rights and to be making, by their suffering and death, a form of expiation and compensatory contribution to the general good.[34]

Even if the reports of vivisection are rejected as polemical exaggeration, there is no doubt that systematic research into the internal anatomy of the human body was first carried out in Alexandria by Herophilus of Chalcedon.[35] Of Herophilus' early life nothing is recorded, save for a period of study with Praxagoras, which may have introduced him to the writings of Hippocrates.[36] But although his familiarity with them even led some later doctors to believe that he was the author of the Hippocratic treatise *Nutriment*, he was no slavish Hippocratic. He took a critical view of Hippocratic prognosis, and, although he based his physiology and pathology on the theory of humours, his interpretation did not necessarily agree with that of *The Nature of Man*.[37] His interest in the meaning of Hippocratic words and technical terms fits nicely with his penchant for giving striking names to some of the anatomical structures that he discovered. The calamus scriptorius (a pen-shaped groove in the brain), the torcular ('wine-press', for the junction of the veins of the head), the choroid plexus of the brain (so-called because it resembles membranes wrapped around a foetus), the styloid 'pen-shaped' process of the skull, the duodenum ('twelve-fingers long') and perhaps the pineal gland ('pine-cone') are all terms coined by Herophilus.[38]

His anatomical studies covered the whole of the body, from a careful enumeration of the coats of the eye and the first detailed description of the human liver and possibly the pancreas, to the male and female reproductive systems.[39] He continued an interest of Praxagoras' by studying the nervous and the vascular systems, distinguishing between veins and arteries anatomically, as well as functionally, by noting the greater thickness of the arterial coats.[40] He may have been the first to recognise the significance of the hepatic portal system, and he was acquainted, at least partially, with the valves in the heart.[41] He seems to have rejected Praxagoras' opinion that the arteries carried only *pneuma*, spirit, the vehicle of sensation, in favour of a belief in a mixture of blood and *pneuma*.[42] Centuries later, Galen was impressed with his work on the nervous system, by which he revealed the various coverings of the brain and distinguished between its ventricles, as well as displaying a detailed knowledge of several of the cranial nerves.[43] Although much of this anatomy was carried out on animals – his description of the womb is that of an animal, while that of the *rete mirabile* is based on an ungulate – several of his comments, and his deliberate use of comparisons when talking about the liver, prove that he indeed dissected humans too.[44]

The emphasis in later authors on his anatomical discoveries has tended to obscure the fact that they formed only one part of his activity as a medical practitioner and writer. They provided information that could then be turned to more practical purposes – his dissection of the womb, for instance, contributed data for his book on midwifery, in which he discussed, *inter alia*, multiple births and uterine prolapse.[45] His division of the nerves into motor

and sensory nerves and his investigation of their co-operation with muscles in voluntary motion have a clear medical value when dealing with cases of paralysis.[46] Above all, his studies provided an anatomical justification and explanation for pulsation, which he considered of crucial importance for diagnosis.[47] To this end he constructed a portable water-clock by which to time the pulses, and delineated a whole series of different pulse types, classifying them by size, speed, vehemence and rhythm, using a vocabulary that has many parallels with music theory of the period.[48]

In contrast to his anatomical researches, what is known of his therapeutics can be characterised as traditional rather than radical, certainly by comparison with Erasistratus. In the eyes of Galen, his anatomical discoveries served largely to confirm the therapeutic truths that he derived from Hippocrates. Herophilus supported blood-letting and treatment by opposites, although expressing a judicious caution about the possibility of always identifying the proper cause with certainty.[49] But his refusal to discuss therapies in terms of the four primary qualities, hot, cold, wet and dry, seemed to Galen a drastic, and unnecessary, reduction in the number of options available to the physician.[50] He believed firmly in a liberal use of medicaments – 'the hands of the gods', he called them – for almost any disease, and contributed to the establishment of the Alexandrian tradition of complex pharmacology.[51] His most notorious, and most dangerous, remedy was the very potent hellebore, which he compared to a very brave general in its ability to stir up all the inward parts of the body before marching out in the vanguard.[52] But he also praised other ways of keeping fit, for 'without health one's skill remains invisible, one's strength unused, one's wealth worthless, and one's speech powerless', and a statue in his memory was adorned with gymnastic equipment.[53] In short, the range of therapies he used and the variety of topics on which he wrote should dispel any impression that he devoted all, or even most of, his time to dissection. That was only one part of medicine, which he defined as 'the science of things relating to health, of those relating to disease, and of those that relate to neither one nor the other'. Medicine thus covered the whole spectrum of physical conditions, and provided the means both to preserve and to restore well-being.[54]

By contrast with the generally favourable verdict of posterity on Herophilus, his contemporary Erasistratus of Ceos was, and remains, a much more controversial figure. Neither when nor where he lived can be established beyond all doubt. There is no need to believe that he was affected by a local law of his island that allegedly ordered all those over 60 to be put to death, and Galen's claim that he performed 'more accurate' anatomical dissection only at the end of his life, when he could devote all his time to anatomy, although plausible, lacks any objective support.[55] Although both his father, Cleombrotus, and his teacher, Chrysippus of Cnidus, were linked with the Seleucid court, there is no clear proof that Erasistratus himself was active there rather than at Alexandria.[56] Although he was later renowned as the doctor who treated the lovesick Seleucid

queen Stratonice, his name appears only at a late stage in the evolution of the story.[57] The tradition that he was, in some way, a student of Theophrastus in Athens, or of another Peripatetic, Metrodorus, cannot be substantiated either, and may simply be an attempt to explain his use of ideas and practices deriving from philosophers and scientists.[58]

None of his writings survives in more than fragments, few of them copied word for word. Even when they are cited directly, they have mostly been manipulated by one side or another in later debates to prove or disprove their case. Galen, our single most extensive source, was ambivalent about him, to say the least. On the one hand, he had little but praise for his work as a dissector of the brain and heart, quoting with approval Erasistratus' comparison of the neophyte investigator to an untrained athlete:

> As soon as his mind begins to work, he becomes confused and bewildered, ready to withdraw from his investigation in a state of mental fatigue and exhaustion, like untrained runners in a race. But with constant practice, pursuing research, not just in an hour or so, but unceasingly throughout his whole life, he comes to penetrate whatever topic he chooses, reaching his goal by persistent enquiry into everything that might be relevant.[59]

Erasistratus appears to have been the first to discover all the valves in the heart and to have examined their workings in considerable detail before concluding that they were there to prevent any reflux as the heart expanded and contracted 'like a smith's bellows'.[60] He traced the pathways of both veins and arteries, concluding that each system split into smaller and smaller veinlets and arterioles that finally joined together, but with so tiny an aperture that blood could not, under normal circumstances, pass from one system to the other.[61] His investigations of the human brain led him to change his opinion on the point of origin of the nerves, at first locating it in the *dura mater* but later within the brain itself.[62]

Galen was equally impressed with his experiments, even going so far as to repeat some of them in order to confirm or reject his conclusions. There is no doubt that Erasistratus sometimes used experimentation as a way of resolving problems.[63] He inserted a cannula into an artery to discover whether pulsation was a property of the arterial tunics or the result of *pneuma* being driven into the arteries by the beating heart.[64] On another occasion he showed that there were invisible effluvia from animals by keeping a bird in a vessel without food for some time and then weighing it together with the visible excreta and comparing this with its original weight.[65]

