

THE PARADOXICAL TEXT 'ON THE HEART'

PART I

by

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‘ἐν τῇ αἰσθησει ἡ καρδία’—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 ΠΕΡΙ ΚΑΡΔΙΑΣ’, *Mnemosyne*, 1923, 51, 1–101.
5. P. Dieppen, *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*).
11. F. Kudlien, *Hermes*, 1962, 90, 419ff.

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 PHŌTOEIDĒS '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).

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says, is 'nourished by a luminous substance (PHŌTOEIDEI PERIOUSIĒI) 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 (PHŌTOEIDĒ)'.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 (NOĒTON)'. 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.

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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' (HAIMORHOŌI 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. Fredrich, *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).

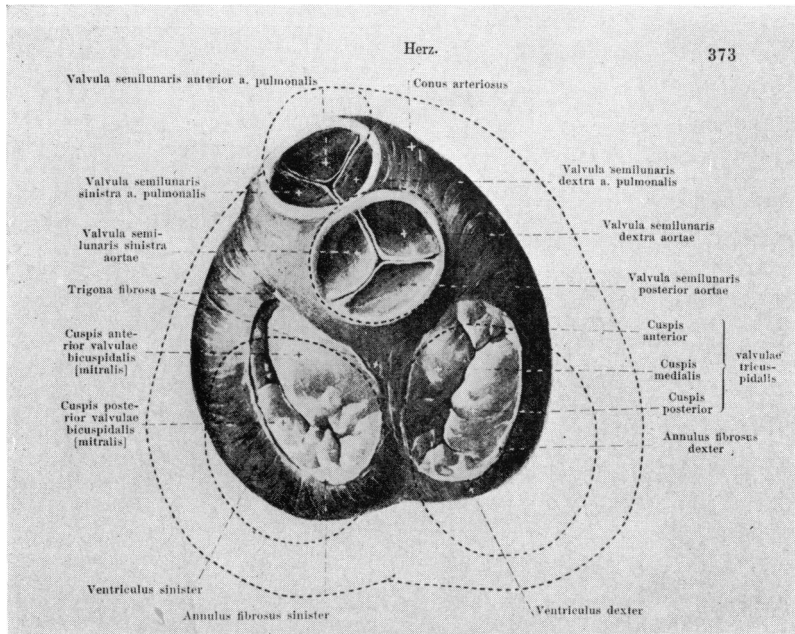


Figure 1

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

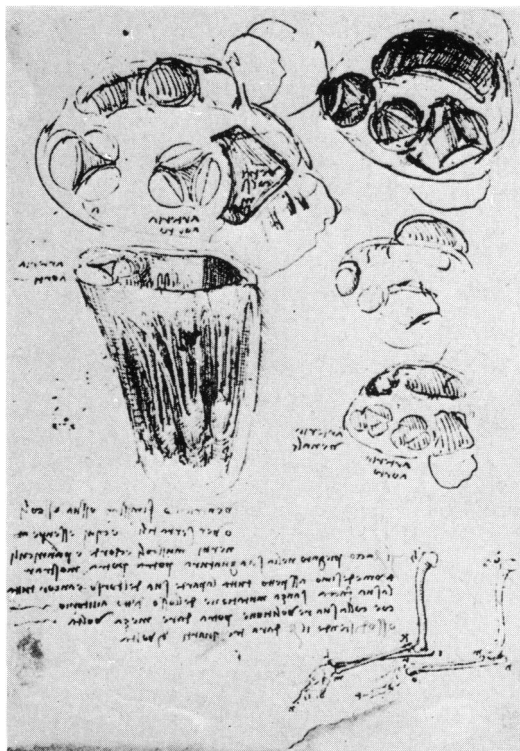


Figure 2

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

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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 originative 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 originative 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.

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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 praesecueris, 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 secueris, 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.

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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-ventriculans 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 HEKASTĒI 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-ventriculans); 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

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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-ventriculans. 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 (TROPHĒ) 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' (TROPHĒ OUKH HĒGEMONIKĒ).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, ANAKŌKHEI] the food which is in a tempest [ZALĒ], it [? the right chamber] closes off the path towards itself'. Littré translates 'l'aliment qui est en fluctuation'; Unger, 'alimentum . . . vehementer motum'. But ZALĒ, 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. ZALĒ, if it is correct (one would suspect SALŌI, the tossing movement of a rough sea, especially since ANAKŌKHEI may contain a nautical metaphor) must surely apply to the confused movement of the 'nutriment inappropriate for the ruling principle (TROPHĒ OUKH HĒGEMONIKĒ)' 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 ZALĒ in 43c. Translate: 'so that the contents of the artery in its squall (EN ZALĒ 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.