Historical Notes on the Iconography of the Heart

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There are various ways of tracing the growth of our knowledge of the heart and the study of its iconography is one of them. The pictorial representations of different periods and places reveal the various views held at the time about this organ and also show the eventual, gradual and uneven progress in the appreciation of its morphology and function. Furthermore, such an investigation is also of interest regarding the technical and artistic qualities of the graphic representations.

As so much else, in the history of medicine, the portrayal of the heart, too, was greatly dominated by Galen's teaching for well over a millennium after his death in A.D. 200. His views on the heart and blood flow are too well known to merit any detailed discussion, but it may not be amiss to give a short recapitulation of those points which are relevant in the present context. According to Galen, blood is formed from chyle in the liver and there endowed with "Natural Spirit", giving the blood its nutritive capacity. Some of the blood is carried into the right heart, the heart being considered to consist of two chambers only, and from there gives off noxious vapours through the vena arterialis (our *arteria pulmonalis*) to the lungs, whence they are exhaled in the breath. The blood thus purified ebbs and flows to and from the tissues through the veins which originate in the liver. Some of the blood has, however, a different fate: It passes through invisible (imaginary) pores of the interventricular septum to the left heart. There it is mixed with cosmic *pneuma* which reaches it through the *arteria aspera* (our trachea), lungs and the

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Fig. 1. Diagram illustrating Galen's physiological scheme. From Singer and Rabin (1946). A Prelude to Modern Science.

arteria venalis (our pulmonary veins) It thereby acquires a higher quality spirit, the "Vital Spirit", which gives it the capacity to endow the tissues with function, and this higher quality blood reaches the various tissues through the arteries which take their origin from the heart. These relations are diagrammatically illustrated in Fig. 1, taken from Singer and Rabin (1946), on whose description of Galenical views the above short summary is based.

It is also pertinent to recall that the works of Galen, with other classical Greek texts, were preserved by the Byzantines and translated from the Greek into Arabic; that this period of trans-

1 For Galen, the left auricle was part of the pulmonary vein, and the right auricle part of the *vena cava*. He believed that the function of the auricles was to protect the thin-walled veins (i.e. *vena*

cava and pulmonary veins! from being ruptured by the ventricular contraction. (Darembert 1, 417, 433 seq.)

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lation started in Persia at about the middle of the 8th century and reached its climax in the 9th century when the Moslem Empire was established with its centre in Baghdad (Elgood, 1951, pp. 101 seq.); and that it was from the Latin translations of these Arabic texts (about 1050-1250, Singer, 1925) that Galen's teaching became first known in Europe.

The first illustrated monograph on anatomy to appear in Persia was the Tashrīh bi al-Taswīr, or "Illustrated Anatomy", by Mansur, which was composed in 1396. If anywhere Galenical features could be expected to be discernible in an early pictorial representation of anatomical conditions, it would be Persia. Fig. 2 reproduces a drawing, made between 1490 and 1500, of an illustration of the venous system, belonging to the Wellcome Historical Medical Library, which is unquestionably a copy of an analogous illustration of Mansur's book. It is surprising how little, if any, of Galenical conceptions are contained in this drawing. It shows a human figure in the squatting position, viewed from in front, with the arms by the side of the body (not raised; regarding the significance of this, see below). The distribution of the veins, as shown, has no relation to Galen's description. There is not even a connexion between veins originating from the liver

= A'UR-Caecum

= QÓLÚN-Colon

= QÓLANJ DARÁI WÁQI SHAWAD- Seat of Colic

= M'ÁI MUSTAQIM- Rectum

= MÁBIZ-UL-RAKABA- Popliteal Vein

= Illegible

= 'IRQ-UL-NISA- Sciatic Vein

= SÁFAN-Saphenous Vein

= MÁBIZ-UL-RAKABA- Popliteal Vein

= 'IRQ-UL-NISA- Sciatic Vein

= SÁFAN-Saphenous Vein

= ASAYLAM í %oo!II *ext ,

30 = ASAYLAM ASLAYM)-? modern equivalent.

= KITFÍ-Shoulder Vein

≈ KÉFÁL-Cephalic Vein

= AKHAL-? equivalent

name ? Median Vein

4 = HABL-UL-ZARÁ'- ?

equivalent name 5/6 = HAJAB-Diaphragm

= DIL-Heart

= GÓSH-i-QALB-Auricle

(lit. Ear) of the Heart

9 = FAM-i-M'ADAH-

Mouth of the Stomach

= HAJÁB-Diaphragm

= KITFÍ-Shoulder Vein

= BASILÍQ-Basilic Vein

= KÉFÁL—Cephalic Vein

= HABL-UL-ZARÁ'—?

equivalent name

15 = AMA'Í ISNA ASHARA

—Duodenum

= SÁ'IM—Jejunum

= ÂMA'Í—Small Intestine

Fig. 2 a. Key to Fig. 2. Transliteration and translation by Dr. C. L. Elgood.

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and the heart, which can be seen, for example, in a similar drawing in an edition of the Tashrīh of 1656 in the Royal College of Physicians, London (Orient. MS. No. 46); nor is there any indication of a trachea. A curious feature of this picture is that some of the veins are drawn outside the body. (This is somewhat reminiscent of a feature found in illustrated Persian manuscripts of about 1520, in which the depicted scene exceeds the margin of the picture where expedient.) All this is, of course, highly suggestive that this pictorial representation is almost entirely imaginative, without any intention of depicting the anatomical conditions. In any case, much of the anatomy of the venous system was still unknown. This is particularly true of the deeper veins, whereas the distribution of the superficial ones had been studied more extensively in connexion with phlebotomy 2.

The representation of the heart would be acceptable, regarding its shape, were it not that the exaggerated size of what appears to be the auricles spoiled this. This is even more marked in the Orient. MS. No. 46 of the Royal College of Physicians, referred to above. (For Mansur's chapter on the heart, see Appendix A.)

Regarding the remaining features of this drawing, the alimentary tract is shown in yellow. The small red spheres indicate the kidneys, and the larger trilobular object on the figure's left the spleen, all at approximately the correct anatomical site. The cres-

2 It was, however, just possible, though extremely improbable, that this illustration might have been intended to illustrate Mansur's textual description of the venous system. This is, of course, a most unlikely possibility, since at that time anatomical conceptions were solely those of the classics and not based on any dissections in man. Furthermore, Elgood (1951) has pointed out that anatomy was viewed not as an exact science, but from a teleological and religious standpoint. However remote this possibility is therefore, it can be definitely excluded by comparing the illustration with Mansur's description of the venous system in the text. This was made possible for the writer by Dr. Elgood's extreme kindness in translating this chapter, as well as those on the Heart and the Gall Bladder, and allowing the writer to include this in the present paper (see Appendix A). It is seen that the text keeps closely to Galenical tradition. The same holds good for a description of the venous system in a later Persian monograph, of the same time as the reproduced drawing, namely the Mirat-ul-Sihhat, or "Mirror of Health", by Ghiyas ibn Muhammad, of 1490, of which a translation by Dr. Elgood is available in the library of the Royal College of Physicians. (Much of the latter's book is based on, and many passages taken from, the Thesaurus by al-Jurjānī. written about 400 years earlier. Elgood, 1951, p. 356.)

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cent-shaped organ in red immediately adjacent to the stomach is obviously the liver. In the middle of this structure is a nearly spherical blue centre, from which three feathery blue lines are drawn, diverging to the left. No explanation of these blue structures is contained in the drawing, but by comparing these with similar features in other Persian drawings of this period which

contained an explanation, Dr. Elgood was able to identify them as gall bladder and bile ducts. Here again the illustration bears no relation to the text, for whereas three bile ducts are represented pictorially without any communication to any organ, it is stated in the text that the gall bladder has two ducts. The first connects with the duodenum, so that bile may be poured out into the duodenum for cleansing the gut; the second duct connects with the stomach and its use is to cleanse bitter bile of blood, so that its violence may not be burnt up. (See Appendix A.) This drawing is undoubtedly a copy of one of the figures of the Fünfbilderserie. Fünfbilderserie is the name given by Sudhoff to these illustrations, because they typically consist of five Plates, each depicting one system of the body: skeleton, nervous, arterial and venous systems, and muscles. In some manuscripts such series have two more pictures, namely one of the gravid uterus, and one of a female figure on which the points for scarification are indicated (Orient. MS. No. 48 in the Royal College of Physicians; Elgood, 1951, p. 346). There are considerable variations in detail between various illustrations of this type. Regarding the venous system, apart from wide variations in the course of the veins drawn, in many of the drawings the veins are depicted feathery, as in Fig. 2; in others they are drawn as plain lines (e.g., Orient. MS-No. 48 in the Royal College of Physicians) 3.