But, on the other hand, Galen rejected with scorn many of the conclusions that Erasistratus drew from his dissections and experiments, using disagreements between later Erasistrateans to point up the failings and inconsistencies of their master. His polemic was at times devastatingly unfair. Erasistratus'

reluctance to believe in the theory of humours as expressed, in Galen's view, by Hippocrates in *The Nature of Man* was interpreted as a wholesale rejection of humours; his refusal to accept the universal application of a Platonic 'directed' teleology as a failure to acknowledge any purposeful organisation within the body.[66] That there were others, like Anonymus Parisinus, who included him among their list of physicians worthy of mention for their views on a variety of diseases was not enough to counteract Galen's biting criticism and secure the survival of his writings much beyond the second century.[67]

In part, this was because, unlike Herophilus, Erasistratus did not fit easily into a line of development running directly from Hippocrates to Galen's own teachers. He wrote no commentary on Hippocrates, and, where influences can be discerned, he owed far more to Aristotle and his school than to Plato.[68] His intellectual exuberance led him to wide-ranging investigations and to challenging conclusions, not all of which were easy to reconcile with earlier ideas about the body. What is most striking about him is his willingness to take over into his medicine a variety of concepts and techniques that were being proposed and put into practice by a range of contemporary scientists and engineers. Far from relying on and repeating the written texts of his medical predecessors, he created his own vision of the body in part from the ideas of non-medical men. By contrast with Herophilus, whose descriptions of the body give the impression of something static, Erasistratus emphasised the body as a living and functioning organism, explicable in terms of mechanics and physics.[69]

Mechanical analogies can be found throughout Erasistratus' writings.[70] The kidneys, liver and bladder act as filters.[71] The stomach grinds and crushes ingested food like a corn-mill, producing sensations of hunger if it continues to grind on after the food has been finely milled.[72] Growth and nutrition are mechanical processes, in which the essential nutriment and *pneuma* are distributed around the body by means of an invisible threefold rope of vessels, nerves, veins and arteries, which gains strength and flexibility from their interweaving.[73] Bone, flesh and even the brain substance are then produced as *parenchyma* from this nutriment, which is distributed in part by a vacuum process. To fill the void left by the nutriment that has been taken up more nutriment is drawn in, since a continuous void is impossible.[74] Humoral fluids are present in the body, but they cause harm through blockages or overflow rather than through inducing qualitative changes.[75]

Many diseases were thus the result of some mechanical failure, which is why Erasistratus' treatises on fevers, paralysis and perhaps those dealing with dropsy and the spitting of blood all included an exposition of the relevant anatomical data.[76] Dropsy, for example, was the result of the scirrhosis of the liver, which felt as hard as a stone and which allowed only the thin watery part of the blood to pass into the veins.[77] Erasistratus' experience of treating those suffering from paralysis and mental disorders both encouraged him to investigate the anatomy of the brain and was enhanced by his discoveries.[78]

More controversial was his belief that fever and inflammation were the result of blood seeping from veins into arteries, which, in the healthy body, contained only *pneuma*.[79] To the obvious objection that, when cut, arteries bled, Erasistratus replied with an ingenious interpretation based on contemporary physics. Like the passage of blood or *pneuma* from aorta to ventricle within the heart, so too the appearance of blood in the arteries could be explained on the principle of the vacuum.[80] Just as blood or pneuma moved from one chamber to the other and then outward as the heart valves opened to allow it to flow into the space left vacant by the expelled material, similarly, when an artery was cut, the *pneuma* within it escaped and blood was drawn into it from the veins to fill the vacuum.[81] Whether Erasistratus derived his theory from Strato of Lampsacus or from observing some of the machines created by Ctesibius is less important than the fact that he saw this as a mechanical process within a system that connected veins and arteries by tiny capillaries.[82] Normally, in health, blood could not pass from one system to the other. But when the artery was cut, *pneuma* within it escaped, a vacuum was created and blood flooded in to fill the empty space. In other circumstances it was not an absence of material, but an excess, that was responsible for blood passing from veins to arteries. Within the veins there might be such a build-up of pressure of blood, 'stirred into motion like the sea moved by a gale', that it forced its way through the capillaries into the arteries.[83] Erasistratus concluded that this seepage of blood would then produce fever or, indeed, according to another report of his opinions, all manner of diseases.[84]

For Galen, this doctrine of infiltration was ludicrous and unnecessary, a perversion of sound anatomical observation for misguided clinical ends. It was open to refutation both by logic (and Galen mercilessly exposed the many weak points in its theoretical basis) and by experiment. Galen's repetition of the experimental insertion of a cannula into a ligated artery showed, he claimed, the falsity of any belief in pulsation as a mechanical process within the arteries as opposed to something transmitted within the coats of the arteries.[85] He also criticised Erasistratus for his failure to adapt his therapeutics to his theories by avoiding all mention of venesection as a swift and effective means of removing excess blood.[86] In its place, Erasistratus favoured diet, drugs and the use of bandages to move the blood away from the swelling and to prevent more blood accumulating.[87] But, at the same time, when pressed, Galen was prepared to acknowledge Erasistratus' concern for his patients, his careful attention to diet and drugs (including a dislike of strong purgatives), and his unwillingness to resort to drastic action that might have more serious consequences.[88] Nonetheless, Erasistratus was prepared to take risks. If bold treatment was called for in dealing with a dropsical patient he was prepared to promote a massive evacuation from the body, a procedure he admitted occasionally ended in death.[89] On another occasion he is said to have 'daringly' removed the covering flesh and membranes to apply drugs directly to the liver.[90] But, in general, he stressed that one was more likely to have success by

gradual means, to which the patient might become accustomed, than by drastic intervention.[91]

Erasistratus aroused controversy already in his lifetime. Yet he was also an authoritative figure whose writings and influence survived for centuries.[92] Galen had access to several of his books, apparently at first hand, which he then used to convict contemporary Erasistrateans in Rome of a lack of fidelity to their master's teachings.[93]

But if there is good evidence for the survival of his therapeutics, even if only in a misinterpreted form, it remains uncertain how far his interest in experiment and dissection was carried on by others both during and after the lifetime of Herophilus and Erasistratus. Within the Hippocratic Corpus there is a short text, *The Heart*, which contains a description of the heart, whose hidden membranes, 'a piece of craftsmanship most worthy of description', would appear to include at least the semi-lunar valves.[94] When and where this tract was written cannot be determined with certainty. Its language suggests a Hellenistic date, but the fact that its author seems to mention one set of valves, not the 'inlet' valves discovered by Erasistratus, and thinks of them in terms of 'stays', 'cobwebs' and 'fibres', not little doors, suggests that he was writing either before or in ignorance of those discoveries.[95] Nor is there evidence of a link with Herophilus or any other Alexandrian, and indications of influence from Stoic philosophy are suggestive at best.[96] While it is tempting to envisage this author carrying out an Aristotelian programme of animal dissection (for his description of the heart is likely to be that of an animal and he unambiguously recommends an experiment on a pig to show how tight the epiglottis fits), not even this is certain.[97] There are no obvious school affiliations, and no references to the work of others. All that can be said is that the author claims to be a very skilful anatomist who thinks about the wider consequences of his theme, and that, whatever his date, he is apparently working away from any obvious centre. For such a man to remain ignorant of the discoveries of Herophilus and Erasistratus might seem implausible, and hence a date in the 270s is most likely. But – and this cannot be overemphasised – our knowledge of medicine and medical groupings at this period is so fragmentary, and our understanding of the process whereby new ideas and discoveries were transmitted so fallible, that this is at best a very fragile conclusion.[98]

