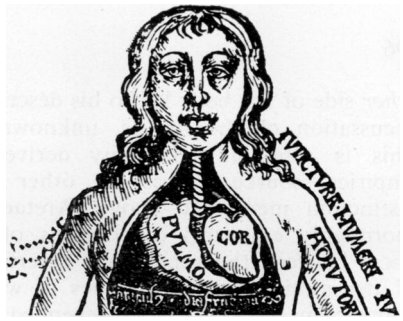
Thorax, 1978, 33, 295–306

The thorax in history 3. Beginning of the Middle Ages



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The end of Hellenistic experiment and observation

When Galen died at the end of the second century, anatomical and physiological research died with him. We are effectively in the dark ages at once, for the continued, if precarious, political stability of the Roman Empire was no substitute for the loss of vigour of the Greek intellectual tradition. Galen's works survived, were commented upon and summarised, but no new inquiry was undertaken. When Galen visited Rome, it was as far west as anatomy and physiology came: Pergamon, Alexandria, and Ephesus were the inheritors of an intellectual climate that sustained anatomy in any form other than that employed by the surgeons of the legions. No more than a vestige of the old knowledge remained in the West.

The two surviving anatomical and physiological traditions, East and West, differed not only in the extent of knowledge they contained but in its nature. In the West the Romans were surprisingly old-fashioned in their medical knowledge, and never really understood what had been going on in Alexandria, or the extent to which Galen was the summation of the Hellenistic tradition. Galen's predecessors in Rome refer back to Hippocrates, not Herophilus, and his own successors seem to have ignored him. The Roman writer Celsus,[1] compiling an encyclopaedia of useful knowledge of which medicine was but a part, gave a brief account of the dissections and vivisections of the Alexandrians in his introduction, but the bulk of his *De Medicina* depends upon a Greek source that antedates Alexandrian experimentalism. Cicero[2] seems to have been entirely ignorant of the Alexandrian discoveries, and he depended instead on fragments of Aristotle and the Hippocratic writings.

Of course, it was not Cicero's business to know about the inside of the human body, although we might expect him to have been aware, as an educated man, of cultural advances now three or four centuries old. However, we find that even physicians and surgeons did not give the Alexandrians the importance that historical hindsight attributes to them, nor did they recognise Galen as authoritative as Galen's and later ages believed him to be. To a certain extent this is true of the East as of the West: Aretaeus of Cappadocia in Asia Minor was contemporary with, or slightly later than Galen, but does not mention him. Fragments of anatomy and physiology that can be gleaned from his surviving works on the signs and causes of acute and chronic diseases[3] come from a variety of sources, some of them purely traditional. Indeed, in Aretaeus we see more clearly than in Galen's synthetic physiology a distinction between traditional, *literary* anatomy, and that derived practically, from dissection and observation of wounds.

From traditional anatomy comes Aretaeus's notion that the heart is the seat of the soul and that the head is the location of the senses. This preserves the ancient distinction between *thymos* and *psyche*, which we have met before, and which in Aretaeus's writings seems to ignore Galen's closely argued physiology. Aretaeus also describes a traditional origin of the vena cava in a liver composed of extravasated blood and paralleled by its analogue the spleen. The vessels of these two organs are described in terms that recall the ancient descriptions of the two fundamental vessels of the body, and his description of the nerves embodies the old confusion between muscular and nervous fibres, both called *neura*.

No one following the authority of Galen would have retained such an ambiguity or allowed the heart such a dominant position. Yet Aretaeus was aware of the work of the Alexandrians, and the hints given in his work of his knowledge of anatomy and physiology suggest that in some respects it may have been greater than that of Galen. His observation that damage to one side of the spinal cord results in the loss of function on the *same* side of the body, while damage to one side of the brain results in loss of function on the

other side of the body led to his description of the decussation of the nerves, unknown to Galen. This is essentially anatomy derived from an empirical source and is the other side of the distinction mentioned above. Aretaeus also has thoroughly empirical descriptions of the differences between the venous and arterial blood and of the motions of the arteries in wounds. Such empiricism seems to have depended on surgery, and as surgery was less dependent upon a continued intellectual Hellenistic tradition than was theoretical physiology, no doubt it suffered less at the eclipse of the classical world.

The Western middle ages

The paucity of Latin writings with anatomical content from the height of Roman civilisation until its final collapse is marked. The third century produced almost nothing in the medical field except minor treatises on popular medicine taken from Pliny. Successors to such as these would be of little importance were it not that association with the rising Christian Church gave them some permanence and importance in the Latin middle ages.

An author of one such work was Vindicianus, a friend of St. Augustine, who flourished in the second half of the fourth century. He deals with the construction of the body briefly, intending his description for those ignorant of Greek medical writings. Vindicianus notes that the ancient Alexandrians dissected bodies of the dead, 'but these are not available to us, for dissection is prohibited'.[4] St. Augustine had, like Tertullian and Celsus, accused the Alexandrians of dissection and vivisection, and it may be that his friend Vindicianus supplied him with some knowledge of the Alexandrians, and in turn was influenced against dissection. Certainly it is an apt reflection of the times that it was St. Augustine and his Church that helped to produce a moral and religious climate in which dissection could not flourish.

