# ARISTOTLE

# *On the Parts of Animals*

*Translated*
*with a Commentary*
*by*

JAMES G. LENNOX

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James G. Lennox

*University of Pittsburgh*
*April 2001*

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# ABBREVIATIONS

ARISTOTLE

| | |
|---|---|
| *An.* | *De Anima* |
| *An. Post.* | *Posterior Analytics* |
| *An. Pr.* | *Prior Analytics* |
| *Cael.* | *De Caelo* |
| *Cat.* | *Categories* |
| *EN* | *Nicomachean Ethics* |
| *GA* | *Generation of Animals* |
| *GC* | *Generation and Corruption* |
| *HA* | *Historia Animalium* |
| *IA* | *De Incessu Animalium* |
| *Int.* | *On Interpretation* |
| *Juv.* | *On Youth and Old Age* |
| *Long.* | *On Length and Shortness of Life* |
| *MA* | *De Motu Animalium* |
| *Met.* | *Metaphysics* |
| *Meteor.* | *Meteorology* |
| *PA* | *Parts of Animals* |
| *Phys.* | *Physics* |
| *Pol.* | *Politics* |
| *Resp.* | *On Respiration* |
| *Sens.* | *On Sense and Sensible Objects* |
| *Som.* | *On Sleep* |
| *Top.* | *Topics* |

DIOGENES LAERTIUS

| | |
|---|---|
| D.L. | *Lives of Philosophers* |

GALEN

| | |
|---|---|
| *De Nat. Fac.* | *On the Natural Faculties* |
| *De Placit.* | *On the Doctrines of Hippocrates and Plato* |

HERODOTUS

| | |
|---|---|
| *Hist.* | *Histories* |

[HIPPOCRATES]

| | |
|---|---|
| *Cord.* | *On the Heart* |
| *VC* | *On Wounds in the Head* |

HIPPOLYTUS

| | |
|---|---|
| *Ref.* | *Refutation of All Heresies* |

LIDDELL–SCOTT–JONES

| | |
|---|---|
| LSJ | H. G. Liddell and R. Scott *Greek–English Lexicon*, rev. H. S. Jones |

PLATO

| | |
|---|---|
| *Rep.* | *Republic* |
| *Tim.* | *Timaeus* |

PLINY

| | |
|---|---|
| *N. Hist.* | *Naturales Historiae* |

PRESOCRATICS

| | |
|---|---|
| DK | H. Diels and W. Kranz (eds.), *Die Fragmente der Vorsokratiker* |

SIMPLICIUS

| | |
|---|---|
| *In Phys.* | *In Aristotelis Physica Commentarius* |

# INTRODUCTION

> For even in the study of animals disagreeable to perception, the nature that crafted them likewise provides extraordinary pleasures to those who are able to know their causes and are by nature philosophers. (*De Partibus Animalium* I. 5)

The *De Partibus Animalium* is the heart and soul of Aristotle's philosophical, that is to say causal, investigation of animals. This is clear from two entirely unrelated considerations.

First, there are reasons that derive from the very nature of the biological enterprise itself. Being is prior to becoming (*PA* I. 1, $640^{a}3$–6, $^{a}13$–19). It is for the sake of being—that is, living—that animals come to be, and for that reason Aristotle argues that teleology, or goal causation, is scientifically prior to motive causation (*PA* I. 1, $639^{b}15$–19; II. 1, $646^{a}25$–$^{b}1$). The first order of business, then, when it comes to the *causal* investigation of animals, is the study of the living animal in its actualized, functional form. Thus explanations of the sort we find in *PA* II–IV are explanatorily prior to the complex account of animal development we find in the *De Generatione Animalium* (*GA* I. 1, $715^{a}1$–17).[1]

Moreover, causes are prior to their effects. Whatever the chronological relationship of the writings that have come down to us under the title *Historia Animalium*, the research they represent was carried out in order to achieve the type of explanatory understanding which is the aim of the *De Partibus Animalium* and *De Generatione Animalium* (*HA* I. 6, $490^{a}7$–14; *PA* II. 1, $646^{a}7$–12).

There are, however, also reasons for the centrality of the *De Partibus* that we owe to the first editor of the zoological works of Aristotle. For he attached what appears to be an independent group of essays on the philosophical foundations of the study of living nature to the causal investigation of animal parts in *PA* II–IV. Now he *may* have done so because he believed one of the lessons of those essays was that *PA* II–IV should immediately follow them—we shall never know. Whatever his reasons, the result is that *De*

[1] And of course the explanations of *PA* presuppose the account of living function in the *De Anima*.

*Partibus Animalium* as we have it not only contains Aristotle's causal/explanatory theory of the parts of fully mature animals; it opens with a book devoted to laying the philosophical foundations of the entire biological enterprise.

A few words need to be said about the translation and following commentary. There are two readily available English translations of the whole of *De Partibus Animalium*, that of William Ogle (now lightly revised for inclusion in Jonathan Barnes's edition of the *Complete Works*) and that of Arthur Peck for the Loeb Classical Library. In addition, the first book is available in David Balme's Clarendon translation, with notes. The latter has served in many ways as a model for my own translation, and where my rendition of *PA* I differs from his it is with his stated aim in mind—'to remain semantically faithful to what Aristotle says, remaining obscure or ambiguous where the Greek is obscure or ambiguous'. I have learnt a great deal from consulting the editions of Ogle and Peck, but ultimately I find the translations, while elegant, often misleading.

The above quote from Balme's preface might lead one to suppose that 'expansive' translations, such as Peck's and even more Ogle's, always decrease obscurity and ambiguity in the Greek original. By means of one example I want to stress that the opposite is often the case.

There are a number of quite extensive groups of animals that Aristotle identified and that he uses with some consistency in organizing his zoological writings. Two such groups are identified by the conjunction of the number of feet these animals have with their mode of reproduction: a straightforward translation might be 'those that have four feet and lay eggs' or 'those that have four feet and bear live young'. Peck and Ogle have taken the perfectly natural and understandable tack of using Latinate scientific terminology—oviparous quadruped, viviparous quadruped.

Understandable though it may be, this practice is misleading in many respects. First, Aristotle tells us that these groups are unnamed; it is sometimes valuable to discuss animals that share these two characteristics as a group, but if one gets the idea from a translation that Aristotle has a technical, taxonomic vocabulary for these groups, one is being seriously misled. The same goes for the groups that Ogle translates 'testacea', 'crustacea', and 'cephalopoda'.

Second, once you opt for the above translations, you will be forced to hide other significant information in the Greek original. For example, Aristotle does not always list mode of reproduction first, followed by number of feet. Which characteristic is listed first is often determined by which grouping of animals serves as the assumed background and which distinguishing characteristic is currently in focus. So, for example, in one discussion the wider group might be the egg-laying animals, within which Aristotle may need to distinguish birds (two feet) and fish (no feet) from those with four feet; in another, he may be discussing four-footed animals and need to distinguish those that lay eggs from those that bear live young. The translation 'oviparous quadruped' hides all such subtlety from the English reader, while at the same time leading him to believe falsely that Aristotle has a fixed taxonomic vocabulary.

The commentary is primarily philosophical rather than 'scientific', though where possible I have tried to give the philosophical reader enough information about the animals and their parts discussed by Aristotle to make his argument intelligible. The notes to Ogle's 1882 edition are still very helpful in this respect, and I have consulted a number of standard works in comparative anatomy as well.

Nevertheless, the commentary *is* primarily philosophical, and there are a number of interpretative questions that unify it thematically:

1. *How should we understand the relationship between the zoological investigation of* PA *II–IV and the philosophical norms of explanation and enquiry defended in* PA *I?* Broadly, this theme has two intertwined aspects. One wonders first of all about consistency—is Aristotle doing in Books II–IV what a reader of Book I would expect him to be doing? Were this the case, then *PA* II–IV may aid us in interpreting the philosophy of zoology of *PA* I. But there is serious danger of interpretative circularity here. Having a preferred reading of Aristotle's philosophical account of a concept may lead one to over-interpret the use of that concept in his working zoology. My default hypothesis is that the philosophical norms of *PA* I are reflected in *PA* II–IV, but I have indicated places where I find this hypothesis under severe strain.

2. *How should we understand the relationship between the science outlined in* PA *I and practised in* PA *II–IV, on the one hand, and the theory of scientific demonstration and inquiry outlined in the* Prior *and* Posterior Analytics*?* This question has been the subject of lively

debate over the last twenty-five years, and the position I adopt in this commentary will come as no surprise to those who have read my contributions to this discussion. Where I think there is clear evidence that Aristotle has in mind a scientific enquiry like that envisaged in *An. Post.* II, or a demonstrative science like that envisaged in *An. Post.* I, I shall point to it and discuss it. But I will also note the many ways in which the *Analytics* conception of science must be enriched and supplemented in order to be applicable to a biological context—indeed, I believe it is the purpose of *PA* I to provide this enrichment and supplementation. To cite just one example: the concept of conditional, suppositional, or hypothetical necessity (*anankē hupotheseōs*) is, as Aristotle notes when he introduces it in *PA* I. 1, not among the concepts of necessity discussed in the *Posterior Analytics*, even though there is a discussion (*An. Post.* II. 11, $94^{b}27–95^{a}8$) of explanations appealing jointly to necessity and teleology. Yet this concept plays a central role in the discussion of biological explanation in *PA* I. 1.

3. *The connections between* Meteorology *IV and the account of the uniform parts in* PA *II.* Recent scholarship has established a close connection between the account of uniform bodies in *Meteorology* IV and Aristotle's account of the uniform parts such as blood, fat, brain, flesh, and bone in *PA* II. I shall make use of and build on that research in the commentary given here. As David Furley indicated in his fine discussion of *Meteorology* IV (Furley 1983/1989), the more precisely these accounts mesh, the more unlikely it is that they were composed by different authors.

4. *The relationship between the accounts of the parts of animals in* PA *II–IV and the discussion of the same parts in* HA. The research undertaken by David Balme for the forthcoming edition of the *Historia Animalium* convinced him that much of the information recorded in *HA* I–IV was borrowed from *PA* II–IV and that a significant amount of the rest reflects more knowledge about the animals discussed than *PA*. This was, and is, a controversial thesis, and one I resisted for a number of years. When asked to contribute a paper to a conference reconsidering the question of Aristotle's philosophical development, I took the opportunity to explore the question (Lennox 1996*a*). I became convinced by that exploration of the complexity of the question, and of the plausibility of 'the Balme hypothesis'. The present commentary allows me, part by part, to explore this issue. This has a consequence that some will

enjoy and others will find tedious. I have in each case explored what *HA* has to say about the parts and the kinds discussed and have often commented on the similarities and differences between the two discussions.

When one takes the above points into account, it adds up to the need for a fuller commentary than is typical of a Clarendon edition. I shall not take all the blame for this, however. My editors, and especially Lindsay Judson, have encouraged me to explore these issues in the commentary. I, at least, thank them for this encouragement.

# TRANSLATION

The translation avoids the use of square or angle brackets as much as possible. If the addition of English terms for which there is no corresponding Greek is necessary to make the translation intelligible, they are added. If this calls for comment, it will be found in the commentary. The paragraphs and the punctuation do not necessarily reflect what is found in the texts I have used. They are intended to make the flow of argument intelligible.

## BOOK ONE

### CHAPTER I

Regarding every study and investigation, the more humble and **639[a]** more valuable alike, there appear to be two sorts of state, one of which may properly be called understanding of the subject-matter, the other a certain sort of educatedness. For it is characteristic of an educated person to be able to judge successfully what is well said and what is not. We think of someone who is generally educated as a person of that sort, and we think being educated is being able to make such judgements—only we consider the one person to be a single individual able to judge about practically *all* things, the other about something of a *delimited* nature; for there might be another person well disposed in the same way as the person we have been discussing, but regarding a particular subject.

So it is clear that for the enquiry into nature, too, there should be certain standards, such that by referring to them one can appraise the manner of its proofs, apart from the question of what the truth is, whether thus or otherwise.

I mean, for example, should one take each substantial being singly and define it independently, e.g. taking up one by one the nature of mankind, lion, ox, and any other animal as well; or should one first establish, according to something common, the attributes common to all? For many of the same attributes are present in many different kinds of animals, e.g. sleep, respiration, growth, deterioration, death, and in addition any remaining affections and dispositions such as these. (I add this because at the moment it is permissible to speak unclearly and indefinitely about these things.) It is apparent that, especially when speaking one by one, we shall repeatedly say the same things about many kinds; for instance, each of the attributes just mentioned belongs to horses, dogs, and human beings. So if one speaks of their attributes one by one, it will be necessary to speak repeatedly about the same things—whenever, that is, the same things are present in different forms of animal, yet themselves have no difference.

Yet there are probably other attributes which turn out to have
639b the same predicate, but to differ by a difference in form, e.g. the locomotion of animals; it is apparent that locomotion is not one in form, because flying, swimming, walking, and crawling differ. Accordingly, the following question about how one is to carry out an examination should not be overlooked—I mean the question of whether one should study things in common according to kind first, and then later their distinctive characteristics, or whether one should study them one by one straight away. At present this matter has not been determined, nor has the question that will now be stated, namely, whether just as the mathematicians explain the phenomena in the case of astronomy, so the natural philosopher too, having first studied the phenomena regarding the animals and the parts of each, should then state the reason why and the causes, or whether he should proceed in some other way.

And in addition to these questions, since we see more than one cause of natural generation, e.g. both the cause for the sake of which and the cause from which comes the origin of motion, we need also to determine, about these causes, which sort is naturally first and which second. Now it is apparent that first is the one we call for the sake of which; for this is an account, and the account is an origin alike in things composed according to art and in things composed by nature. For once the doctor has defined health, and the builder has defined house, either by thought or perception, they provide the accounts and the causes of each of the things they produce, and the reason why it must be produced in this way. Yet that for the sake of which and the good are present more in the works of nature than in those of art.

What is of necessity is not present in all natural things in the same way; yet nearly everyone attempts to refer their accounts back to it without having distinguished in how many ways the necessary is said. That which is necessary without qualification is present in the eternal things, while that which is conditionally necessary is also present in all generated things, as it is in artefacts such as a house or any other such thing. It is necessary that a certain sort of matter be present if there is to be a house or any other end, and this must come to be and be changed first, then that, and so on continuously up to the end and that for the sake of which each comes to be and is. It is the same way too with things that come to be by nature.

However, the mode of demonstration and of necessity is different 640a
in natural science and the theoretical sciences. (These sciences have been discussed elsewhere.) For the origin is, in the latter cases, what is, but in the former, what will be. So: 'Since health or mankind is such, it is necessary for *this* to be or come to be', instead of 'Since *this* is or has come about, *that* from necessity is or will be'. Nor is it possible to connect the necessity in such a demonstration into eternity, as if to say, 'Since *this* is, therefore *that* is'. (These matters too have been determined elsewhere—in what sorts of things necessity is present, what sort of necessity converts, and owing to what cause.)

We should also not forget to ask whether it is appropriate to state, as those who studied nature before us did, how each thing has naturally come to be, rather than how it is. For the one differs not a little from the other. It seems we should begin, even with generation, precisely as we said before: first one should get hold of the phenomena concerning each kind, then state their causes. For even with house-building, it is rather that these things happen because the form of the house is such as it is, than that the house is such as it is because it comes to be in this way. For generation is for the sake of substantial being, rather than substantial being for the sake of generation. That is precisely why Empedocles misspoke when he said that many things are present in animals because of how things happened during generation—for example, that the backbone is such as it is because it happened to get broken through being twisted. He failed to understand, first, that seed already constituted with this sort of potential must be present, and second, that its producer was prior—not only in account but also in time. For one human being generates another; consequently, it is on account of *that* one being such as it is that *this* one's generation turns out a certain way. It is likewise both with things that seem to come to be spontaneously and with artefacts; for in some cases the same things produced by art also come to be spontaneously, e.g. health.

Now in some of these cases there pre-exists a productive capacity like them, e.g. the art of sculpture; for a statue does not come to be spontaneously. The art is the account of the product without the matter. And it is likewise with the products of chance; for as the art has it, so they come to be.

Hence it would be best to say that, since this is what it is to be a human being, on account of this it has these things; for it cannot be without these parts. If one cannot say this, one should say the next best thing, i.e. either that in general it cannot be otherwise, or
640b that at least it is good thus. And these things follow. And since it is such, its generation necessarily happens in this way and is such as it is. (This is why this part comes to be first, then that one.) And in like manner one should speak in precisely this way about all of the things constituted by nature.

Now the ancients who first began philosophizing about nature were examining the material origin and that sort of cause: what matter is and what sort of thing it is, and how the whole comes to be from it and what moves it (e.g. whether strife, friendship, reason, or spontaneity). They also examined what sort of nature the underlying matter has of necessity, e.g. whether the nature of fire is hot, of earth cold, and whether the nature of fire is light, of earth heavy. In fact, even the cosmos they generate in this way. And they speak in a like manner too of the generation of animals and plants, saying, for example, that as water flowed into the body a stomach and every part that receives nourishment and residue came to be; and as the breath passed through, the nostrils were burst open.

Air and water are matter for bodies; that is, it is from such things that all the ancients constitute the nature of bodies. But if human beings, animals, and their parts exist by nature, one should speak about flesh, bone, blood, and all the uniform parts. Likewise too, about the non-uniform parts such as face, hand, and foot, one should say in virtue of what each of them is such as it is, and in respect of what sort of potential. For it is not enough to say from what things they are constituted, e.g. from fire or earth. It is just as if we were speaking about a bed or any other such thing; we would attempt to define its form rather than its matter, e.g. the bronze or the wood. And if we could not do this, we would at least attempt to define the matter of the composite; for a bed is a 'this-in-that' or 'this-such', so that we would have to mention its configuration as well, and what its visible character is. For the nature in respect of shape is more important than the material nature.

Now if it is by virtue of its configuration and colour that each of the animals and their parts is what it is, Democritus might be speaking correctly; for he appears to assume this. Note that he says it is clear to everyone what sort of thing a human being is in respect of shape, since it is known by way of its figure and its colour. And yet though the configuration of a corpse has the same shape, it is nevertheless *not* a human being. And further, it is impossible for something in any condition whatsoever, such as bronze or wooden, to be a hand, except homonymously (like a doctor in a picture). For such a hand will not be able to do its work, just as stone flutes will not be able to do theirs and the doctor in the picture his. Likewise none of the parts of a corpse is any longer such—I mean, for example, any longer an eye or a hand.

What Democritus has said, then, is too unqualified, and is said in the same way as a carpenter might speak about a wooden hand. Indeed this is also the way the natural philosophers speak of the generations and causes of configuration. Ask them by what potencies things were crafted. Well, no doubt the carpenter will say an axe or an auger, while the natural philosopher will say air and earth—albeit the carpenter's response is better; for it will be insufficient for him to say merely that when the tool fell this became a depression and that flat. Rather, he will state the cause, the reason why he made such a blow and for the sake of what, in order that it might then come to be this or that sort of shape.

It is clear, then, that these natural philosophers speak incorrectly. Clearly, one should state that the animal is of such a kind, noting about each of its parts what it is and what sort of thing it is, just as one speaks of the form of the bed. Suppose what one is thus speaking about is soul, or a part of soul, or is not without soul (at least when the soul has departed there is no longer an animal, nor do any of the parts remain the same, except in configuration, like those in myths that are turned to stone)—if these things are so, then it will be up to the natural philosopher to speak and know about the soul; and if not all of it, about that very part in virtue of which the animal is such as it is. He will state both what the soul or that very part of it is, and speak about the attributes it has in virtue of the sort of substantial being it is, especially since the nature of something is spoken of and is in two ways: as matter and as substantial being.

And nature as substantial being is both nature as mover and nature as end. And it is the soul—either all of it or some part of it—that is such in the animal's case. So in this way too it will be requisite for the person studying nature to speak about soul more than the matter, inasmuch as it is more that the matter is nature because of soul than the reverse. And indeed, the wood is a bed or a stool because it is potentially these things.

In view of what was said just now, one might puzzle over whether it is up to natural science to speak about *all* soul, or some part, since if it speaks about all, no philosophy is left besides natural 641b science. This is because reason is of the objects of reason, so that natural science would be knowledge about everything. For it is up to the same science to study reason and its objects, if they truly are correlative and the same study in every case attends to correlatives, as in fact is the case with perception and perceptible objects.

However, it is not the case that all soul is an origin of change, nor all its parts; rather, of growth the origin is the part which is present even in plants, of alteration the perceptive part, and of locomotion some other part, and not the rational; for locomotion is present in other animals too, but thought in none. So it is clear that one should not speak of all soul; for not all of the soul is a nature, but some part of it, one part or even more.

Further, none of the abstract objects can be objects of natural study, since nature does everything for the sake of something. For it is apparent that, just as in artefacts there is the art, so in things themselves there is an other sort of origin and cause, which we have as we do the hot and the cold—from the entire universe. This is why it is more likely that the heaven has been brought into being by such a cause—if it has come to be—and is due to such a cause, than that the mortal animals have been. Certainly the ordered and definite are far more apparent in the heavens than around us, while the fluctuating and random are more apparent in the mortal sphere. Yet some people say that each of the animals is and came to be by nature, while the heaven, in which there is not the slightest appearance of chance and disorder, was constituted in that way by chance and the spontaneous.

We say 'this is for the sake of that' whenever there appears to be some end towards which the change proceeds if nothing impedes it. So it is apparent that there is something of this sort, which is precisely what we call a nature. Surely it is not any chance thing that comes to be from each seed, nor a chance seed which comes from a chance body; rather, *this* one comes from *that* one. Therefore the seed is an origin and is productive of what comes from it. For these things are by nature; at least they grow from seed. But prior even to this is what the seed is the seed of; for while the seed is becoming, the end is being. And prior again to both of these is what the seed is from. For the seed is a seed in two ways, *from* which and *of* which; that is, it is a seed both of what it came from, e.g. from a horse, and it is a seed of what will be from it, e.g. of a mule, though not in the same way, but of each in the way mentioned. Further, the seed is in potentiality; and we know how potentiality is related to complete actuality.

Therefore there are these two causes, the cause for the sake of **642[a]**
which and the cause from necessity; for many things come to be because it is a necessity. One might perhaps be puzzled about what sort of necessity those who say 'from necessity' mean; for it cannot be either of the two sorts defined in our philosophical discussions. But it is especially in things that partake of generation that the third sort is present; for we say nourishment is something necessary according to neither of those two sorts of necessity, but because it is not possible to be without it. And this is, as it were, conditionally necessary; for just as, since the axe must split, it is a necessity that it be hard, and if hard, then made of bronze or iron, so too since the body is an instrument (for each of the parts is for the sake of something, and likewise also the whole), it is therefore a necessity that it be of such a character and constituted from such things, if that is to be.

Clearly, then, there are two sorts of cause, and first and foremost one should succeed in stating both, but failing that, at least attempt to do so; and clearly all who do not state this say virtually nothing about nature. For nature is an origin more than matter. Even Empedocles occasionally stumbles upon this, led by the truth itself, and is forced to say that the substantial being and the nature is the account, e.g. when he says what bone is. He does not say that it is some one of the elements, or two or three, or all of them, but rather that it is an account of their mixture. Accordingly, it is clear that flesh too, and each of the other such parts, is what it is in the same way.

One reason our predecessors did not arrive at this way is that there was no 'what it is to be' and 'defining substantial being'.

Democritus touched on this first, not however as necessary for the study of nature, but because he was carried away by the subject itself; while in Socrates' time interest in this grew, but research into the natural world ceased, and philosophers turned instead to practical virtue and politics.

One should explain in the following way, e.g. breathing exists for the sake of *this*, while *that* comes to be from necessity because of *these*. But 'necessity' sometimes signifies that if that—i.e. that for the sake of which—is to be, it is necessary for these things to obtain, while at other times it signifies that things are thus in respect of their character and nature. For it is necessary for the hot to go out and enter again upon meeting resistance, and for the air to flow in. This
642b is directly necessary; and it is as the internal heat retreats during the cooling of the external air that inhalation and exhalation occur. This then is the way of investigation, and it is in relation to these things and things such as these that one should grasp the causes.

## CHAPTER 2

Some people attempt to grasp the particular by dividing the kind into two differences. But this is in one respect not easy, and in another impossible. For of some things there will be only one difference, the others being superfluous, e.g. footed, two-footed, split-footed; this single difference is decisive. Otherwise, it will be necessary to say the same thing many times.

Further, one should avoid tearing each kind apart, e.g. putting some of the birds in one division and some in the other, as the written divisions have done; there, some of the birds end up divided off with the water-dwellers, some in another kind. Now this similarity has an established name, 'bird', and another has 'fish'. Other similarities are nameless, e.g. the blooded and the bloodless; there is no one established name for either of these. If, then, nothing alike in kind should be torn apart, division into two is worthless. For people who divide in this manner necessarily separate and tear apart; some of the many-footed things are among the land-dwellers, while some are among the water-dwellers.

## CHAPTER 3

Again, it is necessary to divide by privation, and those who dichotomize do so divide. But there is no difference within a privation as a privation; for there cannot be forms of what is not, e.g. forms of footlessness or winglessness, as there are of winged or footed; and there *must* be forms of a general difference; for if this were not the case, why would it be general rather than particular? And some differences are general and have forms, e.g. wingedness—one wing is unsplit, the other split. In the same way too one form of footedness has many splits, another two, like the cloven-hoofed animals, and another is unsplit and undivided, like the solid-hoofed animals. So it is difficult to distribute animals even into such differences as these, of which there are forms, so that any given animal belongs in them and the same animal does not belong in more than one, e.g. in both winged and wingless (for the same animal is both of these, e.g. ant, glow-worm, and certain others). And to distribute animals into bloodless differences is most difficult of all, or impossible. For it is necessary that each of the differences belong to one of the particulars, and so too its opposing difference. Yet if it is impossible for some indivisible and unitary form of substantial being to belong to animals that differ in form—rather, the form will always have a difference, as bird differs from mankind (for their two-footedness is other and different)—then even if they are blooded, either their blood is different, or blood should be reckoned as no part of their substantial being. If this is how it is, one difference will belong to two animals. And if *this* is the case, it is clearly impossible for a privation to be a difference.

The differences will be equal in number to the indivisible animals, if, that is, both the animals and the differences are indivisible, and there is no common difference. But if it *is* possible for something common to be present as well, yet to be indivisible, it is clear that, at least in respect of that common feature, animals that are different in form are in the same form. Therefore it is necessary, if the differences into which all the indivisible animals fall are distinctive, that none of the differences be common. Otherwise animals that are different will end up within the same difference. But the same indivisible animal should not go first into one and then into another difference within divisions, nor should different animals go into the same one, and all should go into them somewhere.

Apparently, then, it is impossible to grasp the indivisible forms by dividing in the way that those do who divide animals—or any other kind—into two. For even on their account the final differences must be equal in number to all the animals that are indivisible in form. For instance, if there is a certain kind, of which shades of white are the first differences, and of each of these there are other differences, and so on down to the indivisibles, the final differences will be four or some other quantity achieved by doubling from one; and the forms will also be that many. And the form is the difference in the matter; for no part of an animal exists without matter, nor is it matter alone; neither will a body in any condition whatsoever be an animal, nor will any of its parts, as has been said repeatedly.

Further, one ought to divide by features in a thing's substantial being, and not by its proper attributes, as would happen if someone were to divide figures on the ground that some have angles equal to two right angles, while others have angles equal to more; for having angles equal to two right angles is a sort of attribute of the triangle.

Again, one should divide by opposites. For opposites are different from one another, e.g. paleness and darkness, straightness and curvature. So if one of the two is a difference, one should divide by its opposite and not in the one case by swimming and in the other by colour.

Moreover, ensouled things, at least, should not be divided by the common functions of the body and of the soul, e.g. in the
643b aforementioned divisions, walkers and flyers; there are certain kinds to which both differences belong and that are flyers and wingless, just like the ant kind. Nor should these kinds be divided into wild and tame; for in the same way this would seem to divide forms that are the same. For in a manner of speaking everything that is tame is also wild, e.g. human beings, horses, cattle, Indian dogs, pigs, goats, and sheep. Each of these kinds, if homonymous, has not been divided apart, and if these are one in form, wild and tame cannot be a difference.

Speaking generally, this is a necessary result of dividing any sort of difference by a single division. Rather, one should try to take animals by kinds, following the lead of the many in demarcating a bird kind and a fish kind. Each of these has been defined by many differences, not according to dichotomy. For if one uses dichotomy, it is either altogether impossible to grasp something (since the same thing falls into many divisions and opposed things into the same division), or there will be only one difference, and this one, whether it is simple or the result of interweaving, will be the final form.

If one does *not* take difference of a difference, one will necessarily make a division continuous in the same way that one makes an account one by conjunction. I mean the sort of thing that results by dividing animals into the wingless and the winged, and winged into tame and wild, or pale and dark. Neither tame nor pale is a difference of winged; rather, each is the origin of another difference, while here it is incidental. Accordingly, one should divide the one kind straight away into many, as we say. In addition, in this way privations will produce a difference, while in the method of dichotomy they will not.

That it is impossible to grasp any of the forms of the particulars by dividing the kind into two, as some thought could be done, is apparent from the following points as well. It is impossible for there to be a single difference of the divided particulars, whether one takes simple or interwoven differences. I call a difference simple if it has no difference, e.g. split-footed, and I call it interwoven if it has a difference, as multi-split-footed is related to split-footed. For the continuity of the differences derived from the kind according to its division means just this, that the whole is a single thing. But the mode of expression makes it seem that the final one alone is the difference, e.g. 'multi-split-footed' or 'two-footed', and that 'footed' and 'many-footed' are superfluous.

**644a** That there cannot be many such differences is clear; for by proceeding continuously one arrives at the last difference, though not at the final difference and the form. This last difference is either split-footed alone, if one is dividing mankind, or the entire complex, e.g. if one were to combine footed, two-footed, and split-footed. And if mankind were split-footed alone, by proceeding in this way one might arrive at this single difference. But since mankind is not merely split-footed, it is a necessity that there be many differences that are not under a single division. There cannot, however, be many differences under a single dichotomous division—at least not of the same thing. Rather, one must end with one difference according to one such division. So it is impossible for those who divide in two to grasp any of the particular animals.

## CHAPTER 4

One might be puzzled why people have not named one kind that embraces both the water-dwelling and flying animals, comprehending both at once by one higher name. For there are some affections common both to these and to all the other animals. Nevertheless, they are correctly defined in this way. For those animals that differ by degree and the more and the less have been brought together under one kind, while those that are analogous have been kept apart. I mean, for example, that bird differs from bird by the more or by degree (for one has long feathers, another short feathers), while fish differs from bird by analogy (for what is feather in the one is scale in the other). But to do this in every case is not easy; for most animals have the same affections by analogy.

Since, however, it is the last forms that are substantial beings, and these, e.g. Socrates and Coriscus, are undifferentiated in respect of form, it is necessary either to state what belongs generally first, or to say the same thing many times. And things that belong generally are common; for things that belong to many we call general. There is, however, a puzzle about which of these two should be our subject. On the one hand, in so far as what is indivisible in form is a substantial being, it would be best, if one could, to study separately the things that are particular and undivided in form—just as one studies mankind, so too bird; for this kind has forms. But the study would be of any one of the indivisible birds, e.g. sparrow or crane or something of this sort. On the other hand, in so far as this will result in speaking many times about the same affection because it belongs in common to many things, in this respect speaking separately about each one is somewhat silly and tedious.

644b Perhaps, then, the right course is this. In some cases—whenever kinds are spoken of by people in a clearly defined manner and have both a single common nature and forms in them not too distant—we should speak in common according to kinds, like bird and fish and any other there may be that, though it is unnamed, embraces, like a kind, the forms within it. But whenever they are *not* such as this, we should speak one by one, e.g. about mankind and any other such kind.

Roughly speaking, it is by the figures of the parts and of the whole body that kinds have been defined, when they bear a likeness—e.g. members of the bird kind are so related to each other, as are those of the fish kind, the soft-bodied animals, and the hard-shelled animals. For their parts differ not by analogous likeness, as bone in mankind is related to fish-spine in fish, but rather by bodily affections, e.g. by large/small, soft/hard, smooth/rough, and the like—speaking generally, by the more and less.

We have said, then, how the investigation of nature should be appraised, and in what way the study of these things might proceed methodically and with greatest ease. Further, about division we have said in what way it is possible by pursuing it to grasp things in a useful manner, and why dichotomy is in a way impossible and in a way vacuous. Having determined these things, let us speak about what comes next, making the following our starting-point.

## CHAPTER 5

Among the substantial beings constituted by nature, some are ungenerated and imperishable throughout all eternity, while others partake of generation and perishing. Yet it has turned out that our studies of the former, though they are valuable and divine, are fewer (for as regards both those things on the basis of which one would examine them and those things about them which we long to know, the perceptual phenomena are altogether few). We are, however, much better provided in relation to knowledge about the perishable plants and animals, because we live among them. For anyone wishing to labour sufficiently can grasp many things about each kind. Each study has its attractions. Even if our contact with eternal beings is slight, none the less because of its surpassing value this knowledge is a greater pleasure than our knowledge of everything around us, even as a chance, brief glimpse of the ones we love is a greater pleasure than seeing accurately many other and great things. Perishable beings, however, take the prize in respect of understanding because we know more of them and we know them more fully. Further, because they are nearer to us and more of our own nature, they provide a certain compensation compared with the philosophy concerned with divine things.

Since we have completed stating the way things appear to us about the divine things, it remains to speak about animal nature, omitting nothing in our power, whether of lesser or greater esteem. For even in the study of animals disagreeable to perception, the nature that crafted them likewise provides extraordinary pleasures to those who are able to know their causes and are by nature philosophers. Surely it would be unreasonable, even absurd, for us to enjoy studying likenesses of animals—on the ground that we are at the same time studying the art, such as painting or sculpture, that made them—while *not* prizing even more the study of things constituted by nature, at least when we can behold their causes.

For this reason we should not be childishly disgusted at the examination of the less valuable animals. For in all natural things there is something marvellous. Even as Heraclitus is said to have spoken to those strangers who wished to meet him but stopped as they were approaching when they saw him warming himself by the oven—he bade them enter without fear, 'for there are gods here too'—so too one should approach research about each of the animals without disgust, since in every one there is something natural and good. For what is not haphazard but rather for the sake of something is in fact present most of all in the works of nature; the end for the sake of which each animal has been constituted or comes to be takes the place of the good. If someone has considered the study of the other animals to lack value, he ought to think the same thing about himself as well; for it is impossible to look at that from which mankind has been constituted—blood, flesh, bones, blood vessels, and other such parts—without considerable disgust. Just as one who discusses the parts or equipment of anything should not be thought of as doing so in order to draw attention to the matter, nor for the sake of the matter, but rather in order to draw attention to the overall shape (e.g. to a house rather than bricks, mortar, and timbers); likewise one should consider the discussion of nature to be referring to the composite and the overall substantial being rather than to those things which do not exist when separated from their substantial being.

645b It is necessary first to divide the attributes associated with each kind that belong in themselves to all the animals, and next to try to divide their causes. Now it has been said before that many common features belong to many of the animals, some without qualification (such as feet, wings, and scales, and affections too in the same way), and others analogously. By analogously I mean that while some have a lung, others have, not a lung, but instead something different which is to them what a lung is to those that have one; and some have blood, while others have its analogue, with the same potential that blood has for the blooded. To speak separately about each of these animals as particulars, as we also said before, will result in saying the same things many times, whenever we speak about all the attributes; the same attribute belongs to many animals. Let these matters be determined in this way.

Since every instrument is for the sake of something, and each of the parts of the body is for the sake of something, and what they are for the sake of is a certain action, it is apparent that the entire body too has been constituted for the sake of a certain complete action. For sawing is not for the sake of the saw, but the saw for sawing; for sawing is a certain use. So the body too is in a way for the sake of the soul, and the parts are for the sake of the functions in relation to which each of them has naturally developed. Therefore one should first discuss the actions—those common to all, those according to kind, and those according to form. I call 'common' those that belong to all the animals, and 'according to kind' those whose differences from each other we see in degree; for example, I speak of bird 'according to kind', but I speak of mankind, and everything without any difference according to its general account, 'according to form'. For what is common some have according to analogy, some according to kind, others according to form.

So it is clear, then, that whenever there are actions that are for the sake of other actions, the things whose actions they are differ in the same way that their actions do. Similarly, if some actions are in fact prior to, and the end of, others, it will be the same way with each of the parts whose actions are of this sort. And thirdly, there are things that are necessarily present because others are. By 'affections' and 'actions' I mean generation, growth, coition, waking, sleep, locomotion, and any other such things that belong to animals; by 'parts' I mean nose, eye, and the whole face (each of which is called a 'member'). And so it is with the other parts as well.

Enough said about our mode of investigation; we must attempt to **646a**
state the causes both of the common and of the distinctive attributes, beginning first, as we have determined, with those that are first.

# BOOK TWO

## CHAPTER I

646a From which parts and from how many parts each of the animals is constituted has been exhibited more clearly in the enquiries about them; it is the causes owing to which each animal has this character that must now be examined, on their own and apart from what was said in those enquiries.

Since there are three compositions, one might put first composition from what some people call the elements, e.g. earth, air, water, and fire. And yet, perhaps it is better to speak of composition from the potentials, and not from *all* of them, but as stated previously in other works. That is, moist, dry, hot, and cold are matter of the composite bodies, while the other differences, e.g. heaviness and lightness, density and rarity, roughness and smoothness, and the other bodily affections of this sort, follow these. Second is the composition of the nature of the uniform parts within animals—e.g. of bone, flesh, and the other things of this sort—out of the primary things. Third and last in the series is the composition of the nature of the non-uniform parts—e.g. of face, hand, and such parts.

In generation things are opposed to the way they are in substantial being; for things posterior in generation are prior in nature, and the final stage in generation is primary in nature. For instance, a house is not for the sake of bricks and stones, but rather these are for the sake of the house—and so it is with other matter. Not only is it apparent from a consideration of cases that this is the way things are, but it also accords with our account; for every generated thing develops from something and into something, i.e. from an origin to an origin, from the primary mover which already has a certain nature to a certain shape or other such end. For a human being generates a human being, and a plant a plant, from the underlying matter of each. So the matter and the generation
646b are necessarily prior in time, but in account the substantial being and the shape of each thing. This would be clear if someone were to state the account of the generation of something; the account of housebuilding includes that of the house, while that of the house does not include that of housebuilding. And so it is in the other

cases as well. Thus the matter of the elements is necessary for the sake of the uniform parts, since these are later in generation than the elements, and later than the uniform are the non-uniform parts; for these have already attained their end and limit, having achieved a constitution of the third sort, as often happens when generations are completed.

Thus animals have been constituted from both of these parts, but the uniform parts are for the sake of the non-uniform; for of the latter there are functions and actions, e.g. of eye, nostril, and the entire face, of finger, hand, and the entire arm. And since the actions and movements present both in animals as a whole and in their non-uniform parts are complex, it is necessary for their components to have distinct potentials; for softness is useful for some things, hardness for others; certain things must have elasticity, others flexibility. Thus while in the uniform parts such potentials are distributed part by part (one of them is soft while another is hard, one moist, another dry, one pliant, another brittle), in the non-uniform parts they are distributed to many and are conjoined with each other; for a different potential is useful to the hand for pressing and for grasping. Accordingly, the instrumental parts have been constituted from bones, sinews, flesh, and other such parts, *not* the latter from the former.

As being for the sake of something, then—on account of *this* cause—these parts are related in the way stated; but when one also seeks how it is *necessary* that they be thus, it is apparent that they were antecedently so related to one another from necessity. For the non-uniform parts are capable of having been composed from the uniform parts, both from many of them and from one, as with some of the viscera; they are complex in configuration, though generally speaking they are composed of one uniform body. But it is impossible that the uniform bodies be composed from the non-uniform; for the uniform part would consist of many non-uniform parts. These, then, are the causes owing to which some parts of **647a**
animals are simple and uniform while others are composite and non-uniform.

Some of the parts of animals are instrumental while others are sense-receptors, and each of the instrumental parts is non-uniform, as noted earlier, while perception occurs in every case in the uniform parts. This is because perception, of whatever sort, is of some one kind of thing, and because the sense-receptor is receptive of each of the objects of perception. That which is potentially is acted on by that which is actually, so that the former and the latter are the same in kind. Because of this, none of the natural philosophers tries to say, of hands, face, or any such parts, that one is earth, another water, another fire; but they do connect each of the sense-receptors to each of the elements, saying that one is air, another fire. And since perception is present in the simple parts, it is perfectly reasonable for touch to arise in a uniform part, and yet in the least simple of the sense-receptors; for it most of all seems to be a perception of many kinds of things, and the sense-object related to it seems to have many oppositions—hot/cold, dry/moist, and such others as there may be; and the receptor for perceiving these, flesh and its analogue, is the most bodily of the sense-receptors. Since it is impossible to be an animal without perception, on this account too it would seem necessary for animals to have some uniform parts; for perception is in these, while actions are present through the mediation of the non-uniform parts.

Since in animals the perceptive, motive, and nutritive potentials are in the same part of the body, as previously stated elsewhere, it is necessary that there be a primary part with origins such as these. And in so far as it is receptive of all the objects of perception, it must be one of the simple parts, while in so far as it is able to initiate motion and action, it must be one of the non-uniform parts. Hence in the bloodless animals the analogue of the heart is such a part, and in blooded animals it is the heart; for the heart is divisible into uniform parts, just like each of the other viscera, yet because of the shape of its configuration, it is non-uniform.

Each of the other parts called viscera follows the heart. That is to say, they are constituted from the same matter; for the nature of all
647b of them is bloody, on account of their being positioned on vascular channels and rivulets. So just as with the silt in flowing water, these other viscera are like silt deposited from the flow of blood through the blood vessels; and it stands to reason that the heart, because it is both the origin of the blood vessels and has within it the primary potential for fashioning blood, is itself constituted of a nutrient such as it receives. So why the viscera are bloody in conformation has been stated, and why they are in one way uniform and in another non-uniform.

## CHAPTER 2

Of the uniform parts present in animals, some are soft and moist, while others are hard and solid. Those that are moist are either generally so or are so while in their natural setting, e.g. blood, serum, soft fat, hard fat, marrow, semen, bile, milk (in those that have it), flesh, and the parts analogous to these; for not all the animals are made of these parts, but rather some are made from analogues to certain of these parts. Others of the uniform parts are dry and solid—e.g. bone, fish-spine, sinew, and blood vessel. And in fact the division of the uniform parts itself has a differentiation; for the parts of some of them are in a way named like the whole: for example, part of a blood vessel is in a way blood vessel and in a way not, while a part of a face is in no way a face.

First of all, then, many modes of cause may be attributed to the moist parts and the dry. Some of them serve as matter for the non-uniform parts (since each of the instrumental parts has been constituted from these, i.e. from bones, sinews, flesh, and other such parts, some contributing to the substantial being of the instrumental parts, some to their operation); some of the moist parts are nourishment for the non-uniform parts (for all derive their growth from what is moist); and some of them turn out to be residues, such as the sediment from dry nourishment and, in those with a bladder, from moist.

The relative differences between things of the same kind are for the sake of the better—that is, the differences both of other parts and of blood from blood. One sort of blood is thinner, another thicker, one purer, another more turbid, and again one colder, another hotter, both in the parts of one animal (for the upper parts of one animal are distinguished from the lower parts by these differences), and between one animal and another. And in general some animals are blooded, while some have, in place of blood, an- 648a
other such part. Thicker and hotter blood is more productive of strength, while thinner and cooler blood is more perceptive and intelligent. And the same difference obtains among the attributes analogous to blood. This is why both bees and other such animals are more discerning in their nature than many blooded animals, and why among blooded animals those having cold and thin blood are more discerning than their opposites. But those with hot, thin,

and pure blood are best; for such animals are at once in a good state relative to both courage and discernment.

It is for this reason too that the upper parts differ in this way compared with the lower parts, and again the male compared with the female, and the right side of the body with the left. And likewise with the other parts, both the parts such as these and the non-uniform parts: they should be assumed to differ in some cases relative to each animal's functions and substantial being, in other cases relative to what is better and worse. For example, among those with eyes, some are hard-eyed, some are moist-eyed, and some do not have eyelids, while others do, but either way it is for greater accuracy of sight.

That it is necessary to have either blood or something with the same nature as it, and what the nature of blood is—one should also study the causes of this by first making distinctions about hot and cold. For the nature of many things is referred to these origins, and many people dispute which sorts of animals and which parts are hot and which are cold. Some assert that water-dwellers are hotter than land-dwellers, stating that their natural heat is in equilibrium with the cold of their region; and that bloodless animals are hotter than blooded, and females than males. Parmenides, for example, and certain others assert that women are hotter than men, saying that the menstrual discharge comes about on account of their heat and from their having a great deal of blood, while Empedocles says the opposite. Again, some assert that blood or bile is hot, while others say that one or the other of them is cold.

If there is so much disagreement about hot and cold, what are we to assume about the other affections? For among the objects of perception, these are the clearest to us. Now these disputes seem
648b to occur because 'hotter' is said in many ways; for each of the disputants, though saying opposed things, seems to say something. Accordingly, we should not overlook the question of how, in the case of things constituted by nature, one ought to say that some are hot, others cold, some dry, others moist, since it seems evident that these things are virtually the causes of death and life, and again of sleeping and waking, of being in one's prime and of ageing, and of sickness and health; while neither roughness and smoothness, heaviness and lightness—nor, so to speak, any other affections of this sort—are. And this result is reasonable; for as has been said

previously, in other works, these very things—hot, cold, dry, and moist—are the origins of the natural elements.

Is the hot, then, spoken of without qualification or in a number of ways? Surely one needs to grasp what the function of the hotter is or, if there are many, how many. In one way that which makes what touches it hotter is said to be hotter; in another way that which arouses greater sensation during touching, especially if accompanied by pain. But it seems that at times this can be deceptive; for sometimes it is the state of the perceivers that is the cause of their feeling pain. Again, of the meltable and combustible, the more meltable and more combustible are said to be hotter. And again, if the same thing is in the one case larger, in the other smaller, the larger is said to be hotter than the smaller. And besides these two, what cools slowly rather than quickly is hotter, and what heats up quickly we say is hotter in its nature than what heats up slowly, as we say one thing is contrary because further away, the other like because nearer.

One thing is said to be hotter than another, then, in at least this many ways, if not in more; but it is impossible that being hotter belong in all these ways to the same thing. For boiling water heats more than flame does, and flame burns and melts the combustible and meltable, while water does not. Again, boiling water is hotter than a small fire, but hot water cools both faster and more than a small fire; for fire does not become cold, but all water does. Again, boiling water is hotter to the touch, but cools and solidifies more quickly than oil. And again, blood is hotter to the touch than water and oil, but solidifies more quickly. Again, stones, iron, and such things heat up more slowly than water, but once hot burn more intensely.

Besides these differences, some things called hot have derivative heat while some have their own, and whether something is hot in the former or the latter way makes the greatest difference. The **649a** former is near to being hot incidentally rather than in itself; it is as if, when someone with a fever happened to be musical, one were to say that the musician is hotter than the person with a healthy degree of heat. When one thing is hot in itself while another is hot incidentally, what is hot in itself cools more slowly, while the incidentally hot is often hotter to perception. And again, what is hot in itself burns more, as flame burns more than boiling water, while boiling water, which is incidentally hot, is hotter to the touch.

So it is apparent that to judge which of two things is hotter is not a simple matter; for in one way *this* will be hotter, in another way *that* will be. Nor is it possible, in some such cases, to say without qualification that something is, or is not, hot. For what the underlying subject happens at some time to be may not *be* hot, but *be coupled* with heat, as if someone were to give a name to hot water or hot iron. In fact it is in this way that blood is hot.

Such cases, namely those in which the underlying subject is hot in virtue of being affected, also make it apparent that cold is not a certain nature, but a privation. Perhaps even the nature of fire may turn out to be some such thing; that is, perhaps the underlying subject is smoke or charcoal, the former being always hot (for smoke is a vapour), while charcoal, when extinguished, is cold. And oil and pinewood might become cold.

Virtually all things that have been burnt possess heat—e.g. cinders and ashes, and the excrement of animals, and, among the residues, bile—through having been burnt and some residual heat having been left in them. But pinewood and fats are hot in another way, through changing quickly into fire in actuality.

The hot seems both to solidify and to melt. Thus cold solidifies those things consisting only of water, while fire solidifies those consisting of earth; and among hot things, the more earthen solidify quickly by means of cold and are insoluble, while the watery ones are soluble. What sorts of things are capable of solidification, and the causes owing to which they are solidified, have been determined more clearly elsewhere.

Since 'hotter' is spoken of in more than one way, the questions
649b 'what is hot?' and 'what sort of thing is hotter?' will not apply in the same way in every case; rather, it must be determined that *this* thing is hot in itself, while perhaps another is hot incidentally; and that *this* thing is hot potentially, *that* one actually, *this* thing by way of being hotter to the touch, *that* one by producing flame and fire. And since hot is spoken of in many ways, it will obviously follow that the same account applies to cold as well. So then: let hot and cold and their degrees be defined in this manner.

## CHAPTER 3

The next step is to review dry and moist as well, in conformity with what has been said. These too are spoken of in various ways;

for example, some things are moist or dry potentially, some actually. For ice and all solidified moist things are called actually and incidentally dry, being potentially and in themselves moist, while earth, ash, and such things, having been mixed with moisture, are actually and incidentally moist, yet in themselves and potentially dry; but when these have been decomposed, the ingredients that consist of water are fluid and both actually and potentially moist, while the ingredients that consist of earth are all dry, and it is in this way most of all that the dry is spoken of properly and without qualification. And likewise too with the other things, those that are moist, hot, and cold—'properly and without qualification' holds of them by virtue of the same account.

With these things determined, it is evident that blood is in a way hot, i.e. in so far as it is what it is for blood to be blood; blood is spoken of just as we would speak of boiling water were we to signify it by a certain term. But the underlying subject, i.e. whatever it is that is blood, is not hot; and in itself blood is in one way hot, and in another not. For heat will belong in its account, just as white belongs in the account of white human being; but in so far as blood is hot in virtue of an affection, it is not hot in itself. And so it is with dry and moist. Hence in the nature of such things as well some are hot and moist but when separated solidify and appear cold, such as blood, while others, like bile, are hot and thick, but when separated from the nature of their possessors suffer the opposite—they cool and become moist; for while blood becomes more dry, yellow bile becomes more moist. (It must be posited that more and less participation in the opposites is present in these things.)

In what way the nature of blood is hot and moist, and in what way it partakes of their opposites, has pretty much been said. 650a

Since everything which grows must take in nourishment, and nourishment is in every case from moist and dry, and the concoction and transformation of these things comes about through the potency of the hot, owing to this cause if no other all the animals and plants must have a natural origin of heat—and this, like the preparation of the nutrients, is shared by numerous parts. For it is evident that the *first* nutritive service in animals is performed by the mouth and, for those animals whose nutrients must be cut up, by the parts within it. But this is in no sense a cause of concoction, but rather of good concoction; for their division into small pieces facilitates the prepration of the nutrients by the heat. The work of the upper and lower gut forthwith concocts the food with the aid of the natural heat.

Just as the mouth is a channel for undigested nutrients—and the part continuous with it extending to the stomach, called the oesophagus, in those which have it—so there must also be many other origins, through which the body takes all the nutrients from the stomach and from the nature of the intestines, as from a trough. For while plants take their already worked-up nutrients from the earth by means of their roots (which is also why residues do not come about in plants, since plants use the earth and its heat as a stomach), virtually all animals, and clearly the locomotive ones, have the stomach cavity, like an earth within them. From this they must somehow take the nutrients—just as plants do with their roots—until they reach the end of this continuous concoction. For the operation of the mouth passes its product on to the stomach, and it is necessary for something else to take it from this, which is just what occurs. For the blood 3vessels extend all through the intestines, beginning beneath the stomach and extending up to it. These things should be studied with the help of the dissections and natural enquiries.

Since there is something receptive of all nutrients and generated residues, and the blood vessels are like a container for blood, it is apparent that blood is the final nutrient for the blooded animals, and its analogue for the bloodless. And the amount of blood decreases on account of *not* taking nourishment, and increases on account of taking it. And when the nourishment is wholesome the blood is
650b healthy, while when it is bad, the blood is bad.

It is, then, apparent from these and like considerations that blood is present in blooded animals for the sake of nourishment. And indeed, because of this, touching it does not produce sensation, any more than it does in the case of other residues. Nor is nourishment like flesh, for touching *it* does produce a sensation. In fact blood is not continuous with flesh, nor united with it, but lies in the heart and the blood vessels as in a container. The way in which the parts derive their growth from blood, and the subject of nourishment generally, is more appropriately considered in the works on generation as well as in other works. For now let this much be said (for so much is useful): blood is for the sake of nourishment, i.e. nourishment of the parts.

## CHAPTER 4

Some blood has what are called fibres, but some, such as that of deer and gazelles, does not. It is for just this reason that this sort of blood does not solidify—the part of the blood that is watery is colder, which is also why it does not solidify; while the part of the blood that is earthen solidifies when the moisture evaporates, and the fibres are made of earth. Now *some* of these animals also have a more subtle intelligence, not because of the coldness of their blood, but rather because it is thin and pure; for what is earthen has neither of these properties. For those animals with finer and purer moisture have quicker perception. Indeed, because of this even some of the bloodless animals have a more intelligent soul than some of the blooded ones, as has been said before; e.g. the bee, the ant kind, and any others there may be of this sort.

The animals that are excessively watery are more timid. This is because fear cools; accordingly, those having such a blend in the heart are predisposed to this affection, since water is solidified by the cold. This is also why the other bloodless animals are, generally speaking, more timid than the blooded, and when afraid become immobile, discharge residues, and in some cases change their colours. However, those with excessively fibrous, thick blood are more earthen in nature, and both spirited in character and excitable because of their spirit. For spirit is productive of heat, and solids that have been heated give off more heat than liquids; and the fibres are solid and earthen, so that they become like sparks in **651a**
the blood, and produce a boiling in the spirit. That is why bulls and boars are spirited and excitable; their blood is most fibrous, and indeed the blood of the bull solidifies most quickly of all. But their blood does not solidify when these fibres have been extracted; for just as if one were to extract the earth from mud, the water would not solidify, so it is with the blood, since the fibres are made of earth. But if they are *not* extracted the blood is solidified by cold, like moist earth. This is because the moisture evaporates when the heat is squeezed out by the cold, as was said before, and moist earth is solidified not by heat, but by being dried out by the cold. And there is moisture in these bodies on account of the heat that is present in animals.

The nature of the blood is the cause of many features of animals with respect to both character and perception, as is reasonable, since blood is the matter of the entire body; for nourishment is matter, and blood is the last stage of nourishment. It therefore makes a great difference whether it is hot or cold, thin or thick, turbid or pure. Serum is the watery part of the blood, either on account of its not yet having been concocted or its having undergone decay, so that serum exists on the one hand of necessity, and on the other for the sake of blood.

## CHAPTER 5

Soft fat and hard fat differ from one another in accordance with the differentiation of blood. For each of them is blood having undergone concoction because of a rich diet, and having not been absorbed into the fleshy part of the animals though well concocted and well congealed. Their oily character makes this clear; for oil is one of the moist things which are a combination of air and fire. It is because of this that none of the bloodless animals has either soft or hard fat—because they do not even have blood.

Among blooded animals the ones with bodily blood have harder fat. For hard fat is earthen, which is why it solidifies, just as both what is itself fibrous and broths of that sort do; for it has a small amount of water but a large amount of earth. That is why animals without a complete set of teeth but with horns have hard fat. That the nature of these animals is full of such an element is apparent from their being horned and having knuckle-bones; for all these parts are dry and earthen in nature. But those with a complete set of teeth, no horns, and toes have soft fat rather than hard, which neither solidifies nor crumbles when it is dried out because its nature is not earthen.

Now when these fats are present among the parts of animals in moderate amounts they are protective (for they do not impede
651b perception, while they contribute to health and potency), but when excessive in quantity they are destructive and injurious. For if the entire body were to become soft fat and hard fat, it would perish. For something is an animal in virtue of its perceptive part, and it is flesh and its analogue that are perceptive. Blood, on the other hand, as has also been said previously, lacks perception; hence so does soft or hard fat, since it is concocted blood. So, if the entire body were to become fat, it would lack perception entirely.

This is also why animals with excessive fat age quickly; for those which have their blood converted into fat are blood-deficient, and those with blood-deficiency are already on the way to passing away. For passing away is a sort of blood-deficiency, and the animal deficient in blood is susceptible to any chance encounter with either cold or heat. And fat animals are more infertile for the same reason; namely, what needed to go from the blood into semen and seed is converted into soft and hard fat; for concocted blood becomes these things, so that in these animals either no residue is generated at all, or only a small amount.

We have stated, regarding blood, serum, and soft and hard fat, both what each of them is, and owing to what causes each of them is.

## CHAPTER 6

Marrow, too, is of the nature of blood, and not, as some think, a seminal potential of the seed. This is clear in the very young; for inasmuch as the parts in the embryos are constituted from blood and their nourishment is blood, the marrow in their bones is also blood-like. But when they grow and undergo concoction, just as the parts and the viscera change colour, in the same way the marrow does too (for again, when animals are young each of the viscera is also excessively blood-like). And among animals with soft fat the marrow is, like soft fat, oily, while in those in which marrow is not like soft fat, but in which the concocted blood becomes hard fat, it is hard. That is why the marrow is hard in those animals with horns and lacking one set of teeth, while in those with both sets of teeth and toes it is soft. But the marrow of the backbone is least fatty because it must be continuous and extend through the entire backbone, which is divided into vertebrae; if it were either oily or of the character of hard fat it would not be continuous in the same way, but either crumbly or moist.

Some animals—those with strong, dense bones—do not have marrow worth mentioning, e.g. the bones of the lion; for its bones, because they contain virtually no trace of marrow, seem not to **652a**
possess it at all. But since either the nature of the bones, or that which is analogous to bones, such as fish-spine in water-dwellers, must be present in animals, it is also necessary for marrow to be present in some, in those cases where the nourishment from which the bones develop becomes enclosed. And that the nourishment for all parts is blood has been said before.

It is also reasonable that there are marrows akin to both hard fat and soft; for it is because it becomes warm by being enclosed within the bones that the blood undergoes concoction, and the concoction of blood by itself is hard and soft fat. It is also reasonable that in some of those with dense, strong bones, marrow is absent, while in others a small amount is present; for the nourishment is converted into the bones. But in those animals with fish-spine rather than bone the backbone alone has marrow, both because they are by nature blood-deficient, and because the backbone is the only hollow fish-spine. For this reason, marrow arises in it, both because it alone has space, and because it alone has need of a bond, on account of its divisions. That is also why the marrow here, as has been said, is somewhat different; for on account of its coming to be in place of a ligament it is viscous and sinewy, in order that it have the ability to stretch.

Why, then, those animals with marrow have it has been stated; and from these considerations it is also apparent what marrow is—the enclosed, concocted residue of the sanguineous nourishment apportioned to bones and fish-spine.

## CHAPTER 7

The very next thing to discuss is the brain; for to many people the brain seems to be marrow, even the origin of the marrow, from observing the continuity of the spinal marrow with it. Yet the brain is, in almost all respects, the opposite of marrow in its nature; for while the brain is among the coldest of the parts within the body, the marrow is naturally hot; this is clear from its oily and fatty character. This is also why the spinal marrow is continuous with the brain; for nature always devises, as a protection against an excessive amount of each thing, the juxtaposition of its opposite, in order that the one equalize the excess of the other.

That marrow is hot is clear from many considerations; the coldness of the brain is apparent on the one hand to the touch; and furthermore, it is the most bloodless of all the moist parts in the body (indeed it has no blood at all in it), and the driest. And the
652b brain is neither a residue nor one of the continuous parts. Rather, its nature is distinctive; and it is reasonable for it to be this way.

That the brain has no connection to any one of the perceptual parts is clear both through visual inspection and even more by the fact that touching it produces no sensation at all, any more than touching blood or animal residues does. Rather it is present in animals for the preservation of their entire nature. For while some crudely posit fire or some such potential to be the animal's soul, it is perhaps better to say that soul is constituted in some such body. This is because among bodies the hot is the one most able to assist with the functions of the soul; for nourishing and producing change are functions of soul, and these things come about most of all through this potential. Saying fire is the soul, then, is like saying the saw or auger is the carpenter or carpentry because the function is accomplished when they are near each other.

That animals must partake of heat is clear from these considerations; and since everything requires an opposing counterweight in order that it achieve the moderate state and the mean (for the mean possesses substantial being and the defining account, while each of the extremes separately does not)—because of this nature has devised the brain in relation to the heart's location and heat. And it is for the sake of this that this part, with the combined nature of earth and water, is present in animals. For this reason too all the blooded animals have a brain, while virtually none of the other animals does, excepting those that have a brain by analogy, such as the octopus; for they all have little heat on account of being bloodless.

The brain, then, makes the heat and boiling in the heart well-tempered; and in order that this part also achieve moderate heat, the blood vessels extend from both the great blood vessel and what is called the aorta to the membrane surrounding the brain. And to prevent harm due to the heat, densely packed and thin blood vessels surround the brain instead of a few large ones, and instead of much thick blood, it is thin and pure. It is also for this reason that fluxes originate from the head, in those bodies in which the region surrounding the brain is colder than the proportionate blend. For when the nourishment vaporizes up through the blood vessels, the residue that undergoes cooling because of the potential of this **653a**
region produces fluxes of phlegm and serum. As a comparison of a great thing to a small, one should take this to happen similarly to the generation of rain—once vaporized and transported by the heat from the earth to the upper region, the mist, when it comes to be in the cold air above the earth, is reconstituted into water because of the cold and falls back down to earth. However, the appropriate place to speak about these things—to the extent that it *is* up to the

natural philosopher to speak about them—is in the discussions of the origins of disease.

It is this part—the brain—which also produces sleep in those animals that have one; while in those without one, it is the analogous part. For by cooling the flow of blood from the nourishment, or on account of certain other similar causes, it weighs the region down (for which reasons those who are sleepy are heavy-headed), and makes the heat recede downwards along with the blood. Because of this greater accumulation in the lower region it produces sleep, and takes away from those animals which are of an upright nature their ability to stand erect, while from the other animals it takes away the ability to hold their head upright. We have spoken about these things independently in works establishing definitions both about perception and about sleep.

That the brain is a combination of water and earth is clear from the following fact about it: boiling it makes it dry and hard, and with the evaporation of the water by heat the earthen material remains. It is just like what happens with boiled mashes produced from legumes and other fruits once the moisture mixed in them departs because they are, for the most part, constituted of earth; that is, these too become completely hard and earthen.

Among animals mankind has the largest brain in respect of magnitude, and among human beings the males have a larger brain than the females; for the region around the heart and the lung is also most hot and most sanguineous in males. This is also why human beings alone among animals are upright; for the nature of the prevailing heat produces growth from the middle according to its own movement. Thus much heat is opposed by much moisture and cold, and because of its magnitude the bone around the head, which some call the frontal bone, is the last to solidify. This is on account of the length of time it takes the heat to produce evaporation; in none of the other blooded animals does this happen. It also has many
653b sutures around the head, and the male more than the females, for the same reason, in order that this place is well ventilated, and the more so the larger the brain. For if it becomes overly moistened or dried it will not perform its function, and either will not cool the blood or will solidify it, so as to produce diseases, mental derangements, and deaths; for the heat in the heart, i.e. in the origin, is extremely sensitive, and quickly produces an awareness of any changes or affections of the blood around the brain.

We have spoken, then, about virtually all the fluids present naturally within animals. Of those kinds that develop later, there are residues of nourishment, the deposits from both the bladder and gut; and besides these, semen and milk, in those which naturally have each of these. Now the residues of nourishment have their own proper accounts in the examination and study of nourishment, stating in which animals they are present, and owing to which causes; and the residues of seed and milk have their proper accounts in the works on generation; for the first of these residues is an origin of generation, and the second is for the sake of generation.

## CHAPTER 8

Next we need to examine the other uniform parts, and first of all flesh, in those animals which have flesh, and its analogue in the other animals; for flesh is in virtue of itself an origin and a body of animals. This is clear even from our account; for we define animal by the possession of perception, and primary in this account is the primary mode of perception. This is touch, and it is of touch that such a part is the sense-receptor—either the primary one, just as the pupil is of vision, or it taken with the medium, as if one were to add the entire diaphanous medium to the pupil. Now, in the case of the other modes of perception, to do this would be by nature both impossible and useless; but in the case of the capacity for touch, it is done of necessity. For of the sense-receptors, this is either the only, or the most, bodily one.

It is apparent to perception that all the other uniform parts are for the sake of flesh, by which I mean bone, skin, sinews, blood vessels, and again hair, and the kind which includes claws, and any other such parts there may be. For the nature of the bones, being hard as it is, has been devised for the sake of the preservation of soft tissue in animals which have bones; and in those which do not have them, the analogue of bone—for example, in some fish, fish-spine, in others, cartilage.

Now some of the animals have this sort of protection inside, but
some of the bloodless animals have it outside, as for instance each 654a
of the soft-shelled animals, e.g. crabs and the crayfish kind, and likewise the kind consisting of hard-shelled animals, such as those called oysters—in all these cases the fleshy part is inside, while the earthy part is outside, enclosing and shielding it. For in addition

to the shielding achieved by the enclosure, in those which, being bloodless, have little natural heat, the shell shields their smouldering heat, like a surrounding damper. The tortoise and the kind consisting of the turtles seem to be in a similar condition to these, though they are a different kind.

The insected and the soft-bodied animals are constituted in a way that is both contrary to those just discussed and opposite to each other. For none of them seems to have a distinguishable bony or earthen part worth mentioning. Rather, while the soft-bodied animals are almost entirely fleshy and soft, these animals have a nature between flesh and sinew, in order that their body is not, as fleshy things are, susceptible to destruction. For while their body is, like flesh, soft, it possesses elasticity, like sinew; and it splits in the manner of flesh, dividing not in a straight line but in a circle; for in this way it would be most useful for strength.

There is even an analogue to the spines of fish in the soft-bodied animals; for example, in the sepia there is a part called the 'sepion', in the squids what is called the 'sword'. On the other hand, the octopus kind has no such part, because it has a small sac (called the 'head'), while the other soft-bodied animals have a sac of considerable length. It is for this reason, in consequence of their straightness and rigidity, that nature added these parts, as it did bone for some of the blooded animals and fish-spine for others.

The insects, on the other hand, have things arranged in a manner opposite to both the soft-bodied animals and the blooded animals, just as we said. That is, none of them has a hard part separated from the soft; rather their entire body is hard, yet the hardness is such that, though more flesh-like than bone, it is more bone-like and earthen than flesh, in order that their body should not be easily divisible.

## CHAPTER 9

The nature of bones and the nature of blood vessels are alike. For each of them, having originated from one thing, is continuous; and a bone on its own is nothing; rather, it is a part either as part of something continuous or through contact and binding, in order that
654b nature may use it both as one and continuous and, for bending, as two and divided. Likewise too a blood vessel on its own is nothing; rather, all blood vessels are part of one thing. And indeed, if any

bone were separate, it would not perform the function for the sake of which the nature of bones exists (for if it were not continuous but disconnected, it would not be a cause either of bending or of straightening). And further, it might be harmful, like a sort of thorn or sting imbedded in the flesh. And if some blood vessel were separate and not continuous with its origin, the blood within it would not be preserved, for the heat from that origin prevents the blood from becoming congealed, which is apparent when the separated blood also putrefies.

While the heart is the origin of the blood vessels, the origin of the bones in all animals that have them is called the backbone, from which the nature of the other bones is continuous. For the backbone of these animals is what maintains their length and straightness. And since it is necessary when the animal moves for its body to bend, the backbone, though one on account of its continuity, is made of many parts by the division of the vertebrae. The bones of those with limbs extending from the backbone and connected to it are suitably arranged. In so far as the limbs are flexible, the bones are both bound together by sinews and their extremities fit together—either one being hollow and the other curved, or both being hollow, surrounding a knuckle-bone in the middle like a bolt, in order that bending and extension may occur. For otherwise it would either be completely impossible for the limbs to perform such a motion, or else they would not do it well. Some of the limbs, however, have the beginning of the one bone like the end of the other, the two having been bound together by sinews. And there are also cartilaginous parts in the middle of the joints, like padding, in order that they do not rub against one another.

The fleshy parts, for the sake of which the kind consisting of the bones exists, grow naturally around the bones, being attached to them by fine, sinewy bonds. For just as those who shape an animal from clay or any other moist composition first set up, for support, some one of the hard bodies, then mould the clay around it, so in the same way has nature crafted the animal from the fleshy parts. Thus bones underlie the other, fleshy parts, and in those parts which move owing to a joint, bones are for the sake of this, while in immobile parts they are present for the sake of protection. For example, the ribs enclosing the chest are for the sake of the preservation of the viscera around the heart, while the region around the gut is 655a
entirely without bones, in order that nothing should prevent the

expansion brought about of necessity in animals by nourishment, and in females by the growth of the embryo in them.

The animals that bear live young both internally and externally are about equal in the potency and strength of their bones. For, speaking according to bodily proportion, all such animals are much larger than those that do not bear live young; indeed in some places many of those that bear live young are large, as in Libya and places that are hot and dry. And for those that are large, there is need of supports which are stronger, larger, and harder, especially for those among them that are more predatory. For this reason the bones of the males are harder than those of the females, especially those of the carnivores (for their nourishment is acquired through fighting) such as the lion; it possesses bones so hard in nature that a fire is touched off when they are struck, just as by stones. And even the dolphin has, not fish-spines, but bones; for it is live-bearing.

In those that are blooded but *not* live-bearing, nature makes a transition by small steps; for example, in the case of birds, they have bones, but weaker ones. And in the case of fish, those that lay eggs have fish-spine, and in the case of snakes the nature of the bones is like fish-spine except in the very large ones. In these, for the same reason as for the live-bearers—for strength—there is need of a stronger skeleton. But the fish that are called selachians are cartilage-spined in nature. This is both because it is necessary for their movement to be more fluid, so that the nature of their supports must also be softer, and not brittle; and because nature has used all the earthy material in their skin, and nature cannot distribute the same excess to many different locations simultaneously.

Many of the bones present in live-bearing animals are also cartilaginous, in those cases where there is an advantage in the hard part being soft and pulpy, because of the surrounding flesh, as is the case with the ears and nostrils; for brittle appendages are quickly broken. The nature of bone and cartilage is the same, though it differs by the more and less; and that is why in neither one does a part that has been cut off grow.

The sorts of cartilage present in land animals have no separated marrow; for it is a thorough mixing of the separable marrow with it that makes the constitution of the cartilage soft and pulpy. In the selachians, however, the backbone is cartilaginous, but has marrow
655b since this part belongs to them instead of bone.

Such parts as claws, solid and split hoofs, horns, and the beaks of birds are, to the touch, closely allied to bone. Animals have all of these parts for the sake of protection; for the wholes that are constituted from and synonymous with their parts, e.g. whole horn or hoof, have been devised for the preservation of each of them. The nature of the teeth is also in this kind, in some cases present for a single function, the preparation of the nourishment, in other cases present both for this and for defence, e.g. in all those with saw-like teeth or with tusks. Of necessity all of these parts have an earthen and hard nature; for this is the defensive potential. And for this reason all such parts are present more in the four-footed live-bearing animals, because all of them have a more earthen constitution than mankind does.

But the causes of these parts and what each one is present in animals for—and related parts such as skin, bladder, membrane, hair, feather, and their analogues, and any other parts of this sort there may—these should be studied later, at the same time as the non-uniform parts. For as with the latter, so too with the former: it is necessary to know them from their functions. But since these parts are synonymous with their wholes, they were taken out of order now, with the uniform parts. And bone and flesh are the origins of all these things. And again, we omitted seed and milk from our study of the moist, uniform parts; their examination is better suited to the works on generation, since the one is the origin of generated things while the other is their nourishment.

## CHAPTER 10

We must now speak as if we are once more at an origin, beginning first with those things that are primary. For in all animals, at least those which are complete, there are two parts that are most necessary, that by which they receive nourishment and that by which the residue departs; for it is impossible to be or to grow without nourishment.

Plants (for we say plants live as well) have no place for useless residue; for they receive from the earth nourishment that has already undergone concoction. Instead of expelling a residue they drop their seeds and fruit. A third part present in all animals lies midway between the two most necessary parts, within which is their origin of life.

It is, then, of the nature of plants, being immobile, not to have

656a many forms of the non-uniform parts; for few actions require the use of few instruments. Accordingly, we should study the visible character of plants independently. But those things with perception in addition to life are more polymorphic in visible character, and some of these more than others. And there is still greater variety among those whose nature partakes not only of living but, in addition, of living well. Such is mankind; for of the animals known to us either mankind alone, or mankind most of all, partakes of the divine. So both because of this and because the shape of the external parts of mankind is most familiar, one ought to speak about mankind first. For straight away the natural parts are disposed according to nature in this kind alone, that is, what is above for mankind accords with what is above for the whole cosmos; for mankind alone among the animals is upright.