Another anatomist, Eudemus, was also a contemporary of Herophilus and Erasistratus, although where he lived and wrote his treatise on anatomy is uncertain. Galen praises him as a practical dissector, although one far from reliable in his conclusions, despite his technical ability.[99] Eudemus prepared a description of the bones and investigated the pancreas and the nerves, as well as the transit of the vessels in the umbilical cord from the foetus to the womb.[100] He may have seen and described the horns of the uterus, but it is more likely that, in this instance, Galen was referring to another doctor, Euenor.[101] Even less reliance can be put on Wellmann's attribution to him of a fragmentary papyrus from the first century BC. Its division of nerves into

motor and sensory postdates Herophilus, while its mention of the nerves in the brain and those issuing from the spinal cord continues a debate begun by Erasistratus.[102] But it is impossible to tell from the badly damaged pieces whether this was an independent record of new dissections or, more likely, a short summary of results achieved much earlier.

This evidence for a keen interest in investigative dissection in the first half of the third century BC, whether performed on animals or, in Alexandria, on humans, stands in sharp contrast to what follows. Galen's list of anatomists has a large gap between Eudemus and Marinus, who flourished at the end of the first century AD.[103] Rufus of Ephesus, who had visited Alexandria, lamented that, in his own day, the late first century AD, one had to learn the parts of the human body from observing the surface anatomy of a slave and dissecting an animal, whereas 'in the old days this was more correctly taught on man'.[104] However, the absence of interest in systematic dissection should not be mistaken for a disdain for anatomical knowledge. Celsus' discussion of dissection in his preface depends on an earlier writer (or writers) for whom the question of whether or not to dissect still addressed a practical possibility.[105] Likewise, at the beginning of the first century BC Apollonius of Citium chided Hegetor and contemporary Herophileans for their inconsistency in proclaiming the value of anatomy while failing to apply it in their practice.[106] He himself rejected dissection in favour of experience, both his own and that of others, rebutting Hegetor's anatomical explanation of a dislocated hip solely by a close interpretation of passages from Hippocrates.[107]

But even as Celsus and Apollonius participate in a debate about the value of anatomy they reveal a shift in the focus of dissection away from the investigative and experimental. They report no new discoveries, no new experiments. Even for those who regard it as essential, anatomical knowledge is subordinated to a wider medical purpose, providing a basis for such ongoing concerns as pulse diagnosis and surgery.[108] The argument of its defenders is expressed pragmatically: if one knows human anatomy well, one will be better able to treat disease and apply remedies. The general ethical objection to human dissection as unnecessarily cruel is countered only by the argument that benefits to the future innocent outweigh the harm done to a few criminals.[109] The epistemological difficulties raised by the Empiricists (see pp. 147–50) and acknowledged by Cicero are not answered in Celsus' prologue: the case for anatomy remains simply at the level of practical advantage.[110]

The perception of dissection as cruel, irrelevant and unnecessary, a perception 'accepted by most people' according to Celsus, helps to explain the decline of Erasistratean anatomy, especially if it was accompanied by social and political changes that gradually put an end to the 'frontier spirit' of early Alexandria. There was never any formal institutionalisation of the sciences, including medicine, in Antiquity comparable to the universities and medical colleges that in the Middle Ages and Renaissance provided the stability that ensured the continuation of ideas and practices from one generation of researchers to

another. It is rare that an interest in one particular aspect of research, in mineralogy or statics for example, is continued with any intensity for more than a generation or two. The shift away from anatomy from 250 BC is an instance of this, although this is not the whole story.[111] That royal protection was ever formally withdrawn is unlikely, but the arguments that might justify supporting those who wished to experiment on criminals became ever weaker.[112] Once the relevant data had been established by Herophilus and Erasistratus there was less need to repeat inhumane investigations in order merely to confirm what was already known. Some argued that new anatomical information might be found as easily by chance as by systematic anatomy, for a trained observer would not let the slightest thing escape his notice.[113] Alternatively, one might acquire all necessary anatomical knowledge from reading about it, becoming, as Galen scathingly put it, like a steersman who navigates solely from a book – and just as dangerous, in his view.[114] Others, and they were the majority, disagreed with this condemnation of book learning, and their objections still form part of a continuing debate today about the role and methodology of human anatomical dissection in the training of a modern medical student. Those who champion the need for dissection of human corpses in order to understand the human body and to become a better doctor are now opposed by those who argue that modern technology has rendered obsolete many of the doctor's former skills and that the simulated reality of an interactive video of a living body can teach the student far more than any dissection of a dead corpse. The Hellenistic dilemma is still with us today.

70 Aleshire (1989: 99) succinctly disposes of the theory that the 'drachma for Asclepius' was a tax on all citizens which created a fund out of which the public physicians were paid. An entrance fee to suppliants at the shrine is more likely, but her estimate of fifteen to twenty suppliants per day raises problems of its own. If she is right, visitors to the shrine on the occasion of any festival would not pay this tax, which would be levied only on those actually consulting the god.

71 For the public physicians, see *IG* 2^2, 772 = T. 552; for the relief, see *IG* 2^2, 4359, with Aleshire 1989: 94–5: there is a good picture in Bertier 1972: frontispiece.

72 The two lists of names were originally the same, but the relationship with the figures is far from clear (cf. Cohn-Haft 1956: 57, n. 13).

73 For these men, see pp. 124–5.

74 Erasistratus (fr. 29 Garofalo) reported that in the sanctuary of the temple of Apollo at Delphi around 280 BC hung a leaden 'tooth-puller', proof, he thought, that one ought to extract teeth when they could be removed easily and safely.

75 Aleshire 1989: 65–6. It cannot entirely be ruled out that the dedication of instruments was meant to represent the treatment previously given the patient, and that the writing tablets were the equivalent of prescriptions. If these were given by medical men, then another seven doctors or surgeons can be added to her list of medical donors.

76 *IG* II^2 483.

77 Sherwin-White (1978: 275) advises caution as the shrine was merely one of several places where such public documents were set up, and the doctors had their main centres of activity elsewhere. But the participation of doctors in the cult is known from the later Hellenistic and Roman periods. Cf. also a fragment of an honorary decree for a doctor erected at the Amphiaraon at Oropus (Petrakis 1997: no. 240).

78 [Hippocrates], *Sacred Disease* 1: VI, 354–64 L. Cf. Edelstein 1967: 205–46; R. Parker 1983: 211–34; Jouanna 1999: 260–79.

79 The author of *Regimen* (4, 87: VI, 642 L.) accepts the validity of prayer, while at the same time counselling medical intervention, and claims to have discovered all there is to know about diet with the god's help (4, 93: VI, 602 L.). But that is not the same as offering to cure solely through prayer and incantantion, for that implies a greater degree of control over divine action.

80 See also p. 65.

81 H. W. Miller 1953; Nörenberg1968; Schölkopf 1968; Kudlien 1977; Jouanna 1999: 278–9.

82 Euripides, fr. 294 Nauck = 292 Nauck^2: the first group are treated 'traditionally' (see Guardasole 2000: 84–6). Cf. the opening attempt by the Hippocratic author to define 'divine' (*Sacred Disease* 1: VI, 352 L.). Some diseases, notably mental afflictions and epidemics, continued to be viewed as in some way caused by the gods, as well as having a physical explanation, and belief in one explanation in one case did not preclude the other in another.

