exhalations' (ANATHUMIASIS) is an idea which is at least as old as Heraclitus. Heraclitus may have said, and probably did say that the soul is fed in the same way, although we must be wary of the fragment and testimonium (DK 22A15 and B12) which suggest this, since the fragment itself says nothing of the soul, but is quoted with that interpretation by the Stoic Cleanthes.⁶⁸ The adaptation by the Stoics of Heraclitus to their own doctrines is a familiar phenomenon.

But of the Stoics themselves we can be certain. Although we may suspect that for Diocles psychic pneuma was nourished by an exhalation from blood, we know beyond doubt that among the Stoics this was settled dogma. For Chrysippus, psychic pneuma or, more simply, the soul 'is connate pneuma (PNEUMA SUMPHUTON) extending through the whole body' (Galen, *de Placitis* 3.1, V, 287K = *Stoicorum Veterum Fragmenta* II, 885). This pneuma is nourished from blood: 'Cleanthes and Chrysippus and Zeno [said] that the soul is nourished from blood, while in its substance it is pneuma' (Galen, *de Placitis* 2.8, V, 283 K = SVF III, 30;⁶⁹ cf. *de Usu Partium* 6.17, III 496K = SVF II, 781, and *de Usu Resp.* IV, 502K = SVF II, 783, where Galen ascribes the view to 'many considerable physicians and philosophers'). The manner of this nourishment is described as 'exhalation' (ANATHUMIASIS): e.g. 'He [sc. Diogenes of Babylon] says that what moves the body in voluntary movements is a psychic exhalation (PSUCHIKĒ ANATHUMIASIS), and all exhalation is derived from nutriment' (Galen, *De Placitis* 2.8 = SVF III, 30); for soul as an ANATHUMIASIS see in general von Armin's index s.v. ψυχῆ. These are clear and unambiguous statements. Where and how the exhalation occurs we are not directly told; it must be, however, from the right ventricle to the left, since for the Stoics blood is created in the liver and sent up the vena cava to the right ventricle.

Now the analogy between the nourishment of the sun from exhalations arising from the earth and ocean, and the nourishment of psychic pneuma by exhalation from the blood—between macrocosm and microcosm—is explicitly associated with Cleanthes

⁶⁸ J. von Arnim, *Stoicorum Veterum Fragmenta* II, 519.

⁶⁹ Cleanthes is put first, suggesting that what is in question here is an interpretation by Cleanthes of his predecessors.

(331–232 B.C.) alone among the Stoics. That man is a microcosm is part of the essence of Stoic philosophy at all periods. But Cleanthes is peculiar in the pre-eminence which he gave, in the macrocosm, to the sun. For Cleanthes the sun is the HĒGEMONIKON, or ruling principle, of the cosmos.⁷⁰ To a Stoic this would mean that the sun in the cosmos corresponds to that part of man to which the term HĒGEMONIKON is properly applied—and this, for all orthodox Stoics, is situated in the heart. Cicero records Cleanthes' own words for us:⁷¹ 'Since then', he says, 'the sun is of fire and is fed by the moisture of the Ocean (for no fire can continue without some fuel), it must resemble either that form of fire which we use for the purposes of daily life or that which is contained by the bodies of animate things. But our fire . . . is a destroyer . . . while that fire which is contained in the body is vital, salutary, preserves, feeds, increases, sustains, and bestows, the power of sensation (*sensuque adficit*)'. He says therefore there can be no doubt which of these kinds of fire the sun resembles, for the sun too makes all things to flourish and grow to maturity each after its kind. Since then the fire of the sun resembles those fires which exist in the bodies of living things . . .'. The heat of the sun and animal heat are for Cleanthes of the same kind: in other words, the sun is the heart of the cosmos, and the heart is the sun of that cosmos which is man. What both have in common is the manner in which they are nourished; and Cleanthes seems to have taken a particular interest in this question, both in the case of the sun, and in the case of the soul. It was by the sun's search for nutriment that Cleanthes explained its 'turnings', or movement along the ecliptic.⁷² In the same way he gave his attention to the meaning of his master Zeno in calling the soul a 'sensible exhalation' (AISTHĒTIKĒ ANATHUMIASIS), and explained it, we are told, by adducing the beliefs of other philosophers, including Heraclitus, as we have seen. Hence, for later writers, Cleanthes was associated with Zeno on the doctrine of the nourishment of the soul by exhalation: as often happens when one Stoic gives an exegesis of a predecessor, the two are thereafter quoted together (cf. SVF I, 520).