It follows necessarily from what has been said about the brain that the head is without flesh. For it is not the case, as some people say, that if the head were fleshy, the kind would be longer-lived; but that (they claim) it is without flesh for the sake of fine perception. For they claim that animals perceive by means of the brain and that perception is not admitted into parts with excess flesh. None of these claims, however, is true. Rather, if the region surrounding the brain were very fleshy, it would produce the opposite result to the one for the sake of which the brain is present in animals (for if *it* were too warm, it would be unable to cool). And surely what is itself, just like any of the residues, imperceptive is not a cause of any of the modes of perception. But failing to discover the cause owing to which some of the senses in animals are in the head, and seeing that the brain is more distinctive than the other parts, they couple these two things together in the manner of a syllogism.

That the region around the heart is the origin of the senses was determined previously in the works on perception, as well as why two of them, touch and taste, are evidently connected to the heart. It was also there determined why, of the remaining three, the sense of smell is in between the senses of hearing and sight, which are in most cases in the head on account of the nature of their sense-receptors. Sight is located there in every case, although hearing and smell in fish and other such animals make what was just stated evident. For these animals hear and smell, though they have no apparent sense-receptor in the head for these perceptibles. And it is reasonable that sight, in all that have it, is in the area around the brain; for the brain is moist and cold, and sight is in its nature water, since water is the most easily confined of transparent things. Again, it is because of parts with purer blood that the more accurate of the modes of perception necessarily *become* more accurate; for the motion of the heat in the blood erases perceptive activity. It is for these reasons that these sense-receptors are in the head. 656b

Not only is the front of the head without flesh, but the back as well, because in all those which have it this part needs to be the most upright; for it is impossible to stand upright with a burden, but such would the head be if it were covered in flesh. From this too it is clear that the head is not lacking in flesh for the sake of the brain's perception; for the back of the head has no brain, but it is similarly without flesh. It is also reasonable that some of the animals have their hearing in the region around the head; for the part called 'empty' is in fact full of air, and we claim that the sense-receptor for hearing consists of air.

The channels from the eyes go to the blood vessels around the brain; and again in like manner a channel from the ears connects to the back of the brain. Nothing bloodless, however, is capable of perception, nor is the blood, but some of the things made from this. This is precisely why nothing bloodless in the blooded animals is perceptive, nor is blood itself; for it is no part of the animals.

All those with a brain have it in the front, because the front is towards what is perceived, perception originates from the heart, the heart is among those parts in the front, and perceiving occurs by means of the parts with blood, while the hollow rear part of the head is devoid of blood vessels. The sense-receptors have in this way been beautifully ordered by nature, those for hearing placed on the midline of the circumference (for one hears not only in a straight line but from everywhere), those for sight in the front (for one sees in a straight line, and movement is in the forward direction, and one needs to see in advance what the movement is towards). And the sense of smell is reasonably placed between the eyes. For because the body is double, one part the right, the other the left, each of the sense-receptors is double. Now in the case of touch this is not clear; this is because the primary sense-receptor is not flesh and parts such as flesh but something internal. And though in the case of the tongue it is less clearly double than eyes or ears, it is more clearly so than touch; indeed, this sense is like a sort of touch.

657a But nevertheless even with the tongue the duality is clear; for it is apparent that it is split.

But perception is most obviously bipartite in the other sense-receptors; for there are two ears and two eyes, and the potential of the nostrils is bifurcated. Now were it positioned in another manner, i.e. widely separated as the power of hearing is, it could not perform its function, nor could the part in which it resides; for this mode of perception, in animals with nostrils, happens by means of breathing, and this part is in the middle and in front. It is for just this reason that nature has united the nostrils in the middle of the three sense-receptors, placing them, as it were, on a single line to serve the motion of breathing.

## CHAPTER 11

These sense-receptors are also well situated in the other animals in relation to each one's proper nature. For the four-footed animals have their ears separated and above the eyes, or so it would seem. That is not actually the case, however, though it appears so because these animals are not upright but bent over. And since most of them move about in this position, it is useful for the ears to be both higher up and mobile; for when rotated they receive sounds from every direction.

## CHAPTER 12

The birds possess only auditory channels, on account of the hardness of their skin and because rather than having hair, they are feathered; accordingly they do not have the sort of matter from which ears may be formed. Likewise too with the four-footed animals that lay eggs and have hard scales—the same account also applies to these. And among the live-bearing animals even the seal has, not ears, but auditory channels, because it is a deformed four-footed animal.

## CHAPTER 13

Human beings, birds, and of four-footed animals both the live-bearing and egg-laying, have a safeguard for the eye. The live-bearing have two eyelids, by means of which they also blink. Both the heavy birds and some others close their eyes by means of a lower lid, as do the egg-laying, four-footed animals. The birds blink by means of a membrane originating from the corners of the eyes.

The eyes have a safeguard because they are moist, which they are by nature in order that they may see sharply. For if the eyes were hard-skinned they would be freer from harm done by things striking them from without, but they would not be sharp-sighted. So it is for the sake of being sharp-sighted that the skin around the pupil is thin, while the eyelids are for the sake of the preservation of the eyes. It is also because of this that all these animals blink, and most of all human beings. They all blink in order to prevent things striking the eyes (and this is not done by choice, but rather nature 657b
does it), and mankind most of all because its pupils are the most thin-skinned. The eyelid surrounds the eye with skin; for which reason as well—because they are skin without flesh—neither it nor the foreskin grow together.

Those birds that close their eyes by means of the lower lid, and the egg-laying, four-footed animals, close their eyes in this way on account of the hardness of the skin surrounding their head. Of the feathered animals the heavy ones, because they are unable to fly, have the growth of their feathers diverted into the compactness of their skin. It is for this reason too that they close their eyes by means of the lower eyelid, while pigeons and the like use both.

The four-footed, egg-laying animals are covered with hard scales; and since these scales are all harder than hair, the skin of these animals is also harder than the skin of those with hair. Hence the skin around the head in these animals is hard, which is precisely why they do not have an upper eyelid. And the skin lower down is flesh-like so that the lower eyelid can be extremely thin and elastic.

The heavy birds do blink, although not with the lower eyelid but with the membrane; this is because the movement of their eyelid is slow, while blinking must happen quickly, and the membrane is quick. The heavy birds blink from the corner of the eye next to the nostrils because it is better that the nature of the membranes be from one origin, and these have an origin at the connection to the nostril; and the front is more of an origin than the side.

The four-footed, egg-laying animals do not blink in the same way as the birds, because since they are terrestrial, it is unnecessary for them to have moist and accurate vision. But for birds it is necessary, since they use vision to see from a great distance. Accordingly the crook-taloned birds have sharp vision (for they search for their food from above, which is also why these most of all soar to the heights), while those which are terrestrial and incapable of flight, such as domestic fowl and the like, do not have sharp vision. For nothing related to their way of life requires them to have it.

Fish, insects, and hard-skinned animals have eyes which differ from one another, but none of them has eyelids. For the animals with hard skin generally do not have them (the usefulness of the eyelid depends on its quick and membranous operation); instead, in place of this safeguard all of these animals have hard eyes, as if seeing through a fused eyelid. And since on account of their hardness they necessarily see more poorly, nature makes the eyes in the insects, and even more so in the hard-skinned animals, mobile
658a (as it does the ears in some of the four-footed animals) so that, by turning to the light and receiving its beam, the eye may see more sharply.

The eyes of fish are moist. For they must use their vision from far off, since they are made to move around a great deal. Now in the case of land-dwellers the air facilitates vision; but in the case of fish, water has the opposite effect on sharp vision, though there are fewer obstacles to vision than with air. For this reason fish do not have eyelids (for nature does nothing in vain), and their eyes are moist in consequence of the density of water.

## CHAPTER 14

All animals with hair have eyelashes on their eyelids, while none of the birds and the animals with hard scales do, since they do not have hair. (We will provide the explanation for the Libyan ostrich later—for this animal *does* have eyelashes.) And of those with hair, only human beings have eyelashes on both eyelids. For the four-footed animals do not have hair on their underbellies, but rather on their backs; while human beings have the opposite arrangement, more on their underbellies than on their backs. Hair is present in those that have it for the sake of covering. Now in four-footed animals the backs have a greater need for covering, and though their fronts are more valuable, they are nevertheless hairless because they are bent over. But in human beings, since on account of their upright posture their fronts and backs are on equal terms, nature adds this protection to the more valuable parts; for it is always a cause of the better among the possibilities.

This is also why none of the four-footed animals has lower eyelashes, though in some a few hairs grow under the lower eyelid; nor do they have hair in the armpits or the pubes, as human beings do. Rather, instead of these arrangements, some are covered by hair over the entire back part of their body, as the canine kind is; others, like horses and such, have a crested mane; and still others have a flowing mane, like the male lion.

Again, in those with long tails, nature has adorned the tail with hair—long hair in those, such as the horse, with a short stump, short hair in those with a long stump, in accordance with the nature of the rest of the body. For nature everywhere gives to another part what it takes from elsewhere. And in those cases where nature has made the body quite hairy, the hair around the tail is wanting, as **658b** happens with the bears.

With respect to the head, mankind is the most hairy of animals, *from necessity*, on account of the moistness of the brain and on account of the sutures (for where there is much moisture and heat there must be much growth), and *for the sake of* protection, so that it may provide covering, warding off the extremes of both cold and heat. And since the human brain is the most moist, it is also most in need of this protection; for what is moist boils and freezes most easily, while what is in the opposite state is less easily affected.

But a digression on these subjects resulted from their connection with the causes of eyelashes—on account of their kinship. Thus about the rest mention should be made on the appropriate occasions.

## CHAPTER 15

The eyebrows and eyelashes are both for the sake of protection. The eyebrows are for the sake of the moisture running downwards, so that like eaves they may shelter the eyes from the moisture from the head. The eyelashes are for the sake of things falling towards the eyes, like the palisades sometimes put up in front of walls. The eyebrows are at the conjunction of bones, which is also why in many cases they become bushy as people age, so that they need to be trimmed. The eyelids, however, are at the ends of small blood vessels; for where the skin terminates, the small blood vessels also reach their limit. So because the moist secretions oozing out are bodily, it is necessary that—unless some function of nature redirects it to another use—even owing to a cause such as *this*, hair from necessity come to be in these locations.

## CHAPTER 16

In all the other four-footed, live-bearing animals the organ of smell does not differ to any great extent from one to the next; though in those with long jawbones that become progressively narrower the part consisting of the nostrils is, as far as is possible, actually present in what is called the 'snout', while in the rest the nostrils are more differentiated from the jaws.

In the elephant, however, this part is most distinctive compared with the rest of the animals—it is extraordinary in both size and potency. For by means of the 'nostril', used like a hand, the elephant conveys both dry and liquid nourishment to its mouth, and
659a wrapping it around trees, it uproots them—again, it is used as if it were a hand.

This animal is at once a swamp-dweller and a land-dweller in nature. So, since on occasion it gets its nourishment from water, and, being a blooded land-dweller, must breathe, and, on account of its size, is unable to make the transition from moist to dry environments as quickly as some of the live-bearing, blooded animals do, it necessarily uses the water as it does the land. Thus as some divers equip themselves with instruments for breathing, in order that they can inhale air through this instrument from outside their moist environment while remaining in the sea for an extended time, nature makes the length of the nostril such an instrument for the elephants. Hence whenever they make their way through a moist environment, they breathe by raising their nostril up through the water; for as we said, the elephant's trunk is its nostril.

Since it would be impossible for there to be such a 'nostril' if it were neither soft nor able to bend (for its length would impede taking in nourishment from outside, just as they claim horns in the backward-grazing oxen do; and indeed they say these animals graze by going backwards, rear end first), such a nostril will therefore be present in the elephant. And since it is present, nature, as usual, turns the same part to more than one use, here using the trunk in place of the front feet. For four-footed animals with many toes have front feet in place of hands, not merely for the sake of supporting their weight. And the elephants are members of this group; that is, they have feet that are neither cloven- nor solid-hoofed. But since the size and weight of their body are great, their feet are only for the sake of support, and because of their slowness and their natural unsuitability for bending, they are useless for anything else.

The elephant, then, has a nostril because of respiration, as indeed does each of the other animals with a lung; but because it spends time in a moist environment and its transit from there is slow, its nostril is long and can be rolled up. And since the elephant has been denied the use of its feet, nature, as we said, also makes use of this part for the service that might have been provided by the feet.

The birds, the snakes, and the other blooded egg-layers among **659b** the four-footed animals have the nostril channels in front of the mouth, but except on account of function they do not have clearly differentiated nostrils to speak of; the *bird*, at any rate, has nothing one would call a nose. This is a consequence of the fact that instead of jaws it has what is called a beak. And these things are so because nature has constituted the birds in this way. That is, they are both two-footed and winged, so that it is necessary that their head and neck have little weight, just as it is also necessary that the chest be narrow. In order, then, that it may be useful for both physical strength and nourishment, the beak they have is *bony*; while it is *narrow* on account of the smallness of their head. And in the beak they have channels for smell, but are unable to have nostrils.

We have previously stated the cause owing to which the other, non-breathing animals lack nostrils; but some perceive odours through gills, some through pipes, and the insects do so through their mid-section. And all of them smell, just as they move, by means of their body's inborn breath; for this is present by nature in all and is not introduced from without.

In the blooded animals with teeth the nature of the lips is beneath the nostrils. For in the birds, as we said, for nourishment and strength their beak is bony. It has been joined together into one, in place of teeth and lips, just as if someone who had removed the lips from a human being were both to fuse the upper teeth together, and separately the lower teeth, and then were to draw them both out to a point; in fact this would already be a bird-like beak.

In the other animals the nature of the lips is for the preservation and protection of the teeth. That is why, as they have either precise and beautiful teeth or the opposite, so too do they have the lips differentiated. But human beings have lips which are soft, fleshy, and capable of separation, both for the sake of protecting the teeth (as the others do), and even more on account of the good; for these can also be used for speech. For just as nature made the human tongue unlike the tongues of others animals, using it for two operations, as we say it does in many cases, so it does with the lips—it makes use of the tongue for the sake of both flavours and speech, while it makes use of the lips for the sake of both speech and the protection of teeth. For vocal speech is composed out of articulate sounds; and if the tongue were not such as it is nor the lips moist, most of those articulate sounds could not be spoken, since some result from pressing of the tongue, others from pursing of the lips. But what sorts of sounds there are and how many, and what their differences are, must be learnt from those who study metre.

It is straightforwardly necessary that each of these parts should be suited to serve the aforementioned use, and to have such a nature; for this reason they are fleshy. And the flesh of human beings is the softest. This is because they are the most perceptive of animals with respect to tactile perception.

## CHAPTER 17

Beneath the roof of the mouth is the tongue. It is nearly alike in all the land-dwellers, while in other animals it is unlike, compared both with one another and with the land-dwellers. Mankind has the most detached, softest, and broadest tongue, so that it may be useful for both its operations. The soft, broad tongue is useful both for the perception of flavours (for mankind is the most keenly perceptive of animals, and his tongue is soft, for it is most tactile, and taste is a sort of touch), and for the articulation of sounds and for speech. In fact being soft in this way as well as detached, it would be especially capable of being pulled in and pushed out in every way. This is clear in those people for whom the tongue is not fully detached; for they speak inarticulately and defectively, and this is from a deficiency of articulate sounds. In what is wide the narrow is also present; for the small is present in the great, but not the great in the small. And that is why among the birds those most able to pronounce articulate sounds have broader tongues than the others.

Those of the four-footed animals that are blooded and live-bearing have little vocal articulation. This is because they have a tongue that is hard, undetached, and thick. Some of the birds, however, are quite vocal, and those with crook-talons have broader tongues. The smaller ones are quite vocal. And though all also use their tongue to communicate with one another, some do so more than others, so that in some cases they even seem to be learning from one another; these things have been discussed in the enquiries 660b
about animals.

Most of the land-dwelling, egg-laying, and blooded animals have an attached, hard tongue that is useless for the operation of vocalizing. For the tasting of flavours, however, the serpents and lizards have a long, forked tongue. The serpents have it *long* so they can stretch it out from small to great, and *forked*, with a fine, hair-like tip, because of their gluttonous nature; for it procures double the pleasure from flavours, having, as it were, double the perception of taste. The bloodless as well as all the blooded animals have the part perceptive of flavours; for even those which seem to most people not to have one, such as some of the fish, have one of a paltry sort, quite similar, in fact, to the river crocodiles. But there is a reasonable explanation why most of these animals do not appear to have this part; it is both because in all such creatures the mouth's location is spinous, and because for water-dwellers there is little time for the perception of flavours, and just as the tongue's use is slight, so too is its articulation. The passage of nutrition into their gut is rapid because they are unable to spend time extracting juices; for water would intrude. So unless one pulls their mouth open, the tongue does not appear to be a separate part. And this location is spinous; for it is composed from the conjunction of the gills, the nature of which is spinous.

In the crocodiles, the possession of an immobile lower jaw also contributes something to the lame character of this part. For their tongue is fused to the lower jaw, and they possess the upper jaw as if it were inverted with the lower; for in the other animals it is the *upper* jaw that is immobile. Yet they do not have their tongue connected to the upper jaw, because it would oppose the ingestion of nourishment, but to the lower jaw, because the upper jaw is, as it were, transposed. And further, while it is a land-dweller it happens to live the life of fish, so on this account too it is necessary for this part to be unarticulated.

Many of the fish also have a fleshy roof of the mouth, and some of the river-dwelling fish have an extremely fleshy and soft one, e.g. those called carp, so that it seems, to those not examining
661a things carefully, to be a tongue. And owing to the cause stated fish have, though it is not obvious, an articulated tongue. And since the perception of the taste found in flavours is for the sake of nutrition, this part is tongue-like, though not in every part equally but mostly in the tip. Because of this, in the fish only the tip is separated.

All animals have a desire for nourishment in so far as they have perception of the pleasure that arises from nourishment; for desire is of the pleasant. But the part by which the perception of nourishment is produced is not alike in all. In some, namely in those with no vocal function, it is detached, while in others it is attached; and in these latter it is hard, while in the former it is soft and fleshy. This is also why in the soft-shelled animals, such as crabs and the like, some such part is present inside the mouth, as well as in the soft-bodied animals such as the sepiae and the octopus.

Of the insects, some have such a part inside, such as the kind consisting of the ants, and likewise too many of the hard-shelled animals; while others have it outside, like a sting, its nature spongy and hollow, so as simultaneously to be able to taste and draw in nourishment. This is clear in the flies, bees, and all such animals, and again in some of the hard-shelled animals; in the purpurae this part has so much potency that it bores through the shell of mussels, such as the ones with spiral shells used as bait to capture them. And again, the deerfly pierces the skin of human beings, while the horsefly pierces the skin of other animals as well. In these animals, then, the tongue is naturally such as to be a counterpart to the nostril of the elephants; for in the elephant the nostril is for protection, and in these the tongue is present in place of a sting. But in all the other animals the tongue is precisely as we said.

# BOOK THREE

## CHAPTER I

Next after the parts just discussed is the nature of the teeth in 661a
animals, and the mouth which is surrounded by them and constituted from them. In animals other than mankind, the nature of the teeth is present *in common* for the preparation of nutrition, yet 661b
*distinctively* according to kinds. In some it is present for the sake of strength, which in turn has been divided into strength to attack and strength to avoid attack; for some animals have teeth for the sake both of avoiding attack and of attacking, e.g. those wild animals which are carnivorous in nature; while others have them for the sake of protection, as many of the wild and tame animals do.

Mankind has teeth well suited by nature to their common use—those in the front sharp in order that they may cut, the molars flat in order that they may grind. And the canines demarcate these from each other, their nature being intermediate between the two; for the intermediate participates in both extremes, and the canine teeth are in a way sharp and in a way flat. And it is likewise with the other animals too, those that do not have all their teeth sharp. But it is especially for language that mankind has teeth such as these and as many as these. For the front teeth contribute greatly to the generation of articulate sounds.

Some animals have teeth, as we just said, for the sake of nutrition alone. But those which have them for protection as well as for strength in some cases have tusks, like the pig, and in other cases have sharp, interlocking teeth, for which reason they are called sawtoothed. For since their strength lies in their teeth, and this comes about because of their sharpness, teeth which are useful for strength fit together in an alternating pattern, so as not to be worn down by being rubbed against one another. And none of the animals is at once sawtoothed and tusked, since nature makes nothing in vain or superfluous—for some, protection is accomplished through spearing, for others, through biting. That is why female pigs bite; they do not have tusks.

There is something general we need to grasp which will be useful both in the cases we are now considering and in many to be spoken of later. Of the instrumental parts that are for strength and protection, nature provides each of them only, or especially, to those animals that are able to use them, and especially to the animals able to use them most—parts such as sting, spur, horns, tusks, and any other such part there may be. And since the male is stronger and more spirited, in some cases he alone has such parts, in other cases he more than the female. For those parts which it is necessary for females to have as well, e.g. parts related to nourishment, they *have*, but they have *less*; while those related to none of the necessities, they do not have. It is also on account of this that among the deer, the males have horns, while the females do not. The horns of female cattle and bulls also differ, and likewise with the sheep as well. And while males have spurs, the majority of females do not. It is the same way too with the other parts of this sort.

All fish are sawtoothed, except the one called the parrotfish; and many also have teeth in their tongues and on the roofs of their mouths. This is because it is necessary, since they are surrounded by moisture, to take in moisture at the same time as nourishment, and to expel the moisture quickly. For it is not possible for them to spend time grinding things up, since the moisture would flow into their digestive parts. Because of this all their teeth are sharp, for cutting. And again, fish have many teeth in many places in order that, instead of grinding their food, they can cut it up into many pieces by means of their large number of teeth. And the teeth are curved because it is in the teeth that virtually all their strength lies.

All those animals that breathe and cool themselves from outside have the nature of the mouth both for the sake of these functions and for respiration besides. For nature, in virtue of itself, as we just said, puts the parts common to all animals to many distinctive uses; for example, in the case of the mouth nourishment is common to all, while strength is distinctive to some and speech to others, and again breathing is not common to all. But nature has collected all these uses together in one, producing a differentiation of this part for the differences of its operation. That is why some mouths are narrower, some wider: those which are for the sake of nourishment, respiration, and speech are narrower, while of mouths which are for the sake of protection, all that are sawtoothed open wide. For since their strength lies in their biting, it is useful for the opening of the mouth to be large; for the mouth bites with more teeth and over a larger area to the extent that it opens more widely.

Among fish, the biting and carnivorous ones also have a mouth of this sort, while those which are not carnivorous have a tapered one; for a mouth of this sort is useful for them, while a wider one would be useless.

In the birds, the beak, as it is called, is a mouth; for birds have this instead of lips and teeth. It differs according to the uses to which it is put and the protection required. For all the birds called crook-taloned have their beak hooked because they are carnivores and eat no seeds; such a mouth is by nature useful for mastering prey and is more powerful. But their strength lies both in this part and in their talons, which is why they also have their talons more curved.

In each of the other birds the beak is useful for its way of life; for example, for the woodpeckers, crows, and crow-like birds, the beak is strong and hard, while for the small birds it is hollow for collecting seeds and grasping mites. Some of those which are plant-eaters and live around marshland, such as those that swim and are web-footed, have a beak useful in other ways, while some of them are flat-beaked: for by virtue of being flat, it can root around easily, just like, among four-footed animals, the snout of the swine; for the swine too is a root-eater. And again, the root-eating group of birds, and some with similar ways of life, have the tip of the beak serrated, since for these birds, which are plant-eaters, such a beak does its work easily.

We have spoken, then, about most of the other parts on the head. But in human beings the region between the crown of the head and neck is called the face [*prosōpon*], having been named, as it seems, after its activity; for it is on account of being the only one of the animals that is upright that they alone see from afar [*prosōthen opōpe*] and transmit vocal sound forward [*to prosō*].

## CHAPTER 2

We must speak about horns; for these too, in those that have them, are by nature on the head. None of those that are non-live-bearing have horns. In virtue of similarity and by extension, however, horns are attributed to some other animals as well; but in none of them is the function of the horn present. For the live-bearing animals have horns for the sake of protection and strength, which is true of none of the other animals said to have a horn. For none of them use their horns in defending themselves or for overpowering, which are the functions of strength.

None of the many-toed animals has a horn. This is because the horn is a cause of protection, while different means of protection belong to the many-toed animals; for nature has provided some of them with claws, others with teeth fit for fighting, and still others with some other part sufficient for self-defence.

Many of the cloven-hoofed animals have horns for strength (as
663a do some of the solid-hoofed), and some have them for protection as well; but to those that do not, nature has given another sort of strength for self-preservation, e.g. as it has protected horses with bodily swiftness, or camels with bodily magnitude. For even excess magnitude is sufficient to prevent destruction by other animals, which is precisely the case with camels, and even more so with elephants. And the animals with tusks, as for instance the kind consisting of the pigs, are cloven-hoofed.

To those for which protruding horns are by nature useless, nature has added another means of protection, such as swiftness to the deer (for the size and extensive branching of their horns harms them more than it helps), as well as to the antelope and gazelle (for against some they make a stand and defend themselves with their horns, while they flee from those that are wild and predatory). And to the bison (since in these the horns are by nature bent towards one another) nature has added the emission of excrement; for in this way they defend themselves when frightened. And by means of the same sort of emission other animals also protect themselves. But nature has not provided modes of protection to the same animals that are at once sufficient and more than sufficient.

The majority of the horn-bearing animals are cloven-hoofed, but there is also said to be a solid-hoofed one, which people call the Indian ass. In the majority of animals, then, just as the body, by means of which they move, is divided into right and left, so the same cause explains why they naturally have two horns. But there are also single-horned animals, such as the oryx and the one called Indian ass. However, while the oryx is cloven-hoofed, the ass is solid-hoofed.

Single-horned animals have the horn in the middle of the head; for in this way each of the parts can, to the maximum extent, have one horn; for the middle is common in a like manner to both the extremes. And it would seem reasonable that the solid-hoofed animals, rather than the cloven-hoofed, be possessed of a single horn; for hoof and nail have the same nature as horn, so that the splitting of the hoofs and horns occurs at the same time and in the same animals. And again, the splitting, i.e. the cloven hoof, is present in virtue of a deficiency of this nature, so it is reasonable that for the solid-hoofed animals nature, having provided an excess in the hoofs, took it from above and made a single horn.

Nature also acted correctly in making the nature of the horns on the head, rather than acting like Aesop's Momos, who blames the bull because it does not have its horns on its shoulders, from whence it would produce the strongest blows, but on the weakest 663b part, its head. Momos made these accusations through a lack of insight. For just as horns, if they developed anywhere else on the body, would provide weight while being otherwise useless and even a hindrance to many of its functions, so too would they be useless if they developed on the shoulders. Indeed, one should research not only from whence would the blows be stronger, but also from whence would they be further forward. So since bulls do not have hands, and it is impossible for horns to be on the feet, and if they were on the knees they would prevent the knees from bending, it is necessary to have them just as they in fact do, on the head. And at the same time too, the body's other movements are thus naturally most unimpeded.

The horns are solid throughout only in the deer, and they alone shed them, on the one hand for the sake of the advantage gained in being relieved of them, and on the other from necessity, on account of their weight. The horns of the others are hollow up to a certain point, though the tips are solid because that is useful for striking blows. But in order that even the hollow part should not be weak, the horn grows by nature from the skin, and a hard part from the bones is inserted into it. For in this way the possession of horns is both most useful for strength and least troublesome for the rest of their way of life.

So then, what the nature of the horns is for the sake of has been stated, and owing to what cause some have such things while others do not; but, since there is a necessary nature, we must say how the nature according to the account makes use of things present of necessity for the sake of something. First of all, what is bodily and earthen is present in greater amounts in the larger animals, while we know of no completely small horn-bearing animal—the smallest one known is a gazelle. And one should study nature with a view to the many; for it is what happens either in every case or for the most part that is in accordance with nature. What is bony in the bodies of animals is in origins earthen; this is also why it is most abundant in the largest animals, to speak with a view to what occurs for the most part. For the residual surplus of this sort of body, being present in the larger of the animals, is used by nature for protection and advantage, and the surplus, which flows of necessity to the upper region, in some cases it distributes to teeth and tusks, in other cases to horns. That is why none of the horn-bearing animals has a complete set of upper and lower teeth (for they do not have 664a upper front teeth); for nature takes from there and adds to the horns; that is, the nourishment assigned to the upper front teeth is expended in the growth of the horns.

Female deer do not have horns, yet with respect to teeth they are like the males. This is because they are both the same nature, i.e. horn-bearing; but the horns have been taken away from the females because, while they are also useless to the males, the males are harmed less owing to their strength.

Of the other animals, in which such a part of the body is *not* formed into horns, in some nature has increased the size of all of their teeth in common, while in others it has made tusks, like horns growing from their jaws.

## CHAPTER 3

Let the parts on the head be defined in this way; and the neck, in animals that have one, is by nature beneath the head. For not all animals have this part, but only those with the parts for the sake of which the neck is naturally present; and these are the larynx and the part called the oesophagus.

The larynx is present by nature for the sake of breath; for through this part animals draw in and expel breath when they inhale and exhale. This is why those without a lung do not have a neck, e.g. the kind consisting of the fish.

The oesophagus is that through which nourishment proceeds to the gut; so that all those without necks manifestly do not have an oesophagus. But it is not necessary to have the oesophagus for the sake of nutrition; for it prepares nothing for nutrition. And further, it is possible for the gut to be placed right next to the position of the mouth, but for the lung this is impossible. For there needs to be something common like a conduit, which is bipartite and through which the breath is separated by the windpipes into passages; and in this way the lung may best accomplish inhalation and exhalation. And since the organ connected with breathing from necessity has length, it is necessary for there to be the oesophagus between the mouth and the stomach. And the oesophagus is fleshy, with a sinuous elasticity—sinuous so that it may dilate when food is ingested, yet fleshy so that it is soft and yielding and is not damaged when it is scraped by the food going down.

The part called the larynx, and the windpipe, are constituted from cartilaginous body; for not only are they for the sake of breathing, but also for the sake of vocalizing, and that which is to produce 664b
sound must be smooth and hard. The windpipe lies in front of the oesophagus, even though this impedes its reception of nutrients; for if something either dry or moist slips over into the windpipe it produces choking, distress, and painful coughing. This surely ought to surprise any of those people who say that it is by means of this part that the animal takes in drink; for the things just mentioned obviously happen in every case where some part of the food slips in. It is clearly ridiculous, in many respects, to say that animals take in their drink in this way. For there is no tube into the stomach from the lung, as we see with the oesophagus coming from the mouth. Further, in cases of vomiting and seasickness, it is no mystery where the moisture appears to be flowing from. It is also clear that the moisture is not immediately collected together in the bladder, but first in the gut; for the dregs of dark wine appear to colour the residues from the gut; and as it happens this is often manifest with injuries to the gut as well. But enough—perhaps it is simple-minded to make excessive scrutiny of simple-minded accounts.

The windpipe, by being positioned, as we said, in the front, is interfered with by the food; but for this nature has constructed the epiglottis. Not all the live-bearing animals have this part, but rather all those that have a lung and hairy skin, and that are naturally neither hard-scaled nor feathered, do. In those that are hard-scaled or feathered, in place of the epiglottis the larynx contracts and opens, in the way that the epiglottis closes and opens up in the other animals. That is, it opens during the entrance and exit of breath and closes when food is being ingested, in order that nothing should slip down the windpipe. But if something goes wrong during such movement and someone inhales while taking nourishment, this produces coughing and choking, as has been said. Thus the movement of the epiglottis and tongue has been well constructed, so that when nourishment is ground up in the mouth, and passes over the epiglottis, the tongue is seldom bitten by the teeth, and it is rare that something slips into the windpipe.

665a The animals just mentioned do not have the epiglottis because their flesh is dry and their skin hard, so that in them a part of this sort, constituted from flesh and skin of this sort, would not move easily. Rather, the closure of the uppermost walls of the windpipe itself would occur as quickly as an epiglottis made of the appropriate flesh, such as animals with hair have.

Let it be assumed, then, that we have stated the following things: the cause owing to which some animals have an epiglottis and others do not, and why nature has remedied the inefficiency of the position of the windpipe by constructing the part called the epiglottis.

But the larynx lies in front of the oesophagus of necessity. For the heart, in which we say the origin of life and of all movement and perception is found, lies in the front and in the middle (for perception and motion are towards what is called the front; in fact, it is by this very account that ‘front’ and ‘rear’ are defined); and the lung lies where the heart is, i.e. surrounding it, and respiration takes place both on account of this and on account of the origin being present in the heart.

Respiration comes about in animals through the windpipe; so, since it is necessary that the heart be placed first among things in front, it is also necessary that the larynx and the windpipe be placed in front of the oesophagus. For while the former extend to the lung and heart, the latter extends into the gut. And generally, where nothing greater impedes, what is better and more valuable is always, in the case of above and below, present more in things that are above; in the case of front and rear, more in things in front; and in the case of right and left, more in things on the right.

## CHAPTER 4

Having spoken about the neck, oesophagus, and windpipe, the next things to speak about are the viscera. These are distinctive to the blooded animals, and while all the viscera are present in some of them, in others they are not. None of the bloodless animals has a visceral part.

Democritus seems not to have understood these things well, if indeed he thought these parts to be invisible because of the smallness of the bloodless animals. For as soon as the blooded animals are constituted and while they are extremely small, both heart and liver become visible. In fact they are sometimes apparent in three-day-old eggs, the size of a point, and very small ones are also apparent in the aborted remains of embryos. 665b

Further, just as, with the external parts, there is not *a* use provided to all animals, but rather a distinctive provision has been made for each of them related to their ways of life and movements, so is it natural that the internal parts are also different in different animals. The viscera are distinctive to the blooded animals, which is also why each of them is constituted from bloody matter. This is clear in their newborns; for their viscera are more blood-like and proportionately greatest, on account of the form of the matter and its quantity being most apparent during the first composition.

A heart is present in all blooded animals; the cause of this has also been discussed previously. It is clear that it is necessary for the blooded animals to have blood; and since blood is moist, a vessel must be present, for which nature appears to have constructed the blood vessels. But there must be a single origin of these; for wherever possible one origin is better than many. And the heart is the origin of the blood vessels; for they are clearly *from* the heart and not *through* it, and its nature is vascular as if it were like in kind to them. Moreover, it is situated in an originative place; that is, it is near the middle, and more above than below, and more in front than in the rear; for nature places the more valuable things in the more valuable locations, where nothing greater prevents it. What we have said is most obvious in the case of human beings, but even in the other animals the heart tends to be placed correspondingly in the middle of the necessary body. (Of this body, a limit is that by which the residues are expelled. The limbs, however, by nature develop differently in different animals, and are not among the necessities of life, which is why even when they are removed an animal continues living; and it is clear that adding limbs would not destroy it.)

Those who state that the origin of blood vessels is in the head make some incorrect assumptions. For first, they produce many scattered origins, and second, these are in a cold place—but it is

clear that the area around the heart, being sensitive to cold, is the opposite. And as was said, while the blood vessels run through the other viscera, no blood vessel extends through the heart; whence it is also clear that the heart is a part, in fact an origin, of the blood vessels. And this is reasonable; for the middle of the heart is a body which is naturally dense and hollow; and further, it is full of blood,
666a inasmuch as the blood vessels originate there; it is hollow to serve as the receptacle for blood, and dense in order to guard the origin of heat. For in this part, alone of the viscera and of the body, is there blood without blood vessels, while each of the other parts has blood in its blood vessels. This is also reasonable; for the blood is conducted from the heart and into the blood vessels, but not to the heart from elsewhere; for this is an origin and spring of blood, or its first receptacle. These things are more manifest with the help of the dissections and the generations; for the heart, which comes to be first of all the parts, is immediately blooded.

Again, the movements of pleasures, pains, and all perception generally evidently originate there and proceed to it. And this is in accordance with our account; for there must be a single origin wherever possible. And the middle is the best suited of places; for the middle is single, and accessible in all directions alike, or nearly so. And further, since none of the bloodless parts, nor the blood, is perceptive, it is clear that the first thing that holds it as in a vessel must be its origin. That it appears to be this way not only accords with our account, but with perception as well; for of the parts in the embryos, the heart is straight away manifestly in motion, as if it were an animal—like an origin of nature in the blooded animals.

Evidence for what has been said is the fact that the heart is present in all the blooded animals. For it is necessary for them to have the origin of the blood. The liver is also present in all the blooded animals; but no one would maintain that it is an origin either of the whole body or of the blood; for in no respect does it lie near to a position originative in form, and in the most perfect animals it has, like a counterweight, the spleen. Further, the liver does not have a receptacle within itself for the blood as the heart does, but just as with the rest, its blood is in a blood vessel. And further, a blood vessel extends through it, while none is from it; for the origins of all the blood vessels are from the heart. So since it is necessary for one or the other of these to be an origin, and it is not the liver, it is necessary that the heart should also be the origin of the blood.

For 'animal' is defined by perception, and the primary perceiver is the primary blooded part, and such is the heart; for it is indeed an origin of the blood and a primary blooded part.

The apex of the heart is sharp and harder than the rest, and lies 666[b] towards the chest and generally in the front of the body, in order that it should not become cold. For in all blooded animals the chest is more fleshless and the back is more fleshy, which is why their heat has plenty of protection in the back. But while the heart in the other animals is in the middle of the chest, in human beings it inclines slightly to the left, in order to balance the cooling of things on the left; for much more than the other animals, in mankind the parts on the left are cold. It has been stated previously that the heart is placed alike in the fish as well, and why it appears to be placed unlike. They have the sharp part of the heart towards the head, but this is the front; for their movement is in this direction.

The heart also has many sinews, and this is reasonable. For the movements are from this part, and are accomplished through contracting and relaxing; so the heart needs such equipment and strength. As we said previously, the heart, in those that have it, is by nature like a sort of animal. It is without a bone in all those we have actually examined, with the exception of the horses and a certain kind of oxen. In these, on account of the heart's great size, a bone lies underneath for the sake of providing a kind of support, just as bones do for whole bodies.

The hearts of the larger animals have three hollow cavities, those of the smaller two, and all have one; and the cause owing to which this is so has been stated. For there must be a certain place within the heart, i.e. a receptacle of the first blood. That the blood comes to be first in the heart we have said many times; and because the originating blood vessels are two, the one called 'great' and the aorta (for each of these is an origin of the blood vessels, and they have differences, about which we will speak later), it is better that their origins also be separated; and this would be the case if the blood were different and separated. For this reason, in those cases where it is possible there are two receptacles. And it is possible in the large animals; for their hearts are also large. And it is better yet for there to be three cavities, so that there may be one, common origin; and the middle and odd-numbered one is an origin; so these hearts must always be larger, which is why only the largest hearts have three cavities.

Of these cavities, those on the right have the most and the hottest
667a blood (which is also why the parts on the right are warmer), those on the left have the least and the colder blood, and the intermediate ones have blood intermediate in amount and heat, though it is purest. For the origin must be most calm, and such will it be when the blood is pure but intermediate in amount and heat.

Hearts also have a certain division similar to the sutures of the skull. These are not lines of conjunction, as with something put together out of many things, but rather, as we said, they are due to articulation. The hearts of the perceptive animals are more articulated, while those of the more sluggish are more unarticulated, as are the hearts of the swine.

The differences of the heart with respect to largeness and smallness, and hardness and softness, extend somehow even to the characters of animals. For the imperceptive animals have a heart that is hard and solid, while the perceptive ones have a softer heart; and those with larger hearts are timid, while those with smaller or medium-sized hearts are more bold. For the affection resulting from being afraid is already present in these animals, because the heat in their heart is not in balance (being small in quantity, it is weakened in large animals), and because the blood is colder. The hare, deer, mouse, hyena, ass, leopard, and marten have large hearts, as do virtually all the others that are evidently timid or devious on account of fear.

Conditions in the blood vessels and in the cavities of the heart are similar; the large blood vessels and cavities are cold. For just as in a smaller and a larger room the equivalent fire provides less heat in the larger, so too with the heat in these parts; for the blood vessel and the cavity are containers. And further, the external motions cool each of the hot things, while in the more spacious areas the breath is greater, and has more strength; this is why none of those animals with large cavities or large blood vessels has fatty flesh, but all, or the large majority of such fatty animals, appear to have indistinct blood vessels and small cavities.

Alone of the viscera, and generally of the parts within the body, the heart does not endure any severe affection, and this is reasonable; for once the origin has been destroyed, there is nowhere from
667b which aid might arise for the other parts that depend on it. A sign of the heart's not admitting affection is that in none of the sacrificial animals is an affection of this sort to be seen in it as in the

other viscera. For the kidneys and the liver often appear full of stones, tumours, and boils, and so too the lung, and most of all the spleen. Many and varied symptomatic affections are apparent in these viscera, but in the lung they are least apparent around the windpipe, and in the liver around the connection to the great blood vessel, and this is reasonable. For it is chiefly by this that they communicate with the heart. But by dissecting those animals that are evidently dying on account of sickness and affections such as those just mentioned, morbid affections are evident in and around the heart.

Regarding the heart, then, what sort of thing it is, what it is for the sake of, and the cause owing to which it is present in those animals that have it, let so much be said.

## CHAPTER 5

The next task is to speak about the blood vessels, both the great blood vessel and the aorta; for these receive blood from the heart first, and the remainder are outgrowths of these. Now it has been said previously that they are for the sake of the blood; for that which is entirely moist has need of a container, and the kind consisting of blood vessels is a container, and the blood is in these. But we need to state why they are two and why they extend throughout the entire body from one origin.

A cause of their terminating together in one origin and being from one origin is that all animals have one perceptive soul in actuality, so that the part having it primarily is also one—in the blooded animals, both potentially and actually one, in some of the bloodless, one only actually. For this reason too it is necessary for the origin of heat to be in the same place; and this is a cause both of the moistness and of the heat in the blood. Thus, because the perceptive origin and the origin of the heat are in one part, the unity of the blood also derives from one origin, and because of the unity of the blood, the unity of the blood vessels also derives from one origin. The origins are two because the bodies of the blooded and locomotive animals are bipartite; for in all these animals the front and the back, the right and the left, and the above and below are distinguished. And to the extent that the front is more valuable and sovereign than the rear, to that extent is the great blood vessel more valuable and sovereign than the aorta. For the former lies in **668a** front, while the latter lies in the back; and all the blooded animals evidently have the great blood vessel, while some have the aorta indistinctly and in some it is not in evidence at all.

A cause of the blood vessels being distributed over the entire body is that the blood and its analogue in bloodless animals are matter for the entire body, while these materials are stored in blood vessel and its analogue. As to how and from what animals are nourished, and in what manner they absorb nourishment from the gut, it is more appropriate to investigate and speak about such things in the works on generation. And since the parts are constituted from the blood, as we said, it is reasonable that the course of the blood vessels runs naturally through the entire body; for the blood too needs to be passing through everything and next to everything, if each of the parts is to be constituted from it.

It seems that, just as in gardens aqueducts are constructed from one origin and spring into many and still more channels, always for distribution to all locations; and in house-building stones are set beside the entire outline of the foundations—in the one case because the garden plants are to grow from the water, and in the other because the foundations are to be built from the stones—in the same way nature too channels the blood through the entire body, since this is by nature matter for all of it. This becomes apparent in those who are extremely emaciated; for nothing else besides the blood vessels is evident, just as in grape leaves, fig leaves, and any others of this sort; for again, when these leaves have withered, only their veins remain.

These things are so because the blood (and its analogue) is body and flesh (or their analogues) potentially. Thus, just as during irrigations the largest of the trenches remain, while the smallest are first quickly obliterated by the mud, but when it is removed they once again become evident, so in the very same way the largest of the blood vessels remain, while the smallest become in actuality flesh, though potentially they are blood vessels no less. For this reason too when the flesh is in any respect preserved, blood flows when it is cut; and though without blood vessel there is no blood, yet no blood vessel is manifest, just as in aqueducts the trenches are not manifest until the mud has been removed.

668b The blood vessels always proceed from the greater to the lesser, until the channels have become smaller than the thickness of the blood. Passage through these channels is impossible for the blood, but is possible for the residue of the moist fluid, which we call perspiration. And this occurs when the body is thoroughly heated and the blood vessels are dilated. Furthermore, in some cases perspiring results in a blood-like residue due to poor conditioning, when the body becomes flaccid and loose and the blood becomes watery due to lack of concoction, the heat in the blood vessels being unable to concoct blood because there is so little of it. For it was stated that every combination of earth and water solidifies when concocted, and nourishment and blood are a compound of the two of them. But the heat is unable to concoct it not only because there is so little of it, but also because of the amount and excess of the incoming nourishment; for the amount of heat becomes small in relation to it. And this excess is of two sorts; there is excess both in quantity and in quality; for not everything is equally well concocted. The blood flows especially through the most wide-open of the channels; this is why from the nostrils, gums, fundament, and sometimes from within the mouth too, emerge haemorrhages which are painless, unlike those from within the windpipe, which arise violently.

The great blood vessel and the aorta, separated above and crossing over below, hold the body together. For as they proceed outwards, they split in accordance with the bifurcation of the limbs, and the former proceeds from the front to the back while the latter proceeds from the back to the front, and they bind the body into one. For just as continuity is increased in things made by plaiting, so too through the crossing over of the blood vessels the front of the body is united to the rear. And in like manner vessels from the heart end up in the upper regions. But to know with accuracy how the blood vessels are situated relative to one another, one should base one's study on the dissections and the zoological enquiry. We may take it that the blood vessels and heart have been discussed; we need to examine the other viscera according to the same procedure.

## CHAPTER 6

A certain kind of animal has a lung because it is a land-dweller. For it is necessary for its heat to be cooled, and the blooded animals must be cooled from without; for they are hotter. (Those that are not blooded are able to cool themselves by their inborn breath.) 669a
And it is necessary for cooling from without to be either by water or by air. This is why none of the fish has a lung, but instead of

this gills, as has been said in the works on respiration; for fish cool themselves by means of water, while the breathers do so by means of air, which is why all the breathers have a lung.

All land-dwellers breathe and some of the water-dwellers do as well, e.g. whales, dolphins, and all the spouting sea creatures. For many animals tend towards both in their nature: On account of their bodily constitution, some that are land-dwellers and take in air spend most of their time in moist surroundings; and some of those that live in moist surroundings partake of the nature of land-dwellers so much that the end of their life is in their breath.

The lung is the instrument of breathing, taking its origin of motion from the heart, and providing ample room for the inflow of breath on account of its own sponginess and size; for when it expands breath flows in, and when it contracts breath goes out again. It has been claimed—incorrectly—that the lung is connected with the leaping of the heart; I say 'incorrectly' because the occurrence of this leaping happens only, roughly speaking, in mankind, because mankind alone becomes expectant and hopeful for the future. Moreover, in most animals the heart lies at a great distance from, and in a location higher up than, the lung, so that the lung contributes nothing to the leaping of the heart.

The lung differs in many ways in animals. Some have a blooded and large one, others a smaller and spongy one. The live-bearing animals, on account of the warmth of their nature, have a large one with much blood. The egg-layers have a dry and small one, though it is able to open wide when being expanded, as for instance with the four-footed, egg-laying land-dwellers, e.g. the lizards, tortoises, and all such kinds, and in addition to these the animals that have a winged nature and are called birds. For the lung of all of these animals is spongy and foam-like; and in fact when foam is stirred a large amount becomes small, and the lung of these animals is small and membranous. This is why they are all free of thirst and drink little, and are able to remain in moist surroundings for a long time; for having little heat, they can be cooled sufficiently over
669b a long time by the lung's own movement, since it is aerated and empty. And these turn out to be smaller in size than other animals, generally speaking. For heat promotes growth, and a profusion of blood is a sign of heat. And further, the bodies of those that are hotter are more erect, which is why mankind is the most erect of all the animals. And the live-bearers are the most erect of the four-

footed animals; for none of the live-bearers dwells in holes as the egg-layers do, since they are neither footless nor creepers.

Generally then, the lung is for the sake of breathing, while it is bloodless and of such a kind for the sake of certain animals. But what is common to these animals is nameless; that is, no name has been applied to them as the name 'bird' has been applied to a certain kind of animal. For this reason, just as being for a bird is constituted from something, so too having a lung is present in the substantial being of these animals.

## CHAPTER 7

Some of the viscera seem to be single-natured, such as heart and lung, some double-natured, such as kidneys, while some present a difficulty as to which they are. For instance, the liver and spleen would appear to tend towards both of these; for in a way each is single-natured, and in another way, instead of each being one, they are a pair with a very similar nature. But all of them are double-natured because of the division of the body which, though it is double-natured, contributes to a common origin. For there is above and below, front and back, right and left. This is why even the brain tends to be double in all animals, and each of the sense-receptors. And according to the same account the heart is, in respect of its cavities, bipartite. And in the egg-laying animals the lung is divided to such an extent that they seem to have two lungs. And that the kidneys are double is clear in *all* cases.

Someone might justly raise a difficulty regarding the liver and spleen. This is because in those animals that have a spleen of necessity the spleen would seem to be like a false liver, while in those that do not have it from necessity, but have a very small one as a token, the liver is manifestly bipartite, one part tending to lie towards the right side, the other, smaller, part towards the left. Nevertheless, even in the egg-layers, though it is less apparent than in those just mentioned, in some cases the liver is clearly divided even there, just as it is in certain live-bearing animals; for example, the hares in certain places seem to have two livers, as do the selachians and certain other fishes. And it is on account of the liver being positioned
more on the right that the nature of the spleen has developed; so **670a**
that while in a way it is necessary, it is not *exceedingly* necessary in all the animals.

So a cause of the nature of the viscera being double is, as we said, the duality of the right and the left; for each seeks its like, just as kidney and spleen tend to be similar and to have the nature of twins; and just as these, though they are twins, are combined into one, so too are each of the viscera.

Viscera that are below the diaphragm are all present in common for the sake of the blood vessels, in order that, though they are unsupported, they may stay in place by being bonded by the viscera to the body. They are just like anchors that have been thrown to the body by the extended parts, from the great blood vessel to the liver and the spleen. For the nature of these viscera, like nails, fastens the great blood vessel to the body, the liver and spleen fastening it to the *sides* of the body (for the blood vessels extend from the great blood vessel to these parts alone), the kidneys fastening it to the *rear*. And in connection with these parts, a blood vessel extends to each, not only from the great blood vessel but also from the aorta. It is by these means that these results come about in the composition of animals. And the liver and spleen help with the concoction of the nutrients (for being blooded they have a hot nature), while the kidneys help with the residue secreted into the bladder.

Now heart and liver are necessary to all animals, the heart because there must be an origin of heat (for there is need of something like a hearth, in which lies the spark of the animal's nature, and that it be well guarded, being as it were an acropolis of the body), the liver for the sake of food concoction. All blooded animals must have both of these, which is why these two viscera alone are possessed by all blooded animals, while those that breathe have a third, the lung.

The spleen is present, in those that have one, as a necessary consequence, as are the residues, both the one in the gut and the one around the bladder. This is why the spleen in some cases is deficient in magnitude, as in some of the feathered creatures, namely those with a warm gut, like pigeon, hawk, and kite. And it is likewise
670b in the egg-laying, four-footed animals (for they have an extremely small spleen), and again in many of the animals with soft scales. These animals also lack a bladder, on account of the residue being directed through their porous flesh into feathers and soft scales. For the spleen draws off the residual fluids from the gut, and since it is blood-like it is able to aid in concoction. But should the residue be great or the spleen have little heat, the gut becomes liable to sickness from the large amount of nourishment; and on account

of the ebb and flow of the moisture there, in many animals their stomachs become firm as a result of being splenetic, as with those animals that urinate excessively on account of their moisture being diverted.

In those that generate a small amount of residue, as in birds and fishes, some do not have a large spleen, while others have a token one. And in the four-footed egg-layers the spleen is small, firm, and kidney-like, because their lung is spongy and they drink little, and because the surplus residue is directed to their body and their hard scales, just as it is directed to the feathers in birds. But in those having a bladder and a blooded lung the spleen is moist both owing to the cause already mentioned and because the nature of things on the left side is generally more moist and cold. For each of the opposites has been divided into its kindred column, e.g. right opposed to left and hot to cold; and the columns are related to one another in the way mentioned.

The kidneys are present in those that have them not out of necessity, but for the sake of the good and doing well. That is, they are present, in accordance with their distinctive nature, for the sake of the residue which collects in the bladder in those animals in which a greater amount of such excrement comes about, in order that the bladder may perform its function better.

But since it is for the sake of the same need that animals turn out to have the kidneys and the bladder, we should now speak about the bladder, departing from taking the parts in serial order. And departing we are, for nothing has yet been definitively stated about the diaphragm, though this is one of the parts in the region of the viscera.

## CHAPTER 8

Not all animals have a bladder, but nature seemingly aims to provide it only to those with a blooded lung, and reasonably so. For on 671a
account of the excess of the nature which they have in this part, these are the thirstiest of animals, and are in need not only of more dry nourishment, but also more moist, so that of necessity more residue comes to be, and not merely as much as is concocted by the gut and expelled with its own residue. Accordingly, there must be something able to receive this residue as well. This is why those with a lung of this sort all have a bladder. Those that do

*not* have a lung of this sort, and either drink very little because they have a spongy lung, or generally take in moisture not for the sake of drink but for the sake of nourishment (e.g. the insects and fish), and again those which are feathered, soft-scaled, or hard-scaled, on account of the small amount of ingested moisture and surplus residue being directed to these parts—none of these has a bladder, except, of the hard-scaled animals, the tortoises. And there alone has nature deviated, because of the fact that the sea tortoises have a lung that is fleshy and blooded, like that of the ox, while the land tortoises have one that is disproportionately large. And again, because the surrounding body is like a hard shell and dense, the moisture does not dissipate through their fine flesh, as it does in birds and in the snakes and other hard-scaled animals; so that so much sediment comes to be that their nature needs to have some part that is receptive and vessel-like. This, then, is the cause owing to which these are the only animals of this kind that have a bladder, the sea tortoise having a large one, the land tortoises a very small one.

## CHAPTER 9

Things are similar with the kidneys as well. That is, none of the feathered, soft-scaled, or hard-scaled animals has kidneys, with the exception of the sea and land tortoises. Rather, as if the flesh assigned to the kidneys had no proper place but was dispersed into many regions, there are flat, kidney-like parts in some of the birds.

The *hemus* has neither a bladder nor kidneys; for on account of the softness of its shell the moisture becomes easily dissipated. This, then, is the cause owing to which the *hemus* has neither of these parts; while the other animals with a blooded lung, as we have said, are found in every case to have kidneys. For nature makes
671b use of the kidneys at once for the sake of the blood vessels and the excretion of moist residue; for a channel runs to them from the great blood vessel.

The kidneys all have a cavity, either large or small, with the exception of those of the seal; these kidneys, since they are like those of the oxen, are the most solid of all. The kidneys of human beings are also like those of the oxen; for they are, as it were, composed of many small kidneys and are irregular, like the kidneys of sheep and other four-footed animals. This is also why an affliction of the kidneys in human beings is difficult to be rid of, once they are diseased. It is as if they had many diseased kidneys; the treatment turns out to be more difficult than treating people with one diseased organ.

The channel that extends from the blood vessel does not terminate in the cavity of the kidneys, but is spent in their body; which is why blood does not come to be in their cavities, nor congeal within them at death. However, from the cavities of the kidneys two vigorous, bloodless channels run to the bladder, one from each of them; and other strong, continuous ones run from the aorta. These things are arranged this way so that from the blood vessel the residue of the moisture can travel to the kidneys, and from the kidneys the excretion which comes to be from the filtering of the fluids can flow through the body of the kidneys and into their centre, where most of them have a cavity. For this reason too they are the worst smelling of the viscera. From the centre of the kidneys through these channels something that by this time is more like a residue is secreted into the bladder. And the bladder is anchored from the kidneys; for strong channels extend to it, as has just been said. These, then, are the causes owing to which the kidneys are as they are, and have the potentials we have described.

In all those animals with kidneys, the right one is higher up than the left; for, because their movement originates from the parts on the right side, and thus the nature of the parts on the right side is stronger, there is a need, on account of their movement, for all these parts to be more predisposed in the upward direction. They even raise the right eyebrow more and have it arched more than the left. And because the right kidney is drawn higher up, the liver is in contact with it in all these animals; for the liver is on the right side.

The kidneys have the most fat of all the viscera. On the one **672a**
hand, this is out of necessity, because the residue is filtered through the kidneys. For the remaining blood, being pure, is capable of good concoction; and soft and hard fat is an end of well-concocted blood. For just as in dry things that have been burnt, such as ash, some fire is left behind in them, so it is in moist things which have undergone concoction as well; that is, some portion of the heat which was operative is left behind in them. This is why what is oily is light and rises to the surface in liquids. Hence, on account of the visceral body being dense, the fat does not come to be in the

kidneys themselves, but surrounds them on the outside, soft in the ones with soft fat, hard in the ones with hard fat. (The difference between these two sorts of fat has been stated previously elsewhere.)

So on the one hand it is of necessity—this is the cause owing to which the kidneys come to be fatty, a consequence of what happens of necessity in animals with kidneys; on the other hand, they also come to be fatty for the sake of the preservation of the kidneys and of their natural heat. That is, being outermost, they have need of more heat; for while the back is fleshy, so that it is a defence for the viscera around the heart, the loin is fleshless (for the joints of all animals are fleshless); so instead of flesh, the fat becomes a defence for the kidneys. And again, they separate and concoct the moisture better when they are fat; for fat is hot, and heat concocts.

These are the causes, then, owing to which the kidneys are fatty, though in all animals the right one is less so. This is because the parts on the right are of a dry and more mobile nature; and the motion is an opposing one; for it rather dissolves the fat.

Now in the case of the rest of the animals it is beneficial to have fat kidneys, and many have their whole kidneys full of it; though when a sheep is affected in this way, it dies. And even if the kidneys are extremely fat, there is nevertheless some deficiency, if not in both, at least in the right. This happens only or most of all in sheep because in animals with soft fat the fat is moist, so that the vapours do not to a like degree produce difficulty by becoming enclosed. Becoming enclosed is a cause of gangrene; which is also why, among human beings who suffer pain in the kidneys, even if it is beneficial for the kidneys to be fat, nevertheless if they become too fat, mortal pains result.

672b The hard fat of other animals is less dense than that found in sheep. Sheep also greatly exceed other animals in its quantity; for sheep become fat around the kidneys quickest of all the animals. Hence, when the moisture and vapours become enclosed, sheep are quickly destroyed on account of gangrene; for through the aorta and the blood vessel this condition spreads quickly to the heart; and there are continuous channels from these blood vessels to the kidneys.

## CHAPTER 10

We have now spoken about the heart and the lung, and about the liver, spleen, and kidneys. As it happens, the first two are separated from the others by the diaphragm. This 'diaphragm' some people call 'midriffs'; it is what demarcates the lung and the heart from the rest. And in the blooded animals this diaphragm is called 'midriffs', as we just stated. All the blooded animals have it, just as they have a heart and liver. This is because it is there for the sake of the demarcation of the gut region from the heart region, so that the origin of the perceptive soul will be unaffected and not be quickly overpowered because of fumes arising from the nutrients and the great quantity of heat introduced. To this end nature divided them, making the midriffs like a partition and a fence—that is, it divided the more valuable and the less valuable, in those animals in which it is possible to divide the upper and the lower. For the upper is that for the sake of which and better, while the lower—the receptacle of nutrients—is for the sake of this and necessary.

The diaphragm is more flesh-like and stronger towards the ribs, and more membranous in the middle; for in this way it is more useful for strength and elasticity. And why there are appendages, as it were, for the heat from beneath them, is indicated by what happens; for when, because of their proximity, the midriffs absorb the hot, residual moisture, straight away it manifestly disturbs thought and perception, which is also why they are called midriffs [*phrenes*], as if they partake in some way in thinking [*tou phronein*]. And though they do not partake in thinking at all, by being *near* to those things that do, they manifestly produce an alteration in thought. This is also why they are thin in the middle—not only is it of necessity (because being fleshy, the parts of them that are towards the ribs are necessarily more fleshy), but also in order that they partake as little as possible in fluid secretions; for being fleshy they would hold and absorb much more secreted fluid.

Another indication that the midriffs manifestly produce percep- **673a**
tion when quickly heated up is what occurs in regard to laughter. For those who are tickled laugh quickly because of the motion that quickly reaches this location. And though they heat up gently, nevertheless they manifestly act and move thought independent of choice. And mankind alone is ticklish both because of the thinness of his skin and because he is the only one of the animals that laughs.

And tickling is an occasion for laughter brought about by such a movement of the part of the body around the armpit.

They say laughter also results from the blows to the region of the midriffs struck in battles, on account of the heat coming about from the blow. Indeed, these reports are from more credible sources than the one about the head that speaks after people have had it cut off. Some even invoke Homer and say that it is because of this that he composed the line 'and as *it* spoke, his head was mingled with dust' rather than 'as *he* spoke'. And in the region of Arcadia this sort of thing was believed to such an extent that they brought one of the inhabitants to trial. For when the priest of Zeus the Warrior was killed, and it was quite unclear by whom, some claimed to have heard the decapitated head saying many times 'Cercidas slew him man to man'; which is also why, having searched for someone in the region whose name was Cercidas, they brought him to trial.

But it is impossible to speak when the windpipe has been severed and without motion from the lung. And among the barbarians, who cut off heads with dispatch, no such thing has ever occurred. And again, what cause accounts for this not occurring in the other animals? Now the claim about laughing when the midriffs are struck is a likely one, since none of the other animals laughs. And that the body proceeds some distance after it has been separated from its head is not unreasonable, since the bloodless animals certainly do live a considerable time. (The causes of these things have been clarified elsewhere.)

So, then: what each of the viscera is *for the sake of* has been stated, and they have come to be *of necessity* at the internal limits of the blood vessels. That is, it is necessary that a bodily fluid diffuse, and that this one, from which the body of the viscera come to be
673b when it becomes constituted and solidified, be bloody. This is why the viscera are bloody, and why they have a bodily nature like one another, and unlike the other parts.

## CHAPTER II

All the viscera are in a membrane; for there is need both of a protective covering for them to be unaffected, and for this to be light, and the membrane is in its nature this sort of thing; for it is dense, so as to shelter, yet fleshless so as not to absorb or retain bodily fluid, and thin, so that it is light and does not add weight.

The largest and strongest of the membranes are those around the heart and the brain, and reasonably so, since these parts are in need of the most protection. For protection surrounds the controlling parts and these parts most of all control life.

## CHAPTER 12

Some of the animals have every one of the viscera, some do not; what sorts of animals do not, and owing to what cause, has been stated previously. But even among those that have them these parts differ; for not all animals with hearts have hearts that are alike, nor with virtually any of the other viscera. Take the liver: in some animals it is divided up into many parts, while in others it is more singular, foremost among these being the blooded and live-bearing animals. Again, the livers of fish and the four-footed egg-layers differ yet more, both compared with the first group and with one another. That of birds is most similar to the liver of the live-bearers; for its colour is pure and blood-like, just like that of the live-bearers. And this is because their bodies are the most fresh-smelling and do not have much foul residue. This is also why some of the live-bearing animals have no bile; for the liver contributes considerably to the proper blend and health of the body; for their end is present most of all in the blood, and the liver is, after the heart, the most bloody of the viscera. The livers of most of the four-footed egg-layers and fish are yellowish, and those of some are in fact completely foul, even as their bodies have taken on a foul blend, e.g. the livers of toad, tortoise, and other such animals.

The horn-bearing and cloven-hoofed animals, such as goat, sheep, and each of the others, have a round spleen, unless, on account of the animal's size, it grows more quickly lengthwise, as happens with the spleen of the ox. The many-toed animals, however, such as pig, human being, and dog, all have a long spleen, **674a**
while those with solid hoofs, e.g. horse, mule, and ass, have a spleen intermediate between these and a mixture of the two; compared with the one group they have a wide one, but compared with the other a narrow one.

## CHAPTER 13

The viscera differ from the flesh not only in bodily mass, but also in that the viscera are positioned inside, the flesh outside. This is because they have a nature that is shared in common with the blood vessels; that is, some viscera exist for the sake of the blood vessels, while some do not exist without blood vessels.

## CHAPTER 14

Beneath the diaphragm lies the stomach; in animals with an oesophagus it lies where this part ends, while in those without one it lies right next to the mouth; and following the stomach is what is called the intestine. And the cause owing to which each of the animals has these parts is apparent to everyone. For it is necessary both that the incoming nourishment be received and that the dehydrated nourishment be expelled; and the unconcocted nourishment and the residue must not be in the same location, and there must be a certain location in which the nourishment changes. Indeed, the one part will hold the incoming nourishment, the other the useless residue; and just as it is necessary for there to be a distinct time for each of these, so is it that they be divided in their locations as well. But while the definition of these parts is more appropriate to the works on generation and on nutrition, the differentiation of the stomach and of its contributory parts should be examined now.

And indeed, in animals with stomachs the stomachs are like one another neither in their magnitudes nor in their forms. Rather, the blooded and live-bearing animals with a complete set of teeth have one stomach, e.g. mankind, dog, lion, and the rest of those with many toes, as do those which are solid-hoofed, e.g. horse, mule, and ass. And those that, though cloven-hoofed, have a complete set of teeth, e.g. pigs, also have a single stomach—unless some animal, owing to its bodily magnitude and the potency of its thorny, woody, hard-to-concoct nourishment, e.g. the camel, has many stomachs, even as horn-bearing animals do. The horn-bearing animals have many stomachs because they do not have a complete set of teeth; because of this the camel too, though without horns, is not among those animals with a complete set of teeth—that is, because of the greater necessity for it to have such a stomach than to have front teeth. So since the camel is, in this respect, like those animals without a complete set of teeth, it is like them too with respect to 674[b] its teeth, since they would be of no use. Yet at the same time, since its nourishment is thorny, and it is a necessity that the tongue be fleshy, nature makes use of the earth from the teeth to provide for hardness in the roof of the mouth.

The camel also chews its cud as the horn-bearing animals do, because it has stomachs like theirs. Each of these, e.g. sheep, ox, goat, deer, and the other animals of this sort, has several stomachs. This is so that, since the performance of the operation of the mouth on the nourishment, because of its lack of teeth, is deficient, the stomachs will receive the nourishment one after another—the first unworked, the next more worked up, the next entirely so, the last finely ground. That is why animals of this sort have several places and parts. These are called stomach, net, vase, and reed. The study of the way in which these parts are related to one another in position and in their forms should be based on the enquiry about animals and the dissections.

It is owing to the same cause that the bird kind also differs with respect to the part that is the receptacle of nourishment. For since they too do not fully perform the work of the mouth (for they lack teeth)—that is, they have nothing either to cut or to grind nourishment—because of this some birds have, in front of the stomach, what is called the crop in place of the operation of the mouth. Other birds have a broad oesophagus, either a bulky part of it in front of the stomach, in which they store up the unworked nourishment, or some swollen part of the stomach itself; yet others have the stomach itself strong and fleshy in order to be able to store up the nourishment for a long time and to concoct it though it is not ground up. For by means of its potency and heat the nature of the stomach makes up for the deficiency of the mouth. But there are some birds—those that are long-legged and marsh-dwelling—that have none of these, but rather a long crop, owing to the moistness of their nourishment. This is because the nourishment in the case of all these birds is easily ground up, so that on account of these things—the lack of concoction and the nourishment—the stomachs of such birds turn out to be moist.

The fish kind has teeth, but these are virtually all, one might 675[a] say, sawtoothed; virtually all, since one small kind is not of this sort, viz., the one called parrotfish. It also seems to be the only fish—reasonably, on account of these teeth—to chew its cud; for the horn-bearing animals without a complete set of teeth also chew their cud.

All their teeth are sharp, so they are able to divide up nourishment, though poorly; for they are not able to spend time lingering over it. This is why they neither have flat teeth, nor are able to grind food up—it would be pointless. Again, taken as a whole fish do not have a gullet, though some have a short one; but to assist with concoction some have bird-like and fleshy stomachs, such as the mullet; and many have numerous appendages next to the stomach, in order that, by storing up the nourishment in these, as in reservoirs, they can help to decompose it and concoct it.

The fish have these appendages in a manner opposite to the birds; for the fish have them upward, towards the stomach, while in the birds that have these appendages they are lower down, towards the end of the intestine. Even some of the live-bearing animals have lower intestinal appendages owing to the same cause.

The entire fish kind, because the parts engaged in the preparation of nourishment are so deficient that they excrete it unconcocted, is gluttonous towards nourishment—and above all those that have straight intestines. For since they excrete quickly, and because of these things their pleasure is brief, it is necessary for the desire also to come about again quickly.

That those with a complete set of teeth have a small stomach has been stated previously. Moreover, nearly all of them fall into two differences; some have a stomach like that of the dog, others like that of the pig. The pig's stomach is larger and has some moderate folds, in relation to the longer time it takes for concoction to occur, while that of the dog is small in size, not greatly exceeding the intestine, and is smooth inside.

After the stomach lies the nature of the intestines in all animals. And this part too has many differences, just as the stomach does. For in some animals it is simple and alike when uncoiled, while in others it is not alike; for in some the part towards the stomach is wider, while the part towards the end is narrower (which is why dogs discharge such residue with difficulty). But in the greater number
675b it is narrower upward, but wider towards the end. The intestines of the horn-bearing animals, however, are larger and have many convolutions, and the bulk of both the stomach and the intestines in these animals is greater, because of their size; for virtually all the horn-bearing animals are large on account of the complete working

up of their nourishment. In all those animals whose intestines are not straight this part becomes wider as it continues on, and they have what is called the colon, and a blind and bulky part of the intestine; then from this point it again becomes narrower and coiled. But the part after this extends straight to the residue's exit, and in some this part, called the rectum, is fatty, while in others it is devoid of fat.

All these parts have been constructed by nature for the appropriate operations on the nourishment and on the residue that comes to be. For as the residue continues on and moves downward it reaches a wider place, and remains there to change in the better-fed animals and in those needing greater nourishment, either on account of their size or the heat of these places. And then in turn, just as a narrower intestine received it from the upper cavity, so from the colon and the wider place in the lower cavity it once more goes into a narrower space and, once the residue is completely dehydrated, into the helix, so that nature may store it up and its exit not be continuous.

Now those animals that need to be more moderate regarding the production of nourishment do not have large open spaces in the lower stomach, but rather many helices, and intestines that are not straight. For an open space produces desire for much food, while straightness produces rapidity of desire; and this is why those animals with simple receptacles are gluttonous in terms of how quickly they eat, and those with spacious receptacles are gluttonous in terms of the amount they eat.

Since in the upper stomach, during the initial entrance of the nourishment, it is necessarily fresh, and as it proceeds downwards, faecal and dehydrated, it is also necessary that there be some intermediate place in which it changes and is neither still undigested nor already faeces. On account of this, all such animals have what is called the 'fasting-place', in the thin intestine after the stomach. For this is between the upper region, in which there is the unconcocted nourishment, and the lower, in which there is the already useless residue. And while it comes to be in all animals, it is obvious in those that are larger and fasting, but not in those that **676a**
have been eating; for it is when they are fasting that a mid-region between these two places comes into being, while when the animals have eaten the proper time for the change is brief. In females the fasting-place comes about in the upper intestine wherever it

chances, while the males have it before the 'blind place' and the lower stomach.

## CHAPTER 15

Animals with multiple stomachs all have what is called rennet, and of those with a single stomach, the hare. Those with multiple stomachs, however, have rennet neither in the large stomach nor in the net, nor in the last one, the reed, but rather in that between the last one and the two first ones, called the 'vase'. All these have rennet because of the thickness of their milk; and the animals with single stomachs do not have it, since the milk of those with a single stomach is thin. For this reason the milk of the horn-bearing animals solidifies, while that of those without horns does not. Rennet comes to be in the hare, however, on account of its grazing on an acidic herb; for such juice curdles the milk in the stomach for the sucklings. Why, among those with many stomachs, the rennet comes to be in the 'vase' has been stated in the problems.

# BOOK FOUR

## CHAPTER I

Regarding the viscera, the stomach, and each of the other parts 676a that have been discussed, things are the same for the four-footed, egg-laying animals, and for the footless ones such as the snakes. For in fact the nature of the snakes is kindred to these: their nature is like that of a long or even a footless lizard. And in these respects all are very similar to the fish as well, except that they have a lung on account of being land animals, while fish do not, but have gills instead of a lung. And neither fish nor any of these animals have a bladder, except the tortoise; for they drink little on account of the bloodless character of their lung, their moisture being diverted to their scales, just as in birds it is diverted to their feathers. And the residue is also white on the surface in all these animals, as too in birds. That is why, in those animals with a bladder, when the residue flows out, an earthy salt is deposited in their cavities; for the sweet and drinkable portion of the residue is used up, on account of its lightness, in the flesh.

The vipers differ from the other snakes in the same respect as the 676b selachians differ from the other fish, for both the selachia and the vipers are externally live-bearing, having first laid an egg within themselves.

All such animals are single-stomached, just like the other animals that have both sets of teeth; and they also have extremely small viscera, as do the other animals without a bladder. But on account of the shape of their body, which is long and narrow, the configuration of the viscera of the snakes is consequently also long, and unlike other animals; this is because their configurations are formed by their place, just as in a mould.