3 A detailed description and explanation of these illustrations was given by Sudhoff (1908, also in the chapter revised by him in Choulant, 1920, pp. 49 seq.), and illustrations were reproduced by Sudhoff (1908); Choulant (1920); Garrison (1929); Elgood (1934, 1951).

The origin of the Fünfbilderserie has not yet been established with certainty. Both Sudhoff and Elgood have stated that they cannot be attributed to Persia. It has been pointed out that there is no parallel in the occidental series for the Persian drawings of the venous system [Choulant, 1920, p. 63]. In the Persian drawings the human figure is depicted with the arms by the side of the body, whereas in occidental drawings, e.g. in Ketham's Fasciculus Medicinæ (see Fig. 3), the arms are drawn raised. However, the latter position may signify a pathological condition, whereas the former may indicate a normal

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Fig. 3. Johannes de Ketham, Fasciculus Medicinæ, 1491. From the facsimile edition by Sudhoff and Singer, 1924. Plate XI.

An example of an early occidental anatomical illustration is provided by Fig. 3, taken from the facsimile edition by Sudhoff and Singer (1924) of the Fasciculus Medicinæ of Johannes de Ketham, which appeared in 1491, that is a few decades after the invention of printing. This seems to have been the first book in which the various rules and guides used by medical men were combined in one volume. The original figure is so large (688X567 mm.) that only a part was reproduced by Sudhoff and Singer. It shows a pregnant woman with the arms raised (see above regarding the significance of this feature), with the various organs indicated and diseases listed to which they may give rise. There is no attempt at showing the position of the organs at anything

body build (Sudhoff, 1908, p. 70). It is assumed by experts that a common source of both occidental and Persian representations of the Fünfbilderserie is likely, going back to views held in antiquity. This source may possibly be discovered as having existed in Alexandria or in the Far East. (See also Choulant, 1920, pp. 49 seq., section revised by Sudhoff.)

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like their anatomical location. Nor does it illustrate any Galenical ideas, except that the trachea is drawn as connecting the mouth with the heart. The explanations are contained in 35 circles.

Ketham has not been identified with certainty. According to Singer he was identical with Johan von Kirnheim, Professor of Anatomy in Vienna about 1460.

A clear representation of Galenical Views in a drawing of the same time—the end of the 15th century—is shown in Leonardo da Vinci's "Tree of the Veins" (Fig. 4), dated c. 1490-1500 by Malley and Saunders (1952), and according to K. D. Keele (personal communication) probably nearer 1490 than 1500. The veins are shown to originate from the liver, with branches up- and downward. The heart, depicted as two-chambered without atria, is drawn as offset from the vena cava, which is represented as one vein. Altogether, the emphasis is laid more on veins than on arteries. All this is very much in keeping with Galenical teaching.

According to Keele (1952), Leonardo knew Galen's views mainly through Avicenna and Mondino (c. 1270-1326), the latter being the author of a text-book on anatomy (*Anathomia*, 1316), both these authors giving a corrupted version. Such misconceptions, resulting from mistranslations, are commonly attributed to misunderstandings of the Greek text on the part of the Arabic translators. Elgood has pointed out that, while this is true for some instances, it was often the occidental translator, rendering the Arabic text into Latin, who was at fault. This view is substantiated by some instructive examples (Elgood, 1951, pp. 114 seq.).

By contrast, a diagrammatic drawing by Leonardo of his later period (Fig. 5) demonstrates the profound changes in Leonardo's views about the heart which resulted from his own observations

4 The exact dating of this drawing is difficult, and I am very grateful to Dr. Keele for his views on this point. "It [this figure] is not drawn on the same blue paper [as another diagrammatic drawing, Fig. 18 in Keele's book, 1952] and for this reason some, and Sir Kenneth Clark is one, date it on stylistic grounds as about 1507-09. From internal evidence, and in particular its account of the heart, others think it belongs to the period of his sojourn in Rome, i.e. to the years 1513-14. Personally I favour the later date, particularly as on the next folio, which continues his thesis about the function of the auricles as 'upper ventricles', he refers rather bitterly to 'scholars impeding anatomy', trouble that he did not meet with until he reached Rome." (K. D. Keele, personal communication.)

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Plate 1

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Fig. 2.

Persian drawing of the Venous

System. Dated c. 1490-1500.

Fig. 1. Leonardo da Vinci, 'Tree of the Veins'. *Quaderni d'Anatomia*. V. 1, r.

Reproduced by gracious permission of H.M. The Queen.

Fig. 21. Mascagni. *Anatomia universale*. 1833. Visceri, Tav. V. Explanations on p. 77.

Fig. 22. Quain, *The Anatomy of the Arteries of the Human Body*. 1844.

Plate 48. Fig 1.

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S. Karger, Publishers, Basle/New York

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F/%. 5. Leonardo da Vinci, Diagrammatic drawing of the heart, showing auricles and ventricles, also pores in the interventricular septum. Quaderni d'Anatomia, I, 3, r. Reproduced by gracious permission of H.M. The Queen.

By the time he made this drawing Leonardo had established that the heart consists of four chambers, the upper ventricles and the lower ventricles as he called them, and he also knew that the contraction of the upper ventricles (our atria) coincided with the dilatation of the lower ventricles and vice versa. Leonardo believed that there was flux and reflux of the blood between upper and lower ventricles, the friction caused by the whirling of the blood being the cause of the heating of the blood which makes it subtle, and suitable for streaming through the narrow pores of the interventricular septum in whose existence he still believed; these are also indicated in the figure. Had he been able to emancipate himself from this belief—had he had any knowledge of Ibn An-Nafis who, two and a half centuries before, had clearly stated in his Commentary on the Anatomy in the Canon of Avicenna that there were no pores in the interventricular septum and had, in fact, discovered the pulmonary circulation (see Meyerhof, 1935)—he might well have anticipated Harvey by more than a century.

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A further example of Leonardo's powers of observation and accurate pictorial rendering is provided by Fig. 6, showing the human thoracic aorta and its branches. This drawing dates from 1504-06 5.

Fig. 6. Leonardo da Vinci, Drawing of the human aorta and its branches. From

K. D. Keele (1952). Leonardo da Vinci on Movement of the Heart and Blood.

Harvey & Blythe, London, Fig. 44.

By the correct representation of the subclavian and carotid arteries Leonardo anticipated the correct pictorial illustration of these vessels by how long it is impossible to say. For the progress made in the following one and a half centuries was very uneven, and different anatomists emancipated themselves to greatly varying degrees from Galenical ideas, or, on the other hand, copied illustrations based on Galen for decade after decade.

The presence of Galenical features in the drawings of Vesalius (1514-1564) is of interest for various reasons. Vesalius objected to Galen's teaching being based on dissections of animals and decided to investigate conditions in man; yet many features of his illustrations show clearly that they were also largely based on findings in animals. It is somewhat ironical that it was this heretical attitude

5 It was thus dated by O'Malley and Saunders (1952). Dr. K. D. Keele (personal communication) agrees with this and feels sure that this drawing is accurately referred to the period after Leonardo left Cesare Borgia. From the fact that the next folio, 34, definitely refers to dissection of "the old man", Keele is inclined to ascribe it to this dissection.

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TABULA III

> ARTERIA MAGNA, AOPH^UJII HAORTI EX SU

NITRO CORDII SINI ORIINS, EI VIIALEK SMRITVM TOTI CORPORI DEPEIENS, NITV.

D AittH*t>, l.rnî, mVf., < „.

Si < vñrêm tirU > J < m,titi>φ < iit < ♦«f«f tnj, tff4m

NOTATV DIGNAE ARTERIAE MAGNAE SOBOLES
CENTVM ET VADRAGTA SEPTM APPARENT

Fig. 7. Vesalius, *Tabulae Sex*. 1538. Tab. III. From Singer and Rabin (1946). A Prelude to Modern Science.

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of Vesalius towards accepting Galen as gospel truth which led to the bitter enmity between him and his teacher Sylvius, who remained a devout follower of Galen. Singer and Rabin (1946) have pointed out that the representation, in Vesalius's drawings, of features found in animals cannot solely, or even mainly, be due to his having been directly influenced by Galen's writings, since the relevant works of Galen are unlikely to have been accessible to him, and believe that it is most probable that Vesalius based such drawings on his own dissection of animals.

Fig. 7 reproduces the third of Vesalius's *Tabulae Sex* (1538) (Singer and Rabin, 1946). The branching of the aorta is of a kind found in apes: a truncus communis (from which the right subclavian and the carotids arise), and the left subclavian arising separately. This conception was taken over into Vesalius's main work *De Humani Corporis Fabrica* (1543), as shown in Fig. 8. Similar, though not identical, erroneous representations of the branches of the aorta can be found as late as 1651 (Highmore, see below).