The adjective HĒGEMONIKOS is familiar to the author of 'On the Heart'. The aorta, he says, is shut off from the left heart because it is full of 'nutriment not appropriate for the leader' (TROPHĒ OUKH HĒGEMONIKĒ). One is tempted to translate 'unsuitable for the HĒGEMONIKON'. Diocles too seems to have used the word HĒGEMON of the intellectual principle, which he placed in the heart.⁷³ The word is used several times of the rational principle of the soul by Plato in the *Timaeus* (41C, 44A, 45B) and Aristotle⁷⁴ applied the adjective to the front of the body, and hence to the 'great blood vessel' or vena cava, which lies forward—as indeed the heart does. Neither the word nor the idea are new. But the Stoics made this sense of the word peculiarly their own, and from them it became part of the technical vocabulary of philosophers. But it is of small importance how far back we can trace the idea of

⁷⁰ SVF I, 499ff.; cf. von Arnim in RE XI, 1 col. 565.

⁷¹ *De Natura Deorum* II 40–41 = SVF I, 504.

⁷² Cicero ND III, 37 = SVF I, 501: *ali autem solem . . . eamque causam Cleanthes adfert cur se sol referat nec longius progrediatur solstitiali orbi itemque brumali, nec longius discedat a cibo.* Notice however that the same explanation of the sun's movement was given by Diogenes of Apollonia (DK 51A17); and cf. *de Flatibus* ch. 3.

⁷³ Fuchs 5.543 Fr. 59 Wellman. Jaeger, *Diokles*, p. 215 has some doubts that this is Diocles' own expression.

⁷⁴ PA 667B35.

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intellect as HEGEMON. What is of significance however is the implicit analogy between sun-HEGEMON and left heart-HEGEMON in respect of their nutrition by exhalation in 'On the Heart'—significant precisely because it is implicit. The author feels no need to spell out the details for us—any more than, in another context (see above), he feels a need to spell out the details of why the pulmonary artery is an artery. To him, these are quite familiar matters, which have small significance for his immediate purpose to which, with characteristic sobriety, he sticks. So far as the evidence goes, he may indeed have written before Cleanthes.⁷⁵ But the manner, the *style*, suggests a time at which Cleanthes, and perhaps others, had made the idea common property.⁷⁶

⁷⁵ Cleanthes was of course not the first to compare vital heat to the heat of the sun. Apart from the fact that it is an idea which might readily occur to the visceral imagination of human beings at any time, there is the famous passage in Aristotle in which connate pneuma is described as a substance analogous to that of the heavenly bodies (GA 2.3, 736B30ff). Xenophon's Socrates, disagreeing with Anaxagoras who regarded the sun as 'just fire', remarked on the difference, in respect of its vitalizing properties, between the heat of the sun and the heat of the fire. Cf. A. S. Pease on Cicero, *De Natura Deorum* 2.40, where these and other references are given. And of course the comparison has to be set in its context of ancient analogies between macrocosm and microcosm. The Hippocratic treatise 'On Sevens' is interesting here. In chapter 6 the veins and the blood in them, in the microcosm, correspond to rivers in the macrocosm, just as they do in 'On the Heart' ch. 7; and possibly—the text is difficult to make out—an analogy between heart and sun is hinted at. In ch. 15 of the same work the heat of the sun is the cause of growth and movement in all things (crementum et motus omnibus). The date and provenance of 'On Sevens' is however quite uncertain. Even more striking is 'On Diet' 1.10 (VI, 484–86 Littré): animal heat = sun's fire and is 'soul, intellect, intelligence, movement, increase and decrease'. (cf. the similar list of characteristics in Cicero, *Nat. Deor.* 2.40 quoted above).

But what we have explicitly in Cleanthes and implicitly in 'On the Heart' is a quite systematic comparison between the nutrition by ANATHUMIASIS of the sun and of the vital heat, which implies a definite physiological doctrine.