All blooded animals have an omentum, a mesentery, and the parts connected with the nature of the intestines, and again the diaphragm and the heart; and all except fish have a lung and windpipe. And the position of the windpipe and the oesophagus is similar in all that have them owing to the causes stated previously.

## CHAPTER 2

The majority of the blooded animals also have bile, some by the liver, others detached by the intestines, since its nature is, no less than these, of the lower gut. This is clearest in the fish; for they all have bile, and the majority have it by the intestines, though some have it hemmed along the whole intestine, such as the bonito. And most of the snakes have it in the same manner. This is why those who say the nature of the bile is for the sake of a certain sort of perception are mistaken. They say the reason it exists is so that when it stings the part of the soul around the liver, that part of the soul congeals, while when it is released it produces pleasure. But they are mistaken; for some animals have no bile at all, such as horse, mule, ass, deer, and roe. And the camel does not have it set apart, but rather has bilious blood vessels. And the seal has no bile, nor, among the sea creatures, does the dolphin.

Within the same kinds some appear to have bile, while others do not, as in the kind consisting of mice. And in fact mankind is among these kinds; that is, some people appear to have bile near the liver, while others do not. And this is why a dispute arose about the entire kind; for those who happen upon one or the other of the two forms assume, about them all, that they are all that way. This sort of thing also happens with sheep and goats. Most of them have
677a bile, but in some places there is so much that the excess seems to be monstrous, e.g. in Naxos, while in other places they do not have it, such as in the Chalcidean part of Euboea, in a certain region of their country. And again, as has been said, the bile of fish is detached to a considerable extent from the liver.

The circle of Anaxagoras would seem to have made the incorrect assumption that bile is a cause of the acute diseases; for they seem to assume that when bile is excessive it flows to the lung, blood vessels, and ribs. This is incorrect, since practically all those who suffer the symptoms of these diseases have no bile, and this would become apparent in dissections. Furthermore, the amount of bile present during these sicknesses is incommensurate with the amount expelled.

Rather, just as bile, when it arises throughout the rest of the body, seems to be a residue or colliquescence, so also the bile near the liver seems to be a residue and not to be for the sake of something, as does the sediment in the stomach and the intestines as well.

Now sometimes nature even makes use of residues for some benefit, yet it is not on this account necessary to seek what something is for in every case; on the contrary, when certain things are such as they are, many other such things happen from necessity.

Those animals in which the constitution of the liver is healthy and the nature of the blood secreted into it is sweet either do not have bile near the liver at all, or have it in certain blood vessels, or some have it while others do not. For this reason as well the livers of those animals without bile are, generally speaking, brightly coloured and sweeter, and of those with bile the part of the liver below the bile is sweetest. But of those constituted from less pure blood, the residue that comes to be is bile. For residue tends to be opposite to nutrient and bitter to sweet, and it is the healthy blood that is sweet. So it is apparent that the bile is not for the sake of anything, but is a by-product.

For this reason those ancients speak most cleverly when, looking to the solid-hoofed animals and the deer, they say that the absence of bile is a cause of living longer; indeed, these animals are without bile and are long-lived. And in addition there are animals, not observed by those ancients, that have no bile, such as the dolphin and the camel, and these turn out to be long-lived. In fact it is reasonable that, since the nature of the liver is vital and necessary to all the blooded animals, its being of a certain character is a cause of living a shorter or longer time. And that the residue of *this* visceral organ 677b
and of none of the others is of this sort is in accord with our account. For no such humour can be near the heart (for the heart accepts no forceful affection), and none of the other viscera is necessary to these animals, but only the liver. That is also why this humour occurs around it alone. And it is absurd not to think that, wherever one should see phlegm or sediment from the stomach, it is a residue; likewise it is clear that bile too is a residue wherever one sees it, and does not differ with its location.

## CHAPTER 3

Regarding bile, the cause owing to which some animals have it and some do not has been stated; as for mesentery and omentum, it remains to speak about them; for they are in the location and among the parts just discussed.

The omentum is a membrane; and in animals with hard fat it is hard, while in those with soft fat it is soft; and what sort of thing each of these is has been stated previously. The omentum arises in the same way in those with a single stomach and those with many stomachs, from the middle of the stomach along the line drawn on it like a seam. It covers the remainder of the stomach and the main body of the intestines alike in both the land-dwelling and water-dwelling blooded animals.

The generation of this part occurs of necessity in the following way; when a mixture of dry and moist is heated, the surface always becomes skin-like and membranous, and this location is full of such nutrient. And further, on account of the thickness of the membrane, it is necessary for the filtrate of the bloody nourishment to be fatty (for this is thinnest), and to become hard or soft fat rather than a fleshy and bloody composition when it undergoes concoction owing to the heat in this region.

The generation of the omentum, then, occurs according to this account, and nature makes use of it for the proper concoction of the nutrient, in order that the animals may concoct their nutrient easily and quickly; for that which is hot is able to concoct, and that which is fat is hot, and the omentum is fat. And it arises from the middle of the stomach, on account of the fact that the liver, which lies alongside that part of the stomach beyond the mid-point, aids in concoction.

## CHAPTER 4

The omentum, then, has been spoken of; as for the mesentery, as it is called, it is a membrane, and stretches continuously from the extension of the intestines to the great blood vessel and the aorta,
678a being itself full of many closely packed blood vessels that extend from the intestines to both the great blood vessel and the aorta.

We will find, then, that its generation is, like the other parts, of necessity; and owing to what cause it is present in the blooded animals is apparent upon examination. For since it is necessary for animals to take in nutrient from outside, and again for the final nutrient to come to be from this, from which it is immediately distributed to the parts (and while in the bloodless animals this final nutrient is unnamed, in the blooded animals it is called blood), there needs to be something through which the nutrient will proceed, as if through roots, from the stomach into the blood vessels. Thus while plants have their roots in the earth (for it is from there that they take their nutrition), for animals the stomach and the potentiality of the intestines is earth, from which it is necessary for them to take their nutrient. This is why it is of the nature of the mesentery to have blood vessels through it, like roots. What the mesentery is for, then, has been stated. How it takes up nutrient and how what is distributed to the blood vessels enters, through the blood vessels, into these parts from the incoming nutrient—these things will be spoken of in the works on generation and on nutrition.

How the blooded animals are arranged as far as the parts defined up to this point are concerned, and owing to what causes, has been said. Next among the things remaining to be spoken of are the parts that jointly contribute to generation by which the female is believed to differ from the male. But since we need to speak about generation, it is appropriate to consider the generative parts as well during the study of those things.

## CHAPTER 5

Those called 'soft-bodied animals' and 'soft-shelled animals' are very different from the blooded animals—for first of all, they lack the nature of the viscera altogether. Likewise, none of the other bloodless animals has it either. (There are two remaining kinds of bloodless animals, the hard-shelled kind and the kind consisting of insects.) For none of these animals has blood, out of which the nature of the viscera is constituted, because some such affection of it is constitutive of their being; for that some animals are blooded while some are bloodless will belong in the account defining their substantial being. Further, none of those things for the sake of which the blooded animals have the viscera will be present in such animals; for they have neither blood vessels nor a bladder, nor do they breathe; rather, for them it is only necessary to have the 678b
analogue to the heart. For in all animals there is a certain origin of the parts and of the body in which is found the perceptive part of the soul and the cause of life. And all these animals have the parts for nutrition of necessity as well; but their ways of feeding differ according to the places in which they get their nutrition.

The soft-bodied animals have, around the part called the mouth, two teeth; and in the mouth, in place of a tongue they have something fleshy, by which they judge the pleasantness of their food.

And like these, the soft-shelled animals also have the primary teeth and the fleshy analogue to the tongue. Further, all the hard-shelled animals also have such a part, owing to the same cause as do the blooded animals, for the perception of nutrients. Likewise, the insects too in some cases, e.g. the kinds consisting of bees and flies, have a proboscis which protrudes from the mouth as has in fact been previously stated; but those that are without a front sting have such a part inside the mouth, e.g. the ant kind, and any other such animals as there may be.

Some insects have teeth, though rather different ones, just as the fly and bee kinds do; others—those that utilize moist nourishment—do not. In fact many insects have teeth not for nourishment but for defence.

Some of the hard-shelled animals, as we also stated in our initial accounts, have the so-called 'powerful tongue'; and those with spiral shells also have two teeth, like the soft-shelled animals. After the mouth, in the soft-bodied animals, there is a long gullet, and following it a crop, just like the birds; continuous with it is a stomach, and following it a simple intestine extending to the anus.

In the cuttlefishes and octopuses the parts around the stomach are alike both in configuration and to the touch. However, while the gastric receptacles in those called squids are likewise two, the one is less crop-like; and these parts differ in shape from those in the former animals because the entire body is actually constituted of softer flesh. These animals have these parts in this way owing to the same cause as the birds do; that is, none of them is able to grind up its nourishment, which is why the crop is in front of the stomach.

For protection and self-preservation these animals have what is
679a called the 'ink', which builds up in a membranous covering with its outlet and end-point right where the residue of the stomach discharges through what is called the 'pipe'; and this is in their bellies. All the soft-bodied animals, then, have this distinctive part, but most of all and to the greatest extent the cuttlefish; for when it is frightened and terrified, it darkens and 'inks' the water—a shield, as it were, in front of the body.

The squids and octopuses have the ink upward, nearer to the *mutis*, while the cuttlefish has it lower down toward, the stomach, since, because it uses it more, it has more of it. And it uses the ink more because, though its way of life is coastal, its has no other means of protection, as the octopus has its useful tentacles and alteration of colour which—along with the ejection of ink—happens to it owing to terror. The squid is the only one of these animals that is a deep-sea dweller.

Thus the cuttlefish has, in consequence of this need for protection, a greater amount of ink, and has it lower down because there is more of it; for, as a consequence of the greater amount it is easily emitted, even from a distance.

Just as, in the birds, a white sediment arises in the earthen part of their residue, so in these animals too the ink arises—in both cases because they do not have a bladder; for the most earthen part of the residue is excreted into the ink, and most of all in the cuttlefish since it is the most earthen. An indication that it is most earthen is its cuttle-bone, which is of such a character; for the octopus does not have one, while the squids have a cartilaginous and thin one. (Owing to what cause some have it while some do not, and what sort each of them has, has been said.)

They are bloodless and on this account are prone to be chilled and timid. And just as in some animals the stomach becomes upset when they are frightened but in some a residue flows from their bladder, so in these animals there occurs a discharge on account of fear. And this discharge, just like that from the bladder in animals that urinate, is of necessity; yet at the same time nature makes use of such residue for their protection and self-preservation.

The soft-shelled animals too—both the crayfish form and the crabs—have the two primary teeth, and between them the tongue-like flesh, as was also said previously; and immediately following the mouth they have a gullet which—comparing greater with lesser—is small in comparison with the size of their bodies. Following this they have a stomach, in which the crayfish and some of the crabs have another set of teeth because the upper teeth cut insufficiently; and from the stomach a simple intestine runs straight to the outlet **679b**
for residues.

Each of the hard-shelled animals also has these parts, some more articulated and some less; and each part is more distinct in the larger animals. The spiral-shelled animals also have hard, sharp teeth, as was said previously, and they have the fleshy part between the teeth, in the same way as the soft-bodied animals and the soft-shelled ones do. They also have, as was said, a proboscis intermediate between a sting and a tongue, a sort of bird-like crop following the mouth, and following this a gullet. After this comes the stomach, in which is the *mēkōn* as it is called, continuous with which is a simple intestine originating from the *mēkōn*. In fact this residue, which seems to be especially edible, is present in all the shelled animals.

The other trumpet-shelled animals, e.g. the purpuras and whelks, are like the spiral-shelled ones. But there are many kinds and forms of hard-shelled animals; some are trumpet-shelled, as the ones mentioned just now, while some are bivalved and some univalved. And in a way even the trumpet-shelled ones seem to be bivalves; for all such animals, e.g the purpuras, whelks, nerites, and every such kind, have, from the start, a covering over the visible part of the flesh, for protection. For where the shell does not serve as a covering, it is easy for the animal to be harmed by assaults from without.

The univalves, on account of being attached to something, protect themselves by having their shell on the underside, and become, by means of a foreign protection, in a way a bivalve, e.g. those called limpets. The bivalves however, such as scallops and mussels, protect themselves by drawing their covering together, while the spiral-shelled animals do so by means of this foreign covering, as if becoming bivalves from univalves. But above all it is the sea urchin that has a shelter; for its shell encircles it with a thick covering that has been fortified by spines. And among the hard-shelled animals this is distinctive, as previously stated.

The nature of the soft- and hard-shelled animals has been constituted in a manner opposite to the soft-bodied animals; for in the latter the fleshy part is outside, while in the former it is inside and the earthen part is outside. The sea urchin, however, has nothing fleshy.

All these, and the other hard-shelled animals, as was said, have a mouth, a tongue-like part, a stomach, and a residual outlet, though each part differs in position and size. (The manner in which each
680a of them has these parts should be studied with the help of the enquiries about animals and of the dissections. For some of these things need to be clarified by an account, others rather by visual inspection.)

The sea urchins and the kind called 'the ascidians' are distinctive among the hard-shelled animals. The sea urchins have five teeth, and between them the fleshy part which is present in all the animals mentioned. Following this there is a gullet, and after this the stomach, which is divided into many parts, as if the animal had many stomachs. For though they are separated and full of residue, they hang from the one gullet and end up at a single residual outlet. Apart from the stomach, sea urchins have nothing fleshy, as was said, though they have several 'eggs' as they are called, each in a separate membrane; and spread around in a circle, extending from the mouth, are certain dark masses which have no name.

Though there are several kinds (for there is not one form of all sea urchins), all of them have these parts; but not all the parts called 'eggs' are edible, and they are extremely small outside the abundant varieties. And this holds true generally for the other hard-shelled animals as well; there too the flesh is not equally edible in all cases; and the residue called the *mēkōn* is in some cases edible and in other cases not. In the trumpet-shelled animals this *mēkōn* is in the spiral, in the univalves (e.g. the limpets) in the base, and in the bivalves at the connection; and in the bivalves the 'egg', as it is called, is on the right side, while the residual outlet is on the opposite side.

Those who call this part an egg do so incorrectly; for this, like fat in the blooded animals, is present when they are flourishing. That is also why it arises during the seasons of the year when they flourish, i.e. in the spring and autumn; for during cold and warm periods all the hard-shelled animals suffer, and are unable to bear the extremes of climate. A sign of this is what happens to the sea urchins: immediately when they develop they have these 'eggs', and have more of them during full moons, not because of increased feeding as some think, but because the nights are warmer on account of the light of the moon. For since they are sensitive to cold on account of being bloodless, they need heat. That is also why during the summer they are more thriving, everywhere except those in the straits of Pyrrha; those thrive no less in the winter. **680b**
This is because they are better supplied with food then, since the fish leave the region during this season.

All the sea urchins have both an equal—and odd—number of eggs; for they have five, and the same number of teeth and of stomachs. This is because the 'egg' is, as was said previously, not an egg, but a thriving condition of the animal. This so-called egg comes to be on one side only in the hard-shelled animals. And it is the same in the sea urchins as well.

Now since the sea urchin is spherical, and not, as with the body of the other hard-shelled animals, a single circle; and since it is not the case that the sea urchin is circular in one way but not in another, but is alike in *all* ways (since it is spherical), it is necessary for the egg too to be likewise. For there is not, as in the others, an inequality in its circumference. The head is in the middle in all the others, while in the sea urchin a part of this sort is upward. But the egg cannot be continuous; for it is not so in the other hard-shelled animals, but it is on one side of the circle only. Accordingly, it is necessary (since this part is common to all of them, while the spherical body is distinctive of the sea urchin) that the eggs should not be even in number. For they would be in opposition, on account of the need to have one side like the other, if they were even and in opposition. But if they were arranged in this way, then the eggs would be on both sides of the circumference. Yet this is not as it is in the other hard-shelled animals; in fact, the oysters and scallops have a part of this sort on one side of their curved surface. Accordingly, it is necessary that there be three, five, or some other odd number. Now if it had three 'eggs', they would be too far apart, but if more than five, they would be continuous; and of these options the one is not good, the other not possible. Therefore it is necessary for them to have five eggs.

Owing to the same cause, their stomach too is so divided, and the number of teeth is as many. For each of the eggs, inasmuch as it is a certain body part of the animal, necessarily has a likeness to the character of the animal; for growth comes from there. Otherwise, if the stomach were *one*, the eggs would either be distant from it, or it would occupy the entire cavity, so that the sea urchin would be sluggish and the cavity not full of nutrient. But since the interstices are five, it is necessary that, being in each one, the stomach be divided into five. And owing to the same cause the number of the teeth is as many; for in this way nature may assign them in a like manner to the parts already discussed.

681a So then, why the sea urchin has an odd number of eggs, and why just this many, has been stated; and the reason why some have extremely small ones while others have larger ones is because the latter are hotter in nature. For the hot is better able to concoct the nutrient, which is why the inedible sea urchins are more full of residue. And the hotness of their nature readies them for greater movement, so as to graze and not remain sedentary. A sign of this is that such sea urchins always have something on their spines, as though frequently in motion; for they use their spines for feet.

The ascidians differ slightly from plants in their nature, but nevertheless are more animal-like than the sponges; these have, in every respect, the potentiality of a plant. In fact nature passes continuously from soulless things into animals by way of those things that are alive yet not animals, so that by their proximity the one seems to differ very little from the other.

Now the sponge, as just stated, by living only while it is attached, but not when removed, is completely like the plants. The ones called 'holothurians' and 'the lungs', as well as other such sea-dwellers, differ slightly from sponges in being detached; for none of them has perception, and they live as though they were detached plants. Moreover, there are, even among the terrestrial plants, some creatures of the sort that both live and come to be, some in other plants, others even unattached, such as the one from Parnassus called by some 'rock plant'—it lives for a long time when hung up on pegs. And sometimes, even with the ascidians (and any other such kind which, by living only when attached is like a plant but by having something fleshy would seem to have some perception), it is unclear on which side one is to put them. This animal has two openings and one division, by which it both receives moisture for nourishment and then expels leftover secretions; for it has no apparent residue, like the other hard-shelled animals. Accordingly, it is most fitting to call this—and any other animal of this sort there might be—plant-like, since none of the plants has a residue either.

Through the mid-line of the ascidians there is a thin diaphragm, in which it is reasonable for that which controls life to preside. But those that some call 'nettles' and others 'anemones' are not hard-shelled, but fall outside the divided kinds, and tend in their **681[b]**
nature towards both plant and animal. For by being detached and falling upon their nourishment, and by being perceptive of what they fall upon, some of them are animal-like; and further, they use the roughness of their body for self-preservation. But by being incomplete and becoming quickly attached to the rocks, and by having no apparent residue though they have a mouth, they are akin to the kind consisting of plants. And the starfish kind is similar to this group as well (for it too, after falling upon many of the hard-shelled animals, sucks their juice), and it is also like the detached animals already spoken of, e.g. the soft-bodied and soft-shelled ones. And the same account holds for the hard-shelled animals as well.

The parts concerned with nutrition, then, which necessarily belong to all, have the aforesaid character; and clearly there is a need to have some part analogous to those present in the blooded animals to govern the modes of perception; for this part must be present in all animals. But this part is, among the soft-bodied animals, a fluid lying within a membrane, through which the gullet extends to the stomach; it is attached more to the back and is called *mutis* by some people. There is another such part in the soft-shelled animals as well, and that one too is called *mutis*. This part is fluid and bodily at the same time, and as was just said, the gullet extends through the middle of it; for if it were between this part and the back, it would be unable to undergo distension as it does when the nutrient enters, because of the hardness of the back. The intestine rests on the outside of the *mutis*, and the ink is near the intestine, in such a way that it can keep as far as possible from the entrance and its offensiveness can be far from the better and the origin.

Its location makes it clear that this part is the analogue of the heart (for the location is the same), as does the sweetness of the fluid, inasmuch as it is well concocted and blood-like. But though the part in the hard-shelled animals with authority over perception has the same character, it is less manifest. However, in those that are sessile this origin should always be sought intermediate between the part that receives nourishment and that through which the spermatic or residual secretion is produced; while among animals that are mobile, it should always be sought in the mid-point between the parts on the right and on the left.

682a In the insects, the part possessing this sort of origin, as stated in the initial accounts, is between the head and the hollow region around the stomach. In the majority of insects it is one, but in the rest, as in those that are centipede-like and long, it is more than one. This is why they live when they are cut up. For nature aims in every case to make only one such part, and when unable it makes only one in actuality, but in potentiality more than one; but this is clearer in some than in others.

The parts for nourishment are not alike in all insects, but are different in many respects. For in some the sting, as it is called, is inside the mouth, as if the potentials of the tongue and lips were conjoined and possessed together; while in those that do not have the sting in front there is a sense-receptor of this sort behind the teeth. Following this part in all of them is a straight and simple intestine leading to the residual outlet; though in some this part has a spiral.

Some insects have a stomach right after the mouth, and from the stomach a winding intestine, so that those that are naturally more voracious and larger may have a reservoir for a greater amount of nourishment. But the cicada kind has the most distinctive nature of them all; for the same part unites together mouth and tongue, through which, as if through a root, it receives nourishment from fluids.

All the insected animals are light feeders, not so much because of their smallness as because of their coldness (for the hot needs nourishment and concocts nourishment quickly, while the cold needs little nourishment), and most of all the cicada kind; for the moisture left behind by the air is sufficient nourishment for their body, as with the ephemeral animals (these arise around the Pontus), except they live for a period of one day, while the cicadas live more than one, though few enough.

Since the internal parts present in animals have been spoken of, we must return again to the rest of the external parts. And we must begin with the animals about which we have just now spoken, not with those with which we left off, so that proceeding from those needing less discussion, the account may give more attention to the complete and blooded animals.

## CHAPTER 6

The insected animals do not consist of a large number of parts, but nevertheless are different from one another. For all are many-footed, because being many-footed makes their movement more rapid relative to the slowness and coldness of their nature; and the **682b**
most many-footed are the ones that become most chilled on account of their length, e.g. the centipede kind. Further, it is on account of having many origins that their 'insections', and the many feet distributed to them, exist.

Those insects that have fewer feet are flyers as a consequence of the deficiency of feet. And those flyers whose way of life is nomadic and for whom it is necessary to range widely for nutrition are four-winged and have a light body mass, e.g. the bees and the animals akin to these; that is, they have two wings on each side of the body. But those flyers that are small are two-winged, like the ant kind.

And those that are light and lead sedentary lives, such as cockchafers and insects of this sort, are many-winged, like the bees, but with sheaths for their wings; this is so that the potentiality of the wings may be preserved. For since they are sedentary, they are more easily destroyed than those that are mobile, on which account they have a means of protecting their wings.

Their wing [*to pteron*] is unsplit and without a shaft; for it is not a feather [*pteron*] but a skin-like membrane, which because of its dryness from necessity becomes detached from their body when their flesh cools.

They are insected both owing to the causes just stated, and so that they may keep themselves alive by curling up to avoid harm; for those that have length roll themselves up, and this would not happen to them if they were not insected. By contrast, those that do not roll themselves up increase their hardness by drawing their sections together. This becomes clear when they are touched, e.g. in those called dung beetles; for when frightened they become motionless, and their body becomes hard. And it is necessary for these animals to be insected; for having many origins is present in their substantial being, and in this they are near to the plants. For just as with the plants, these are also able to live when divided up; except that while insects can do so up to a point, plants become *complete* in nature; that is, two or more plants come to be from one.

Some of the insects also have stings, for protection from predators. Now in some the sting is in front, in others behind; and in those that have it in front, it is by the tongue, while in those that have it behind it is at the tail-end. For just as in elephants the receptor of odours has become useful both for strength and for
683a the acquisition of nourishment, so in some of the insects the sting has been positioned by the tongue; for they both perceive their nourishment by means of this part, and take hold of and convey it.

Those that do not sting from the front have teeth, some for the sake of feeding, others for the sake of grasping and conveying their nourishment, e.g. the ants and the kind consisting of all the bees. Those that sting from the rear have, because they are spirited, the sting as a weapon. Again, some have their stings within themselves, as do the bees and wasps, because they are flyers. For being thin and external, the sting would be easily destroyed; while if it projected outwards, as it does in the scorpions, it would weigh them down. But because the scorpions are land animals and have tails, it is necessary either to have the sting on these, or for it to be useless for strength.

Nothing two-winged stings from the rear. For it is on account of being weak and small that something is two-winged, since a smaller number of wings is sufficient for the small insects to become elevated. And for the same reason this group has the sting in front; for being weak, it is just barely able to strike by means of things in front.

Those insects with many wings turn out to have a greater number of wings on account of being larger in nature; and they are strong in their rear parts. And it is better, where possible, not to have the same instrument for dissimilar uses, but rather the defensive one most sharp, and the one that is to be a tongue spongy and able to draw in nourishment. For where it is possible for two things to be used for two functions without impeding each other, nature is unaccustomed to making things as does the coppersmith who, to economize, makes a spit-and-lampstand; but where this is not possible, nature makes use of the same thing for multiple functions.

Some of the insects, since they have, owing to their hard eyes, inaccurate vision, have long front feet so that they can clear away things that fall in front of them. This is what the flies and the bee-like animals appear to do; for they are always crossing their front legs. Their rear legs are longer than their mid-legs, on account of walking and for ease of taking off from the earth when flying away. And in those that are able to leap [*pēdētika*], e.g. the locusts and the flea kind, this is still more apparent; for when they bend and then extend the rear legs, they necessarily take off from the earth. The locusts do not have these rudder-like legs [*pēdaliōdē*] in the front but in the rear only. For it is necessary that the joint of these legs **683b**
incline inwards, and none of the forelimbs is of this sort. All such insects are hexapods with the leaping parts included.

## CHAPTER 7

The body of the hard-shelled animals is not composite. This is because they are sessile in nature; that is, it is necessary for the mobile animals to be more composite, on account of their activities; for those partaking of many motions are in need of many organs. Some of these animals, however, are entirely immobile, while others partake of slight movement; but for self-preservation nature has wrapped the hardness of the shell around them.

Some of them are univalves, some bivalves, and some trumpet-shelled, as was said before; and among the latter are some with a spiral, such as whelks, and some that are only spherical, like the sea urchin kind. And among the bivalves there are some that open up, e.g. scallops and mussels (for they are closed on one side so that they may be opened and closed on the other), and others that have been fused on both sides, e.g. the pipe kind.

All the hard-shelled animals, like the plants, have their head downward. This is because they take their nourishment from below, just as plants do by means of their roots. Accordingly, they turn out to have the below above, and the above below. And the head is in a membrane, through which they filter drinkable water and take their nourishment. And though all have a head, the other parts of the body, besides the receptacle of nourishment, are unnamed.

## CHAPTER 8

The soft-shelled animals are all locomotive, wherefore they have numerous feet. There are four extensive kinds of them, called crayfish, lobsters, prawns, and crabs; and of each of these kinds there are many forms, differing not only in shape but also greatly in size; for some are large while others are altogether tiny.

The ones that are crab-like and crayfish-like are similar in that they both have claws. These they have not for the sake of locomotion, but for grasping and holding, in place of hands. This is also the reason why these organs bend in the opposite direction to the feet; for the feet bend and twist towards the concave, the claws towards the convex, since in this way they are useful for grasping the nourishment that is to be conveyed to the mouth.

684a They differ in so far as the crayfish have a tail, while the crabs do not; for in the former group, on account of their being swimmers, the tail is useful (for they swim by propelling themselves with their tails, as if by oars); but in the crabs it is of no use, because their way of life is to be near the shore, and they are hole-dwellers. And those among the crabs that are deep-sea dwellers have, because of this, feet that are much less useful for locomotion, e.g. the spider-crabs and the so-called Heracleotic crabs, because they move very little, but preserve themselves by being like the hard-shelled animals.

This is why the spider-crabs are thin-legged, while the Heracleotic crabs are small-legged.

The extremely small crabs that are hauled in among the small fish have their hindmost feet flat, in order that they may be useful to them for swimming—having these feet as fins or oars. The shrimps differ from the forms of crab by having a tail, and from the forms of crayfish because they do not have claws, which they lack on account of having many feet; for the growth from one place has been used up elsewhere. And they have many feet because they are walkers as much as swimmers.

The parts on the underside and around the head are in some cases gill-like to receive and expel water; but the female crayfish have the lower ones more laminar than the males, and the female crabs have hairier parts on the flap than the males, because they deposit their eggs towards them, rather than expelling them, as do the fish and the other egg-layers; for being more spacious and larger, these parts have more space for their eggs.

The crayfish and the crabs all have the right claw larger and stronger; for all animals naturally do more things by means of the parts on the right side; and nature always provides each thing, either exclusively or more, to those able to use it, e.g. tusks, teeth, horns, spurs, and all parts of this sort that are for protection and defence. The lobsters alone have one claw or the other, whichever one it chances to be, larger, in both the females and the males. They have claws because they are in the kind that has claws; while they have this part randomly distributed because they are deformed, and do not use it to do what claws are naturally for, but for the sake of locomotion.

Each of the parts—what their positions are and what differences there are from one animal to another, including in what way the males differ from females—should be studied with the help of the dissections and the enquiries about animals. **684b**

## CHAPTER 9

The *internal* parts of the soft-bodied animals have been spoken of previously, as too have those of the other animals; externally, they have the trunk of the body, which is indefinite, and in front of this they have feet around the head, between the eyes, and around the mouth and teeth.

Now the other animals with feet in some cases have them in the front and the rear and in other cases projecting out from the side, as do the many-footed, bloodless animals. But the soft-bodied kind is, when compared with these others, distinctive; for they have all their feet towards the 'front', as it is called. This is because the rear of these animals has been joined to the front, just like the conical, hard-shelled animals. In fact on the whole the hard-shelled animals are in one respect like the soft-shelled animals and in another like the soft-bodied animals. In so far as the earthen part is outside and the fleshy part is inside, they are like the soft-shelled animals; but in the way in which the configuration of the body has been constituted they are like the soft-bodied animals—this is so for all of the hard-shelled animals to a certain extent, but most of all for the conical-shelled ones with a helix. The nature of the internal parts of both is as if one were to conceive of it in a straight line, as in fact it is in the four-footed animals and the human beings: first, at the extreme upper point of this straight line is the mouth, designated as $A$, next the gullet, $B$, then the stomach, $C$; and from the intestine to the residual outlet, $D$.

In the blooded animals, then, the nature of the internal parts has this character, and around it is the head and what is called the thorax. And nature has added the remainder of the parts, e.g. the front and hind limbs, for the sake of these parts and for the animal's movements. Moreover, at least the straight course of the intestines tends to have the same character in the soft-shelled animals and in the insects, though with respect to their external, locomotive equipment they are different from the blooded animals.

The soft-bodied animals and the conical, hard-shelled animals are very similar to one another, but opposed to those just mentioned.
685a For the end-point has been bent around to the starting-point, as if, by bending the straight line, to which we give the symbol $E$, one were to bring the $D$ around to the $A$. Since this is how the internal parts are in fact positioned in the soft-bodied animals, the mantle—which is called a head only in the case of the octopuses—surrounds them; while in the hard-shelled animals the cone does so. They have no other difference except that in the soft-bodied animals the surrounding part is soft, while in the hard-shelled animals nature, in consequence of their sluggishness, has placed something hard around the fleshy part so that they are protected. And because of this the residue, in both the soft-bodied and the conical-shelled

animals, exits in the region of the mouth, albeit in the soft-bodied ones it exits beneath it, in the conical-shelled from the side. It is, then, owing to this cause that the feet of the soft-bodied animals have this character, contrary to the other animals.

The cuttlefish and squids are unlike the octopuses because they are only swimmers, while the octopuses are also walkers. This explains why the former groups have the small legs above, and of these the two at the extremes are larger, while of those remaining the two of the eight that are down below are largest. For just as the rear limbs are stronger in the four-footed animals, so in these animals the limbs underneath are larger. For these bear the weight and move the animal most of all. And the two extreme pairs are larger than those in the middle because they work together with them. The octopus, on the other hand, has the four limbs in the middle largest.

All of these have eight feet, but the cuttlefish and the squid have short ones, the octopus-like animals long ones. For the trunk of the body in the former two groups is large, in the latter group small, so that in the octopuses nature takes from the body and adds to the length of the feet, while in the cuttlefish and squid, by taking from the feet, the body increases. Accordingly, in the octopuses the feet are not only useful for swimming, but also for walking, while in the other two groups they are useless for this; for their feet are small, while they have a large trunk.

Since, moreover, they have small feet that are useless both for taking hold of, and not being torn from, the rocks when there are waves and storms, and for conveying food from afar—for these reasons they have two long proboscises by which they moor themselves and lie at anchor, like a ship when it is in a storm, and by which they—the cuttlefish and the squids—hunt down prey from afar and convey it to themselves. The octopuses, on the other hand, 685b
do not have these proboscises, because their feet are useful for these activities.

Those animals that have suckers and tentacles added to their feet have a potentiality and composition such as the plaited tube in which the ancient doctors set fingers; thus too have they been plaited from fibres, by which means they draw in fleshy, yielding objects. They surround them in a relaxed state; but when they contract, they grasp and take hold of everything touching them within. Since there is nothing other than the feet in some and the proboscises in the others by which they convey their food, they have these parts instead of hands for strength and other protective purposes.

Now while the other octopuses have two rows of suckers, one kind of octopus has a single row. This is because of the length and thinness of their nature; for it is necessary that the narrow tentacle should have a single row of suckers. It is not, then, because it is best that they have this feature, but because it is necessary owing to the distinctive account of their substantial being.

All these have a fin in a circle around their trunk. In the other soft-bodied animals, as well as in the large squid [*ho teuthos*], this encloses them and is continuous; but the smaller ones, the ones called squids [*hai teuthides*], have this part both flatter than the cuttlefish and octopuses and not as narrow; and it begins from the mid-point and does not encircle them continuously. And they have this part so that they may swim, and for steering, just as in the flyers there is the rump and in the fish the tail fin. But this part is smallest and least visible in the octopuses, because they have a small trunk and are steered sufficiently by their feet.

So then: we have spoken about the internal and external parts of the insects, the soft-shelled animals, the hard-shelled animals, and soft-bodied animals.

## CHAPTER 10

We need to examine again from the beginning the blooded, live-bearing animals, starting with those of their previously mentioned parts that remain. Once these have been defined, we will go on to speak about the blooded, egg-laying animals in the same way.

The parts surrounding the head of these animals have been spoken of previously, and those around what are called the neck and throat. All the blooded animals have a head; while in some of the
686a bloodless animals this part is indefinite, e.g. in the crabs.

All live-bearing animals have a neck, while some of the egg-layers have it and some do not; this is because those that have a lung also have a neck, while those that do not inhale do not have this part. The head is present above all for the sake of the brain; for the blooded animals must have this part, and in a place opposite the heart, owing to the causes stated previously. And nature placed some of the modes of perception on the outside of it as well, on account of the blend of the blood being well proportioned, i.e. adapted both for the warmth of the brain and for the quietness and accuracy of perception.

Further, nature has added a third part which works on the incoming nutrient; for it is most suitably placed there. That is, it was not possible that the stomach should lie above the heart and origin, nor, being below the heart, which is the way it in fact is, was it possible for the food intake also to be below the heart; for the length of the body would be great, and the mouth would be very distant from the moving and concocting origin.

The head, then, is for the sake of these things, while the neck is for the sake of the windpipe; for it is a defence, and protects the windpipe and the oesophagus by encircling them. Thus while in other animals it is capable of bending and has vertebrae, wolves and lions have a single bone in their neck. For nature saw to it that they would have a neck useful for strength more than for other aids.

Following the neck and the head in these animals are the forelimbs and chest cavity. Mankind, however, instead of forelimbs and forefeet has arms and what are called hands. For it alone of the animals is upright, on account of the fact that its nature and substantial being are divine; and it is a function of that which is most divine to reason and to think. But this is not easy when much of the body is pressing down from above, since the weight makes thought and the common sense sluggish. For this reason, when their weight and bodily character become excessive, it is necessary that their bodies incline towards earth, so that for stability nature placed forefeet beneath the four-footed animals, instead of arms and hands. For it is necessary that all those able to walk should have two hind limbs, and such animals become four-footed because their soul is unable **686b** to bear the weight.

All the other animals besides human beings are dwarf-like—something is dwarf-like the upper part of which is large while the weight-bearing and walking part is small. And the upper part is what is called the 'chest cavity', extending from the head to the residual outlet.

Now in human beings this part is proportionate to the lower part, and is greatly reduced as they mature; but when they are young the opposite is the case, the upper part being large, the lower part small. And it is for this reason that the young crawl and are unable to walk. And at first they do not even crawl, but are immobile; for all children are dwarfs. But as human beings advance in age the lower parts grow, while in four-footed animals the opposite occurs—the lower parts are largest at first, but as they advance in age growth occurs in the upper part, which is the trunk, extending from the rump to the head. This is also why in height foals are either not at all, or only a little, smaller than horses, and when young they can touch their head with their hind limb, but when older are unable to do so. The solid-hoofed and split-hoofed animals have this character, while those with toes and without horns, though dwarf-like, are less so than those with hoofs. This is also why the growth of the lower parts relative to the upper parts is proportional to the deficiency.

The bird and the fish kind, and every blooded kind are, as has been said, dwarf-like. And because of this all animals are less intelligent than human beings. And in fact among human beings, children compared with adults, and among adults in their prime the naturally dwarf-like, are deficient in the possession of reason even if they have a surplus of some other potential. And a cause of this deficiency, as was said before, is that the origin of the soul is, in very many animals, sluggish and bodily. And further, as the heat which rises becomes less and the earthen material becomes greater, the bodies of animals grow smaller and many-footed, and finally become footless and stretched out on the earth. Proceeding in this way a little, even their origin is below, and the part corresponding to the head is in the end unable to move and perceive, and a plant comes to be, having the above below, and the below above; for the roots of plants have the potentiality of a mouth and a head, while
687a the seed is the opposite; for it comes to be above, on the uppermost shoots.

The cause on account of which some animals are two-footed, some many-footed, and some footless, and some things become plants and some animals, has been stated, and why mankind is the only upright animal. And being upright in nature, mankind has no use for forelimbs, and instead of these nature provides arms and hands.

Now Anaxagoras said it was because they have hands that human beings are the most intelligent of animals; it is reasonable, however, that it is because they are most intelligent that human beings are given hands. For the hands are instruments and nature, like an intelligent human being, always apportions each instrument to the one able to use it. Surely it is more fitting to give flutes to the flautist than to provide the ability to play flutes to one who has them; for nature has provided the lesser to the greater and superior, not the more honourable and greater to the lesser. So if it is better thus, and nature does, among the possibilities, what is best, it is not because they have hands that human beings are most intelligent, but because they are the most intelligent of animals that they have hands. For the most intelligent animal would use the greatest number of instruments well, and the hand would seem to be not one instrument, but many; indeed it is, as it were, an instrument for instruments. Accordingly, to the one able to acquire the most arts, nature has provided the most useful of instruments, the hand.

Those who say that mankind is not well constituted, but on the contrary is the worst constituted of animals—for (they say) he is barefoot, naked, and without weapons for defence—are mistaken. For the other animals have but one protection, and cannot exchange another one for it. Rather it is necessary for them to sleep and do everything as if they were permanently shod, and never to shed the shelter surrounding their body, nor to exchange whatever weapon they may have. But for mankind it is always possible to have many forms of protection and to exchange them, and furthermore, he **687b**
may choose what sort of weapon to have, and where. For the hand becomes a talon, claw, horn, spear, sword, and any other weapon or instrument—it will be all these thanks to its ability to grasp and hold them all. And for this the form of the hand has been adapted by nature. For it is divided and has many digits, and it is possible for something in a divided state also to be composite, while it is impossible for something in a composite state to be divided. And it is possible to use the hand as one, two, or many.

Again, the joints of the fingers are well disposed for grasping and squeezing. And one finger extends out of the side of the hand, and is short and thick, not long; for just as, if there were not a hand at all, one could not grasp, so too one could not grasp if this finger were not growing out of the side. For it squeezes from below upwards, while the others squeeze from above downwards. And this must happen if it is to bind things together strongly, like a strong clamp, in order that, though one, it may be equal to many. And this finger is short both on account of the strength thus achieved and because no advantage would result if it were long. (The last finger too is appropriately small, and the middle one long, as is the middle oar of a ship; for in most cases it is necessary that what is grasped be grasped around the middle for its operation.) And on this account it is called 'large' though it is small, because the other fingers are virtually useless without it. The form of the nails too has been well arranged; for the other animals have nails as well to provide a service, while in human beings they are a covering—that is, they are a shelter for the fingertips.

The joints of the arms are, both for the conveyance of nutrient and for other uses, arranged in a manner opposite to the four-footed animals. For in these it is necessary for the forelimbs to bend inward (since they are used as feet), in order that they be useful for locomotion—although even among these animals, in those with toes the forelimbs tend to be useful not only for locomotion but also in place of hands, as in fact is apparent when they are
688a used; for they both grasp things and defend themselves with their forelimbs. Hoofed animals, however, defend themselves by means of their hind limbs; for in them the front limbs do not have an analogue to the elbows and hands. And some of the many-toed animals, for this very reason, have five digits on the front feet but four digits on the rear, e.g. lions and wolves, and again dogs and leopards; for the fifth toe is large, just as the fifth digit on the hand is. But the small, many-toed animals have five digits on their hind limbs as well, because they are creepers. Thus, by means of their many nails they may grasp easily and creep higher up, even overhead.

The breast, as it is called, is between the arms in human beings, and in the others between the forelimbs. In human beings it is wide, which is reasonable (for since the arms are attached to the sides of the body they do not prevent this region from being wide), while in four-footed animals, on account of the forward extension of their limbs when they walk and change place, this part is narrow. And because of this, four-footed animals do not have mammae in this location. In human beings, however, because of the wide expanse of the breast and the need to shelter the parts around the heart, and since the location is fleshy, the mammae have been differentiated. In males they are fleshy owing to the aforementioned cause, while in females nature has turned them to another function as well, which we claim it often does; for it stores nourishment there for the offspring. The mammae are two on account of the duality of the parts, the right and the left. And they are harder, yet distinct, on the one hand because the ribs are also connected to each other in this place, on the other hand because the nature of the mammae is not burdensome.

In the other animals, however, it is impossible to have the mammae on the breast between the limbs (for they would be an impediment to walking); and in fact they are arranged in many ways. Those with few offspring, solid hoofs, and horns have their mammae near the thighs, and have two. Those with many offspring or many digits in some cases have them around the sides of the belly, and have many, e.g. pig and dog; and in other cases have only two, around mid-belly, e.g. lion. This is not because the lion has few off- 688b
spring, since sometimes it bears more than two, but because it does not produce much milk; for it expends the nourishment it takes in upon its body, and takes it in rarely because it is carnivorous.

The elephant has only two mammae, and these are below the axillae of the forelimbs. A cause of its having two is that it bears only one offspring; and of its not having them by the thighs, that it is many-toed (for none of the many-toed animals has them by the thighs); and of its having them up towards the axillae, that these are the primary mammae in those that have many mammae, and yield most milk. An indication of this is what occurs in the pigs; to the first-born of the piglets they offer the primary mammae. Accordingly, when the first-born is the only one, it is necessary for it to have the primary mammae; and primary are those below the axillae.

So this is the cause owing to which the elephant has only two mammae and in this location; on the other hand, those with many offspring have the mammae around the belly. This is because there is a need for many mammae for those who are going to rear many offspring; accordingly, since it is impossible to have any number other than two mammae crosswise (on account of the right and the left being two), it is necessary to have them arranged lengthwise; and the region between the forelimbs and hindlimbs alone has length.

Those that do not have many toes and bear few offspring or have horns also have their mammae by the thighs, e.g. horse, ass, and camel (for these have a single offspring, and while the first two are solid-hoofed, the third is split-hoofed), and again, deer, ox, goat, and all other such animals. And this is because in these animals growth takes place in the direction of the upper part of the body. So where an accumulation and excess of residue and blood comes to be (and this place is downward, around the effluvia), there nature has made the breasts; for wherever a change of nutrient takes place, from there too it is possible for the mammae to receive it. Both the female and the male human being have mammae, while in the other animals some of the males do not have them, e.g. some male horses do not, while some do—those that bear a likeness to their mother.

The mammae, then, have been spoken of; after the chest is the region around the stomach, which is unenclosed by the ribs owing
689a to the aforementioned cause—so that they will not impede either the expansion of the nutrient (which necessarily takes place when it is heated) or the uterus during pregnancy.

At the end of what is called the trunk are the parts concerned with the outlet of both dry and moist residues. Nature makes use of the same part in the outlet of the moist residue and in connection with copulation, alike in both females and males, in (with few exceptions) all the blooded animals, and in all the live-bearing ones. This is because the seed is something moist and a residue—let this be assumed for now; later it will be proven. And of the same character too are the menstrual discharges in females and that by which there is an emission of seed. (These things too will be defined later; for now let it only be assumed that menstrual discharges in females are a residue.) The menstrual discharges and the seed are both moist in nature, so it is in accord with our account that the discharge of things that are the same and alike be assigned to these parts.

Both how the parts concerned with the seed and embryo are arranged internally and in what manner they differ are apparent with the help of the enquiry about animals and the dissections, and will be stated later in the works on generation. But that the *configuration* of these parts is necessarily for their operation is not hard to see. Moreover, the male organ differs in accordance with differences of the body. For they are not all sinewy in nature in the same way. And further, only this part grows and shrinks in the absence of changes stemming from sickness; for its growing is useful for intercourse, while its shrinking is useful for the needs of the rest of the body; for were it always in the same state it would be an impediment. Moreover, this part has been naturally constituted from things of a sort that allows for both changes to happen—on the one hand it is sinuous, and on the other cartilaginous, wherefore it is able both to contract and be erect, and be receptive of air.

The female four-footed animals all urinate to the rear because this is a useful arrangement for them for copulation. And a few of the males urinate to the rear as well, such as lynx, lion, camel, and hare; but none that is solid-hoofed does.

The posterior parts and the parts around the legs are distinctive 689b
in human beings when compared with the four-footed animals. For practically all of them have a tail, not only the live-bearing ones but the egg-layers as well; for even if in those which have this part it is not large, at least they have, as a token tail, a sort of stump. Mankind, however, while tailless, has haunches, though none of the four-footed animals does. And furthermore, mankind has fleshy legs, both thighs and shanks, while all the others have fleshless legs, not only the live-bearing but generally all those animals that have legs; that is to say, they have sinewy, bony, and spiny legs. And there is, so to speak, one particular cause of all these things, namely that mankind alone of the animals is upright. So in order that it may easily carry the upper parts, which are light, nature, taking that which is bodily from the upper parts, added the weight to the lower parts. This is why it made the haunches, thighs, and calves fleshy. At the same time, the nature of the haunches is rendered useful for taking rests; for while remaining standing is not wearisome for the four-footed animals, and they do not tire from doing this continuously (for it is as if they are continuously lying down, since they have four underlying supports), yet in human beings it is not easy to remain standing upright—the body has need of rest and of sitting down.

Mankind, then, has both haunches and fleshy legs owing to the cause just mentioned, and on account of these facts is tailless (for the nourishment which is conveyed there is used up on these parts, and on account of having haunches, the use, for which the tail-end is a necessity, is removed). But the four-footed animals and the other animals are just the opposite; since they are dwarf-like, what is heavy and bodily, having been removed from the lower parts, is placed entirely towards the upper body; for this reason they are without haunches and have hard legs. And so that the part serving as the residual outlet may be guarded and sheltered, nature has provided to them the so-called tail-end and tail, taking from the nourishment that comes to be in the legs. But the ape, because its shape tends in both directions and because it is neither one and also both, has neither a tail-end nor haunches—as two-footed, no tail, as four-footed, no haunches.

690a Among the things called tails there are many differences, and nature has found uses also in these cases, not only for guarding and sheltering the rump, but also for the benefit and use of those that have them.

The feet in four-footed animals differ; for some of them are solid-hoofed, some split-hoofed, and some many-toed. The feet are solid-hoofed in animals in which, on account of their size and their possession of much earthen material, this sort of part receives a secretion to use for the nature of the nails instead of horns and teeth; and on account of the abundance of the secretion, instead of many nails there is one, the hoof. Generally speaking they also lack a knuckle-bone both for this reason and because the flexure of the rear leg is more sluggish when a knuckle-bone is present. For limbs with one joint straighten and bend more quickly than those with many, while the knuckle-bone, being a fastener, is like a foreign limb that has been inserted between the two—on the one hand adding weight, but on the other making the gait more stable. In fact, it is for this reason that those with a knuckle-bone do not have a knuckle-bone in the forelimbs but in the rear—namely that the leading limbs must be light and flexible, while there must be stability and elasticity in the rear limbs. Further, for defence, the knuckle-bone makes the kick more violent, and such animals use the rear limbs for kicking out at what hurts them.

The split-hoofed animals, however, do have a knuckle-bone (for their hind limbs are lighter), and because they have a knuckle-bone they are also not solid-hoofed, as the bony material omitted from the foot remains in the joint. But those with many toes do not have a knuckle-bone; for then they would not be many-toed, but the foot would be split over as much breadth as the knuckle-bone extends. And because of this, the vast majority of those that have it are split-hoofed.

Mankind has the largest feet of the animals, relative to size, with good reason; for mankind alone stands upright, so that since the feet are two, and are destined to bear all the weight of the body, they must have both length and breadth. And the size of the digits in the feet is opposite to that in the hands, which is in accordance with our account. For the function of the hands is to grasp and squeeze, so that the digits must have length (for the hand grasps by means
690b of the part that bends), while the function of the feet is to walk with stability, so that this unsplit part of the foot must be considered to

consist of the digits. And it is better that the extremity be split than unsplit; for if it were unsplit, the entire foot would suffer together if one part were harmed; and likewise, since the extremity is split into toes, this does not occur. And further, being short, the toes are less prone to injury, for which reason the feet of human beings are *many*-toed, but not *long*-toed. And they have a kind of nails owing to the same cause as the hands; the extremities most of all must be sheltered because of their lack of strength.

## CHAPTER II

Virtually all the blooded animals that are both live-bearing and land-dwelling have been spoken of. Of the blooded animals that lay eggs, some are four-footed while others are footless. In fact only one such kind is footless, that of the snakes. The cause of their footlessness has been stated in those works that provide definitions of animal locomotion. In other respects they are quite similar in shape to the four-footed, egg-laying animals.

These animals have a head, and the parts on it, owing to the same causes as the other blooded animals do. They also have a tongue in their mouth, except for the river crocodile; this animal seems not to have one, but only the place for one. This is because in a way it is at once a land-dweller and a water-dweller; accordingly, while on account of being a land-dweller it has a place for a tongue, yet on account of being a water-dweller it is without a tongue. For some fish, as previously stated, do not seem to have a tongue, unless one opens their mouth very wide, while the rest have an unarticulated one. This is because there is little use for a tongue in these animals, on account of the impossibility of chewing or tasting—rather, in all these animals the perception and the pleasure of their food comes about during swallowing. For the tongue produces the perception of juices, while the pleasure of solid foods comes about during their descent; for it is while they are being swallowed that the fatty, warm nutrients and other such things are perceived.

The live-bearing animals also have the same mode of perception, and the enjoyment of nearly all concocted, solid foods occurs during 691[a]
swallowing, as the oesophagus expands. For this reason the animals that are intemperate about potables and juices are not the same ones that are intemperate about concocted, solid foods; rather, in

the other animals even taste perception is present, but in these animals the other way of perceiving, as it were.

Among the four-footed, egg-laying animals, the lizards, like the snakes, have a forked tongue that is entirely hair-like at the tip, as previously stated. The seals also have a forked tongue; which is why all these animals are gluttonous.

The four-footed egg-layers are also razor-toothed, just like the fish. And all their sense-organs, e.g. of smell, nostrils, of sight, eyes, and of hearing, ears, are like those of the other animals; though, like the birds, their ears have no protrusion but only the channel. In both cases this is because of the hardness of their skin; for birds are feathered, while all these animals are hard-scaled; and their scale is similar in location to the soft scale, but harder in nature. This is clear in the tortoises, the large snakes, and the river crocodiles; for their scales come to be stronger than their bones, as though stronger in their nature.

The four-footed, egg-laying animals do not have the upper eyelid, just as the birds do not; and they close their eyes by means of the lower lid, owing to the cause noted in the case of the birds. Some of the birds also blink by means of a membrane which comes from the corners of their eyes, but these animals do not blink, for they have harder eyes than the birds do. This is because for the birds, being flyers, sharpness of vision is more useful to their way of life, while for the four-footed egg-layers it is less useful; for all such animals burrow.

Since the head is divided in two, the upper part and the lower jaw, mankind and the live-bearing, four-footed animals move their jaws up, down, and sideways, while fish, birds, and egg-laying, four-footed animals only move them up and down. That is because up-and-down movement is useful for biting and cutting, while sideways movement is useful for grinding. Therefore for those that have
691b grinding teeth, sideways motion is useful, but for those that do not, it is not useful at all, which is why it is absent from all such animals; for nature produces nothing superfluous.

So then, all these other animals move their lower jaw, but the river crocodile alone moves the upper. This is because it has feet that are useless for grasping and holding, for they are in every respect small. Accordingly, instead of feet nature has made for it a mouth that is useful for these purposes. In relation to holding or grasping, it is more useful for the jaw to be moved from whichever of the two directions the stroke is stronger; and it is always stronger from above than from below; therefore, since the function both of grasping and of biting is carried out by the mouth, and the function of holding is more necessary for an animal having neither hands nor feet naturally adapted for it, it is more useful for these animals to move their jaw from above than from below.

For the same reason crabs also move the upper part of their claw, not the lower; for instead of a hand they have claws, so the claw needs to be useful for grasping instead of for cutting. Cutting and biting are, however, the function of teeth. Accordingly, with the crabs, and with all the other animals that are able to grasp at their leisure on account of not using their mouth in the water, cutting and grasping are divided; that is, they grasp by hand and foot, and cut and bite by means of the mouth. But in the case of the crocodiles, nature has made the mouth useful for both activities, by the jaws moving in this way.

All such animals have a neck as well, on account of having a lung; for they breathe through the windpipe, which is long. And since the part between the head and shoulders has been called the neck, the snake would seem least of all such animals to have a neck—rather it would seem to have an analogue of the neck, if, that is, one must define this part by the extremes specified.

A distinctive feature present in the snakes as opposed to kindred animals, is their ability to turn their head to the rear while the rest of **692a**
the body is at rest. This is because, like insects, they are capable of coiling, so that their vertebrae are flexible and cartilaginous. Thus while they do this of necessity, owing to this cause, nevertheless it is also for the better, i.e. for the sake of guarding against dangers from behind; for being long and without feet, they are naturally unsuited both for turning around and for watching for dangers from behind; for it is of no use to be able to raise the head, yet be unable to turn it.

Such animals also have a part analogous to the chest. But they do not have mammae, either there or on the rest of the body. Neither does any bird have them. This is because none of these animals has milk; and the mamma is a receptacle, a vessel as it were, for milk. For neither these animals, nor any of the others that do not bear live young internally, have milk, because they lay eggs, and it is in the egg that the milky nourishment present in the live-bearing animals arises. These things have been stated more clearly in the works on generation. There was also a previous investigation of the bending of the joints common to all animals in the works on locomotion.

Such animals also have a tail, longer in some, shorter in others; the general cause of this we have stated previously. The chameleon is the leanest of all the egg-laying, land-dwelling animals; for it has the least blood of all. This is because of the character of its soul; for on account of fear it becomes variable in appearance, and fear is cooling because of paucity of blood and want of warmth.

692b About the blooded animals, then, both footless and four-footed, we have in a general way discussed those of their parts that are external, and owing to which cause each is present.

## CHAPTER 12

Among the birds, differentiation of one from another is by means of excess or deficiency of their parts, and according to the more and less. That is, some of them are long-legged, some short-legged, some have a broad tongue, others a narrow one, and likewise too with the other parts. Considered distinctly, they differ slightly from each other in their parts, but in relation to other animals they differ even in the shape of their parts. Thus they are all feathered, and this feature distinguishes them from other animals; for the parts of animals in some cases are covered with hard scales, in others with soft scales, while the birds are feathered. Indeed, the feather is split and not alike in form to the whole-winged insects; for in some animals the wing is unsplit, in others split, and the unsplit wing lacks a shaft, while the split one has one.

Birds also have, on their head, the nature of the beak, an odd and distinctive feature in comparison with other animals; and while in elephants there is a trunk in place of hands, and in some of the insects a tongue in place of a mouth, in the birds there is a bony beak in place of teeth and lips. Their sense-receptors have been spoken of previously.

Birds have a neck that is by nature stretchable, and owing to the same cause that other animals do; and in some it is short, in others long, generally following the legs in most cases. That is, those that are long-legged have a long neck, while those that are short-legged have a short one—setting aside those with webbed feet; for if it
693a were short in those with long legs, the neck would not be of service to them for eating food off the ground; nor if it were long in those

with short legs. Again for those that eat flesh lengthiness would be contrary to their way of life; for a long neck is weak, while for these animals their way of life is based on overpowering. That is why none of the crook-taloned birds has a long neck.

Those that are web-footed, as well as those that have their feet divided, yet turned upwards because they are in the same kind with the web-footed birds, have a long neck (since being long-necked is useful for nourishment that comes from the water), but have short legs for swimming.

Their beaks differ in accordance with their ways of life. Some have a straight beak, others a curved one; straight, those that have it for the sake of nourishment, curved, those that are carnivores; for such a beak is useful for overpowering, and it is necessary that their nourishment be procured from animals. But all birds whose way of life includes swamp-dwelling and plant-eating have a flat beak; for such a beak is useful both for digging up and cropping off their nourishment. And in some cases the beak of such animals is also long, as is the neck, for taking nourishment from the depths. And most of those with such beaks and either entirely or partially webbed feet live by preying on some of the small water-dwelling animals; and for such birds the neck is just like a fishing rod, while the beak is like a line and hook.

The back and the underside of the body, which is called the trunk in the four-footed animals, is a naturally unified location in the birds; and attached to it they have, instead of arms and fore-limbs, feathered wings—a distinctive part—which is why, instead of shoulder blades, the termini of the wings are on their back. And 693b
their legs are two, as with mankind, though bent inward, as with four-footed animals, and not outward, as with mankind; and their wings, like the forelimbs of four-footed animals, are bent in a convex manner.

They are two-footed of necessity; for the substantial being of the bird is that of the blooded animals, but at the same time that of the winged animals, and blooded animals do not move by more than four points. Accordingly, the attached parts are four—as in the other locomotive land-dwellers, so too in the birds. But four arms and legs are present in the one group, while in the birds, instead of forelimbs or arms, wings are a common feature; and in virtue of these they are able to stretch out, and the ability to fly is in the substantial being of the bird. So it remains for them to be, of necessity, two-footed; for in this way they will move, with their wings, by means of four points.

All birds have a sharply pointed and fleshy chest; sharply pointed for flight (for those chests that are flat, by pushing so much air, are a hindrance to movement); and fleshy because what is sharply pointed is weak, since it does not have much protection. Under the chest is the gut, which extends to the outlet for residues and to the leg-joints, just as in the four-footed animals and human beings.

These, then, are the parts between the wings and the legs; and each and every animal that bears live or lays eggs has an umbilical cord during generation, though when birds are growing it is not obvious. This is made clear in the works on generation; the umbilical cord becomes united with the intestine, and is not, as it is in live-bearing animals, a part of the blood vessels.

Further, some of the birds are able to fly and have large, strong
694a wings, e.g. those with talons, and the flesh-eaters; it is a necessity for them to be able to fly on account of their way of life, so for the sake of this they have both many feathers and large wings. It is not, however only the taloned birds, but other kinds of birds as well, that are able to fly, namely all those for whom self-preservation lies in the quickness of their flight or that are migratory. But some birds are not able to fly, but are heavy—those whose way of life is earthbound and that are fruit-eaters or are swimmers and spend their life around water.

The bodies of the taloned birds—excepting the wings—are small, on account of the nourishment being used up in their weapons and their defence. But in the case of those birds that are not able to fly the opposite is true—their bodies are bulky, which is why they are heavy. Some of the heavy birds have, as protection, instead of wings, things called 'spurs' on their legs. But the same birds do not simultaneously come to possess both spurs and talons; and that is because nature makes nothing superfluous. And for those that are taloned and powerful flyers spurs are useless; for they are useful in ground fighting. That is why spurs are present in the heavy birds, while in these birds crooked claws would not only be useless but actually harmful, being, by getting stuck in the ground, contrary to walking. That is also why the taloned birds all walk with difficulty and do not perch on rocks; for the nature of their claws is contrary to both.

It is from necessity that this difference comes about during generation. For the earthen effluence in the body becomes parts useful for aggression; when it flows upward, it makes either hard or large beaks, while if it flows downward it makes spurs on the legs or large and strong claws on the feet. But it does not make each of these in different places simultaneously; for were it spread about, the nature of this residue would become weak.

In some cases nature provides length for the legs. In some, however, instead of doing these things it fills in gaps in their feet. And it 694b
is on account of this that the swimming birds are necessarily web-footed. Some are without qualification web-footed, while others have the nature of the toes individually divided, yet taken as a whole continuous, something having been added by nature to each of the toes, like an oar-blade.

These things, then, happen of necessity owing to these causes; and it is on account of the better that they have such feet, for the sake of their way of life—in order that, since they live in water where wings are useless, they will have feet that are useful for swimming. For they become oars for sailing just as do the fins of fish; and this is why if the fins of fish or the filling between toes of the waterfowl deteriorate, they are no longer able to swim.

Some birds are long-legged. This is because such birds have a marsh-dwelling way of life; and nature makes the instruments to fit the function, not the function to fit the instruments. Hence, on account of being non-swimmers they are not web-footed, and on account of spending their life on boggy ground they are long-legged and long-toed, and the majority of them have many joints in their toes. And since they are not capable flyers, yet all birds are composed of the same matter, when the nourishment expended on the tail in the other birds is expended on their legs, they increase in size. That is why during flight, instead of the tail they use these—that is, when they fly they stretch the legs out to the rear; in this way the legs are useful to them, whereas otherwise they would impede them. And some birds fly while holding their short legs up to their bellies; for in these birds the feet do not impede them thus, and in the taloned birds they are also useful for grasping prey.

Among birds with long necks, those with a thicker one fly with the neck stretched out, while those with a thin, long neck fly with it bent up; for on account of this protective device the neck is less easily broken if they fly into something.

All the birds have an ischium in such a way that it might seem, 695a on account of its length, that they do not have one, but rather two thigh bones; for it extends to the middle of the belly. This is because this animal is two-footed, but not upright, so that if it had, as in human beings or four-footed animals, an ischium extending a short distance from the rump, and the leg immediately next to it, it would be unable to stand upright. For mankind is upright, while the four-footed animals, in consequence of their weight, are supported by forelimbs. But the birds are not upright on account of being dwarfish in nature, yet they do not have forelimbs; because of this they have wings instead of forelimbs. And instead of this nature has, by making the ischium long, attached it firmly to the mid-section; and has placed the legs beneath the mid-section, so that, with an equal distribution of weight on either side, they are able to walk about and to stand.

The cause owing to which they are two-footed though not upright has been stated. The cause of their legs being without flesh is the same as in the four-footed animals, about which we also spoke previously. Every bird, split- and web-footed alike, is four-toed. (We will speak about the Lybian ostrich later—about the fact that it is cloven-hoofed, and at the same time about the other features by which it seems to stand in opposition to the bird kind.) Three of these toes are in front, while one is behind for stability, in place of a heel. Among the long-legged birds this toe is deficient in size; for example, it is so in the ruff. But they do not have a greater number of toes.

In the other birds, then, the position of the toes is thus; the wryneck alone has two in the rear and two in the front; this is because its body is inclined forwards less than that of the other birds.

All the birds, while they have testicles, have them internally; the cause will be stated in the works on the generation of animals.

## CHAPTER 13

695b The parts of the birds have this character; the kind consisting of the fish has even more stunting of the external parts. They have neither legs, nor hands, nor wings (the cause of these things was stated before), while their entire trunk is continuous from the head to the tail. The tail is not alike in all fish, but, while some have quite similar ones, some of the flatfish have a spiny and long one;

for growth from the tail region develops into the flat area, as in torpedo-fishes, stingrays, and any other selachian of this sort there may be.

In such fish, then, the tail is spinous and long, but in some fish it is fleshy, yet short, owing to the same cause operative in the torpedo-fish; for it makes no difference whether the tail be short with more flesh or long with less flesh. In the fishing frogs the opposite situation arises; for, on account of their flat, forward part not being fleshy, as much flesh as nature takes away from there it adds to its rear and to the tail.

The fish do not have distinct limbs, owing to the fact that the nature of fish, according to the account of their substantial being, is to be able to swim, and since nature makes nothing either superfluous or pointless. And since they are blooded in virtue of their substantial being, it is on account of being swimmers that they have fins, and on account of not being land-dwellers that they do not have feet; for the addition of feet is useful in relation to movement on land. And they are not able to have four fins and at the same time feet, nor any other such limb; for they are blooded. The water newts, however, though they have gills, have feet, for they do not have fins, but a flaccid, flattened tail.

Those fish that are not flat (as are the skate and the stingray) have four fins, two on the back and two on the underside. None 696[a]
has more than this, for they would then be bloodless. Virtually all of them have the fins on the back, but some with long, thick bodies do not have those on the underside, e.g. the eel and conger eel, and the kind of mullet found in the lake in Siphae. And those that grow even longer and more serpentine, like the sea eel, have absolutely no fin, but move by bending, using the water as snakes use the land; indeed snakes swim the very way that they slither on the ground.

The cause of the serpentine fish not having fins is also the cause of the snakes being footless. The cause has been stated in the works on locomotion and on the movement of animals. They would move badly if they moved by means of four points—that is, if the fins were close together they would move with difficulty, and likewise if they were far apart, on account of the distance between them. But if their motive points were more than four, they would be bloodless. And the same cause is operative in the case of the fish that have only two fins; for they are serpentine and longer, and use the bending technique instead of two fins. This is why even on dry land, they slither and live a long time, and some of them do not pant immediately, while those that are naturally akin to land-dwellers do so less.

Of the fins themselves, the fish that have only two have them on the back, at least all those not prevented from having them on account of being flat. Those having fins by the head have them on account of not having length in that place, by which, instead of fins, they could move; for it is towards the tail that the body of such fish is elongated. The skates, however, and fish such as these, swim by means of their flat outer edge, instead of with fins.

The torpedo-fish and fishing frog have the fins below on the back because of their flatness above, while those on their underside are towards the head (for this does not prevent the flat area being moved); but in return for being above, these are smaller than those on the back. The torpedo-fish has two fins by the tail; but in place of these two it uses the flat area on each of its semicircles like two fins.

The parts on the head and the sense-receptors have been spoken of previously. The kind consisting of fish has a distinctive feature
696b relative to the other blooded animals—the nature of the gills; the cause owing to which they have this feature has been stated in the works on respiration. Some of those with gills have coverings for them, but all the selachians, since they are cartilaginous, lack coverings. This is because the former group is spinous, and the coverings are spinous, while all the selachians are cartilaginous. Further, the movements of the selachians are sluggish on account of their being neither spinous nor sinuous, while those of the spiny fish are quick; and the movement of the gill-cover must take place quickly; for the nature of the gills is as it were for exhalation. On account of this, in the selachians the closure of the gill-channels comes about on its own, and a covering is not needed for it to come about quickly.

Some fish have many gills, some few, and some have double gills, some simple ones; in most of them, however, the last one is simple. (For accuracy, one should study with the help of the dissections of these things and the enquiries about animals.) A cause of the number of gills being larger or smaller is a larger or smaller amount of heat in the heart; for the movement must be more rapid and stronger for those with more heat. And those with more gills and double gills have a nature of this sort more than those with simple and fewer gills. This is also why some of them are able to live out of water for a long time, namely, those with fewer and less powerful gills, such as eels and all those that are serpentine; for they do not need much cooling.

Fish also differ with respect to the mouth. In some the mouth is placed straight across, and towards the front, but in others on the underside, e.g. in the dolphins and selachians; and they turn belly up to seize their nourishment. And nature appears to do this not only for the sake of the preservation of the other animals (for during the turn the other animals escape, because of the delay; for all such creatures are carnivorous), but also in order that they do not follow their gluttonous ways regarding nourishment; for if they could grasp it easily, they would be destroyed owing to being quickly sated. And in addition to these reasons, the nature of the snout, being curved and narrow, is unable to open widely.

Further, among fish with the mouth upward, some have a gaping mouth, others a tapering one: all those that are carnivorous have **697a** a gaping mouth, such as the razor-toothed ones, because for such fish, their strength lies in their mouth; while all those that are not carnivorous have a tapering mouth.

Some of them have skin that is scaly (but the scale can be removed from the body on account of its luminescence and thinness), others have skin that is rough, e.g. the angelfish, the skate, and fish of this sort; and fewest in number are those with smooth skin. The selachians have skin that, though lacking scales, is nevertheless rough, on account of their being cartilaginous. For their nature has expended earthen material from the skeleton on their skin.

None of the fish has testicles, either internal or external ones, nor does any other footless animal, which is why the snakes do not. But the passage for the residue and the generative secretions is the same, as it is with all the other egg-laying, four-footed animals, on account of their having no bladder or moist residue arising within them.

The kind consisting of fish differs in these ways from the other animals—but the dolphins and whales and all such sea creatures, though they do not have gills, have a pipe on account of having a lung; the sea water taken in through the mouth is discharged through the pipe. It is necessary that liquid be taken in because they get their nourishment in a liquid environment; and once it has been taken in, it is necessary to discharge it.

Gills are useful for those animals that do not breathe, owing to which cause was stated in the works on respiration—that is, it is impossible that the same animal should at once breathe and have gills; rather, for the discharge of water these animals have the pipe. It is placed in front of their brain; for otherwise it would be separated from the backbone. And the cause of these animals having a lung and breathing is that the larger among the animals need more warmth in order to move; on which account the lung within them is full of warmth from the blood.

These animals are in a way land-dwellers and in a way water-dwellers; for they take in air like land-dwellers, yet are footless and seize their nourishment from a liquid environment just like
697b water-dwellers. The seals as well, and the bats, on account of their tending in the one case towards both water-dwellers and land-dwellers, in the other case toward flyers and land-dwellers—on this account they partake of both and of neither. For the seals, as water-dwellers, have feet, while as land-dwellers they have fins (for their rear feet are entirely fish-like, and moreover all their teeth are razor-toothed and sharp); and the bats as flyers have feet, but as four-footed they do not; and they have neither tail nor rump—no tail owing to being a flyer, no rump owing to being a land-dweller. And this happens to them of necessity; for they are membranous-winged, and nothing has a rump unless split-feathered. For the rump arises from such a feather. And a tail would also be an impediment if it were present among the feathers.

## CHAPTER 14

In the same way too is the Libyan ostrich; in some respects it has the manner of a bird, in others that of a four-footed animal. In so far as it is not four-footed, it has feathers, while in so far as it is not a bird it does not take to the air in flight, and its feathers are not useful for flight, but are hair-like. Furthermore, in so far as it is four-footed it has upper eyelashes and is bald around the head and above the neck, so that it has hairier eyelashes; yet in so far as it is a bird the lower body is feathered; and while two-footed like a bird, it is hoofed, as though four-footed. For it has, not toes, but hoofs. This is because its size is not that of a bird but that of a four-footed animal; for generally speaking it is necessary for birds to be as small in size as possible, since it is not easy for a body of great mass to get off the ground.

About the parts, then, the cause owing to which each is present in the animals has been stated, of each of the animals in turn; these things having been determined, the next step is to go through the facts about their generation.

# COMMENTARY

## BOOK ONE

*PA* I is generally recognized to be independent of the rest of *PA* and to have the character of a loosely connected set of discussions (Düring 1943: 35; Le Blond 1945: 51–4; Balme 1992: 69). There is less agreement on its purpose(s). Balme claims that the first paragraph 'makes it clear that he (Aristotle) is not setting out to discuss scientific method . . . he is not considering how to arrive at an explanation . . . but how to judge an explanation when it is made' (1992: 69). Le Blond, on the other hand, describes it as 'a lecture to the general public on the nature, method and interest of biology' (1945: 52; cf. Ogle 1882: 141). The first paragraph does stress the development of standards for the evaluation of natural investigations and explanations. But elsewhere in Book I Aristotle also states that the subject includes how we ought to study, enquire, and investigate (cf. $639^b4$, $639^b8$–11). There are, for example, recommendations to search for the final cause as well as the material and efficient, and to give priority to the former; and to follow the model of the astronomers in establishing the phenomena prior to explaining them through their causes.

While all its examples and many of its topics suggest that this book is devoted to developing principles of *zoology*, the demarcation of natural objects which is stressed is not between living and non-living, but between eternal and generated natural things. This may be because Aristotle views living things as the paradigmatic natural, generated objects. Palaeontologist G. G. Simpson has similarly suggested that philosophers of science should adopt biology, rather than physics, as their paradigm, on the ground that biology studies objects that exemplify all the principles of nature, while physics searches only for those principles that apply to all natural objects (Simpson 1964: 107).