Fig. 8. Vesalius, *De Humani Corporis Fabrica*. 1543. Lib. VI, Fig. 6.

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Fig. 9. Vesalius, *De Humani Corporis Fabrica*. 1543. Lib. VI, Fig. 5. G = Beginning of the V. azygos.

Fig. 9 is included to show the exaggerated way in which the V. azygos is represented. Vesalius held peculiar views about this vein. In his *De Fabrica* he points out that the vena cava, as it ascends from the heart, rests on the aorta, and does not pass dorsally to the bodies of the vertebrae, which space is occupied by other organs. The diaphragm is an obstacle for the cava to send branches to the vertebrae and ribs, where it expands below the liver; and the base of the heart is so far elevated from the vertebrae, and the pulmonary vessels lift the cava so much away from them, that here too the cava cannot give off any branches to them. For these reasons, he writes, the Great Architect has created a large branch from the cava, which takes its place in its whole course where its own trunk cannot reach the vertebrae, and this sends branches to the vertebrae and parts of the back. Because this vein is single, the Greeks termed it αζυγος and he calls it *venam absque coniuge et pans expertem* (the vein without a companion and devoid of a counterpart). Vesalius then details the reasons why the azygos originates from the right side of the vena cava. It does not arise from the left side because, he says, it has to unfold along the right aspect of the back because of the aorta. Should it originate from the anterior aspect its route to the back would be unnecessarily longer; nor can it take its origin from the

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posterior aspect because this rests on other organs and such origin would also have resulted in a further diversion to the right. (For the relevant passage in Vesalius and its translation, see Appendix B.)

This figure (Fig. 9) also shows the caval system depicted as forming one vessel from which the heart is offset. Singer and Rabin (1946) have pointed out that, in apes, the superior and inferior vena cava seem more nearly continuous than in man, because the right pulmonary veins, which separate them in man, are "less intimately applied to the heart in ape than in man". Furthermore,

conditions in the human foetus are more similar to those depicted by Vesalius, and foetuses were more easily accessible for dissection to Vesalius than adults.

These figures from the *De Fabrica* were reproduced as late as 1645 in Caspar Bartholinus's *Institutiones anatomicae*, edited by his son Thomas, the current textbook for students at that time. While Vesalius's fame as the founder of modern anatomy has been established for a long time, the great importance of his contemporary Bartholomaeus Eustachius (c. 1524-1574) has become recognized only more recently. Little of his work was published in his lifetime, and when he died childless in 1574, the plates went to a relative and were lost, until Lancisi found them some one and a half centuries later in the Vatican library and published them in 1714, together with the eight tables already published in Eustachius's lifetime, and with his own commentaries.

Fig. 10 reproduces the last of the eight tables published by Eustachius himself. It shows not only the valve which bears his name, but also the valve of the coronary sinus, named after Thebesius who described it in 1708. From the explanation of this figure it is obvious that Eustachius realised that this was the valve covering the "orifice of the major coronary vein, which other anatomists pass over through negligence". (*Membrana cornutae*

6 Vesalius's emphasis on the origin of the azygos from the right side of the cava is noteworthy since, in man, it enters the vena cava from behind (Cunningham; Sobotta and Uhlenthuth) and the same seems to hold good for the rhesus monkey (see Singer and Rabin, 1946, Fig. 4-1 on p. lix) and the horse (Strangeways and Goodsir, 1870, Plate XXV, Fig. 3; M'Fadyen, 1884, Plate XXVI). Estienne (before 1539) had also represented the azygos as entering the v. cava from the right and, according to Singer and Rabin (1946), Vesalius had possibly seen Estienne's figure by 1538.

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Fig. 10. Eustachius, *Opuscula anatomica*. 1564. Tab. 8.

lunae figuram referens, orificio maioris uenae coronariae, ceu operculum ultra medium obducta, qua ceteri anatomici oscitanter praetereunt.) (See also Appendix C, Lancisi.) The figure also shows that there is no lettering in the picture and that Eustachius uses a co-ordinate system to which he refers when describing a particular structure. The artistic value of the figure falls short of the anatomical one. The stiffness of the representation has been attributed to the fact that the figures were engraved by one Giulio de Musi of Rome, who is otherwise known chiefly as an architectural draughtsman.

Eustachius's powers of observation may be further illustrated by Fig. 11, taken from Lancisi's edition of 1722 of his work, one figure of which was also reproduced by Singer and Rabin (1946) (their Fig. 20 on p. xxxvi). These show approximately correct representations of the branches of the aorta.

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Fig. 11. Eustachius, *Opuscula anatomica*. Edited by Lancisi. 1722. Tab. XVI, Figs. 1 and 2.

Fig. 12. Spigelius, *Opera quae extant omnia*. 1645. Lib. IX, Tab. I, Fig. 1.

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Charles Singer is of the opinion that, had Eustachius's work been published when it was completed, which appears to have been about 1552, his name would rank equally with that of Vesalius as co-founder of modern anatomy. It is an interesting speculation how our knowledge of some features of the anatomy of the heart would have developed between Eustachius's observations and the long-delayed publication of his work, had this become known in his lifetime. This may be illustrated by Spigelius (1578-1625). Born in the same year as Harvey, he had the same teacher as Harvey, Fabricius, and also succeeded as Professor of Anatomy in Padua

another pupil of Fabricius, Casserio. Casserio had illustrated the anatomy of the whole body, but died in 1616 before he could publish it. He had, however, published in 1600 a book on the Organs of Speech and Hearing. Spigelius survived him by only nine years and, when he died in 1625, he requested in his will that a German physician Rindfleisch (Bucretius) should publish his manuscript *De Humani Corporis Fabrica*, which was without illustrations. Bucretius asked the heirs of Casserio for the

Fig. 13. Highmore, *Corporis Humani Disquisitio anatomica*. 1651. Tab. XIV, p. 142.

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plates which Casserio had drawn and engraved, in order to add these to Spigelius's work. Fig. 12 is taken from this book, the *Opera Omnia*, edition of 1645, but is one which was copied, with slight alterations, from a plate of an illustration in Casserio's book of 1600 (his Tab. XV, Fig. 1 on p. 83). It shows errors of the branches of the aorta, whereas Eustachius had already established the correct view (Singer and Rabin, see above) and Leonardo had been much nearer the truth nearly one and a half centuries before (see above, and Fig. 6). A detail worth mentioning is that the ductus arteriosus is correctly drawn, but not labelled, whereas in Casserio's earlier work it was labelled and explained (*Coniugatio hie fit arteriae magnae cum arteria venosa, magni usus ipsius foetus ad huc in utero contenti*).

Simian features of the branches of the aorta are clearly shown in Fig. 13, taken from Highmore's *Corporis Humani Disquisitio Anatomica* of 1651. A curious feature of this drawing is that the left recurrent nerve is depicted as curving round the pulmonary artery. This is particularly noteworthy as Vesalius had represented the condition correctly 108 years earlier in his *De Fabrica* (Fig. 14).

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Fig. 15. Lower, *Tractatus de Corde*. 1669. Plate I.

The uneven progress in our knowledge, and its rapid advance in the middle of the 17th century, is well illustrated by Fig. 15, taken from Lower's *Tractatus de Corde* of 1669. It shows in its "Fig. 4" the branches of the aorta somewhat diagrammatically, but essentially correct. And Lower's thoughts went beyond describing and depicting the anatomical conditions: he analysed the dynamics of the blood flow through the aorta and its branches. In his own words (translation by K. J. Franklin):—

"While the above-mentioned swelling at the threshold of the right ventricle, where the ascending vena cava meets the descending vena cava, prevents blood flowing down the latter vein and pressing down on that which is coming up the former vein [this refers to the *Tuberculum intervenosum*; see below]; equal ingenuity has been employed outside the opening of the left ventricle to prevent the blood, which is ejected with such force, from being unequally distributed to various organs. For this opening of the Heart faces directly upwards, and hence, if the channel, which receives directly the first shock of the blood, led it likewise to the cranial region, too much blood would inevitably be sent to the brain; it would also of necessity gradually increase owing to the force of vibration, with the result that the lower parts of the body would be cheated of their appetite and food. To avoid such a disaster, the divine Artificer constructed the trunk of the aorta (next the Heart) with such skill in Animals, whose Hearts move rather forcibly, that the blood does not run straight into the axillary and cervical arteries, but first turns through part of a circle. Midway between the ventricle and these arteries, the aorta (to a varying degree in different animals) is strongly arched. Consequently it is the curved angle

which bears the shock and the full force of the ejected blood, and directs the greatest part of the rushing stream into the descending trunk of the aorta. But for this too much of it would be distributed to the higher branches of the aorta; these it would distend unduly, and would soon by its impetus put an end to the head. All this is fully shown in Plate I, Fig. A. In this figure

- a is the root of the Human aorta.
- b is its descending trunk.
- c is the angle where it curves on itself.
- d is the right axillary artery.
- e is the right cervical artery.
- f is the left cervical.
- g is the left axillary.
- h are the two coronary arteries.