83 [Hippocrates], *Regimen* 4, 87: VI, 642 L.

84 Ibid. 87; 89; 90: VI, 642; 652, 656–8 L. The Athenian doctor Euenor (fl. 322 BC) commended the medicinal virtues of the spring at the Amphiaraon (Athenaeus, *Sophists at Dinner* 2, 46d).

85 Lanata 1969; R. Parker 1983: 208–13.

86 And, of course, many so-called 'irrational' prejudices remained and were often justified by 'rational' argument (see Lloyd 1979). Other healers, like the pharmacologists and rootcutters, occupy an intermediate place on the spectrum between medicine and magic.

87 See R. Parker 1983: 215, citing Plato, *Cratylus* 405a–b for an assertion that purification serves the same ends in both medicine and mantic of making man 'pure in both body and soul'.

88 Cf. Graf 1997: 30–5. The relationship of religion, magic and healing in the ancient world is notoriously difficult, both conceptually and textually, since the great bulk of our information comes from the Roman Imperial period, and there is a temptation to elide chronological differences. For a range of interpretations, see also Edelstein 1967: 205–46; Lanata 1969; Luck 1985; Faraone and Obbink 1991; Lanternari 1994; Dickie 2001.

89 [Hippocrates], *Prorrhetic* II, 1: IX, 8 L.

90 Graf 1997: 25–6, 35 (from the city of Teos *c.*470 BC), cursing those who harm it or its citizens through deadly '*pharmaka*' [spells]); but Meiggs and Lewis (1969: no. 30, p. 65) translate '*pharmaka*' simply as poisonings. Note the (much later) defence of Apollonius of Tyana against a charge of magic when curing a plague at Ephesus (Philostratus, *Life of Apollonius* 8, 7, 9–10): his forecasting of the plague was the result of his own perceptions, but the cure itself was wrought by Hercules, a healing god.

91 Galen, *Commentary on the Hippocratic Oath*, fr. 2a–e Rosenthal.

92 Cf. R. Parker 1996: 184: 'The truest explanation for the rise of Asclepius may be that he was, as it were, in partnership with Hippocrates'.

8 FROM PLATO TO PRAXAGORAS

1 Celsus, *On Medicine*, pref. 8.

2 What he did mean is far from clear, especially, as he goes on (pref. 9) to praise some eminent physicians for using their 'knowledge of nature' to improve dietetics. However, a belief in the Hippocratic authorship of *Ancient Medicine* could have led Celsus to conclude that Hippocrates rejected speculative hypotheses in medicine.

3 Plato, *Second Letter* 314d.

4 Athenaeus, *Sophists at Dinner* 2, 59C, a fragment of the comic poet Epicrates, has often been interpreted to show that he came to Athens.

5 Anonymus Londinensis 20, 25–50.

6 Plato, *Timaeus* 84a, 84d–e, perhaps also alluding to the theories of the author of *Sacred Disease*? See also Lloyd 1968; Craik 2001b.

7 Plato, *Timaeus* 82a–e.

8 Ibid. 82e–83a.

9 Ibid. 84a–c.

10 H. W. Miller 1962; Burgess, unpubl. Longrigg (1993a: 242) notes that Thrasymachus of Sardis, according to Anonymus Londinensis (11), believed that blood changed into the harmful bile and phlegm with changes of temperature. But (ibid.: 112) this is still some way from Plato's idea of the degeneration of tissues, and then of the individual parts back down into their constituents.

11 Plato, *Timaeus* 81b–e.

12 Ibid. 75a–76d. Some protection is given by hair, 'sufficient to provide shade in

summer and shelter in winter, but not to impede perception', which then raises questions about baldness.

13 Ibid. 69e.

14 Williams 1973.

15 Plato, *Timaeus* 44d–45b, 69e–72d.

16 Ibid. 86b–89d.

17 Anonymus Londinensis devotes more space, four columns (XIV–XVIII), to Plato's ideas in the *Timaeus* than to those of any other author.

18 See pp. 222, 231.

19 Todd 1976.

20 Chalcidius (*c.*AD 400), *Commentary on Plato's Timaeus* 246; pp. 256–7 Waszink, discussed on p. 48 here; Lloyd 1991: 164–93.

21 One might compare their different uses of medical information in their ethical discussions (see Jaeger 1954).

22 Aristotle, *On Sensation* 436a; *On Breathing* 480b; van der Eijk 1999c.

23 This hypothesis was not as strange as it might seem to us, since the discovery that the nerves originated in the brain was not made for another generation.

24 For the Aristotelian sections of Anonymus Londinensis, see pp. 58–9, 72

25 Theophrastus, *Enquiry into Plants* 4, 3. *The Oxford Classical Dictionary*, ed. 3: 238, s.v. bematists.

26 Ross 1971: 112–14; for the ostrich, see Aristotle, *The Parts of Animals* 4, 13: 697b.

27 Aristotle, *The Parts of Animals* 1, 5: 644b–645a.

28 Longrigg 1993a: 161; cf. Gotthelf 1985; Gotthelf and Lennox 1987.

29 Aristotle, *Enquiry into Animals* 1, 16: 494b.

30 Kollesch 1997.

31 C. R. S. Harris 1973: 121–56. One should remember that this is also the first Greek description of the heart to refer to chambers.

32 Aristotle, *Parts of Animals* 3, 4: 666b.

33 Aristotle, *Enquiry into Animals* 3, 3: 514a.

34 Lloyd 1983: 94–104; Dean-Jones 1994: 81; Föllinger 1996.

35 He wrote a work, now lost, on 'Health and Disease', and possibly others. Cf. van der Eijk 1999e.

36 Moraux 1984: 729–72.

37 Scarborough 1978; Fortenbaugh and Gutas 2002; Fortenbaugh *et al.* 2003; Debru, unpubl.

38 Kollesch 1997: 370.

39 Galen, 2, 281–2 = Diocles, fr. 17; cf. also fr. 24. The fragments of Diocles are cited from van der Eijk 2000–1, which supersedes Wellmann 1901.

40 Quotations from Pliny, *Natural History* 26, 6, 10–11 = fr. 3; and Anonymus Bruxellensis, *On the Seed* = fr. 2 van der Eijk.

41 Van der Eijk 2000–1: II, xxxi–xxxviii. The older theory of Jaeger that he was much younger than Aristotle is based on very doubtful evidence (see von Staden 1992b).

42 Diocles, fr. 23c–d van der Eijk, with the commentary at II: 39–41, pointing also to the divergences from the theory attacked by Aristotle (*Generation of Animals* 746a).

43 Wellman 1901: 234; against the attribution, see C. R. S. Harris: 1973: 105–6;

van der Eijk 2000–1: I, xi, who does not include this passage among the fragments of Diocles.

44 Diocles, fr. 40, 6 van der Eijk.

45 His notions of embryology included a belief in both male and female seed, and in an embryo that was formed in forty days and then developed faster in the womb for boys than girls (see fr. 40–8 van der Eijk).

46 For bandages, see fr. 162, 166 van der Eijk; for the spoon, see fr. 167 van der Eijk, with the drawing in Krug 1985: 101. The so-called Dioclean spoon, now in the Meyer-Steineg collection at Jena, is a modern forgery (or a copy of a lost original) (Salazar 2000: 49, 102).