### CHAPTER 1

#### $639^a1$–15

This opening section is a dense and difficult attempt to delineate the discussion to follow. It begins with a distinction common to every enquiry, focuses our attention on one side of that distinction, and then narrows that focus to the study of nature. There is no explicit narrowing of our focus to living things, however.

$639^a1$–2: 'every study and investigation'. Aristotle often opens philosophical discussions with general claims about every enquiry as a way of locating the current one. (Compare *Phys.* I. 1, 184a10–12; *EN* I. 1, 1094a1, *An. Post.* I. 1, 71a1–2.) The reference to relatively humble enquiries is echoed in chapter 5, part of which defends the value of a study of generated things despite their more humble character in comparison with the eternal objects of astronomy (cf. 644b22–645a30).

'Study' (*theōria*) may refer either to the active contemplation of something already known, or to the active investigation of a certain subject-matter just for the sake of understanding it. In either case, a study is a theoretical, in contrast to a practical or productive, activity. 'Investigation' (*methodos*) stresses the pursuit of knowledge guided by special standards. (The root noun is the Greek term for 'path' or 'route'; cf. *An. Pr.* I. 31, 46a32; II. 1, 53a2.)

639a3–12: 'understanding . . . a certain sort of educatedness'. The term translated 'understanding' (*epistēmē*) is sometimes rendered 'scientific knowledge', 'science', or just 'knowledge'. It is used in the *Posterior Analytics* and elsewhere to refer both to a subject organized as a system of causal explanations based upon indemonstrable principles, and to the disposition of a person with such knowledge. 'Understanding' seems to capture the disposition of the person with such knowledge better than does 'scientific knowledge' (but compare 'natural science', 641a33–b10).

The primary focus here, however, is 'a certain sort of educatedness' (*hoion paideian tina*). The Greek *paideia* carries connotations of being cultured and well educated. Two similar discussions elsewhere in Aristotle (*Pol.* III. 6, 1282a3–7, *EN* I. 3, 1094b23–1095a2) stress that the generally educated person is able to judge the competence of those claiming expertise without having that expertise himself, and able to judge what level of precision is reasonable for different disciplines.

It has been suggested that Aristotle had in mind especially training in logic and dialectic (Le Blond 1945: 129–30). But while such training would no doubt be of value, and perhaps even necessary, for the skills being discussed here, it would not be sufficient.

639a12–15: 'for the enquiry into nature, too, there should be certain standards'. The connection with the preceding remarks is perhaps that to acquire standards for judging the explanations in natural investigations is to become well educated about a particular discipline.

Prior to Aristotle, the term *historia*, which I am rendering 'enquiry', variously refers to the *process* of enquiry, to the *results* of enquiry, to *reports* of those results, and in some cases includes causal enquiries (for various uses see Herodotus, *Hist.* I. 1, 44; II. 118, 119; Hippocrates, *On Ancient Medicine*, 20; Plato, *Phaedo*, 96 A 8; Galen, *On the Sects for Beginners*, 2).

Aristotle usually uses the term in a more restricted fashion to refer to a *preliminary* stage of scientific investigation, in which data are gathered and organized, in contrast to a later stage in which causal explanations of this information are sought (see $639^b5$–11, $646^a8$–12, and notes). Here it has a less restricted meaning.

The term translated 'standards' (*horoi*) is also used by Aristotle for definitions (e.g. *An. Post.* II. 10, $93^b37$–8). Its primitive meaning is 'boundary-marker'. It is claimed that these standards are independent of the truth, but it is unclear whether this means the truth of the explanation, of (one or more of) the premisses, or of the fact to be explained.

## $639^a15$–$^b5$

The discussion of the standards to be adopted by natural enquiry now ensues. It begins as a series of questions, though once the question of which cause is to be given priority in investigation is introduced ($639^b11$), this format disappears. The first question raises an issue at the heart of Aristotle's epistemology and metaphysics. *An. Post.* I. 24 presents a dialectical debate over whether partial demonstration is better than universal demonstration; and *Met. Z* presents a case both against the notion that the universal can be a substance and against the notion that the particular can be an object of unqualified knowledge (an attempt at resolving the final aporia of *Met. B*, $1003^a7$–17). That this tension—the greater epistemic value of the universal, the greater reality of the particular—lies behind this passage becomes clear when the question raised here is finally answered at $644^a29$–$644^b7$, where the solution to the problem presented here is explicitly framed in terms of this tension. Aristotle makes no effort to resolve the question here, and I shall suggest a reason why as we proceed. As we shall see, the organization of *PA* II–IV reflects in detail Aristotle's resolution of this problem.

$639^a16$: 'each substantial being singly'. The Greek term translated 'substantial being' (*ousia*) is an abstract noun derived from the feminine participle (*ousa*) of the verb 'to be' (*einai*). It is traditionally translated 'substance'. Balme adopts 'being', but this most directly translates the neuter participle *on*, which is another central Aristotelian philosophical term. *PA* I makes use of this term in a variety of ways, and is one of the more interesting texts in which to explore its meaning (cf. $641^a25$–32 and notes).

$639^a16$–19: 'the nature . . . the attributes common to all'. The contrast is not between more particular and more general animal kinds (e.g. between lion and quadruped), but between individual animal *natures* studied independently and common *attributes* established 'according to something common' ($639^a18$) and 'in common according to kind' ($639^b5$). The rest of this passage indicates how difficult it is to decide how animals are to be grouped. If 'flyers' are treated as a natural kind embracing some insects, some birds, and all bats together, then already recognized groups will be fragmented. This is one of the first problems raised for dichotomous division in chapter 2. Solving the related problems of when to study common attributes and how to establish general kinds is the focus of chapter 4 (644$^a$29–644$^b$7). The solutions offered presuppose the theory of division defended in chapters 2 and 3, and thus postponing the resolution of this question until then is reasonable.

639$^a$25–27: 'repeatedly say the same things', 'speak repeatedly about the same things'. Overtly, the only problem with studying each being one at a time is the needless repetition it engenders. But it is only *needless* repetition if there is a way to get at the nature of animals that focuses on more general kinds. In fact not only does Aristotle hold that there is—he also holds that at times one only fully understands particular kinds by focusing on their more general properties. For a fuller discussion of this issue and its relevance to understanding the organization and method of Aristotle's zoological investigations, cf. Lennox (1987*a*) 114–18; and *An. Post.* I. 5, 24.

639$^a$27–30: 'present in different forms . . . no difference . . . differ by a difference in form'. Aristotle's language of classification consists of three key terms, kind (*genos*), form (*eidos*), and difference (*diaphora*), and its *method* is division, the central topic of chapters 2 and 3 (cf. Pellegrin 1986; 1987; Lennox 1987*b*). I am purposefully avoiding the standard Latinate translations 'genus', 'species', and 'differentia', which are embedded in modern taxonomic theory and practice in ways that systematically mislead the modern reader of Aristotle. More general *kinds* may be divided into *forms* in virtue of *differences* in their shared, or common, attributes.

A number of features of Aristotle's use of these terms are worth noting:

1. All three terms can refer to attributes, including parts, as well as to animals. This chapter, for example, provides a division of the kind 'locomotion' into its forms.

2. One and the same group of animals, at almost any level of generality, can be referred to either as a kind or as a form. Typically, however, if a group and its subdivisions are being discussed, the subgroups will be termed forms, while the group divided will be their kind (cf. Balme 1962*b*; Pellegrin 1986; Lennox 1987*b*).

3. As with the English terms 'kind' and 'form', the Greek terms *genos* and *eidos* suggest a different basis for relatedness—*genos* suggests kinship, while *eidos* suggests shared visual appearance.

4. Finally, *genos* is connected, in Aristotle's *Metaphysics*, to his concept of matter, while *eidos* is typically the word translated 'form' in Aristotle's

analysis of substance into matter and form (cf. *Met.* *Z* 12, and below, 643a24–7 and note). This point and point 3 are not unrelated—Aristotle typically begins discussing the metaphysical analysis of objects into matter and form by distinguishing the shared material out of which different things are made (bronze) and the visible shapes that differentiate them (bronze *spheres*, bronze *statues*). In fact later in *PA* I. 1 Aristotle introduces the matter/form distinction in just this manner, and then refines it by progressively indicating the limitations of this approach.

Here, Aristotle insists that 'locomotion' is a general term that designates formally different activities, whereas 'respiration' does not. This is surprising, since *On Respiration* discusses differences in respiration, and roots them in differences in the respiratory organs, in much the same manner as *On the Progression of Animals* discusses locomotive differences. He may have in mind that respiration has a single designation because it is always an activity of the lung, an organ present in all blooded kinds except fish; while each mode of locomotion is given a distinct designation (swimming, flying, walking), in virtue of being performed by distinct kinds of limbs (fins, wings, feet).

Distinguishing these two sorts of general attribute implicitly raises a problem which is the converse of the repetition problem noted above (and like the repetition problem, it is pointed out early in the *Posterior Analytics*, at I. 1, 71a17–28). A general account of locomotion will tell us very little about differences related to the medium through which the animal moves or the way it moves. Indeed, just such a complaint is raised about stopping enquiry into soul with a definition of soul in general at *An.* II. 3, 414b20–8. This complaint is relevant, since the general attributes discussed here are *all* soul functions, not parts; and many of the differences mentioned—sleep, death, respiration, locomotion—are the subjects of distinct treatises.

## 639b6–640a33

At this point the discussion turns to the relationship between two different sorts of enquiry into nature: systematic observation of the phenomena and giving a causal explanation (or a scientific demonstration) of these phenomena. That in some sense this is a continuous discussion is indicated by the fact that the question Aristotle begins with, regarding which of these two enquiries should take place first, is asked a second time at 640a10, this time applied to the subject of natural generation. And when the question is asked this second time, Aristotle gives an answer which he says is 'precisely as we said before' (640a13–15). Yet there is no explicit answer given the first time the question is asked. The long discussion of causality and necessity that lies between these two questions, however, gives an implicit answer. Throughout that discussion it is taken for granted that causal investigation presupposes a prior observational investigation.

$639^b6$–10: 'just as the mathematicians'. Aristotle considers astronomy to be a science in which the phenomena to be explained are the observed motions of certain natural objects—the sun, the moon, the five observable planets, and the visible stars—while the explanations for those motions are provided by geometry (An. Post. I. 13, $78^b32$–$79^a16$; *Phys.* II. 2, $193^b22$–$194^a12$). In a number of places Aristotle claims that the discovery of the appropriate geometric explanations is based on the prior observation of the movements of the heavenly bodies (cf. *An. Pr.* I. 30, $46^a17$–22). In the case of astronomy, then, the observational data are conceived as the source for the explanatory theory, though Aristotle never suggests how.

This distinction between two stages of investigation has important implications for the organization of Aristotle's biological studies. *Historia Animalium* announces that it is concerned with grasping the differences and attributes which belong to all animals, and says that only after this task is completed should we attempt to discover their causes (*HA* I. 6, $491^a10$–12). *Historia Animalium* is indeed for the most part devoid of causal explanation. In a similar vein *PA* II. 1, $646^a8$–12, identifies the task of its investigation as the examination of the causes of animals being constituted of the parts they are, a task explicitly distinguished from that of *Historia Animalium* (and compare the similar claim at *IA* 1, $704^b6$–11). In the way his own treatises are organized, then, Aristotle appears to honour both the distinction and the order of priority defended in these passages (cf. Balme 1987*b*; Kullmann 1974; Lennox 1987*a*).

This distinction may be derived from a general feature of Aristotle's philosophy of science. He sees explanation as the identification of the factors responsible for a given fact being as it is, i.e. its causes (*Phys.* II. 3, $194^b16$–23, *An. Post.* II. 1, $89^b23$–35). Such identifications are always given as answers to questions of the form 'Why *p*?' Framing such questions requires that, in some sense, *p* be taken as established. Even if an investigator is familiar with *q*, the cause of *p*, before he has established *p*, the *explanation* '*p* because *q*' presumes that *p* is an established fact. Thus, if scientific explanation is driven by questions regarding the causes of established matters of fact, settling those matters of fact is a necessary preliminary to explanation (cf. Lennox 1991).

$639^b11$–21: 'since we see more than one cause'. *Phys.* II. 3 identifies *four* causes (matter, motive cause, form, and end) as answers to the question 'why?' (*dia ti*, literally 'on account of what?'), and argues in a number of places (e.g. *Phys.* II. 7, $198^a21$–$198^b9$, *Met. H* 4, $1044^a32$–$1044^b20$) that full understanding of many natural phenomena requires knowledge of all four. In both of these discussions, however, Aristotle insists that the answers to the questions 'what is it?', 'what is it for?', and 'what is the source of its movement?' are closely related. Regarding animals, *An.* II. 4, $415^b8$–27, argues that soul is the cause of living body in all three ways, the body being matter. These connections gradually emerge throughout *PA* I. 1, as we shall see.

There is here no argument either for the thesis that natural generation has more than one cause, or for the particular modes of causation mentioned, but only for the *priority* of goal-causation (Gotthelf 1987*b*: 204). 641$^{b}$12–642$^{a}$14 claims to have established that there are two modes of causation. Even there, however, Aristotle repeatedly relies on the claim that it is apparent (641$^{b}$24–5) that there are goals towards which natural changes proceed unless prevented. Likewise the argument here depends on the undefended assertion that goals are present more in the products of nature than of art. It also depends on the use of a number of key technical concepts that are discussed below.

Here, as elsewhere, Aristotle initiates his defence of the *priority* of goal-causation with the aid of familiar examples from the arts, in this case medicine and house building. The argument is straightforward:

(1) The goal of a generation is its account (*logos*).
(2) The account is the generation's origin (*archē*).
(3) ⟨The origin is primary.⟩
(4) The goal is primary.

Premiss (3), which I have supplied, might seem to be unnecessary—it might be said that Aristotle has simply made the innocuous substitution of 'primary' for 'origin'. But the cause that is treated as secondary here is referred to as that from which comes the origin (*archē*) of motion, so that it too is in a sense an origin of generation. To avoid confusion, then, it needs to be made explicit that goals are causally primary because they are origins in the sense that accounts are origins.

Support for the goal's claim to primacy, then, depends on a similarity Aristotle sees between artistic and natural generation—accounts are origins in both. This similarity sanctions his use of examples from the arts of building and medicine to support the idea that defining their goals—the house, health—precedes the determination of the process of bringing the goal about. Though it is never explicitly noted, this is the key to the priority of goal-causation in natural generation.

The argument here trades on an ambiguity in the Greek term I have translated throughout as 'account' (*logos*). (I discuss the variety of uses of this term at 639$^{b}$15, below.) A craftsman's goals are 'accounts' in the sense that the desired end product must be defined before he determines what actions are to be taken in its achievement—in that sense the account of his end product is causally primary. The *content* of that definitional account may be thought of as the end product itself, and Aristotle does sometimes seem to use *logos* to refer to the content of a definition (i.e. to the form of the thing defined). But in the case of the crafts, the way in which the end product shapes the activities that produce it is through the presence of the definition in the soul of the craftsman. We are not here told what the natural analogue of the craftsman's account of his end product is in the case of natural generation. The various discussions of goal-causation in this chapter, however, gradually enrich the account of natural teleology, and I shall withhold a final assessment of the defence of teleology in *PA* I. 1 until all of these discussions have been considered. For a valuable discussion of the use of the 'craft analogy' in Aristotle's philosophy of nature, see Broadie (1990).

$639^b12$–13: 'the cause for the sake of which and the cause from which comes the origin of motion'. The Greek (*tēn hou heneka* ⟨*aitian*⟩, *tēn hothen hē archē tēs kinēseōs* ⟨*aitian*⟩) would have looked as odd to Aristotle's readers as the English translation does to mine. Aristotle identifies a number of fundamentally different factors responsible for something's coming to be and being as it is, which he calls *aitiai*, a word borrowed from legal/moral contexts of ascribing responsibility. In natural science, the term appears to refer to facts which are necessary for a thing's coming to be, being, or changing: 'cause' is a reasonable translation for such a concept. It is then a philosophical and scientific issue what sorts of things can be causes, an issue as hotly debated in the ancient world as in the modern (cf. Frede 1980; Freeland 1991).

Aristotle insists that the question 'Why?' (*dia ti*) has four fundamentally different sorts of answer, only two of which are discussed here. One answers the question 'What *initiated* this change?', while another answers the question 'What is the change *for*?' The 'cause for the sake of which' is sometimes simply referred to as 'the end' (*to telos*), while 'the cause from which comes the origin of motion' is often referred to more simply as 'the origin of motion', or even more simply as 'the agent'. The value of the admittedly cumbersome expressions used here is that they make clear the connection of each cause to the distinctive questions it answers.

$639^b14$, 18: 'the account'. The word *logos* can refer to a variety of linguistic units (words, definitions, reasons, arguments, books), as well as to mathematical relationships, such as ratios; and it can also refer to the *content* of a definition, or to the *relationship* denoted by a ratio. Here Aristotle seems to have a *defining* account of the goal in mind in the artistic cases; while in natural generation it appears he has in mind the goal to which a defining account refers. While the term will nearly always be translated 'account', such variations in meaning will be noted.

$639^b20$: 'the good' (*to kalon*). Aristotle often conjoins, as here, references to what is good with references to goals. The particular concept of evaluation Aristotle chooses here, however, *to kalon*, carries connotations of a goodness *inherent* in the nature of the thing valued. Aristotle would not use this expression of something valued instrumentally, nor even of something which, while good in itself, was of trifling value. Other common translations, such as 'fine' or 'beautiful', are not suitable here; but the fact that these are often suitable translations is to be kept in mind when it is used in *Parts of Animals*.

Aristotle's claim that such goals are more characteristic of the works of nature than are those of art is, if there are natural goals at all, defensible. Craft products, after all, have no intrinsic goals; they are means to *our* ends. By contrast, if an animal's organs and functions are to support *its* life, its life is an intrinsic goal. It is reasonable, then, to claim that *to kalon* is present in them more than in artefacts. The basic question is whether there are natural goals at all.

639$^b$22: 'nearly everyone attempts to refer their accounts back to it'. Aristotle stands in a tradition of investigators of the natural world who sought to explain its complex features as necessary consequences of the interactions of various basic, simple entities acting according to their natures. It is not giving such explanations that is being criticized, but rather the failure to recognize, and apply, the distinction between two sorts of necessity that he is about to defend.

639$^b$24–30: 'That which is necessary without qualification . . . that which is conditionally necessary'. In *Met.* *Δ* 5 Aristotle says that everything else is said to be necessary in virtue of a first and primary necessity, 'what cannot be otherwise' (1015$^a$34–36, 1015$^b$10–15), which he calls unqualified necessity. The first use he notes there is 'that without which, as a contributory cause, it is impossible to live' (1015$^a$20–2), citing food and respiration as necessary for animals in this sense. Aristotle's assertion that what is conditionally necessary (sometimes misleadingly called 'hypothetical necessity') is present in all generated things is open to (at least) three different interpretations, because of the presence of the particle *kai*, which I have translated 'also':

(1) If one reads the particle to connote 'addition', it might either mean (*a*) that unqualified necessity is present in both eternal and generated things, and conditional necessity is *also* present in generated things, or (*b*) that unqualified necessity is present in eternal things, while in addition there is another sort of necessity present in generated things.

(2) Balme (1992) 84 takes *kai* simply to emphasize the quantitative adjective 'all' (as discussed in Denniston 1959: 316–23). On this reading Aristotle is saying that unqualified necessity is present in eternal things,

while conditional necessity is *in fact* found in all generated things. On behalf of (1(*a*)), it can at least be said that Aristotle does not take pains to indicate that unqualified necessity is to be restricted to eternal objects, which he could easily have done.

One might hope that the fuller discussion of this distinction in *Phys.* II. 9 would help us decide how to read our passage, but there are reasons for doubt. First of all, that discussion is restricted to generated things ($200^a1$), so the basic question of our passage—*whether* necessity is present in some sense in generated natural things—is not at issue. Further, the entire discussion there is focused on determining how the necessary natures associated with matter play a role in explaining natural coming to be, an issue not raised in our passage. By contrast, *PA* I. 1 is concerned to extend necessity beyond the *eternal* objects, where everyone from Democritus to Plato agreed it applies, to the realm of *generated* things. Necessity, Aristotle insists, is in fact (or also!) present here.

What sorts of eternal objects constitute the contrast class? A number of scholars suppose them to be the objects of the mathematical sciences (Balme 1992: 84–5; Gotthelf 1987*a*: 170; Grene 1985: 12–13). Four points suggest a more restricted reference, to astronomy or cosmology: (1) the prior reference to the necessity of eternal *natural* objects ($639^b20$–30); (2) the prominence of the contrast between these objects and those that are generated at the opening of chapter 5; (3) the terminological echoes of, and apparent reference to, the discussion of the same contrast in *GC* II. 11; and (4) the overall contrast in this very passage between the study of generated things and of astronomy. Thus demonstrations in the biological treatises would, at least in part, be contrasted with those in *De Caelo*, as suggested by $644^b22$–$645^a7$.

$639^b30$–$640^a9$: 'the mode of demonstration and of necessity'. On the sort of necessity associated with demonstration, see *Met.* *Δ* 5, $1015^b7$–9; *An. Post.* I. 4, $73^a21$–5; 6, $74^b5$–21. Can conditional necessity be displayed in a scientific demonstration? The barest outline of an answer is sketched in this passage, but we are referred elsewhere (see below) for many of the crucial arguments. But one thing is clear—there *is* a mode of demonstration and of necessity appropriate to the natural sciences.

$640^a1$–2: 'natural science and the theoretical sciences'. The reference to a discussion of the theoretical sciences is probably to *Met.* *E* 1, $1025^b18$–$1026^a30$. An especially clear review of the available interpretations of this passage—and their respective problems—can be found in Lloyd (1996) 29–30.

The Greek here may be contrasting the natural and the theoretical sciences with craft (Lloyd's option 2a; see Ogle 1882: 142; Düring 1943: 84;

1961: 215; Pellegrin 1986: 131–3); or the natural sciences with the theoretical sciences (Lloyd's option 1; see Balme 1992: 84; Grene 1985: 9–13). (A variant on this latter, Lloyd's option 2b, is found in Kullmann 1974: 13–16, in which the contrast is between these two sciences on the one hand, and the products of craft and nature on the other.) On the first reading, this passage seeks to limit the similarity between the realms of art and nature just noted, by claiming that the manner of demonstration and that of necessity differ (i.e. from that in the arts) in the natural and theoretical sciences. Against this reading, (1) the distinction between natural and theoretical science remains puzzling, and (2) the explication that follows appears to oppose both natural *and* artificial outcomes (man and health) to cases in which the starting-point of demonstration is what is (cf. Balme 1992: 84; Grene 1985: 9–13).

On the second reading, the problem is that Aristotle typically insists that natural science *is* a theoretical science (cf. *Met. E* 1, $1025^b18$–$1026^a23$; and $641^b11$, below). The context nevertheless favours this reading. Aristotle has just linked the mode of necessity to the question of whether the objects under consideration are eternal or generated. In this respect, the part of natural science focused on *generated* things is to be contrasted with all other theoretical pursuits—even that part of natural philosophy concerned with eternal objects (cf. $644^b22$–4, below). And if demonstration requires necessity, but with things that come to be there is a different sort of necessity (conditional necessity), that part of natural science focused on generated things will also have a different mode of demonstration.

$640^a3$–6: 'the origin is, in the latter cases, what is, but in the former, what will be'. Given the differences in the necessities governing eternal natural objects and generated ones, the type of scientific demonstration for each will also differ. Such demonstrations will appeal to distinct sorts of origins (*archai*)—what *is* in the one case and what *will be* in the other (compare *Phys.* II. 9, $200^a15$–30; cf. Cooper 1987: 243–69; Gotthelf 1987*a*: 197–8; Charles 1991: 119–28; Lloyd 1996: 32–6). One might initially be struck by how unlike the examples of demonstrations in the *Posterior Analytics* the example here is. But at *Phys.* II. 9, $200^a16$–22 (not discussed in Lloyd 1996), the point of which is to show that the necessity in geometric demonstrations is somehow 'parallel' to that of demonstrations in natural science, the examples are *formally* identical:

*Geometry*: Because the straight is so and so, it is necessary that a triangle should have angles equal to two right angles.

*Physics*: If the end will be or is ⟨so and so⟩, ⟨it is conditionally necessary that⟩ that which comes before will be or is.

And as the geometric example used in *Phys.* II. 9 is his favourite example in the *Posterior Analytics*, it is unlikely that Aristotle imagines this to be a serious difficulty (cf. Gotthelf 1987*a*: 197–8).

Again, it is important to stress that much of the material necessary to construct fully adequate demonstrations is left out of *both* of these examples. If Aristotle had taken this to be a serious difficulty, it would be equally serious for his pet geometric example. Both, however, begin from definitional starting-points (the goal being the definition in biology, as he has just noted), and by reference to that starting-point demonstrate the necessity of a universal but non-definitional property belonging to the subject.

Now Lloyd has claimed that 'The theory of the *APo.* certainly does not prepare us for *that* [i.e. for "a variety of modes of demonstration in one of which the condition of eternity is relaxed and the necessity in question is not unqualified but merely hypothetical"]' (Lloyd 1996: 32). But in fact it *does*, in *An. Post.* II. 11, which opens by virtually quoting *An. Post.* I. 2 (cf. *An. Post.* I. 24, $85^b28–86^a3$). That chapter begins by noting the problem that in fact there are four causes, not just one, and then discussing each in the context of demonstration. It concludes with a discussion of how one deals with those cases in nature and the arts where things come to be 'both of necessity and for the sake of something'. Notoriously, the discussion is unsatisfactory—but that only prepares us for a more satisfactory discussion, such as we find in *PA* I. 1 and *Phys.* II. 9.

Are there clear breaks with the demonstrative ideal of the *Posterior Analytics* here? Lloyd (1996) 36–7 insists there are:

> [*PA* I. 1] does not take as its starting-points the primary indemonstrables identified in *APo.* I 2 . . . but uses end-products as its starting-points and works back to their conditionally necessary antecedents. While the reasoning is deductive, the nature of the premises, the mode of necessity and the goal of the inquiry all differ from those in view in the opening chapters of *APo.* I.

Lloyd poses two important questions for us. First, can a *telos* be a primary indemonstrable in a science? We have just been told that in the study of living things the *telos* provides the definition. And since definitions are among a science's first principles, this implies that goals *can* serve as first principles. Moreover, in *Phys.* II. 9 Aristotle states quite clearly that in natural science they certainly can be—and it is worth noting that he clearly says as much in the *Posterior Analytics*, at I. 24, $85^b28–86^a3$. Second, is the *Posterior Analytics*' account of demonstrative science fully articulated in the first few chapters of that great work? It is true that there are many revelations about demonstration in later chapters that we are not prepared for in I. 2. But, to note just one example, the fact that *An. Post.* II. 11 introduces the problem of multiple causes with a self-conscious reminder of the definition of unqualified understanding in *An. Post.* I. 2 should encourage us to read that work as a unified account of demonstration.

$640^a6$–8: 'into eternity'. Balme assumes that in these examples Aristotle is contrasting a correct and incorrect understanding of conditionally necessary sequences (Balme 1992: 85). Another possibility is that they are examples of sequences presupposed by the two distinct demonstrations being contrasted. The reference elsewhere is likely to be *GC* II. 11 (note the wording of $337^b33$–$338^a17$) or *An. Post.* II. 12, $95^b36$–$96^a8$, where Aristotle argues that under a strict set of conditions it is possible for natural processes and outcomes to occur by simple and convertible necessity, if they are (1) eternal and (2) cyclical (cf. Le Blond 1945: 139).

It is made clear in the examples that explanations both of being and coming to be may refer to conditional necessity. The distinction in tense between the premisses is provided only to stress that in the domain of generated objects what takes priority in explanation is the end of a generative process. There is no suggestion that the demonstrations themselves will have different 'tense structures' (cf. Gotthelf 1987*a*: 197–8).

$640^a14$–15: 'first . . . the phenomena, then . . . their causes'. This distinction is extended to the study of animal generation ('even with generation'). The recommendations here mirror the organization of Aristotle's animal studies. In addition to causal investigations such as those reported in *PA* and the *Generation of Animals*, the *Historia Animalium* has four self-contained books presenting the phenomena regarding animal parts, and three self-contained books regarding animal generation.

$640^a15$–19: 'generation is for the sake of substantial being'. This is probably a conscious echo of Plato's *Philebus* (54 A 8, C 4; cf. *GA* V. 1, $778^b5$–6). The model explanation here, again house-building, is in the *precise* form specified at $640^a4$–5: 'Since the form of the house is such, (it is necessary) that it comes to be thus and so.' In some way, not yet specified, the end result is causally determinative of the character of its production. Aristotle still owes us an account of the way in which the substantial being that is in the process of being generated is causally determinative of the process that is generating it.

$640^a22$–6: 'the backbone is such as it is because'. This is the first explicit reference to a group of thinkers he has had in mind at least since $639^b21$, the Presocratic natural philosophers. The one mentioned here, Empedocles, is usually assumed to have written two works, both in verse, referred to as *On Nature* and *Purifications*. (For doubt about whether these fragments derive from two distinct poems, see Inwood 1992.) One plausible reconstruction of his ideas has it that he believed the world was involved in an endless cycle of ebb and flow, during which the world would alternately become more and more unified and undifferentiated, and then more and more differentiated. He referred to the former periods as the reign of Friendship, the latter as the reign of Strife. During the former period he apparently conceived of animal tissues being created by the coincidental interactions of four basic elements, earth, air, fire, and water, animal organs out of similarly coincidental interactions of these tissues, and finally all sorts of animals out of coincidental combinations of organs. One quotation tells us of a time when 'here sprang up many faces without necks, arms wandered without shoulders, unattached, and eyes strayed alone, in need of foreheads' (31 B 57 DK). (A clear and balanced discussion can be found in Inwood 1992.)

Empedocles would, then, probably account for the series of disjointed vertebrae that constitute the vertebrate backbone as the result of a twisting process that happens during development. The fact that the vertebrate backbone is useful to us would not lead Empedocles to conclude that it developed in this way for the sake of being useful (cf. *Phys.* II. 8, $198^b23$–32).

$640^a23$–26: 'seed . . . with this sort of potential'. Aristotle responds as follows. (1) The process of generation originates from seed, and seed must have, at the outset, the potential (*dunamis*) to produce an animal with such a backbone. (2) In addition, seed with that potential originates from a parent organism of the same kind. (3) So, prior to the development of vertebrae, there was an organism of a certain (vertebrate) kind, which produced the seed proper to its kind, with the potential to produce another creature of the same (vertebrate) kind. The production of a vertebrate backbone thus does not occur by coincidence—it is part of the actualization of the potential for the production of a vertebrate animal. (Cf. *Phys.* II. 8, $199^a33$–$199^b9$; Gotthelf 1987*b*: 225–6; Meyer 1992.) This is Aristotle's first attempt to clarify the sense in which goal-causation has priority over motive causation in nature as well as in art. The formal nature of the vertebrate animal, which would be the content of a definitional account of such an animal, is present—as a *potential* for being a vertebrate animal—from the beginning of the process of coming to be such an animal.

$640^a24$–5: 'prior—not only in account but also in time'. Aristotle works with a number of senses of priority (cf. *Met.* *Δ* 11; *Θ* 8, $1049^b4$–28; *PA* II. 1, $646^a35$–$^b2$). 'Prior in account' harbours the ambiguity noted earlier in the concept of an 'account' (see $639^b11$–16 and note); it may be prior in definition, in explanation, or in virtue of what is *referred to* in its definition. Here it is stressed that the actual animal is prior in account to the potential animal (since to say that it is a potential vertebrate presupposes an account of what it is to be a vertebrate). Thus the producer of the seed (i.e. of that which is potentially the sort of thing that the producer is actually) is prior both in account and in time to the seed.

$640^a25$: 'For one human being generates another'. Aristotle repeats this catchphrase often, for various purposes. Often, as here, the point is to stress the reliability of the reproductive process.

Greek has distinct words for the male of our species and for the species. Here, Aristotle uses the word for human being in the singular to refer to a single human being. On other occasions he uses the singular with a definite article (*ho anthrōpos*) to refer collectively to the kind; and finally, he also uses the plural to refer to the kind distributively. I have adopted the convention of translating the indefinite singular as 'human being', the plural as 'human beings', and the collective singular as 'mankind'.

$640^a27$–$33$: 'spontaneously and with artefacts'. The connecting thread of argument here is very thin. Aristotle may be making the following points. Health may return to a sick person either spontaneously or owing to the actions of a doctor. A statue, however (at least of the sort produced in fourth-century Athens) arises only owing to the artistic ability already present in the soul of an artist. The need to qualify the sense in which the art of sculpture involves a pre-existent agent resembling the product probably gives rise to the statement commented on in the next note. The discussion of the relationship between things that come to be spontaneously and those that come to be owing to a formally identical producer may be related to Aristotle's belief in certain 'spontaneously generated' animals (cf. *HA* V–VI, $539^a24$, $546^b15$–$547^b32$, $548^a11$–$24$, $551^a1$–$13$, $559^a11$–$^b21$, $570^a2$–$24$; *GA* III. 10–11). Whether this belief can be held consistently with his views on chance and teleology is controversial (cf. Balme 1962*a*; Lennox 1982; Gotthelf 1989*b*).

$640^a31$–$2$: 'The art [*hē technē*] is the account [*ho logos*] of the product [*to ergon*] without the matter [*hē hulē*].' The craftsman possesses an account of the product—we may think of it as a set of instructions for its production, or a conceptual 'blueprint'. I have here rendered *to ergon* as 'the product'. But the Greek term has the same ambiguity as our word 'work'—it can refer to the activity of a craftsman or to the 'work' of art produced. So Aristotle might have in mind that the art is the *logos* of the artist's activity.

This enigmatic comment is usefully compared with the following, from Aristotle's discussion of zoological reproduction in *Generation of Animals*: 'For the art is origin and form of the product, but in another thing; while the movement of nature is in the thing itself, being derived from another nature which contains the form actualized' (*GA* II. 1, $735^a2$–$4$).

The defence of teleology in *PA* I. 1 relies heavily on the analogy between artistic and natural production, but only rarely and briefly mentions the important disanalogies. In production, the craftsman acts and uses his tools in ways dictated by an account, but the account remains independent of the product. In nature—and this is the point of the contrast made in the passage from *GA* II. 1—the productive capacity to make an animal is, in the act of reproduction, transferred to, and becomes a capacity of, the developing zygote. A second disanalogy is that a house-builder's art is *not* the capacity to make a house-builder—i.e. to reproduce himself—but to make a house, something quite unlike himself. In natural reproduction, on the other hand, the actual human being first has in himself the capacity to make another human being, and then transfers that capacity to the material which is a potential human being. Finally, throughout the process, the capacity to make a human being is always 'within the matter', i.e. a capacity of an ensouled human body (cf. Balme 1992: 86).

## $640^a33$–$640^b3$

This passage appears to rank various ways of explaining 'things constituted by nature'. It is highly schematic, the reference to mankind as the subject being its only substantive content. Any interpretation thus depends on theoretical claims made elsewhere and on the explanations we actually find in Books II–IV (see especially $670^a23$–30). Even the number of distinct explanations is controversial, since the 'sentence' at $640^b1$ ('And these things follow'), consisting of two Greek words, could explicate the previous sentence, introduce the next, or add a distinct mode of explanation.

$640^a33$–4: 'since this is what it is to be a human being, on account of this it has these things; for it cannot be without these parts'. The formula 'what it is to be an *X*' frequently refers to a thing's defining form, in which case 'this' in the above formula refers to human form, and some *other* features are present because of this form. If the final clause explicates what precedes it, then at least some *parts* are said to be best explained by showing that human form requires them. Read thus, the explanation takes the form of conditional necessity. Sorabji (1980: 155–6) reads the passage this way, which leads him to conflate the second type of explanation with this one (see below).

Another option, suggested by Balme (1992: 87) and followed by Cooper and Gotthelf, is to see this explanation as 'within' the essence—'Since to be human is to see, they therefore have eyes' (cf. *GA* V. 1, $778^a31$–$^b13$). Aristotle certainly provides such explanations (cf. Cooper 1985: 152–3), but the issue is difficult to resolve (cf. Gotthelf 1985*b*, esp. note 5). Nor are these options necessarily exclusive: the *form* of an explanation by conditional necessity may be common to this explanation and the next, while their *content* (i.e. what counts as *explanans* and *explanandum*) may be different.

$640^a35–6$: 'either that in general it cannot be otherwise'. The issue, clearly, is how to understand the difference between *this* necessity and the necessity discussed in the previous note. Presumably (*pace* Sorabji 1980: 155–6) it *is* different, because Aristotle tells us that this is the sort of explanation we give when the first sort is unavailable. As noted above, Balme makes the plausible suggestion that Aristotle has in mind here non-defining features of an animal that are none the less necessary for survival (he suggests that the heart and liver fall into this category, relying on $670^a23–30$). Again, both might take the *form* of explanation by conditional necessity, even if Balme is correct.

$640^a36–^b1$: 'at least it is good thus'. Occasionally, Aristotle contrasts parts an animal has of necessity with those it has because 'it is better thus' (cf. *GA* I. 4, $717^a12–21$; *PA* II. 14, $658^a15–24$). Since 'what cannot be otherwise' is his core notion of necessity, and is the alternative form of explanation here, this might be the contrast intended. If you have established that a part *P* is for function *F*, and that some animals accomplish *F* without *P*, you may still be able to show that certain animals accomplish *F* better because they have *P*. That, in conjunction with Aristotle's principle that 'nature always makes what is best, given the possibilities, for each kind of animal' (*IA* 2, $704^b15–18$), provides an explanation for the presence of *P*.

$640^b1$: 'And these things follow.' The word translated 'to follow' is an expression Aristotle sometimes uses to refer to features which belong to something *as a consequence of something else belonging* (*An. Post.*. II. 14, $98^a1–22$). Balme takes this to refer to explanations, such as those at $670^a30$ ff., where we are told that the spleen, as well as the residues in the gut and bladder, are necessary consequences of other processes. Others take it simply to explicate the previous line (Le Blond 1945: 145), or punctuate the passage so that it introduces the following explanations (Peck 1961: 62–3). One Renaissance translator (Gaza) threw up his hands and removed it. Balme's suggestion seems best: it gives us a distinct form of explanation, and it accommodates certain explanations we actually find in Books II–IV that are not otherwise accommodated.

$640^b1–3$: 'since it is such, its generation necessarily happens in this way'. Explaining the actual animal's nature takes priority over explaining its development (a view defended at $640^a13–26$). Even the *order* in which the parts develop is explained in terms of the nature of the actual animal (see

*GA* II. 1, $734^b21$–$735^a4$). Indeed, *PA* IV concludes ($697^b27$–30) by saying that, having explained why animals have the parts they do, the next step is to account for their generation.

## $640^b4$–$641^a14$

So far Aristotle has proceeded without defending a distinction between matter and form. This is the task of much of the rest of the first chapter. He begins by presenting an alternative account, one which assumes that 'matter in motion' is a sufficient explanation for all products of nature, including animals and their parts. His own account is developed in stages by pointing out deficiencies in the materialist's explanations, and indicating how his alternative position avoids these deficiencies.

$640^b4$–17: 'the ancients'. For similar attributions, see *Met. A* 3–4, $983^b6$–$985^b22$; *Phys.* I. 4–5; II. 1, $193^a9$–$193^b8$; II. 2, $194^a12$–27; II. 8, $198^b10$–32; *GC* II. 9, $335^b23$–$336^a13$. Because Aristotle provides us with three quite specific examples of primary moving causes—friendship and strife, reason, spontaneity—we can identify two of these 'first natural philosophers' with some confidence. The first is Empedocles (cf. $640^a19$–26 and note). Anaxagoras, who claimed that Reason (*nous*) controlled and arranged all things, is the second (cf. Plato, *Phaedo*, 97 B 8–C 5, and *Met. A* 3, $984^b15$–20; 4, $985^a18$–23). The third is usually assumed to be Democritus (Ross 1924: 515; Charlton 1970: 105; Balme 1992: 87). But Aristotle never attributes such a cause to Democritus, and in the very next passage Democritus is explicitly identified, without mentioning a belief in spontaneity. Further, the doctrine that the heavens, but not the animals and plants around us, are due to spontaneity is discussed at $641^b15$–23 without mentioning Democritus (the same is true of *Phys.* II. 4, $196^a25$–$196^b5$).

We can see this passage as a sketch and critique of a model of explanation abstracted from elements common to a number of Aristotle's predecessors. The model has two elements: (1) an investigation into the nature of the 'material origin', that *from which* things come to be, and (2) an investigation of the 'motive origin' of the whole cosmos. Such a model is difficult to reconcile with the examples Aristotle provides. The production of the 'gut' and the nostrils is portrayed as the necessary outcome of the natural movements of different material elements (all the standard four being mentioned at some point in the discussion). That is, there is no explicit reliance on investigations of type (2).

$640^b8$–11, 13–17, 22–3: 'fire . . . earth . . . water . . . air'. Such divergent texts as Empedocles' *On Nature*, Plato's *Timaeus*, Aristotle's *Generation and Corruption*, and a number of the Hippocratic treatises treat these four as the basic sublunary materials. The account in *Generation and Corruption* is that earth, air, fire, and water are the most basic elements capable of independent existence, but that they are each constituted of two primary qualities or potentials, one from each of the primary oppositions hot/cold and moist/dry. In addition, air and fire have a natural *upward* motion, while earth and water have a natural *downward* motion. Heat and cold are the *agents* of material-level change, moist and dry the *patients*. All of this is summarized in the accompanying table.

| Element | Earth | Water | Air | Fire |
|---|---|---|---|---|
| Potentials | cold/dry | cold/wet | hot/wet | hot/dry |
| Motion | downward | | upward | |
| Causal role | passive | | active | |

Aristotle agrees that the bodies of animals and plants are constituted of these elements ($640^b15$–16, 22–3), and that each element has its own determinate potentials to act and be acted upon. It is the *sufficiency* of an account of animals and their parts, couched *solely* in these terms, that he is questioning.

$640^b20$–4: 'all the uniform parts . . . the non-uniform parts'. What is missing in his predecessors, Aristotle claims, is an account of the nature of flesh as flesh, or of a hand as a hand. Once more he reverts to familiar products of craft for an analogy. If someone were asked to provide an account of the nature of a statue, we would hardly think he had answered the request satisfactorily if he said, 'Well, a statue is bronze.' First of all, being bronze is neither necessary nor sufficient for being a statue: not all statues are made of bronze, and many things other than statues are bronze. Yet even if all and only statues were bronze, the above account would be incomplete. It is in virtue of being a representation, a work of art, that this bronze is a statue—features due to the sculptor's skill, not to the material alone.

$640^b24$–6: 'its form . . . the matter of the composite'. Two basic alternatives to the materialist account are suggested: define the form of the composite, or define the matter as matter of a composite, i.e. mention the form/matter composite as well as the matter. In fact, the latter is presented here as a second best, and the passage closes by stressing the greater importance of knowing the formal rather than the material nature. Again, it is not hard to see why—if it is the statue we are trying to understand, and a particular material is neither necessary nor sufficient for being a statue, while the form is either necessary or sufficient, then the form is more important. The argument is refined later, at $641^a14$–32.

$640^b27$–9: 'configuration [*schēma*] . . . visible character [*idea*] . . . in respect of shape [*kata tēn morphēn*]'. These terms have connotations that are highly sensitive to context. Most of the argument here is by analogy with artefacts, where Aristotle is inclined to substitute configuration and visible shape for form—though he quickly qualifies even this substitution (cf. $641^a1$–2, 8–14). The concept of form he wishes to defend in biological contexts, however, is one in which form is identified with soul. He is about to argue that in these contexts there are reasons why thinking of form in terms of configuration and shape is misleading.

$640^b30$–3: 'Democritus . . . appears to assume this. Note that he says'. The wording suggests that Aristotle infers Democritus' beliefs from what he actually says. He *says* that it is clear what sort of thing a human is because this is known by way of configuration and colour. From this epistemic claim, Aristotle infers a metaphysical assumption on Democritus' part—that animals and plants *are what they are* by virtue of configuration and colour.

As the chief Presocratic exponent of atomism, one would expect Democritus to dismiss accounts in terms of external shape and colour as mere conventions, in favour of those in terms of underlying types of atomic complexes. Furthermore, he would have held that a corpse was, at the micro-level, unlike a living animal, having lost the spherical atoms that constitute an animal's soul and give it life (cf. Aristotle's own account of the theory, *An.* I. 2, $404^a1$–16, $404^a28$–31, $405^a6$–14; *Resp.* 4, $471^b30$–$472^a27$). But philosophically Aristotle's dissatisfaction would remain, since, as I shall comment on below, this would still not be an account of form in terms of functional capacities of living bodies.

$641^a1$–6: 'such a hand will not be able to do its work'. It is of course important to draw attention to Aristotle's stress on the fact that something is truly, rather than nominally, what it is in virtue of its ability to perform its appropriate functions (cf. *Meteor.* IV. 12, $390^a10$–12). But it is also central to the position defended here that a necessary condition of something performing its proper functions is its *being constituted of the appropriate material*. Bronze and wooden hands, paintings of doctors, flutes made of stone are all 'in the wrong condition' to perform their functions. That suggests that a corpse is not simply *functionally* unlike its former living self, but that it has also undergone a disabling *material* change, making it akin to a statue of a human.

$641^a6$–14: 'the carpenter . . . the natural philosophers'. Cf. on $639^b11$, $640^a27$, $640^a31$. As we have already seen, references to the crafts are extensive in *PA*, and I shall adopt the policy of taking each on its own terms, rather than presupposing some univocal aim lying behind each. These appeals cover a wide range of crafts, activities and products, so that the particulars of a reference may be crucial.

Here, for example, there are two quite distinct appeals to the crafts. The first stresses the fact that artistic representations—whether the object represented is natural (humans, hands) or artificial (flutes)—are representations partly *because* the materials used are incapable of functioning as the real thing does. Whether the object represented is an artefact or organic is not crucial.

The carpenter is invoked to note a deficiency in the materialist natural philosophers' account of how things come to be. The carpenter will make a point of saying *why* his instruments move as they do, stressing the *end* towards which his actions are directed.

The elements (earth, water, air, and fire) in the accounts of the natural philosophers are given a role akin to the carpenter's tools—it is by the capacities of these elements, to heat and cool, or move upward or downward, that these natural philosophers explain an animal's development (recall the earlier explanations of the vertebrae (640$^a$19–22), stomach, and nostrils (640$^b$12–16)). Compare the remarks about Democritus' account of the growth of teeth, *GA* V. 8, 789$^b$8–9.

## 641$^a$14–641$^a$32

In the previous section Aristotle developed a view of animals as unities of matter and form out of a critical evaluation of those who try to account for the development and existence of animals and their parts in purely material terms. The final step in this development is to argue that animate form must be understood in functional terms—the form of an animal is not merely its structure or shape, but the capacity to perform living functions possessed by living tissues and organs. He also argues that in order to understand the structure or shape of the parts of a living thing, one must know why it is that they have the structure they have—what is that part for, such that this is the shape it must have? The next step he takes is to argue that such a functional and teleological understanding of living form amounts to saying that the form of a living thing—what it is as such (i.e. as living)—is its soul. Interestingly, the entire discussion is framed in conditional terms. The case is not made here for understanding soul as the form, in the sense of the capacities, of an organic body. One has to take as understood something like the *De Anima* understanding of soul—soul as the first actuality of a living body with organs. Specific references to relevant passages will be made as analysis of the argument proceeds.

641$^a$15–32: 'one should state that the animal is of such a kind'. Three identifications are made explicit for the first time here:

(1) The animal as such is its soul, or some part of it. (641$^a$14–20, 23–4)
(2) An animal's soul is its nature, and its nature, more than its matter, is its being. (641$^a$25–9)
(3) The formal nature of the animal is its nature both in the sense of its own origin of movement and as the goal of its bodily parts and their movements. (641$^a$27)

Aristotle thus concludes that the soul of an animal is both its motive nature and the goal of all its other features (641$^a$28).

641$^a$17–18: 'Suppose what one is thus speaking about is soul'. The reference is to 'the animal as such'. The sentence leading up to the statement of this guiding presupposition asserts that the proper aim of the zoologist is to say what the animal as such is, and what sort of thing it is (and likewise with each of its parts). It closes with a comparison with discussing 'the form of the bed', and suggests, but does not directly state, that to discuss what the animal as such is is likewise to discuss its form (cf. Balme 1992: 88; 641$^a$17–32 note).

641$^a$17–18: 'or a part of soul'. Minimally, this qualification looks forward to the problem discussed at 641$^a$32 ff., that while reason is a part of the soul of certain animals, it is not to be studied by the natural philosopher. More immediately, however, it looks to $^a$22–4, which stresses study of the part of the soul that distinguishes animals *as such*, i.e. the possession of perception and desire, which are nearly always accompanied by locomotion. A bit later, however, the suggestion is that since 'nature' means an internal origin of change, any natural function (even growth) should be studied (cf. 641$^b$5–6).

*De Anima*'s generic definition of soul is 'the first actuality of a natural, instrumental body' (II. 1, 412$^b$4–6), a first actuality being, roughly, a developed capacity to perform a function. There is no reason to think that *PA* I has a different theory of soul in place. In *An.* II–III, as here, the various organic capacities are sometimes referred to as 'parts' of soul (e.g. *An.* 413$^a$4–5, $^b$13–16, 432$^a$23), meaning something like *distinguishable* capacities. He is, moreover, sensitive to the difficulties of making such distinctions (cf. 415$^a$22–5 and 416$^a$19–20 on nutrition and reproduction as a single capacity).

Aristotle's account of soul has been of profound interest to contemporary philosophy of mind. (For a representative sample of discussions see the papers collected in Nussbaum and Rorty 1992.) With the possible exception of the active intellect, Aristotle's account of soul is decidedly non-dualistic, while at the same time being non-materialist. Unfortunately, philosophers have found it easier to say what his theory is *not* than what it is. A number of philosophers have tried to assimilate it to one or another contemporary version of 'functionalism', without success.

At least part of the problem of assimilating his views to contemporary ones stems from the fact that Aristotle is decidedly not, in the *De Anima*, developing a philosophy of mind; rather, it is a philosophy of *life* (cf. *An.* I. 1, 402$^a$4–7). His starting-point is the question 'What distinguishes living from non-living?', not what distinguishes conscious states from their material substrate. Each part of each animal is capable of performing, or contributing to performing, a function (which does not always involve an activity); that function contributes some good to that animal's life, and in some, but not all, cases the animal could not live without that functional contribution.

Another part of the problem stems from the fact that Aristotle treats mankind as he treats every other animal—whatever we share in common with a wider group is treated as a feature of that wider group. Humans are singled out for separate discussion, just as elephants or camels are, only when there is some part that distinguishes them from all other animals. In so far as contemporary philosophy of mind has been myopically focused on human consciousness, assuming it was utterly unlike the consciousness of other animals, Aristotle's approach will seem alien.

641$^a$17–18: 'or is not without soul'. Speaking about soul and speaking about what cannot be without soul may mirror the distinction at 640$^b$24–9, between defining by form and defining by the matter of the composite. Another reading is that Aristotle is leaving open the possibility that the formal nature of an animal may include features other than soul, but only if they are ensouled (Gotthelf 1999: 47).The parenthetical remark indicates that even without a natural philosopher explicitly recognizing that he is investigating soul, he may acknowledge that animals and their organs are able to lose the capacities that most define their natures while maintaining their configuration. If he acknowledges that, then that is tantamount to saying that the proper subject of investigation is the soul.

641$^a$24–25: 'and about the attributes [*ta sumbebēkota*] it has in virtue of the sort of substantial being [*ousia*] it is'. This conforms to the description of scientific explanation provided by the *Posterior Analytics*, which sees demonstrations as valid arguments deducing the necessity of certain attributes belonging *per se* to a subject, from necessarily true premisses about the *being* of that subject. (Cf. *An. Post.* I. 6, 75$^a$28–37; 7, 75$^b$1–2; 9, 76$^a$4–16.)

641$^a$25–7: 'the nature of something . . . is in two ways'. The distinction of two aspects of a thing's nature here—as matter and as substantial being—was earlier (640$^a$24–5, 640$^a$28–9) expressed as a distinction between matter and *form*. This again reflects the definition of soul given at *An.* II. 1, 412a19–21: 'soul is *substantial being as form* of a natural body having the capacity for life'. Here, however, Aristotle needs the broader term 'substantial being' because he is about to go on to discuss soul in two roles typically distinguished from form, as mover and as goal. See the next note.

641a27: 'nature as substantial being is both nature as mover and nature as end'. Again this mirrors *An.* II. 4, 415a7–14, where the soul is said to be the cause of the living thing in three respects—as origin of motion, that for the sake of which, and form.

Soul is the end in the sense that any part of an animal's body is as it is *for the sake of* the capacities that constitute the animal's life: Birds have wings for the sake of flight, and the capacity for flight is part of a bird's soul. In fact at 642a11–14 Aristotle makes the further controversial claim that the entire body of an animal is an instrument for the sake of that animal's soul, a claim we shall examine shortly.

## 641a32–b23

Two excellent recent discussions of this difficult passage are available: Balme (1992) 89, 91–3; Charlton (1987) 410–11.

In the immediately preceding discussion (cf. 641a18, 641a28) Aristotle has been hinting that there are reasons to doubt whether the *entire* soul should be an object of natural study. These qualifications are now seen to reflect a particular concern about reason (*nous*) and the activity of discursive reasoning (*dianoia*). What are Aristotle's grounds for excluding the study of reason from natural science? He sometimes suggests that reason or some part of it is immaterial, and that would certainly be ground for exclusion; but that suggestion plays no role in the argument here.

641a34: 'whether it is up to natural science to speak about *all* soul'. The passage from 641a34–b4 presents the following argument:

(1) Suppose: natural science studies soul in its entirety.
(2) Soul includes reason.
(3) So natural science studies reason.
(4) Reason is 'of' its objects.
(5) Reason and its objects are thus correlative phenomena.
(6) Correlatives are studied by the same science.
(7) So natural science also studies the objects of reason.
⟨(8) The objects of reason are the only objects of study besides natural objects.⟩
(9) So natural science would study everything.

*Conclusion*: There would be no philosophy over and above natural science. (641a34–6).

Proposition 8 is the minimal necessary addition to the passage to give us the result. Perhaps the argument's most problematic components are propositions 4, 5, and 6, though there is no question that Aristotle endorses all three. *An.* III insists that actual knowledge is identical with its objects ($430^a2–5$, $431^a1$), and the Platonic view that strict correlatives are studied by the same science is regularly endorsed and followed in practice, e.g. in the *Parva Naturalia*. Even if these two claims are accepted, however, they do not imply the conclusion that other theoretical disciplines will be reduced to the one that studies reason. If the correlatives to be studied by the same science are a form of cognition and its object, the study of these correlatives need not bear the same relationship to *them* as does the cognitive activity being studied to *its* object. For example, Aristotle's philosophy of science is deeply informed by his study of mathematical reasoning and its objects, but not in a manner that leads to the collapse of mathematics into epistemology.

Charlton (1987) presents this argument as a *reductio ad absurdum*. But this cannot be correct. It does not conclude by simply asserting the contradictory of the initial supposition. Nor is the conclusion presented as an obvious absurdity. Aristotle thinks it is false, but not obviously so; and he thinks the principal error in the argument lies in its initial supposition. What Charlton treats as a separate argument ($641^b4–8$) is in fact Aristotle's first challenge to that assumption. It runs as follows.

(1) Natures are origins of change.
(2) The natural scientist studies natures.
(3) Therefore only those aspects of soul which are origins of change (nutritive, generative, perceptive, and locomotive change) are proper objects of natural science.
(4) Not every part of soul is an origin of change—in particular, reason is not.

*Conclusion*: Natural science does not study all soul—in particular, it does not study reason.

The strength of this argument depends on two claims not seriously defended here. The first is that natural science is restricted to the study of change and its causes. This is argued for in *Phys.* I. 1–2. The second, discussed at length in *An.* III, is that reason is not an origin of movement.

Commentators have had worries about this claim (Balme 1992: 89, 92; Charlton 1987: 411), and with good reason. Human beings are agents, and our most characteristic actions are grounded in reason. Aristotle believes this, and argues eloquently for it in his ethical and psychological writings. So why should he not view reason as an origin of change, a nature, as much as any other part?

Aristotle distinguishes, in his psychological and ethical theorizing, between practical and productive uses of reason on the one hand and theoretical reasoning on the other. He denies that theoretical reason moves humans to action (*An.* III. 9, 432$^b$26–7) and argues that practical reason does so only once desire has an object—practical reason only produces movement in the sense of directing it towards the desired end (433$^a$13–17). Further, desire can bring about human action without the aid of such reasoning, showing that even practical reason is not by itself the origin of human behaviour (433$^a$22–30).

Aristotle carefully avoids the question of whether the natural philosopher should study *practical* reason here. Among the 'parts' of soul that *are* sources of movement (and thus natures) are those related to growth, perception, and locomotion. Of these, only the perceptive capacity is actually named. And the part that is said *not* to be a source of movement is the rational (*to noētikon*), which in this context is most likely *theoretical* reason.

David Balme has noted that the correlative nature of reason and its objects, which supports the conclusion that there would be no philosophy other than natural philosophy, provides the basis for another exclusionary argument. For the objects of theoretical reason are abstractions. Such objects, being immaterial, do not change and do not partake in goal-directed processes. They are therefore not natural objects. If to study reason is to study its objects, and these are abstractions, the study of reason would be excluded from natural philosophy on this ground. This argument, or something like it, is hinted at in the opening lines of the next passage.

641$^b$10–15: 'none of the abstract objects can be objects of natural study'. Düring (1943: 91–2) saw no connection between the claims that natures are goal-directed and that they are not 'abstractions', and suggested changing the text and punctuation to 'disconnect' these ideas. Balme (1992: 98–9) explains the connection clearly. 'Abstract objects', for Aristotle, are objects 'separated in thought from change' (*Phys.* II. 2, 193$^b$33–4). The natural scientist and the mathematician both begin with the same objects of study, but the geometrician can, for his purposes, ignore their physical properties, including their characteristic changes: 'number, line, and shape can be defined *without change*, but flesh, bone, and man cannot' (194$^a$4–6). As Balme points out (1992: 98–9), Aristotle typically stresses, *not* abstraction from matter, but from *change*. Changes due to nature are always goal-directed (cf. *Met.* α 2, 996$^a$22–996$^b$1). Change, and its most fundamental cause, nature as the goal of change, are precisely the things from which abstract objects are abstracted.

641$^b$12: 'nature does everything for the sake of something'. This could also be translated 'nature acts in all respects for the sake of something'. It is an oft-repeated refrain (cf. Bonitz 1870: 836$^a$50–$^b$53), and one open to various interpretations (cf. Balme 1992: 93–8; Lennox 1996*c*; 1997). Two in particular raise fundamental questions about the defensibility of Aristotle's teleology. The first argues that the goal for the sake of which nature is said to act is the good for mankind. This view has been defended by David Sedley (1991). This interpretation rests primarily on a small number of passages outside the biology, and, as Sedley acknowledges, finds virtually no support in biological texts. A second argues that the nature referred to is nature as a whole, rather than the nature of particular sorts of animals. On this view the webbed feet of ducks, for example, would need to be explained in terms of their role in the overall design of nature. A variant of this view defended by Kahn (1995) is that all such natural, sublunary design must ultimately be accounted for by reference to the striving of the heavenly spheres to be divine. Nature ultimately does everything for the sake of something that is not natural, but supernatural.

The principle that nature acts not in vain, but for some end, which plays a very central role in the actual explanations in *PA* II–IV, will be treated in some detail when those explanations are discussed. I shall be arguing that these passages are best understood as generalizing over the formal natures of specific kinds of animals, and that the goals that such natures are acting for are the lives of specific kinds of animals.

641$^{b}$17–23: 'by such a cause'. This passage, like many in *PA* I, echoes a fuller discussion in *Phys.* II, in this case 196$^{a}$25–196$^{b}$5. The sentence begins with 'This is why', suggesting an inferential link with the previous sentence which is both unclear and, even when clarified, loose.

The argument appears to be this:

(1) Order and determinateness are more apparent in the movements of the heavenly bodies than in those on earth, where the natural course of events may be interfered with.
(2) Order in nature is due to forms acting as ends.
(3) So, supposing both animals and the heavenly bodies came to be, it would be more reasonable to attribute the production of the perfectly ordered heavens to such a cause than the less regular animals.
(4) Therefore those who claim that the animals come to be by nature, but that the heavens come to be by chance, are being unreasonable.

It is not clear to whom this argument is directed, though, as I argued earlier, the usual suggestion, that it is Democritus, is implausible. But the argument is clear enough. The implied counterfactual reflects Aristotle's belief that the heavens are eternal, and thus that there is no cause of their coming to be.

**$641^b23$–$642^b4$**

Armed with an understanding of living things as unities of matter and form—or alternatively as consisting of both a material and a formal nature—and a theory of the soul as the form, or formal nature, of living things, Aristotle now returns to the intertwined concepts of causality, necessity and scientific demonstration.

$641^b23$–$642^a3$: 'We say 'this for the sake of that'. This passage begins cautiously, stressing that goal-directedness is *apparent* and that it is when it is apparent that we *say* 'this for the sake of that'. (This stress on what is apparent has in fact been dominant from $641^b8$ ff., and also dominates the presentation of the case for teleology in *Phys.* II. 8.) But the language of 'appearance' is ambiguous between what *obviously is the case*, and what *appears to be the case*. The opening lines of this argument would seem to be giving us a description of the conditions under which people unreflectively say 'this for the sake of that'. That does not imply that they are correct; but Aristotle takes what is apparent to most people very seriously. Nor does the use of this language imply tentativeness on Aristotle's part: the conclusion of the argument for natural teleology in *Phys.* II. 8 reads 'So then, *it is apparent* that nature is a cause, and a cause in the manner of that for the sake of which' ($199^b32$–3).

The verb Aristotle uses to describe the change, rendered here as 'to proceed' (*perainein*), has the same root as a noun which means 'limit' (*peras*), a noun Aristotle often uses as a near synonym for 'end' or 'goal'.

What is the thing which is apparent and which 'we call' nature? The best candidate is the goal towards which things apparently proceed (cf. *Phys.* II. 8, $199^b26$–33). If that is so, then the whole argument down to $642^a1$ must be intended to support this claim. For elaboration of the theory of biological generation relied upon here, see *GA* I. 21–II. 4; it is clearly explained in Balme (1992) 155–62; Balme 1987*c*; and Gotthelf 1987*b*.

Aristotle uses an example where the offspring (a mule), being a hybrid, is actually named differently from the parent (either a horse or an ass), presumably to stress the distinction between the motive origin of the seed and its goal. In another respect this is not an apt example, however, as the mule is his standard example of an *unnatural* production. (Cf. *GA* II. 8; *Met.* *Z* 8, $1033^b29$–$1034^a5$.)

On the notion of priority here, see $640^a24$ note.

$642^a1$: 'complete actuality [*entelecheia*]'. Aristotle distinguishes both complete actuality (*entelecheia*) and actuality (*energeia*) from potentiality (*dunamis*). It is not uncommon to see both translated 'actuality', but the roots of the two words are quite different, *entelecheia* stressing completeness, *energeia* stressing activity. The relationship between them will be captured by rendering *energeia* 'actuality' and *entelecheia* '*complete* actuality'.

*Met.* Θ 1 argues that the distinction between potentiality and actuality begins with a commonplace distinction between the potential for change and change—e.g. between a sphere's potential to roll and the actuality of that potential when it rolls. After analysing that distinction for five chapters, Aristotle makes a case for extending it to help elucidate, among other things, the distinction between capacities and their realizations, e.g. between sight and seeing, and between matter and substantial being. As in *PA* I. 1, this latter distinction is complex, since 'substantial being' can refer to the actual complex of matter and form, or to the formal aspect of that complex. It is by virtue of this complexity that the two distinctions converge in Aristotle's theory of the soul as the form and first actuality of the body.

Consider the rabbit. Most things in the world not only are not rabbits—they could never become rabbits either. But there are certain things that, while not rabbits, could become rabbits under suitable conditions—in Aristotle's account, the menstrual residue of female rabbits, or developing rabbit embryos, for example. Such things as these, which are naturally suited to become *actual* rabbits under appropriate circumstances, Aristotle refers to as *potentially* rabbits. Their natural development is the realization of that potential. Thus *in contexts of change* what is potentially *X* is what will *become X* if acted upon by the appropriate causal agent, and if nothing impedes development. Both the *completed rabbit* and what it is to be a rabbit (i.e. its form or soul) are treated as the 'actuality' of such potentials.

This distinction between actual and potential being is, thus, a first cousin of that between matter and form. Those very things that are *potentially* rabbits are also the *materials out of which* rabbits are made, while what makes them *actually* rabbits is their acquiring the *form* or soul of rabbits. Aristotle refers to this form as the 'first complete actuality' of the body. Why 'first'? Because he sees the importance of distinguishing between the potential that the rabbit embryo has to hop and hear predators, and the potential of a sleeping adult rabbit to do the same things. The set of developed capacities of the latter sort Aristotle calls 'first complete actualities'—the actual hopping and hearing being second complete actualities.

Finally, Aristotle takes the controversial step of applying the potential/actual distinction to the two aspects of fully developed organisms themselves—their body and their soul. In *An.* II. 1 (412a3–21) he argues that the body is the animal as matter and potential, while the soul is the animal as form and first actuality. This move is controversial for a number of reasons, but for now I want to point out only one. The relation of the fertilized menstrual residue to the adult rabbit it becomes is not at all like the relation of a rabbit's ear to its ability to hear. This is at least one reason for distinguishing grades of potentiality and actuality—the zygote is first potential, the body of the sleeping rabbit second; the soul of the sleeping rabbit is first complete actuality, the activity of the hopping and listening rabbit second complete actuality. Thus characterizing the relation between the body and soul of an actual organism in terms of potentiality and complete actuality requires a philosophical justification like that found in *An* II. 1–5 and *Met. Θ*, a justification that is absent here. (See the distinct solutions in Kosman 1987, Freeland 1987, and Gill 1989*a*: chs. 6–7.)

642$^a$ 1–13: 'Therefore there are these two causes'. This passage picks up where 639$^b$11–640$^a$9 left off. There, however, the two causes mentioned were that for the sake of which and that from which comes the origin of change, after which necessity was discussed as a separate topic. Here the discussions of causality and of necessity are integrated into one. Two steps have been taken in the interim to allow this transformation.

First, Aristotle's materialist predecessors have been characterized as appealing to the natures and potentials of matter and to certain origins of movement in order to explain natural phenomena (cf. 640$^b$4–15). Thus the appeal to necessity was portrayed as an appeal to the explanatory sufficiency of 'the motive cause' and 'the matter'. Second, Aristotle has argued that the soul is the nature of the living thing in three distinct senses—as substantial being, as goal, and as origin of motion—and that each of these is more important to a proper understanding of the living thing than is its material nature, or body (cf. 641$^a$14–32).

The comment is sometimes made that, in presenting this bifurcation of causality into teleology and necessity in this manner Aristotle acknowledges his debt to Plato's *Timaeus*. The *Timaeus*' duality is, however, necessity and reason (or the divine) (48 A 1–3, 68 E 3–7). And while reason in the *Timaeus* always directs necessity towards the good or the best, the good is not identified with one of the two causes. (See Aristotle's criticisms of Plato in this regard at *Met. A* 7, 988$^b$6–11; on the analysis of the *Timaeus* doctrine just suggested, Aristotle is not open to the criticisms found in Ross 1924: i. 176, 988$^a$9 n.; 179, 988$^b$11–14 n.) Further, Plato's teleology is based entirely on the premiss that the order in the universe is a *contrivance* of an extra-natural divine reason. Necessity is persuaded by 'reason' and 'the divine', not directed towards goals by the nature of the developing thing (cf. Lennox 1985*a*). This is probably what Aristotle has in mind when, in the passage in the *Metaphysics* noted above, he includes Plato among those who *in a way* say that for the sake of which is a cause, but not in the sense that it is *naturally* a cause.

642$^a$4–8: 'cannot be either of the two sorts . . . the third'. The reference to 'the philosophical discussions' is difficult to determine (see Balme 1992:

100; Cooper 1987: 259–60 and nn. 19, 20; Balme 1987*c*: 284–5 and nn. 32, 33). The two most likely candidates are *Met. Δ* 5 and *An. Post.* II. 11, $94^b36$. The third sort of necessity discussed here is the first mentioned in *Met. Δ* 5—'that without which, as an auxiliary cause, life would not be possible, as respiration and nourishment are necessary for certain animals' ($1015^a20$–2). The *Posterior Analytics* passage opposes necessity based on a thing's nature and impulse to that based on force and contrary to impulse.

Cooper (1987: 259 n. 19) argues for the *Metaphysics* on the grounds that 'the third' (*hē tritē*) suggests a place where a threefold distinction is deployed. But our passage says that two necessities are mentioned in the philosophical works, while the third exists in things that partake of generation. This need not mean that the third one was mentioned in the philosophical discussions, but could mean the third sort of necessity besides the two mentioned in the philosophical discussions.

In either case, the three kinds of necessity are:

(1) unqualified necessity involved in objects obeying their natural impulses;
(2) the enforced necessity of objects changing contrary to their own natures due to an external power;
(3) the conditional necessity of materials and processes necessary for a living thing's coming to be or continuing to exist.

$642^a10$: 'of bronze or iron'. Mentioning two materials may suggest a view congenial to modern 'functionalist' theories that stress the independence of cognitive descriptions from a particular material substrate. We shall see, however, that Aristotle sees a disanalogy between the natural and the artificial on precisely this point. Eye material will vary from one class of organism to another (cf. *PA* II. 10, $657^a25$–$658^a10$), but such variations are related to differences in the organisms' lives which require differences in function, structure, and material. Thus cognitive ability and the material of the organ co-vary in causally significant ways.

$642^a11$–13: 'so too since the body is an instrument'. The analogies Aristotle seeks to exploit are (1) a function identified for the entire object (axes should split things); (2) a certain material *potential* required for this function (it must be hard); (3) a determinate *sort* of material it must be made of (bronze or iron; cf. 'bronze or wooden', $640^b36$); and finally (4) necessitation *conditional* on their being such an object. (See Freeland 1987: 394–8.)

Since tissues and organs are what they are in virtue of their capacities to function ($640^b18$–24, $640^b34$–$641^a5$), and soul is characterized teleologically ($641^a18$–32), the analogy of the animal's organs to the instrumental nature of the axe is not surprising (cf. *An.* II. 1, $412^b9$–25). What is surprising, and problematic, is the undefended assertion that 'each of the parts is for the sake of something, and likewise also the whole'. There is an argument for this extension, however, at 645b13–20. Here Aristotle is *not* arguing that since each of the parts is for something, so is the whole—he is merely asserting that what is true of the parts is true of the whole.

The fact that an object is for the sake of something, notice, is taken to license the claim that it is an instrument. The word translated 'instrument' is derived from the word for 'function' or 'work'; and both are rooted in the context of craftsmanship. Plato had already relied heavily on this network of concepts in the natural theology of the *Timaeus*, and Aristotle, in his distinctive way, is doing the same.

642a13–17: 'there are two sorts of cause'. Presumably a reference to the two causes mentioned at 642a2, necessity and that for the sake of which. Aristotle has not explicitly argued that *only* conditional necessity is operative in the case of generated objects—only that it does operate there. This is important to the consistency of the claims here with the explanations found in *PA* II–IV, since there are a number of parts argued to be present from necessity but not for the sake of anything (cf. 677a11–19). However one understands such necessitation, it cannot be conditional in the sense specified here.

There is no ranking of necessity relative to teleology here, but a simple statement that the naturalist must investigate *both*. The remark that the nature of a thing is more an origin than its matter is a reason for studying *both* causes. Nature here must be that identified with substantial being earlier (641a23–8), and in the following lines (642a19).

642a17–24: 'Even Empedocles occasionally stumbles upon this'. 'This' refers to nature in the sense of substantial being. Empedocles does not define bone as earth, fire, and water, but gives an 'account' (*logos*) of their mixture. One of the more specific meanings of *logos* is quantitative ratio. A quotation from Empedocles' poem *On Nature*, in Simplicius' commentary on Aristotle's *Physics*, argues for it having this nuance here. 'And kindly earth received in its broad melting-pots two parts of the glitter of Nestis out of eight, and four of Hephaestus; and they became white bones, marvellously joined by the gluing of Harmonia' (*In Phys.* 300. 21 = 31 B 96 DK). Nestis is a mythological name for water, and Hephaestus for fire—and as we are only given six parts out of eight, and the mixing is in the melting-pots of earth, perhaps the account looked like this:

Bone = 2 water : 4 fire : 2 earth

The reference to the glue of *harmonia* is further evidence for this understanding of Empedocles: it was originally a term for the act of joining two things into one, and Empedocles seems to have used it as synonymous with 'Friendship', the cosmic force behind unification.