⁷⁶ Kudlien, op. cit., p. 424ff. remarks that since Posidonius can now be definitely brought into connexion with the Pneumatic school, it is at least not absurd to suspect a connexion between 'On the Heart' and the 'Posidonian' doctrines for which K. Reinhardt argues; though wisely Kudlien does not commit himself on the rightness of Reinhardt's arguments. The facts are these: there is certainly in the late sources a quite explicit analogy between sun and heart; moreover, this analogy is physiological. The earliest direct and explicit analogy is in Plutarch, *De Facie in Orbe Lunae* ch. 15, where the sun (a) dispenses light and warmth to the cosmos, just as the heart dispenses blood and pneuma to the body; (b) is nourished by exhalations from earth and sea, just as the heart is nourished from the organs beneath it; (c) has its nourishment purified by the moon, (which in turn moderates the heat sent down by the sun), just as the heart has its nourishment purified by the liver. On this and later passages, particularly Macrobius I, 20, 6 (the sun is called 'cor caeli') see K. Reinhardt, *Kosmos und Sympathie*, 330ff. and RE XXII, I, col. 692ff. Reinhardt elaborately argues that Plutarch represents, in a modified form, the doctrine of Posidonius. But whether by Posidonius or not, the physiological analogy (the physiology is Erasistratean, says Reinhardt in RE XXII, I, col. 695) is fully developed by the end of the first century A.D. My own view is that Reinhardt is right in seeing Posidonian material in the Plutarch passage, but this is always a contentious matter, and in any case we do not know the extent of Posidonius' debt to Cleanthes. But, as Kudlien says, it would not be absurd to place 'On the Heart' as late as Posidonius: cf. also what I have said at the beginning about the word PHOTOEIDÉS. However the fact that 'On the Heart' describes only two valves, not four, is a difficulty. It would help a little if we knew for certain whether the Pneumatic School recognized all four valves, and also whether they accepted Herophilus' terminology of 'venous artery' and 'arterial vein' for the pulmonary vein and pulmonary artery. The terms do not appear in Aretaeus.

Posidonius, or at least the Stoics, comes up again in connexion with a passage in Vindicianus, *De Semine* ch. 17, p. 219 Wellmann. Here too there is a comparison of the heart to the sun, not however in respect of its nutrition, but in respect of the way in which the power of the soul makes itself felt in all parts of the body, by 'radiating', like the sun, from the heart: 'sic enim supradicto exemplo ignei splendoris seu radii ex partibus loci in corde constituti, in quo anima consistit, usque ad omnes fines corporis nostri superveniet, et consensus in illis partibus fiet, in quibus etiam irruentia perficiuntur'. Wellmann (pp. 46–47) finds the influence of Diocles in the passage, but there is no reason for doing so. The last authority to be mentioned by Vindicianus before this passage is Hippocrates (in ch. 13), and in any case there is a break in continuity, in Vindicianus' text, between the beginning of ch. 17 and what has preceded ('igitur cor': but what has this to do with the development of the embryo, the subject of ch. 16?) Nor is there any antecedent in the Vindicianus passage as it stands

RETROSPECT

The intention of the present essay has been to canvass dispassionately a number of possibilities; to suggest grounds for rejecting some and approving others; and to subject certain aspects of 'On the Heart' to a more searching examination than they have perhaps received hitherto. It is better to travel than to arrive; to deepen one's understanding of the problem than to draw spuriously precise conclusions. But hypothetical conclusions may after all be regarded as merely another way of stating the problem. In that sense, then, what are the conclusions which we may provisionally draw about the date and affiliations of the treatise? The reasons for dating it not earlier than the middle or late fourth century B.C. are overwhelming, and are hardly disputed. The question is rather how much later it should be placed. A date in the third century would suit the relative degree of anatomical sophistication which we notice in the treatise, particularly in the matter of veins and arteries. On the other hand, the author cannot be regarded as a direct pupil of either Herophilus or Erasistratus: there are too many divergences from both, and on matters which are too important. Further, an examination of the text makes it reasonably certain that the author recognizes the working of only two valves, not four. In view of the author's evident aim to draw a teleological moral, this fact is a strong objection to dating it much after Erasistratus—assuming, what seems to be the case, that the beauty and economy of Erasistratus' conception was all but universally accepted and was irreversible.⁷⁷ And the fact that the author does recognize at least the semilunar valves does not conflict, as we have seen, with Galen's attribution of the discovery of the valves to Erasistratus, since what Erasistratus discovered was the co-ordinated function of all four valves. On the whole, a date in the first half of the third century B.C.—late enough for the author to have some knowledge of Stoicism—while not entirely congenial, would seem to create the fewest problems. If so, the treatise would be an invaluable index to the state of anatomy and physiology shortly prior to the work of the great Alexandrians Herophilus and Erasistratus. In particular it would prefigure, though it cannot be by much, the 'classical' portrait of the heart which we associate with Erasistratus, and then Galen.