In the figure, the curving of the aorta (c) deflects a very large part of the rushing stream of blood ejected from the Heart into the descending trunk, but, to prevent it all from going in that direction, the intervening axillary and cervical arteries are so made that they must receive their requisite share of the blood as it flows past. The right side of any one of these arteries is much higher than the left, and hence some part of the fluid in the larger trunk must be intercepted by them. This will be more readily grasped from Plate I, Fig. 5. In this figure

aaa is the right-hand and higher part of each successive artery.
b is the angle of the aorta curving on itself, ccc are the lower sides of the arteries which intercept the blood as it flows past, and against which the blood dashes, d is the descending channel of the aorta.

If these arteries, on the other hand, left the aorta perpendicularly, practically the whole of the blood would pass by their orifices without any diminution, as Plate I, Fig. 6 shows. This figure, though it represents a condition which never actually exists, is put side by side with Fig. 5 to allow a better understanding of the arrangement therein depicted.”

This reasoning testifies to Lower’s genius and remains impressive even if it is realised that the branches of the aorta do not originate in man in the way in which Lower assumed them to do, at least regarding the innominate artery. The question of the haemodynamic conditions prevailing in branching (elastic) tubes, which Lower here opens, has proved a difficult problem up to our time (see for example Wiggers, 1928, pp. 74 seq.). The flow of fluid through branching tubes was studied from a haemodynamic point of view by Jacobsön in 1860. Even the seemingly simpler problem of pressure drop per unit length of a blood vessel in a branching system is a highly complicated one, being investigated in our time (Groat, 1948). The effect on blood flow of

the particular way in which the parent vessel gives off a branch, to which Lower draws attention, has not been investigated to the writer’s knowledge.

Figs. 1 and 2 of Plate I (Fig. 15) show the structure which Lower first described and which bears his name, the Tuberculum intervenosum Loweri, or Torus Loweri as Tandler (1913) prefers to call it. Its description, in Franklin’s translation, reads as follows:—

“Just before the threshold of the right auricle, that is to say, where the ascending vena cava joins the descending and prepares to discharge into the auricle of the Heart, a certain small swelling is formed by underlying fatty tissue. This swelling is well worth attention. Its interposition at this point causes the blood, which falls down the descending vein, to be diverted into the auricle,

when it would otherwise have continued on down into the ascending vein, and would have caused great hindrance and slowing to the blood flow up through that vein into the Heart. The danger from this was greater in the upright position and form, and hence the swelling in the vena cava of man was made larger and much more prominent, so that, if you put a finger into either of the two trunks, you will only with difficulty reach the other.”

His Fig. 1 is taken from man; Fig. 2 from a quadruped (sheep, dog, horse or ox; he does not say which).

Lower’s description of the “Tuberculum” gave rise to a great deal of controversy. Haller denied its presence altogether: “Id tuberculum cupide receptum est ut fere fit ab iis scriptoribus, quibus occasio ad propria experimenta nulla est, deinde etiam ab iis qui tandem in corporibus humanis dissecandis se exercuerunt.” (Haller, *Elementa physiologica*, T. I., Lib. IX. Quoted from Tandler, 1913, p. 51.) (This tubercle was eagerly accepted, as often happens by those writers who had no opportunity of experimenting themselves, and thereafter also by those who in the end practised dissection of human bodies.)

Lancisi (1745) attacked Lower in the belief that Lower had appropriated Eustachius’s discovery of the Eustachian valve and turned it into his intervenous tubercle, which was, of course, unjustified. (For Lancisi’s attack, see Appendix C.)

Tandler (1913) has pointed out that though the original illustration of Lower greatly exaggerates the structure, its presence can certainly be established in the human heart and is due to a distinct muscle bundle; fatty tissue can also always be demonstrated in this region.

The above discussion of Bucretius adding Casserio’s illustra-

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tions to Spigelius’s book provided an example of one author’s graphic work being incorporated in another’s book. Another example of one anatomist publishing another’s work, but in an altogether different and not particularly honourable manner, is that of Cowper’s publishing—in his *The Anatomy of Humane Bodies* (1698)—the work of Bidloo of 1685, with hardly any intimation that this work was Bidloo’s (to put it charitably). Fig. 16 is

Fig. 16. Cowper, *The Anatomy of Humane Bodies*. 1698. Tab. XXII, Fig. 7.

taken from this book. It shows that even at that time some remnants of Galenical teaching are still traceable: the structure marked A, which is obviously the left atrium, is called V. pulmonalis. A further feature of interest is that the high artistic value is not matched by anatomical accuracy. This is understandable if it is remembered that Bidloo was apparently not too particular about portraying the true anatomical conditions (Haller epitomized his mode of living as “Vitae liberiori plura tempora dedit quam studiis”), whereas the engraving was executed by the celebrated artist Gerard de Lairese (1641-1711). Lairese was regarded as the greatest historical painter of his time and particularly noted as engraver. Even after losing his eyesight at the age of fifty he

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communicated his ideas which were posthumously published as a treatise on design and colouring. The plagiarism by Cowper of Bidloo’s work has been described in detail by Beekman (1935).

Bidloo was a pupil of Ruysch (with whom he quarrelled). Ruysch (1638-1731) is credited with having been the first to develop to a high level the technique of injecting blood vessels with a solidifying injection mass. This technique was invented by his contemporary Jan Swammerdam (1637-1680). (See also Cole, 1921.)

Fig. 17. Ruysch, *Thesaurus anatomicus*. IV. 1704. Tab. III.

Fig. 17 is taken from Ruysch's *Thesaurus anatomicus* (Amsterdam, 1704). By his technique he was able to demonstrate the ramifications of the coronary arteries, as the figure shows. Ruysch is also credited with the discovery of the bronchial arteries and veins.

The secret of the composition of the material he used for injecting seems to have been jealously guarded by him and has not come down to us. He obviously had a very high opinion of his

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discovery; for he suggested that it would be much better for important people in England to have the heart of their deceased wives embalmed by his method and keep it in a golden or silver box, so that his art would flourish, instead of the then custom to keep in their eternal memory a ring woven artistically from their hair. ("Magnatibus in Anglia mos est, ut ex uxorū denatarum capillis artificiose contextis, conficiantur annuli, idque in per-petuum memoriam, potius vero Cor ita balsamatum in pyxide aurea aut argentea conservarent & sic ars mea vigeret." IV, p. 43.)

Fig. 18. Haller, *Iconum anatomicarum* . . . Fasciculus IV. 1749. Tab. I, Fig. 1.

Fig. 18 is taken from Albrecht von Mäler's *Icones anatomicae* (1749), from a chapter specially devoted to the foramen ovale and allied structures. It reproduces the heart of a girl who survived only a few days. (A: Heart, B: Hepar, C: Vena cava inf., D: Ostium venae Coronariae magnae, E: Sinus dexter apertus, proxime venas hepaticas, F: Valvula foraminis retro isthmum conspicua, G: Isthmus Vieussentii sive annulus fossae ovalis, H: Hiatus apertus in parte superiori foraminis ovalis.) The artist of this illustration was J. P. Kaltenhofer (d. 1777); its engraver G. D. Heumann (1691 to 1759), engraver to the English Court and to the Göttingen Academy.

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Of Haller's copious annotations to this figure, two may be discussed:

Regarding the valvula foraminis ovalis (marked F), he states that, in experiments with air, he found that this valve prevents air from flowing from the left to the right atrium and concludes that this must therefore also be true for blood.

Regarding the structure marked G: Haller criticises the term "Isthmus Vieussentii". In the first place, as this structure has not the shape to which the term isthmus is usually applied, he suggests calling it annulus. This, in his opinion, is appropriate despite its not being a complete ring, because this term is also used for the similarly incomplete ring of the tympanum. (This is, in fact, the term used in present standard textbooks on anatomy, e.g., Gray's Anatomy, 30th ed., 1949/50.) Furthermore, since this structure still bears the name of Vieussens (1641-1716),

Haller's

Fig. 19. Fabricius ab Aquapendente, *De Formato Foetu*. 1600. Tab. X, Fig. 24.