It is not surprising then that Vindicianus depends entirely on earlier sources, and what takes our interest are the sources selected, for on these and those of similar writers depend the anatomical ideas passed down through the Western middle ages—for example, to Salerno. Surprisingly little attention was paid in the West at this time to the works of Galen, Soranus appearing more popular. The dependence on earlier sources gives Vindicianus's anatomy a predictable slant. Little attention is given to the nervous system, and the heart reassumes some of the importance it had anciently possessed. Its anatomy is as fully described as that of any other part (except the uterus): it is muscular, defended by a tough membrane, shaped like a pine cone, and inclined to the left. It has four 'veins'—two sanguineous and two spirital.[5] Medieval texts characteristically talk of veins when arteries are also included, even though the difference between the vessels was known to the classical author whose work formed the basis of the medieval work. 'Artery' is used in Vindicianus to mean only the trachea. According to him the two sanguineous veins from the heart reach the liver, and the two spirital reach the lungs; the heart is the source of respiration. It has two 'ears' (*aures*),[6] in which are located the mind and soul of man. By ears, we should normally expect to be meant the auricles, 'little ears', but there appears to be no precedent for Vindicianus placing the soul in the auricles. The Hippocratic *De Corde* had spoken of ears of the heart, but had put the soul in a ventricle. Perhaps Vindicianus meant the ventricles, which are not otherwise mentioned; the term used for the ventricles by the second-century Greek lexicographer Pollux is also rendered into Latin as ears.[7] It is also unusual that the mind and the soul, *mens* and *animus*, if Vindicianus means to imply two different principles, should be located in the same organ, both in the heart. Perhaps Vindicianus was influenced by the Christian tradition, which had other ancient sources for such ideas—Jewish and Babylonian. Everything worthy of our attention, says Vindicianus, comes through these ears and with them is associated cogitation.

Nevertheless, the brain is more important to Vindicianus than it was to those in antiquity for whom the heart was the central organ, and the opinions of the Alexandrians appear when he observes that the human brain is more convolute and interspersed with venules than that of animals, and it is for this reason that we are wiser than any of them. This, however, is not owing merely to the convolutions, as Herophilus said, but is because the brain has more tubes 'by which understanding can reach us'. By the context, 'understanding' (*intellectus*) is to be listed among the senses—sight, hearing, taste, and smell. All sense-organs are connected to the brain, the membranes of which, drawn outwards, play an important role. This, too, seems to be an echo of the idea of some of the Alexandrians that the nerves were composed of the meningeal membranes of the brain. Sensation involves motion of the brain, according to Vindicianus.

Altogether, this is an odd mixture of ideas with

regard to the debate over the most important organ of the body—a debate which should have ended with Galen. The failure to give due regard to Galen's works brought the debate back to life and returned it to a pre-Galenic position.

Some of the few vehicles of learning in the early middle ages were the early Christian writers. Lactantius is a good example: the purpose of his *De Opificio Dei*[8] is to praise God through His creation, and it is not surprising that Lactantius sees in the human body much evidence of design and its Designer, a component of Christian thinking on science until the nineteenth century. Lactantius attacks Epicurus as vigorously as Galen attacked Asclepiades and for the same reason: not all is chance and blind necessity, but underlying the structure of the body is the purpose of its parts, set out by its Maker.

Lactantius's sources include more Latin writers than is good for his anatomy. He has an interest in Latin terminology, just as Rufus pursued the history of Greek terms. The familiar pattern of later academic anatomy is present in Lactantius's borrowings of Varro's etymologies. God covered (*occoluit*) the eyes with the eyelashes, and from this Varro derives *oculus*, 'eye'. Is not the name of the eyelids, *palpebrae*, derived from their rapid motion, which is almost a palpitation?

The ancient terminological confusion of *nervus* survives in Lactantius, who says that nerves bind the bones together. This is another of those questions that would have been settled had Galen's works been known. 'Vein' is also used as a general term, and the veins pour blood and humours into the body from the heart, the fount of living blood. Because of the religious significance of the soul much attention is given to its anatomical location. Wisdom appears to be located in the heart, perhaps on Biblical authority, but after reviewing the opinions of several Greek authors, Lactantius suggests that the soul is located in the brain, but moves to the chest in periods of abstraction or concentration, when we no longer notice things about us. Apart from these opinions of the Greeks, Lactantius's sources are mostly Latin. Varro is the most frequently cited, with constant reference also to Cicero and the *De Natura Deorum*. What became the medieval formula *homo constat ex corpore et anima*, 'man is compounded of body and soul', is employed by Lactantius, and it was the thought that the body was the means whereby the soul's action may be known that brief accounts of body structure were kept alive in the middle ages.

An ever-decreasing stock of anatomical ideas and information was maintained by the encyclopaedists. Such a writer was Isidore of Seville, whose *Libri Differentiarum* dates from about 600. It discusses the nature of the body, as did the better known *Origines* or *Etymologiae* of some thirty years later.[9] Although the two accounts did not agree in all respects, Isidore was taken as the basis of many later accounts of the structure of the body, from the seventh to the twelfth centuries.

The first chapter of the eleventh book of the *Etymologiae*, on man, is little more than a collection of glosses. The anatomical terminology is less technical than that of other subjects and is drawn from literary sources. Like Lactantius, Isidore depends on Varro for many of his etymological derivations, and while Varro drew from earlier Greek writers, Isidore knew no Greek. The purpose of Isidore's work was to provide an understanding of medical literature for those fortunate enough to count medicine among the subjects of their general education; in the early middle ages, as in Rome, the medical *craftsman* learnt his trade by apprenticeship, the master physicians by formal grounding in the Greco-Roman literature, and the well-educated lay and clerical readers, not being practitioners, from the literature with the aid of guides like Isidore. By the sixth century the study of compendia of classical medicine was an established part of monastic routine, and the Christian duty of the care of the sick provided a small channel for the survival of a medical tradition and texts.

The anatomical content of Isidore's work is a sad reflection of the general state of knowledge at the time. Veins and arteries are not clearly distinguished, and the term 'arteria' is used for the cavities of the heart, of which the *right* is said to contain more spirit, and the left more blood. The pericardial area is said to be the seat of cogitation, although the nerves (not clearly distinguished from 'sinews') are correctly said to arise from the brain. The old idea that the spleen is the homologue of the liver makes its appearance again.