for *supradicto exemplo* in ch. 17. The source of the comparison in ch. 17 may well be Stoic: the idea of the extension of the HEGEMONIKON to all parts of the body is certainly Stoic, an idea which they had a particular predilection for illustrating with striking comparisons. Notice too the word '*consensus*', presumably a translation of Greek SUMPATHEIA or SUMPHONIA, a key concept in Stoicism. The same may be said even more surely of Vindicianus ch. 18 (the faculty of sense is a unity, which alters its character according to the different sensory channels in which it is active) and ch. 19: *sicut, inquit, ignis . . . sic etiam anima in cordis altitudine habens rationabilem virtutem, quae tendit usque ad corporis fines, omnes sensus perficit—pure Stoicism—and 'accedit etiam quod secum plurimum luminis ex anima trahat [sc. sensifica virtus] [atque] ex corde perfecto in similitudinem radii per visificas vias irruat etc.'* This is simply the doctrine that sight is a modification of the HEGEMONIKON which sees by acquiring the nature of light: that is, the doctrine for which Posidonius, as noted above, found the word PHOTOEIDES so useful, and which is expressed in Cicero *De Natura Deorum* II and in several Stoic passages. The presence of Stoic views on sensation would not be surprising in Vindicianus: his source is very probably Soranus (cf. Wellmann, pp. 6ff.; Jaeger, Diokles p. 187ff; Deichgräber, RE IXA, 1, sv. Vindicianus col. 34; cf. col. 36 where he stresses the Stoic-pneumatic content of Vindicianus), who wrote a book 'On the Soul', which was used by Tertullian as a source for his *De Anima* (cf. RE IIIA, 1, s.v. Soranus, col. 1115). There is therefore no reason for attributing these passages about light in Vindicianus to Diocles. Yet this was one of Wellmann's better arguments for seeing a relation between Diocles and 'On the Heart'.

⁷⁷ This then emerges as the most cogent reason against giving the treatise a date in the first century B.C.—which would otherwise appear not implausible.

The Paradoxical Text 'On the Heart'

And that point, indeed, underlines the paradox of such attempts at dating: the apparently fixed points by which we initially attempt to locate a particular work may themselves become changed in the process. But we may also reasonably hope that their contours will become clearer. Thus the question of date offers a convenient approach to other, more fruitful, problems. The treatise 'On the Heart', apart from its intrinsic value, also has the value of a surveying instrument. It serves to give bearings, and to bring into sharper focus a number of problems in Alexandrian medical science: for example the distinction between veins and arteries in Herophilean anatomy, the nature of Erasistratus' discovery of the valves, the meanings of 'mechanism' in Greek science, and the effect of teleological assumptions upon the accuracy of anatomical observation. All these are matters worth pursuing for their own sake.

NEW FILMS ON THE HISTORY OF MEDICINE

Two short films in the history of medicine have recently been produced by Dr. Thomas R. Forbes. *John Hunter—Enlightened Empiricist* (11 minutes), shown on 5 May 1972, at the meeting of the American Association for the History of Medicine in Montreal, presents Hunter as an anatomist and surgeon. His application of his knowledge of collateral circulation for the successful surgical relief of a coachman's popliteal aneurysm is portrayed as an example of his ability to reject dogma and to apply in a clinical situation lessons learned at the dissecting table.

Vesalius, Founder of Modern Anatomy (12 minutes), reveals the colourful Belgian's progress from Galenism to a new and more accurate knowledge of anatomy through his own labours as a dissector. Examples of his scientific thinking are drawn from the text and illustrations of the *Fabrica*.

The 16 mm. films in sound and colour were specially designed to interest medical and nursing students, members of the health professions, biologists, and historians, and were made by Miss Susan Wheeler and Mr. William Guth of the Communications Media Group of the Yale School of Medicine. Costs were met from a grant from the National Fund for Medical Education. Prints at \$40.00 each may be ordered by writing to Mr. William Guth, Communications Media Group, School of Medicine, Yale University, New Haven, Conn. 06510, U.S.A.