Such an account, while not the functional account of biological tissues Aristotle thinks best, is in the right direction. It goes beyond simply referring to the elements; it focuses on their precise organization. Aristotle's derisive description of Empedocles stumbling on it, led by the truth itself, reflects his opinion that Empedocles does not provide a theory of natural enquiry that recommends such accounts, and does not consistently provide them. (Note the similar remark about Democritus at 642$^a$28.)

642$^a$25–31: 'there was no "what it is to be" and "defining substantial being"'. Aristotle here identifies in fundamental terms his place in the history of natural enquiry. The Presocratics were focused on giving a theoretical account of nature, but lacked a proper theory of essence and definition. Socrates and his followers—including Plato—developed such a theory, but were almost entirely focused on questions in moral and political philosophy. The implication is that Aristotle is revolutionizing natural philosophy by deploying a more adequate theory of definition, which he owes in part to Socrates. (For more on Socrates' role, cf. *Met. M* 4, 1078$^b$13–1079$^a$4.)

'What-it-is-to-be' is a much-discussed Aristotelian coinage (cf. Owens 1978). It is an articular infinitive (the being) enclosing the primary Aristotelian 'predicable', what-it-is. *Met. Z* 3 gives this as one of four principal candidates for substantial being (1028$^b$33–6), and it is the first discussed (*Z* 4–6). *Met. Z* makes it clear that the two phrases conjoined here, 'what-it-is-to-be' and 'defining being', are virtual synonyms. To give a definition of a thing's being is to state 'what it is to be' for that thing (1031$^a$7–17). Such a definition refers primarily or exclusively to form viewed in abstraction from matter (cf. 1035$^b$32, 1037$^a$21–$^b$7).

642$^a$31–32: 'breathing exists for the sake of *this*, while *that* comes to be from necessity because of *these*'. Cf. *PA* IV. 2, 677$^a$17–18. The discussion is carefully constructed so that the contrast between teleology and necessity is first introduced, followed by the contrast between conditional necessity and a necessity rooted in an element's natural propensities.

642$^a$31, 642$^a$35–$^b$2: 'breathing'. The example unfortunately is highly compressed and does not appear to represent Aristotle's own theory, according to which the lung is expanded by the organism, air naturally flows in to 'fill the void' caused by the expansion, and being cool this air reduces the heat around the heart. The lung then contracts, forcing the warmed air out (*Juv.* 27 (=*Resp.* 21) 480$^a$25–$^b$4).

Here, apparently, 'the hot (air?)' goes out, is 'beaten back' by the cool external air, and as the hot returns, external air flows in with it. This is apparently an example of what occurs necessarily as a consequence of having a certain character and being a certain way by nature. It is, we would say, the 'mechanics' of breathing, and is to be viewed as embedded within a demonstration that this process of breathing is necessary for a certain end. (For further discussion, see $668^b33$–$669^b13$ and notes, on the lung.)

## $642^b5$–$643^b9$

David Balme's notes on this extended critique of dichotomous, single-trait division (Balme 1972: 101–19) remain the starting-point for further discussion (along with some second thoughts in Balme 1987*b*). For further references, see the notes below.

The discussion of division has a negative and a positive aspect. It begins as a critique of a method of division that is (1) dichotomous and (2) sequential. Throughout this negative critique it is clear that Aristotle is not rejecting division as a scientific method, and is using certain criteria to evaluate dichotomous, sequential division. Then, at $643^b9$, he introduces a radically different method of division that he claims can avoid the difficulties he has argued plague dichotomous division. Many of those difficulties stemmed from insisting on trying to grasp the nature of a complex entity by dividing a single attribute dichotomously, then selecting one side of that dichotomy and repeating the process. Other difficulties stemmed from introducing new differentiae in each repetition of the process that are not determinate forms of the previous differentiae—for example, dividing animals into flyers and non-flyers, and then dividing flyers into wild flyers and tame flyers.

Aristotle will recommend beginning with a list of all the general characteristics of the animal kind under consideration, dividing those into as many natural subdivisions as is required, and ensuring that the subdivisions are forms of the general differentiae chosen. Aristotle sketches a number of principles of proper division against the background of the problems encountered by repeated dichotomous divisions of unrelated traits prior to presenting his alternative. Discussion of these principles will be focused primarily on Aristotle's emerging positive theory. The extent to which the theory of division that emerges plays a positive role in his zoology will be explored in notes to *PA* II–IV.

### CHAPTER 2

$642^b5$–7: 'Some people attempt'. Presumably these people are 'the dichotomizers' ($642^b22$) and the authors of the written divisions ($642^b12$). The theory and practice of division in the early Academy has been discussed extensively (cf. Balme 1992: 101–19; 1987*b*; Cherniss 1944: ch. 1;

Stenzel 1940; Tarán 1981; on Aristotelian division see Balme 1987*b*; 1992: 101–19; Furth 1988: 96–109; Pellegrin 1982; 1986).

Cherniss, Stenzel, and Tarán argue that the criticism here applies not to Plato but to Speussippus. But the criticisms apply quite well to Plato's later dialogues (especially the *Sophist* and *Statesman*; cf. Le Blond 1945: 59–66). There, 'division' is described as a method for discovering 'what exactly something is' in which an interlocutor is offered a series of *dichotomous* divisions of successive kinds, and is asked which of the two the object to be defined is. The final account is a list of such differences which uniquely applies to the object of search.

Aristotle himself discusses right and wrong ways of carrying out divisions in four other works: *Top.* VI. 6; *An. Pr.* I. 31; *An. Post.* II. 5, 13, 14; *Met. Z* 12. He occasionally refers to divisions he has made, and the lists of Aristotle's works compiled in the ancient world include mention of seventeen books of *Divisions* that are unfortunately lost. The 'written divisions' mentioned at $642^b12$ may be lost as well, if this does not refer to those found in the *Sophist* and *Statesman*.

$642^b6$–7: 'not easy . . . impossible'. The summary at $643^b28$–30 shows that it is grasping the particular by dividing the kind in two that is impossible, rather than dividing the kind in two. 'The particular' (*to kath' hekaston*) is used by Aristotle to refer both to individuals and to the most determinate forms of a kind; here the latter use is to the fore. $642^b7$–9 considers cases where dichotomy provides only one difference, the problems with which are taken up in more detail at $643^b29$–$644^a12$. $642^b10$–20 considers cases where the use of dichotomy tears identifiable kinds apart (cf. $643^b17$ and note).

$642^b7$–9: 'there will be only one difference . . . this single difference is decisive'. The example here, present in all the manuscripts—footed, two-footed, split-footed, footless—is problematic, because the last term is not a determinate form of 'footed'. Ogle, Le Blond, and Peck therefore excise it, with some warrant, since we find the same list at $644^a5$, but without 'footless'. But this does not entirely resolve the problem (cf. Balme 1992: 106–7, $642^b7$–9 n.). If the example is of progressive division of the sort defended in *Met. Z* 12, $1038^a9$–21—and this is strongly suggested by the claim that only the last term is important, the rest being superfluous—then the more specific differences should *imply* the more general. But split-footedness does not imply two-footedness.

Balme suggests that we imagine a lost diagram that the text represents in note form (Diagram 1). But this reading requires that an 'or' be read between 'two-footed' and 'split-footed' and again at $644^a5$, without support

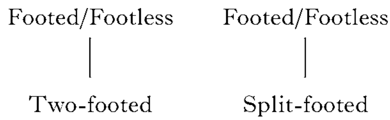


DIAGRAM 1

in the manuscripts. (The manuscript variations at $644^{a}5$ and $^{a}6$ do not affect this point.)

Another interpretation suggests itself if this is an extremely condensed version of the argument from $643^{b}28$–$644^{a}8$. The only point of that argument is that grasping the particular by dichotomous division of a single trait is impossible. I suggest that this is the point of $642^{b}7$–$9$ as well. Like Balme, we may begin by imagining a diagram, but one suggested by Platonic dichotomy (Diagram 2). As Aristotle goes on to note, one problem with dichotomy is that once a privative term is introduced, division must stop, so there will be no division under 'footless'. Thus, even collecting the whole series, you will still end up with only one *last* difference, and it will not identify the *complete* difference or form of the animal ($644^{a}2$–$3$). If this is the point, then Aristotle will be unconcerned with whether the last difference implies its predecessors; his only concern will be to show that if there is but one series of divisions, it must end with one difference, and that is not enough.

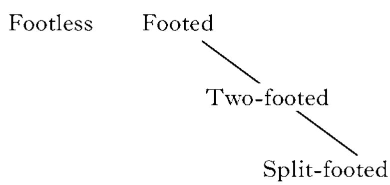


DIAGRAM 2

$642^{b}10$: 'for example putting some of the birds'. This example could well be based directly on Plato's writings. The *Sophist* divides water-dwellers into flyers (by which, Plato makes clear, he means waterfowl) and swimmers, while the *Statesman* divides land-dwelling walkers into two-footed and four-footed, then the two-footed walkers into winged and wingless—the winged, two-footed, land animals being birds. Birds thus end up falling into two opposed groups, land-dwellers and water-dwellers. Again this is only a problem if one hopes to capture the nature of bird with a single series of dichotomous divisions.

$642^{b}13$–$16$: 'this similarity has an established name, "bird"'. For now, Aristotle rests content with the assumption that terms like 'bird' and 'fish' refer to a similarity that counts as a single kind. But he quickly disabuses his readers of the idea that *only* similarities with familiar names should be considered kinds, by citing the nameless similarities 'blooded' and 'bloodless'. At 644$^a$12 he begins to defend this idea, and to provide some criteria for determining *which* likenesses should be treated as kinds (whether they have been named or not).

Here, as elsewhere in Aristotle, a name is a noun that can refer in the singular to a group. The noun is a conventional sign (bird), rather than a nominalized description (the feathered ones). On the conventional nature of names, see *Int.* 16$^a$19–27. On the difference between names and 'name-like expressions', see *An. Pr.* I. 35, 48$^a$28–38; *An. Post.* II. 10, 93$^b$29–32.

## 642$^b$21–643$^a$27

Balme argues that this section is 'all based on the premiss that a privation . . . is not differentiable . . . On that premiss Aristotle argues (*a*) that a privation cannot stand as a general differentia, because it is not further divisible; (*b*) that it cannot stand as a specific differentia, because it is the same for different species; (*c*) that it prevents the proper one-to-one correspondence between final differentiae and species' (1992: 108).

These conclusions pose insurmountable problems for the use of privative terms only for 'the dichotomists', not for the view of division Aristotle is going to defend.

## CHAPTER 3

642$^b$21–643$^a$6: 'it is necessary to divide by privation, and those who dichotomize do so divide'. This sentence has sometimes been taken to say that dichotomy forces the use of privation in division, which is a bad thing (see Peck's expansive translation). But the Greek simply does not say this, and at any rate Aristotle condones, in theory and practice, the use of privative terms in division. See in particular 643$^b$24–26: 'In addition, in this way privations will produce a difference, while in the method of dichotomy they will not.'

The argument of this section is:

(1) All division requires the use of privative terms.
(2) Dichotomy forces division of privative terms.
(3) But division of privative terms is impossible.
(4) So those using dichotomy cannot use privative terms.

The argument for point 2 is that dichotomy makes use of only one difference at a time, so that if there are two or more forms which share a privation, they must be distinguished by subdividing it. The reason for premiss 3 is given in a form a Platonist would understand—'there are no forms of what is not'. A privative term does not identify an attribute that can come in different forms—it identifies the absence of an attribute. Thus the dichotomists are forced by their method to do the impossible.

642b22–4: 'there cannot be forms of what is not'. Suppose one begins, within the realm of animal locomotion, by distinguishing winged from wingless animals. It would make sense to ask next what sorts, or forms, of wings there are (Aristotle's most general answer is 'feathered', 'skin', and 'membrane'—the wings of birds, bats, and insects, respectively). But it would not make sense to search for forms of winglessness, as if it were a generic feature that comes in determinate varieties. The use of a privative term therefore rules out further division into specific differences on one side of the dichotomy. For example, all wingless animals (e.g. tigers, spiders, and whales) must be treated as of the same kind, if this is the only division under consideration.

642b24–30: 'there *must* be forms of a general difference'. The very description 'general' implies that the differences referred to range over a number of more specific differences. But privations cannot display specific differences—there cannot be forms of what is not (b22–4). Hence privations cannot be general differences.

642b30–5: 'it is difficult to distribute animals even into such differences as these'. The examples indicate that Aristotle is thinking of a dichotomy, one 'half' of which is a 'privation', e.g. winged/wingless, blooded/bloodless. The difficulty is sorting forms of animals by such differences so as to ensure *exhaustive* sorting ('so that any given animal belongs in them'), and *exclusive* sorting ('and the same animal does not belong in more than one').

642b34–5: 'is most difficult of all, or impossible'. Most modern editors needlessly emend the text at b35, replacing 'bloodless' with various more general terms (see Balme 1992: 110, 642b30 n.; Peck 1961: 82, 642b36 n. 1). The argument is that even when we have general differences with determinate forms, it is very difficult to manage a proper division. But when the difference is a privation, such as 'the bloodless', it has no forms—and thus is not even a general difference, properly speaking (see previous note). That makes proper division most difficult—i.e. impossible. In Aristotle's usual condensed manner, the 'impossible' case is not first described abstractly, but is given immediately in the form of a concrete example.

The Greek term translated 'winged' primarily refers to feathers. It was extended to refer to feathered wings, and sometimes (as here) it is simply used to refer to wings. (Cf. *HA* IV. 7, 532a19–25, on flying insects, and *PA* IV. 6, 682b7–21, on insect wings.) The ambiguity of the term can make for some odd claims, as in the following assertion about winged insects: 'Their wing is unsplit and without a shaft; for it is not a feather [literally, "not a wing"] but a skin-like membrane' ($682^b18$–$19$). In either case the differentiation is clear—feathers are 'split' into individual fibres, and bird wings are 'split' into feathers; and whether one imagines the insect wing as analogous to a feather or to a bird wing, it is unsplit by comparison. Functionally, nevertheless, it is a wing.

Aristotle on occasion lists nine 'extensive kinds' (*megista genē*) which are grouped into those with blood and those which are bloodless, but which have some analogous nutritional fluid. The groupings are given below, with examples of each group. (Cetacea are treated as an extensive kind in *HA* (cf. I. 6, $490^b9$; II. 15, $505^b30$), but are not so identified in *PA*.)

| *Blooded* | *Bloodless* |
|---|---|
| Four-footed live-bearing (horse, tiger) | Soft-bodied (squid, octopus) |
| Four-footed egg-laying (lizard, crocodile) | Hard-shelled (conch, snail) |
| Birds (hawk, dove) | Soft-shelled (lobster, crab) |
| Fish (shark, salmon) | Insects (ant, bee, fly) |
| Cetacea (dolphin, porpoise) | |

These groups are not exhaustive of the animal kingdom, and most of them lack actual names (in the strict sense discussed above). As one can see, they differ widely in extension, which raises serious doubts that they have a primarily taxonomic purpose. What purposes they may serve will be discussed in subsequent notes.

$643^a2$: 'some indivisible and unitary form of substantial being'. The claim that a single indivisible form cannot be shared by things differing in form may sound self-evident, but it goes to the heart of problems in Plato's ontology of participation. Problems with the assumption of many different particulars sharing in a single form were raised by Plato himself in the *Parmenides*, and as the following remark at *Met. I* 8, $1058^a2$–$4$, indicates, they concerned Aristotle as well. 'For not only must that which is common belong to both things, e.g. both must be animals, but the animal itself must also be different in each, the one a horse, the other a human being, when this common thing is different one from another in form.'

Minimally, Aristotle is insisting that, if a feature is shared by, or common to, things different in form, and cannot be further differentiated, then it does not belong in the being of either one. If the two-footedness of birds and humans were not capable of differentiation, this feature would not specify the being of either. This does not, it should be stressed, rule out the possibility that a common, undifferentiable feature may specify the being of a more universal kind.

In fact, the human and avian types of bipedalism *are* specifically different; cf. *PA* IV. 12, $693^b2$. Differences in blood are also discussed extensively; cf. especially *PA* II. 2, $647^b29$–$648^a22$, and 4, $650^b14$–$651^a36$.

$643^a3$–4: 'their two-footedness is other and different'. This probably has the force 'other, that is, different'. There are many ways that two things can be 'other', but the focus here is on otherness owing to differentiation of a common feature (cf. 'difference is otherness in kind', *Met. I* 8, $1058^a5$).

$643^a6$–7: 'if *this* is the case, it is clearly impossible for a privation to be a difference'. 'This' refers to the previous conclusion that a feature common to two distinct forms, but with no difference, cannot be in a thing's being. The impossibility is for the dichotomists, for whom the privation would be the *only* common feature to be divided. But since privations cannot be differentiated and they are common to distinct forms of animal, they cannot be used to define these animals, which will therefore be unknowable.

Aristotle may be hoist with his own petard, however. Take the following claim from the *PA* IV discussion of bloodless animals:

> For none of these animals has blood, out of which the nature of the viscera is constituted, because some such affection of it is constitutive of their being; for that some animals are blooded while some are bloodless will belong in the account defining their substantial being. ($678^a31$–4)

If Aristotle believes that 'bloodless' is a privation common to many forms of animal, and that it cannot be differentiated, the above argument should deny him the conclusion that 'bloodless' will be part of the being of bloodless animals, accounting for their lack of viscera.

$643^a7$–13: 'The differences will be equal in number to the indivisible animals'. The concept of privation is not mentioned in the next three sections. None the less, David Balme has argued that it is continuous with the previous discussion. One strictly syntactic point favours this suggestion. Aristotle in this passage marks the transitions to new criticisms of dichotomous division with the Greek particle *eti* ('moreover', 'furthermore')—cf. $642^b21$, $643^a27$, $643^a31$. The current passage seems governed by the *eti* at $642^b21$, suggesting that it is part of the argument which begins there.

On Balme's interpretation, Aristotle is continuing to argue (1) that privations will occasionally be required in the use of division; (2) that privations are likely to be both common and not further divisible; and (3) that if you are using dichotomous division, privations will force you to fail to grasp the species you are trying to grasp.

Here the argument is that, while the dichotomists agree that it is important that the number of final differences should equal the number of indivisible forms, their method of division will necessarily fail to produce this equality. The details of the argument are difficult. The initial sentence states the conditions for the equality of indivisible (forms of) animals and final differences: (1) the animals must be indivisible (i.e. not further divisible in more specific kinds); (2) the differences must be indivisible; and (3) no difference can be common. What Aristotle argues is that dichotomy will violate condition 3.

643a9–11: 'if it *is* possible for something common to be present as well, yet to be indivisible'. All manuscripts read a negation with the main verb. The problem with doing so is that the very next clause seems to assume that the operative hypothesis is that what we are discussing *is* common. Balme argues that there is a parallel problem in not reading it, but the problem arises only if one reads the sentence (as Peck's translation does) as a counterfactual. However, one can avoid that problem if the sentence simply reiterates the point that if privations are common, yet indivisible, then animals different in form will end up grouped under the same differentia. I thus, reluctantly, suggest eliminating the negation.

643a13–16: 'Therefore it is necessary'. At this point three principles of proper division are laid down. They are mentioned here because Aristotle is about to argue that the dichotomists will be forced to violate them:

(1) Nothing that is the same indivisible form of animal should be placed in different subcategories of a division.
(2) Different indivisible forms of a kind should not be placed in the same sub-category of a division of that kind.
(3) All indivisible forms of a kind should be placed in some subcategory within the division of that kind.

He has already argued that dichotomists will be forced to violate (1) and (2). The third rule is equivalent to insisting that in any division, there should be equality in number of differences and indivisible forms.

643a16–24: 'in the way that those do who divide . . . into two'. The usual interpretation of this passage is that this is a conclusion supported by an argument of the following form:

(1) Dichotomists seek numerical equality between indivisible forms of animals and final differences (a18–20).
(2) But the method of dichotomy generates differences that are powers of 2.

(3) It is absurd to suppose that the number of forms of a kind will always be some power of 2.
(4) Therefore, dichotomy will fail to achieve the desired equality (a16–17)

Balme (1992: 112–13) has shown that the example here does not necessarily generate numbers of differences that are powers of 2. Further, nothing in the text suggests that this is an argument showing an absurd consequence of dichotomy. It looks as if it is a very simple illustration of the claim that it is necessary that there be an equal number of final differences and indivisible forms of animals ('and the forms will also be that many', a23–4). But if this is true, we still do not have a reason for the claim that dichotomists will be unable to grasp the indivisible forms of animals.

Commentators prior to Balme take the sentence following this argument to be unconnected with it. But it is syntactically linked to it, and is then followed by a clear introduction of a new criticism. For these reasons it is worth considering Balme's argument that the following sentence is in fact the missing conclusion of the argument.

643a24–6: 'And the form is the difference in the matter'. Balme argues that this passage is connected to the previous argument in the following way. The previous discussion has centered on the equivalence of the number of differences within a divided kind and the number of forms of that kind. This sentence provides the ontological grounds for that equivalence. A central conclusion of chapter 1 was that animals are unities of matter and form—it is the formal differences that make a body this or that sort of animal. This seems to be the claim here.

But then how does this claim show that the dichotomists will fail to grasp the indivisible forms? This question has an answer if the background premiss remains that dichotomists will have to define certain animals by privations, common differences that are nevertheless not divisible. Since they are common, they are shared by two or more forms of the kind. In Aristotelian terms, that makes a privation, not a difference, but merely matter. The dichotomists will thus be attempting to grasp animals as if they were matter alone, rather than formally differentiated matter.

This reading is speculative. The background premiss is never explicitly stated, nor is there an argument for the equation of 'common' with 'material'. Its primary value is that it reads a syntactically continuous passage as logically continuous, and links an otherwise out-of-place aside to the main line of argument. In favour of the equation of 'common' and 'material', as Balme points out, Aristotle often draws parallels between the matter/form distinction and the kind/differentia distinction, particularly when discussing division (cf. *Met.* Z 12, 1038a5–9). His use of the term 'form' is the link between the two distinctions, for it refers both to the subdivisions of a kind and to the defining essence of substantial beings, in contrast to their matter.

## $643^a27$–$643^b9$

Three rules of proper division are now introduced, each of which poses problems for dichotomous division. Their discussion leads directly to Aristotle's proposal of a new method of division which avoids all of these problems.

$643^a27$–31: 'Further, one ought to divide by features in a thing's substantial being'. This recommendation is stated explicitly in the language of *An. Post.* I (cf. $641^a24$–5 note), which distinguishes three ontological levels within the features of an object:

(1) those 'in the substantial being', which will be stated in its most proper definition, and which are explanatorily primitive; for example, having three angles enclosed by three straight lines is in the being of a triangle;
(2) those attributes which are proper to the object, which belong necessarily to all the members of a kind *qua* that kind, but which are not explanatorily basic; for example, having interior angles which add up to 180° belongs to all and only triangles, but only because triangles are planes enclosed by three straight lines with three angles;
(3) those attributes which are incidental to the object, which may or may not belong to a member of a kind and which bear no explanatory connection to its nature; for example, a triangle may or may not be red, or have sides of 1 cm. (cf. *Met.* Δ 30).

How does Aristotle think we come to distinguish defining and proper attributes? As one systematically observes a domain, one will gradually discover those characteristics which seem to belong to all and only the members of the kinds of things you are studying. But this provides no help in distinguishing defining from proper attributes.

Two answers have been suggested. One is that Aristotle holds that reason (*nous*) is, after a certain amount of experience, able to 'intuit' the nature or form of a type of object (Ross 1949: 84–6; Kahn 1981; Irwin 1990: ch. 7). A number of commentators have suggested an alternative that is broadly supported by Aristotle's zoological practice (Kosman 1973; Lesher 1973; Bolton 1987; Charles 2000; Charlton 1987). The distinction between defining and proper attributes of a kind arises as a consequence of the recognition that certain features are causally more fundamental than others.

*An. Post.* II suggests this second interpretation in two respects. First, it argues that the enquiry into the nature of a kind is closely intertwined with enquiry into why the kind has the proper attributes it has (II. 1–2, 8–10). Basic definitions, which are among a science's first principles, are statements of the cause(s) of attributes belonging to their subject. There is no mystery about how the distinction between a proper attribute of thunder—noise—and a definitional attribute—quenching of fire—is made. It is based on our recognition that one feature is a causal consequence of another.

A second feature of the *Analytics* model of science supports the same hypothesis. There the language of 'attributes which belong to something in virtue of itself'—proper attributes, as I am calling them—is used particularly to describe those features which appear in the conclusions of scientific demonstrations. They are not distinguished from 'essential' properties in virtue of some epistemological distinction between two forms of cognitive access; the distinction emerges in the process of discovering the causal structure of the domain being investigated.

What, then, is Aristotle here recommending with respect to the practice of division? He is telling us that in seeking to grasp the natures of things, we should divide by features in a thing's being, not by its proper attributes (cf. *An. Pr.* I. 27, 43b1–11). This recommendation presupposes, it seems, that we know, before using division, which are which. But given that presupposition, it is a sound recommendation. When one divides a general difference, one should always list the determinate forms that it takes. If one starts with a proper attribute of the general kind under investigation, each division will identify more determinate forms of that attribute—at no point in such a division will you encounter any feature in the being of the particular kinds you are studying. If, on the other hand, you start with a general defining feature, and each division provides an exhaustive list of the determinate forms of that feature, division will be a useful aid in grasping the being of the animals you are studying. (See the more detailed discussion of this recommendation at *An. Post.* II. 13, 97a6–b7.)

But what of the presupposition of a prior knowledge of which attributes are in the being of the object? If division is intended as a tool for grasping what things are, surely we cannot begin already knowing this? Furthermore, at 645a36–b3 we shall be told that we must first divide the proper attributes and then attempt to divide their causes, which agrees with this passage in presupposing a distinction between the two, yet conflicts with it in recommending division of proper attributes.

One solution to this problem, offered by Michael Ferejohn (1990: 24–8), is that division aids in grasping particulars only to the extent of ensuring the completeness and proper ordering of our list of essential attributes within a kind. Another suggestion (Gotthelf 1997*b*) is that division is not limited to one stage of scientific enquiry, but may have different functions at different stages.

It is important to remember that these chapters are intended primarily as a critique of dichotomous division. Within that context, Aristotle is probably thinking of the error of dividing a general difference by subdifferences that are only incidentally related to it. For example, if figures are divided into those enclosed by straight lines and those enclosed by curved lines, then dividing rectilinear figures based on the equivalence or non-equivalence of the interior angles to two right angles will be incidental. In essence, it is to begin a new division, based on angle-sum equivalencies rather than the nature of lines. Whether Aristotle's own procedure conflicts with this rule is discussed at $645^a36$ note.

$643^a31–4$: 'one should divide by opposites'. There is a careful exploration of the network of concepts related to difference—opposition, contrariety, contradiction—in *Met. I* 4, 7, and 8. Briefly, objects that are alike in kind, but different in form will be *opposed* in some respect. The word used here is the general term covering both contrariety and mere opposition; two items are contrary in a respect if they display maximum difference in that respect, as in the examples here. But Aristotle is content to speak of intermediates between these extremes as also opposed (though not contrary)—yellow and blue are of the same kind (both are colours), and are opposed, but are intermediate between white and black. Aristotle extends this idea to kinds in which the determinate forms do not fall on any obvious continuum between extremes—locomotion, for example. Admittedly, it sounds odd to us to speak of swimming and flying as opposites: but the problem is ours, not his. He never makes it a condition for two items being differentially opposed that they fall along a single continuum.

Against such a background, this recommendation follows from the rule against importing differences into a division which are incidental to it. Under locomotion we might have swimming, walking, flying; under colour, pale, dark. What we should not do is divide locomotion into walking and dark forms. And in fact, if we remained focused abstractly on the differentia, it is unlikely that we would do so. But if we were to focus on the animals which are sorted into the divisions, and we noticed that all the swimmers are dark and all the flyers pale, we might, in the absence of this rule, sort our animals into the swimming ones and the pale ones.

Note again that this rule presents a problem for the dichotomist, who must be combining incidentally related differences into the same division.

$643^a35$: 'the ensouled things, at least, should not be divided'. A verb is assumed in the Greek, but it is unclear whether it is 'should be divided' or 'should not be divided' (the dative inflection of 'by the common functions' makes it clear that we are continuing to discuss rules of division). The previous sentence's main thought is positive—'one should divide'—but a negative example—'and ⟨should⟩ not ⟨divide⟩ . . .' is then appended. Most editors and translators have felt the need to amend the text by adding a negated verb. Düring (1943: 107) suggests making this part of the previous sentence, so as to read '. . . and one should not divide the one by swimming, the other by colour, and in addition to these . . . not by the common functions'. Whether we follow Düring's punctuation or not, his main point stands; the thoughts are so closely tied by syntax that the negation should be supplied.

$643^a35$–6: 'by the common functions of the body and of the soul'. This phrase might mean (1) 'the general bodily functions and the general soul functions', (2) 'the functions shared by body and soul', or (3) 'the functions of the body and soul shared by the same animal'. In favour of (1) is the fact that this is the meaning of 'common' throughout this discussion; in favour of (2) Aristotle uses this phrase to designate a special class of affections peculiar to animals in his treatises on the soul, on the senses, and on waking and sleeping (*Sens.* 1, $436^a7$, $^b2$; *Som.* 1, $453^b13$; *An.* III. 10, $433^b20$); in favour of (3) is the fact that this is the point his examples seem to make. Further weight is given to (2) by the fact that this rule is explicitly restricted to ensouled things, whereas the two previous 'rules' were quite general; however, the examples Aristotle gives are not the sorts of properties he refers to elsewhere as psychosomatic (cf. Balme 1992: 116; and Balme 1987*b*: 76 n. 6).

On the other hand, the examples favour (3), since they both make one simple point—walker/winged and wild/tame may be opposed differences, but a dichotomist must not use them, since they are found together in one and the same form of animal. Note the explication which follows: 'for there are certain kinds to which both ⟨the opposed⟩ differences belong and that are flyers and wingless' ($643^b1$–3). These are common attributes because they associate in one kind. This use of 'common' (*koinon*) to mean 'shared' is possible (cf. LSJ s.v. *koinon*, II.2.b, IV.2), though unusual in Aristotle outside of political contexts.

$643^b2$–3: 'and which are flyers and wingless, just like the ant kind'. For consistency's sake I translate 'flyers' both here and at $^b1$, where the contrast is with 'walkers'. However, the word can mean both 'winged' and 'flyer', and both at $642^b34$–5 and at *HA* IV. 1, $523^b19$–20, the ants are said to be both winged and wingless.

$643^b7$–8: 'if homonymous, has not been divided apart, and if these are one in form'. While Aristotle uses 'homonymous' technically to mean two things which are different in account but have the same name (*Cat.* 1, $1^a1$–8), normally it simply means 'have the same name'. Taken thus, the point here is clear: if wild and tame horses have the same name, then they have not been divided. If, furthermore, they share the same form, then they should not be differentiated by the difference wild/tame, for this will then divide up animals which are the same in form. Again, this is on the assumption that only one difference will be used, and that it is being used to grasp the particular forms of animal. This example then makes the same point as the previous one.

## $643^b9–644^a12$

The criticism of dichotomy has not been a mere negative polemic—Aristotle has been after a way of using division that really can be useful in grasping the natures of the kinds of animals. Platonic dichotomy is not useful for this purpose. Aristotle now suggests two revisions in method that together will be helpful in deploying division in the scientific investigation of animals.

$643^b12$: 'Each of these has been defined by many differences, not according to dichotomy.' Popularly identified groups such as 'bird' and 'fish' are defined, not by one difference, but by many—birds are blooded, egg-laying, two-footed, winged, feathered, have beaks, and so on. It gradually becomes clear (especially at $643^a23–8$) that Aristotle is still thinking of a method aimed at 'grasping the particulars'. When he says we should 'try to take the animals by their kinds', he is thinking of trying to grasp the forms of birds ($^b26–7$) under the kind bird—and that means we must consider this kind as consisting of many general differences ($^b23–4$), and divide all of them.

$643^b13–17$: 'either altogether impossible . . . or there will be only one difference'. This passage confirms the reading of the 'not easy or impossible' distinction offered in the notes to $642^b6–7$. But as Aristotle considers the 'one difference' method as applied to animals here, he eventually decides that as practised by dichotomy, it also cannot be used to grasp the particular (see $644^a8–11$).

$643^b16$: 'the result of interweaving' (cf. $643^b30$, 31–2; $644^a4$). The Greek word here translated 'interweaving' (*sumplokē*) is the word used by Plato in the *Sophist* (cf. 259 E 4–6) to refer to the 'interweaving of forms' which it is the task of dialectic to grasp (cf. Ackrill 1955). That this task is accomplished by division is clear (cf. 253 D–E; Stenzel 1940: 96–106; Lloyd 1954: 227–8), so that Aristotle's language here, in the midst of a critique of dichotomy, may be intentional. But the precise method of interweaving described here is not, at least not obviously, what is at issue in the *Sophist*.

$643^b17$: 'difference of the difference'. A single line of division should specify determinations of some more general difference—to use the example Aristotle gave us early in chapter 1, flying, swimming, walking, creeping are determinate forms of locomotion ($639^b2$–5), different ways an animal may move from place to place. The contrasting method can be found in the divisions of Plato's *Sophist* and *Statesman*: divide animal into wingless/winged, winged into tame/wild, etc. ($643^b19$–23). It is quite legitimate, Aristotle says, to treat the question of an animal's potential for domestication as 'the origin of another difference' ($^b22$–3); but the question of whether an animal is wild or tame is *incidentally related* to the question of whether it is winged or wingless. This example shows how dichotomists violate the rule of not dividing by what is incidental ($643^a27$–31), and also indicates how a multiple-division method can avoid the problem—it treats incidentally related differences as embedded in distinct divisions, rather than as stages of the same division.

$643^b18$: 'makes an account one by conjunction'. This gnomic expression is an Aristotelian commonplace. A central concern of *Met. Z–H* is how to ensure the unity of a definitional account of a substantial being. The standard characterization of definitions that fail to do so is that they merely *conjoin* elements, which is not a real unification. Cf. *Met. Z* 4, $1030^b9$; *H* 6, $1045^a13$. The elements of a proper division should be a unified series, and in fact Aristotle presents division as one way to avoid 'conjunctive accounts' at *Met. Z* 12, $1038^a25$–36.

But by beginning division with a multitude of general differentiae, Aristotle has created a new problem of unity peculiar to his own multi-differentiae theory of division, a problem of *horizontal* unity (Gotthelf 1999: 47–8). Why is the conjunction of the general differences characteristic of birds—beak, feather, biped, wing, egg-laying, etc.—not just as incidental as the conjunctions he criticizes the dichotomists for making? They are not part of one division, and certainly no one of them logically entails any other, in the way two-footed entails footed. Allowing that bird is 'defined by many differences' ($643^b12$), why is that not terrible news for a philosopher who wants definitions to reflect the unity of the beings defined? Indeed, David Charles argues that 'the study of biological kinds precipitated a crisis in Aristotle's thinking about definition' (Charles 2000: 312). It is puzzling that Aristotle nowhere explicitly addresses this question (though Furth 1988: 249–68 thinks an answer can be constructed from *Met. H*).

$643^b24$–5: 'privations will produce a difference'. If one starts with many general differences straight away, it will not matter if one line of division ends at the general level, as is likely with privations, since one can continue down through more and more determinate differences with the other, positive differentiae.

$643^b30$–$644^a7$: 'split-footed . . . multi-split-footed . . . two-footed . . . footed . . . many-footed'. The use of the various 'foot' divisions in this passage should alert the reader to be careful to attend to the point of each illustration. For example, 'split-footed' is used as the last difference in a line of division at $644^a3$–7, and also as an example of both a simple difference and a member of a complex unified division; while at $643^b30$–3 it is used first as a difference with no further difference, and then as a difference further differentiated into 'many-split-footed'. These are examples used for philosophical purposes, and the fact that Aristotle actually uses these terms in his biological practice is not sufficient warrant for treating each division as representing Aristotle's biological views about the division of footedness.

$644^a4$: 'or the entire complex'. The word I have translated 'complex' (for lack of an English equivalent) is an abstract noun referring to the result of interweaving.

$644^a6$–11: 'many differences that are not under a single division'. The upshot of this final argument, then, is that dividing by 'difference of a difference' is a necessary condition of proper division, but it is not sufficient, at least not in the case of complex beings like animals. One must be prepared to divide by 'difference of a difference' every general difference belonging to the kinds marked off by popular usage. How, then, does one identify these kinds, and their general differences—for doing so appears to be a precondition of using division for grasping particulars? These are among the concerns taken up next.

## CHAPTER 4

### $644^a14$–$644^b22$

This chapter deals with a question that is implicit in the discussion of division, namely, how are we to identify the general kinds that are presupposed by this new, multi-differentia method of division? How general should these kinds be, and how do we know when we have identified a kind at that level? Aristotle recognizes that these questions are intimately connected to the unanswered question he began this methodological enquiry with: should we study the natures of particular kinds of animals independently, or should we study them according to general attributes they share in common? Here he deals with these two closely related questions in a philosophically intense discussion.

$644^a14$–22: 'One might be puzzled'. This passage raises an aporia or puzzle about the common practice of not naming as a single kind animals which have merely analogous likenesses—e.g. the flyers and water-dwellers. Aristotle defends common practice on the ground that one should treat animals as members of a single kind only if their differences are a matter of degree, or 'more and less' (see Lennox 1987*b*; Pellegrin 1986: 84–6). If their likenesses are only analogous, you should keep them separate.

644a14–15: 'For there are some affections common both to these'. All Aristotle has done so far to give content to the notion of 'kinds with many differences' that are to be the starting-points of division is to say that they 'have a likeness' (642b14–15) and that certain ones have been correctly defined by the many (643b10–12). Thus this puzzle has real bite—do we simply put everything 'with a likeness' together? If so, why not the water-dwellers and flyers?

644a16–22: 'that differ by degree and the more and the less . . . while those that are analogous'. In order to deal with the above puzzle, one needs to distinguish degrees of similarity and difference. Aristotle makes extensive use of the distinctions introduced here, and there is a more detailed discussion of them at *HA* I. 1, 486a14–487a10. (Cf. Lennox 1987*b*; Pellegrin 1982; 1986; Furth 1988: 106–9.) From this passage and 645b3–28 below, it is clear that the following distinctions are made:

(1) *Analogous likeness*: comparable, but differently designated, features of different kinds.
(2) *Kindred likeness*: features with a common designation belonging to a single kind.
(3) *Formal likeness*: features with a common designation restricted to a single form of the kind.

We might imagine that by *analogous* likeness Aristotle has in mind that while the parts are *structurally* different, they play *functionally* similar roles in their respective animals (cf. Le Blond 1945: 178). But Aristotle never says that this is his point, and the examples here do not require it. Fish spine is similar to bone both in terms of texture and position; and scales are all over the outside of a fish's body, just as feathers are all over the outside of a bird's—they are comparable in ways that are independent of understanding their biological function.

What does it take for a *kind* to differ in degree or by analogy, as Aristotle allows here (644a16–22)? The examples suggest that they do so because their *parts* do. But *how many* such differences of degree, and of what sort, do there have to be between two different animals before they should be treated as members of a kind? And how does one know when parts are so different that they should be viewed as differing by analogy rather by more and less? These are not questions Aristotle explicitly addresses.

Another question this analysis of 'kind' raises is the extent of its 'level neutrality'. As we have seen, Aristotle identifies groups which he calls extensive kinds, such as the soft-shelled bloodless animals (cf. *HA* IV. 1, 523b2–6). But these kinds have kinds, such as lobsters and crabs (cf. *HA* IV. 2, 525a30 ff., *PA* IV. 8, 683b25–9). When the time comes to make comparisons between lobsters and crabs, what form will these comparisons take? In so far as lobsters and crabs are forms of crustacean, we might expect them to differ only in degree; but in so far as each is a kind with its own forms, perhaps they are only alike by analogy (cf. Pellegrin 1986: 88–94; Lennox 1984*b*: 73–7).

The most extensive discussion of this question has been that of Pellegrin (1982; 1986) ch. 2. Briefly, his conclusions are that the vocabulary of analogy and more and less is logically tied to that of kind, form, and difference; and that this entire network of concepts operates at a variety of different levels, so that a relation described as one of analogy in one text may well be described as one of degree of difference in a kind in another. And apart from shifts in the generality of the kinds being discussed, there are also shifts in whether kinds or parts are being discussed—bone, fish spine, and cartilage may themselves differ only in degree, but play analogous roles in different kinds (see the examples and discussion in Pellegrin 1986: 84–90).

The gravest problem for Pellegrin's account presented by our passage is that the technical distinction between 'differing by the more and less' and 'differing according to analogy' is used to determine when groups, such as bird and fish, have been correctly identified. As I have argued elsewhere (Lennox 1990), Aristotle appears to have a systematic method for identifying his 'extensive kinds', and this distinction seems to be central to that method. If this is true, then this distinction would appear to be more independent from that between form and kind than Pellegrin's analysis would suggest (for further doubts see Lloyd 1996: ch. 7; Wilson 1997).

644a23–8: 'Since, however, it is the last forms that are substantial beings'. This is a difficult passage that has been variously translated and interpreted. The 1992 reprint of Balme (1972) revises his original translation and note, in accordance with suggestions of his quoted in a review (Longrigg 1977: 39); see Balme (1992) 168. The first step in interpreting the passage is to focus on the inference being made:

> The last (i.e. most determinate) forms are substantial beings.
> Such substantial beings are the same in form.
> Therefore, they must either be discussed in general or repetitiously.

This implies that substantial beings will *not* differ in respect of form. Socrates and Coriscus are thus examples of things that do not differ in form (cf. *Met.* Z 8, 1034a5–8). If, then, we are going to speak of each being separately, we shall repeat information about their form each time. It is therefore preferable to speak about them in common.

$644^a28$: 'There is, however, a puzzle about'. The puzzle raised at $639^a15$–$639^b3$ is that if we take as our subject-matter beings which are formally different, since these will share many attributes in common we shall constantly repeat ourselves. So now we must ask whether we may also discuss *kinds* in common as well, and not just animals of the same form. Typically, Aristotle's answer is: yes . . . and no.

Metaphysical considerations might incline us to study each indivisible form of a kind, such as bird, individually. For formally indivisible beings are most real, while what is most universal is furthest removed from reality (cf. the analogous worries of *An. Post.* I. 24; and on the conflict between being and universality, *Met. B* 6, $1003^a5$–17; *Z* 13, $1038^b10$–12).

But from the standpoint of methodological economy, this will be silly and long-winded—the same attribute often belongs in common to many forms, so that, taking each form individually, we shall end up repeating ourselves. The solution is in the recognition that not everything does in fact fall under a wider kind. Where there is a true kind, whether it has been named or not—that is, where there is one nature, common to a number of closely allied forms—we should investigate the forms in common, kind by kind. Otherwise, we should study the formally indivisible being. Human beings, for example, do not fall into any of Aristotle's extensive kinds—there is not a variety of formally different, two-footed, viviparous animals, no common kind to discuss.

The only problem with investigating 'being by being' mentioned here is needless repetition—but there may be a more serious problem at issue. *Posterior Analytics* argues that certain properties belong to their subjects as kinds, rather than as forms of a kind. The possession of interior angles equal to two right angles, for example, belongs to determinate forms of triangle (such as scalene or equilateral) only because it belongs to all triangles as such. Therefore, only when we understand the causes of its belonging to triangles as such shall we understand why scalene triangles possess it (cf. *An. Post.* I. 4, $73^b25$–$74^a3$; 5, $74^a12$–$74^b4$; 23, $84^b3$–18; 24, $85^b4$–14). This provides a much more powerful reason for seeking to grasp common attributes according to kind, rather than case by case.

$644^b3$–4: 'a single common nature and forms in them not too distant'. The stress in this passage should be placed on the fact that the kinds here mentioned are those that people have clearly delinated. Nothing here implies that all kinds identified by people have been clearly defined; in fact, Aristotle goes on to specify criteria for doing so. Further, he goes on to stress that there are other animals that people have *not* identified as kinds which nevertheless meet these criteria and thus should be discussed in common.

The criteria noted are that the animals share a common nature, and that the forms of the kind 'not be too distant'. What, then, counts as a common nature, how do we identify such a thing, and what makes forms closely allied to each other? Aristotle does not explicitly answer these questions, though there are the materials here and elsewhere to construct an answer. For different interpretations of these materials, compare Charles (1990) and the reply of Lennox (1990). Briefly the interpretation that guides the notes to follow, outlined in Lennox (1990), is this. The enquiry represented by the *Historia Animalium* is primarily a product of multi-differentia divisions and the identification of universal, and where possible commensurately universal, predicative relations among divisional differences. These divisional and predicational relationships provide the materials for causal explanations as well as for the identification of scientifically important kinds. Such a kind is one that (*a*) shares many differences at the same level of generality (providing evidence of a common nature) and (*b*) shares differences that vary only in degree among the different forms of that kind (the forms thus being 'not widely separated'). At this stage of investigation, we have grasped that there is a common nature. To go on to understand what that common nature is, one must have a fully articulated causal understanding of how certain of these differences, especially the functional capacities associated with the kind's way of life, explain the others. For a recent critical response to this view see Charles (2000) 316–30.

$644^b5$: 'though it is unnamed'. The soft-bodied and the hard-shelled animals mentioned just below lack proper names in Greek. But they meet the criteria for being studied in common, as kinds are. See the similar language at *HA* IV. 7, $531^b20$–5; VIII (IX). 40, $623^b5$–13; *PA* III. 6, $669^b8$–12; the issue of unnamed kinds is discussed in Lennox (1987*a*: 114–18). *An. Post.* I. 5 notes that failure to discover the kind to which an attribute belongs *per se* may be due to failure to recognize by name the more general kind (*An. Post.* I. 5, $74^a4$–12; cf. 14, $98^a13$–19).

$644^b7$–13: 'by the figures of the parts and of the whole body'. The account of similarity and difference in animals in *HA* I is more detailed, but complementary to this one. There too it is insisted that animals differ 'first and foremost in virtue of their parts' ($491^a14$–19). But it is stressed that animals also differ in virtue of their manner of life, actions, and character traits, and when the discussion of these other differences begins, the machinery of identity and difference in form, kind, and by analogy is extended to those differences (cf. *HA* VII (VIII) 1, $588^a16$–$^b12$). At $645^b20$–$646^a1$ Aristotle introduces differences in actions corresponding to the differences in parts mentioned here. The tense and mood of the verb suggest that Aristotle is here focused on how people actually mark off kinds.

$644^b13$: 'but rather by bodily affections'. This adds some content to the notion of more/less differences. These are measurable variations of the perceptible qualities (affections) of parts. So we might first identify the beak, and then discuss variations in beaks of width, hardness, length, curvature, and so on. For this method in practice see *PA* IV. 12, 13.

$644^b15$–22: 'We have said'. While in general this conclusion describes the previous discussion, it provides no detail at all. If it were removed, along with the clearly independent first section of chapter 5, $644^b22$–$645^a36$, the remainder of the fifth chapter would be a fitting conclusion to this discussion. There appears to have been some 'cutting and pasting' done here.

## CHAPTER 5

### $644^b22$–$645^a36$

This justly famous defence of the value of the study of animals is quite independent, both syntactically and stylistically, from the rest of *PA* I. It argues for the legitimacy of a causal/theoretical study of animals on two distinct grounds: (1) its objects, while in some respects less noble than those of astronomy, are more accessible to investigation ($644^b22$–$645^a4$); (2) while less noble than the eternal celestial objects, when studied properly they have a nobility of their own which is often missed ($645^a4$–36).

$644^b23$–24: 'some are ungenerated and imperishable . . . others partake of generation and perishing'. This distinction is *within* the class of naturally constituted objects, so that it is presumably the heavenly bodies with which 'the animals and plants around us' are being contrasted. Aristotle typically ascribes divinity to an object in virtue of its eternality (e.g. *Cael.* II. 1, $284^a2$–10; *An.* II. 4, $415^a29$; *GA* II. 1, $731^b24$; Lennox 1985*c*: 68–76).

$644^b31$–$645^a4$: 'Each study has its attractions.' Two scales of value are used to compare the objects of natural science—intrinsic honour or divinity, and knowability. The heavens are higher on the scale of divinity, the perishable animals and plants are higher on the scale of knowability. This is one of Aristotle's strongest assertions of the centrality of extensive perceptual experience in developing scientific understanding of nature.

This argument is bound to strike us as odd, even if we grant the premiss that the stars and planets are eternal. Why should an object of scientific study be valued more highly even if we grant that it is eternal?

In responding to this question, it is important to recall that Aristotle stands in a tradition that flows from Parmenides through Plato, according to which what is and cannot not be—what *eternally* is—is of higher value than what is transient. The higher value of the eternal objects rests in the fact that they always *are*, and being is causally prior to coming to be. Aristotle accepts this priority of the eternal to the changing in two respects. In *Phys.* VIII. 4–6 and *Met.* *Λ* 7–10 he argues that there must be an unchanging origin of change; and in a variety of texts, some of which we have already discussed, he argues that coming to be is for the sake of being—that is, that particular cases of coming to be are causally dependent on a goal which is an actual being (cf. $640^a18$–19, $641^b31$–32; $640^a15$–19 note). The Platonic question, 'Now which of these shall we say exists for the sake of which? Generation for the sake of being, or being for the sake of generation?' (*Philebus* 54 A 7–9), is answered, as we saw above, in the Platonic mode in *PA* I: 'For generation is for the sake of substantial being, rather than substantial being for the sake of generation' ($640^a18$–19).

Another verbal echo of the *Philebus* is heard later in our passage. In that dialogue, that for the sake of which things come to be is said to be 'in the place of the good': 'Now that for the sake of which what is always coming to be will be coming to be for, *that* is in the place of the good; while what comes to be for the sake of something must, my good man, be located in another place' (*Philebus*, 54 C 9–11). Here, Aristotle says virtually the same thing about the coming to be of animals: 'the end for the sake of which each animal has been constituted or comes to be takes the place of the good' ($645^a25$–6). For both Plato and Aristotle, then, being is the goal of coming to be, and for that reason is valued more highly. But Aristotle goes further, and (in an echo of Diotima in Plato's *Symposium*) insists that organic reproduction takes place in order to allow transient living things to have one foot in the eternal realm. The following passage, from *GA* II. 1, is worth quoting in full as a clear statement of each of the themes in this note (for a fuller discussion of its import, cf. Lennox 1985*c*: 68–76):

> For since some existing things are eternal and divine, while the others are capable both of being and of not being, and since the good and the divine is always according to its own nature a cause of the better in things that are capable, while the non-eternal is capable both of being and of partaking in both the worse and the better, and since soul is a better thing than body, and the ensouled than the soulless because of the soul, and being than not being, and living than not living—for these reasons there is a generation of animals. For since the nature of a kind of this sort cannot be eternal, that which comes into being is eternal in the way that is possible for it. Now it is not possible in number (for the being of existing things is in the particular, and if it were of this sort it

would be eternal) but it is possible in form. ($731^b24$–$732^a1$, and cf. Plato, *Symposium*, 208 A–B)

$645^a1$–2: 'take the prize in respect of understanding'. This is a remarkable statement of Aristotle's empiricism. It is in line with *An Pr.* I. 30, $46^a17$–22, which claims that the principles of astronomy are provided by experience with the perceptual phenomena, and then generalizes the claim to all sciences and arts.

$645^a4$–36: The cascade of elevated expressions should be noted: 'provides extraordinary pleasures' ($^a9$), 'prizing even more' ($^a14$), 'something marvellous' ($^a17$), 'in every one . . . something natural and good [*kalon*]' ($^a23$), 'takes the place of the good [*kalon*]' ($^a25$–6). These remarks, together with the story about Heraclitus, the reminder that we ourselves are of flesh and blood—not to mention the elegant balance of the prose—make this a consummate piece of rhetoric. It is also quite unlike the rest of *PA*.

$645^a17$–18: 'Heraclitus'. We have no other evidence for this anecdote. For a thorough discussion of interpretations of the passage see Gregoric (2001) 73–85.

$645^a10$, $^a15$, $^a25$, $^a33$–5: 'for those who are able to know their causes'. In all these passages Aristotle stresses that the value of the study of the nature of animals comes from its philosophical, i.e. theoretical, focus. To the senses, blood is, perhaps, a disgusting object of study; but to study its causal role in cognition, in desire, as the final nourishment of the animal, the ways in which its differences influence an animal's character, this elevates it to a marvellous and beautiful thing, the study of which should provide great pleasure to the philosophically inclined.

## $645^a36$–$646^a1$

As I have indicated, the previous discussion, beautiful though it may be, appears to be an intrusion in the flow of *PA* I. This section returns to the discussion of the appropriate principles and methods for the study of animals. It can be seen as a systematic attempt to integrate the discussion of division, similarity, and difference with the teleological conception of animals defended from $639^b14$ to $642^b4$.

Animals are unities of body and soul, i.e. of parts and functions. If there are zoological universals they will, then, come in pairs—every function will either be a function of the whole body or of some part; and every part, and the body as a whole, comes to be and exists for that function. Our divisions of the various general features of animals will thus be two-sided. In order to explain the structural or material differences of organs or tissues in different kinds of animals, it must be demonstrated that the organ *must* be structured in a certain way *in order to* function as it does. And if one function is physiologically subordinate to another, there will be a similar subordination of the corresponding parts.

$645^b1$–3: 'first to divide the attributes . . . and next to try to divide their causes'. This is a puzzling recommendation, since one of the rules of division ($643^a27$) was *not* to divide by such attributes, but only by attributes in the substantial being of the kind. But as we saw earlier, that rule simply prohibits the introduction of something into a line of division that is incidental to that line. Here, where we might be operating with two or more distinct lines of division, the above distinction is acceptable. This distinction may look forward to the causally related similarities and differences, between and among parts and soul functions, discussed from $645^b29$ to $646^a1$ (on this passage see Gotthelf 1997*b*).

The same general contrast, between a study of the attributes and the *attempt* to study the causes—with the same stress on the more problematic nature of the latter study—is found also at *HA* I. 6, $491^a7$–11: 'first *grasp* the attributes and differences, then *attempt to discover* the causes'.

$645^b4$–13: 'many common features belong . . . some without qualification . . . others analogously'. This passage continues, within a divisional context, the discussion of speaking of common attributes by kind in order to avoid repetition, even referring back to the previous conclusions ($645^b10$–12). Previously, Aristotle distinguished features that are common to kinds, but that differ by more and less, from others that are analogous. Of the three attributes described here as common without qualification, at least two (feathers and scales) are said to differ from each other by analogy and to vary within their kind by more and less. So features which are 'common without qualification' may vary by more and less. Second, we see analogously common features demarcated in two ways: (1) by noting the proportionality relation involved, and (2) by noting that the one part may provide *the same potentiality* ($645^b9$) to one kind which its analogue provides to the other kind.

$645^b16$: 'each of the parts of the body is for the sake of something'. This paragraph brilliantly ties two threads of *PA* I together. As we learnt from chapter 1, Aristotle views the *psuchē* or soul, not as a distinct sort of substance 'animating' the body, but simply as the special capabilities of a body with organs. Each organ develops and exists to perform a specific function, and the organism as a whole develops with the ability to perform the unified set of functions that we call the organism's life. As he sums up here, 'the body too is in a way *for the sake of* the soul, and the parts are *for the sake of* the functions in relation to which each has naturally developed'. Certain natural objects exist in part *because of* the actions or functions they perform. To say that an animal has eyes for the sake of sight means that sight is one fundamental reason why that animal's development included the formation of eyes (Cooper 1987; Gotthelf 1987*b*; Sorabji 1980: pt. III; Waterlow 1982).

$645^b16–17$: 'it is apparent that the entire body too'. This argument, like the so-called 'function' argument of *EN* I. 6, $1097^b24–1098^a8$, appears to commit the fallacy of composition (see $642^a11–13$ and note, above). The argument appears to be that every instrument is for an action; that parts, being instruments, are thus for specific actions; and therefore that the whole body composed of these parts is for a single action. The easy way of removing the fallacious taste would be to take 'complete action' to mean simply the composite of all of the parts' actions. But Aristotle later replaces 'complete action' with 'soul', strongly suggesting a single, unified end served by the body.

The saw example, following this argument, seems intended to support its conclusion; but this example is singularly unhelpful—it is more like an eye than an entire body, composed of many parts with many functions.

Thus while *De Anima* has an argument for the unity of the soul—for treating it as a single, 'first complete actuality' of the organic body—we are not given that argument here, so that this argument is quite weak.

$645^b20–7$: 'the actions—those common to all, those according to kind, and those according to form'. Aristotle now imposes the levels of generality distinguished with respect to parts upon the actions that they perform. Given what he has said previously, we would expect him to tie this back to the opening remark about distinct divisions, of attributes and causes. This connection is never explicitly made, however. But it will be argued, in the notes that follow, that Aristotle does often run parallel divisions, of general functions and of general parts, showing how determinate variations in parts are for the sake of performing determinate variations in function.

The language here is somewhat confusing. 'Common' is spelt out in terms of what *belongs* to all the animals, which presumably means an action or part. Both 'according to kind' and 'according to form' refer, however, to the animal, not the attribute—to bird, or human being. But the first sentence makes the intent clear. Aristotle wants to distinguish actions common to all animals, actions belonging to all the members of a kind, and actions belonging to all the members of a form of a kind. This understanding is confirmed by $^b$26–8—where *actions* are distinguished by reference to whether they belong analogously across all kinds, or within a kind, or within a form.

645$^b$25–6: 'without any difference according to its general account, "according to form"'. With this remark one should compare 644$^a$23–8. This does not mean that things that are one in form are indistinguishable in any way whatever, but only that *the general account* of their form is identical. There are many accidental features that would distinguish one from another, but these would not enter into a general account of their form. That there is a common general *account* of their form does not entail that there is a common, general form.

645$^b$28–33: 'actions . . . those things whose actions they are'. Aristotle envisages at least the following teleological relationships ($\rightarrow$ = 'is for the sake of'):

(1) $\text{Action}_1 \rightarrow \text{Action}_2$
(2) $\text{Part}_1 \rightarrow \text{Part}_2$
(3) $\text{Part}_1 \rightarrow \text{Action}_1$

One other relationship is discussed, which seems akin to the type of non-teleological necessitation allowed for at 640$^a$33–$^b$4 and 642$^a$31 (see notes):

(4) $Z$ is necessarily present because $X$, $Y$ . . . are.

The four explanations can be illustrated by Aristotle's theory of respiration, as follows:

(1) Breathing, i.e. taking in and expelling air, is for the sake of cooling.
(2) The windpipe exists for the sake of the lung.
(3) The lung exists in order to cool the blood.
(4) The expansion and contraction of the lung are necessary because air is being taken in and expelled.

As Balme (1992: 124) notes, this last category is stated so obscurely that it may also be intended to cover more incidental by-products—useless by-products of nutritive activity, or the colour of a part where the colour arises necessarily owing to the developmental processes involved, but plays no functional role in the organism's life.

645$^b$33–646$^a$1: '"affections" and "actions" . . . and "parts"'. This distinction is not made with care. In chapter 1 sleep and growth were referred to as affections (639$^a$20), i.e. as *passive* capacities of living things; and generation (i.e. reproduction) and coition (copulation) are discussed in the section of the *Historia Animalium* devoted to activities. But here there is no attempt to distinguish them. Similarly, while Aristotle is about to give us, in the first chapter of Book II, a systematic way of distinguishing animal parts, there is no such attempt here.

# BOOK TWO

## CHAPTER I

### $646^a8$–12

Book II begins with connective particles indicating a transition, and the first paragraph continues the thought of the last lines of Book I. Whether this reflects Aristotle's actual order of thought, of writing, or of teaching we shall probably never know. Nevertheless, a strong case can be made that Books II–IV reflect the philosophical standards that are articulated in Book I.

The opening paragraph also indicates that this is the beginning of an enquiry into the causes of facts exhibited more clearly in certain animal enquiries (*historiai*). It then takes the first steps of that causal enquiry.

$646^a8$–12: 'in the enquiries'. Cf. $639^a12$–15 note on *historia*. The reference may be to the books passed down to us as the *Historia Animalium*, or to something that eventually served as their basis. *HA* I. 7–IV. 8 records information about animal parts and their differences, organized most broadly in terms of the distinction between uniform and non-uniform parts, the very distinction with which this causal enquiry begins. These enquiries, or 'histories', are said to exhibit the facts about animal parts more clearly—more clearly than in *PA* II–IV, presumably. As Balme points out (1991: 21–2), this is seldom true of our *Historia Animalium*. As noted in my introduction (p. xiv), Balme's detailed comparison of *PA* and *Historia Animalium* led him to propose the hypothesis that facts presented in *PA* II–IV served as part of the basis for *HA* I–IV, a hypothesis I explore in Lennox (1996*a*).

'How many' might mean how many *parts*, but it fits better with what we actually find in *HA* if it means how many of a *given* part (e.g. how many legs, wings, or gills). On the distinction between the presentation of such facts (*to hoti*) and their explanations (*to dioti*), cf. $639^b5$–10 and note; *An. Post.* II. 1.

### $646^a12$–$647^b9$

The explanation of the uniform parts begins with a compositional account of animal parts—from the most basic material level up to the whole animal—which is then followed by a causal account. A case is made for the teleological priority of instrumental parts or 'organs' over uniform parts or 'tissues'. The remainder of the first chapter depends heavily on a set of complexly related divisions among parts: into uniform and non-uniform, simple and composite, and instrumental and sensory. A discussion of sensory parts leads into a discussion of the heart, the ultimate seat of sensation, and this leads to a consideration of its character as one of the viscera. The second chapter then returns to the initial distinction between uniform and non-uniform, and begins the lengthy account of the uniform parts of the blooded animals which makes up the next eight chapters of Book II.

$646^a12$–24: 'three compositions'. According to Aristotle's 'chemical' works—*GC* II and *Meteor.* IV—each of the so-called 'four elements' is constituted of two potentials, one each from the oppositions hot/cold, moist/dry (cf. $640^b8$–11 note). These potentials never exist independently, but they must be analytically distinguished because it is in virtue of changes in them that one element becomes another—if water (cold/moist) is heated sufficiently, it becomes air (hot/moist). Aristotle here appears to substitute these contrary potentials for the elements as 'the matter of the composite bodies', while a variety of other potentials are said to 'follow' these primary potentials. For the contaries as matter, cf. *Meteor.* IV. 1, $378^b32$–$379^a2$; 10, $388^a22$; *Long.* 5, $466^a21$–3. *GC* II. 2 provides an argument for the primacy among contraries—assumed here—of hot/cold, moist/dry. *GC* II. 1–4 is a detailed discussion of the relationship between the four elements and the four contraries. (Cf. Gill 1989*a*: chs. 2–3; Furth 1987: 32–7; 1988: 76–83.)

Of the first composition, we are told that the four potentials are the matter of the composite bodies, but we are not told explicitly what the composite bodies are. Of the second, on the other hand, we are told what the composites are—the natures of the uniform parts—but the components are simply referred to as 'the primaries', which could be either the primary *composites* (i.e. the four elements) or the primary *potentials*. The discussion would be consistent if:

(1) the four primary potentials form the four elements, and this is the first level of composition;
(2) the primary *bodies* (i.e. the four elements) compose the nature of the uniform parts;
(3) the uniform parts in turn compose the non-uniform parts.

Initially it might seem surprising that Aristotle does *not* mention (as he does at $646^b10$) animals being constituted from their parts. But this analysis is to serve as the basis for a causal study of animal parts, of which non-uniform parts are most complex.

In the discussion of uniform parts, then, Aristotle appears to see the four *potentials* as the basis of material explanation. From the standpoint of causal explanation, these are primary. Further, since there is no stage of biological development when the uniform parts are actually composed from the elements (development begins with blood or its analogue), it is the four causal powers rather than the elements that are relevant. Thus preliminary to the discussion of the uniform parts which begins in chapter 4, chapters 2 and 3 enquire into the different meanings of hot, cold, moist, and dry (cf. *Meteor.* IV. 10, $388^a20–6$; $389^a8–9$). Throughout those chapters the implications of the discussion for a proper understanding of blood—the primary uniform part—are a constant focus.

$646^a25–{}^b4$: 'for things posterior in generation are prior in nature'. This is actually one extremely long sentence, beginning with a 'Since . . .' (*epei*) which is not answered for ten lines. The intervening lines provide both inductive and deductive justification for the antecedent clause. For an exactly similar construction see *Meteor.* IV. 1, $378^b10–27$.

A number of related principles argued for in *PA* I. 1 are presupposed here, without which this passage is hardly intelligible:

(1) Goals are naturally prior to processes leading to them, because they are in fact the *causes* of those processes. ($639^b11–14$)
(2) The *goal* of coming to be is the *nature* of the developing thing, its form and its substantial being. Coming to be *is for the sake of* being. ($640^a18–19$; $641^b23–642^a1$)
(3) This causal priority underwrites a *priority in account* of the 'shape' and being of each thing (cf. $639^b14–19$), because *scientific accounts specify causal primaries*, and in the case of things which come to be and pass away, it is the *form* that is the causal primary. ($640^b28–9$; $641^a14–31$; $642^a13–17$)

This passage is hardly intelligible without *PA* I.

$646^a28–9$: 'other matter'. Probably the matter of natural things, as opposed to that of artificial things mentioned here; compare 'the other generations', at $646^b5$ below.

$646^a30–1$: 'apparent . . . from a consideration of cases . . . also accords with our account'. Cf. $666^a13$, where the account is contrasted with what is clear to perception. 'A consideration of cases' translates *epagōgē*, traditionally rendered 'induction'. Aristotle is contrasting two sorts of support for his claim that the final outcome of a process is naturally prior to it: (1) generalizing from an apt example, and (2) deriving it from general philosophical principles previously defended. On the uses of *epagōgē*, cf. Ross 1949: 47–51, 481–5.

$646^a31–2$: 'from an origin to an origin'. On each of the causes—and in particular that for the sake of which and nature—as origins, cf. *Met.* Δ 1, $1013^a16–24$, and *Phys.* II. 1, $193^b11–18$.

646b10–27: 'the uniform parts are for the sake of the non-uniform'. Mature organisms possesses both uniform parts—tissues, the 'stuff' of the body—and non-uniform parts, which Aristotle refers to at the close of this passage as *instrumental* parts or 'organs' (the Greek adjective is *organika*). Temporal priority in development cannot be used to determine teleological priority—some organs are fully developed before some tissues (cf. *GA* II. 6, 742b10–11; 742b35–743a4). Aristotle provides a different way of deciding 'What is for the sake of what?' The actions and movements of animals belong primarily to the instrumental parts, hands, arms, and so on—we grasp, build, and dissect with these parts. (Eyes and nostrils pose a problem: see on 647a5–6.) But such activities are highly complex. Typing this sentence, for example, involves the co-ordination of the muscles, nerves, tendons, flesh, and bones of my hands and arms. This is because performing this activity requires a variety of opposed potentials. A single uniform part cannot possess opposed potentials. Thus an activity requiring a part which is both rigid and pliant, flexible and brittle, soft and hard, cannot be carried out by a single uniform part. Not all organs, however, require this sort of complexity to perform their functions (cf. 646b31–2; 647a1; a31–5).

646b27–35: 'how it is *necessary* that they be thus'. In the preceding argument tissues were said to be *necessary for the sake of* organs (646b5–6). But here, the necessity in question is contrasted with teleology. The necessity now being discussed is thus *not* conditional necessity (on which cf. 639b14–30 and note; 642a4–8 and note). But there is also a necessity deriving from the nature of uniform parts which prevents them (1) from performing complex actions and (2) from being made out of organs which can. It is this necessity that leads to the uniform and non-uniform being 'antecedently so related'.

647a1: 'simple and uniform . . . composite and non-uniform'. Each of these divisions marks a distinct contrast. The simple/composite distinction is based on the number of material constituents in an object—one indicating maximal simplicity. The uniform/non-uniform distinction—the Greek terms literally mean 'with like parts' and 'with unlike parts'—rests on whether or not a body is indefinitely divisible into like parts (cf. *HA* I. 1, 486a5–8). It is thus possible for there to be simple uniform, simple non-uniform, composite uniform, and composite non-uniform parts. See notes to 647a15, 647a31–5, and 647b17–20 for details. There is an interesting discussion of this and related passages in Furth (1987) 34–7 =(1988) 80–2, though he does not mention the fact that there are two distinct contrasts in these passages.

$647^a5–6$: 'perception occurs in every case in the uniform parts'. This does *not* say that the perceptual *part* is uniform, but that *perception* takes place in a uniform part. The sense-organ taken as a whole (e.g. the eye or ear) is not uniform, but that part of it that is essentially *receptive* of the perceptual form (e.g. the watery liquid or the air) *is*. I use the term 'sense-receptor' for the reception region of the sense-organ.

The distinction between instrumental and perceptual parts is surprising, given Aristotle's use of eye and nostril alongside hand and arm as examples of instrumental parts at $646^b13–14$. Perhaps it reflects the association of instrumental parts with animal *activity*, while perception is a *passive* capacity, a *being affected by* an object of perception—colour in the case of vision, sound in the case of hearing, and so on. (Cf. *An.* II. 6–III. 2, 12–13; and *On Sense and Sensible Objects*.)

$647^a15$: 'it is perfectly reasonable'. The Greek rendered 'reasonable' is *eulogos*. The arguments associated with this term are discussed in detail in Le Blond (1938). There are 27 uses of this term and its adjectival counterpart in *PA*. The pattern is virtually always the same: a general fact is stated, it is claimed to be reasonable, and that claim is backed up by an argument from principles already established that has the 'reasonable' fact as a conclusion.

$647^a16$: 'touch . . . a uniform part . . . the least simple of the sense-receptors'. Flesh (or an analogous part) is the 'perceptual part' in which touch arises. It may be 'the least simple sense-receptor' because it is 'most bodily', i.e. a *compound* of the elements—all other sense-receptors are air (within the ear and nostrils) or water (within the eye). Aristotle seems to see a relation between the fact that flesh is made of more than one element and its ability to be affected by more than one perceptible object, but no details are provided. (Cf. *An.* II. 9; and on the association of different perceptual parts with the four elements, *Sens.* 2, $438^b16–439^a5$.)

$647^a21–4$ 'Since it is impossible to be an animal without perception'. Cf. *An.* II. 3, $414^b1–7$. *PA* II. 8, $653^b19–27$, makes a related point: 'we define animal by the possession of sense perception, and primary in this account is the primary sense. This is touch.' *An.* II. 2, $413^a20–413^b10$, presents a hierarchical account of living capacities. The nutritive capacity is common to plants and animals, tactile perception to all animals ($414^b1–10$), and with it desire. Indeed, in the concluding chapter of *De Anima* Aristotle argues that animals deprived of touch would die (*An.* III. 13, $435^b4–18$).

$647^a25$: 'the perceptive, motive, and nutritive potentials are in the same part'. We are told this has been established elsewhere. Previous translators refer to *Som.* 2, $455^b34$–$456^a5$; yet it provides no argument, but only discusses perception and motion, and also refers us elsewhere. A more likely reference is *Juv.* 3, which provides an extended argument for the heart being the origin of both nutrition and sensation ($468^b28$–$469^b20$). That passage, however, refers to *PA*, and this may explain why previous translators look elsewhere; but the presence of such cross-references, provided they are on different issues (as here), poses no problem. There is no single passage that argues that the heart is the origin of all three capacities mentioned here. Perception and motion are mentioned in *De Somno*, nutrition and perception are argued to be functions of the heart in *On Youth and Old Age*, and the heart is argued to be the origin of movement in *MA* 10. As our text refers in the plural to other places, I lean towards taking the passages in *De Motu Animalium* and *On Youth and Old Age* as the origin for the doctrine here.

$647^a30$–1: 'in the bloodless animals the analogue of the heart . . . and in blooded animals it is the heart'. Cf. $642^b34$–5 note. The heart is the origin of *blood* and thus is not, strictly speaking, present in bloodless animals. But perception, movement, and nutrition are present in *all* animals, blooded and bloodless animals alike. So Aristotle infers that they must have an *analogue* of the heart. Aristotle's attempt to locate it can be seen at $681^b12$–33. On biological analogues cf. $644^a16$–22 and note. On the nutritional priority of the heart in development cf. *GA* II. 1, $735^a23$–6; 4, $738^b16$–17, $740^a16$–22; 5, $741^b15$–24; 6, $742^b36$–$743^a1$.

$647^a31$–5: 'divisible into uniform parts . . . yet because of the shape of its configuration, it is non-uniform'. This must mean that *qua* material it is divisible into uniform parts, but *qua* functional organ it is not. It is not made clear why the perceptual centre needs to be simple, since the simplicity of the individual receptors was based on their being the origin of perceptual *contact*. Likewise, while it is clear why its configuration would account for its non-uniformity, it is not clear why its being an origin of motion requires this.

The claim that the heart is both non-uniform and divisible into uniform parts rests on the fact that the visceral material is uniform throughout, while the heart has a number of features—its walls, chambers, valves—that make it structurally complex. (On the heart, see *PA* III. 4–5; cf. *HA* I. 17, $496^a4$–35; III. 3, $513^a8$–$515^a26$; *GA* II. 4–5; and Furth 1987: 34–6 = 1988: 80–2).