Anatomical illustration in the middle ages

Besides the transmission of anatomical and physiological ideas from the classical period in the writing of the authors mentioned in the previous section, there seems to have been little other activity in the field we are considering. In particular we have little information on what was *taught* of practical and theoretical anatomy. There are seventh-century manuscripts of Oribasius in Paris[10] and some Galen and Soranus

had been translated in the previous century. There were public lectures in Ravenna in the eighth century, and Salerno came into prominence a little later. Monastic schools, significant as repositories of manuscripts, came into existence in the sixth century. Alexandria remained a centre of work for many centuries, and her scholars collected and commented on the ancient works of science. Anatomy was doubly fortunate in this, for Alexandria had been the location of much practical anatomy and of the first anatomical 'revolution'. Both in the pre-Christian centuries and, despite the destruction of the library, for several centuries in the Christian era, Alexandria was the source to which we can trace back widely spread traditions of medical and anatomical knowledge. Greek medicine was taught in Alexandria up to the eighth century and a new attitude of scholasticism was developed.[11]

One of the most interesting pieces of evidence we have of the survival of the teaching of Greek medicine is a family of manuscripts illustrated with anatomical drawings belonging to a very old tradition. The five anatomical figures of the drawings have given the group the name of the 'five figure series', and they are said by Sudhoff, who first recognised them, to express a tradition that goes back to Alexandria. Although there are Persian examples of the series, the interest of the group is that they represent survivals in the West of an anatomical tradition that did not pass under Arabic influence.[12] Surely it is no coincidence that the *five* anatomical works of the Alexandrian summary of Galen's anatomy (see below) concern themselves with the same topics as the traditional illustrations and text of the five figure series? Is not the traditional and ancient text the last stage in the summarisation of the five short anatomical works of Galen? Let us look at the evidence.

It must be said at once that although very similar in the few known examples, the text is so garbled through repeated copying that it makes little anatomical sense. One reason for this is that the text appears to have been intended as a guide to practical dissection, perhaps for students in the medical school at Alexandria, and therefore it was not capable of concise abbreviation or of ready translation into the language of the culturally inferior West, which neither understood the anatomy nor had technical terms sufficient for the Greek. We shall see that it was just these technical and practical guides to dissection that were dropped from Galen's works by the compilers and summarisers as unfit for compression. In other words the five figure series text was not a literary condensation and transmission of Hellenistic anatomy, as we may find in the patristic writers praising God for His construction of the body, but a more tangible, if more fragmentary, relic of practical anatomical teaching.

The extant manuscripts date from 1158 to 1420, but of course all are copies of very much older examples. The traditional text[13] begins: 'Here begins the description of dissection, just as Galen, that most skilful physician, dissected, vein according to vein, bone to bone, muscle to muscle, nerve to nerve'. The text continues with descriptions of the course of the vessels and nerves, and it is in these details that the texts degenerate.

The illustrations are of great interest.[14] Few of the great anatomical works of antiquity were illustrated, and nor were those of the Arabs. Galen advised against the representation of flowers by drawing, perhaps because he realised that frequent copying quickly debases the original. The unusual circumstance that the five figure series texts *were* illustrated may again suggest that they had a practical origin in a medical school. The traditional five figures show the systems of the body: there is characteristically a 'bone man' and 'vein man', and similar pictures of the arteries, nerves, and muscles. Each thus depicts one of the 'similar' parts of the body. We can recall that the similar parts were the very elements of the body. Aristotle began the *Historia Animalium* with a discussion of the similar parts, and Galen introduced beginners to anatomy by means of his short anatomical books on the five basic similar parts as they were built up into systems in the body. These five systems are illustrated by the figures of the five figure series. We shall see below that anatomical education for a long time after Galen consisted in compressing his works into an ever decreasing compass, and it was natural that teachers should seize upon Galen's own summaries of his great anatomical works, rather than use those large treatises themselves. It became customary in anatomical teaching to begin with the similar parts, as they, consisting of the elements and qualities, at once linked up with the wider world of natural science and philosophy and became a convenient beginning for a theoretical, *synthetic*, mode of teaching that went from the similar parts to the organs and systems. Galen's five short anatomical books thus stand at the head of pedagogical tradition that may also be reflected in the five figure series.

Although drawings degenerate quicker than words in the process of repeated copying by a scribe who is literate but not necessarily a gifted draughtsman, there is still a family likeness between the extant manuscript drawings. In some

cases the degeneration of the figures has meant that the organs they are supposed to exhibit are unidentifiable, such as the muscles of the muscle men. The most notable common feature of the series is the 'squatting' posture. In all cases the knees are bent out, and it has been suggested that this represents the position of the body laid out on the dissection table with the legs apart to give access to the genital organs and the inside of the thighs. One very curious feature that is in agreement with this idea is that some of the bone men and the nerve men appear to have heads in an inverted position. Is this not also the result of placing the body on the dissection table, but on its *ventral* surface with the chin extended forwards? That is, the dissection to expose the nerves is best tackled from the dorsal surface, as is that for the bones and particularly the vertebrae of the spine, regarded as the centre of the osseous 'system'. If a cadaver in this position were drawn perpendicularly on the page, the chin would be uppermost, and the mouth, nose, and eyes below it, as we see in the five figure series illustrations. In contrast, the vessels and muscles are dissected from the ventral surface, and the body is laid on its back.