47 For poisons, see fr. 215 van der Eijk; for vegetables, see fr. 200; cf. fr. 193–211; for *Rhizotomikon*, see fr. 204; for pharmacology, see fr. 145–8; for a prescription, see fr. 221 = P. Antinoopolis 123.

48 Fr. 65–71 van der Eijk. Caelius Aurelianus complained that he regulated the patient's diet according to the number of days of illness (fr. 92 van der Eijk).

49 Fr. 97, 143 van der Eijk. W. D. Smith 1979: 181–9. Hippocratic texts possibly known to him are *Aphorisms*, fr. 55b; *Epidemics 3*, fr. 57; *Prognostic*, fr. 64; and *Joints*, fr. 162–3, but the linkage is made clear only by later authors. For the apparent citation of *The Eighth-month Child* and *Nutriment* (fr. 40, 5), see van der Eijk's commentary *ad loc.*

50 Diocles, fr. 27, 51 van der Eijk.

51 Diocles, fr. 27, 40 van der Eijk; the different version given in fr. 183a, 6 does not come from a genuine work by Diocles.

52 Diocles fr. 95, 98, 102 van der Eijk. But note that Diocles speaks only of the thick artery and offshoots coming from it and the heart. His vascular anatomy is still sketchy.

53 Diocles, fr. 74, 80; cf. fr. 101, 107 van der Eijk. The words 'psychic *pneuma*', however, may not be those of Diocles himself.

54 Jaeger 1913; Verbeke 1945.

55 Diocles, fr. 51, 53, 89, 92, 182 van der Eijk.

56 Diocles, fr. 183: 40, 5; 41 van der Eijk.

57 Diocles, fr. 168, although the conditions mentioned are all directly related to the womb and to childbirth (fr. 168–75 van der Eijk).

58 Diocles, fr. 180–1 van der Eijk.

59 Diocles, fr. 185 van der Eijk.

60 Diocles, fr. 176–7, 188, 191, 195, 200, 222–3, 225, 228–9, 233 van der Eijk. Several other unassigned fragments are likely to come from this work.

61 Diocles, fr. 176 van der Eijk 1996, noting also the modification of Galen's position with regard to this passage from Diocles in *On Medical Experience* 13, 4–5: tr. Walzer and Frede 1985: 109 = Diocles, fr. 16, cf. fr. 49.

62 Galen, *On Examining the Physician* 5, 2: *CMG* Suppl. Or. 4, 69; *On Medical Experience* 13, 4. Pleistonicus was a pupil of Praxagoras but his home town is not recorded.

63 The most recent edition is by Garofalo (1997).

64 Anonymous Parisinus 8, 1, 1–4 = Erasistratus, fr. 180 Garofalo; Diocles, fr. 87 van der Eijk; Praxagoras, fr. 67 Steckerl; [Hippocrates], *Places in Man* 14: VI, 303 L.

65 van der Eijk 1999b.

66 Galen, *On Medical Experience* 13, 4: tr. Walzer and Frede 1985: 70 (not in van der Eijk: should one read Dieuches for Diogenes?).
67 Fragments in Bertier 1972. Mnesitheus, fr. 10, 11 B.: for the Hippocratic method of division, see p. 57 here.
68 Diocles, fr. 40, 2; 27, 5 van der Eijk.
69 Mnesitheus, fr. 12–16 B.
70 Fragments in Steckerl 1958. Praxagoras, fr. 50–2, 54–60 St.; Phylotimus, fr. 12 St.
71 Galen 2, 141 = Praxagoras fr. 21 St.; Rufus, *The Names of Parts* pp. 165–6 Dbg = fr. 22 St., linking with older ideas about fluids.
72 Galen 10, 260 = Praxagoras, fr. 97 St.; venesection, Galen 11, 163 = Mnesitheus, fr. 5 B. = Dieuches, fr. 3 B. = Praxagoras, fr. 98 St.; prognosis, Galen 9, 728 = Praxagoras, fr. 93 St.; Galen 9, 775 = Pleistonicus, fr. 24 St.
73 Galen 9, 728 = Praxagoras, fr. 93 St.; Plutarch, *Questions about Nature* 26: 918D = Mnesitheus, fr. 16 B.
74 Dieuches, fr. 15 B.; Praxagoras, fr. 105–8, 113 St.; Phylotimus, fr. 21 St.; Pleistonicus, fr. 6 St.; Herophilus, T. 255 von Staden.
75 Mnesitheus may have written a whole tract on hellebore (fr. 48 B.). Cf. Pliny, *Natural History* 25, 21, 47–25, 61; André 1955; Girard 1988. Both black and white hellebore were still noted in *The British Pharmaceutical Codex* for 1907 (although by then the rhizome of the white variety was recommended only in a powder to keep moths away). From the 1950s, extracts have been used against hypertension (see Trease and Evans 1978: 619–20).
76 Caelius Aurelianus, *Acute Diseases* 3, 17, 163 = Praxagoras, fr. 109 St. Details of other surgical treatments advocated by this group of doctors are scanty; Celsus and Galen report that both Diocles (fr. 165 van der Eijk) and Phylotimus (fr. 23 St.) devised a successful way of resetting a dislocated femur.
77 Porphyry, *Homeric Questions* 165 Schrader = Praxagoras, fr. 36 St. With the possible exception of fr. 120, none of his fragments deals specifically with the properties of foods, although diets are recommended as part of the healing process.
78 Cf. the slightly later discussions about dietetics as the third part of medicine by the Alexandrian commentators on Homer (Erbse 1974: III, 222).
79 Mnesitheus, fr. 18–20 B.; Dieuches, fr. 13–18 B.
80 Dieuches, fr. 19 B.
81 Scarborough 1970.
82 Phylotimus, fr. 4–21 St. I take the numbers in fr. 11 to refer only to one book, 13, *pace* Steckerl (112–13), who understands, 3 and 10. For another (late) Hellenistic writer on dietetics, the Erasistratean Hicesius, see Gourevitch 2000.
83 Phylotimus, fr. 11, 12 St.
84 Galen, 15, 136 = Dieuches, fr. 4 B.
85 The one surviving fragment of Mnesitheus' treatise on the *Constitution of the Body* (fr. 17 B), although revealing little about his own dissections, seems to depend heavily on Aristotle.
86 Although his authorship of a treatise on *Foreign Diseases* (fr. 63 St.) suggests that he spent some time away from Cos, either as a student or, later, as a travelling physician. His dates are disputed. If he is the father of Praxagoras, son of Praxagoras, named on a Coan contribution list of *c.*260 BC (Sherwin-White 1978: 102), he was active in the last quarter of the fourth century and the first decades