$647^a35$–$^b9$: 'Each of the other parts called viscera'. The rest of the passage concerns the heart's relation to the other viscera, on which see *PA* III. 6–IV. 4. They are mentioned here because, like the heart, each is composed of only one uniform part, yet in virtue of shape is non-uniform ($647^a34–5$; $647^b8–9$). From the material standpoint they are constituted of 'residual blood'—constructed analogously to islands built up in river deltas.

$647^b6–7$: 'is itself constituted of a nutrient such as it receives'. Though the Greek is, owing to its compressed form of expression, difficult, Peck's unsupported conjectures are unnecessary (cf. Düring 1943: 132). *GA* II. 4 raises an analogous puzzle about the heart—if blood is the nourishment for the animal's parts, and the heart makes the blood, what initially is the heart made from? There Aristotle notes that the material out of which the developing embryo is first formed is in fact a portion of the *mother's* menstrual blood, which the generative heat from the father transforms into a heart.

## CHAPTER 2

### $647^b10–648^a19$

This passage begins a long, detailed study of the uniform parts and the reasons why animals have them. As *PA* I. 5, $645^b1–5$, recommends, there is a differential division of the uniform parts based on proper attributes, and then an explanation of those differences based on the causes, especially the teleological causes, of those differences. (On the pervasiveness of this method in *PA* II–IV, cf. Gotthelf 1997*b*.) Though this practice apparently conflicts with *PA* I. 3, $643^a28–31$, which recommends dividing kinds by features in the substantial being *rather than* by proper attributes, it is possible to reconcile these two recommendations (cf. $643^a23–31$ note; and $645^b1–3$ note).

$647^b10–11$: 'some are soft and moist, while others are hard and solid'. The general account begins with a basic division of uniform parts along two axes: hard/soft, and solid/moist. The word I have rendered 'moist' is often—even often in this chapter—contrasted with 'dry', rather than with 'solid'. The parts Aristotle has in mind have two quite different features—tactile wetness (and the associated ability to increase the malleability of dry materials), and an amorphous character, their tendency to be shaped by their container. Thus when he begins to discuss the other side of this division, he refers to dry and solid parts. *GC* II. 2 explains that both solidity and dryness are opposed to the moist, and that hardness and softness are derivative properties ($329^b3–330^a24$; cf. *Meteor*. IV. 8). The division we are given here, then, conjoins a primary opposition—moist vs. dry/solid—with a secondary one, hardness vs. softness.

$647^b17–20$: 'the division of the uniform parts itself has a differentiation'.

This apparently refers to a further difference among the uniform parts. A characteristic of uniform parts is that, when divided up, the segments are called by the same name as the original whole, but some uniform parts follow this rule fully, others only to an extent. A part of a blood vessel is *blood vessel*, but not *a* blood vessel; a part of a bone is *bone*, but not *a* bone (cf. II. 9, $653^b32–654^b11$). It is unclear whether this is a subdivision found in both the moist and in the dry/solid uniform parts, or only in the latter (from which the example is drawn).

$647^b20–9$: 'many modes of cause'. Note that a division based on proper attributes is now followed by causal analysis, the method recommended at *PA* I. 5, $645^a36–^b3$. The uniform parts, *qua* uniform, are:

(1) Matter (both dry and moist) for the non-uniform parts,
  (*a*) contributing to substantial being,
  (*b*) contributing to functioning;
(2) nourishment for the non-uniform parts (moist);
(3) residues of dry and moist nutrients (both dry and moist).

In a sense, both (1) and (2) specify ways in which uniform parts may be the material cause (that out of which) of the non-uniform parts (cf. $651^a10–15$ and discussion); nevertheless, there is a clear distinction to be made. Blood, which Aristotle calls the final nourishment for the rest of the body, is directly the matter of the other uniform parts. It is matter for the non-uniform parts only because they are made directly from the uniform parts. So it appears that what Aristotle has in mind by 'as matter' here is the *constituent* matter of the organs, i.e. bone, flesh, sinew, nail, hair, and so on.

In (1) and (2) we see both material and teleological explanation in operation, though the teleology is left implicit. As specifying 'that out of which' (though as we have seen, in two quite different senses) the non-uniform parts are constituted, the uniform parts are their 'material' cause. But these materials are also present *for the sake of* the non-uniform parts, contributing to their construction and providing their nourishment.

The distinction, among 'component' uniform parts, between contributors to the *substantial being* of their organ and contributors to its *functioning* is puzzling. While in opposition here, these sorts of contribution are conjoined at $648^a15–16$, and together contrasted with differences that contribute to 'better or worse'.

Category (3), the residues (*ta perittōmata*) are, from a functional point of view, of two kinds: useful and useless. Urine and faeces are useless by-products of nutrition which are made no further use of. But male semen and a small special portion of the female menstrual fluid are both formed from residual blood (cf. *GA* I. 18, $724^b24–726^b5$), and are thus useful residues, by-products of one process that contribute to another. One might ask why they are considered to be residues at all—why not suppose that the amount of blood produced was just the amount needed for nutrition *and* reproduction? Perhaps because, while semen and menstrual blood are occasionally used for reproduction, often they are not. They are residues because they only *occasionally* play a biological role.

647b29: 'the relative differences . . . are for the sake of the better'. Cf. 640a36–b1 and note. This passage provides the first extended example of explanation by reference to 'the better': differences in blood and its analogues are thus explained, from which Aristotle generalizes, finally closing with another example, variations in the construction of eyes.

Such explanations present a host of difficulties. (1) How wide is the scope of 'differences for the sake of the better' (647b30)? (2) How is it related to the contrast at 648a15–16 between differences 'relative to each animal's functions and substantial being' and those 'relative to what is better and worse'? (3) In what sense are these differences not 'necessary', and if they are not, are they then indemonstrable? (4) What is Aristotle's view of the relationship between physical differences in blood and behavioural differences in character, sexual differences, and differences in bodily location (648a2–13)? These questions will be pursued in the following five notes.

647b32–5: 'both in the parts of one animal . . . and between one animal and another'. That is, differences may be within the same animal or between animals; as an example of the former, *Som.* 3, 458a13–15, asserts that 'the blood in the head is thinnest and purest, while that in the lower parts is thickest and most turbid'.

648a1–10: 'more productive of strength . . . more perceptive and intelligent . . . more discerning in their nature . . . more discerning . . . in a good state relative to both courage and discernment'. Blood types (and blood-analogue types) are correlated with differences in character and intelligence (*noēsis*). It would be wrong to see this as accounting for the character differences by reference to differences in blood—ultimately, the blood/blood-analogue differences will need to be explained by reference to the role of differences in character and intelligence in the animal's life. On character differences, including degrees of discernment (*phronēsis*), in other blooded animals, cf. *HA* VII (VIII). 1, 588a15–b4; VIII (IX). 1, 608a10–16. Attributions of intelligence and discernment—though not wisdom or scientific understanding—to other animals can be found in *HA* VIII (IX) at 611a15–20, 612b18–33, 614b32–5, 615a19, a34, 616b10–33, and 622b20 ff.; with these compare *Met. A* 1, 980b21, *GA* III. 2, 753a11–14, and *EN* VI. 7, 1141a20–3. See discussions in Labarriere (1990); Eijk (1997); Coles (1997); and Lennox (1999*a*).

$648^a9$: 'those with hot, thin, and pure blood are best'. Most of this passage can be understood as the application of one of Aristotle's first principles of biological study: 'Nature does nothing in vain, but always the best from among the possibilities for the being of each kind of animal; wherefore if it is better in a certain way, that is also how it is according to nature' (*IA* 2, $704^b15$–18) The 'best' in the first clause, as shown by 'better' in the second clause, means 'better than the other possibilities'. The claim that because hot, thin, and pure blood makes for a courageous and discerning animal, it is *best*, however, suggests that the different kinds of blood can be ranked better or worse according to some standard *other than* each particular animal's life. Here, for example, it seems that an animal that is at once both courageous and discerning is better off than one that has only one of these traits. Similarly, *GA* I. 23, $731^a28$–$^b4$, tells us that compared with having intelligence, having only the sense of touch seems lacking in value, but compared with being a plant or a stone, having touch is wonderful. (Cf. *GA* II. 1, $731^b24$–31; and Gotthelf 1989*a*: 127–8 for a good discussion of such 'across kind' evaluations.) Such claims are more difficult to defend because the standard of evaluation is not clear. Why should one sort of character and life be better than another? How does one judge that a life with a developmentally fixed range of complex behaviours (say that of a bee or spider) is better than a life with a learnt repertoire of relatively simple, yet plastic, behaviours?

Lloyd (1983: 23) rightly notes that the discussion here and in chapter 4 of blood differences provides the background for a discussion of differences in character and intelligence. He also attempts to see this background as part of an attempt to use 'man as model' for other organisms. Thus Aristotle's view that hot, thin, and pure blood is best because it grounds both courage and intelligence is claimed to show that he 'obviously' has humans in mind (Lloyd 1983: 33). Yet Aristotle makes no mention of this, and the one text Lloyd cites to confirm this claim, *HA* III. 19, $521^a2$–3, mentions only that humans have the thinnest and purest blood, and says nothing about heat or about intelligence. I have criticized this aspect of Lloyd's argument in Lennox 1985*b* and 1985*d*.

$648^a11$–13: 'upper parts . . . lower parts . . . the male . . . the female . . . the right side . . . the left'. The manner of difference referred to is presumably in blood type. Cf. $647^b32$–5 note. Cf. *PA* III. 4, $666^b35$–$667^a4$, on differences in warmth of blood in the different chambers of the heart; and compare $670^b18$–23; *GA* IV. 1, $765^b1$–18. While in our passage Aristotle apparently takes it for granted that right is hotter than left, male than female, at $648^a30$–3 he notes that his philosophical predecessors were not in accord on such questions, and argues that without careful disambiguation it is impossible to make such claims with certainty. There is virtually no discussion in

Aristotle of what evidence he feels supports these beliefs. Lloyd (1983, esp. 20–36) builds a case in favour of folklore and 'ideology' playing a significant role in determining Aristotle's views on such questions, though he cites very few pre-Aristotelian texts to establish that these were widespread beliefs in the culture of fourth-century Greece.

At *IA* 4, 706a18–26, and *GA* II. 1, 732a1–7, it is argued, in the case of both right and left and male and female, that it is better that they be separate. The male is the origin of generation, the right side of the body the origin of movement, and causally it is better that these origins and what they affect be as distinct as possible. The value judgement is with reference, *not* to location or sex *per se*, but to their *separation*. The discussion in the *Generation of Animals* concerns why animals so often have the male and female principles separated in distinct individuals, given that plants prove that procreation does not require it. Thus, as *PA* I. 1 suggests, explanation by reference to the better presupposes that the fact asserted to be better is 'possible otherwise'. (Cf. Balme 1992: 95–8; 1987*c*: 276–9; 1987*d*: 298–302; Gotthelf 1988: 120–35.)

648a14–15: 'in some cases relative to each animal's functions and substantial being, in other cases relative to what is better and worse'. Recall the distinction at *PA* I. 1, 640a33–b3, between explanations based on 'what it is to be *X*' and those based on 'being good thus'. *PA* I. 5, 645b14–33, argues that certain actions are prior to, and the ends of, others, and that the parts performing the basic actions are likewise prior to parts that perform less basic actions. The differences related to 'functions and substantial being' may, then, be differences among parts which perform basic functions, and which are explained by reference to an animal's substantial being. Other differences are to be explained by displaying how they make things better for the organism (640a36). Eyes contribute a basic function, seeing, to the substantial being of an organism, while certain variations make the eye a *better* organ of vision. Aristotle mentions two such differences here, which involve a trade-off between visual acuity and liability to injury. Fluid eyes are both more accurate *and* more susceptible to harm (cf. 657a31–5). Thus the continuum hard/moist implies both a scale of accuracy of vision and a scale of safety. Eyes that do better on the former scale do worse on the latter one. Eyelids are functionally related to the same scales. They serve as a natural protection for those animals with more fluid eyes (actually, the story is more complicated; cf. 657a25–658a10).

## 648a19–648b25

Of the differentiae just discussed, hot and cold are among the four basic potentials of Aristotle's matter theory. It is now recommended that certain distinctions be made (the verb literally means 'to divide') regarding hot and cold prior to explaining (1) that blood or its analogue is necessary for animals, and (2) why it is different in different animals. The need to do this is demonstrated by pointing out the range of contrary opinions regarding both which animals and which parts are hotter than which.

$648^a19$–21: 'That it is necessary to have either blood or something with the same nature as it, and what the nature of blood is'. Note that the analogue of blood is said to have the same nature as blood, which sanctions limiting the investigation to what the nature of blood is. It might be assumed that it has the same nature in the sense that it performs the same primary function, namely nutrition.

There are, however, two problems with this assumption. First, the difference between being blooded and being bloodless is said to be 'in the account defining their ⟨the animals'⟩ substantial being' ($678^a34$–5). Second, the investigation here, in so far as it requires clarification of the concepts of hot, cold, moist, and dry, would seem to be an investigation of the *material* nature of blood. Thus, if the results of this investigation are to apply to the analogue of blood in the bloodless animals, this must be of the same *material* nature as blood. Nevertheless, there is evidence within the first few chapters of *PA* II that, at a level of generality above the distinction between blooded and bloodless animals, there is indeed a common nature. Both blood and its analogue are fluid uniform parts (note the inclusion of analogues at $647^b14$); both are the final nutrient out of which the other animal parts are immediately constituted (note the inclusion of the analogue of blood at $650^a34$–5); and finally, the material differences in blood correlated with differences in character and discernment are said to have analogous differences in bloodless animals ($648^a4$–8).

$648^a36$–$^b1$: 'these disputes seem to occur because "hotter" is said in many ways'. Lloyd (1991: 392–4; 1996: chs. 3–4) has singled out the discussion of hot, cold, moist, and dry in *PA* II. 2–3 as an example of the way in which Aristotle's zoology 'puts considerable strain' on the *Analytics*' requirement that terms be used 'univocally' in a demonstrative science—that is, that in any particular demonstration, each term must be used in the same sense in premisses and conclusion to avoid invalid inference. *PA* II. 2–3, however, seems to be in line with the ideals of the *Posterior Analytics*, since its aim is to *remove* ambiguities in the use of the concepts 'hot', 'cold', 'moist', and 'dry'. It seeks to resolve or to sharpen disputes over which parts are hot or cold by differentiating the various legitimate uses of these terms. Further, Aristotle does not here simply *enumerate* the different ways in which these terms are used: he also argues that certain modes of reference are primary, while others gain legitimacy by standing in certain relations to the primary cases.

648$^{b}$4–8: 'virtually the causes of death and life . . . sleeping and waking . . . being in one's prime and of ageing . . . of sickness and health'. On heat and cold as causes of sleeping and waking, see *Som.* 3, 458$^{a}$ 26–32; of length of life, cf. *Long.* 5, 466$^{a}$18–466$^{b}$4; of ageing, cf. *Juv.* 4, 469$^{b}$8–20; of life and death, cf. *Juv.* 6, 470$^{a}$19–$^{b}$6. There is no surviving treatise on sickness and health; but *Long.* 1, 464$^{b}$32–465$^{a}$1 says that 'life and death, and likewise too sickness and health—in so far as these topics fall to natural philosophy—are to be discussed later'. Moreover, *Resp.* 21, 480$^{b}$23–31, concludes by noting that health and disease should be discussed, from different perspectives, by both the natural philosopher and the physician. It appears that this was a project Aristotle intended to carry out. There are close ties between the treatises of the *Parva Naturalia* and *PA* II, since both rely on the matter theory of *GC* II and *Meteor.* IV to account for biological phenomena.

648$^{b}$6–8: 'while neither roughness and smoothness, heaviness and lightness'. Cf. 646$^{a}$17–20. *GC* II. 8 claims that fire is 'most of all of ⟨the nature of⟩ form, because it is by nature carried towards the limit' (335$^{a}$19–20). Thus a case can be made that a thing is light or heavy because it is hot or cold. *GC* II. 2, 329$^{b}$18–21, mentions rough and smooth in a list of *derivative* tangible properties, but unlike the others on the list, their derivation from hot/cold/moist/dry is never explained. *Meteor.* IV. 5–10 is no more helpful; it provides a comprehensive explanation of eighteen pairs of contraries by means of the actions of heating and cooling, but roughness and smoothness are not on the list.

648$^{b}$8–10: 'these very things—hot, cold, dry, and moist—are the origins of the natural elements'. Cf. 646$^{a}$15–20 and note; and 646$^{b}$4–5. The reference is either to *Meteor.* IV. 1, where these four potentials are referred to as four *causes* (*aitia*) of the elements; or to *GC* II. 2, 330$^{a}$24–5, where all the other differentiae are referred to these four.

648$^{b}$12: 'the function of the hotter'. For Aristotle 'function' typically refers to a goal-directed action, and thus one might well question its use here. But just as a biochemist today will discuss the function of a chemical reaction if the context is clearly organic, so will Aristotle; compare *Meteor.* IV. 12, 390$^{a}$10–$^{b}$1, where the elements are included in the claim that 'each thing is most truly its capacity to perform its function'.

The discussion is not, primarily, of 'the hot', but of 'the hotter', since the disputes being considered are over which one of the pairs, right or left, male or female, blooded or bloodless, bile or blood, was the hotter.

648$^{b}$12–14: 'that which makes what touches it hotter'. This presumably means that when two things are brought into contact, if one of them causes the other to become hotter, it was initially the hotter of the two. In this first case, it is the effect of one body on another that is the basis of the judgement, though of course tactile stimulation may be the way in which the effect is perceived.

$648^b14–17$: 'that which arouses greater sensation . . . especially if accompanied by pain'. If *X* arouses a greater sensation of heat than *Y*, *X* is hotter than *Y*. Here contact of the compared bodies with the organ of touch is the basis of judgement. While it is not a necessary condition for such judgement, apparently, Aristotle stresses the case in which heat inflicts pain on the perceiver. The claim about deceptive judgement appears restricted to the question of pain, although it seems valid whenever tactile stimulation is used as the measure of which of two things is hotter.

This passage may seem to conflict with Aristotle's claim that perception of the special sensibles is never deceptive at *An.* III. 3, $427^b12–13$, $^b18–19$. Here is a case where the sensation of a proper object of touch, heat, is said to be deceptive (literally 'false'). The restriction of the claim of potential falsehood to the case of the awareness of pain caused by heat may avoid this problem, since pain is not itself a proper sensible and involves some sort of implicit judgement.

$648^b17–18$: 'the more meltable and more combustible are said to be hotter'. These properties and their contraries are on the list of passive potentials in *Meteor.* IV. 8 (cf. $385^a12–13$, 18). The reference is to the capacity for melting or being burnt, not the active power of causing melting or burning. Both are reactions of uniform materials to heat, and are thus crucial in Aristotle's matter theory (cf. *Meteor.* IV. 9, $387^a18–388^a9$). Materials more easily taken from a solid to a liquid or an ashen state by heat are hotter than those less easily melted or burnt.

$648^b18–19$: 'the larger is said to be hotter than the smaller'. Each new 'sense' of 'hotter' is introduced by the adverb *eti*, 'further', or 'again'. The previous senses all involve qualitative comparisons, while here the comparisons are quantitative. Since differences in heat are a *consequence* of the same thing differing in this way, the initial contrast cannot be one of degree of heat; I suggest it refers to differences in size. Everything else, including temperature, being equal, the larger thing can legitimately be called hotter than the smaller. The concepts *pleon* and *elatton* are used in this way in the discussion of the different forms of heating in *Meteor.* IV (cf. $379^b2–6$, $380^b1–2$, $381^a19–20$, $381^b19$, $389^b4$; *GC* II. 6, $333^a29–34$).

$648^b19–20$: 'And besides these two'. Even if one includes hotter to touch as a variety of hotter by contact, there have been *three* senses mentioned up to this point, not two. Aristotle probably means 'besides the last two', both of which were introduced with 'again'. In addition, these three cases are all judgements independent of the tactile sensation of heat.

648$^b$22–3: 'one thing is contrary because further away, the other like because nearer'. What is the relation of this comment to the case in point, in which what heats quickly and cools slowly is judged naturally hotter that what heats slowly and cools quickly? Perhaps this: when comparing two like objects, the hotter will be the one that cools more slowly or is more quickly heated. In the first case, we are comparing the rates of cooling of two hot things; in the second, the rates of heating of two cold things. In the first case, then, we are judging a thing to be hotter—contrary to the cold—because it is 'further away' from the cold; in the second, like the hot because it is 'nearer to' being hot.

## 648$^b$25–649$^b$9

The remainder of the chapter at first appears to be a random collection of examples of the general claims made previously, but this appearance is deceptive. The detailed notes will be organized around two philosophical themes:

(1) The examples support the philosophical thesis that, because one thing can be hotter (or colder) than another in a number of different respects, it is important to specify the respect in which something is hotter or colder (648$^b$25, 649$^a$11–14, 649$^a$34–$^b$7). This provides a means of avoiding one plank of 'Heraclitean' scepticism about the perceptual world, namely that all the objects of sensation 'roll around between being and not being' (Plato, *Cratylus* 411 B–C, 439 C–440 D; *Theaetetus*, 179 E–180 C; *Republic*, 5, 476 A–477 D), e.g. between being and not being hotter than something else. This claim has sceptical bite only if $X$ is both hotter and not-hotter *in the same respect*. If $X$ is hotter to touch than $Y$ but not more combustible, $X$'s being both hotter and not-hotter than $Y$ is not in conflict with the law of non-contradiction (cf. *Met.* $\Gamma$ 3, 1005$^a$18–34). Aristotle thus aims to avoid the worries raised by Lloyd, mentioned earlier, that the material first principles of *PA* will be unsuitable for use in demonstration.

(2) There is an attempt to articulate a distinction between 'derivative' (*allotria*) and intrinsic (*oikeia*) heat (borrowed from *Meteor.* IV) by reference to the more philosophical distinction between attributes which belong to a subject 'incidentally' (*kata sumbebēkos*) and those which belong in virtue of itself (*kath' hauto*) (648$^b$35–649$^a$20). Compare *Meteor.* IV. 1–2, 379$^a$17–380$^a$7.

648$^b$26–34: 'For boiling water'. This rapid series of examples provides evidence for the claim that the same thing cannot be hotter in all the enumerated senses. The discussion mobilizes the five ways of being hotter discussed in the previous section of text.

As far as one can tell from this discussion, these claims are taken to be perceptually obvious—at least no further evidence is given for them. In every case $X$ is noted to be hotter than $Y$ in one respect, and $Y$ hotter than $X$ in another. Thus, the truth of any claim such as that oil is hotter than boiling water, without further qualification, cannot be scientifically evaluated.

$648^b35$: 'some things . . . have derivative heat while some have their own . . . The former is near to being hot incidentally rather than in itself'. Aristotle distinguishes objects with *derivative* heat from those with *their own* heat, gradually shifting to the more philosophical vocabulary of a feature which belongs to a subject either incidentally (*kata sumbebēkos*) or in itself (*kath' hauto*). Yet he does so with apparent misgivings: he says that things with derived heat *approach* being, are *almost*, are *as if*, incidentally hot.

$649^a16$: 'as if someone were to give a name to hot water or hot iron. In fact it is in this way that blood is hot.' Cf. $649^b20$–7, and notes.

$649^a17$: 'Such cases, namely those in which the subject is hot in virtue of being affected'. Recall that the example used to introduce the notion of being hot incidentally was of a musical person who was hot in virtue of having a fever—the subject being hotter in virtue of an affection, but not in virtue of being a musician ($649^a4$–5). This would suggest that blood is not properly speaking hot, precisely the problematic conclusion that Aristotle will grapple with in chapter 3.

$649^a18$–19: 'the cold is not a certain nature, but a privation'. The manuscripts are more or less evenly divided between texts which make contrary claims:

(1) The cold is a certain other nature, and *not* a privation.
(2) The cold is *not* a certain nature, but a privation.

Bekker, Langkavel, and Peck print the text from manuscripts PSU corresponding to (1), though it is in direct conflict with *Meteor.* IV. 2, $380^a8$, *Met.* *Λ* 4, $1070^b12$, *GA* II. 6, $743^a36$, and *GA* IV. 4, $784^a33$, each of which states that cold is a privation of heat. I have translated the reading of manuscripts EYZ, corresponding to (2). Since it so clearly conflicts with Aristotle's stated views elsewhere, it might seem odd that all previous editors and translators prefer the first option.

They have, I believe, been guided in their choices by more local considerations; that is, option (1) is taken to be dictated by the overall logic of the surrounding text. Their argument would be this: 'Aristotle is considering certain subject/affection combinations, and tells us that consideration of these cases makes it apparent that cold is a certain distinct nature from heat. Why? Because these things are not hot in themselves, but are only incidentally hot. Well then, what are they in themselves? Aristotle does not tell us, but they must be cold.' This argument is reasonable, but it is compatible with cold being a privation.

Nor need we following Düring's suggestion that our passage is a 'confutation of his [Aristotle's] earlier opinion ⟨of⟩ meteor. IV' (Düring 1943: 136). If this were true, it would also be a confutation of all the other cited passages, including those in *Generation of Animals*, which Düring believes is later than *PA* II–IV (Düring 1943: 30). (Another difficulty for this claim is the clear reference to *Meteor.* IV. 6–8 at $649^a33$.) Aristotle can hold the 'privation' view of cold while believing it to be an active potential. He views perceptible properties as continua, one end of which is referred to as 'privation', the other as 'affection' or 'form'. (Cf. *Phys.* I. 7, $190^b32$–3, $191^a6$–7; *Sens.* 4, $441^b27$–8.) Thus 'not a nature but a privation' locates 'cold' at one end of a continuum, at the other end of which is 'hot'. But he views this as the 'agent' continuum, whereas the dry/moist continuum is the passive one.

$649^a24$: 'all things that have been burned possess heat'. The same point is made, with the same examples, at *Meteor.* IV. 11, $389^b1$–7.

$649^a30$–4: 'determined more clearly elsewhere'. Cf. *Meteor.* IV. 6, $383^a26$–$^b17$, and 7, $384^b2$–23.

$649^b6$–7: 'it will obviously follow that the same account applies to cold'. According to a principle enunciated explicitly at *NE* V. 1, $1129^a23$–5: 'It follows for the most part that if one of a pair of contraries is spoken of in many ways, so is the other; if, for example, what is just is spoken of in many ways, so is what is unjust.'

## CHAPTER 3

### $649^b10$–21

There is now a brief and cursory discussion of the other two primary, passive potentials, dry and moist.

$649^b9$–10: 'in conformity with what has been said'. Among the many distinctions made in the previous discussion of hot and cold, only those between 'incidental' and 'in itself', and between 'actually' and 'potentially', are adapted for the distinction between moist and dry.

$649^b11–13$: 'all solidified moist things are called actually and incidentally dry, being potentially and in themselves moist'. By the criteria of *Meteor.* IV. (mentioned above), things of a certain *material* nature are 'watery' regardless of their usual state. Gold, silver, copper, and tin are 'of water' because they can be melted by intense heat. Similarly, the application of the 'incidental/in itself' distinction to such materials rests on theoretical considerations. On the basis of the above criteria, one can determine whether or not an object is watery in terms of its abiding underlying subject. Anything that is a 'form of water' is, in itself, cool and moist, though materials that are composed from water may incidentally be otherwise.

$649^b14–15$: 'actually and incidentally moist, yet in themselves and potentially dry'. The predicate 'moist' is applied to materials such as earth or ash in virtue of their being mixed with moisture—this is the point of saying that they are actually moist, though only incidentally so. To call *them* moist is very different from calling a solid such as 'ice' moist; ice in its nature is moist, even though it is only (while ice) potentially so, as is indicated by its melting when heated. What is incidentally moist but in itself dry is the earth or ash, not the compound made when they are moistened.

$649^b16$: 'but when these have been decomposed'. It is in virtue of the fact that these compounds are only incidentally moist that there can be a decomposition into the moist ingredient and the dry ingredient. Nevertheless, this is a true Aristotelian compound. The two ingredients, earth and water, have a common potential (cold) as well as two contrary potentials (moist and dry). Their combination brings about a change in which the contrary potentials reach a condition of equilibrium between them, rather than one being transformed into the other. The potentials of each are thus preserved. They are uniform bodies, indefinitely divisible into like parts, yet constructed from, and resolvable into, *unlike* constituents. Aristotle thus clearly distinguishes composition (*mixis*) from mere mixture (*sunthesis*) in which separate ingredients are *actually* present. (Cf. *GC* I. 10, esp. $327^b27–31$; Bogaard 1979; Gill 1989*a*: 145–9; Lennox 1989: 64–75; Sorabji 1989: 35–47; Waterlow 1982: 83–7.)

$649^b16–17$: 'consist of water . . . consist of earth'. Literally 'are of earth' and 'are of water'. These expressions take on a semi-technical character in *Meteor.* IV. 10, which states its purpose to be to 'grasp which of the uniform bodies are forms of earth (*gēs eidē*), which forms of water (*hudatos eidē*), and which are combinations' ($388^a25–6$). Thus different uniform bodies are there classified as 'of earth', 'of water', 'more of earth', and so on. Given the close connection between *Meteor.* IV and *PA* II, the genitive nouns here may mean 'form of earth', 'form of water'; or this may be the 'genitive of material', in which case these expressions may simply indicate that the uniform parts are constituted of water or earth. Given Aristotle's metaphysical commitments, these come to much the same—to be a form of water is to be 'generically' or 'materially' water, but differentiated in some respect from other items of the same kind. (See the conflation of kind, constituent, and matter at *Meteor*. IV. 12, 389$^b$24–8.)

## 649$^b$21–650$^b$13

The stated point of this review of the four basic potentials was that such a study would help us achieve a causal understanding of the nature of blood (cf. 648$^a$19–24). Here Aristotle returns to a discussion of blood with his account of hot, cold, moist, and dry in hand. In fact that discussion, and the background theory in *Meteor*. IV, is important throughout the discussion of the uniform parts—but, as we shall see, all of them are composed from blood, so that the claimed purpose of the digression is reasonable.

649$^b$21–2: 'blood is in a way hot, i.e. in so far as it is what it is for blood to be blood'. Following a suggestion of Düring's, I take this phrase to be a conscious application of Aristotle's notion of what it is [for something] to be—essence—to blood (cf. *PA* I. 1, 642$^a$25–6, and note). Given Aristotle's views that parts incapable of performing their function are parts in name only, and that functional, nutritional blood is necessarily warm, the claim that blood is incidentally hot is initially puzzling. Blood, *qua* blood, we might expect to read, is hot in virtue of itself, while blood removed from its organic setting is blood only incidentally. Compare *Meteor*. IV. 11, 389$^b$8–15:

> So blood, semen, marrow, rennet, and all such things are *hot while 'having the nature', but when undergoing destruction and 'giving up the nature' they are not; for the matter, which is either earth or water, is left.* Therefore some say these things are cold, while others say they are hot, seeing that when 'in the nature' they are hot, but when separated ⟨from it⟩ they solidify.

Note the precise correspondence in wording between this passage and ours, in particular the contrast between being in 'their nature' and being separated from it. *PA* II. 3 argues that 'blood' names a complex which, *qua* complex, is *essentially* hot; but that complex is the result of a subject, which is *not* intrinsically hot (since it is a compound of two cold elements, earth and water), being acted upon by the natural heat of a living thing. Thus the proper subject of blood is *not* in itself hot; but blood, in so far as it is the functional nutrient of blooded animals, *is* in itself hot.

The use of 'pale human' in this discussion is unfortunate. It is a favourite example of an incidental unity (e.g. *Met*. *Z* 4, 1029$^b$22–1030$^a$1; 5, 1030$^b$18–

20; 6, $1031^a19$–27). Here, however, it exemplifies that which is hot in virtue of itself. Humans are incidentally pale, but *pale* humans are pale in virtue of themselves; blood is akin to pale humans, a complex of subject and affection.

$649^b28$–32: 'in the nature of such things . . . when separated from the nature of their possessors'. It is apparently not the nature of blood and bile that Aristotle is discussing, but the natures of the organisms of which blood and bile are parts (cf. $649^b20$–1 note). Blood is not in *its* nature hot, but is *essentially* hot as a functional part of the nature of a blooded animal. Heat is an *affection* of blood, due to the animal's (presumably ultimately the heart's) heat acting on an earth/water compound whose underlying nature is cold. What we might expect Aristotle to say, which he does not, is that such separated 'blood' is 'blood' in name only—though by saying that 'hot' belongs in the definition of what it is to be blood, he comes very close.

$649^b33$–5: 'more and less participation'. Cf. *PA* I. 4, $644^a16$–23, $644^b7$–15 and notes. Throughout, the hot/cold and dry/moist continua have been described as varying in degree. 'It must be posited' (*dei tithenai*) suggests that this is a 'hypothetical' first principle, something which a demonstrative science must assume, rather than prove, to be the case (cf. *An. Post.* I. 10, $76^a32$–6). For an opposing point of view, see Plato, *Philebus*, 24 A–26 E.

$650^a2$–8: 'Since . . . all the animals and plants must have a natural origin of heat'. With only slight expansion, this is a continuous demonstration, the introductory 'since' (*epei*) indicating that the premisses are taken as established. (An unstated intermediate conclusion has been added in italics):

(P1) All growing things must take in nutrients.
(P2) All nutrients are derived from moist or dry material.
(C1)/(P3) *All growing things must take in moist or dry material.*
(P4) Moist or dry material is transformed/digested into nutrients by heat.
(C2) All growing things (=animals and plants) must have a source of heat.

The sources for the premisses are *Meteor.* IV. 1–2 and *GC* I. 5. I regret retaining the antiquated translations of *pepsis* and *pessein*, 'concoction' and 'to concoct'. Having searched for a similar abstract noun/verb pair in English that refers to a natural process of nutrient and tissue transformation due to natural heat, I am reasonably convinced that none exists. Alas today, in so far as 'concoction' is used at all, it is to refer to a notably *unnatural* putting together of elements. *Meteor.* IV. 2, $379^b17$–20, states that 'concoction is a completion, by means of the natural and appropriate heat, out of opposing passive potentials [i.e. moist and dry]; and these (the passive potentials) constitute the appropriate matter for each thing.' The first illustration of the process is the working up of nutrients (cf. *Meteor.* IV. 2, 379$^b$21–5). A convenient summary of the discussion of concoction in *Meteor.* IV. 2–3, followed by a survey of its explanatory roles in *PA* and *Generation of Animals*, can be found in Lloyd (1996) 83–103. The argument here also takes it as a given that growth requires nutrients—an elaborate defence of which is to be found in *GC* I. 5, 321$^b$12–322$^a$28.

650$^a$6–8: 'and this, like the processing of the nutrients, is shared by numerous parts'. All the manuscripts read *kai tautēn hōsper*, which cannot be right. There have been many suggestions for emendation, none of which is entirely satisfactory (cf. Langkavel 1868: 650$^a$7 n.; Düring 1943: 138–9; Peck 1961: 132 n. 2). I have adopted the textual emendation suggested by Barnes (1984: 1012 n. 8) *kai autē hōsper*, with a slightly less interpretative translation.

650$^a$8–32: 'shared by numerous parts'. Each of the parts mentioned is discussed in detail in *PA* III (mouth and teeth, III. 1; oesophagus and related organs, III. 3; heart, III. 4; blood vessels, III. 5). The intent here is to describe the nutritive process, and to establish the necessity of an origin of heat to that process, *at the most abstract level possible.* What is said here is typically with reference to all blooded animals, and is usually extended by analogy to the bloodless; when this is not the case (as at $^a$16 and $^a$23), the widest class to which the restricted claim applies is noted. Conversely, the fundamental difference between plant and animal nutritive processes is indicated with a minimum of fuss.

Elsewhere (*Juv.* 3, 468$^b$28–469$^a$10; 4, 469$^b$6–20; *Resp.* 20, 480$^a$2–14) Aristotle suggests that digestion in the gut produces, along with the solid and liquid waste that is excreted, a liquid or vaporous substance that passes through this network of blood vessels to the heart, where this 'origin of natural heat' finally produces blood.

650$^a$19: 'as from a trough'. Cf. Plato, *Tim.* 70 E 2.

650$^a$31–2: 'with the help of the dissections and natural enquiries'. See 646$^a$8 and note; and Lennox (1987*a*) 97 n. 16; (1991) 261 n. 2.

650$^a$32–5: 'blood is the final nutrient for the blooded animals'. Three arguments support the claim that blood is concocted nourishment. (1) The blood vessels are a container for blood, and the body's containers are either for nutrients or residues; blood is apparently not a residue, so it must be a nutrient. (2) There is a quantitative correspondence between the amount of food taken in and the amount of blood in an organism. (3) There is likewise a qualitative correspondence of wholesome food to healthy blood, and of bad food to diseased blood. Taken together, these considerations suggest that blood is a product of ingested food, and that it is the final form of nutrient distributed throughout the body.

$650^b2$: 'blood is present in blooded animals for the sake of nourishment'. The evidence that blood serves as the final nutrient for the parts suggests something further—that animals possess blood (or its analogue) *for the sake of* serving as nourishment. Blood not only does this—it is present in blooded animals *because* it does this. Aristotle's defence of teleological reasoning (cf. $639^b26$–30, $640^a18$–$^b4$, $642^a6$–35, $646^a24$–$^b27$ and notes) justifies this step if, in addition to blood being appropriate for nutrition, it can be demonstrated that, if there are to be blooded animals, then they must have such a nutrient.

$650^b3$–5: 'because of this, touching it does not produce a sensation'. The claim that blood's insensitiveness and its distinctness from flesh follow from its nutritive function is strange, and no explanation is provided. Empedocles (31 B 98 DK = Simplicius, *In Phys.* 32. 6) apparently held that blood was a form of flesh, and (31 A 86 DK = Theophrastus, *De Sensu*, 9) that blood is that by which we think. Theophrastus also ascribes to Empedocles a tendency to identify thought and perception. By a stretch, then, Empedocles held blood to be a sort of flesh and to be the organ of perception, which are the claims from which Aristotle is here distancing himself. Alternatively, the thought may be that it is associated with the *nutritive* capacity of soul, *not* the perceptive capacity.

$650^b10$: 'in the works on generation as well as in other works'. The grounds for supplying 'works' (*logoi*) is the reference at $668^a8$–9. Peck and Ogle suggest that this may be a reference to passages in *GA* II, or to *GC* I. 5 and II. 8; the 'other works' may include those 'on nutrition' often referred to, but which do not appear in our manuscripts or in the ancient lists of his works. *An.* II. 4, $416^a19$–$416^b30$, refers to itself as 'on nutrition' ($416^a20$), and concludes by saying it has stated in outline what nutrition is ($416^b30$). Unfortunately, it claims for itself *only* the character of an outline and refers the reader to later, more appropriate accounts for clarification ($416^b30$–1). Caution is the appropriate attitude to these references, for a number of reasons. First, the expressions often translated as if they are book titles are highly variable and occasionally have nothing about them indicating that they in fact do refer to books. Second, they are nearly always in the plural and thus could refer to various discussions of the same topic in different places and forms, including lectures. Third, authorship is never ascribed, and we do not know if Aristotle would refer us to work done by other members of the Lyceum. For example, are the works on plants he occasionally mentions his own, or Theophrastus'? Fourth, we know virtually nothing about the state of Aristotle's written work prior to the edition of Andronicus, centuries after his death. Finally, as David Balme has pointed out, most of these references could be easily excised from the text without grammatical disruption, and thus could have been added for the sake of cross-reference by a later editor.

## CHAPTER 4

### $650^b14$–$653^b18$

From this point on until the beginning of chapter 10, Aristotle discusses the various uniform parts both in terms of the material differentiae and in terms of their functional roles within the animals that have them. However, there is a clear demarcation between chapters 4–7 ($650^b14$–$653^b18$) and chapters 8–9 ($653^b19$–$655^b28$). The first four chapters deal with the 'fluid' uniform parts (though, as we shall see, this can be misleading), the last two with flesh, bone, and their analogues. At the end of the discussion Aristotle announces, with some fanfare, a new beginning.

$650^b14$–15: 'Some blood has what are called fibres, but some . . . does not'. Aristotle now returns to the basic differentiations of blood and related differences of character and cognition, begun at II. 2, $647^b31$–$648^a13$. He begins by explaining blood's ability to coagulate or clot by reference to the presence of 'fibres' (*ines*). Modern accounts of blood plasma (the liquid in which blood cells and platelets are suspended) distinguish serum from proteins called fibrins, which aid in clotting; and fibrin levels do vary from animal to animal, and are in fact quite high in the species Aristotle mentions. Aristotle discusses the extraction of these fibres from the blood as if he knew of a method for doing this (cf. *HA* III. 6, $515^b32$–3), but the method is never described.

$650^b16$–17: 'the part of the blood that is watery is colder'. Translators have found the reference to the watery blood being colder irrelevant to the point at hand, and thus have followed a single manuscript (*Z*) in leaving this reference out. But the same claim is introduced to make the same point at *Meteor* IV. 7, $384^a26$–8. The question at issue is why the blood of certain animals does *not* solidify when cooled (cf. *HA* III. 6, $515^b33$–5; 19, $520^b23$–7). *Meteor.* IV. 10, $389^a11$, says serum (*ichōr*) is solidified by being cooled, and this is consistent with *PA* II (cf. $647^b12$, $651^a17$–18, $651^b18$, and $653^a2$) which claims that serum is an improperly concocted or already corrupted form of the watery part of blood.

$650^b18$: 'the part of the blood that is earthen solidifies . . . and the fibres are made of earth'. The argument is again dependent on the 'biochemistry' of *Meteor.* IV. In evaporation, external cold forces the internal heat in a body out, which draws moisture out with it, leaving a cool, dry (i.e. earthen) body (cf. $651^a4$–10). Thus, after evaporation the fibrous (earthen) element remains (cf. *Meteor.* IV. 5, $382^b17$–26; 6, $383^a14$–19; and on blood, 7, $384^a25$–$^b1$). This background theory is used throughout the rest of the chapter.

$650^b22$–3: 'those animals with finer and purer moisture have quicker perception'. The backward reference (at $^b25$) is to $648^a4$–13. The causation here appears to be the reverse of what we found in the earlier passage to which we are referred—here the nature of the blood appears to determine character (cf. Freudenthal 1995: 49). But Aristotle is not forced to make a choice. The position here seems to be an instance of the philosophical position defended in *An.* I. 1, $403^a3$–$^b15$: states such as fear and anger are changes in the blood due to a desire to escape, or retaliate. In the next passage, for example, emotional reaction is the initiating cause of changes in the blood. The explanatory pattern is:

(1) $650^b27$–31: Fear causes cooling, cooling solidifies watery things, thus fear solidifies watery things. Certain animals have blood of a watery nature, and thus fear produces immobility in them—or, as we say, fear leads them to freeze.

(2) $650^b36$–$651^a4$: Spirit (*thumos*) produces heat, and more earthen/fibrous blood is more easily heated. Thus animals with more earthen/fibrous blood are more easily excited.

$650^b27$–33: 'The animals that are excessively watery are more timid.' Timidity is a character trait of animals with relatively moist blood, which predisposes them to the cooling effects on moist blood of fear and fear-related behaviours (cf. the freeze behaviour of the dung beetle (IV. 6, $682^b25$), or the cuttlefish's discharge of ink (IV. 5, $679^a6$) and change of colour ($679^a13$; cf. *HA* VIII (IX). $622^a8$)). Fear excites different reactions (flight, aggression, immobility) depending on the nature of the blood—the character traits are the dispositions to react in particular ways to particular emotions given certain material characteristics.

$650^b34$: 'both spirited in character and excitable because of their spirit'. This suggests a distinction between fundamental traits of character such as timidity or spirit and a range of behavioural situations—a spirited animal is excitable, aggressive, gregarious, and so on, as the context demands. What is added by 'excitable' here is not a layer of character, but a specification. This account is no more materialistic than one would expect from the programmatic remarks on defining character traits at *An.* I. 1, $403^a3$–$^b19$.

$651^a12$: 'The nature of the blood is the cause of many features of animals with respect to both character and perception'. The reasonableness of this claim is said to rest on the syllogism that follows: nourishment is matter, blood is the final stage of nourishment; thus blood is matter. Thus differences in blood will be the material cause of many other differences. The point may be this: A given perceptual object, say a bear, may provoke fear in both a boar and a deer, but their responses will depend on how the body of that animal is affected by fear—and *that* will depend on the nature of its blood. A similar story is to be told regarding identical perceptual responses to variable stimulus conditions.

$651^a17$–$19$: 'serum exists on the one hand of necessity, and on the other for the sake of blood'. To be called serum, blood must either not be concocted or be decaying. Since decay is not a goal-directed process—though Aristotle will regularly specify the material conditions that necessitate it (cf. *Juv.* $467^b10$–$470^b6$ on old age and death)—the serum that exists for the sake of blood must be unconcocted blood. At *HA* III. 19 serum is said to be unconcocted blood—either not yet concocted or decayed ($521^b2$–$3$). The distinction is made there in a way that avoids any hint of the teleology of *PA* II. 4.

## CHAPTER 5

### $651^a20$–$651^b19$

The unity of the discussion of blood, serum, and fat, suggested by the closing statement of this chapter, is that serum and hard and soft fat are all derivatives, of various sorts, of blood in a more direct sense than the other uniform parts are. The closing statement also suggests that the discussion has accomplished two theoretical tasks: (1) giving an account of what each part is (i.e. a definition), and (2) giving a causal explanation for it.

$651^a20$: 'Soft fat and hard fat'. The Greek terms are *pimelē* and *stear*, usually translated 'lard' and 'suet'; but these translations carry connotations that the Greek terms do not.

$651^a20$–$1$: 'in accordance with the differentiation of blood'. The first step is to explain fat's primary differentiation. Aristotle provides a causal theory based on his fundamental material differentiation in blood: those with earthen (i.e. fibrous) blood have hard fat, those with watery (i.e. serous) blood have soft fat. Properties cited to differentiate soft from hard fat in *HA* III. 17, 520$^a$8–12—solidification or non-solidification by cold, crumbling or melting when heated—are here *explained* by the relatively earthen or watery nature of the constituent blood. Similarly, the correlation between soft or hard fat and the presence or absence of incisors in the upper jaw referred to in *HA* III. 17, 520$^a$14–16, without explanation, is here explained by the relatively earthen or watery natures of the creatures in question.

651$^a$26: 'because they do not even have blood'. A privative differentia is here used to explain the absence of parts.

651$^a$33: 'for all these parts are dry and earthen in nature'. This is the first reference in *PA* to a set of systematic correlations among differences in teeth (II. 9, 655$^b$11–15), horns (III. 2, 663$^b$24–664$^a$3), stomachs (III. 14, 674$^a$22–674$^b$17), hoofs (IV. 10, 690$^a$4–27), knuckle-bones (IV. 10, 690$^a$10–27). It is used as an example of an explanatory problem involving an unnamed kind at *An. Post.* II. 14, 98$^a$13–19 (cf. Lennox 1987*a*; 1991; 1995). Here Aristotle mentions that animals with hard fat have horns, knuckle-bones, and hoofs, but lack certain teeth; elsewhere these features are said to be related to a digestive system with many stomachs. The presence of all of these features is consistently explained, in part, by the preponderantly dry and earthen nature of the animals that have them (651$^a$31–6). These notes will track the evidence for the claim that goal causation is constrained in its operation by certain universal material factors—the formal nature is operating, from the inception of biological development, on a certain blend of earthen/watery material which is not teleologically explained and is explanatorily fundamental. (Gotthelf 1997*a*; Lennox 1997).

651$^a$36: 'in moderate amounts they are protective'. The nature of the contribution of fat to health and potency (*dunamis*) is never explained, nor is the claim that moderate amounts do not impede perception. The argument running from 651$^b$2–8 is:

(P1) Blood is imperceptive (cf. 650$^b$3–4).
(P2) Fat is a form of blood.
(C1) So fat is imperceptive.
(P3) Having a perceptive part is essential to being an animal.
(P4) Anything that was all fat would have no perceptive part (by C1).
(C2) So anything that was all fat would not be an animal.

But what Aristotle needed to establish was that a moderate amount of fat does not impede perception, and this argument comes nowhere near establishing that.

651$^b$8–17: 'animals with excessive fat age quickly . . . are more infertile'. Each of these suggestions is problematic. The *explananda* are unsupported—*do* fatter animals age more quickly, and *are* they more infertile? Second, we have been given no reason to think that production of excess fat detracts from the amount of blood an animal requires for proper functioning. If fat is a by-product of *excessive* nutrient, why should the presence of fat detract from the amount of blood used for reproduction and nutrition? What this explanation lacks, then, is a supplementary theory that excessive fat is produced *at the expense of* blood required for other purposes, but this is not part of Aristotle's general theory.

651$^b$17–19: 'what each of them is, and owing to what causes'. This accords with Aristotle's typology of enquiries in *An. Post.* II. 1, 89$^b$23–35 (compare the conclusion of the discussion of marrow, 652$^a$19–23). Whether or not such language reflects, intentionally or otherwise, the model of scientific knowledge developed in the *Analytics* is an interesting and important question (on which compare Barnes 1975; 1981; 1982; Lloyd 1990; 1996; with Bolton 1987; 1997; Charles 1990; 1991; 1997; Gotthelf 1987*a*; 1997*a*; and Lennox 1987*a*; 1990; 1991). The answer depends, *not* on these summary claims, which are merely programmatic, but on how closely the actual pursuit and achievement of knowledge about animals to which they refer matches *Analytics*-based expectations. We have already seen that the theories of definition, division, teleology, and necessity in *PA* I, while interestingly related to those in the *Analytics*, present more complex accounts of each of them. It thus seems that the issue is whether *PA* is an enriched and modified application of the *Analytics* model of definition and explanation, or reflects an unrelated, if equally interesting, account of each.

These chapters do, in fact, provide accounts of the uniform parts' underlying material nature, the differentiae of each part's material nature in the different animals, and an explanation for why certain groups of animals have the material differentiated in one way rather than another (e.g. why their fat is soft rather than hard, or their blood is thick and turbid rather than thin and pure). Those explanations may include both a teleological component and a material/motive causal component, or only the latter. Of the former explanations, the end for which the uniform part is said to be present may itself be a part (serum for blood, blood for the parts it nourishes) or a function (blood for nourishment). Further, the part may be conditionally necessary for its end, or it may come to be or be present because it makes a part or a function better. The *Analytics* gives us very little guidance on these features of explanation specific to natural enquiry.

On the other hand, the explanations have the following *Analytics*-style features:

(1) They are often easily rendered into syllogistic form.
(2) The premisses are either basic principles or at least more basic than what is to be explained, and are typically modally qualified.
(3) The fact to be explained is typically that a certain part belongs *per se* to a certain kind of animal.
(4) The explanations often provide the ingredients for a definition of the part whose presence is being explained.

In these respects they are fully in the spirit of the *Analytics*.

## CHAPTER 6

### $651^b20$–$653^b18$

The discussion of marrow flows naturally out of the previous chapters since it too is treated as a direct product of blood, and is differentiated in precisely the same way as fat is. But that the brain is discussed next is due more to the fact that Plato had argued for a close connection between them in the *Timaeus*. In fact, throughout these chapters there is a strong emphasis on countering the views put forward in the *Timaeus*.

$651^b20$: 'of the nature of blood'. The genitive is of origin, indicating that marrow is a concoction *from* blood, as is fat.

$651^b21$: 'as some think'. Cf. Plato, *Tim.* 73 B–E. The *Timaeus* argues that marrow is the origin (*archē*) of all the other tissues. Aristotle rejects the claim that marrow is the 'seminal potential of the seed' (*contra Tim.* 73 C 1, which refers to marrow as 'the *panspermia* in all mortal kinds'), and insists ($651^b13$–$17$) that semen and marrow both derive from blood. Plato turns out to have been closer to the truth: red and white blood cells are in fact manufactured in the bone marrow.

$651^b23$: 'in the embryos'. Aristotle's claim of marrow's more bloody character in the embryo is sound. Though evidence from embryological development is relied on here (and is reported at *HA* III. 20, $521^b8$–$11$), the brief discussion of bone formation in *Generation of Animals* does not mention marrow.

$651^b36$–$652^a1$: 'e.g. the bones of the lion'. Cf. $655^a14$–$16$. *HA* III's discussion of marrow makes a slightly different claim:

> Not all bones have marrow, but only the hollow ones, and even in some of these it is not present. Some of the bones of lions do not have it, while others have a very small amount. This is why, as was said previously, some people say that lions *as a whole* have no marrow. And in pigs' bones there is very little, and in some it is entirely absent. (*HA* III. 20, $521^b11$–16)

*Historia Animalium* and *PA* agree on the common belief about the bones of lions, find a reasonable source for it, and agree in rejecting it. But *Historia Animalium* has a more precise alternative, stating that marrow is entirely absent in some bones, but present in small amounts in others; while *PA* suggests a minimal amount in all bones.

$652^a4$: 'or that which is analogous to bones, such as fish-spine'. The term translated 'fish-spine' seems originally to have referred to thistles, but was in use as a term for the backbone of fish before Aristotle. To avoid confusion, I have translated *rhachis*, which refers to spines generally, as 'backbone'.

On analogy generally, cf. $644^a16$–22, $645^b4$–13, and notes. On the analogy of fish-spine to bone, cf. *PA* II. 8, $653^b33$–6, $654^a20$–3; *An. Post.* II. 14, $98^a20$–4; and *HA* I. 1, $486^b19$; 2, $511^b6$–7; 7, $516^b14$–16; 8, $517^a1$–3; and 16, $519^b28$–9.

$652^a6$: 'has been said before'. Cf. $650^b12$–13; the precise phrase used here, 'nourishment for all', is found at $650^a3$, but refers to moist and dry.

$652^a7$–10: 'marrows akin to both hard fat and soft'. We are not provided with any way of differentiating fat from marrow, other than its location within bones. But this passage implies that there are two kinds of marrow that correspond to the two kinds of fat.

$652^a17$–18: 'the marrow here, as has been said, is somewhat different'. Cf. $651^b32$–6. But how is this differentiation produced? In this passage and the previous one, Aristotle may be presupposing that blood concocted by natural heat within an enclosed container takes on distinctive properties.

$652^a19$–23: 'Why, then, those animals with marrow have . . . it is also apparent what marrow is'. Cf. $651^b17$–19 and note. This passage provides a summary definition and suggests that considering the explanation for marrow's presence also reveals what marrow is. This recalls *An. Post.* II. 10: 'another definition is an account revealing the reason why . . . like a demonstration of what *X* is, ⟨the terms⟩ differing in position from ⟨the terms in⟩ the demonstration' ($93^b38$–$94^a2$).

The summary account here is 'the enclosed, concocted residue of the sanguineous nourishment apportioned to bones and fish-spine', and its grammatical structure is similar to the account of thunder in the *Posterior Analytics*. But the interplay of explanation and definition is much more complex, reflecting the complexity of the biological domain. Supporting that summary account are explanations of why marrow belongs only to blooded animals, why it is differentiated in ways correlated with differences in fat, why different marrows belong to animals with and without upper incisors, why some blooded animals have no marrow, and why in some groups some bones (or bone analogues) have marrow and some do not. This summary definition does not specify a soul function for marrow, nor, with the exception of spinal marrow, is a teleological explanation given for it (in stark contrast to the *Timaeus*).

## CHAPTER 7

$652^a24$: 'The very next thing to discuss is the brain'. The reason Aristotle gives for discussing the brain next is that the brain 'seems to many people to be marrow'. He mentions no one by name, but *Tim.* 73 D refers to the brain as a part of marrow, and the origin of 'divine seed' (cf. 91 B), a theory that Cornford (1937: 295) attributes to Alcmaeon of Croton and Hippo of Rhegium. This evidence suggests that it was a widely held view.

$652^a27$–$^b1$: 'the opposite of marrow in its nature'. The most obvious way to take this claim is that marrow and brain are, respectively, warm and cold, which are opposites. It is, then, a claim about *material* natures. Aristotle claims that many things make it clear that marrow is warm, but the only evidence presented here is that it is oily ($652^a29$–30; on the relation of oil to heat, cf. $651^a25$–6). The brain's coldness is apparent to touch ($652^b27$–8) and it has the least blood and moisture of all the moist parts ($652^a28$–9), which apparently also tells in favour of its cold nature. Further, this opposition promotes the animal's health ($652^a30$–3).

$652^a31$: 'for nature always devises'. The first appearance of a recurrent formula (cf. $652^b21$, $653^b34$, $655^b7$, $664^b22$, $^b32$, $665^a8$, $^b13$, $675^b11$) used in contexts where a co-ordination of different features is required for the sake of something fundamental to the animal's life. The animal's nature produces each part relative to the needs of the whole organism; this often requires the production or modification of a part primarily to ensure the proper operation of the system as a whole, rather than for the performance of a specific function. Thus in this chapter this expression is used to indicate that the brain's function, and thus its physical nature, is defined relative to the excess heat of marrow and of the heart.

$652^b2–6$: 'the brain has no connection to any one of the perceptual parts'. Plato associates the rational soul with the brain (cf. *Tim.* 73 C 5–D 2; 85 A–B on the effects of phlegm on 'divine circuits in the head'). The Hippocratic treatise *On the Sacred Disease*, chs. 5–21, also assumes that the brain is the chief organ of cognition. But neither claims a direct connection between sense-organs and the brain. Aristotle claims, much to our surprise, that visual inspection rules out any functional connection between brain and the sense-organs. This is the more surprising in that he reports on optic 'channels' (in fact three from each eye) running to the brain (*HA* I. 16, $495^a11–18$), or to the blood vessels around it (*PA* II. 10, $656^b18–19$). However, it should be kept in mind that without knowledge of the nerves, the connection of perceptual systems to the brain is not at all obvious.

$652^b6$: 'for the preservation of their entire nature'. Aristotle's own theory ties the brain to the central instrumental role of heat in life's functions, which some (at least the atomists) have taken to establish the identity of soul and fire ($652^b8$; cf. *An.* I. 2, $404^a1–5$; II. 4, $416^a10–18$). The function of the brain is to moderate the production of heat by the heart. It is well suited to this, for it is a compound of earth and water—the cold elements ($652^b16–23$).

Aristotle's most powerful piece of evidence for this claim is a matter of *comparative* anatomy. Aristotle has noted, he thinks, a correlation between the brain and blood ($652^b23–6$). *All* animals by nature have at least one organ of perception—if the brain subserved cognition, all animals would have one. Since the bloodless animals do not, its presence must be explained otherwise.

In many cases, the contention that bloodless animals lack a brain is understandable—insects and most molluscs and crustaceans have no part of the central nervous system resembling a vertebrate's brain. But the cephalopods give Aristotle problems (see $652^b24–5$). Further, though Aristotle claims that the heart too is missing in bloodless animals, he is willing to posit a bloodless analogue of the heart and blood; why not do the same for the brain? Indeed, in explaining the brain's role in sleep below, he refers to an analogue of the brain in brainless animals ($653^a11–12$).

$652^b16–19$: 'everything requires an opposing counterweight'. Given that the brain is devised as a counterpoise to the heat of the heart and blood, it must be cold. Aristotle later provides empirical grounds for claiming *that* the brain is an earth/water (hence cold) compound ($653^a20–7$). This passage explains *why* it is, and why it is restricted to animals with blood.

$652^b24–5$: 'excepting those that have a brain by analogy, such as the octopus'. Here Aristotle claims that animals such as the octopus have only an *analogue* of the brain. At *HA* I. 16, 494$^{b}$28, and IV. 1, 524$^{b}$4, however, he claims that the entire class of soft-bodied animals (our 'cephalopods') has a small brain, which constitutes a serious exception to the claim that only the blooded animals have one. The implications of these conflicts between *PA* and *HA* for their relative dating are discussed in Balme (1987*a*) 13–16 and (1991) 21–5; this case in particular is considered in Lennox (1996*a*). Aristotle's functional theory of the brain would require radical revision if it turned out that an entire kind of bloodless animal had one.

652$^{b}$31–4: 'densely packed and thin blood vessels . . . thin and pure'. The brain is to cool the blood, but it cannot be too cold itself, and the blood serves reciprocally to moderate the brain's temperature. But were this done by large blood vessels with thick, hot blood, the brain would become too warm to function properly. Thus, it is surrounded by a network of *small* blood vessels full of the *thin* blood that has 'evaporated' upward, and that (see next note), when cooled, produces 'fluxes'.

652$^{b}$33–653$^{a}$10: 'that fluxes originate from the head'. The passages previously noted in Plato's *Timaeus* and the Hippocratic *On the Sacred Disease* imagine a similar origin for certain diseases. But the specific mechanics are different in each author.

653$^{a}$2–8: 'similarly to the generation of rain'. The description of the rain/evaporation cycle, which serves as an analogy for the production and then flow of phlegm, may be based on *Meteor.* I. 9, 346$^{b}$21–36. The same analogy is used at *Som.* 3, 457$^{b}$32–458$^{a}$6.

653$^{a}$8–10: 'the natural philosopher . . . the origins of disease'. Compare *Sens.* 1, 436$^{a}$18–436$^{b}$2; *Resp.* 21, 480$^{b}$22–31; cf. 648$^{b}$4–8 note. Here Aristotle seems to be saying that the topic of the way in which basic physiological processes originate diseases is part of what a natural philosopher could discuss in works devoted to the principles of health and disease.

653$^{a}$10: 'also produces sleep'. Cf. *Som.* 3, 456$^{a}$30–458$^{a}$32.

653$^{a}$19–20: 'in works establishing definitions both about perception and about sleep'. Cf. *On Sense and Sensible Objects* and *On Sleep*, though only the latter discusses the causes of sleep directly.

653$^{a}$20–7: 'the brain is a combination of water and earth'. While the brain is not specifically discussed in *Meteor.* IV, the evidence and theory cited here is. The theory of boiling (defined as concoction by moist, external heat) in *Meteor.* IV. 3, $380^b13$–$381^a12$, argues that anything which is boiled has its moisture drawn off by the heat of the surrounding moisture. The analogy with fruits (within which group Aristotle includes legumes: cf. $389^a15$) follows *Meteor.* IV as well, for they are there, as here, argued to be earth/water compounds with earth predominating in the mixture. That the brain becomes dry and hard when boiled thus establishes it as an earth/water compound relative to the chemical theory of *Meteor.* IV.

$653^a27$–30: 'mankind has the largest brain . . . the males have a larger brain than the females'. *HA* I. 16, $494^b28$, *PA* II. 14, $658^b8$, *GA* II. 6. $744^a28$, and *Sens.* 5, $444^a30$, all make the same claim about the size of the human brain, and add that it is also most moist. Given Aristotle's theory of the brain, this has nothing directly to do with cognitive superiority of humans to other animals, or men to women, but *indirectly* it does, as we shall see in chapter 10. Most commentators credit Aristotle with seeing this as a claim about *relative* brain size, though the Greek in these passages simply states that the human brain is greatest in respect of magnitude, and the male's greater than the female's. In fact, regarding differences between the brains of men and women Aristotle is probably correct:

> But the difference in brain size between men and women cannot be accounted for just in terms of body size. Men's brains are on average 15% larger than those of women, about twice the difference in average body size between men and women. (Roediger *et al.* 1996: 72; cf. Gibbons 1991)

$653^a30$–3: 'human beings alone among animals are upright'. This is a straightforwardly thermomechanical explanation of man's upright posture (cf. $669^b3$–8). Elsewhere our fleshy buttocks and lack of a tail ($689^b11$–28), our large feet ($690^a28$–30), and our possession of hands ($687^a2$–23) are explained as *consequences* of our upright posture. *PA* IV. 10 provides a teleological explanation for it, though even that explanation has a thermodynamic component. (Cf. IV. 10, $686^a25$–31, $686^b28$–31, and notes.)

$653^a32$–$^b8$: 'the bone around the head'. In more detailed discussions of the skull Aristotle reserves the term I have translated 'frontal bone' for the anterior portion of the cranium (cf. *HA* I. 7, $491^a31$–$^b5$; 16, $495^a9$–10; III. 7, $516^a13$–23), but here it seems to refer to the entire cranium (it has many sutures, and surrounds the head). Compare the discussion in the Hippocratic *On Wounds in the Head* (*VC*) 1. The differences between the sutures of male and female humans, and between humans and other animals, are repeatedly discussed in *Historia Animalium.* These claims are false, but their specificity argues for their being based on some sort of observation (for a speculation, see Ogle 1882: 168 n. 26; 1912: $653^b1$ nn. 3, 4). None the less, it has been argued that Aristotle's theory of the cooling function of the sutures may have led to the uncritical adoption of such claims (Lloyd 1983: 102 and nn. 165–7; 1987*a*: 57).

$653^b12$–18: 'in the examination and study of nourishment . . . in the works on generation'. This reference to a study of nutrition is not in the formulaic pattern of references to books, but is rather a reference to the actual investigation, while the reference to *Generation of Animals* is in the formula that appears to be reserved for references to books. It tells us that the investigation of nutrition, like other investigations, has one part which aims to determine (1) the scope of the predications (in this case of the residues associated with nutrition), and (2) their causal explanation. There is a full discussion of milk in the various live-bearing animals in *GA* IV. 8; in *GA* II. 4, $739^b25$, it is said to have the same nature as the *katamēnia*.

## CHAPTER 8

### $653^b20$–$655^b27$

Chapter 8 focuses on the existence and explanation of hard and soft parts in animals generally, followed by specific accounts of the presence or absence of hard parts in the most extensive bloodless kinds. Chapter 9 first discusses bones in blooded animals *generally*, then their variations in the most extensive kinds. Next there is a discussion of cartilage in the cartilaginous fishes, which leads naturally to a general comparison of cartilage and bone. This comparison leads to a discussion of other parts made of similar material and to the announcement of a decision to put off discussion of other uniform parts until after the discussion of the wholes they compose. The entire discussion displays Aristotle's method of moving from the more general to the more specific explanation. The narrowest class considered—other than to cite an example or a possible exception—is that of the cartilaginous fishes.

$653^b20$–1: 'flesh . . . and its analogue'. Aristotle refers to 'fleshy' and 'flesh-like' parts at $654^a4$, $^a13$, $^a16$, $^a29$–30. In the soft-bodied animals (i.e. cephalopods) the soft part of the body is 'between flesh and sinew', as judged by its manner of elasticity and divisibility ($654^a15$–18). The body of an insect is not differentiated into hard and soft parts, but is in its entirety more flesh-like than bone and more bone-like than flesh ($654^a28$–31).

This allows for a fairly precise characterization of the 'analogue' to flesh here. Thus the bloodless animals will have uniform parts that (1) perform the same function as flesh, (2) are the soft part of their bodies, (3) have similar, though distinct, dispositional properties, and (4) are derived from a substance analogous to blood.

$653^b21–4$: 'in virtue of itself an origin and a body of animals'. Up to this point blood, its residual derivatives fat and marrow, and the brain (which 'many' take to be the origin of marrow and which Aristotle takes to function as a moderator of the blood's heat) have been discussed. Aristotle provides two intimately related reasons for turning next to flesh: (1) it is an 'origin' and (2) it is a body belonging to animals in virtue of its very nature.

The first argument for this claim is *kata logon*—it follows from the definition of animal. Perception is the defining capacity of animals, tactile perception is the form of perception common to all animals, and flesh (or its analogue) is the organ of touch. Flesh thus belongs necessarily to all animals and follows in virtue of its nature as the organ of touch. (See *An.* II. 3, $414^b1–14$; II. 11, $422^b34–423^b26$; and *Sens.* 1, $436^b8–437^a3$.)

$653^b24–30$: 'the sense-receptor—either the primary one . . . or it taken with the medium'. Ogle (1912: $653^b29$ n. 1) finds an inconsistency, even within *PA*, concerning the role of flesh in tactile perception. In II. 1,[1] he claims, Aristotle treats flesh as the organ, not the medium, of touch, while in chapter 10[2] he denies that it is the organ of touch. Ogle also argues that the present passage is, unlike the other two, in line with the theory outlined in *An.* II. 11.

These passages *do* reveal a good deal of hesitation on Aristotle's part. $647^a20$ states that flesh (or its analogue) is the seat of tactile awareness. $653^b24–5$ says that touch is the primary sense, and that the seat of tactile awareness is flesh or its analogue. Aristotle then offers the alternative that flesh is either the primary part, as the pupil is of the eye, or the primary part inclusive of its medium, but does not opt for one alternative or the other. *An.* II. 11 reveals the origin of his concern. All the other senses are activated by movement in a medium; if the object is placed directly on the sense-organ, perception fails. But just the opposite appears to be the case with touch—it is only when the object is placed directly on the sense-receptor that there is awareness. His tentative solution (offered at $423^b23–6$) is to see flesh as the medium of tactile sensation, with 'something within' acting as the receptor. *PA* II. 10, $656^b35$, follows this solution, saying that something internal, not the flesh, is the *primary* seat of sensation.

$653^b29–30$: 'of the sense-receptors, this is either the only, or the most, bodily one'. Again this claim is clarified by *An.* II. 11. Touch perceives the

[1] Ogle's note erroneously refers to $651^a20$; the reference should be $647^a20$.
[2] Again the reference should be to $656^b35$, not $656^b25$.

primary differentiae of body—hot, cold, moist, dry, and their derivatives solid, liquid, hard, soft, and so on. Perception is passive, and for Aristotle this requires that what is affected be like in kind with what acts on it, capable of becoming hotter or colder, more moist or dry.

$653^b30–4$: 'It is apparent to perception that all the other uniform parts are for the sake of flesh'. The phrase 'apparent to perception' is probably in contrast to the earlier argument *kata logon* that flesh and its analogue belong to animals in virtue of being the organ of the defining capacity of animal. 'Apparent to perception' must be taken to mean something like 'apparent on empirical grounds'; that the parts mentioned here are for the sake of preserving flesh is certainly not a perceptual given. This rather sweeping claim may be intended only to apply to the parts mentioned here, though nothing in the Greek so restricts it.

$653^b31–3$: 'bone, skin, sinews, blood vessels, and again hair, and the kind which includes claws'. The manner in which the parts mentioned here are discussed in *PA* is not straightforward. Hair, skin, and sinew are only discussed in association with other uniform and non-uniform parts, in marked contrast to *HA* III, where they are discussed sequentially, sinew at $515^a26–515^b26$, hair, skin, and other animal coverings at $517^b2–519^a30$. Claws and their analogues, on the other hand, are discussed in the same sequence in *PA* II and in *HA* III, following bone and its analogues because of their material kinship to bone (cf. $516^a8–517^b2$). See below, $655^b2–22$, and notes.

$653^b36$: 'some of the bloodless animals have it outside'. $654^a9–31$ discusses insects and cephalopods, the first having no distinguishable 'skeletal' part, some of the second having such a part internally. Aristotle begins with the groups corresponding to our 'crustaceans' and 'testaceous molluscs'.

$654^a1–3$: 'each of the soft-shelled animals . . . the kind consisting of hard-shelled animals'. Rather than substituting modern classificatory labels for Aristotle's, I have chosen translations with connotations corresponding to those the Greek term might have had in fourth-century Athens. (Perfectly literal translations might be 'the soft pots' and 'the pottery skins', since the shared root of the two terms—*ostrakon*—refers to earthenware.

As he notes in *PA* I. 4, Aristotle inherited a vocabulary with very few names for biological kinds of wide extension (only 'bird' and 'fish' are mentioned). Crabs, oysters, and squids had common names, but not the wider kinds to which they belonged. Thus the names for his bloodless animal groups are neologisms based directly on obvious features of their bodies.

Philosophically, the conceptual identification of such groups is important for Aristotle, since his science seeks explanations for why properties belong to the widest class to which they truly belong. *An. Post.* I. 5 makes the point with a number of geometric examples, but it is no less true in biology (as Aristotle illustrates in *An. Post.* II. 14). If a horseshoe crab possesses an exoskeleton because of its 'soft-shelled' nature, true understanding requires that you recognize this, and explain why *all* soft-shelled animals have exoskeletons. If one kind of soft-bodied animal (i.e. the octopuses) lacks an internal hard part, that requires an explanation based on the nature of octopuses, not soft-bodied animals.

Animal groups more specific than these 'extensive kinds' are usually only mentioned either as examples of generalizations, or as exceptions to them: 'crabs' are examples of soft-shelled animals; the octopus is exceptional because, unlike the other two 'soft-bodied' kinds, it has no internal hard part.

$654^a8–9$: 'The tortoise and the kind consisting of the turtles'. Such shells warrant mention here, because they are the only example of external hard features among the blooded animals Aristotle knows of, and are thus a peculiarity requiring explanation. In other respects they are standard 'four-footed egg-layers', and indeed have internal skeletons along with this shell.

$654^a20$: 'in the sepia is a part called the "sepion", in the squids what is called the "sword"'. The word 'sepia' is still in use to refer to cuttlefish; I have transliterated the Greek to make it obvious that the name for the internal skeletal remnant is the neuter noun corresponding to the (feminine) name for the animal. The use of 'what is called' indicates that these terms were in common use—not surprisingly, since cephalopods were (and are) a popular seafood in Greece. Thus the accuracy of Aristotle's descriptions of the internal hard structures in the cephalopods should not over-impress us. What is more impressive is the ability to systematize available information about familiar animals in generalizations of such wide extension, and to provide explanations for such generalizations.