A curious feature of the illustrations is a series of concentric circles in the position of the heart in the vein-man (Fig. 1). It was taken by Sudhoff to represent the vital centre, but we should expect such a representation to be in the artery-man (Fig. 2), for it was the arteries that arose from the heart, a vital centre. Perhaps these circles are a very corrupt representation of the diaphragm[15]

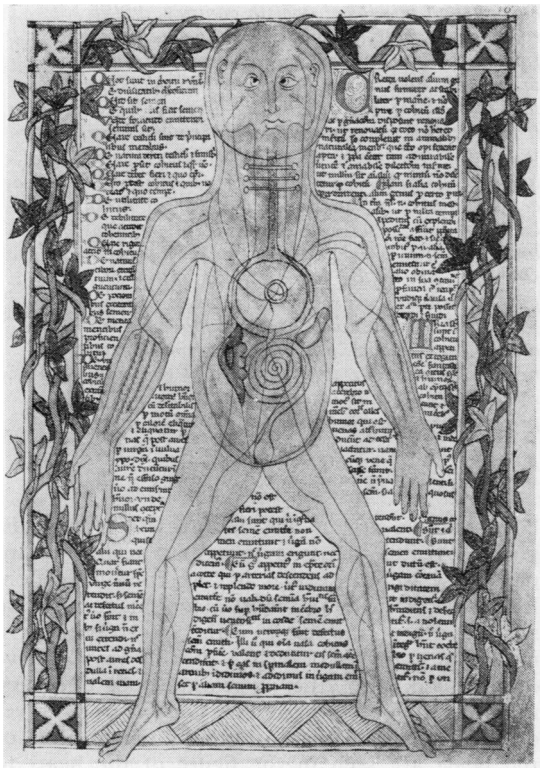


Fig. 1 *Vein-man from Ashmole 399 in Bodleian Library illustrates nutritive system of debased Galenic physiology of early middle ages: oesophagus, stomach, and intestines carry food into body and convert it into chyle, which is in turn changed into blood in liver and distributed throughout body in veins as food. Heart played no part in this process and is not shown.*

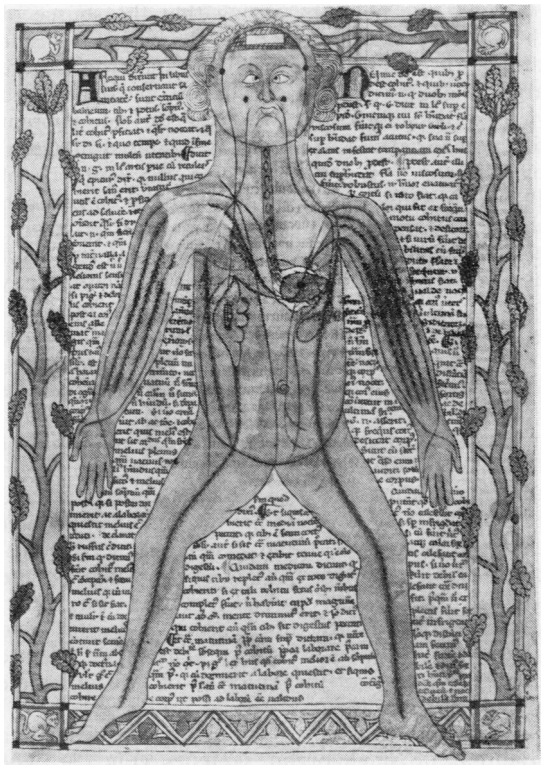


Fig. 2 *Artery-man from Ashmole 399 illustrates respiratory system: air enters mouth and is transmitted down trachea into lungs, which grasp heart closely. Spirit derived from air is passed from heart to arteries, which arise at 'black grain' within heart. Representation of branching of arteries has become so corrupt in repeated copying that arteries have taken on a feathery appearance.* Anaphusa *or* rete mirabile *is shown arising from arteries of brain.*

—that is, the point where the vena cava, as one of the fundamental pair of vessels, disappears into the thorax.

The sequence of exposition in the text follows Galenic physiology in beginning from the veins arising in the liver (which is sometimes said to be five lobed). There is some confusion between veins and arteries, but the term *arteria* is used, as we might expect in such a vestige of Hellenistic teaching: medieval texts that have passed through the Arabic generally have the phrase 'pulsatile vein' instead, because the Arabs had no technical term for artery.

This description is followed by one of the arteries, in agreement with the next stage of Galenic physiology in which venous blood is turned into arterial in the heart. There is sometimes confusion over which side of the heart gives rise to the arteries, and some manuscripts elaborate the point by saying that the source of the arteries is a mysterious 'black grain' inside the heart, 'where the spirit lives and from where arises a great vein that goes in two parts, left and right'.[16] O'Neill[17] thinks that the Galenic content of the text derives from an unrecognised medieval translation of Galen's book on the opinions of Plato and Hippocrates, in which he is at pains to show the cardiac origin of the arteries. Galen also uses the analogy of a seed placed in the heart as the origin of the arterial 'tree', and this may be the origin of the 'black grain' of the medieval texts. A branch of the artery arising from the heart forms a network over the brain, guarding and governing it; this network, the *anaphusa*, is generally illustrated in the accompanying drawing and probably represents the *rete mirabile* of Galenic physiology. It is probably a vestige of the ancient distinction between the nutritive and respiratory blood vessels of the fundamental pair that the vein-man of the five figure series illustrates the intestines, liver (and its analogue the spleen), and veins, while the second illustration contains the trachea, lungs, heart, and arteries in place of the intestines and veins. Do we see bubbles of air in the trachea of the Ashmole artery man?