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statement is of interest that it can already be seen in Fabricius's (1537-1619) *De Formato Foetu*, which was published in 1600. The relevant figure is reproduced as Fig. 19 and shows the structure quite clearly, though perhaps somewhat crudely represented. (F: Foramen cum suo ostiolo.) (In some textbooks on anatomy, this structure is called "Limbus". This term was first used by Verheyen (1648-1710) in 1710 (Franklin, 1948). For the relevant passage, see Appendix D.)

Fig. 20. Scarpa, *Tabulae neurologicae*. 1794. Tah. III.

Proceeding to the end of the 18th century, a remarkable combination of brilliant anatomist and superb artist is encountered in the person of Scarpa (1752-1832). Fig. 20 is taken from his *Tabulae neurologicae* of 1794. Apart from the acute anatomical observation which must have gone into this drawing, it shows the exceptional artistic quality of the engraving. According to Chou-lant (1920), Scarpa was not only "one of the most excellent men of his day", but himself

also an admirable artist who himself trained his engraver, Faustino Anderloni who, on Scarpa's recommendation, was appointed Professor of Drawing at the University of Pavia in 1801, Scarpa having held the Chair of Anatomy there since 1783. Dr. John Bostock described the illustrations of the *Tabulae neurologicae* as "admirably expressive of the subject, without the gaudiness of the French engravers, who appear to aim principally at effect, or the tameness of the English, who seem to think of little except economy" (Bishop 1954). An impressive detail is the representation of the carotid sinus, which demonstrates the remarkable powers of observation and pictorial representation, exemplified in a structure, the elucidation of whose physiological significance had to wait for well over a century (until 1923).

The last two illustrations from works of the 19th century are reproduced mainly because of their artistic qualities.

Fig. 21 is taken from the *Anatomia universale* by Paolo Mascagni (1752-1815), one of the leading anatomists of his time and renowned for his work on the lymphatic system. His great anatomical work was published in Pisa, of which a selection was published in Florence in 1833 from which the figure reproduced is taken. All illustrations were handpainted, the artist being Seran-toni. Compared with the engraving taken from Scarpa's work (Fig. 20), the striking effect of colour becomes immediately noticeable. In the general explanation to this illustration it is stated that it shows the heart, with the pericardium and adjacent structures removed, also some abdominal and thoracic viscera in part elevated, in part in their natural position, and the nervous plexuses and ganglia in their course and origin as they arise from the "eighth" pair and intercostals. The picture of the heart is not particularly impressive, but the distribution of nerves and the nervous plexuses are depicted with a clarity made possible only by the use of colour. The details shown far exceed in number those represented by his predecessors; this applies especially to the nervous plexuses and, regarding the heart, to the cardiac plexus in particular. A line drawing of each painted illustration is provided on the opposite page, in which all the structures are numbered, each being explained in a list of references contained in a separate volume. Regarding the reproduced figure, the numbers run to over 200, going into so much detail as to confuse the reader rather than enlighten him.

Fig. 22 reproduces an illustration taken from *The Anatomy of the Arteries of the Human Body* by Richard Quain (1800-1887), published in 1844. It is a coloured lithograph. By depicting the heart viewed from in front with the pulmonary artery cut away at its origin, an unusual and striking artistic effect is achieved. Moreover, the origin of the left coronary artery from the aorta is clearly shown. Altogether, the main branches of the coronary arteries are represented with exceptional accuracy and clarity. The superb artistic quality of this illustration, taken as a whole, requires no comment.

Richard Quain became Assistant at the newly-founded University of London and was appointed Professor of Anatomy in 1852. He was the brother of the well known anatomist Jones Quain (1795-1865), who became Professor of Physiology at University College Hospital, and was a first cousin of Sir Richard Quain, Bart. (1816-1898).

Compared with Scarpa's representation of the heart (Fig. 20), the last two illustrations do not demonstrate any material advance in the portrayal of the essential features of the heart. The use of colour, on the other hand, made possible a new approach to pictorial representation which artistically is most effective. The first half of the 19th century thus appears to be distinguished by

an advance on the artistic side, rather than by much progress in the accurate anatomical representation of the heart which had already been achieved previously.

This brief survey of some stages in the historical development of the iconography of the heart tends to demonstrate that the progress in knowledge of the heart's features and function was uneven and attained by devious routes. When at the beginning of the Renaissance interest in the classics and in learning generally was re-awakened, anatomy was amongst the subjects pursued early and with great vigour. Since Galen's teaching became accessible in Europe at an early stage, though at first in corrupted versions, it was to be expected that Galenical features should dominate the earliest pictorial representations of the heart, but the examples included in this paper show that this is not the case. Not even in Persia, to whose scholars and translators Europe owed indirectly the first texts of Galen's writings, did such drawings bear any relation to Galenical teaching. With the beginning of the 16th century great progress in the iconography of the heart was

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made, but, in the absence of dissections of human bodies (with rare exceptions), was marred by the indiscriminate application to human anatomy of features found in animals. This represented a perpetuation of Galenical teaching, but early exceptions to such misrepresentations occurred. As in so much else, here too Leonardo's genius anticipated others by many decades and, in some respects, by centuries, and Eustachius's great importance has become realized only more recently. Progress in the 17th century can be shown to be particularly uneven. Harvey's discovery of the circulation did not prevent Galenical features from being represented decades later, such as copies of Vesalius's drawings being reproduced in 1645 in the then current textbook by Bartholinus, or similar conditions being depicted in Highmore's anatomical "Disquisitio" of the human body of 1651, which was dedicated to Harvey. The outstanding personality of that period is unquestionably Lower, whose genius encompassed physiology as well as anatomy, in keeping with the time which saw the opening stages of the former, furthered by contemporary advances in physics and chemistry. With Scarpa, a high degree of artistic representation of accurate anatomical features was achieved at the end of the 18th century, preceded in the middle of that century by the achievements of Haller who can rightly be said to have made medical history while writing it. The first half of the 19th century added much to the artistic value of the pictorial representations by the use of colour, be it in the shape of handpainted illustrations or by the use of coloured lithographs.

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A. Tashrih bi ul-Tuswir, or "Illustrated Anatomy", by Mansur.

Translation by Dr. C. L. Elgood. Oriental MS. No. 46. Royal College of Physicians, London.

Copy dated A.D. 1656.

The Fourth Discourse—On Veins. (Folio 8 a.)

The Veins are non-pulsating vessels which arise from the Liver. And from this they acquire the Faculty of growth and nutrition.

All veins are single excepting only the Arterial Vein which is double. This Vein runs to the Lungs and carries the nourishment of the Heart and Lungs by a method of distillation. And since the blood of the Liver is very thick, it is created double that it may become distilled and light and clean and suital > le for a food of the Heart and Lungs.

The origin of the Veins is two vessels which spring from the concave surface of the Liver. This is known as The Gate or Vena Porta, because whatever comes to the Liver needs must pass through it. The probable use of the Gate is that it attracts chyle towards the liver.

Another vessel springs from the convex surface of the Liver. This is known as the Hollow Vein or Vena Cava because it has a large interior. Its use is to convey chyme to the organs.

The Anatomical preference of the Vena Porta is because the School of Anatomists give higher preference to the lower and further subdivisions has ceased for collecting. [This sentence is unintelligible. C.L.E.]

Since chyle within the Liver turns into chyme, there needs must be a channel from the stomach to the Liver and from the Liver to other organs. This is why there needs must be two Veins.

The Vena Porta divides within the Liver into five branches. Every ramification is contiguous with many others, and the branch which runs to the convex surface splits into many sub-branches and becomes scattered throughout the Liver. One of the branches goes to the Gall Bladder and near to the concave surface of the Liver. The vein which comes into sight divides into seven branches. The smallest of these passes to the Duodenum in order to attract the rest of the food, and then divides into several vessels scattered within the mesentery.

The second branch is scattered within the lower part of the stomach to extract the food.

Of the remaining six branches, one goes to the upper surface of the stomach to supply food, because the nourishment of the inside of the stomach, as some suppose, comes from the juice of the food. This opinion depends upon the view of some physicians that food is blood alone or blood with other humours. Now, the generation of the humours lies within the Liver. Hence if eating of the juice of the food takes place within the stomach, there is some change from the normal condition. For the food there arrives raw. And because the stomach is busy with two duties the digestion of food is the work of other organs. Hence the correct view is that the interior of the stomach receives its blood after coction from a branch of the vein which conies to it.

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The second of the six branches goes to the Spleen to supply it with food. Before arriving it gives off two branches. A few branches go to the soft tissues for their nutrition. After reaching the spleen there is a branch to the left of the stomach for its nourishment. After it has entered the spleen, part goes up and part goes down. The upper part scatters, part going to the upper part of the spleen and part appearing to reach the convexity of the stomach. When it reaches there, it divides into two, one being visible on the left of the stomach for its nourishment and the other plunging in and becoming hidden within the mouth of the stomach, to pour the black bile there to

create the appetite for food. The descending part divides, like the ascending part, into external and internal divisions. Scattered branches go to the lower pole of the Spleen to augment appetite. The external division appears in the mesentery for its nourishment.