$654^a24–5$: 'nature added these parts'. The verb here is *hupographein*. Its two concrete meanings are something *written under* a text (such as a codicil), and something *sketched in or traced out*. There are a small number of apparently metaphorical uses in the biology—*GA* II. 4, $740^a23$; 6, $743^b18–25$; and *PA* II. 14, $658^a23$—nature being the subject. The two uses in *Generation of Animals* seem to trade on the second meaning, since it is the gradual development of the vascular and skeletal systems that is being discussed. The two uses in *PA* II are less clear, though both suggest the idea of something added as an afterthought.

$654^a26$–31: 'The insects . . . contrary to both the soft-bodied animals and the blooded animals'. Cf. $653^b20$–1 note. The conjunction 'bony and earthen' is quite common and shows that at one level the uniform parts can be conceived of in elemental terms. A teleological explanation is provided for the basic material constitution of the insect's body.

## CHAPTER 9

$654^a32$: 'The nature of bones and the nature of blood vessels are alike.' This comparison runs through the entire discussion down to $654^b10$. It involves three related points. (1) Both 'natures' consist of a continuous system deriving from one origin. (2) No part of either system truly 'is' unless it is a part of that system. (3) The parts can only perform their function when connected to their system. The second and third bases of the comparison are closely connected to Aristotle's principle that dead organs or organisms, or their artistic representations, are organs or organisms *in name only* (cf. *PA* I. 1, $640^b36$, and note; *Meteor.* IV. 12, $389^b31$, $390^a12$; *An.* II. 1, $412^b14$, 21; *GA* II. 1, $735^a8$; Cohen 1992: 60–4). Presumably it is the inability of a disconnected bone to perform its supportive function that explains why it is not a bone ($654^b3$–7). Aristotle thus puts very strong functional requirements on the proper application of terms for organic parts. It is does not follow, however, that he thinks that possession of a certain functional capacity is *sufficient* for a name's proper application. There are two reasons to doubt that this is his view. First, he thinks scientific definitions of natural objects characterize a certain sort of matter functioning in a certain way—that is, definitional identity of parts may require both material *and* functional identity (cf. *PA* I. 1, $640^b22$–9, $641^a28$–32, $642^a2$–13; *Met. E* 1, $1025^b34$–$1026^a7$; *Phys.* II. 2, $194^b7$–13). Second, were functional identity *sufficient* for true synonymy, one would expect the bloodless analogues of blooded parts—which are functionally identical to their counterparts—not to be analogues at all, but forms of the same kind of part. As Cohen points out (1992: 60–4), that touch is realized in both flesh and its analogue speaks both against a view which states that organs are fully defined by their function and one which states that a unique material structure is necessary for each organic function.

The phrase 'the nature of the bones' is used a number of times in this chapter (e.g. $654^a32$, $^b12$–13; $655^a20$). Sensing a special use of 'nature' here, Ogle and Peck translate 'the system'. This is a mistake. What 'the nature of the bones' refers to is the *single nature* of the skeletal bones, in virtue of the fact that they function as a unit. Similarly, the phrase 'the nature of cartilage and bone' at $655^a32$ must refer to the material nature, but it would be a mistake to translate 'the matter of cartilage and bone'.

654$^b$14–15: 'the backbone . . . the division of the vertebrae'. Since it is the origin of the continuity of the nature of the bones, the backbone's 'divided' character requires comment. The continuity requirement demands that it be one, but the need for bending (combined with the inflexibility of bone) requires that it be divided. The vertebrae are viewed by Aristotle as a fitting solution to this biomechanical problem. See the critique of Empedocles' account of the vertebrae at *PA* I. 1, 640$^a$19–26.

654$^b$16: 'of those with limbs'. That is, not fish or snakes (cf. *HA* III. 7, 516$^b$26–29). A somewhat suppressed 'conditional necessity' explanation governs the reasoning in this passage: since limbs must bend and straighten, their bones require sinews and either fitted joints or cartilaginous padding.

654$^b$19–26: 'and their extremities fit together'. Aristotle is distinguishing ball and socket, bolted, and cushioned joints (see Ogle 1882: 170 n. 2). But strangely, he offers no explanation for the differences—and, having suggested that the ends of bones in joints of the first two sorts are shaped to fit with each other, he has to admit that bones meeting at joints such as the knee are not, and thus need cartilaginous material to keep them from rubbing against each other.

654$^b$27–655$^a$4: 'just as those who shape an animal from clay . . . so in the same way has nature crafted the animal from the fleshy parts'. The verb here, *dēmiourgein*, recalls the divine Demiurge of Plato's *Timaeus*. Historically, such comparisons encouraged anatomists such as Galen to identify Aristotle's formal nature with intelligent craftsmanship. (The same language is found at *PA* I. 5, 645$^a$9; II. 1, 647$^b$6; IV. 10, 686$^a$12.)

655$^a$4–5: 'The animals that bear live young both internally and externally'. This wording is intended to exclude those selachians that have an internal egg-case but bear live young externally, since they have cartilage, not bone.

655$^a$6–8: 'about equal in the potency and strength . . . speaking according to bodily proportion'. The reference to 'bodily proportion' qualifies the claim that the *vivipara* are generally larger than the *ovipara*, a qualification obviously needed, given that Aristotle knows about tuna and ostriches on the one hand, and moles and mice on the other. But he does not explain what the qualification means. One way of taking 'about equal in power and strength' is as a claim that the true live-bearing animals all have bones of fairly uniform consistency and strength (655$^a$5–6).

655$^a$10–16: 'need of supports that are stronger, larger, and harder . . . the bones of the males are harder than those of the females, especially those of the carnivores'. The *primary* claim here is that larger animals need stronger, harder supports, and from this Aristotle infers that male bones will be harder than female. Since female humans are more prone to osteoporosis than males, and since this was probably even more true in Aristotle's culture and time than in ours, one can imagine what uncontrolled evidence might have suggested this inference. He does, however, go on to claim that it is especially among carnivores that the males have harder bones than the females, citing the lion. This is an unfortunate example, since it is the female lion that is the primary hunter in that species. The claim he makes about lion bones, however, is apparently not restricted to the males.

$655^a16$–17: 'And even the dolphin has, not fish-spines, but bones; for it is live-bearing.' These attributes are predicated separately of the dolphin at *HA* III. 7, $516^b11$–12, with no mention of an explanatory relation between them (cf. Lennox 1987*a*: 109–10). The point of also stressing that dolphins do not have fish-spine is that, since they are aquatic, one might expect them to have fish-spine like fish rather than bones.

This is the first reference to a cetacean in *PA*. *HA* I. 6, $490^b7$–9, and II. 15, $505^b29$, use the Greek term for large sea creature, *kētē*, to designate a distinct extensive blooded kind; elsewhere, the references are less formal (e.g. *HA* VII (VIII). 2, $589^a31$–$^b2$; *Resp.* 12, $476^b13$–16; *PA* III. 6. $669^a8$; IV. 13, $697^a15$). Aristotle appears fascinated by the combination of lung, blowhole, lactation, and live birth in a water-dwelling, limbless animal.

$655^a17$: 'nature makes a transition by small steps'. Cf. $655^a32$–3 and note. In *HA* III. 7, $516^b12$–17, the point about bones differing in small steps is explicitly restricted to the birds. Though less often cited than *PA* IV. 5, $681^a10$–$681^b13$, and *HA* VII (VIII). 1, $588^b4$–$589^a10$, these passages might be added in support of the claim that Aristotle believes in a continuous 'scala naturae'. But it is advisable to be cautious about reading the eighteenth-century passion for the 'chain of being', with its Neoplatonic and Christian roots, back into Aristotle's discussions of observed differences that are continuous across kinds rather than discreet.

Some of the variations noted are explained, others not. The weak nature of bones in birds and the presence of fish-spine in fish are left unexplained, while the presence of something approaching true bones in the larger snakes allows Aristotle to mobilize the explanation for their presence in the large *vivipara*.

$655^a26$–8: 'nature cannot distribute the same excess to many different locations simultaneously'. This is the only passage in which this principle is explicitly invoked (but cf. *PA* II. 14, $658^a31$–6; IV. 12, $694^a26$–8); but it lies behind a number of explanatory claims in *PA*, in which the absence of some part is taken to be sufficiently explained by arguing that the material for that part was used up elsewhere (e.g. *PA* III. 2, 663$^a$31–3; IV. 12, 694$^a$8–11, 694$^a$26–8, 694$^b$18–22). There is an implicit 'double explanation' for the presence of a cartilaginous skeleton in selachians here. Functionally, their manner of swimming requires a flexible skeleton; materially, their nature has expended the earthen material needed to make true bone in producing their tough skin. The formal nature of the animal determines the optimal distribution of material. But the selachians appear to have a fixed amount of 'surplus' earthen material which constrains the actions of the formal nature.

655$^a$32–33: 'The nature of bone and cartilage is the same, though it differs by the more and less'. The language of 655$^a$32–4 is virtually identical to *HA* III. 8, 516$^b$30–3, except for the inferential 'for which reason' in the *PA* passage. Compare *HA* III. 7 (cf. 516$^b$4–5, $^b$14, $^b$28–32). On bone and cartilage as both analogues and differing by more and less, see 644$^a$16–22 note. What makes cartilage an analogue of bone is that it is a differently designated part which is present *for the same function in a different kind of animal* (cf. 644$^a$16–22, 645$^b$4–13, and notes). What makes it the same nature as bone, differing only by more and less, is its material constitution (cf. *HA* III. 7, 516$^b$3–5).

655$^a$34: 'marrow'. In this passage Aristotle faces up to a difficult anomaly: while the cartilage in land-dwelling animals is without marrow, that of the backbone of the selachian fishes has separate marrow (cf. 652$^a$13–15). His explanation is that in land-dwellers the cartilage is softer, owing to the marrow being mixed with it; in selachians the cartilage functions as bone, and therefore marrow is enclosed within it just as in bone.

Both the awareness of and the refusal to dismiss these puzzling similarities and differences are impressive. The explanation, on the other hand, seems *ad hoc*—we are not told how Aristotle decided that the cartilage of land-dwellers is a mixture of bone and marrow, nor why the selachian's cartilaginous backbone requires separate marrow.

655$^b$2–4: 'closely allied to bone to the touch'. Owing to a shared earthen and hard nature.

655$^b$5–8: 'for the sake of protection . . . have been devised for the preservation of each of them'. At first it appears as if there are two disconnected 'unities' among these parts—they appear similar to the touch, and they are present to serve the same general function. This passage gradually connects them.

$655^b7$: 'the wholes that are constituted from and synonymous with their parts'. For further discussion see $647^b17$–20 and note.

$655^b8$–9: 'The nature of the teeth'. Cf. *PA* III. 1, $661^a34$. In both cases 'nature' refers to the functional nature shared by the teeth. On their various possible functions cf. *PA* III. 1, $661^a34$–$662^a15$.

$655^b11$–13: 'Of necessity . . . an earthen and hard nature; for this is the defensive potential.' Since we have just been told that these parts are present for the sake of defence, this amounts to providing a teleological explanation for their material nature. The necessity, then, is conditional. To have a *nature* that is earthen and hard is to have a *potential* of a certain sort.

$655^b15$–20: 'the causes . . . and what each one is present in animals for . . . it is necessary to know them from their functions'. A clear statement of two principles of Aristotelian biology. (1) Even the simple, uniform parts are to be explained teleologically. (2) To explain teleologically is to know a part through its functions.

$655^b21$–2: 'since these parts are synonymous with their wholes'. This apology is puzzling, since the same claim can be made for bone(s)—in what sense are horns or claws any different?

$655^b22$: 'we omitted seed and milk'. Compare $653^b13$–18; and see *GA* II. 4, $739^b25$, and IV. 8 on milk.

## CHAPTER 10

### $655^b28$–$665^a26$

A significant transition from the uniform to the external, non-uniform parts of blooded animals takes place at this juncture. At $664^a11$ Aristotle announces that he has discussed all of the external, non-uniform parts on the head, and he begins to discuss the neck. But at III. 3 this move turns out to be a transition to the *internal*, non-uniform parts of blooded animals. A cursory mention of the neck as protection for the windpipe and oesophagus leads into a discussion of all the innards of blooded animals, which carries on until well into Book IV, where a discussion of the bloodless animals then begins. Aristotle does not, in fact, return to the *external* non-uniform parts of blooded animals until chapter 10 of Book IV, at which point he announces that he will begin where he left off earlier! I shall discuss these transitions, and the puzzles associated with each of them, as we come to them.

There are a number of convenient subdivisions within this discussion of the non-uniform parts on the head which will be signalled as we proceed.

$655^b28–9$: 'once more at an origin, beginning first with those things which are primary'. There is a repetitive stress on the identification of a new beginning: The noun translated origin (*archē*) is cognate with the verb (*archein*) from which the participle translated 'beginning' derives; and 'first' (*prōton*) is an adverbial use of the same word that is translated 'primary'. Furthermore, in many contexts, as Aristotle says at *An. Post.* I. 2, $72^a6–7$, 'To be "from primaries" is to be "from appropriate origins"; for I refer to the same things as primary [*prōton*] and as an origin [*archēn*].' At the risk of some awkwardness, therefore, I have translated this opening sentence so that it is clear that Aristotle is saying more than that we are making a 'fresh start'. Among the likely candidates for the previous origins are hot, cold, moist, and dry, identified as starting-points of the elements ($648^b9–10$) and ultimately of the uniform parts themselves ($648^a23–4$). We are now going on to the non-uniform parts, and are going to begin with those that are 'most necessary'.

$655^b29–30$: 'at least those which are complete'. This might refer to the mature stage of each animal, or it might imply a distinction between more and less 'complete' or 'perfect' kinds of animals. Aristotle is capable of making both points, and occasionally both at once, as at *GA* II. 1, $733^a33–^b2$.

$655^b30$: 'two parts that are most necessary'. The discussion of 'the most necessary organs' owes a great deal to the discussion of the nature of blood at II. 3–4, where it has already been argued that all animals and plants require certain parts for ingesting and processing of nutrients (cf. $650^a2–32$). *HA* I. 2, $488^b29–489^a19$, states that the organs of ingestion and reception of food are common to all, while the organ for elimination is common to most, but not all—perhaps because that discussion is not restricted to the 'complete' animals. More surprisingly, the 'intermediate' part is *not* mentioned in the passage of *Historia Animalium*. There is a very similar remark in *On Youth and Old Age*, to the effect that the *complete* animals are divided into parts for the reception and the elimination of food, and a third between them, called the 'chest' (*stēthos*). If this is also the referent in *PA*, then the heart (or its analogue) would be the origin of life within. And since *HA* I is discussing what is common to all or most animals, not just the complete ones, the chest would certainly not be mentioned.

655$^{b}$32: 'for we say plants live as well'. Cf. *An.* I. 5, 410$^{b}$17–411$^{a}$2. Aristotle there notes that previous accounts of the soul make either locomotion, or perception, or respiration necessary conditions for being alive, thus denying that plants are living things. Thus he has to make a case that they are (cf. *An.* II. 2, 413$^{a}$20–413$^{b}$1).

656$^{a}$1: 'few actions require the use of few instruments'. Cf. *PA* IV. 10, 687$^{a}$10–12: 'and nature, like a discerning human being, always assigns each part to that which is able to use it'.

656$^{a}$2–3: 'we should study the visible character of plants independently'. 'Visible character' translates *idea*. The assertion at $^{a}$4 that animals are more 'polymorphic' in this respect may suggest that Aristotle is thinking primarily of organic structures. This is one of many references in the corpus to a study of plants (cf. Bonitz 1870: 104$^{b}$38–44). The modern editions of Aristotle include two books *On Plants*, but these are based on a Latin translation of an Arabic text that answers to nothing in our Greek manuscripts. Some slight support for there being a Greek original is the inclusion, in the ancient list of Aristotle's writings of Diogenes Laertius, of two books *On Plants* (V. 25); but these lists are not trustworthy guides. Aristotle's younger associate, Theophrastus, produced a nine-book *History of Plants* and a six-book *Causes of Plants*, apparently modelled on *Historia Animalium* and *Generation of Animals*, though Diogenes lists an eight-book *History of Plants* and a ten-book *Causes of Plants* (D.L. V. 46). Aristotle's references to other discussions are seldom in the first person, and it is possible that the internal references are to Theophrastus' works rather than to his own.

656$^{a}$4: 'more polymorphic in visible character'. 'Polymorphic' transliterates the Greek—the idea is that there is more structural diversity found in organisms with sense perception.

656$^{a}$6: 'not only of living but, in addition, of living well'. This claim is about a class to which humans belong, but is carefully not restricted to humans. In *EN* (I. 4, 1095$^{a}$17–20; 8, 1098$^{b}$22–3; IX. 10, 1170$^{b}$27) living well is associated with living according to practical intelligence; but Aristotle does not restrict practical intelligence to humans (cf. 648$^{a}$1–10 note for references). He does not explain how such a life is connected to greater organic diversity.

656$^{a}$7–8: 'either mankind alone, or mankind most of all, partakes of the divine'. *EN* X. 7–9 defends the life of reason as based upon an activity of that which is most divine in us, and which allows us to partake of the divine (cf. *PA* IV. 10, 686a26–32, 686b23–8, 687a15–23). It is not clear who else Aristotle might have in mind by the qualification 'only or *most of all*'. There are two possibilities. (1) *HA* VII (VIII). 1, 588a16–b3, sanctions the use of the language of 'practical intelligence' in characterizing a variety of non-human kinds (cf. 648a1–10 note). (2) *GA* II. 1, 731b24–732a1, and *An.* II. 4, 415a24–b8, argue that all organisms, in virtue of being able to reproduce another the same in form as themselves, 'partake in the everlasting and divine'. If this comment is related to that regarding 'living well', then the second possibility is ruled out, since it applies to all organisms. Since this is a ranking of *participants* in the divine, it does not conflict with *Met.* *Λ* 7, 1072b14–31, which ranks the life of the Prime Mover as best, on the grounds that it *eternally* enjoys the best life.

656a9–10: 'and because the shape of the external parts of mankind is most familiar'. This is the *only* justification for starting with mankind given at *HA* I. 6—but it is explicitly noted that this involves starting with what is more familiar to us, a qualification lacking in *PA*. *PA*'s primary justifications for beginning with mankind are based on established theoretical principles regarding human nature, reasons that are inappropriate to a non-explanatory treatise such as *Historia Animalium*. The latter work also explicitly defends starting with the instrumental parts and then going on to the uniform parts (491a23–6), while *PA* does just the opposite with no explicit justification at all.

656a13: 'for mankind alone among the animals is upright'. For a fuller discussion of this human feature see *PA* IV. 10, 687a2 ff. Mankind's upright posture plays at least a supporting role in the argument for making the instrumental parts of human beings our starting-point.

Aristotle handles dimensionality in two distinct ways. The cosmos as a whole has a centre and periphery, and cosmic up and down refers to movement either towards the periphery or towards the centre. In organisms, however, up and down are determined, as he says in *IA* 3–4, by biological function rather than simply by cosmic position (705a30–1). *Cael.* II. 2, 284b13–34, gives clear *priority* to the zoological account, in which the location of nutritive intake is 'up', of residual expulsion, 'down' (705a28–705b8). This allows for comparisons between functional and cosmic ups and downs (and for his oft-repeated quip about up and down being reversed in plants). Since in humans the orientation of 'biological' above and below and 'cosmic' above and below are the same, we have our parts organized 'naturally'. Given the divinity of the cosmos, this provides another argument for humans 'partaking most of all in the divine'. Lloyd (1983) 28–42 sees this passage as evidence that Aristotle imports from popular 'folklore' the notion of man as a model for other animals; I argue for the alternative presented here in Lennox, (1985*b*), and critically evaluate Lloyd's account in Lennox (1985*d*).

656a14–15: 'from what has been said about the brain'. Cf. 652a24–653b18.

656a16–27: 'as some people say'. Cf. Plato, *Tim.* 75 A–C. The views of the *Timaeus* are accurately, if sketchily, reported. Plato's explanation requires a trade-off between optimal cognition and long life. Aristotle is quick to point out that, on his view of the brain's function, there is no trade-off required.

Plato's defence, and Aristotle's rejection, of the brain as a cognitive apparatus raises the question of whether brain trauma is ever used as evidence to settle this matter. At *Sens.* 2 Aristotle notes that blows to the head occasionally produce blindness. But he attributes the blindness to the pupil being cut off from its channels to the bloodstream and ultimately to the heart.

656a24–7: 'in the manner of a syllogism'. The Platonic syllogism might be:

(P1) Certain of the senses belong to the head.
(P2) The most unusual part of the head is the brain.
(C) The senses belong to the brain.

656a27–8: 'in the works on perception'. Cf. 647a25–32 and note. Neither *De Anima* nor *On Sense and Sensible Objects* does anything more than allude to such a view, while *Juv.* 3 provides an argument for it.

656a33–4: 'hearing and smell in fish and other such animals'. This passage has a near doublet at *HA* IV. 8, 533a34–b5, that goes on to add a great deal of evidence to show that fish do, despite the lack of obvious organs, hear and smell. In that passage the cetaceans are mentioned as raising similar questions, and again evidence is cited which establishes that they do, in fact, hear and smell. This might be the intended reference of 'other such animals', i.e. other water-dwellers with no clear organs of smell and hearing. As far as I can make out, Aristotle never decides how fish hear. In the passage of *Historia Animalium* noted above he denies that the 'apparent' nostrils in some fish are such; and at *PA* II. 16, 659b15–19, he says that some non-breathers detect odours through their gills, and others through their pipes (cf. 659b15–19 note).

656a37: 'it is reasonable that sight . . . is in the area around the brain'. There are two explanations for the eyes being near the brain. (1) The visual receptor is water (cf. *An.* III. 1, 425$^a$3–6; *Sens.* 2, 438$^a$5, $^b$28–30; *GA* V. 1, 779$^b$22–6), and the brain is cold and moist, i.e. 'watery'. *Sens.* 2 makes the causal connection clear: 'The genesis of the eye occurs in the same manner; for it is constituted from the brain, since this is the most watery and coldest of bodily parts' (438$^b$28–30). (2) The accuracy that is a hallmark of vision is least impeded where the blood is purest. On the connection between cool, watery blood, purity of blood, and superior perception, cf. 650$^b$19–24 and note. On the special status of vision, cf. *Met. A* 1, 980$^a$22–7, and *Sens.* 1, 437$^a$5–9; the claim to greater accuracy may be related to the claim that vision perceives 'many differences', which may in turn rest on the fact that it provides access to many of the 'common sensibles' (motion, shape, size, and number, 437$^a$9) as well as the special sensible of colour.

656$^b$1–2: 'the most easily confined of transparent things'. Presumably Aristotle has in mind that the water needs to be confined within the eyeball, and thus that this is a good thing. To say that sight is in its nature water is highly elliptical; he may mean that the material nature of the organ of sight is water. That the organ of vision must be transparent is not stated here, but is at *Sens.* 2, 438$^b$5–8. If Aristotle is restricting the scope of 'the transparent things' to the elements, air is the only other candidate; he gives us no insight into why he thinks it is less easily confined than water. Might air, being thinner, be able to escape through an enclosing membrane?

656$^b$11–12: 'the head is not lacking in flesh for the sake of the brain's perception'. Against the theory of Plato's *Timaeus* (75 B–76 E), Aristotle uses a 'method of difference' test of causal relatedness: 'if *X* (lack of flesh) is present when *Y* (the brain) is absent, *X* is not for the sake of *Y*'. Since this is a teleological relationship, *Y* is the supposed cause.

656$^b$13: 'for the back of the head has no brain'. The claim that the brain is present in the front of the skull, while the rear is empty (a claim also made at *HA* I. 16, 494$^b$25–495$^a$1), should be compared with similar remarks in the Hippocratic *On Wounds in the Head*, 1, 2. This claim plays an important role throughout this discussion. The passage in *Historia Animalium* also indicates that on questions of internal anatomy such as this, we are at our most ignorant with humans, and must base our knowledge on those other animals most like mankind (494$^b$20–5). This is apparently because of proscriptions against dissection of the human body. Ogle (1882: 174–5 n. 18) notes that the claim is closer to the truth with certain of the *ovipara* than with humans.

656$^b$13: 'some of the animals have their hearing in the region around the head'. The continued centrality of premisses regarding directional orientation and location throughout this discussion amply justifies Aristotle's assertion, at *IA* 2, $704^b18$–22, that these principles are basic starting-points of natural investigation.

$656^b16$: 'we claim that the sense-receptor for hearing consists of air'. For example, at *Sens.* 2, $438^b20$. The word I am consistently rendering 'hearing' (*hē akoē*) can also refer to the ear; but since here, and elsewhere, Aristotle explicitly refers to the sense-receptor (*aisthētērion*) of hearing, and consistently uses the term *akoē* in the singular, it seems clear that he has the faculty of hearing in mind. Further, he uses the term *ta ōta* for the ears, though usually in reference to the outer ear.

$656^b19$–22: 'Nothing bloodless'. These lines are bracketed in their entirety by Peck, and partially by Ogle. Düring (1943: 148–9) argues for their retention. There is little manuscript authority for deletion; and while there is some uncharacteristic wordiness to the passage, it makes perfect sense. The claim is that nothing that lacks blood can perceive, nor, as we were previously told ($650^b3$–7), is blood itself perceptive. The discussion is explicitly restricted to blooded animals, and rules out the brain and the blood itself as sense-receptors. It is somewhat odd to say that blood is no part of the animals—elsewhere Aristotle treats it as a uniform part ($647^b10$; $647^b30$; *HA* I. 1, $487^a3$; III. 2, $511^b2$); but he may have in mind that it is also that from which all the other parts are made ($650^a34$–$^b11$; $651^a12$–15). The second sentence is not strictly a repetition, for it applies a general point about the connection between blood and perception to the bloodless parts (e.g. brain) of blooded animals.

$656^b23$: 'the front is towards what is perceived'. This is a definitional connection, according to *IA* 4, $705^b8$–13:

> To such things as not only live but are also animals belong the front and the back. For all these ⟨animals⟩ have perception, and front and back *are defined by reference to this*; for the location in which perception naturally develops and whence it is found in each of them is front, while those locations opposite to these are back.

In a later passage Aristotle makes it clear that it is the orientation of the eyes that is the crucial determinate of 'front' ($712^b18$–19). Compare *PA* III. 3, $665^a10$–18.

$656^b28$: 'hearing placed on the midline of the circumference'. Take front and back to be determined as above; then the ears are placed at the midpoint between front and back going around the circumference of the head in either direction.

656$^b$30: 'movement is in the forward direction'. See 656$^b$23 note.

656$^b$32–A 4:'because the body is double . . . each of the sense-receptors is double'. Cf. *PA* III. 7, 669$^b$18–24, on the double character of the viscera. That animal *bodies* are bilateral may be a sort of hypothetical first principle—at any rate, in both texts it provides the explanation for double organs and is nowhere itself explained.

656$^b$34–6: 'in the case of touch . . . something internal'. Aristotle never makes clear what this something is; negatively however, he is inclined to view flesh, as we have seen (653$^b$24–30), as the medium of tactile sensations, not the organ.

656$^b$36–7: 'the tongue . . . is less clearly double than eyes or ears . . . more clearly so than touch'. Presumably Aristotle means that the tongue, though one organ, in some animals is actually split (660$^b$7), and in most has a clear 'midline'.

657$^a$5: 'the potential of the nostrils is bifurcated'. Throughout it is the position of *nostrils* that is being explained, *not* the nose; and a clear distinction is maintained between (1) the *potential* of the nostrils, (2) the *function* of the nostrils, and (3) the *organ* of smell. Nostrils present an interesting dilemma. Given that they are so close together, why are there *two*? Or, to turn the question around, there may be good reasons for sense-organs coming in pairs, but why are the nostrils so nearly *one*? That is the puzzle that Aristotle seeks to solve. The dual nature of any sense-organ follows from the bilateral symmetry of the body (cf. 656$^b$32–657$^a$4 and note). A functional explanation is offered for the nostrils being united in the middle—smell is accomplished through respiration, and thus its organ must be connected to the windpipe (657$^a$4–11). Thus the third pair of biological dimensions, right and left (656$^b$33–4) have now played a role in the explanation of the senses.

## CHAPTER 11

657$^a$11: 'also well situated in the other animals'. That is, other than man; cf. 656$^b$26–31. The absence of fish from the following discussion is explained at 656$^a$33–7; they have no apparent organs for hearing or smelling.

657$^a$11–12: 'in relation to each one's proper nature'. Aristotle often makes judgements of value regarding the way a part is placed. As here, the asserted value is often relativized to the natures of specific types of animals. For example, in this passage the ears of viviparous quadrupeds are as far above the ground as possible, and mobile because this is a valuable arrangement, given the actual orientation of their heads in relation to their movements. In other cases, the argument is harder to make out; cf. *PA* III. 3, $665^a10$–18, on the positions of the windpipe, lung, and heart.

$657^a13$: 'their ears'. More properly, as this discussion demonstrates, the auricle or *outer* ear.

$657^a13$–14: 'above the eyes, or so it would seem'. That is, if these animals were to stand upright, their auricles would then *not* be above their eyes but at approximately the same level. But given their characteristic posture during locomotion, this placement puts them in the highest location. The further usefulness of the *mobility* of the auricles to these animals is also stressed. *HA* I. 11, $492^a23$, states that humans are the only animals with immobile auricles.

CHAPTER 12

$657^a20$: 'the sort of matter from which ears may be formed'. The account of the lack of outer ears in birds and oviparous quadrupeds is the first application of a common pattern of material explanation: the lack of a certain structure is explained, not by its lack of value, but by appeal to the material constitution of that kind of animal. Birds, reptiles, and amphibians lack outer ears because they lack the appropriate material out of which to make them. Schematically: *Part P requires material M, K has M*/lacks M, K lacks P.* The hardness of their skin and feathers (or scales) serves as evidence for the minor premiss. Similar explanations are offered at $657^b13$–15 (lack of eyelids due to hard skin), $657^b36$ (poor vision in insects due to the hardness of their make-up), $665^a2$ (absence of epiglottis due to dryness of flesh and hardness of skin), and $678^a32$–5 (lack of viscera in bloodless animals because they have no blood). The fundamental role of 'material natures' in Aristotle's biology is explored in Lennox 1997.

$657^a22$–4: 'even the seal has, not ears, but auditory canals, because it is a deformed four-footed animal'. Aristotle leaves it entirely unclear why being a deformed four-footed animal would explain the absence of outer ears. Moreover, at *GA* V. 2, $781^b22$–8, he gives an explanation for the absence of outer ears by reference to the seal's aquatic way of life: 'The outer ears are added to the channels for the preservation of movements coming from a distance through air; therefore they would be of no use to the seal, and in fact would be just the opposite, taking in a large quantity of water.' This fits with the fact, noted at *HA* I. 11, $492^a25–30$, that the cetaceans, which share the same aquatic way of life, are the only other live-bearing animal that lacks outer ears. The following Darwinian explanation sounds remarkably similar:

> hence in the course of their evolution aquatic mammals have lost all trace of *external ears*. This not only renders the contour of the head smoother, but removes a practically useless appendage, for the pinna of the ear has for its especial use the collection of aërial sound waves, a function which is valueless in a submerged form. Thus the ears are reduced in amphibious mammals, and are totally lost in the whales and true seals and walrus . . . (Lull 1924: 325)

The seal is discussed as 'like a deformed, four-footed animal' at *HA* II. 1, $498^a32–498^b4$; *IA* 19, $714^b12–13$. The Greek term translated 'deformed' (noun: *pēros*, verb: *pēroō*), can refer to any instance of maiming or mutilation, including castration, as well as to congenital abnormalities producing functional impairment. Aristotle on a number of occasions refers to deformed *kinds* of animals, a usage that needs defence since it is not clear what the standard for such a judgement would be in that case (cf. Lloyd 1983: 46–7). One possibility is that Aristotle viewed an animal kind as 'deformed' *relative to some wider class to which it belongs*—the limbs of the seal or the subcutaneous eyes of the mole are deformed relative to the class of four-footed, live-bearing animals (cf. Gotthelf 1985*b*: 39–41). At *HA* II. 1 he qualifies the claim by saying that the seal is 'just like a deformed quadruped' (see also $487^b23$), and at $697^b1–8$ the seal is included among animals which 'tend in contrary directions'. *HA* VII (VIII). 2, $589^b29–590^a12$, hints at an embryological account of how 'the nature of all these animals *seems to be, as it were, diverted*'—perhaps a reference to the diversion of materials from their kind-typical use.

## CHAPTER 13

$657^a25$: 'Human beings, birds'. The 'extensive kinds' are used when they coincide with the extension of a part, but Aristotle abandons them (though not arbitrarily) when they do not. *Some* sort of eye protector extends across humans, birds, and all four-footed animals. *Two eyelids* are found throughout the live-bearing animals. A *single, lower lid*, on the other hand, is found in *some* birds and *all* egg-laying, four-footed animals. Among the birds, the heavy ones use the nictitating membrane.

$657^a28$: 'and some others'. Aristotle appears unsure of the extent of this characteristic in the birds. Interestingly, *HA* II. 12, $504^a25–7$, notes that 'the owl-like birds' blink with the upper eyelid, scientifically important information not mentioned in *PA*.

$657^a30$: 'The eyes have a safeguard because'. *GA* V. 1, $779^b30$–$781^a12$, suggests that the sharpest vision is possessed by those with a moderate (for their kind, presumably) amount of fluid in the eye and a thin skin over the pupil: $780^a26$–36 discusses thickness of skin as an additional cause of vision being dull or sharp.

The argument seems to be: sharp vision requires that the eye be fluid, but this makes it vulnerable to impact damage. A hard covering on the eye (as in the insects and crustaceans, $657^b31$–5) would solve that problem, but would dull vision (cf. $657^a32$–4, $^b35$–6). Thus the teleological connection between fluidity, thin skin, and eyelids is this: sharp vision requires *both* fluid eyes and a thin covering. Eyelids provide protection while not interfering with accurate vision (see Cooper 1987: 255). Thus eyelids rather than hard-skinned pupils are provided. The argument is made more confusing than it needs to be because Aristotle contrasts thin with hard covering without explaining why a hard covering could not be sufficiently transparent for sharp vision. On the connection between hardness and solidification, cf. *Meteor.* IV. 5, $382^a22$–7.

$657^a37$–$^b1$: 'not done by choice, but rather nature does it'. Presumably Aristotle means the movement is an involuntary reflex. Among the many cases of 'nature' being the subject of the active verb *poiein* (to do, act, or make), eight, including this one, are in the aorist tense (cf. $657^b37$, $659^a12$, $^b35$, $663^a33$, $688^b29$, $689^b14$, $691^b9$). Here, and at $657^b37$, this may be due to the rapidity of the movement being performed (the 'momentary' aorist); in other cases it may have the force of a gnomic aorist, stating a general truth.

$657^b1$–2: 'and mankind most of all'. No grounds are supplied for either of these claims.

$657^b6$: 'on account of the hardness of the skin surrounding their head'. Cf. $657^a17$–20 and note.

$657^b20$: 'it is better that the nature of the membranes be from one origin'. Aristotle seems to be imagining someone accepting the argument for heavy birds needing to blink with the nictitating membrane, but asking for an explanation of these originating from the corners of the eyes nearest each other rather than from the outside corners.

$657^b29$: 'nothing related to their way of life requires'. The appeal to the 'way of life' (*bios*) of an animal to account for its having a part is a common, and under-appreciated, tool in Aristotle's explanatory repertoire. *HA* I. 1, $487^a11$ ff., lists four basic kinds of differences found in animals—parts, activities, habits, and ways of life—and *HA* is organized according to them, with Book VII (VIII) devoted to ways of life. The concept refers to an animal's behaviour viewed from the perspective of its environment: is it a flyer, a swimmer, migratory, carnivorous, predator, hibernator, etc.? Here the concept is invoked negatively, to explain the *absence* of acute vision.

$657^b30–658^a10$: 'Fish, insects, and hard-skinned animals'. It seems odd that fish are discussed in conjunction with these two bloodless kinds in particular. If Aristotle is here aiming to generalize over *all* animals with eyes that lack eyelids, then he ought to have mentioned the cephalopods.

Aristotle's usual term for our 'crustaceans' is *malakostraka*, which I translate 'soft-shelled animals'. The term here—*sklēroderma*—is often used by him for parts and eggs with hard coverings, but rarely for animals. Since an example of such an animal at *HA* I. 5, $490^a2$, is a crab, it is likely that here too he has crustaceans in mind.

$658^a8–9$: 'for nature does nothing in vain'. The first of eight statements of this principle in *PA*. In *IA* 2, $704^b14–17$, this claim, conjoined to the claim that nature does what is best, given the possibilities for the substantial being of each kind of animal, is said to be an assumed starting-point of natural enquiry. In Lennox (1997) I have argued for the need to distinguish the use of the merely negative assumption (which I label *NP*) from the use of the conjoined assumption (which I label *NP**). Typically, as here, *NP* is a premiss in an explanation for something's *absence*, given a prior reason to expect its presence. Without this premiss, the fact that most blooded animals have eyelids and that they do no particular harm in fish produces a prior expectation of their presence. If, on the other hand, they are not needed, and animal natures typically produce only what is needed, there is good reason *not* to expect them. *NP**, on the other hand, is invoked to explain that an organism has a feature because it is best among the possibilities.

## CHAPTER 14

$658^a11$: 'All animals with hair have eyelashes'. The part to be accounted for is said to belong *to all the animals with hair*. This leaves the extension of the class with the part open-ended—any animal with hair will have eyelashes. This in turn provides the major premiss in an explanation for the *absence* of eyelashes in birds and in 'those with scales'. Again, this latter group is identified only by the relevant explanatory feature, leaving open the question of which, and how many, kinds are covered by this explanation.

658a13: 'the explanation for the Libyan ostrich later'. Cf. 697b17–18: 'and its feathers are not useful for flight, but are hair-like. Furthermore, in so far as it is four-footed it has upper eyelashes'. In respect of eyelashes, the ostrich does not fall under the universal negation about birds at 658a12, because its feathers are *hair-like*. Moreover, though ostriches have only two legs, it is Aristotle's view that their legs are more like those of quadrupeds than those of birds.

658a15: 'only human beings have eyelashes on both eyelids'. Cf. *HA* II. 1, 498b22–6. This is the basic difference among eyelashes, and the long diversion on hair is apparently intended to establish that the lack of lower lashes is a non-teleological consequence of the fact that four-footed animals have most of their hair on their backs. Rather than leave it at that, however, Aristotle provides a teleological explanation for the differences in hair distribution between mankind and the four-footed animals, and a few subsidiary explanations of differences among the four-footed animals.

658a20, 23: 'more valuable'. The explanation begins with the teleological premiss that hair's function is to provide protective covering. Hence, if it is not found everywhere, one might expect to find it protecting the more valuable parts—which Aristotle takes to be near the front, i.e. the location of perception, and hence the heart (cf. *IA* 5, 706b11–16; *PA* III. 4, 665b18–21). But because the quadrupeds have their 'front' underneath, there is less need of hair there, so it is disproportionately on their backs. In humans, front and back are equally exposed, and nature thus provides a little hair in the front.

'For this reason as well', we are told, four-footed animals with hair lack lower eyelashes. Aristotle gives us little guidance as to how this explanation is to proceed, but two possibilities suggest themselves. (1) Hair on the back provides hair material for upper, but not for lower, lashes. (2) Being bent forward also provides protection from below for the eye, so that the lower eyelash is not necessary in quadrupeds—and nature does nothing in vain.

The claims here are hard to credit. Aristotle surely knew of four-footed animals, such as cats, that have hair on their 'chest' and 'bellies'. In many it does not even seem credible to claim that there is *less* there than on the back. Conversely, however little there may be, in most cases it is considerably more than most human beings have, a point Aristotle himself makes at *HA* II. 1, 498b16–18.

$658^a23$–36: 'nature . . . is always a cause of the better among the possibilities'. Cf. $658^a8$–9 note and Lennox (1997). This is the other half of the conjunction that makes up *NP**, defended as a principle of natural enquiry at *IA* 2, $704^b15$–18; cf. Lennox (1997). Nature as a goal-oriented cause is referred to four times in this section: nature adds protection for the more valuable parts ($658^a23$); it adorns the tails of hairy animals with hair ($658^a32$), which is done according to the nature of the rest of the animal ($658^a34$–5); and, taking material from one place, nature gives it to another ($658^a35$–6). The last three suggest that the formal nature is highly constrained in its actions by both the type and the quantity of material constituting the animal in question (cf. Lennox 1997). This pattern of explanation will be discussed more fully in the notes to *PA* III. 2, $663^b20$–$664^a11$.

$658^a28$–$^b2$: 'a crested mane . . . a flowing mane'. Cf. *HA* II. 1, $498^b28$, where a number of other kinds of animals with each are discussed. The Greek terms are not etymologically related.

$658^b2$: 'With respect to the head, mankind is the most hairy of animals'. Cf. *HA* II. 1, $498^b18$–19. This explanation provides the background to that found at $^b14$–26 for eyelashes, and accounts for its presence here (cf. $658^b11$–12). A single *explanandum* is explained both as *necessary* and *for the sake of protection*. The necessity is presumably conditional, but Aristotle does not make this obvious. We are not told, for example, that the moisture, warmth, and sutures that materially necessitate hair growth are present *because* hair is needed for protection. Further, the very conditions that materially necessitate hair growth include the brain's moistness, the very fact about the brain that requires it to be protected (since moist things are most subject to boiling and freezing).

## CHAPTER 15

$658^b22$–6: 'unless some function of nature redirects it'. This brief account of eyebrows and eyelashes begins with an account of the functions for which they are present. But the passage closes by stressing that, unless nature redirects the bodily secretions that produce them, hair will *necessarily* (and the necessity is stressed by a pointed repetition) arise in these locations. The formulation once more (cf. $658^b2$–7 and note) leaves the connection between the teleological and necessary accounts unclear. (Cf. Gotthelf 1997*a*; Lennox 1996*c*.)

## CHAPTER 16

$658^b27$: 'In all the other'. Particles make it clear that this is an anticipatory contrast, looking forward to the elephant, mentioned at $^b33$; but a subdivision, between live-bearing, four-footed animals with and without snouts, intrudes, obscuring the contrast to some extent. Again we have an 'open-ended' universal—the relevant groups are identified only through the correlation of snout with a distinct nostril configuration. It is thus unclear which animals this subdivision is intended to distinguish. The description of the 'snout' applies to those in the canine and equine families, certainly. What about the rodents and felines; do they have snouts, or are they to be viewed as having a 'more differentiated' olfactory organ?

The same Greek term refers to organs we would distinguish as 'snouts' and 'beaks'. Aristotle himself seems to find this odd, regularly qualifying his use of the term by adding 'what is called'.

$658^b33$: 'In the elephant, however, this part is most distinctive'. It is generally assumed that Aristotle is discussing the Indian elephant (cf. Bonitz 1870: $236^b29$–$237^a38$). One passage in *Historia Animalium* (VIII (IX). 1, $610^a19$) refers to the Indians using them for war; two others discuss them in ways suggesting that the information comes from India (VII (VIII). 9, $596^a3$–9; VIII (IX). 46, $630^b19$–30). On the other hand, *Cael.* II. 14, $298^a12$–15, cites the presence of elephants in both India and Northern Africa as evidence of the continuity of the two regions, without suggesting any differences between the two populations. Aristotle occasionally provides disproportionately long discussions of unusual organs. Some role is probably played by how much he knows about the oddity in question, and whether he has a plausible explanation for it. He knows a surprising amount about the elephant. A number of unusual features of the animal not mentioned in *PA* are discussed at *HA* II. 1, $497^b5$–$498^a13$. For a detailed and careful discussion of the explanation here see Gotthelf 1997*a*.

There are four general components to the elephant's basic nature which play a role in the explanation of (*a*) the unusual structural properties of the nostril and (*b*) its dual function as a snorkel and as a hand-like limb. The elephant is by nature (1) blooded, (2) a land-dweller, (3) a swamp-dweller, and (4) a live-bearing, four-footed animal. (1) and (2) necessitate its having a lung and breathing air, and therefore having some sort of nostril ($659^a4$–5, $^a10$–12, $^a29$–31); (3) presents a problem in that respect ($659^a8$, $^a31$–3); (4) necessitates that it either be polydactylous or hoofed, and it is not hoofed ($659^a23$–6). To these relevant *general* characteristics, we must add three *specific* features to complete the explanations of the structure and function of the elephant's nostril: (5) the elephant is extremely heavy ($659^a7$, $^a26$–7); (6) it transports itself from water to land slowly ($659^a5$–6, $^a28$, $^a32$); (7) its legs flex in an unnatural manner (659$^a$29). This gives us the materials for two explanations:

*Explanation* (1): Given its nature, the elephant *must* breathe air through a nostril, *must* spend much time submerged, and *cannot* quickly escape being submerged; therefore it needs a long, flexible nostril. Therefore its nature produces such a nostril.

*Explanation* (2): Given its enormous weight, its feet are such that it cannot use its forelimbs to convey food to its mouth like other polydactylous quadrupeds; hence it needs another method for doing so. Therefore nature uses the nostril, already long and flexible for submerged breathing, as an arm and hand.

658$^b$35–6, 659$^a$1–2: 'like a hand . . . as if it were a hand'. Cf. 692$^b$17; *HA* II. 1, 497$^b$26–9.

659$^a$2: 'at once a swamp-dweller and a land-dweller in nature'. As Aristotle puts it at *HA* VIII (IX). 46, 630$^b$26, the elephant lives *around* rivers, but is not a river-dweller. This is, however, part of its *bios*, for it derives some of its nourishment from this environment. Ogle over-translates 'it has to get its food from the water', and then in a footnote argues that 'A. appears to have imagined its habits of life to be much more aquatic than they really are' (1882: 180, 659$^a$3 n. 2). But Aristotle does not say that it must get its food from the water, only that it frequently does.

659$^a$8: 'divers equip themselves with instruments'. There are two brief references to sponge-divers in Plato (*Protagoras*, 350 A; *Sophist*, 220 A), which provide no help. *Problems* 32, 960$^b$30–3, mentions a mechanical method used by sponge-divers to breathe under water: 'they enable the divers to respire equally well by lowering a cauldron; for this does not fill with water, but retains the air, for it is forced down straight into the water'. It is usually assumed that in our passage Aristotle has in mind something like an air-tube, which would be directly analogous to the trunk (cf. Ogle 1882: 180 n. 3). But he does not actually say how the instrument he refers to in our passage conveys the air to the diver, so it is just possible that he has such a 'diving-bell' in mind.

659$^a$11, $^a$21, $^a$34–5: 'nature makes . . . turns the same part to . . . makes use of'. There is a useful discussion of this language in Preus (1969). Here we have three distinct references to nature's activity that will be repeated over and over again throughout *PA*. To say that nature *makes/does X* indicates that *X* is a direct consequence of the animal's nature; to say that nature *makes use* of *X* (*katachrēsthai*) indicates that *X* is present as a consequence of the animal's nature, and is *also* used for some further use. The last reference here simply repeats the second, suggesting that the prefix *para-* (*parakatachrēsthai*) is added simply to emphasize that the use of the organ is *besides* a primary use. Contrast these uses with 659b6–7, 'nature has constituted the birds in this way'. There, the basic nature of birds—being flying bipeds—constrains, in specific ways, the sort of 'mouth' it can have.

659a11: 'makes the size of the nostril such an instrument for the elephants'. Cf. *HA* VIII (IX). 46, 630b27–30. The elephant behaviour described here has been reported frequently by naturalists, and has been captured in recent years on film. That Aristotle stresses this function is probably due to his discussing the Indian, rather than the African, elephant, for it is more common in the former species.

659a14–15: 'the elephant's trunk is its nostril'. The word I have translated 'trunk' here is *proboskis*, literally a 'projection for eating'. Aristotle uses it as well for the fly's proboscis (*HA* IV. 4, 528b29) and the tentacles of cephalopods (*PA* IV. 9, 685a33; *HA* IV. 1, 523b30). The point is that the part that conveys food to the mouth is, uncharacteristically, also the organ of breathing.

659a16: 'Since it would be impossible for there to be such a "nostril" if it were neither soft nor able to bend'. Note that this is worded in precisely the *form* of explanations by appeal to 'conditional necessity' defended at *PA* I. 1, 640a4–5, 34–5, and at 642a9–11. It is especially akin to the explanation of the material out of which the axe must be made, since the point here is particularly that the nature of the instrument requires that it have certain material *dispositions*, which in turn requires that it be made of certain materials.

659a17–20: 'horns in the backward-grazing oxen'. Note the repeated qualification of this as a second-hand report (probably taken from Herodotus, *Hist*. IV. 183). It is common for Aristotle to qualify reports of unusual natural phenomena in this way, perhaps signalling some level of scepticism on his part. (cf. Pliny, *N. Hist*. VIII. 45)

659a23–6: 'four-footed animals with many toes'. On the general claim, that in such creatures the front feet are used as hands, compare *HA* II. 1, 497b18–23. Aristotle treats the elephant as a member of this group, and then accounts for its almost total lack of polydactyly by reference to the demands of its bulk; cf. *HA* II. 1, 497b23–6; III. 9, 517a32. That four-footed animals are either toed, cloven-hoofed, or solid-hoofed is claimed at *PA* IV. 10, 690a5–7.

659$^a$28–9: 'their slowness and their natural unsuitability for bending'. 'Slowness' and 'unsuitability' apparently modify 'bending', and Aristotle appears to be discussing toes and feet, not legs. *HA* II. 1, 498$^a$8–9, claims that the facts regarding limb flexion in the elephant 'are not as some have said', and at *IA* 9, 709$^a$10–11, 'the old account' of the elephant, which claimed that it walked without bending its legs, is declared false (cf. 712$^a$10–13). Our passage may only mean to say that elephant *toes* are not suitable for bending.

659$^b$1: 'the other blooded egg-layers among the four-footed animals'. All manuscripts but one have 'live-bearer' (*zōotoka*) rather than 'egg-layer' here. Nevertheless, Aristotle is clearly going on to discuss the egg-laying animals, and I thus follow Bekker and Düring in accepting the minority reading.

659$^b$2–6: 'except on account of function they do not have clearly differentiated nostrils'. This passage is the only one in *PA* II–III where the Greek word for nose—*rhis*—appears. Nostrils are, from the standpoint of *function*, primarily the organ of smell (658$^b$28); but this discussion of the beak suggests this is not sufficient. A nostril must be a separately differentiated part, such as a human nose, or the elephant's trunk. As for breathing, it is mentioned as a function for nostrils only after Aristotle mentions that elephants use them for this when submereged. He may have thought that, were there no need for a separate sense of smell, breathers might well breathe through their mouth alone.

659$^b$6–7: 'nature has constituted the birds in this way'. Cf. 659$^a$12 note. As with the elephant's trunk, we have here a complex, but typically Aristotelian, explanation of the beak's presence in birds, which invokes generic features of the bird's nature, its being bipedal and winged (a flyer).

Though being a flyer appears to be an 'unexplained explainer', the bipedal nature of birds is defining, yet explicable by reference to their being both blooded and winged (for the explanation, cf. 693$^b$6–15, and note). The light and narrow character of the head is conditionally necessary, given the bird's flying and bipedal nature; and the narrowness of the beak is conditionally necessary given the nature of a bird's head. Finally, the beak's being bony is conditionally necessary, given the bird's form of nutrition and defence.

659$^b$12–13: 'in the beak they have channels for smell, but are unable to have nostrils'. Aristotle is unwilling to define 'nostrils' in *purely* functional terms (cf. 659$^b$3); and he earlier suggests that what would be needed for them to have nostrils is a nose (659$^b$4).

$659^b14$: 'previously stated'. Ogle (1912) suggests *Sens.* 5, $444^b6$ (more precisely, $444^b7$–15); Peck refers us to *Som.* 2, $455^b34$ ff.; Düring to *HA* VIII. 2, $589^b13$. None of these passages says what Aristotle claims has been previously said; I suggest that the reference is to $656^a35$, where he discusses the lack of apparent organs of smell in 'the fish and such'.

$659^b15$: 'the other, non-breathing animals'. Translators have assumed that the reference to a hollow tube here is to the cetacean's blowhole. But if the assumed reference class is the non-breathers this is impossible, since Aristotle knows that cetaceans have lungs and breathe (cf. below, III. 6, $669^a7$–14, which itself refers to *Resp.* 12). Thus Ogle (1882: 182 n. 9) says their inclusion here is 'an accidental slip'. But since Aristotle does not mention the cetaceans here, it is possible that he is referring to something else. He uses the same term to refer to the funnel of the cuttlefish (*HA* IV. 1, $524^a10$) and to a tube running from the heart to the gills in fish (*Resp.* 16, $478^b8$, *HA* II. 17, $507^a10$), but neither of these is a likely reference.

$659^b17$: 'all of them smell, just as they move, by means of their body's inborn breath'. The syntax *suggests* that the extension of 'all' is all three previously distinguished groups, but passages such as *PA* III. 6, $669^a1$–2, and *Som.* 2, $456^a11$–14, might incline one to restrict the point to the insects (which are said to be able to cool themselves by natural breath rather than by taking in water or air from outside). But as Düring (1944: 153, following Jaeger 1913) correctly notes, natural breath is involved in all perception of odour; and the discussion here is not about methods of cooling, but of perception of odours.

$659^b20$: 'In the blooded animals with teeth'. When one simply subdivides the blooded into those with and without teeth, the birds stand out (see $662^a34$–$662^b17$ and notes).

$659^b20$, 28: 'the nature of the lips'. As with the previous occurrences of this type of expression (see $654^a32$, $^b12$–13, $655^a2$), the point is that the lips are structurally two but constitute an organ with a single nature.

$659^b23$–7: 'just as if someone who had removed the lips'. An amazing thought experiment, rare in Aristotle. Here I have rendered *rhunchos* as snout, since he is discussing its imagined transformation into a beak. Elsewhere, though it is the same Greek word, I translate as 'beak'.

$659^b33$–$660^a2$: 'both for the sake of protecting the teeth . . . and even more on account of the good'. Structures are sometimes said to be present 'for the good' because they aid the animal in performing a function which could be performed without the structure, but not as well (e.g. *PA* II. 9, 654$^b$22; III. 7, 670$^b$23; *GA* I. 4, 717$^a$15). The good served by our lips is secondary and unrelated to the function they serve in all toothed animals, ourselves included—but it nevertheless is an essential human function which could not be performed at all without them (660$^a$2–5).

660$^a$1: 'for the sake of both flavours and speech'. Throughout this passage I translate *logos* as 'speech'. For similar uses of the term cf. *Sens.* 1, 437$^a$2; *An.* III. 12, 434$^b$25–9.

660$^a$3–7: 'articulate sound'. The Greek term *gramma* refers primarily to something drawn or written with a pen, more specifically to the letters from which words are formed, and finally to the corresponding *units* of spoken language. 'Phoneme' carries far too much theoretical baggage for the purposes of translation, but is the contemporary analogue of this last use of *gramma*.

660$^a$8: 'those who study metre'. Aristotle gives a brief general account of the subject at *Poetics*, 20, 1456$^b$20–38, where he also refers to studies of this subject for specifics.

660$^a$11: 'for this reason they are fleshy'. The material character of lips is conditionally necessary: since lips *must* be suitable to the performance of their function, they *must* be fleshy. Flesh is the organ of touch (653$^b$21–30, notes); humans are most tactile; so humans have the softest flesh.

## CHAPTER 17

660$^a$17: 'Mankind has the most detached, softest, and broadest tongue'. This section follows the rule of beginning with the human part as the standard. The basic differences around which the entire discussion is organized are here laid down: tongues vary along detached/attached, broad/narrow, soft/hard continua. Human beings possess tongues at one end of each continuum—most detached, broad, and soft. Each of these physical differences is explained functionally. The human tongue, as we have been prepared for (659$^b$34–660$^a$7), plays a role in two distinct activities, taste perception and articulate speech. There is a compressed argument here for the tongue's softness being required for taste, and all three properties being useful for vocalization. A premiss that states that 'the organ of touch must be soft' must be assumed (cf. *An.* II. 3, 414$^b$6–11; 9, 422$^a$8–11).

The discussion of animal vocalization at *HA* IV. 9, 535a28–536b22, while devoid of explanation, has both a richer collection of information and a more sophisticated division of the subject, including a special category of animal vocalization—*dialektos*—defined as 'the articulation of the vocal by means of the tongue' and attributed only to humans and broad-tongued birds. Elsewhere in *Historia Animalium* Aristotle refers to parrots (VII (VIII). 12, 597b27) and woodpeckers (VIII (IX). 9, 614b2) as having broad tongues.

660a19: 'the perception of flavours'. Aristotle distinguishes between flavours and taste: flavours are the *objects* of the sense of taste, taste is the *perception* of flavour. Indeed, *On Sense and Sensible Objects* insists on such a distinction for all the senses. But ordinary Greek tends to confuse them, as does English. To confuse matters further, the primary meaning of the Greek word here rendered 'flavour' is also a common word for 'juices', and is in fact the term meaning 'humours' in the Greek medical texts. Aristotle's careful distinction between taste and flavour leads to the somewhat odd-sounding phrase 'the taste of flavours', e.g. at 660b5, 661a3–4.

660a21: 'taste is a sort of touch'. Cf. *Sens.* 4, 441a3.

660a27–8: 'In what is wide the narrow is also present'. Perhaps the point is that those with broad tongues can use various narrow 'subunits', while broader surfaces are unavailable to those with narrow tongues.

660a33–b2: 'Some of the birds'. Aristotle appears to correlate smaller size in birds with greater vocalization, and broader tongues with crook-talons. But he also argues (660a30; cf. *HA* IV. 9) that the broad-tongued birds are the most able to vocalize in a more articulate manner.

660b1–2: 'the enquiries about animals'. Probably the fuller discussion of bird vocalization at *HA* IV. 9, 535a28–536b22, where such topics as vocal sex differentiation, the role of song in mating, and some evidence for some birdsongs being learnt are discussed. There is also a brief, though better-organized, comment regarding their tongues at *HA* II. 12, 504a35–b4. The correlation between crook-talons and broad tongues is also made at *HA* VII (VIII). 12, 597b25–9.

660b2–11: 'Most of the land-dwelling, egg-laying, and blooded'. Classificatory subtlety is again in evidence. At *HA* II. 17, 508a8–11, Aristotle says that if one imagines a lizard stretched out with its legs removed, one has a snake in mind. He is discussing both groups here, and so needs a less specific difference, which nevertheless sets them off from the other egg-layers—birds, on the one hand, and fish, on the other. Land-dwelling egg-layer does the trick.

On the gluttonous habits of snakes, cf. *HA* VII (VIII). 4, $594^a6$. No reason is provided for the restriction of the explanation for the long and split tongue to the serpents. And the discussion raises the issue of what counts as 'detached', given that these creatures can extend their tongue outside the mouth. Aristotle may have in mind the nature of the attachment to the floor of the oral cavity.

$660^b10$: 'having, as it were, double the perception of taste'. That is, a doubling of the sense-receptor. See $660^a19$ note.

$660^b13$: 'such as some of the fish'. The explanation for the paltry tongue of fish is both material and teleological—(1) it is found in the same area as the gills, and is thus formed out of gill-like, spinous material; (2) and fish ingest food rapidly, the flow of water in their mouth preventing (or perhaps negating the value of) the extraction of juice from food, which is the origin of flavour. So: given the material available, the tongue *must* be of this sort; and given the nutritional conditions for water-dwellers, a different sort of tongue would be useless (and nature makes nothing in vain). There is no sense here, however, that the spinous material of the mouth and gills of fish was in any sense conditionally necessary for the tongue. If that material with its physical characteristics is conditionally necessary, it will follow from the requirements for *gills*, not tongue.

$660^b14–15, 25–34$: 'quite similar, in fact, to the river crocodiles'. *HA* II. 10, $503^a1–6$, discusses the tongue in virtually identical language, attributing it to 'the crocodiles of Egypt' (cf. Herodotus, *Hist.* II. 68); river crocodiles are explicitly mentioned at *Resp.* 10, $475^b28$, *HA* I. 11, $492^b23$, and *HA* V. 33, $558^a15$, where they are explicitly contrast with *land* crocodiles. Here we have the brief mention of the river crocodiles first, and then the longer explanatory passage which simply refers to 'the crocodiles'. The river crocodile is mentioned briefly again in *PA*, at IV. 11, $691^b4–28$. This may represent the changing status of Aristotle's familiarity with these creatures, or his terminology may simply be fluid. Today it is common to distinguish salt-water and freshwater species, but not land and water species. (An excellent comparative study of the discussions of crocodiles in Herodotus and Aristotle can be found in Kullmann 2000.)

The argument that the immobility of the lower jaw contributes to the 'lameness' of the crocodile's tongue may be this: in other animals the tongue is connected to the lower, mobile jaw. As crocodiles have the jaws functionally reversed, you might then expect them to have their tongue on the upper jaw. But if they did it would interfere with eating. It is therefore connected to the lower jaw, which in them is the immobile jaw, further reducing the tongue's mobility. Aristotle then adds the further argument that they share the way of life—the *bios*—of fish, so that reasons for the tongue being unarticulated in the fish apply here too (on which see 660$^b$11 note). On the crocodile's jaw cf. *PA* IV. 11, 691$^b$4–28.

661$^a$3–4: 'since the perception of the taste . . . is for the sake of nutrition'. It is relatively unusual for Aristotle to explain one basic soul capacity as being for the sake of another. But this claim is generally in line with *De Anima* (cf. *An.* II. 3, 414$^b$6–11; 10, 422$^a$8–11; III. 12, 434$^b$17–24).

661$^a$8: 'desire is of the pleasant'. Cf. *An.* II. 3, 414$^b$5–6.

661$^a$21–3: 'in the purpurae this part has so much potency that it bores through the shell of mussels'. They themselves have spiral shells (cf. *PA* IV. 5, 679$^b$15–20). Their powerful proboscis is also mentioned at *HA* IV. 4, 528$^b$30; 7, 532$^a$9. Ogle (1882: 186 n. 15) discusses possible candidates among the gastropods, though there is no reason to suppose that Aristotle has a single species in mind.

661$^a$25–30: 'naturally such as to be a counterpart to the nostril of the elephants'. The extension of the claim is most probably all those which have a sting-like proboscis (661$^a$17–19). The analogy could be based on structural and positional similarity, but what is claimed is that *as* the trunk is related to protection, *so* the tongue in these animals is in place of a sting. The term translated 'counterpart' has a technical sense of 'conversion' or 'inversion'. That suggests an interesting reading: in elephants, an organ for drawing in *air* is turned to protection; while in these animals an organ primarily for protection (the sting) is turned to drawing in *food*. But at any rate the protective function of the elephant's trunk is not stressed at all in the earlier discussion.

# BOOK THREE

## CHAPTER 1

661$^{a}$34: 'Next after . . . surrounding'. The Greek I have rendered 'next after' (*echomenon*) could refer to the order of exposition, but more often in *PA* (cf. 679$^{a}$34, $^{b}$9, $^{b}$10, 680$^{a}$7, 682$^{a}$13) refers to the position of a part next to another part (as e.g. the intestines coming next after the stomach). I have chosen to translate in a way that harbours the ambiguity, since Aristotle's *expository* order is determined by taking the parts in *positional* order from top to bottom in humans. That the term at least includes a positional reference may be suggested by the use of the related word *periechomenon* to denote that the teeth 'surround' the mouth.

661$^{a}$34: 'the nature of the teeth'. On this form of language cf. 654$^{a}$32, $^{b}$12–13, 655$^{a}$20, 659$^{b}$20, $^{b}$28 and notes. A nutritive function for teeth common to all animals including humans (cf. $^{b}$6–7), which in some animals is their sole function (cf. 661$^{b}$16–17), is distinguished from other functions which are found in some kinds, but not in others. This discussion is probably the prior discussion referred to at *GA* V. 8, 788$^{b}$3–6. The data explained here, and some not mentioned here, are collected in *HA* II. 2, 501$^{a}$8–502$^{a}$2. The division of teeth is thoroughly functional, rather than based on material or structural differences.

661$^{a}$34–5: 'the mouth which is surrounded by them and constituted from them'. The mouth is the next 'part' to be discussed (662$^{a}$16–33). In *HA* I. 2, where it is 'defined' as 'that by which nourishment is taken in' (489$^{a}$1–2), it is said to be possessed by all animals and to differ either in form, or in degree (i.e. in kind), or by analogy, or in position. As Aristotle does not hold that all animals have teeth, this statement must be implicitly restricted to the class of toothed animals.

661$^{b}$1, $^{b}$7: 'common'. That is, 'found in many kinds'. Cf. 639$^{a}$15–$^{b}$5, 644$^{a}$28–$^{b}$7, 645$^{b}$3–14, and notes.

661$^{b}$2–6: 'strength to attack and strength to avoid attack'. Aristotle does not provide us with descriptive examples to help us with this distinction. The Greek term translated 'strength' is throughout contrasted with 'protection'. Various organs—teeth, tusks, horns, beaks, talons—are discussed in terms of this distinction.

661$^{b}$6: 'Mankind'. Human dentition is taken as the baseline for comparison;

but since we share a pattern in common with many non-linguistic animals, the claim that the form and placement of our teeth are as they are especially for language (*dialektos*) initially seems odd. However, the last sentence makes it clear that this reference is to the tight placement and non-serrated character of our front teeth.

See *Phys.* II. 8, $198^b24–7$, and *GA* V. 8, $788^b3–789^b22$, for criticisms of the non-teleological accounts of teeth provided by Empedocles and Democritus. Their development is discussed at *GA* II. 6, $745^a18–^b16$, where they are said to 'have the same nature as the bones, and to come to be from the bones'.

$661^b16–26$: 'for protection as well as for strength'. Here again, a basic distinction of *structure*, between having tusks and being sawtoothed ($661^b18–19$), is explained by reference to differences of *function* (spearing vs. biting ($661^b24–5$)), but with a *common goal*.

$661^b23–4$: 'nature makes nothing in vain or superfluous'. Cf. $658^a8–9$ note; Lennox (1997). *Resp.* 10, $476^a6–15$, explains why no creature has both a lung and gills. This first principle reflects Aristotle's practice only if 'nature' means the formal, goal-oriented nature of the animal: otherwise it flies in the face of his many discussions, in this chapter and elsewhere, of functionless differences within kinds and the various 'useless residues' resulting from materially necessary organic processes.

$661^b28–31$: 'nature provides each of them only, or especially, to those animals that are able to use them, and especially to the animal able to use them most'. Apparently the remark about the sow caused this generalization to occur to Aristotle. The wording is careful: nutrition is mentioned merely as an example of 'necessary' functions; nor is it denied that parts such as stings, spurs, horns, and tusks may be found in females, only that if they are they will be reduced (on the general accuracy of the specific claims about horns and spurs, see Ogle 1882: 187 n. 6). The explanation provided for the differentiation is that males are stronger and more spirited than females and thus better able to use such aggressive/defensive parts.

$662^a6–15$: 'All the fish'. The parrot-wrasse is one of a number of species of fish without serrated teeth, and there are many species with teeth projecting all over the inside of the mouth. Aristotle explains both the quantity and the shape of their teeth as a requirement of (i.e. conditionally necessary for) their aquatic way of life (*bios*).

$662^a16–18$: 'have the nature of the mouth both for the sake of these functions and for respiration besides'. 'These functions' presumably refers to those of the teeth just discussed.

$662^a17$–18: 'those . . . that breathe and cool themselves from outside'. This wording excludes fish from the extension of the claim. For Aristotle respiration is the taking in of *air* in order to moderate heat in the region of the heart, a function fish perform by taking in water.

$662^a18$–24: 'nature, in virtue of itself . . . puts the parts common to all animals to many distinctive uses'. On nature using one part for more than one use, see $659^a12$ and note. On the mouth as a 'common' part, cf. *HA* I. 2, $488^b29$–32.

Again we see the pattern of causal division discussed in Gotthelf 1997*b*. The commonality is functional, and thus its primary differentiation is by function. The common function (nutrition) is differentiated for specific eating habits (for example, beaks are differentiated for eating different sorts of food, $662^a33$–$^b16$); but there are also differentiations to allow the mouth to fulfil various additional functions—aggressive/defensive, linguistic, and respiratory. There is thus a tight connection between division and explanation. A commonly possessed part is accounted for by reference to a common function; and the differentiation of that part is explained by noting both a differentiation of the common function *and* a differentiation to accommodate various other functions.

$662^a24$–31: 'That is why some mouths are narrower, some wider'. This is the first step towards explanation of a physical difference between mouths by reference to functional differences. The *explananda* are the dimensions of the mouth's opening: wider opening—at least in those with saw teeth—is more effective for biting. This is akin to certain 'optimal design' explanations in evolutionary biology, in which one estimates on engineering principles the best design for a structure, given its task, and then compares this with what one finds in nature—closeness of fit suggesting adaptation (cf. Beatty 1980).

$662^a31$–3: 'Among fish'. As Aristotle was familiar with various types of gars, one must assume the dimension under consideration here is not the narrowness of the snout, but how widely the mouth can be opened.

$662^a33$: 'the beak . . . differs according to the uses to which it is put and the protection required'. On the beak, cf. $659^b4$–13, $^b21$–7. It is only within the birds that Aristotle pursues differentiation of mouth based on variations in ways of life ('useful for their way of life', $662^b5$); specifically, the explanatory differentiae are modes of feeding; the *explananda* are differences of beak and bill. The crook-taloned birds are a group often singled out, since a number of other features, including the hooked beak, are correlated with crooked talons. Here causal differentiation is by reference to way of life (*bios*). A fuller discussion of the differentiation of beaks is to be found in *PA* IV. 12.

$662^b18–22$: 'called the face [*prosōpon*], having been named . . . after its activity . . . they alone see from afar [*prosōthen opōpe*] and transmit spoken sound forward [*to prosō*].' A bit of armchair etymology on Aristotle's part, rightly qualified by 'as it seems'. (Compare Plato, *Cratylus*, 399 C.) It suggests that only in humans is this region called 'the face', a point made even more emphatically at *HA* I. 8, $491^b8–10$. And yet the very first lines of *Historia Animalium* seem to use the term quite generally ($486^a12$); and elsewhere we hear of the faces of baboons ($502^a27$), chameleons ($503^a18$), lobsters ($526^b4$), and deer ($579^a2$).

## CHAPTER 2

$662^b23–4$: 'by nature on the head'. The discussion of the non-uniform parts has proceeded, using man as the starting point, from the top downwards, beginning with 'the parts on the head' ($656^a7–16$). All those that human beings possess have now been discussed, as has their possession or non-possession by, and differentiation in, other animals. Horns are not found in humans, but are in certain other live-bearing animals, and are taken up here as the last of the parts associated with the head.

$662^b25–30$: 'In virtue of similarity and by extension'. 'By extension' translates the Greek word *metaphora*. Organic parts may have the same name based on function even though they appear very different (e.g. mouths and nostrils, above). Here the converse point is made—the word 'horn' may be extended to appendages on the heads of other animals (e.g. the antennae of crustaceans, *HA* IV. 2, $526^a6–8$; VII (VIII). 2, $590^b27$) in virtue of appearance, but these things do not function as horns (cf. $640^b36–641^a7$ and note).

$662^b30$: 'None of the many-toed animals has a horn.' The principle that nature provides nothing superfluous is being assumed (cf. $661^b23$ and note)—otherwise the fact that all these animals have some other means of defending themselves does not account for their lacking horns. The principle is finally stated explicitly at $663^a17–18$.

$662^b35$: 'of the cloven-hoofed . . . (as do some of the solid-hoofed)'. The imperfect correlation between types of hoof and types of horns leads Aristotle to explain why some cloven-hoofed animals do not have horns; at this point he leaves the horned, solid-hoofed animals alone. Later ($663^a18–33$) they are treated as part of an explanation for a pair of narrower, but universal, correlations: all horned, solid-hoofed animals have only one horn; whereas all the horned, cloven-hoofed animals have two.

$663^a6$: 'with camels'. There is a complex web of explanatory connections among hoofs, digestive organs, teeth, and the presence or absence of horns. The camel makes the web more complicated than it would otherwise be. Though cloven-hoofed, it lacks horns because its large size is a sufficient protection against predation. Its lack of horns is problematic because it has the same dentition and digestive system as other ruminants, all of which have horns. (Cf. *PA* III. 14, $674^a9–^b17$ and note; and for discussion Gotthelf 1987*a*: 178–85; Detel 1997.)

$663^a7$: 'the animals with tusks'. Ogle, followed by Peck, unnecessarily emended the text without any manuscript support. Aristotle has noted that some cloven-hoofed animals lack horns, where there is another means of defence. The tusked animals are another example: they are cloven-hoofed, but tusks, rather than horns, provide an alternative means of defence.

$663^a8$: 'horns are by nature useless'. This passage is in apparent conflict with the claim of $662^b27–30$ that horns exist for defence and strength. These useless horns are explicitly said to be natural growths—indeed that deer are by nature horned is used as an explanatory premiss at $664^a5–6$. On the other hand, at $663^b12–14$ it is said to be advantageous to deer that they shed them—so that it is hard to see where they fall in Aristotle's overall explanatory scheme. I discuss this problem, and a possible reference to it in Theophrastus, in Lennox (1985*b*). At any rate, that the horns are useless means that there must be other means of defence, of which fleetness and the emission of excrement are mentioned.