Apparently related to the five figure series is a tradition of single-organ sketches (Fig. 3). The two traditions are particularly well illustrated by two manuscripts, Ashmole 399 at Oxford and Roncioni 99 in Pisa. It is worthy of note that the right side of the stomach is represented on the left, and vice versa. This is a convention that arises from the circumstance that such organs are dissected from the cadaver from the ventral surface, so that the right side of the body and its organs are on the left of the dissector. Again, this is a hint that in the distant past these were drawings of an actual dissection. Below the stomach in the Roncioni manuscript we see a figure of the heart, with blood vessels arising from it. The branches of the vessels have degenerated into the appearance of feathers, reminiscent of the branching vessels and nerves of the five figure series. Perhaps the auricles of the heart are seen in the figure of the heart to the right of this. Below and to the left of the stomach is the five-lobed liver embracing the stomach, and below that is a representation of the trachea bearing the words, 'fauces et inde spirat' to indicate the passage of the breath; the cross hatching probably represents the cartilaginous rings of the organ.

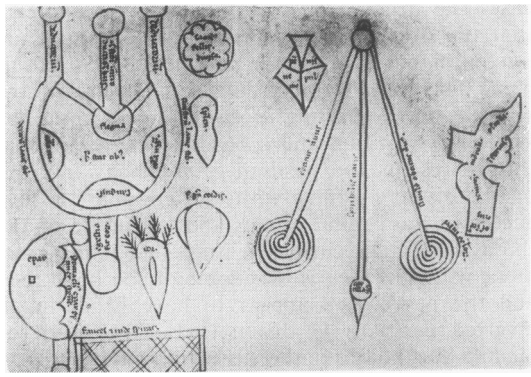
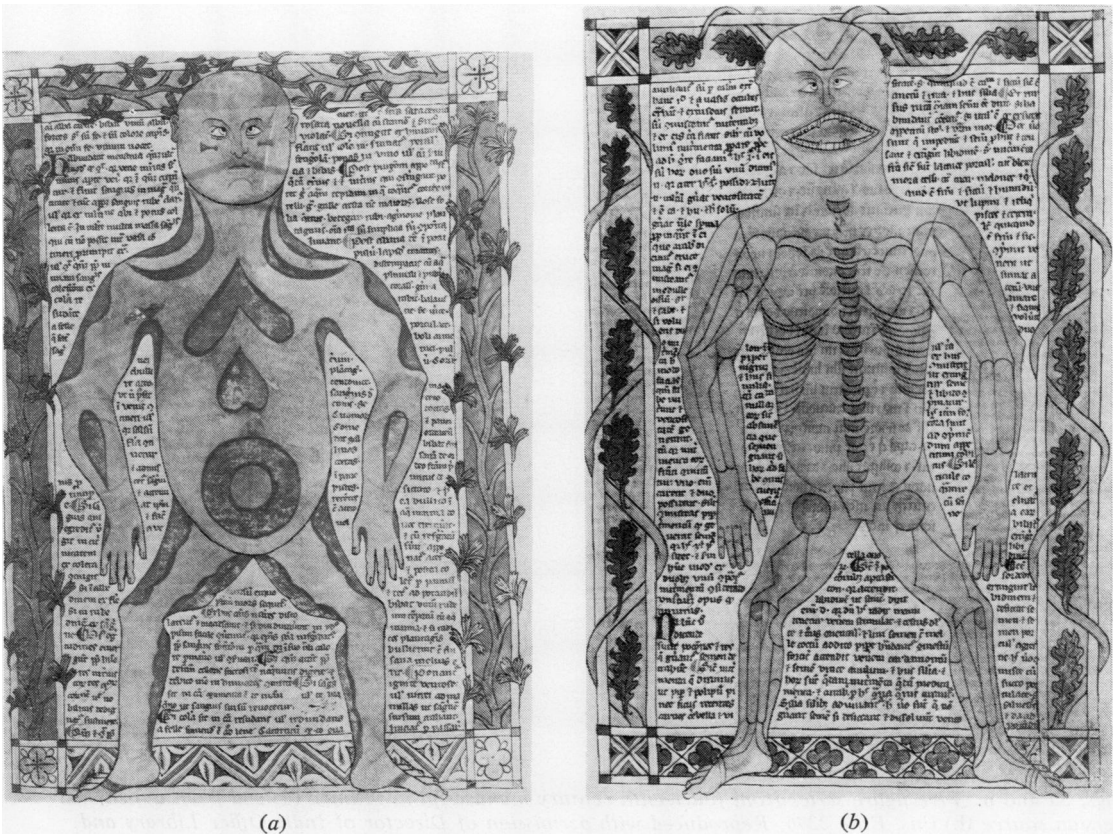


Fig. 3 *Single-organ sketches in Codex Roncioni in Pisa. Drawings like these in number of medieval manuscripts represent tradition probably as old as that of five figure series. They may have originated in practical drawings of dissected organs in late Alexandria. No extant manuscript containing them is earlier than middle of twelfth century, and in repeated copying drawings have degenerated into formal shapes. Thoracic organs in this group are diamond-shaped lungs at top centre, pear-shaped heart with feathery, branching vessels emerging from its top (below lungs to left), and its neighbouring 'figure of the heart' showing what are perhaps auricles. Below these two figures is section of trachea, cross-hatching possibly vestige of representation of cartilaginous structure of organ. Other organs, from left to right, are liver (above trachea), grasping stomach with its five lobes; stomach (top left) with part of oesophagus, showing symbolic separation of food into four humours at its periphery; gall bladder and below it spleen; a pair of eyes and a nose, with nerves to the brain; and a section of gut, including* monoculus, *caecum of herbivores, thought to be present (like the five-lobed liver) also in man.*



(*a*) (*b*)