The third branch of the eight goes to the right and is dispersed among the rivulets of veins which lie around the rectum to suck up the remaining food from the faeces.

The fourth branch is very fine and like a hair. Some of it passes to the upper surface of the stomach on the right and some to the mesentery on the right.

The fifth branch is dispersed among the rivulets of the Colon to extract food from there.

The sixth branch surrounds the Jejunum.

The remaining two branches are slender and run to the Caecum to pick up food from the branches of the Vena Porta. For the Vena Cava comes from the upper surface of the Liver and its interior, whilst the Portal Vein comes from the under surface of the Liver and towards the upper border.

When the Vena Cava appears at the upper surface of the Liver, it divides into two branches, ascending and descending. The ascending branch passes to the diaphragm, pierces it, and ramifies there. Scattered branches give food to the diaphragm. Then it lies opposite the sheath of the Heart and passes towards the Heart. Here it unites with the sheath which divides the thorax into two halves and divides into branches within. After this the two large veins unite with the two auricles of the Heart. But this vein is larger than the other veins of the Heart. The reason for this is that the veins of the heart are for respiration, whereas this vein is for nourishment. There is no doubt that food is thicker than air. Hence its channel is broader and bigger.

The vein which has entered the Heart divides into three branches. One enters the right cavity of the Heart and from there goes to the Lungs, because its substance and creation is similar to a Pulsating Vessel, for it has two sheaths, like arteries. Its function is twofold. One, it distils the blood to exceeding great subtlety and thinness, being like the substance of the Lung, and in it coction takes place a second time and it receives a good consistency, like the blood in the arterial vein. The other function is that blood receives within it ample coction.

The second branch of the three passes around the Heart and then plunges within for its nourishment.

The third branch passes to the left and reaches the Fifth Thoracic Vertebra and the muscles and organs which lie beneath the ribs. When it passes the

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heart, it divides into seven spider-web-like branches in the upper part of the pleura and pericardium.

When it approaches the Clavicle, two branches spring from it, like narrow paths, and reach the Clavicle. Each of these two has two posterior branches. Each of these passes down to the Sternum to the right and to the left. One terminates at the Ensiform Cartilage and anastomoses with the branches between the intercostal vessels. Two divisions can be seen on the external muscles of the chest. Other branches reach the Ensiform and curve round it. Another branch goes to the intercostal muscles and anastomoses with two vessels distributed there. A portion of it becomes visible on the external muscles of the chest. Whenever a branch reaches the Ensiform Cartilage, a branch of it passes to the muscle.

One vein appears passing down the Rectus Muscle and its branch anastomoses with the branches of the ascending branches of the Sacral Vein of which we shall speak later.

The remaining pair each comes from a single unit [? C.L.E.] and can be divided into five branches. One splits up in the chest and supplies food to the four upper ribs. The second gives

food to the shoulders. The third descends towards the muscles at the bottom of the neck. The fourth enters the foramen of the sixth cervical vertebra and passes up to the head. The fifth branch, which is a large branch, on each side splits up into four branches—one going to the anterior muscles of the chest, one going to the soft tissues and the axilla, a third goes towards the chest forming a curve, and the fourth splits up into three, one going to the muscles beneath the shoulder, one to the big muscles of the axilla, and one passes the muscles and reaches the hand. And this is called the Axillary Vein. The remaining pair splits up into an ascending branch going to the neck. Some say that when it reaches the neck it splits up; each of them becoming two, known as the Jugular Veins, one more visible and called the External Jugular, and one deeper called the Internal Jugular. When the External Jugular becomes level with the Clavicle, it divides into two branches. One inclines anteriorly; the other at first passes anteriorly and then descends and again becomes visible and then rises from the clavicle superficially upon the neck and joins with the first part.

The External Jugular is the well known one.

Before arriving from each two pairs appear. One is a broad vessel and both pass to the deep tissues. The second appears running diagonally in the neck. These two anastomose with one another. From each branch off imperceptible branches. But from the second pair spring three perceptible branches. One is a vessel which winds round the shoulder until it gets to the tip of the hand. It is called the Scapular Vein. From it two perceptible veins pass to the Shoulder—one to the top of the shoulder, one to the top of the arm, and after these have anastomosed, they divide into two. One is superficial and divides into two. One branch is a small one. This small branch subdivides in the upper jaw and into a few other branches which are small and unimportant and divide up in the lower jaw. There is a place of meeting of the two systems. A few branches spring from them and ramify around the tongue and appear on the muscles situated there. A second appears externally and is scattered in the neighbourhood of the ears and head.

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But the division which is internal is the servant of the oesophagus. A few branches spring from it, being partners of the external branches, and they ramify over the oesophagus, trachea and muscles of the interior. The remainder pass on to terminate at the Lambdoid Suture. A few branches spring from them which pass to the 1st and 2nd vertebrae. There are also a few capillary vessels springing from them which pass to the membrane of the skull and reach the skull itself. They pass within and the remaining branches pierce the cavity of the skull at the end of the Lambdoid Suture and scatter. Some branches pass to the two membranes of the brain, that is the Dura and the Pia Mater, and after that pass down from the Pia Mater to the Brain and branch up there like the branching up of the arteries: Around over the meninges. It reaches a broad part of the brain, known as the Torcula. Where the brain is near to a broader inside, its size is greater because it sucks up food.

After this it is prolonged to the outside of the brain and anastomoses with the arteries which have ascended, and then becomes interwoven with a thin membrane, called the Arachnoid Membrane. Now as for the veins which are in the Hand, they originate in a vein of the shoulder, called the Cephalic Vein. In the origin of the Cephalic there is ? [MS. defective. C.L.E.] dispute. Some say it is the name of a King in India. Some say it is the name of a Biver. This is more likely to be correct. Others call it the Basilic Vein, still others the Axillary Vein.

Now the Vein of the Shoulder, however it reaches the arm, there divides up into many small branches whose ramifications can be seen. When they reach the elbow joint, they can be divided into three groups. First comes the vein HABL-UL-ZABÁ' (i.e. rope of the forearm) which can

be seen over the radius. After that it inclines inwards towards the ulna and splits up beneath the off-side of the wrist.

The second of the three groups inclines to the bend of the elbow, lying superficial upon the forearm, and joins a branch of the Axillary Vein. That is, the Shoulder Vein and the Axillary Vein are contiguous and join one with another. The resulting vein is known as AKHAL.

The third of the three groups passes down and joins the Axillary Vein where it passes into the arm. Small branches arise which are scattered among the muscles beneath it, that is to say, they are concealed by these muscles. As soon as it draws near the joint, it splits into two. One division goes deep and joins the Cephalic Vein and becoming its fellow companion for a short time. After a while they part and fall into the declivity of the near side between the 3rd, 4th and 5th fingers. A fourth branch appears on the outer side of the hand.

The second of the two groups is distributed superficially on the forearm. One branch runs to the forearm near the wrist, another branch runs above this. A third branch is distributed to the centre of the forearm. A fourth branch, the biggest of them all, becomes superficial and sends off a branch which anastomoses with a branch of the Shoulder Artery, a thing of great importance as has been already said.

There remains the Basilic Vein. It passes deep a second time. The Basilic and the Akhal arise on the near side above the radius. They then incline to the outer side. Then they divide into two like a Greek lambda. The upper branch passes to the radius and enters the wrist and splits up behind the

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thumb. One branch lies between the thumb and the index finger. All the lower branches pass towards the ulna and split up into three branches. One branch runs between the index and middle finger and anastomoses with a vessel which comes from above and they become one. Another branch comes towards the middle and ring fingers. This is called the ASAYLAM. A third branch comes between the ring and little fingers and this is called the Asaylam of Rhazes. All these branches ramify in the fingers.

Now the descending veins which go to the end of the body come from the Vena Cava. The first is branched, but before it plunges into the loins it gives off a few slender vessels which clothe the right kidney and scatter there and in the vicinity. Then comes a large vessel which passes to the left kidney. It divides into several small vessels passing into the substance of the kidney and adjacent structures.

Next come two large vessels which are called TÁL'ÁN. They pass to the kidney and by these vessels the materies of the kidney is attracted. From the side of the left kidney comes a vein which passes to the testicle.