of the third, which would agree with the evidence for influence from Aristotle and Diocles.
87 Sherwin-White 1978: 216; for Phylotimus and his family, see ibid. 105, 195.
88 Although it is highly likely that he was acquainted with the writings of Hippocrates and traditions about him, proof is singularly elusive (see Nickel, unpubl.).
89 Praxagoras, fr. 15 St.; Phylotimus, fr. 1–2 St.
90 Praxagoras, fr. 10–11 St. The word that later is used for 'nerves', *neura*, can also mean ligaments and sinews, but the association with sensation suggests that Praxagoras thought of them as our 'nerves'.
91 Praxagoras, fr. 7, 8, 9, 11 St.; cf. Solmsen 1961.
92 Praxagoras, fr. 85 St.; for Diocles, see p. 121 here. Longrigg (1993a: 174–5) argues for a substantial influence of Diocles and Sicilian medicine on Praxagoras, although he allows for some independence. An alternative view is that both Diocles and Praxagoras were working out the consequences of Aristotle's ideas, for example that *pneuma* and the source of sensation were located in the heart.
93 Pleistonicus, fr. 3 St.; Phylotimus, fr. 2 St.; Herophilus, see pp. 132–3 here.
94 C. R. S. Harris 1973: 110–13.
95 Praxagoras, fr. 26–8 St.
96 See p. 133.
97 *Planudean Anthology* 273 = Crinagoras, poem 52, ed. Gow and Page. It is tempting, but unnecessary, to see a link between this epigram and poem 22, referring to a recent incident on Cos, and to conclude that Crinagoras had seen this statue during a visit to Cos.
98 This is not to deny that many texts still lack a known author, either by accident or because their authors wished to associate their ideas with a famous name, as with the so-called *Letter* of Diocles to King Antigonus (fr. 183 van der Eijk), with its unusual seasonal medicine.
99 See Chapter 3, n. 97.

9 ALEXANDRIA, ANATOMY AND EXPERIMENTATION

1 Edelstein 1967: 247–302; Kudlien 1969; Fraser 1972: I, 335–56; Longrigg 1981, 1988; 1993a: 177–219; von Staden 1989, 1992a.
2 The fragments of Herophilus are collected by von Staden (1989); those of Erasistratus by Garofalo (1988).
3 Although Erasistratus, through his father, was connected with the court at Antioch in Syria, no ancient source associates his anatomical investigations with that city, referring to dissections taking place only in Alexandria. The one story that links his medical activity with the Seleucids, his alleged discovery of the love of Antiochus I for his stepmother Stratonice, is also attributed, with greater likelihood, to other and less familiar names (see p. 362, n. 57).
4 See pp. 213–14.
5 See p. 126.
6 For Galen, 2, 890, as emended at *CMG* 5, 2, 1, 38, see p. 364, n. 101 here; for his gynaecological experience, see Soranus, *Gynaecology* 1, 35; 4, 14 and 36.
7 This is the formulation of Viano (1984).

8 Von Staden 1989: 43, with T. 9–11: Garofalo 1988: 20, 60–1. The weakness of the tradition as historical evidence is pointed out by Scarborough (1985b).
9 Kudlien (1969) stresses the new importance of careful observation of a wide range of phenomena.
10 R. Parker 1983: 33–41. Teles, *On Exile* 31, 9 Hense.
11 Edelstein 1967: 274–81.
12 Carlino 1999; French 1999.
13 Herodotus, *History* 2, 86–9; Diodorus, *History* 1, 91–2.
14 Fraser 1972: I, 70–4.
15 Although no source specifies the origin of the corpses, save that they were criminals, the continuation elsewhere of Greek taboos about violating a corpse and the ways in which Greek justice systems worked suggest that the bodies were far more likely to be of non-citizen Egyptians or foreigners than of Alexandrian Greeks. For the apartheid or 'frontier' mentality, cf. von Staden 1989: 29.
16 Weeks 1970; von Staden 1989: 1–22; Nunn 1996: 42–53.
17 Longrigg (1993a: 187) rightly points out that the brain and often other organs were removed crudely or by being first liquefied inside the body.
18 The accounts in Herodotus and Diodorus (see n. 13) certainly show a good general knowledge of embalming procedures, and must have been obtained at least through an interpreter, but they say next to nothing about the precise information that an anatomist would need to know.
19 Cf. Nunn 1996: 43–4.
20 Fraser 1972: part II and 305–35 for patronage; von Staden 1989: 26–31.
21 Poets and litterateurs were, directly or indirectly, useful for propaganda, while many of the discoveries of Hellenistic scientists had a practical, military value.
22 Menecles of Barca, *FGrH* 270 F 9: his list of exiles comprises 'grammarians, philosophers, geometers, musicians, painters, teachers, doctors and many other craftsmen'.
23 But, as far as I know, there is no evidence that any of the scholars who visited Alexandria ever consulted these manuscripts there. For the story of the Library, see Fraser 1972: 320–34; Canfora 1987; el-Abbadi 1992; Vallance 2000. Galen's references (in his commentaries on *Epidemics* III: 17A, 606–7, and *The Nature of Man* 1, 44: 15, 105, 109) are critically reviewed by W. D. Smith (1979: 199–204).
24 For the founding of the Museum, see Fraser 1972: 312–20.
25 Naphtali Lewis 1963.
26 Most 1981; Langholf 1986.
27 Pfeiffer 1968: 98. Fraser (1972: 318) thinks it likely that provision was made for lecturing on the premises of the Museum, although he rightly notes that 'much would be effected by means of informal discussion and conversation'. Vallance (2000) is very sceptical.
28 Von Staden 1989: 458, 478, 486.
29 Longrigg 1993a: 179.
30 Celsus, *On Medicine*, pref. 23–6 = Herophilus, T. 63a von Staden 1989.
31 For the (lost treatise) on vivisection, see Galen, 19, 55, tr. P. N. Singer 1997: 25. There may be traces of it still in Arabic. But note that at 12, 252 Galen distinguishes between those kings who experimented on condemned criminals and pharmacologists who reported potentially dangerous drugs of which they had

no experience. The former, he argues, did nothing wrong. His allusion may extend beyond the pharmacological experiments of Attalus III and Mithridates.
32 John of Alexandria, *Commentary on Galen, On Sects*, p. 57 Pritchet; Agnellus, *Commentary on Galen, On Sects* 23; p. 92 Westerink = Herophilus, T 63b–c von Staden 1989. Agnellus and John depend on the same material, which, at the very least, shows that the story was known in Late Antique Alexandria, although a direct dependence on Celsus is unlikely. Galen is their most favoured source.
33 Tertullian, *On the Soul* 10, 4 = Herophilus, T. 66 von Staden 1989.
34 Lloyd 1991: 356–7; Grmek 1996. The author of the (implausible) story in the Jewish Talmud (*Tosefta Niddah* 4: 17; Babylonian Talmud, *Niddah* 30b) that Cleopatra carried out anatomical experiments on pregnant female slaves to see the various stages of the formation of the foetus also insists that these unfortunates were condemned criminals.
35 Dates for both Herophilus and Erasistratus are imprecise (see von Staden 1989: 43–50; Garofalo 1988: 18–21, placing both men in the period 330/320–260/250 BC, and noting that some of Erasistratus' experiments presuppose some of Herophilus' discoveries).
36 Galen, 10, 28; 8, 723 = Herophilus T. 10–11 von Staden 1989. Although the belief in a link with Praxagoras is not as strongly based as one might like, it certainly predates Galen.
37 Von Staden 1989: 427–42.
38 Respectively, Herophilus, T. 79; 122–3; 124; 90–2; 98–9 von Staden 1989; for the pineal gland, cf. Galen, *Anatomical Procedures* IX 3: 2, 723 = p. 569 Garofalo: tr. C. Singer 1956: 233. Cf. P. Potter 1976.
39 Respectively, Herophilus T. 86–9; 60a–b; 95; 61, 101–14 von Staden 1989.
40 Herophilus, T. 115–18, with von Staden's (1989) discussion, p. 240.
41 Ibid. T. 60, 95–6, 115; 119–20; cf. 54 von Staden 1989, although Galen and others thought his descriptions somewhat careless. See also C. R. S. Harris 1973: 178–81.
42 Von Staden 1989: 260–7; but note Longrigg 1993a: 200–2, arguing for *pneuma* alone.
43 Herophilus, T. 80–5, 121–5 von Staden 1989.
44 Herophilus, womb T. 61, 114; *rete mirabile* T. 121 ; liver T. 60 von Staden 1989.
45 Ibid., T. 193–202 von Staden 1989.
46 Ibid. T. 80, 212–13 von Staden 1989.
47 C. R. S. Harris 1973: 186–95; von Staden 1989: 262–88.
48 For water-clock, see Marcellinus, *On Pulses* 11 = Herophilus T. 182; for definitions, see T. 163, 177, 187–8 von Staden 1989. A direct influence from Aristoxenus of Tarentum, the pupil of Aristotle, although often suggested by modern scholars, is not attested in the ancient sources; the 'musicians' are perhaps more likely to have included scholars in Alexandria.
49 Herophilus, T. 237–8; 234; 58–9 von Staden 1989, with Hankinson 1990; 1998a: 297–302.
50 Herophilus T. 232; cf. 233 von Staden 1989, for Galen's complaint that he limited treatment to remedies indicated by the 'instrumental' parts of the body and not by its 'homoeomerous' tissues as well.
51 Ibid. T. 248–9 von Staden 1989.