Figs. 4a and b *Bones and external musculature of thorax from Ashmole 399.*

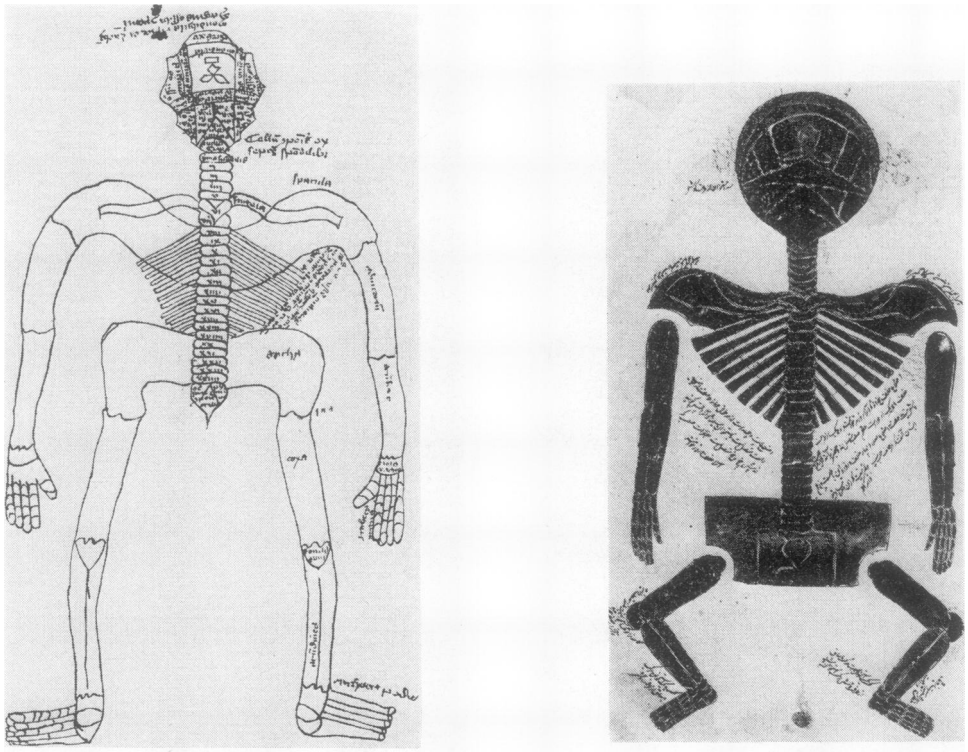
Eastern translators and encyclopaedists

Hellenistic medical knowledge was preserved, but not added to, by scholars of the Eastern Empire and by the Arabs. Oribasius[18] in the fourth century collected fragments of Galen's anatomy with a degree of scholarship that enables us to reconstruct lost Greek texts of Galen[19] (including details of the experiments on the recurrent laryngeal nerve, the spinal nerves, and the control of thoracic motions).[20] The process of summarising Galen's works ultimately produced in Alexandria the 'sixteen books of Galen', a very condensed version of his entire medical system that became the Byzantine canon of medicine from the seventh century. The anatomical and physiological works[21] were compressed into a single *On Anatomy for Beginners*,[22] which is possibly the origin of the five figure series.

Translation into oriental languages began with the Christian priest Sergios in the sixth century, who rendered Galen's five short anatomy books into Syriac.[23] The Nestorian Christians, moving east from Byzantium, took Galen's medical knowledge with them and translated the important Greek texts into Syriac and then Arabic for prominent practitioners, both Christian and Arabic. Alexandria itself became a Christian city in the seventh century, and a historical silence descends over the final two centuries of its medical school; the surgical work of Paulus Aegineta[24] stands out alone from this period. Byzantine medicine was little better. Aëtios, Alexander of Tralles, and Theophilus[25] in the sixth and seventh centuries are names that move from Byzantine Hellenism to the Western middle ages; Meletios the monk and Leo the physician[26] (eighth and ninth century) wrote with a Christian piety and medical ignorance that were extreme.

The Arabs[27]

When the Arabs overran Eyypt in 642 it was not the end of Alexandrian science. The library sur-



(a) (b)

Figs. 5a and b *Five figure series from fourteenth century manuscript in Munich* (a) *and from a medieval Persian source* (b) (*ms. Ethé 2296. Reproduced with permission of Director of India Office Library and Records.*) *Both examples have inverted head, probably indicating practical origin of drawings. Vertebrae of spine are numbered in Munich drawing, as they are in 'nerve-man' drawing in Persian manuscript where, however, thoracic vertebrae appear to be numbered separately.*

vived, the major medical works had already been translated into Arabic and Syriac, and figures such as Paulos Aegineta stayed in Alexandria under Islam. Down to the ninth century the methods of the Alexandrian school were followed in the 'School of Wisdom' in Bagdad.

The most important of the early translators[28] was Hunain Ibn Ishaq, the Joannitius of the Latin West, born in 809, and the most important works that were translated, for our purposes, were Galen's technical and detailed work on anatomical procedures and his reasoned, functional anatomy of *De Usu Partium*. This work was translated by Hunain, working from an incomplete and faulty translation of his relative Hubaish. The existence of a faulty Syriac and *incomplete* Arabic translation at one stage is interesting, for the first version of the work to reach the West was an abbreviated, imprecise, and incomplete translation known as *De Juvamente Membrorum*. The abridgment was probably made in the translation from the Greek rather than during its passage from Arabic or Syriac to Latin. This abbreviated version became popular in the West and survived even after the recovery of the full work, and had some influence on the development of anatomy in the West, being used for example by Mondino. This work will be looked at a little more closely in a later article.