Next come two veins in the female. One goes to the left. From this two veins pass down. One branch of this is a big one and is called the TÁL'AIN. The vessel that runs to the right kidney has no branches in the female or only rarely. And there is a place of collection of the vessels which terminate at the kidney. The vessels which are attractive to the kidney in the female are exceedingly ...[? C.L.E.]. The object of this is because semen gets coction there and helps the ovum. This vessel lies concealed within the penis and the neck of the uterus.

Next the Vena Cava in the region of the loins passes down and near the sacrum gives off a few vessels which pass to the umbilicus and terminate there in the abdominal muscles. A few branches enter the spinal cord.

At the level of the last vertebra the Vein terminates and divides into two branches, like the Greek letter lambda, one branch running to the Right Thigh and one to the left. From these two vessels

before their arrival there, there are ten branches, known as TAWÁ'ÍF. The first branch divides into six. The second branch goes to the lower part of the peritoneum and these vessels are exceedingly fine. The third branch goes to the muscles of the sacrum. A fourth branch goes to muscles of the perineum and superficial structures. A fifth branch goes to the os uteri and bladder and then divides into two. One ramifies there and one goes to the neck of the bladder. This branch in the male is large because it supplies the penis. The sixth branch goes to the muscles of the coccyx. The seventh branch goes to the back of the two abdominal muscles and anastomoses there with the veins which have come down from the chest to the soft parts of the belly.

There emerge from the origin of these veins several vessels passing to the uterus and by means of them the stomach and the uterus are united.

An eighth branch passes to the front. A ninth branch enters the deep muscles of the thigh. A tenth branch runs down in the region of the root of the thigh and becomes superficial at the waist. Its extremities anastomose with vessels from the region of the breasts.

There arise two large vessels from the TAWÁ'ÍF. Ten branches run to the muscles of the thigh. *Cardiologia*, Vol. 28, No. 4 (1956)

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The remaining twelve unite and from each of them comes a branch which is distributed to the muscles which lie in front of the thigh and another branch to the muscles behind the thigh. Many branches run deep into the thigh. What remains when it approaches the knee divides into three branches. The outer branch descends along the Fibula to the Astragalus and is called the Sciatic Vein. The inner branch opposite to it is called the Saphenous Vein. And the Vein that is in the centre is called the Popliteal Vein. Nearby where this passes into the interior of the thigh it gives off many branches to the muscles. Of the remaining two veins, one goes to other parts of the thigh and the other penetrates the Fibula of each thigh until it arrives at the anterior part of the foot and then anastomoses with the outer branches. This vein has four branches which pass to the toes. Two go to the outer side, lying externally, and the two internal ones go to the inner side of the foot. And all rejoin to form one vein.

And God knoweth all.

The Heart. (Folio 11 a.)

The heart is the noblest of organs and an absolute master. It is the seat of the Animal Soul.

It is composed of variously shaped fibres, hard tissue, and a thick membrane around it. The heart lies within the membrane, like an object held in the hand is comprehended within the hand. The lungs and the heart in this respect are similar.

The Heart is shaped like a fir cone, its base being uppermost. It lies within the thoracic cavity. Its head is conical and inclined toward the left.

In the base of the Heart is a bone or rather a cartilage named QÁ'IDA-I-QALB, that is, Governor of the Heart.

The Heart has two chambers, right and left. Each is continuously in movement, though that on the left moves more because it is the seat of the Animal Soul. And because it is present here in great quantity, the arteries arise from this side. In the Right Cavity are two passages with membranes. Through one of them blood passes from the Liver to the Heart. And through the other blood passes from the Heart to the Lungs. The Left Cavity too has two passages. One is a passage for air from the Lungs to the Heart. The other is the mouth of the Pulsating Veins which are Arteries. The channel which passes from the Right Cavity to the Left Cavity is wider on the

right side. Later it becomes narrow until it ends gradually on the left side. By this means refined blood passes from the right side to the left side.

Each cavity of the heart has an appendage outside resembling an ear. These are called Auricles of the Heart.

Some say that the Heart has three cavities, this last lying within. The first and third Cavities are big and exposed; the second is small and embraced.

The membrane of the Heart is for its protection and is called the Sheath of the Heart. This membrane is not adherent. Hence if any disaster reaches the Sheath, the Heart is protected. And again it will not be harmed by the movement of systole.

The lungs, as we have said, encircle the heart. Their movement follows the movement of the chest. The need for this is twofold: (1) they are the organ

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of respiration and voice. And (2) the heart needs respiration, because the heart is the mine of the Innate Heat and it requires Soul-filled air for heat and expulsion of smoky vapours. For this purpose there are two opposing movements. One is the movement of systole which expels smoky vapours. And because it is not desirable that cold air should reach the Heart at once because it is the mine of the Innate Heat and the Foetal Clot [?C.L.E.], it requires protection, so the Lungs were created for that purpose, namely, to attract air and pass it on to the Heart that the Innate Heat may become Soul-laden.

Smoky vapours are expelled by systole. This is why the Heart is inclined to the left. For the liver lies to the right and is full of heat. If the heart, too, which is the mine of Innate Heat, inclined to the right, the Heat would be split with a great tearing and this would be a cause of harm. And moreover the spleen lies to the left and is the vessel of humoral spleen. Its temperament is cold and dry. Hence the wisdom of Almighty God requires that the Heart incline in this direction that there may be moderation in the splitting.

Since the Heart is the most noble of the master organs, if any disaster or wound occur to it, it could not be endured. Hence the saying: The Heart endures no wound and associates with Death. They say that the bigger the heart of an animal, the braver and more impetuous it is, but the less is its Innate Heat.

The Gall Bladder. (Folio 12 a.)

The gall bladder is a nerve bearing organ and its mouth connects with the concave surface of the liver for the purposes of drawing up bile from within the humours which lie within the liver. It has two ducts, the first branch is the bigger and connects with the duodenum in order that the bile may be poured out into the duodenum for the sake of cleansing of the gut from heaviness as far as the lower end of the bowel. The second branch connects with the stomach and its use is to cleanse the bitter bile of blood in order that its violence may not be burnt up. Whenever the poison of bile is not attracted or there is incomplete attraction, then the liver will swell. And if bile becomes infected within the liver, a violent heat is generated. If that quantity which should be expelled by means of the urine (is not expelled, then) there are produced spots and burning of the urinary bladder. And if that materies morbi is excreted by another organ, erythema and an irritant rash appear in that organ. And if the whole body becomes filled, then jaundice becomes evident. And if it descends by the bowel, then a bilious diarrhoea and a colitis is caused.

B. Vesalius. De Fabrica. 1543. Lib. 111, Cap. VII, pp. 278/9.

A posteriori vero cavae ad cor connexus sede, insignis vena promitur (non autem, ut Galenus libro de Venarum sectione docet, exigua) quae secundum cordis posteriora & sinistrum latus ita porrigitur, ut cordis basin coronae modo succingat, ac ab inferiori ipsius sede ramos deorsum ad

cordis usque mucronem dispergat, quorum praecipii sunt, qui cordis substantiam illic petunt, ubi haec est crassissima. Unde etiam frequentiores venas sinistro cordis lateri, & ubi sinuum ipsius septum consistit, nobis occurrunt. Haec vena interdum gemina visitur, grandiori quidem a posteriori sede orificij cavae initium du-

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 cente, minori vero ab anteriori sede. Verum longe saepius unica tantum observatur, etiam si Galenus alibi hanc perpetuo geminam esse scripserit. Vena cava a cordis basi suysum ascensura gracilior fit, & cordis involucrum perforat, & versus corporis medium sensim ducta magnae arteriae innititur, non autem retrorsum ducta vertebrarum corporibus insidet, quae a stomacho occupantur, cui rursus aspera incumbit arteria, & huic non infima magnae arteriae propago cui ultimo cava insternitur: adeo sane ut quum cava tantum a vertebris distet, mirabile artificio illis vena fuerit offerenda, quae ipsis costisque sanguinem subministraret. Quum enim septum transversum impedimento sit, quo minus cava ubi sub iecore exporrigitur, ac renibus soboles dispensat, vertebris costisque propagines tribuere queat, & deinde quum cordis basis adeo a vertebris elevetur, & vasa in pulmones diffusa cavam a vertebris ita sublevent, ut etiam hinc ad ipsas cava nullos derivare queat ramos, rerum Opifex a cava magnam eduxit propaginem, postquam haec cordis involucrum transcendit, atque pulmonis dextrae partis cum sinistro connexum (qui vasorum pulmonis intervntu perficitur) superavit, ipsaque dorso propinquius quam antea accedit. Haec propago seu vena a dextro cavae latere pronata, deorsum ad quartae propemodum thoracis vertebrae corpus contorquetur, et declivis secundum dextrum vertebrarum latus, porrecta suo fine unà cum magna arteria, sub septo trans-verso ad aliquot lumborum vertebrae pertingit. Haec vena, cavae vicem totu progressu gerit, quo ipsius caudex vertebrae ita atque in lumborum regione nequivit contingere, ac geniculatim ramos ad vertebrae ipsas quae adeo dorsi partes offerre. Porro cava hanc sine coniuge & pari venam a se tam grandem deprompsit, ut arteriae magnae ritu untrinque ad costarum intervalla, ut nunc dicam, ramos germinare posset, quos quidem a lateribus non diffudit, sed ex media regione posterioris ipsius sedis, quae vertebris innititur. Quia vero coniuge privatur, neque in altero latere parem assciscit a cava propaginem, ἀζυγοῖ Graeci, nos venam absque coniuge, & paris expertem nominamus. Oritur autem potius a dextro cavae latere, quam a sinistro, quod secundum dextram dorsi sedem explicari debuit, sinistra nimirum sede, & media quodammodo a magna arteria dignissimo organo occupandis. Ab anteriori etiam cavae sede non enascitur, ne frustra tunc longiori ductu quam nunc versus dextrum reflecti, itaque spinam accedere deberet. A posteriori quoque principium sumere nequivit, quod haec sedes alijs incumbat organis, quodque hinc venam coniugis expertem dextrorsum magis deduci, quam nunc, oportuisset.