52 Ibid. T. 255 von Staden 1989. By being quickly excreted it could thus be taken in large amounts (Girard 1988). For identification, see Raven 2000: 79–81.
53 Ibid., T. 230, 229 von Staden 1989.
54 Ibid. T. 42–8. T. 42 and 44 von Staden 1989 interpret these 'neutral things' as therapies, but Galen (T. 45 and 48) extends this to cover causes, signs and symptoms, as well as states that are neither fully healthy nor ill, such as convalescence or old age.
55 Strabo, *Geography* 10, 5, 6 = fr. 4A G.; Galen, *On the Opinions of Hippocrates and Plato* 8, 3, 7 = fr. 289 G. But the latter passage could be simply Galen's way of reconciling divergent notices about what Erasistratus had discovered, based on no sound information.
56 The report that he promised an ointment to one of the Ptolemies (fr. 12 G.) is far from conclusive proof that he worked in Alexandria, even if it is interpreted to mean that he dedicated his book *On Gout* to a Ptolemy.
57 *Pace* Fraser 1969; contrast Lloyd 1975. For the variant names in the story of the cure of the lovesick Stratonice, see Galen, *On Prognosis* 6: 14, 630–4, with Nutton 1979: 195; and Mesk 1913.
58 Erasistratus, fr. 5–8 G.; Scarborough 1985b.
59 Galen, *On Habits* 1: *CMG* Suppl. Or. 3, 12–14 = fr. 247 G., from *On Paralysis*, Book 2. Erasistratus is here associated with Hippocrates as 'most glorious'.
60 Galen, 5, 548 = Erasistratus, fr. 201 G.; Lonie 1975: 136–42.
61 Galen, 11, 153 = fr. 198 G. That he could see the join with the naked eye is unlikely, but it was a logical inference.
62 Erasistratus, fr. 42, 289 G. Garofalo (1988: 26) notes that a belief, shared with Aristotle and his school, that the brain was cold and bloodless may well have influenced his first thoughts.
63 For Greek experimentation, see von Staden 1975; Lloyd 1991: 70–99.
64 Galen, 2, 646 = fr. 52 G., with C. R. S. Harris 1973: 379–88.
65 Anonymus Londinensis 33, 43 = fr. 76 G.
66 For Erasistratus' views on humours, see W. D. Smith 1982; for his teleology, see von Staden 1997c.
67 With the possible exception of fr. 158 G. = Oribasius, *Synopsis, for Eustathius* 2, 32, none of the quotations of him by the Byzantine encyclopedists is taken directly from his writings; see Garofalo's (1988) index of sources.
68 Cf. Garofalo 1988: 47 for evidence of his familiarity with some Hippocratic treatises.
69 Vegetti 1993; 1998b: 92–9.
70 Von Staden 1997c: 199–208.
71 Erasistratus, fr. 140–2 G.
72 Ibid. fr. 119–33, 144, 284 G.
73 Ibid. fr. 86–8; 76 G.
74 Ibid. fr. 74, 93, 96, 109, 150, 198 G. By acting as a pump the heart also sends out nutriment and *pneuma*, so that the processes of nutrition and respiration are not entirely governed by a vacuum.
75 W. D. Smith 1982. Galen, (8, 191 = Erasistratus, fr. 192 G.) complained that Erasistratus made no mention of 'black bile'.
76 Erasistratus, fr. 195, 240, 248–50, 162; cf. 229 G.
77 Ibid. fr. 248 G.

78 Garofalo (1988: 27; and fr. 176–7 G.) argues that he continued to attribute mental disorders, like phrenitis and lethargy, to problems affecting the meninges; he located the cause of apoplexy (fr. 174 G.) in the brain.
79 Ibid. fr. 195–6 G.
80 Ibid. fr. 109 G. Each side of the heart, according to Erasistratus, belonged to a different vascular system and did not communicate with the other. For *pneuma* drawn in by a vacuum process, see fr. 103–8 G.
81 Ibid. fr. 47–9 G. The reconstruction of his views has to be made largely on the objections to them by Galen (cf. C. R. S. Harris 1973: 195–233; Furley and Wilkie 1984: 26–37; Garofalo 1988: 33–43).
82 For possible links with other Peripatetics, see Scarborough 1985b.
83 Erasistratus, fr. 195 G.
84 Ibid. fr. 195; 169; cf. 162, 185 G., for plethora, an excess of blood, as the cause of disease. But fr. 168 G. suggests that Erasistratus also accepted other general causes of disease. The new Cologne Papyrus 327 explains 'burning fever', *kausos*, as caused by the entrance of 'fluid' (i.e. probably blood) from veins into the arteries, thereby blocking the flow and distribution of *pneuma*. This long fragment on fever, copied in the early second century BC, is likely to come from an Erasistratean source, and possibly even from Erasistratus himself, although it contains none of the specific technical terms associated with Erasistratus.
85 That Galen's own conclusion was wrong also points up the difficulty of this experiment, as modern replications of it have shown (see C. R. S. Harris 1973: 379–88).
86 Erasistratus, fr. 63 G.; Brain 1986.
87 Erasistratus, fr. 156–67, 231 G.; to which add Galen, 11, 176; W. D. Smith 1982. Galen has great fun with Erasistratus' preference for fasting as a way of drawing excess blood back into the veins.
88 Erasistratus, fr. 63–4, 66, 161–2, 267–8 G.
89 Ibid. fr. 253 G.
90 Ibid. fr. 184b G.
91 Ibid. fr. 117–18, 162, 247 G.
92 Brain 1986; Vallance (1990: 22–30) suggests that Asclepiades (see pp. 167–70 here) derived some of his theories from Erasistratus. For the new Cologne fragment, see n. 84 here.
93 Especially in *On Venesection, against the Roman Erasistrateans* (11, 187–249: tr. Brain 1986: 38–66), where Galen claims that they have now gone over to wholesale bleeding.
94 [Hippocrates], *The Heart*: IX, 80–92 L.; the quotation comes from Chapter 10. The most accessible English translation is that of I. M. Lonie in Lloyd 1978: 347–51. Important discussions are by C. R. S. Harris 1973: 83–94; Lonie 1975; Manuli and Vegetti 1977: 101–13, arguing for a date around 350 BC; Duminil 1983: 299–302.
95 Lonie 1975: 10–15.
96 Ibid. 2–4; Manuli and Vegetti (1977) emphasise its Platonic teleology and language.
97 [Hippocrates], *The Heart* 2: IX, 78 L. The problem, already noted by Plato (*Timaeus* 91a), was familiar even to non-medics (cf. Plutarch, *Table Talk* 7, 1: 697F–700B).