It is certain that Mohammedan authors had no experience of practical anatomy, for there was an absolute prohibition on the dissection of the human body and the pictorial representation of the human or animal body;[29] the Arabs were necessarily commentators and compilers. The first author to assimilate and represent Galenic anatomy in the ninth century[30] after the labours of the translators was Abu Bakr Muhamma ibn Zakariyya, who was born in the Persian town of Ray and so was called in Arabic al-Razi; in medieval Latin, Rhazes. Of interest to the historian of anatomy is his *Liber Almansoris*[31] as it was known in the West. The admiration that

Galen showed for the wise and provident creator of the body became as easily a reverence for Allah among the Arabic writers as a reverence for God and Creator among the Christian writers of the West. Rhazes's anatomical section begins 'The Creator, who is great and powerful, created the bones to be the framework and support of the body'. The prooemium to the anatomical chapters deals with general considerations and is the closest Rhazes comes to discussing the place of anatomy in medicine and the foundations of anatomy.

Rhazes continues with a brief description of the function of the nerves, brain, and spinal cord, together with observations that recall Galen's experimental lateral section of the cord in the thorax and the comparatively innocuous longitudinal section of the cord. The importance of such anatomy in medical practice is not lost on Rhazes, and he mentions Galen in retelling the story of the traveller who fell from his carriage and damaged several vertebrae.

In condensing Galen's anatomy into a synopsis, Rhazes naturally omits much detail 'For it is not intended to be a complete and detailed book, but a concise and compendious work'.[32] The blood vessels between the heart and lung are only mentioned, and the reader gains no clear idea of the motion of blood, air, and *pneuma* through them, nor of Galen's elaborate reasons for calling the pulmonary artery the arterial vein and the pulmonary vein the venous artery, questions fundamental in physiological history. Similarly, although the valves of the heart are briefly described in a Galenic manner (that is, regarding the auricles as extensions of the vessels) and they are said to allow a flow in a particular direction, they are described as 'membranes' and the looseness of the descriptions indicates the beginning of a loss of force of the concept of 'valve' that continued through the middle ages and contributed to the lack of precision in thought about the action of the heart and motion of the blood. This is further illustrated in another summary of Galen's anatomy, the *De Juvamente Membrorum*.

The next important Arabic medical compilation with an anatomical content after that of Rhazes was the work of his fellow Persian Ali ibn ul-'Abbas al-Majusi, known to the Latins as Haly Abbas. He flourished in the latter half of the tenth century and died in 994–5; his *Liber Regius* was designed to overcome the shortcomings of original Galenic writings, and earlier summaries of them. It was to cover the whole field of medicine; it was to be detailed, but not long-winded or too concise; it was not to engage in lengthy justification of an opinion in the face of criticism. Here is an explicit criticism of Galen's 'faults' which the Arab writers attempted to overcome in their summaries. They often, too, omitted his lengthier discussions of nature and her purposes, and of his practical instructions, just as Oribasius had.

One fundamental anatomical question that has to be asked of Galen's anatomy in Arabic hands concerns the fate of the notorious 'pores' in the interventricular septum of the heart. Haly Abbas describes only a 'passage' between the ventricles, 'which several call a third cavity, but which is not'. Does the then current notion of a third ventricle derive from Aristotle? And is the 'passage' described by Haly a kind of compromise between Galen's and Aristotle's account? Haly observes that the passage is wide on the right side of the heart and becomes progressively narrower until it opens into the left ventricle. The reason for this is said to be to allow into the left ventricle only the finest parts of the coarse, liver-produced blood of the right ventricle. Galen does not assign such a function to his septal pores, although such a process as Haly describes would serve the Galenic purpose of having fine and pure blood in the left ventricle. There seems to be some slight echo of Aristotle here, but the structure and function of the 'venous artery' and 'arterial vein', on the other hand, are dealt with in an orthodox Galenic manner.

Without question, the greatest of the Arabic-writing medieval natural philosophers and physicians was Avicenna. Like his two predecessors in Arabian medicine, he was Persian by birth, Abú 'Alí Husain ibn 'Abdu'llàh ibn Sina. He was born in 978 and died in 1036 and thus for a short time his life span overlapped that of Haly Abbas. Unlike Rhazes, Avicenna was noted for his complete mastery of philosophy, and this appears in his treatment of medicine.

There can be little doubt that the anatomical sections of the *Canon* owe at least their principles of exposition to Haly Abbas or Rhazes, or both. General considerations are followed by a very detailed account of the similar parts and the organic parts in the same sequence as the accounts given by his predecessors. It is therefore no surprise to find that the detailed anatomy is basically Galenic (although with a more Arabicised terminology) nor to learn, in the works of one also known as the 'Second Teacher' (Aristotle being the first) that much of the *presentation* of this anatomy is modified by Aristotelian ideas. The problem was an acute one for the encyclopaedist and compiler; who of the ancients is the

most authoritative? Whose authority shall prevail and in what field? In anatomy the dispute lay for Avicenna as for more recent times between Aristotle and Galen. No philosopher, and particularly one like Avicenna who made a summary of Aristotle's writings on animals, would ignore the Philosopher on the nature and function of the parts, and no physician, educated on precise translations of the Galenic canon would dismiss the Prince of Physicians on the same ground.

Which, then, is the most important organ of the body? Many of the ancient philosophers, answers Avicenna, thought it was the heart, the organ that gave life and faculties to the rest of the body and which received nothing in return. On the other hand, he adds, the physicians consider that the faculties are distributed through the body and that there is no part which gives and does not receive. His own view is that although the physicians at first sight seem to have the clearer case, yet deep and subtle reflection reveals that the argument of the philosophers is the more correct. (It will be seen below that Avicenna's adoption of the Aristotelian view here leads him to accept the anatomical absurdity of a three-chambered heart). His attachment to the philosophers' case stems from his conception of the relative roles of medicine and philosophy. It is not, he says, the function of the physician to demonstrate by arguments which of these opinions is true. It is not the concern of his practice or of his research, for it does not matter to him, medically, whether the heart acts *through* the brain as the source of the psychic functions and through the liver as the source of the nutritive faculty, or whether the brain and liver act independently, for in all cases the effect is the same for the practical physician.