From the posterior aspect of the junction of the vena cava with the heart, a prominent vein arises (not an insignificant one, as Galenus teaches in “de Venarum sectione”), which passes along the posterior and left side of the heart in such a way that it encircles the base of the heart in a girdle-like fashion, and from its inferior aspect sends branches downwards as far as the apex of the heart, the important ones being those which reach the substance of the heart where it is thickest. For this reason we meet more numerous veins on the left side of the heart, and where the septum of its cavities is placed. This vein sometimes occurs as a pair, the larger one originating from the posterior aspect of the caval orifice, the smaller one from the anterior aspect. Much more frequently, however, only one vein is observed, though Galen writes elsewhere that there are always two. As the vena cava ascends upwards

from the base of the heart, it becomes smaller, and perforates the cover of the heart, and with a course gently towards the midline of the body rests on the aorta, not passing dorsally and lying on the bodies of the vertebrae which are occupied by the stomach, on which in turn the trachea rests, and on this does not (rest) the lowest branch of the aorta, on which the cava is finally spread: it is thus reasonable that, as the cava is so far away from the vertebrae, by an admirable device a vein is offered to them which supplies blood to them and the ribs. Now, since the diaphragm is an obstacle for the cava to send branches to the vertebrae and ribs, where it expands below the liver and gives off branches to the kidneys, and furthermore, since the base of the heart is so far elevated from the vertebrae, and the vessels, which spread in the lungs, lift the cava from the vertebrae in such a way that here too the cava cannot give off any branches to them, the Great Architect has made a large branch originate from the cava, after it has crossed the cover of the heart, and passed the connexion between the right part of the lung and the left (which is accomplished by the assistance of the pulmonary vessels), and this approaches the back more closely than before. This branch, viz. the vein originating from the right side of the cava, runs a tortuous downward course to nearly the body of the fourth thoracic vertebra, and sloping downwards along the right side of the vertebrae and extending at its extremity alongside the aorta, reaches several lumbar vertebrae below the diaphragm. This vein takes the place of the cava in its whole course where its own trunk has not been able to reach the vertebrae in the same way as in the lumbar region, and at intervals send branches to the vertebrae themselves and also to the parts of the back. Moreover, the cava gives off this vein without a companion or counterpart, so large that, in the same way as the aorta, it can send off branches on both sides to the intercostal spaces, as I would now say, which however it does not give off from the sides, but from the middle part (midline) of its posterior aspect, which rests on the vertebrae. Because this vein is devoid of a companion, nor receives an equal branch from the cava on the other side, the Greeks termed it ἀζυγος, and we call it the vein without a companion and devoid of a counterpart. However, it originates from the right side of the cava rather than the left, since it has to unfold along the right aspect of the back, the left being unquestionably, and the middle to some extent occupied by the aorta, which is a most important organ (structure). Moreover, it does not originate from the anterior aspect of the cava lest it should then unnecessarily be turned to the right and so approach the spine by a longer route than now. Nor can it take its origin from the posterior, because this aspect rests on other organs, and because on this account it would have been necessary for the vein without a companion to be diverted further to the right than is now the case.

C. Lancisi. De motu cordis et aneurysmatibus. Rome, 1745. Propositio XXXVI, p. 107.

Cum nolimus usquam alicujus laudibus detrahare; immo vero fateri sum-mopere laetemur per quos profecerimus, eisque, quibus multum debemus, plurimum semper voluisse debere; non piget hic observationes quasdam acceptas

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referre Clarissimo nostro Bartholomaeo Eustachio, per cujus vestigia progredientes singularia quaedam in vestibulo venae cavae deteximus.

Sed quoniam Vir doctissimus notitia circuitus sanguinis (quae illius erat temporis infelicitas) destituebatur, nonnulla eo turn ordine, turn situ, quo rei natura postulabat, minime fuit assequutus. Nam descripsit utique, iconeque expressit Membranam, quae foramini venae cavae a Jecore ascendentis, cum primum haec in auriculam degenerat, praefecta est, ac deinceps

reticulum efformat, aliamque pariter membranam cornutae lunae figuram referentem, Ofificio majoris venae coronariae, ceu operculum, ultra medium obductam.

Sed iconem postea exhibiturus non aperuit dextram cordis auriculam, ac truncum ascendentis cavae secundum directionem influentis sanguinis; verum secuit dexterum ventriculum per ejus longitudinem; hinc factum arbitror, ut neque figuram falcatae membranae in icone adamussim ostenderit, neque usum potuerit demonstrare; eaque ratione laudatissimum hunc alioqui Anatomicum quanquam veritatem indicaverit, tamen nemo Recentiorum sequutus sit praeter unum Lovverinum qui hanc Eustachii valvulam, suppresso inventoris nomine, quoquo modo subolfecit; ejus tamen situm, usumque haud integre attingere visus est; cum putaverit esse Tuberculum a subiecta pinguetudine elatum, cujus obtentu, ne sanguis in auriculam descendens motum ascendentis perturbaret, prohiberetur.

As we do not wish anywhere to detract from somebody's praise; on the contrary we greatly rejoice in acknowledging through whom we make progress, and always to be willing to owe the utmost to those to whom we owe much; it behoves us to return certain accepted observations to our most brilliant Bartholomaeus Eustachius, in whose advancing tracks we have made some remarkable discoveries in the entrance of the vena cava.

But because the most learned man lacked the knowledge of the circulation of the blood (which was a misfortune of that time), he has not by any means understood some features in the arrangement and position to the extent that the nature of the matter demanded. For he certainly described and represented by an illustration a membrane which guards the foramen of the vena cava ascending from the liver, when it first descends into the auricle and thereafter forms a reticulum, and in a like manner another membrane resembling the shape of a sickle moon, being drawn over the orifice of the major coronary vein beyond the midline, like a lid.

But when showing the picture he then did not open the right auricle of the heart, and the trunk of the ascending cava along the direction of the inflowing blood. In fact, he cut the right ventricle longitudinally. Because of this, I believe it happened that he neither showed accurately the shape of the sickle-shaped membrane in the picture nor could demonstrate its function. For the same reason none of the younger ones has followed on this otherwise excellent Anatomist, although he indicated the truth, except for one Lower who somehow smelled out this Eustachian valve, suppressing the name of the discoverer; however, he does not seem to have altogether arrived at its place and function; since he thought it to be a swelling raised by underlying fat, by the intervention of which the blood descending into the auricle would be prevented from disturbing the ascending [blood].

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D. Verheyen. Supplementum anatomicum . . . 1710, p. 408.

. . . quia propter rationes, quas allegavimus, aër debet transire per foramen ovale, & omnibus repletis, debet etiam foramen ovale esse repletum aëre, & valvula a latere venae esse remota, cumque in tali statu exsiccentur, limbus foraminis ovalis & valvula, non possunt amplius conjungi ad occludendum istud foramen.

. . . because, on account of the reasons which we have adduced, air must pass through the foramen ovale and, everything being filled up, the foramen ovale also must be filled with air and the valves drawn away from the side of the vein and, since in such a situation the rim of the foramen ovale and the valves are rendered dry, they cannot be joined together more closely to seal up that foramen.

[The meaning of this passage is difficult to understand, even if taken in conjunction with the definitions of 'humiditas' and 'siccitas' given earlier (on p. 9). It seems a curious variety of humoral theory, which is of no interest in the context of this paper.]

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