98 The author's decision to place the 'ruling part' of the soul in the left ventricle might suggest a date as late as the first century BC (cf. Lonie 1975: 149–53).
99 Galen (18A, 7) makes him a contemporary of Herophilus. For his general standing as an anatomist, see Galen, 5, 651; 8, 212; 15, 134.
100 Rufus, *The Names of Bodily Parts* p. 142 Dbg; Galen 3, 203; 4, 646; Soranus, *Gynaecology* 1, 57.
101 The attribution to Eudemus is found only in a mediaeval Latin version of Galen's *On the Anatomy of the Womb* (3, 2), not in any Greek manuscript (see Nickel 1971: 38 and 72). For Euenor, see p. 128 here.
102 Marganne 1981: 55–60.
103 Galen, 5, 651; 15, 134; 18A, 7; cf. 8, 212.
104 Rufus, *The Names of Bodily Parts* p. 134 Dbg.
105 Celsus, *On Medicine*, pref., 12–53.
106 Apollonius, *On Joints*: *CMG* 11, 1, 1, p. 80. But von Staden (1989: 445–6) can show no anatomical discovery or investigation by the later Herophileans. The comment of Andreas (ibid. An. 5 = Cassius the Iatrosophist, *Problems* 58 Ideler) seems to have been made in passing, and not to come from a work on anatomy or necessarily to be based on his own dissections.
107 P. Potter 1993.
108 For the development of pulse doctrine by the Herophileans, see von Staden 1989: 446–8.
109 Celsus, *On Medicine*, pref., 26. This defence of experimentation on criminals stands in opposition to what 'plerique proponunt'.
110 Cicero, *Academics* 2, 122; Celsus, *On Medicine*, pref., 40–4, 74–5. Deuse (1993: 835–7), noting that Celsus is likely to have been repeating an Empiricist account of the debate, suggests that these standard epistemological objections were at some point countered by the supporters of anatomy. But, if they were, neither Celsus nor Galen refers to them, and they did not lead to any consistent anatomical dissections of human subjects.
111 Cf. Lennox 1994.
112 Edelstein (1967: 286) notes the weakness of the argument that only by anatomy could one learn about the body: other methods had been, and would be, found (cf. Celsus, *On Medicine*, pref., 43), and only after the introduction of dissection would anyone have thought to claim it as 'essential'.
113 Celsus, *On Medicine*, pref., 43.
114 Galen, 6, 480; 13, 605.

10 HELLENISTIC MEDICINE

1 Pfeiffer 1968: 97–8, 283; Fraser 1972: 317–19.
2 Algra *et al.* 1999; a good selection of translated texts is given by Long and Sedley 1987.
3 There exists no overall study of medicine in this period: the best survey of social conditions is Kudlien 1979.
4 Schmidt 1924; Raschke 1978: 650–76, 904–1055.
5 Lloyd 1983: 119–26; Scarborough 1978.
6 Diocles, fr. 177 van der Eijk.
7 Erasistratus, fr. 35 G. (Garofalo (1988: 72) casts doubt on the existence of a specific tract called *On Causes*.) For his poison tract, see frs. 270–84 G.

8 Erasistratus, fr. 280 G.; for an autopsy on a dropsical patient, see fr. 251 G.
9 For Herophilus himself, see p. 133.
10 Dioscorides, *Materia medica*, pref. 1. For surviving fragments of his pharmacology, see von Staden 1989: 473 and fr. An. 18–42. For Heraclides' view, see p. 142 here.
11 Ibid. 516 and fr. Ma. 1–16.
12 Effe 1974.
13 Nicander, ed. Gow and Scholfield 1953; a major new edition of the poems, by J. M. Jacques, has begun to appear in the Budé series (see Jacques 2002).
14 Kudlien 1970b; cf. also the *Hedypatheia* of Archestratus of Gela, 'the Hesiod of foods' (fl. 350 BC): tr. Wilkins and Hill 1994; Olson and Sens 2000; and the (much later) Heraclitus of Rhodiapolis, 'the Homer of medical poetry', *TAM* 2, 2, 910.
15 Jacques 1979. Not everyone could understand his language easily, and his poems were later often accompanied by interpretative commentaries or by simpler summaries.
16 Most 1981: 109; Langholf 1986.
17 Galen, 14, 214, 237.
18 Pliny, *Natural History* 25, 3, 6–7; Galen, 14, 283–5. Cf. also Galen, 14, 150, an alleged letter of Zopyrus to Mithridates, offering him a condemned criminal on whom to try out an antidote for snakebite; Watson 1966; Totelin 2004.
19 Pliny, *Natural History* 25, 3, 5–7.
20 Ibid. 25, 26, 62, which does not prove that Crateuas was in his service, *pace* Wellmann 1897. Collins 2000 is a beautifully illustrated survey of illuminated manuscripts of ancient pharmacology, with a good bibliography.
21 Heraclides, fr. 1–5 Gu.; Antiochis, *TAM* 2, 2, 595.
22 Ibid. fr. 7 Gu., although if the title alludes to Herophilus' description of hellebore as 'the general' it could be simply dealing with other herbs. He wrote at least two other large works on pharmacology, (fr. 6–7, 37–8 Gu.).
23 Heraclides, fr. 25 Gu, ; Ullmann 1972b. Cleopatra's *Cosmetics* was cited by Galen indirectly through Statilius Crito.
24 Michler 1968, 1969; Marganne 1998.
25 The last two books of Celsus, *On Medicine*, are the major literary source for Alexandrian surgery (see Mazzini 1999; Sabbah and Mudry 1994: 103–210).
26 Dasen 1993; Garland 1995.
27 R. Jackson 1994. Oribasius (*Medical Collections* 49, 4–6) gives a very detailed description of an instrument devised by Andreas of Carystus to reduce dislocated limbs, which neatly demonstrates the links between Alexandrian medicine and technology (see Drachmann 1963: 171–3; and, for later developments, 173–85).
28 Apollonius of Citium, ed. Kollesch and Kudlien 1965.
29 W. D. Smith 1979: 212–22; P. Potter 1993.
30 Cf. Stuckelberger 1994. A good selection of the illustrations in colour is given by Waugh *et al.* (1984). Schöne (1896) gives the complete set of illustrations in black and white.
31 Herophilus, fr. 261–6 von Staden 1989.
32 Von Staden 1989: 453–5. The glossary of Bacchius (fl. 230), covering at least eighteen Hippocratic texts, was particularly influential (ibid. fr. Ba 12–76); for Zeno and the sign controversy, see ibid. fr. Zn 5–6; W. D. Smith 1979: 199–201.