In suggesting that the heart acts *through* the brain as the origin of the psychic faculties, Avicenna is anticipating or originating a device that came into full flower in the later middle ages in similar circumstances; that is, the reconciliation of Galenic and Aristotelian positions. It was then common to say that the heart was (as Aristotle had said) the *true* source of the nerves, but nevertheless the *immaterial* source of the nerves, which were seated *radicaliter* in the heart and took merely their physical origins in the brain.

In dealing with the anatomy of the heart, Avicenna observes that it has three cavities, two large and a central small cavity. In the latter is preserved a supply of nourishment for the heart, and like the heart's own substance, it is thick and strong. With the other evidence we have of the influence of Aristotle upon Avicenna, we might well suppose that this is a recurrence of Aristotle's statement. We have seen above that Aristotle did indeed think that the central cavity was a common centre for the other two, which might imply a function as storage for nutriment, but he states that it is full of pure and fine blood, not 'thick and strong' as Avicenna said.

Moreover, when we turn to Avicenna's treatise on animals, much of which is taken expressly from Aristotle, we have an ambiguous account of the heart. At first Avicenna gives a Galenic account of the structure of the heart, with the three kinds of fibres, longitudinal, circular, and transverse, for the three faculties of attraction, retention, and expulsion. Then the description of the three ventricles follows as in the *Canon*, and this in turn is followed by a Galenic account of the vessels of the lung and heart. Next comes a loose description of the valves of the heart, which cannot be Aristotelian, and in necessary relation to this, a clear reference to the *two* ventricles of the heart. In fact, *De Natura Animalium*[33] is no abridgment of either the *Historia Animalium* or *De Partibus Animalium* of Aristotle, but a reasoned discourse with material selected from both Aristotle and Galen, and the frequent contests we have met before between the Philosopher and the physician. Again we have the dispute over the cardiac 'origin' of the nerves, with the interpolated ' . . . dixit Medicus maximus . . . ' and ' . . . dixit Philosophus' of Michael Scot's translation. The conflicting opinions of the two authorities on generation are again aired, and if Avicenna depends more on Aristotle[34] for the comparative anatomy of the generative organs, then his basic physiology is Galenic in all its major branches. Human anatomy is on the whole taken from Galen, comparative anatomy from Aristotle. The structure and function of the lungs for example are taken from *De Usu Partium*, and the nature of the liver and veins follows the familiar Galenic pattern.

The pulmonary transit

The most interesting Arab contribution to medicine was the announcement, afterwards forgotten, of the pulmonary circulation, which has received much attention from historians of medicine. Although its author, Ibn al-Nafís, died in Cairo in 1288 and thus lived after the revival of medicine in the West, he is best considered in the context of earlier medieval Arabic medicine.

It was in commenting on Avicenna's *Canon* that Ibn al-Nafís observed that while the blood must get from the right to the left ventricle of

the heart, yet 'between these two there exists no passage. For the substance of the heart is solid, and there exists neither a visible passage, as some writers have thought, nor an invisible passage which will permit the flow of blood, as Galen believed'.[35] 'Some writers' clearly refers to Avicenna and Haly Abbas.

The necessary conclusion of denying a passage through the interventricular septum of the heart, while still accepting the remainder of Galen's physiology, was that blood moved from the right ventricle through the lungs into the left; in other words the pulmonary circulation. What was the origin of Ibn al-Nafís's anatomical observation of the impenetrability of the septum? He himself said that he had no first hand knowledge: '. . . the veto of the religious law and the sentiments of charity innate in ourselves alike prevent us from practising dissection. This is why we are willing to be limited to basing our knowledge of the internal organs on the sayings of those who have gone before us'.[36] However, he disagreed with Avicenna not only over the penetrability of the septum, but over the existence of a third ventricle. His admiration is reserved for Galen,[37] whose mistakes he does not emphasise beyond pointing out the absence of septal pores. Ibn al-Nafís must have had in his library an anatomical work that he respected, if he was to prefer its opinions to those of Galen, Aristotle, and Avicenna. It must also have been detailed, if it dealt with the nature of the septum, which Ibn al-Nafís says is 'thicker than the other parts'. What 'sayings of those who have gone before us' could answer this description? A possibility is the Hippocratic *De corde* (*On the Heart*), in which as we have seen the blood is said to be *prevented* from reaching the left ventricle, the seat of the mind. Certainly the author of this work did not envisage pores in the septum. On the same theme Ibn al-Nafís says that the right ventricle contains blood, but that the left contains spirit, which blood from the right ventricle is *prevented* from reaching for fear of damage. Only the very finest, almost spiritualised blood reaches the left side of the heart through the lungs.

In modifying Galen's anatomy, Ibn al-Nafís is able to proceed almost undisturbed in Galenic physiology. He has Galenic reasons for the difference in structure of the arterial vein and venous artery, and has no need to conjecture a different structure for the lungs, for Galen himself had said that it was possible for blood to flow across them. It is worth repeating Temkin's observation[38] that apart from the existence of pores in the septum, Ibn al-Nafís differed in another important anatomical particular from his co-discoverer of the pulmonary circulation, the later Michael Servetus. This was that Servetus believed in the existence of vessels intermediate between the venous artery and arterial vein in the lung, while Ibn al-Nafís held that the blood filtered out of the one vessel into the other. Ibn al-Nafís had written a separate commentary on Galen's anatomy[39] and so was well acquainted with the subject. He emphasised the use of comparative anatomy in coming to conclusions about human anatomy, and he suggested that the studies entered into by the 'ideal man' should begin with anatomy.

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