$663^a13–17$: 'nature has added the emission of excrement'. Cf. Balme (1987*a*) 17.

$663^a17$: 'And by means of the same sort of emission'. E.g. the emission of ink by cephalopods, *PA* IV. 5, $678^b36–679^a30$.

$663^a18–34$: 'the Indian ass . . . the oryx'. The 'phenomena' here are reports of others ('is said', 'called') perhaps Ctesias' *Indica* (cf. Photius, *Bibliotheca*, 72, $48^b18$). Thompson (1910: *HA* II. 1, $499^b18–19$ nn. 3, 4), Peck (1961: 218–19 n. c), and Ogle (1882: 190 n. 10) all suppose that 'Indian ass' refers to the Indian rhinoceros. The discussion in *Historia Animalium* claims that it is also the only solid-hoofed animal with knuckle-bones. The oryx is conjectured to be some species of North African gazelle or antelope (cf. Ogle 1882: 190 n. 12).

The combination of differentiae reported in the oryx cannot be accounted for given the principles in operation in this discussion, but are mentioned none the less. The combination of two horns with cloven hoofs suggests a tendency to split the earthen material in two in such animals. Likewise the median *location* of single horns—sharing, as it were, in both sides—can be seen as the operation of this tendency, but constrained by a solid-hoofed nature, which directs earthen material from horns to the hoofs ($663^a24–35$). The oryx, then—cloven-hoofed and single-horned—is an *explanatory anomaly*, which accounts for Aristotle's cautious attitude to this report.

$663^a35–^b12$: 'acting like Aesop's Momos'. This name is a personification of the Greek noun meaning 'blame' or 'reproach'; the spirit of finding fault was one of the children of Night in Hesiod's *Theogony*, 214; cf. Plato, *Republic*, 487 A. For Aesop's fable cf. Babrius, *Fabulae*, 59. 6–10, where, however, fault for the placement of the bull's horns rests on a slightly different basis. The Greek I have rendered 'further forward' has other, extended meanings, but this is the core notion, and the interpretation Aristotle offers is consistent with that core notion—the head is obviously superior to the shoulders in virtue of allowing the horns to be in a more forward position (and *thus* more functional). The only placement that might be better than the head would be somewhere on the forelegs, and that is why Aristotle goes on to argue against any such placement.

$663^b12–14$: 'solid throughout only in the deer, and they alone shed them'. These two facts are noted, in virtually the same words, without explanation, at *HA* II. 1, $500^a6–11$; cf. Lennox (1987*a*) 112–13. The combined teleological/material explanation for the shedding of horns is odd given the apparently universal explanation for horns as defensive organs.

$663^b14–20$: 'The horns of others are hollow'. Editors and translators have needlessly tampered with this text (but see Düring 1943: 157–8). The point of the last sentence is that the design described allows the horns enough strength to function, while keeping them light enough so as not to interfere as the heavy horns of deer do.

$663^b20–4$: 'the nature according to the account'. For a detailed interpretation of this passage see Lennox (1997) 169–76. The subject of the verb 'uses' is 'the nature according to the account' (*hē kata ton logon phusis*, $663^b23$), while the object is 'the necessary nature'. 'For the sake of something' modifies the main verb 'uses'. The discussion of horn production that follows strongly suggests that 'according to the account' means the nature specified in the formal account of the animal under discussion. It is this formal nature that makes use of the necessary nature for a specific end.

When Aristotle discusses instances where the formal nature of an animal 'uses' or 'makes use of' materials for various ends, it may be that he has in mind a form of indirect teleology. In some cases the material being directed to a beneficial end is residual or excessive in some way; in others, a part with a primary function is 'made use of' for another function. Presumably this is to be contrasted with the production of the principal organs of biological function, for which the uniform parts come to be. (Compare $655^a26–8$ and note, where nature is said to be *unable* to distribute the same excessive material to many places at the same time.) It is explicitly *denied* that this is part of the discussion of what horns are for and why some animals have them and some do not. This is an explicit recognition of a type of explanation—the mechanics of teleology—which has been used a number of times already. Cf. e.g. $657^a20$, $658^a23–6$, $658^b22–6$, $659^a12$, $^a21$, $^a34–5$, and the associated notes.

$663^b25$: 'what is bodily and earthen is present in greater amounts in the larger animals'. This claim is ambiguous between saying they have (1) more than *other animals* or (2) more than *they need*. The discussion suggests the latter; but if these animals truly need horns to live, it is unclear how this can be so.

The upward movement of this material cannot be necessitated by its earthen nature *per se*—earth's natural motion being downward. The material is described as *flowing* upward, suggesting an efficient cause at work. What is determined by the *formal* nature, on the other hand, is the functional *distribution* of this flow. Cf. $663^a6$ note.

$663^b27–9$: 'in every case or for the most part'. Cf. *Phys.* II. 5, $196^b10–17$; 8, $198^b35–199^a1$; cf. *Met. E* 2, $1026^b35$, $1027^a19–27$. Two features of the natural world lead to such qualifications. First, we are dealing with objects which are complexes of matter and form; *GA* IV–V discusses a variety of natural phenomena as due to the 'failure' of the formal nature thoroughly to master the material (explicitly noted at *GA* IV. 4, $770^b9–27$). Second, interactions between natural objects may thwart each object's own natural behaviour. Thus 'with that which is natural it is always thus *if there is no impediment*' (*Phys.* II. 8, $199^b23–6$, trans. Charlton, emphasis added).

It is unclear what this regulative principle applies to in the present case.

While the gazelle is the smallest of animals with an excess of bony material, this does not make it an exception to what Aristotle has said.

$664^a3$–8: 'Female deer do not have horns'. An explanation for the male deer alone having horns was provided during the discussion of teeth ($662^a1$–2). The issue here is: If the female lacks horns, why does nature not provide her with a full set of teeth? The answer—that both share the horn-bearing nature—appears to beg the question. But the horn-bearing nature also involves a particular sort of digestive system, designed to deal with relatively unmasticated food, and it would make sense that the teeth be suited to the 'horn-bearing' digestive system, even in females which actually lack horns.

$664^a8$–11: 'Of the other animals . . . nature'. 'Nature' is the understood subject of the verbs throughout this passage. Both this remark and the previous one on the relevant sex differences in deer develop the theme of the formal nature 'making use of' the necessary nature—fixed amounts of material with fixed dispositions—for various ends.

## CHAPTER 3

$664^a12$–$^b2$: 'the parts for the sake of which the neck is naturally present . . . the larynx and the part called the oesophagus'. The full complexity of teleological relationships promised by *PA* I. 5, $645^b28$–33 (see note) is displayed in this explanation. One organ, the neck, is for the sake of two other organs (the oesophagus and larynx); the larynx, an organ, is said to be for breathing, an activity; the activities of inhaling and exhaling are also said to be for the sake of breathing, another, more fundamental, activity; and the affections associated with flesh and sinew (being elastic, soft, and yielding) are for the sake of the oesophagus and windpipe and the actions they perform.

Two forms of syllogistic argument are discernible in these explanations, those known in the scholastic vocabulary as Barbara (*A* belongs to all *B* (*A*a*B*), *B* belongs to all *C* (*B*a*C*), *A* belongs to all *C* (*A*a*C*)) and Camestres (*A* belongs to all *B* (*A*a*B*), *B* belongs to no *C* (*B*e*C*), *A* belongs to no *C* (*A*e*C*)). (The vowels in these names indicate whether the premisses are universal or particular, affirmative or negative: 'a' stands for a universal affirmative predication, 'e' for a universal negative predication.) *An. Pr.* I. 37–8 discusses the fact that the 'belongs to' connective can take a variety of different values. In the arguments below, wherever Aristotle specifies a teleological connection, I have built this into the subject or predicate term. A further condition on scientific demonstration is that the premisses must be necessary. In this passage, the expression 'is *by nature* for the sake of' is twice used to import both necessity and teleology into the premisses. Elsewhere in this chapter (e.g. $664^a23$, $^a26$, $^a27$, $^a30$, $^a31$) Aristotle qualifies various premisses as holding 'of necessity'. There are, of course, alternative ways of revealing the formal structure of these arguments, but the following seems to capture it reasonably well.

(S1): *Barbara* ($664^a12–16$)

(P1) Necks belong by nature to everything with what necks are for.
(P2) Having what necks are for belongs to everything with a larynx and oesophagus.
(C1) Necks belong to everything with a larynx and oesophagus.

*Codicil* ($664^a20–2$)

(CO) Having no neck belongs to everything without a windpipe and oesophagus.

The codicil could be an added premiss justified inductively; but it feels as if Aristotle has in mind that since nature does nothing in vain, and necks only exist to protect the windpipe and oesophagus, things without the latter must lack the former.

(S2) *Barbara* ($664^a17–20$)

(P1) Being present for breathing belongs to everything that inhales and exhales.
(P2) Inhaling and exhaling belong to all larynxes.
(C2) Being present for breathing belongs to all larynxes.

(S3) *Camestres* ($664^a19–20$)

(P1) Necks belong to every lung-possessor.
(P2) Being a lung-possessor belongs to no fish.
(C3) Necks belong to no fish.

The connection between the windpipe's function of transporting breath and the possession of a lung (a single bifurcated organ for Aristotle) has not yet been explained, so (S3) helps itself to an as yet unjustified major premiss.

In addition, there is an argument at $664^a21–3$ which presupposes a view about the oesophagus that is only stated later (at $^a30–2$).

(S4) *Camestres* ($664^a21–3$)

⟨(P1) The oesophagus belongs to all animals with a distance between mouth and stomach.⟩
(P2) Having a distance between mouth and stomach belongs to no neckless animal.
(C4) The oesophagus belongs to no neckless animal.

$664^a19$: 'those without a lung'. This organ is discussed on its own at $668^b33$–$669^b12$. Its primary function is to moderate the heat generated by the heart. Aristotle views it as a single, bifurcated organ (though at $669^b13$–25 he admits that in the egg-layers there seem to be two).

$664^a20$. 'The oesophagus is that through which nourishment proceeds'. Since it is possible to have the stomach immediately next to the mouth, the oesophagus is not required for nutrition ($664^a22$–4). Nor does it seem to improve nutrition in any way, so it cannot be said to be 'for the sake of the better'. Thus no teleological explanation of the oesophagus is provided—in fact, the wording carefully avoids one: 'Since the organ connected with breathing *from necessity* has length, it is *necessary* that the oesophagus be between the mouth and the stomach' ($664^a29$–31). This raises the question of how indirect the connection between an organ and a biological function must be before the function is no longer properly viewed as the goal of that organ. One might say that the oesophagus is necessary for the sake of nutrition, *given* an animal with a windpipe, even though it plays no role in the preparation of food.

$664^a35$–6: 'The part called the larynx, and the windpipe'. 'Larynx' translates *pharunx*, since when it is distinguished from the windpipe (*artēria*), it is to the larynx Aristotle seems to be referring. To complicate matters further, Aristotle uses *larunx* for the same organ at *HA* I. 12, $493^a6$, II. 1, $499^a1$, and IV. 9, $535^a32$ (see Ogle 1882: 192 n. 1; 1912: $664^a16$ n. 2). At $664^a16$, $^b26$, and $665^a10$ *larunx* appears to refer to the entire breathing channel; $664^a35$–6 and $665^a19$–20, however, conjoin *pharunx* and *artēria* as if they were distinct parts. Finally, *artēria* is used in the plural at $664^a27$–8 to refer to the bifurcation of the breathing apparatus just above the lung, but in the singular as if referring to the entire breathing channel at $664^b3$, $^b20$, $^b29$, $665^a4$, $^a7$–8, and $^a18$. All three terms thus appear to be used in a fluid and unstable way.

$664^b6$–7: 'those people who say that it is by means of this part that the animal takes in drink'. Cf. *Tim.* 70 C. The refutation reveals something of Aristotle's method for determining the function of an organ. He objects on three grounds:

(1) There is no connection between the lung and the stomach.
(2) One can see that liquid vomit comes from the gut.
(3) There are a number of signs that liquid nutrients do not go directly to the bladder, but go first to the gut.

The first argument assumes agreement that fluid nutrients end up in the gut, and the second and third support that assumption. Aristotle seems, then, to use evidence of anatomical connections to help establish functional hypotheses. He seldom comments on this methodology, but *Resp.* 3 stresses, as a prelude to a critique of previous theories of respiration, the importance of pursuing anatomical and teleological enquiry together.

> The major reason for their failure to speak correctly about respiration is a lack of experience with the internal parts *and a failure to grasp that nature in every case acts for the sake of something. Had my predecessors been seeking what respiration was present in animals for* and been investigating this among parts such as gills and lung, they might have discovered the cause with ease. (*Resp.* 3, $471^b24–9$)

$664^b21–665^a9$: 'for this nature has constructed the epiglottis'. (Cf. $655^b5–8$ and note.) This passage concludes with the crucial point—'nature has remedied the inefficiency of the position of the windpipe by constructing the part called the epiglottis' ($665^a7–9$). Aristotle is no defender of what Daniel Dennett refers to as the 'Panglossian paradigm', the view expressed by Dr Pangloss in Voltaire's *Candide*, that 'all is for the best in this best of all possible worlds' (Dennett 1995: 239–40; cf. Dennett 1983). The verb translated 'to remedy', *iatrein*, which refers to medical treatment, implies that, though the windpipe's position is necessitated by the positioning of more basic structures (see $665^a9$ note), it is far from ideal.

$665^a6$: 'the cause owing to which some animals have an epiglottis while others do not'. Since the epiglottis is restricted to a subset of the breathers, an explanation is needed for the two alternative mechanisms for closing off the windpipe during eating. In such cases Aristotle often looks to material constraints (cf. $655^a26–8$, $657^a17–22$ notes).

Ogle (1912: $664^b23$ n. 1) states that Aristotle is 'obviously wrong' to say that not all live-bearing animals have an epiglottis, and suggests changing the text to read 'the blooded animals'; Peck agrees (1961: 229 n. b). But, since there are viviparous snakes and fish (cf. *GA* II. 1, $732^b20–3$), neither of which have an epiglottis, Aristotle is precise, and correct. Thus he constructs a class coextensive with the epiglottis—animals with a lung, hairy skin, and neither scales nor feathers. This is the best that Aristotle's linguistic resources provide; it allows for bats and flying foxes while excluding vipers and selachians. The problems that Ogle and Peck have with this passage highlight the importance of recognizing Aristotle's method of identifying the *relevant explanatory population* through a conjunction of differentiae coinciding with the part whose presence needs to be explained. Identifying the population in this way has a further advantage: the mention of feathers and scales directs attention to the *material* explanation for the absence of an epiglottis in certain breathers, since feathers and scales indicate relatively dry flesh, which would make a poorly functioning epiglottis (cf. $664^b36$–$665^a5$).

$665^a9$–26: 'the larynx lies in front of the oesophagus of necessity'. On 'front' and 'rear' being defined by reference to the orientation of perception and locomotion, see *IA* 4, $705^b1$–20, and the notes to $656^a13$, $^b13$, $^b23$, and $^b30$. *IA* 5, $706^b11$–16, argues that a location is 'valuable' because an 'origin' (e.g. of perception or locomotion) is found there. So assertions about the value of locations are parasitic on those about the value of the function of the organs present there. What this argument lacks, however, is a reason to think that the location of the *origin* of perception or locomotion is dictated by the *orientation* of perception or locomotion. Without this it does not seem necessary that the heart and the lung be forward. Similarly, there is no argument given for why the windpipe could not have been shaped so that the opening at the top is behind the oesophagus while it still ends up reaching the lungs.

## $665^a27$–$678^a27$

At this juncture Aristotle makes an unannounced choice regarding the order in which the parts are to be considered. In the case of the head and neck, both internal and external parts were discussed. Perhaps because of the functional connection of the windpipe to the lung (and the lung's connection to the heart), and of the oesophagus to the digestive tract, Aristotle begins here to focus on the 'innards', the visceral parts constituted from blood. This focus continues until *PA* IV. 5, $678^a27$, where he turns to a discussion of the internal and external parts in each group of the bloodless animals ($678^a27$–$685^b28$). Finally, at $685^b30$, he announces a return to the blooded live-bearing animals, beginning with the head and the neck—suggesting that the previous discussion was really focused on the parts *about* the head and *in* the neck, rather than on these external parts *per se*. Aristotle never justifies proceeding in this order.

## CHAPTER 4

## $665^a27$–$667^b14$

The discussion of the heart is the longest devoted to a single part, which is entirely fitting given that Aristotle considers it to be the primary organ of nutrition, perception, and locomotion in blooded animals. The discussion begins with a general defence, against Democritus, of the claim that viscera belong exclusively to blooded animals. This leads naturally into an argument that the heart is the origin of the blood vessels, and finally of blood itself; and then to an argument for it being the source of perception as well.

Only after this defense of its functional centrality does the discussion of its anatomical structure commence, at which point Aristotle turns to the way in which it is differentiated in the different kinds of blooded animals. Once more we see the pattern of moving from a preliminary discussion of the part at the widest possible extension to a discussion of differentiated forms of the part in groups of more limited extension, groups often identified only in terms of differentiae co-extensive with the distinct form of the part being investigated.

$665^a28–30$: 'all the viscera are present in some of them, in others they are not'. That is, some have all the viscera and some only have some of them. Viscera are distinctive characteristics (*idia*) of the blooded animals; all blooded animals have a heart, liver, and diaphragm ($672^b13–14$), fish lack a lung ($669^a36$), and certain egg-layers lack a bladder ($670^b3–4$, $670^b33–4$) and kidneys ($671^a26–8$).

$665^a31–^b2$: 'Democritus seems not to have understood these things well, if'. The Greek could also be taken inferentially—'Democritus seems not to have understood these things well, *since*'. On the early embryonic appearance of the heart, cf. *GA* II. 1, $734^a21–5$; 5, $741^b15–24$. The celebrated discussion of the development of the chick embryo within the egg at *HA* VI. 3, $561^a4–562^a21$, mentions that the embryo first appears on the third day, and that the heart appears like a speck of blood; cf. *Juv.* 3, $468^b28–469^a23$, where these observations are referred to in the first-person plural. There is, however, surprisingly little said in *GA* II or *Historia Animalium* regarding the formation of the viscera.

$665^b5–9$: 'The viscera are distinctive to the blooded animals'. On the viscera as constituted from bloody material, cf. *PA* II. 2, $647^a30–647^b9$; III. 10, $673^a32–^b3$. The term translated 'viscera' (*splanchnon*) is found from Homer on to refer to the internal organs used for sacrificial offerings or prophecy.

$665^b7–9$: 'the form of the matter and its quantity'. This is an unusual turn of phrase for Aristotle. Nevertheless, 'form' and 'matter' should be taken in their technical senses. Blood is the matter of viscera (i.e. that *from which* viscera are constituted, *potential* viscera, $647^b1$), but it has an actual form of its own, which is more apparent in the early stages of development, having not yet been fully worked up into the visceral organ in question. The claim that the *quantity* of the matter is most apparent in neonates may be a closely related point. Aristotle may suppose that what gives (say) the liver or kidney its blood-like form is precisely the greater amount of unconstituted blood apparent, relative to a later stage. On the meaning of the phrase 'the first constitution', cf. *PA* II. 1, $646^a12–24$, and note.

$665^b9$–26: 'A heart is present in all blooded animals'. Aristotle has briefly discussed the necessity of the heart before at $647^b2$–8 (cf. $654^b8$–12; *HA* III. 3, $513^a22$–6).

$665^b15$: 'wherever possible one origin is better than many'. The operative presupposition here is, of course, that nature produces the better where possible (cf. *IA* 2, $704^b12$–18; $658^a23$–36 and note). What Aristotle does *not* explain is why one source is better than many; perhaps his best-known statement of this principle comes in the closing lines of *Met. Λ*, where, after chastising those who provide the cosmos with many origins, he quotes *Iliad*, II. 204: 'The rule of many is not good, one ruler let there be.' Perhaps his chief concern is unity: In order that an organism act in a co-ordinated manner, a single origin for the blood—which he has already claimed as the source of perception, locomotion, and nutrition—is preferable (cf. IV. 5, $682^a6$–8).

$665^b20$–1: 'nature places the more valuable things'. Cf. $665^a9$–26 and note; and Balme (1987*b*) 277; Lennox (1985*b*) 149–54; Gotthelf (1989*a*) 126–8.

$665^b23$: 'the necessary body'. That is, the part of the body in which the functions necessary to life are located, i.e. nutrition. This is the point of the remark about its limit being the excretory organs and about the limbs not being necessary in relation to living. Whether the remark about adding limbs is a purely imaginative flourish, perhaps intended as a joke, or is a reference to limb regeneration, is unclear; Aristotle mentions the regenerative ability of the tails of lizards and snakes (but not of limbs) at *HA* II. 17, $508^b4$–8.

$665^b27$: 'Those who state that the origin of blood vessels is in the head'. At *HA* III. 3, $513^a11$–12, Aristotle makes it clear that the prevailing opinion was that the blood vessels originate around the brain. (The apparent exception in the Hippocratic corpus, *On the Heart*, is post-Aristotelian, probably Alexandrian.) *HA* III. 2–4, $511^b2$–$515^a26$, on the blood vessels, begins with lengthy quotations from Diogenes of Apollonia and Polybus (supposed to be Polybius, the son-in-law of Hippocrates—the quoted passage appears in two treatises in the Hippocratic corpus, *On Human Nature*, vi. 58–60 Littré, and *On the Nature of Bones*, ix. 174–6 Littré).

Aristotle's rebuttal here ($665^b28$–30) is highly compressed. I suggest the following possible expansion. (1) Unlike the heart, which is unitary and from which extend two very large blood vessels, what we find in the head is a complex system of small vessels with no unitary source—thus this idea involves a multitude of sources for the blood vessels. (2) The blood, as was established in *PA* II, must be kept warm within the body, and thus one would assume it to originate in a warm place. But the blood vessels are the containers for the blood, so one would expect them to originate not in a cold place, but a warm one. The brain, however, is the coldest organ in the body (cf. $652^a28$–30, where a similar argument is used against the claim that it is the source of marrow).

$665^b31$: 'as was said'. Cf. $665^b15$–17.

$665^b34$–$666^a11$: 'And this is reasonable'. This passage marks the transition to discussing the heart as the source, not simply of the blood vessels, but of the blood itself. Typically Aristotle looks to what is distinctive of an organ in determining its function, and here it is the fact that the heart is a container full of free-standing blood. The other evidence he relies on is developmental. The heart is the first organ to come to be, and is blooded from the start. Again the argument is incomplete—presumably the missing premiss is that the blood could not originate elsewhere, since there is no organ prior to the heart in development.

Aristotle gives no indication why he is so sure that blood flows *from* the heart *into* the blood vessels but not vice versa. The discovery of blood circulation was accomplished by an Aristotelian, William Harvey, and it was in part the Aristotelian training he received in Padua that led him to reject the liver-centred physiology of the Galenists. But he did not get the circulatory hypothesis from Aristotle.

$666^a8$–10: 'with the help of the dissections and the generations'. Not necessarily a reference to treatises, but possibly simply the facts learnt from dissection or from observation of development. When Aristotle refers to books on these subjects, these phrases are sometimes preceded by a masculine plural definite article, sometimes explicitly completed by *logos*. See Düring (1943) 160.

$666^a11$–16: 'the movements of . . . all perception'. Aristotle claims it is evident that the movements associated with perception originate in the heart, and further claims that this accords both with the account he is giving and with observation. The account is apparently that given at $665^b14$–23 and reiterated here: that there should be one source where possible, and that it should be in the middle of the body. The argument appears to rely on an unstated premiss that the blood, while not itself able to perceive, conveys the data of perception, since it is taken to follow immediately from the fact that blood is incapable of perception that the primary vessel of the blood must be the origin of perception. On the inability of blood to perceive, cf. *PA* II. 3, $650^b2$–8.

$666^{a}19$–22: 'but with perception as well'. That the heart is the source of perceptual movements is said to accord with the observation of the heart moving spontaneously early in development, 'like an animal among the parts' (a phrase repeated at $666^{b}16$–17). Notice that this is not the stronger claim that these observations provide additional *evidence* for this claim, only that they are consistent with it.

$666^{a}24$–$666^{b}1$: 'The liver is also present in all the blooded animals'. Aristotle's starting-point in establishing causal connections is often establishing coextensive relationships. Only two of the viscera (heart and liver) are present in all the blooded animals; Aristotle's strategy is to establish that the heart must be the source of blood, by ruling out the only other candidate on extensional grounds, the liver.

$666^{a}34$–$^{b}1$: 'For "animal" is defined by perception'. Cf. *PA* II. 8, $653^{b}22$–3. Since this is equally true of bloodless animals, this argument is clearly understood as restricted to the blooded animals only. The previous discussion has provided various positive arguments for the heart being required for perception, and has ruled out the only other candidate.

$666^{b}1$. 'The apex of the heart'. No indication is given of the inductive base for the claim that the heart is near the front, but the qualification about the human heart shows that it is intended to be true of all hearts. Similarly with the argument that the human heart is slightly to the left—the explanation for this fact is that the left is coldest in humans, and the heart is inclined to the left in order to moderate the coolness of the left side; but there is no evidence given to support the major premiss.

$666^{b}10$–11: 'stated previously . . . alike in the fish as well'. Ogle and Peck cite *Resp.* 16, $478^{b}3$, which gives the requisite argument; and though the form of reference here suggests a passage earlier in *PA*, there is none.

$666^{b}13$–17: 'The heart also has many sinews'. These two sentences are quoted in Galen, *De Placit.* 1. 8. 3–4, with three semantically irrelevant variants not found in any of our manuscripts. By 'sinews' (*neura*) Aristotle probably referred to things we might distinguish as tendons, ligaments, and nerves (see Ogle 1882: 196–7 n. 20; 1912: $666^{b}14$ n. 4). Aristotle explains the many sinews of the heart by reference to its role in originating movement. The connection is slightly clearer in an argument in *MA* 9.

> the capacity of perception is there ⟨in the heart⟩ as well, so that when the area around the origin is altered due to perception and changes, the

> parts next to it change with it, both contracting and relaxing, so that from necessity because of these changes movement comes about in animals. ($702^b20–5$)

Thus the changes produced in the region of the heart by perception are translated into animal movement by the heart's movements causing the stretching and relaxing of the body's sinews, and this requires that the heart have the same sort of materials and ability to pass such movements on. This passage from *De Motu Animalium* also provides the link between the heart as origin of perception and as origin of movement.

$666^b17–21$: 'without a bone . . . with the exception of the horses and . . . oxen'. See Ogle (1882) 197 n. 22; (1912) $666^b21$ n. 2, who points out that 'It is not uncommon to find in large mammalia . . . a cruciform ossification in the heart, below the origin of the aorta.'

$666^b21–667^a6$: 'The hearts . . . hollow cavities'. There is a long tradition of scholarship, in modern times beginning with T. H. Huxley, attempting to sort out Aristotle's claims on this topic. This literature begins with the assumption that it is fairly obvious that the heart of a typical mammal has four cavities, not three; from that starting-point, the aim is to determine why Aristotle says that there are three. There is a balanced and thorough discussion of this topic, and of previous debate on it, in Shaw (1972). Lloyd (1978) has a thorough discussion of the problem of integrating the accounts of the heart's structure in *HA* III. 3 with that in our text and *Somn.* 3, $458^a15–20$; and of the role that normative judgements about location play in the discussion.

Shaw reaches the same conclusions—but with better reasons—as Huxley and Ogle (cf. 1882: 197–8 n. 23), that Aristotle viewed the right auricle as part of the 'great blood vessel' (our 'Vena Cava'). Hence his three chambers are the right and left ventricles and the left auricle, with the left ventricle being the middle one, when there are three.

We are not told which animals Aristotle thinks have only two cavities and which only one. One likely possibility for two would be the fish, since they lack the secondary (pulmonary) circulation. But Aristotle associates the different number of cavities with size rather than with a specific group.

Because discussion of this passage has been dominated by the questionable interpretative goal of determining whether Aristotle 'got it right', and if not, why not, the *argument* of this passage has typically been ignored. It begins with the general premiss that hearts are, with respect to internal structure, differentiated into three types. Aristotle claims that these differences are correlated with overall size. From this starting-point, the characteristic pattern of causal division follows naturally: find the *universal*, and explain why it belongs to *all* hearts; then identify the differences and explain in each case why that is the best sort of heart for a certain kind of animal. In this instance, the explanation can be mapped as follows:

| *Explananda* | *Explanans* |
|---|---|
| (1) All hearts have at least one cavity. | It is necessary that there be a receptacle for the first blood produced. |
| (2) Larger hearts have two cavities. | Since there are two distinct blood vessels, it would be better to have two distinct origins for them. But this *is* possible in larger animals. Nature does what is best, where possible. |
| (3) The largest hearts have three cavities. | It would be better still if there were a third chamber, to be a common origin for the blood in each of the other cavities. But this *is* possible in the largest animals. Nature does what is best, where possible. |

With explanations that move from a premiss that *p*, if possible, is better, to a conclusion that *p*, logic requires the assumption that 'nature produces what is better, where possible', an assumption that, as we have seen, Aristotle treats as a first principle in *PA*. (See e.g. the notes to 648a9, 652a31, 658a8–9, a23–6, 658b2–7, b22–6.) Aristotle's complete statement of this principle is that 'nature does nothing in vain, but always does, concerning each kind of animal, what is best among the possibilities for its substantial being' (*IA* 2, 704b15–17). He occasionally invokes the initial, negative phrase to account for the absence of a part, or for the use of a single part for multiple functions. And, sometimes explicitly, but more often, as here, implicitly, he uses the positive side of the principle, that nature always does what is best (or the better of the available options) for each kind of animal's being if it is possible. As I have argued in Lennox (1997), these are generalized references to the actions of formal natures, not to a Platonic Demiurge or a 'Dame Nature', and thus are perfectly compatible with there being animal parts that are not 'for the best'.

667a7: 'similar to the sutures of the skull'. Cf. 653a37–b3, 658b4. The words 'of the skull' are not actually in the Greek, but that is the only other use Aristotle makes of this term.

667a13: 'extend somehow even to the characters of animals'. The differences of the heart discussed from this point on are on a 'more and less' continuum. The earlier discussion of the relation between differences in the nature of the blood and character differences ($648^a2$–19; $650^b19$–$651^a19$) provides the background for this passage. No explanation is provided for the association between variation in perceptivity and in the heart's texture and 'articulations'. Boldness, timidity, and deviousness are character differences due to an affection stemming from fear; that affection either is, or is produced by, a combination of a small amount of heat relative to the size of the heart and colder blood. It is unclear whether the colder blood is an independent causal condition or a result of the relatively small amount of heat in the heart.

$667^a29$–32: 'none . . . with large cavities or large blood vessels have fatty flesh'. The explanation depends on a number of unstated premisses. Breath, as the bearer of 'external motions' here, must refer to breath inhaled for the sake of cooling the area surrounding the heart. It has this effect more in a heart with larger cavities. This decreases the heart's effectiveness in preparing the blood. And since fat is simply prepared blood, animals with larger cavities and blood vessels will have less fat.

$667^a32$–$^b12$: 'the heart does not endure any severe affection'. The primitive meaning of the verb here (*hupopherein*) is to bear up under—the point here is not that hearts are not affected, but that they do not *survive* such affections. The evidence from animal sacrifice (where the animal is not dying of disease) indicates that while the other viscera are often beset with pathology, the hearts are not ($667^b1$–10). On the other hand ($667^b10$–12), hearts of animals that have died from sickness *do* have 'morbid affections' which apparently killed them. The use of empirical evidence in support of this highly general theoretical claim is complex.

$667^a34$: 'and this is reasonable'. On the use of this phrase, cf. $647^a15$ note.

$667^b1$: 'A sign'. There is a valuable discussion of Aristotle's use of signs (*sēmeia*) in inductive reasoning in Burnyeat (1982) and Allen (2001); and of the role of the concept in the *Meteorology* in Freeland (1990). Signs are *indicative* of what they signify, but are not *direct* evidence for it. This use of *sēmeion* is found also at $669^b4$, $672^b28$, $679^a21$, $680^a31$, $681^a7$, and $688^b10$. The term has two other uses. At $669^b29$ and $670^b12$ the spleen in certain animals is said to be present 'as a token' (*charin sēmeiou*); and in the discussion of external limbs at $693^b8$, 14, and $696^a13$, 15, it refers to the number of 'points' of locomotion an organism has.

$667^b13$–14: 'what sort of thing it is . . . and the cause'. On the *Analyt-*

*ics* background to programmatic summaries such as this, see the notes to $651^b17$–19 and $652^a19$–23. This passage adds an interesting twist: it distinguishes the *account* of what the heart is, the *cause* of its presence, and what it is *for*. For Aristotle, of course, both a scientific definition of the heart and its causal explanation will make central reference to what the heart is for. But the addition is not redundant, since not every biological definition/explanation will include reference to teleological function, and every definition/explanation will refer to other things as well. The *kai*, then, may have the force of 'i.e.', specifying the mode of causation.

## $667^b15$–$669^b13$

The next two chapters deal with the blood vessels, which Aristotle treats as a single vascular system, and the lung. Both are connected with the heart anatomically and physiologically, but the lung is not found in all animals with hearts, fish having gills instead.

### CHAPTER 5

$667^b17$–20: 'said previously that they are for the sake of the blood'. Cf. $665^b12$–18. Interestingly, this suggests that a non-uniform part is for the sake of a uniform part, the reverse of the relationship defended in II. 1, $646^b10$–27. True, Aristotle considers *phleps* to be a synonymous uniform material of the blood vessels, but that is not the way the term is being used here (cf. $667^b20$ note). Though Aristotle does not stress this, the earlier discussion in II. 1 appears to be focused on the teleological relationships holding between composites and their components. Here, for example, it is clear that blood vessel is composed of blood, and in that sense blood is for the sake of blood vessel.

$667^b18$–19: 'that which is entirely moist has need of a container'. The moist is 'that which is able to fill, owing to being without boundary yet easily bounded' (*GC* II. 2, $329^b34$–$330^a1$).

$667^b20$: 'the kind consisting of blood vessels'. The dangers of translating *genos* by 'genus' is obvious here (cf. the *genos* of bones, $654^b29$). The blood vessels constitute a kind differentiated into the aortic system and that of the great blood vessel. *HA* III. 4, $515^a16$–21, stresses that, beyond a very general level of description, there are important differences within each of these systems, differences that depend on the differences in the limbs and viscera of the various kinds of animals.

$667^b25$–8: 'in some of the bloodless, one ⟨perceptive soul⟩ only actually'. Aristotle was fascinated by the ability of segments of certain bloodless organisms to survive after segmentation (cf. *An.* I. 5, $411^b19$–31; *Met.* Z 16, $1040^b10$–16; *Juv.* 2, $468^a21$–$^b16$). Such an ability presents a challenge to the principle that the soul is an origin of unity for the whole organism. He meets the challenge by arguing that these organisms have one soul *actually*, but many *potentially*. The act of segmentation actualizes the potential for many souls. *De Anima* further argues that while the segments come to have numerically distinct souls, they are each formally one, since the entire soul—constituted of capacities for nutrition, reproduction, perception, and locomotion—is actualized in each segment (cf. $411^b19$–23).

$667^b29$–31: 'the unity of the blood . . . the unity of the blood vessels'. 'Unity' is not in the Greek, only a feminine definite article. If (as Düring 1943: 163, suggests) this is brachylogy, then we require something to be supplied from the immediate context, and there are only two possibilities—'unity' and 'origin'. Since supplying 'origin' makes the sentence into a tautology, 'unity' is preferable. The point is that, for the sake of nutritive, locomotive, and perceptive function, the blood must be continuous from the heart throughout the body.

$667^b34$–$668^a5$: 'the front is more valuable and sovereign'. Assumed from $665^a10$–26, $665^b18$–21 (cf. notes). Given the value of unity, it is reasonable to ask why the vascular system is bifurcated. The distinction that we mark by the terms 'artery' and 'vein' is for Aristotle primarily an anatomical rather than a physiological distinction. Functionally, the two systems play the same nutritive, perceptive, and locomotive roles in the organism's life.

The claim that the aorta is indistinct in some animals may be an artefact of Aristotle's methods of study—killed animals or corpses would retain blood in the 'great blood vessel' but not in the aorta, because of veins, in distinction from arteries, having valves, a fact discovered by William Harvey's great Aristotelian teacher at Padua, Fabricius d'Aquapendente, in the late sixteenth century .

$668^a4$–25: 'the blood . . . matter for the entire body'. On this claim cf. $651^a14$–15; it is repeated at $668^a21$.

$668^a7$–9: 'in the works on generation'. Cf. $650^b8$–11. Nothing in our text of *Generation of Animals* clearly corresponds to this reference.

$668^a14$–20: 'just as in gardens . . . and in house-building'. For other uses of the irrigation analogy cf. Plato, *Tim.* 77 C 6–9; Galen, *De Nat. Fac.* III. 15, 210 Kühn; *HA* III. 4, $515^a23$–5. The irrigation and construction analogies both stress that materials must be distributed; irrigation, however, (1) with a single source, (2) with distribution of fluid, (3) through a system of channels, (4) for the sake of nutrition and growth, is a much richer analogue.

$668^a22$–5: 'in those who are extremely emaciated'. Aristotle recommends starving animals until emaciated and then killing by strangulation as a means of studying the vascular system at *HA* III. 3, $513^a12$–14. It is not entirely clear what is claimed to be clearer 'in the extremely emaciated', but it is perhaps that blood vessels run throughout the entire body. Compare the following passage in *Historia Animalium*: 'If the nature of the sinews were continuous, the continuity of all of them would become apparent in the emaciated animals' (*HA* III. 5, $515^b5$–6).

$668^a31$–2: 'the smallest become in actuality flesh, though potentially they are blood vessels'. The analogy with an aqueduct system with channels that disappear when filled with mud, yet continue to exist, fits well with the claim that blood flowing from flesh when it is cut indicates that there are invisible blood vessels there. But this idea is not well expressed by saying that the small blood vessels are actually flesh, yet potentially blood vessels. *HA* III. 5, $515^b1$–3, carries the same ambiguity. Both passages appear to be trying to express the idea that the smallest blood vessels 'become' flesh, but in a way that allows them to be reconstituted as blood vessel when flesh is reduced by starvation. *GA* II. 6 argues only that blood flows through pores in the blood vessels and is thence solidified into flesh by being cooled. 'The nutriment, oozing through the blood vessels, i.e. the pores in each, like water in unbaked pottery, becomes flesh or its analogue, being solidified by cold, for which reason it is also dissolved by fire' ($743^a8$–11).

$668^b9$–11: 'it was stated that every combination of earth and water solidifies when concocted'. Cf. *Meteor.* IV. 6, $383^a14$–27. But the reference may be internal to $649^a30$–4 (which, however, itself refers to *Meteor.* IV) or to $653^a22$–6.

$668^b24$: 'just as continuity is increased in things made by plaiting'. The basic anatomy here appears to conform to modern descriptions—the inferior vena cava has a more forward position than the inferior arteries, but the subclavian veins (those of the shoulders and upper limbs in humans) run behind the arteries (cf. Ogle 1912: $668^b16$ n. 1). The analogy with plaiting seems intended to stress an increased physical continuity, though given the basic physiological roles subserved by this system it is possible that Aristotle also had in mind increased continuity of movement and perception.

$668^b28$–30: 'on the dissections and the zoological enquiry'. Unlike the reference to *On Respiration* a few lines later, there is no reference to *logoi* here, and I have followed my usual practice of not suggesting in the translation that there is a reference to written work when there is not. The reference here is unusual in two other respects. First, it is to dissections and an enquiry, in the singular; second, the adjective derived from the Greek for 'animal' is used, which accounts for the translation 'zoological'. Perhaps Aristotle is referring to the investigation reflected in the long discussion in *HA* III. 2–4. On the question of what the dissections might have been, see $646^a8$ note, $650^a31$–2 note, and references. The Greek term rendered here 'accuracy' (*akribeia*) may stress subtly different qualities, including attention to detail. (Cf. Barnes 1993: 189, $87^a32$ note.)

## CHAPTER 6

$668^b32$–$669^a17$: 'A certain kind of animal has a lung because it is a land-dweller.' This opening claim is also the conclusion of the complex argument that follows. The lung and gills are organs of cooling, both deriving 'coolant' from the environment. Bloodless animals have neither organ—thus the aside here. The distinction between gills and lung is anatomically central, as noted in the discussion of the organs of the neck ($664^a14$–$665^b26$). This opening sentence encourages us to believe that it derives from a more basic distinction between land-dweller and water-dweller, but Aristotle concludes that all the land-dwellers *and some of the water-dwellers* have a lung ($669^a6$–8). We must, then, take seriously the qualification that 'a certain kind' has a lung because of being a land-dweller. The problem arises because of the cetaceans, which are lunged water-dwellers.

Aristotle occasionally lists the cetaceans among the 'extensive kinds' of blooded animals (e.g. *HA* I. 6, $490^b9$). However, they are not simply *sui generis* feature by feature, but are like live-bearing four-footed animals in many respects and like the fish in many others—they tend, in different respects, towards each group (*epamphoterizein*) and are discussed with other such animals in the very last chapter of *PA* (IV. 13, $697^a15$–30).

The passage thus makes the following consistent set of claims:

(1) One kind of animal has a lung because it is a land-dweller.
(2) All land-dwellers breathe.
(3) Some water-dwellers breathe (e.g. cetaceans).
(4) Some animals are land-dwellers that spend much time in the water, others are water-dwellers that partake to a great extent in the land-dwelling nature.

*Resp.* 10, $475^b15$–19 make the point more clearly, however. It notes that all true live-bearing animals have a lung, a universal that includes cetaceans.

And in *Resp.* 12, devoted to cetaceans, Aristotle makes no attempt to treat them as land-dwellers. The last paragraph of our chapter looks towards the approach in *On Respiration.*

$669^a11$–13: 'the end of their life is in their breath'. Similarly odd-sounding phrases are given somewhat more context in *Resp.* 21: 'the end [*telos*] of living and not living is ⟨consists?⟩ in the breathing' ($480^b19$–20; cf. $480^b12$: 'living is ⟨consists?⟩ in breathing in and out'). It would be reasonable to take these phrases to mean 'the end consisting of life', since the Greek preposition translated 'in' can signal dependence. The claim is then that, for animals that breathe, life, the primary goal of all our activity, is dependent on breath (i.e. on breathing). One of the parallel passages in *Resp.* 21 is difficult to read this way, however, since it says that the end of living *and not living* is in breathing. If the key notion is the dependence of life on breathing, this may be taken to say that whether an animal lives or not depends on breath.

$669^a14$–15: 'taking its origin of motion from the heart'. The mechanics may be as follows: the heart warms the lung, causing the lung to expand; this allows the inflow of cool air, which cools the heart, causing the lung to deflate; as the heart warms back up, the process is repeated. Cf. *Resp.* 21; Ogle 1882: 206 n. 6; 1912: $669^a18$ n. 2; and Ogle 1897: 34–42.

$669^a18$–24: 'the leaping of the heart'. Cf. Plato, *Tim.* 70 C. 'Leaping' is not a reference to the heartbeat, but to a rapid increase in beating. Plato was only discussing humans—but Aristotle's point is that if the purpose of the lung is to dampen the heart's leaping, one should find this phenomenon in all animals with lungs. The remarks regarding the relative positions of lung and heart in other animals are too telegraphic to force the radical emendation suggested by Ogle (1912: $669^a22$ n. 1).

$669^a24$–$^b8$: 'The lung differs in many ways in the animals'. Having established which animals have lungs and which do not, and why, the discussion, following the pattern of causal division, moves to the *differences* of the lung among those that have it and their explanation. The lung varies in size, texture, and quantity of blood—but at base it is the relatively warm and moist character of the live-bearing animals, and the cool and dry character of the egg-layers, that underlie all these differences.

$669^b4$–7: 'mankind is the most erect of all the animals'. Cf. $653^a27$–32, $656^a10$–14, and the fuller explanation for this fact found in IV. 10, $686^a27$–$687^a8$. The 'less upright' nature of the egg-layers, as opposed to the viviparous quadrupeds, is evidenced in the splayed character of their limbs: cf. *IA* 15, $713^a15–26$.

$669^b8–12$: 'the lung is for the sake of breathing'. This is one of the most discussed passages in Aristotle's biology. Cf. Balme (1992) 120–1; (1987*b*) 84–5; Gotthelf (1985*b*) 31–3; Pellegrin (1986) 71; Lennox (1987*a*) 117; Charles (1990) 164 n. 29 and (2000) 325 n. 29; Lennox (1990) 181 and n. 3).

These four lines give rise to at least three problems.

(1) There appears to be a lack of symmetry between the functional character of the general goal of the lung (breathing) and what the bloodless form of the lung is said to be for (certain animals). The asymmetry would be eliminated if 'for the sake of a certain kind of animal' is understood as shorthand for 'for the sake of the breathing requirements of a certain kind of animal'—i.e. the cooler, drier egg-layers.

(2) The import of the assertion that what is common is nameless is unclear. Possibly it is that Aristotle sees a causal unity among the features of the unnamed group which is similar to that found in groups such as birds. Cf. *PA* I. 4, $644^b5$, and notes, on unnamed kinds, and Lennox (1987*a*) 114–18.

(3) The consequences of claiming 'having a lung is present in their substantial being' (*ousia*) are not specified. However, earlier it was claimed that for these animals, living depends on breathing, which is the function of the lung. Note that it is the lung, not its function, which is said to be in the substantial being of the animal, on which cf. Gotthelf (1985*a*). (Of course, to be a lung is in part to be able to perform certain functions.)

Adding to the difficulties are a number of semantic ambiguities:

(1) In the phrase 'what is common to these animals is nameless', it is unclear which animals 'these animals' are. The logic of the rest of the passage rules out the just-mentioned kind with bloodless lungs. The other two possibilities—all the lunged animals or the two kinds that exhaust all the lunged animals—are extensionally equivalent.

(2) The last sentence begins with an inferential connective ('For this reason'), but it is entirely unclear how it can be an inference from what precedes it. The best I can do here is to suggest a very loose inference of the following sort: since these animals have something in common—lungs—just as the named kind bird does (e.g. feathered wings), lung-possession belongs in their being as much as feathered wing belongs in the being of birds. Whatever is meant, it is stated with needless obscurity.

(3) It is unusual for Aristotle to talk about a thing's being as 'constituted from something'; nevertheless, the parallel construction indicates that to

be a constituent of a thing's being is roughly equivalent to being *in* that thing's substantial being.

## $669^b13$–$674^a8$

Chapter 7 provides explanations which conform tolerably well to three of the explanation types discussed in the notes to $640^a33$–$^b4$—though there is a danger of interpretative circularity here, since interpreters of that earlier passage rely to a significant degree on this, and other similar, passages to make sense of the explanatory typology of *PA* I (cf. Balme 1992: 87).

The liver exemplifies 'teleological necessity': since blooded animals cannot exist without it, they have it. The spleen follows as a consequence of the liver and the bilateral construction of blooded animals; the kidneys, however, are present because it is better to have them, though not necessary (i.e. blooded animals could exist without them). This last claim must be understood with respect to the appropriate reference class—kidneys are not necessary for all blooded animals, since not all blooded animals separate their residues into solid and liquid (cf. chapter 8).

Chapter 10 discusses the diaphragm as a division between the heart and lung, on the one hand, and the liver, spleen, and kidneys, on the other. Similarly, chapter 11 discusses membranes surrounding certain viscera. Chapter 12 then discusses differences among livers and spleens.

### CHAPTER 7

$669^b13$: 'Some of the viscera seem to be single-natured . . . some double-natured'. The viscera are formed directly out of blood (II. 1, $647^a31$–$^b4$) and are therefore restricted to blooded animals (cf. IV. 5, $678^a28$–9). The overriding difficulty of the present discussion is its puzzling insistence on the 'doubleness' of the viscera. Aristotle denies that it is perceptually apparent, except in the kidneys, and at $669^b18$–$670^a7$ attempts to establish their 'double' nature and to explain it. Since the effort involves him in a variety of contortions, it is reasonable to ask what motivates it.

Some discussions (the best of these being Lloyd 1962; 1966) see Aristotle as at times uncritically accepting the symbolic associations of right and left in Greek culture generally, noting its importance in early Greek philosophy. His appeal to the claim that cold and left are on the same side of the 'columns of opposites' at $670^b21$–3, presumably a Pythagorean reference (cf. *Met. A* 5, $986^a15$–34), lends support to this picture.

Nevertheless, the premisses of the argument derive from Aristotle's own biological perspective, and nowhere (in this passage, at least) does he appeal to extra-biological norms in making his case. And since 'right and left' are for Aristotle biological terms, derived from a prior determination of the orientation of sense-organs and direction of motion (i.e. of 'front' and 'back'), it makes sense to look for prior biological principles which might predispose him to argue for such an arrangement of organs. Such principles were already explicit in his account of the bipolar nature of the sense-organs at II. 10, $656^b22–657^a11$, to which we are referred at $669^b22–3$. They are: (1) that organic bodies have a right and left side, and (2) that determination of right and left is parasitic on determining front and rear. There too, effort is expended to argue that, appearances notwithstanding, the nose, and even the tongue, are double. As here, where Aristotle appeals to the obviously double character of the lung in the egg-layers to defend the claim that the lung tends to be double in all cases, so there he appeals to the split tongue of certain oviparous quadrupeds to defend the claim that the tongue is double in all cases.

The Greek adjectives rendered 'single-natured' and 'double-natured' (*monophuē*, *diphuē*) carry the connotation that the object being described developed that way naturally.

$669^b18–21$: 'because of the division of the body'. Cf. $670^a2–8$. As noted previously, *IA* 2 says that it is a first principle laid down and used often in the study of nature that there are six dimensions in nature, linked in pairs, the up and down, the front and back, and the left and right ($704^b18–22$). Its principal application is to the bodies of blooded animals, but Aristotle also insists that each organ on the left is a double of one on the right; no real argument for this is provided, and it leads him to insist that the spleen, which often is virtually non-existent and is functionally unrelated to the liver, is nevertheless its 'double'.

$669^b26–670^a2$: 'a difficulty regarding the liver and spleen'. On the comparative anatomy of these organs Ogle (1882: 206–7 nn. 1–6) remains useful (though the *function* of the spleen was unknown when he wrote). Aristotle's claim is that there is a correlation between the size of the spleen and the extent to which the liver is double (or as we would say, has lobes). When the spleen is greatly reduced, the liver becomes double in its nature, the larger lobe on the right, the smaller on the left. It is 'necessary in a way' in that it is necessary for the liver to have a double; it is not exceedingly so in that as the liver itself approaches being double in nature, the spleen becomes a mere token.

$670^a8$: 'are all present in common for the sake of the blood vessels'. In addition to their *distinctive* functions, they serve a common 'anchoring' function. Since the blood vessels provide the nutritive, sensory, and motor connections between the heart and the remainder of the body, the importance attributed to this function is understandable.

670a23–670b27: 'heart and liver are necessary'. The common functions having been dealt with, Aristotle turns now to the distinctive functions of heart, liver, lung, spleen, and kidneys. The claim that heart and liver are necessary for all animals must be taken in context, to mean all *blooded* animals. The heart and lung are mentioned again briefly because the liver, like them, is necessary for a basic living function, the concoction of nutrition (670a23–7).

670a26: 'an acropolis of the body'. Perhaps a reminder of the difference between Aristotle's and Plato's views of the respective importance of brain and heart. *Tim.* 70 A 6 says that the heart aids in carrying out the orders '*from* the acropolis,' i.e. from the region of the brain.

670a30–1: 'The spleen is present . . . as a necessary consequence'. The necessity of the spleen is not made clear. We have been told a number of inconsistent things on this score. (1) Some animals have it of necessity, some do not (669b27–9). (2) Those that do not have it from necessity nevertheless have it 'as a token' (669b29–30). (3) The spleen is present in order to bond the blood vessels to the left side of the body (670a12–17). (4) The liver and spleen contribute to the concoction of nourishment (670b5–6). (5) It is in a way necessary, though not exceedingly so (670a1–2). (6) The spleen is incidentally necessary (670a30).

Some order can be made of this, though Aristotle clearly vacillates on whether the spleen is necessary in any sense. The right/left duality ensures a left-side part corresponding to the liver; furthermore, such a part seems necessary as a left 'anchor' for the vascular system. Given its presence and its character, the spleen can, when sufficiently large, aid in the concoction of food, though it is clearly not required for this. And its variations are explained not by changes in need, but as consequences of changes in other organs. Perhaps the view is that, while the spleen is teleologically necessitated in virtue of the 'common' visceral function of anchoring blood vessels, it is not necessary *qua* spleen. A considerable advance has been made beyond the *Timaeus* (70 E–72 D), but this is one of the most confusing accounts of a part in the entire *PA*.

670b7: 'liable to sickness'. 670b6–11 appears to be based on medical diagnosis, and the palpitation of the spleen is a common diagnostic technique in the Hippocratic corpus (cf. also *Tim.* 72 C–D). Throughout this passage, the variations in the spleen are accounted for by reference to the relative warmth and moistness of the animals in question (as judged by the presence or absence of a bladder, the character of the lung, and frequency of urination). The final appeal to the Pythagorean-esque 'column of opposites' is an indication that the explanations for the spleen's variations appeal almost entirely to material factors.

670$^b$23–7: 'The kidneys . . . not out of necessity, but for the sake of the good'. The full account of the kidneys runs from 671$^a$26 to 672$^b$8. They are briefly mentioned here, since they share with liver and spleen the common function of anchoring the vascular system.

Explanatory appeals to 'the better' are sometimes made when not all animals that have a primary organ have an associated secondary one (e.g. penis vs. testicles, *GA* I. 4, 717$^a$15–21). But Aristotle appears to think that all animals with bladders have kidneys; at any rate, nowhere in *PA* does he discuss an animal that deals with fluid excretion solely by means of a bladder (compare *HA* II. 16, 506$^b$25–30, which notes the lack of both organs in birds and fish). If this is correct, then the denial of necessity here must be an 'engineering' judgement.

The final apology for departing from serial order would lead a reader falsely to conclude that the discussion of the kidneys is completed, and that discussions of the bladder and then the diaphragm are to follow.

## CHAPTER 8

671$^a$1–2: 'on account of the excess of the nature which they have'. Some manuscripts read 'the heat' rather than 'the nature', which reflects a correct understanding of the point. Lungs with blood are *exceedingly hot in nature*, which creates thirst and the subsequent need for more moist nourishment, and thus more moist residue. And as this residue is fluid, it needs a receptacle (cf. 667$^b$18–20 and below, 671$^a$22–3).

671$^a$8–9: 'those with a lung of this sort all have a bladder'. More literally, 'as many as have a lung *all* have a bladder', a redundancy that typically marks a convertible predication with an open-ended subject. It has been stressed throughout these notes that Aristotle's deliberate practice in *PA* is to group animals in this manner. For philosophical discussion of his reasons for doing so, see Gotthelf (1988); Lennox (1990) 177; Lennox (1991) 285–92 and n. 30.

671$^a$9–14: 'none of these has a bladder'. This long and complicated sentence identifies three groups without a bladder: (1) those with a spongy (vs. a bloody) lung; (2) those without a lung—insects and fish—which take in water incidentally to eating, but do not drink; (3) those with feathers or scales (many of which do have a lung). There are a variety of puzzles here. Why the reference to insects, when it is the blooded animals that are under consideration? Moreover, there is a puzzling redundancy in this threefold grouping—the members of the third group belong in the first, and the scaly animals include some fish. Perhaps it is dictated by Aristotle's desire to distinguish the question of why some animals with lungs do not have a bladder from the question of why animals that take in a lot of moisture do not need a bladder; and from the question of why animals with feathers and scales lack bladders. It is, in fact, the case that birds and most reptiles and amphibians lack a bladder, and that there is none to speak of in fish; cf. Ogle (1882) 208–9 nn. 1–6; (1912) 671a15 n. 2. This once again raises the question of how widely Aristotle dissected, and what principles governed his selection of animals to dissect.

671a15–16: 'And there alone has nature deviated'. The verb used here can also mean 'to be mutilated' or 'stunted', but this is not the point here. The tortoises possess something their scaly brethren typically lack, a deviation from their scaly nature certainly, but one which involves neither mutilation nor stunting. Aristotle's claims about their lungs are, again, roughly correct (cf. Ogle 1912: 671a18 n. 1).

671a24–5: 'the sea tortoise having a large one, the land tortoises a very small one'. Ogle translates both as plural (as they are at a15–18), Peck as singulars. In fact the first reference is singular, the second plural. Nothing can be deduced from this with certainty, especially given the earlier plurals; but the earlier reference may be to individuals of the kinds, leaving it as an open possibility that here Aristotle is referring to one kind of sea turtle but many kinds of land turtle.

## CHAPTER 9

671a26–b3: 'Things are similar with the kidneys'. The transition from the bladder to kidneys is seamless, accomplished by continuing with the list of animals lacking a bladder and the exceptional tortoises. But certain birds have many kidney-like parts (cf. Jollie 1972: 297), and we now hear of a tortoise, the *hemus* (simply a transliteration of the Greek), which lacks both kidney and bladder, making it an exception to an exception! The *hemus* is also referred to in *HA* II. 15, 506a19; V. 33, 558a8, and (if the *emus*—same spelling, different aspiration—is the same animal) VII (VIII). 2, 589a28 and 17, 600b22 (cf. Pliny, *N. Hist.* XXXII. 4). However, the discussions of kidneys and bladder in *Historia Animalium* do not mention a tortoise without a bladder, and the various references to the *hemus* do not discuss kidneys or bladder. To confuse matters further, though I follow Bekker in reading *hemus* (a reading supported by a small number of manuscripts), the majority of manuscripts actually have a word otherwise unknown in Greek, *aimus*, at both 671$^a$31 and $^a$33.

671$^b$1–3: 'nature uses the kidneys'. As is common (cf. 659$^a$12 and note), this language appears where the same organ is used for a primary and a secondary function; cf. 670$^a$16–23. There is further discussion of the channel running from the great blood vessel to the kidneys at 670$^a$17–19.

671$^b$6: 'as it were, composed of many small kidneys'. A couple of brief excerpts from a recent morphology text indicate how perceptive Aristotle's wide-ranging comparisons are: 'man has a number of papillae opening into calyces of the pelvis. Next in order of increasing complexity, the outer surface of the kidney reveals the individual lobules as in the cow, or the lobules may be even more distinct as in the seal' (Jollie 1972: 292).

671$^b$15–28: 'two vigorous, bloodless channels run to the bladder'. A reference to the ureters. Their specific function is inferred, in part, from the details of their connections to other organs. They do not contain blood, they originate in the centre of the kidneys, which contains a residue rather than blood, and they terminate in the bladder, all of which suggests that they transport this residue from the kidneys to the bladder. Combined with a theory of the need to remove 'useless residues' from the body, this gives a theory of their function. On Aristotle's understanding of such inferences, cf. *Resp.* 3, 471$^b$23–9.

671$^b$25–7: 'the causes owing to which the kidneys are as they are, and have the potentials we have described'. The 'and' (*kai*) should not be taken as epexegetic. The potentials in this case—e.g. the ability to filter residues from the blood, to store and prepare them prior to their flowing to the bladder—have corresponding activities with predictable results. But to establish what those activities are *for* requires a theory of the needs of the organism that these results can be seen to subserve, and these teleological causes are what Aristotle has been primarily concerned to establish. Nothing said here prevents Aristotle from having a thoroughly mechanical notion of these processes: for example, the filtering could be a simple consequence of the kidney's material preventing fluid beyond a certain viscosity from entering into the cavity, which when full overflows into the ureters, whence it flows into the bladder.

671$^b$28–672$^a$1: 'the right one is higher up than the left'. Aristotle's view that the parts on the right are 'stronger', given his claim that motion originates there, is understandable—but why this should incline the right kidney (or eyebrow, for that matter) to be higher up is never explained.

672a1–13: 'The kidneys have the most fat of all the viscera.' The claim that the fat around the kidneys is 'out of necessity' is reiterated at a13, and syntactically co-ordinated with the following teleological explanation by reference to the fat's function as a preserver of the heat in the kidneys. The premisses of the explanation by appeal to material necessity are borrowed from *PA* II. 2–5: well-concocted blood becomes fat (651a20–4); heat is retained in that upon which it acts (649a25); and there are two sorts of fat, hard and soft (651a28–36, to which 672a12–13 presumably refers). The claim that fat rises to the surface of liquids because of the presence of heat is based on the theory of the elements (cf. *Cael.* IV. 3–4).

When Aristotle picks up the reference to necessity again at a13, he adds that the soft fattiness of the kidneys is 'the cause owing to which the kidneys come to be fatty, a consequence of what happens of necessity'. That is, the immediate material/motive causes of the production of soft fat around the kidneys are *themselves* the result of such causes.

672a15–22: 'also . . . for the sake of the preservation . . . and of their natural heat'. If the conjunction here is read as epexegetic, it is the preservation of the heat in the kidneys that is the function of the fat around them. Taken as a pure conjunction, the idea would be that it is important for the preservation of the animal that the formation of soft fat around the kidneys maintains their warmth. The final argument here is tightly syllogistic, giving the conclusion first, and then the premisses of a Barbara syllogism from which to deduce it.

672a26–672b7: 'though when a sheep is affected in this way'. Aristotle is apparently trying to account for a correlation between the suety nature of the kidney fat and high rate of death from kidney disease in sheep. It is based on an appeal to a theory of morbidity due to enclosure of 'vapours' (*pneumata*), however, which is obscure, and about which we are told nothing.

## CHAPTER 10

672b8–10: 'the first two are separated from the others by the diaphragm'. The Greek word order makes it clear that this means that the first two organs (heart and lung) are separated *from the other three* (liver, spleen, and kidneys) by the diaphragm.

672b10–13: 'This "diaphragm" some people call "midriffs"'. Cf. 672b20,

$^b30$–3, $673^a11$, $^a28$. Aristotle may have a number of thinkers in mind here, including Plato (cf. *Tim.* 70 A). Aristotle uses his preferred terminology interchangeably with that adopted by others. His preferred expression (*to diazōma*), which is translated 'the diaphragm', is singular, whereas the term employed by Plato and others (*phrenes*), translated 'midriffs', is always used in the plural. (Plato also refers to the midriffs as a *diaphragma*, a partition—this is the etymological source for our term 'diaphragm'.) Part of the explanation for this oddity is explained by the 'etymology' at $672^b30$–3. In Homer and others it is not uncommon to refer to various cognitive and emotional capacities by the term *phrenes*, again often in the plural, variously translated 'wits', 'passions', 'desires'—apparently on the ground that they were thought to originate in the chest area. Aristotle's claim is that the term *phrenes* comes to be applied to the diaphragm because its assumed influence on cognition leads people to think that it partakes of cognition (*to phronein*). Aristotle thinks they have been misled and would prefer that this term not be used for this structure, but he nevertheless ($673^a11$, 28) continues to use it himself. Our terms 'phrenetic' and 'phrenology' reflect the meaning of the term *phrenes* to which Aristotle is referring.

$672^b14$–24: 'for the sake of the demarcation of the gut region from the heart region'. The differences between Aristotle's and Plato's views follow from their different views about the heart. The *Timaeus* locates rational cognition in the brain and spirit in the heart, which is susceptible to influence by the mind (from above) or by the appetites (from below). The diaphragm thus helps prevent the passions being ruled by appetite (cf. *Tim.* 70 A–C, 84 D–E). Since for Aristotle the heart is the organic centre of cognition, he sees the diaphragm as preventing a direct disruption of perception by the hot fumes or vapours emanating from the digestive tract. Neither of them is aware of its role in respiration.

The conclusion that the structure above the diaphragm is more valuable and better than that which is below expresses Aristotle's fundamental belief that perception is the essential feature of animals, which as a form of cognition is better than mere nutritive capacities (cf. *GA* I. 23, $731^a15$–$^b8$). There is, however, no argument for the assignment of values here. Here again we have an Aristotelian twist on the *Timaeus*, which also sees the diaphragm as separating the better from the worse.

$672^b25$–$673^a1$: 'more membranous in the middle . . . .also . . . thin'. We are not told what disruptions of perception and thought Aristotle has in mind here. There is no functional explanation for the extremities being fleshy—that is apparently a necessary consequence of their location (presumably the extremities are formed out of fleshy material, though he does not say so explicitly). Nor is the requirement that it be elastic explained—it plays no role in respiration on Aristotle's view.

673a1–31: 'what occurs in regard to laughter'. This is a good example of 'sign inference'—i.e. reasoning back from consequences to causes. The signs are two forms of involuntary laughter, due to tickling and the so-called *risus sardonicus*. The latter Aristotle treats as a report, yet plausible because it involves the same mechanism that he infers leads from tickling to laughter. These explanations are somewhat unusual, in that the diaphragm is present in order to prevent digestive interference with cognition, while most of the discussion focuses on phenomena which occur because the best it can do is to minimize such interference.

673a12–32: 'from more credible speakers than the one about the head'. Peck is quite mistaken to bracket 673a28–31 as *corrupta et inepta*. It is an integral part of a digression focused on evaluating the plausibility of a report for which direct evidence is lacking, as with the reports about blows to the ribcage causing laughter. The claim that severed heads can continue to vocalize can be treated as false for purely mechanical reasons ('it is impossible to speak when the windpipe has been severed'). Aristotle notes that one uses evidence from other animals in this case, and then returns to the plausibility of the reports of blow-induced laughter in humans. That this does not happen in the case of other animals is reasonable, since humans are the only animals that laugh. In a similar fashion, one could reasonably believe that a blooded animal's body could move for a time without its head, since this in fact happens in bloodless animals. What appears to be a fanciful diversion is in fact an insightful discussion of the cautious use of indirect evidence.

673a15–17: 'even invoke Homer'. *Iliad*, X. 457; *Odyssey*, XXII. 329. Oddly, our Homeric manuscripts have the reading that supports Aristotle! It is possible that Aristotle's point is that these people go so far as to claim that Homer's *actual* verse is different from that which everyone reads and recites, and Homer's actual poem supports their claim.

673a17: 'And in the region of Arcadia'. The majority of manuscripts read 'Caria' rather than 'Arcadia'. However, one has 'Arcadia', and there are two other variants: this, in the light of the evidence noted in Peck (1961) 282 n. b, leads me to prefer the minority reading. Peck's note should also be consulted for references regarding the cult of Zeus the Warrior.

673a30–1: 'The causes . . . clarified elsewhere.' Presumably this refers to the causes of bloodless animals moving after being cut up; if so, see $667^b21$–$31$ and its note for references.

$673^a31$–$673^b3$: 'each of the viscera . . . *for the sake of* . . . of *necessity*'. This is a conclusion of the entire discussion of viscera, not merely of the diaphragm. The explanation for the viscera coming to be of necessity is briefly summarized, as it was given initially in *PA* II. 1, $647^b1$–8.

## CHAPTER 11

$673^a4$–11: 'All the viscera are in a membrane'. The heart's membrane is presumably the pericardium, the brain's the dura mater. The explanation for the use of membrane for the protection of the viscera is by conditional necessity—if the viscera are to be protected, their covering must be dense; if this protection is not to interfere with their functioning, it must be light (i.e. by being thin and fleshless). The antecedent of the conditionals is assumed to be necessary; the *explananda* are two basic material-level capacities, density and lightness. It is not claimed that membrane is the *only* organic material that possesses both these properties, only that it is sufficient to the task. However, developmentally it may be the only dense light material able to arise given the elemental constitution of the kinds of animals being investigated.

## CHAPTER 12

$673^b12$–14: 'what sorts of animals do not, and owing to what cause'. Cf. $670^a23$–$670^b27$.

$673^b14$–$674^a4$: 'these parts differ'. Though allegedly dealing generally with the differences among the viscera in those that have them, the present discussion is limited to variations in liver and spleen. Furthermore, there is no particular reason why they are considered after the discussion of the diaphragm. The egg-layers diverge with regard to liver and spleen—the birds are more like the live-bearing animals than the other egg-layers (fish and four-footed). This is unlike many of the divisions in *PA*, where all the egg-layers are on one side, all the live-bearing animals on the other. Multiple-difference division, defended in *PA* I. 2–4, permits the grouping of birds with live-bearing animals in one division while opposing them in another.

$673^b23$–4: 'their bodies are the most fresh-smelling'. The superlative here can either mean most fresh (pure, sweet-smelling) or most easily or freely breathable. In a number of previous passages, related verbs have been used in the second sense ($653^b2$, $671^a21$, $671^a30$, $672^a34$, $672^b3$). But the context here does not suggest this meaning, and the later discussion of bile strongly suggests that the verb here refers to properties detectable by smell or taste (cf. $677^a19$–$^b10$).

$673^b24$–5: 'no bile'. On the connection between the condition of the liver and the presence or absence of bile, cf. *PA* IV. 2, $677^a19$–$677^b10$ and notes.

$673^b26$–7: 'their end is present most of all in the blood'. Livers, in virtue of their hot, bloody nature, are for the sake of the concoction of nourishment ($670^a20$–1, 27), i.e. turning it into blood. The 'purer' livers of the live-bearing animals and birds possess little foul residue, and thus play a role in producing *pure* blood. So, while the end (*telos*) of a healthy and moderate body is found in the animal's blood (in the sense that a healthy body is one constituted of pure, well-concocted blood), the liver (after the heart, of course) makes a major contribution to that end.

$673^b32$–$674^a4$: 'a round spleen . . . a long spleen'. All the correlations in this section are with variations in locomotive organs in the live-bearing animals. No reason for this restriction is given. Elsewhere the spleen is described as small or a token in most of the egg-layers ($669^b27$–30, $670^a32$–$670^b4$, $670^b10$–12). The variations discussed are all in shape, and no explanation for the variations is provided.

## $674^a9$–$676^a18$

Book III concludes with two chapters that discuss the organs related to digestion (chapter 13 is best treated as a non-chapter). As with the chapter divisions, the book divisions (other than the quite distinct Book I) do not mark divisions of subject-matter. The beginning of Book IV continues the discussion of the viscera and digestive organs of blooded animals, first extending some claims to the snakes, then going on to discuss bile, the omentum, and the mesentery.

There is a good analysis of the structure of the discussion of the stomach, and its relationship to other parts of *PA* II–III, in Gotthelf (1987*a*) 178–85, and in Detel (1997). *HA* II. 17, $507^a30$–$509^a25$, is the corresponding discussion of the stomach and intestines. The notes to this chapter in Ogle (1882) 213–16 and (1912) are also valuable.

### CHAPTER 13

$674^a7$: 'a nature that is shared in common'. Here is yet another example of an intrusive chapter division. It appears to conclude the discussion of the viscera by stressing their special connection with the blood vessels. In general Aristotle's point here is clear enough, especially when one recalls the argument in *PA* II. 1 that the viscera are essentially sedimentary deposits at the ends of the blood vessels ($647^a34$–$^b7$). Moreover, that some of them (i.e. those below the diaphragm, cf. $670^a8$–19) are for the sake of the blood vessels is also clear. But what is intended by the contrast class, those that 'do not exist without blood vessels'? Perhaps the point is that while some do not exist for the sake of blood vessels, at least they do not exist without them.

## CHAPTER 14

$674^a9$–12: 'in animals with an oesophagus . . . in those without'. See III. 3, $664^a20$–6, for the background. Fish are the blooded animals without oesophaguses that have the stomach right next to the mouth (although *HA* II. 17, $507^a10$–11, says that the conger and the eel have small oesophaguses). The word translated here 'stomach' (*hē koilia*) sometimes refers to the entire digestive tract (cf. $650^a13$), in which cases I render it 'gut'. Here, Aristotle is contrasting the stomach with the intestines, using this term only for the former organ. Later ($674^b14$) he uses it for the *first* of the four 'stomachs' of the ruminants, and further complicates matters by occasionally referring to this complex of stomachs in the singular ($674^a33$), but more commonly in the plural ($674^a30$, $674^b6$, $^b7$, $^b11$).

$674^a12$–19: 'the cause owing to which'. No explanation is provided for why the place in which nourishment is received and changed must be distinct from the place in which the useless residue is located. It may be that were the residue to remain in the stomach digestion would work on it, leading to an impure result. The physical positions and relationships of the organs apparently suggest their respective functions.

This passage depends heavily upon two passages in Book II, $650^a2$–32 and $655^b28$–$656^a14$; the latter notes that 'there are two parts that are most necessary, that by which they receive nourishment and that by which the residue departs; for it is impossible to be or to grow without nourishment' ($655^b28$–30). The reference to *On Generation* ($674^a20$) is often taken to be to *GA* II, but virtually nothing is said there about the transformation of nutriment into blood, nor about the development of the organs involved with that transformation. *GA* II assumes the presence of blood and discusses the production of the various uniform and non-uniform parts out of it. There are no extant books devoted solely to nutrition, nor is one mentioned in the ancient lists of Aristotle's works. (For similar references, cf. $653^b17$–18 and $668^a9$.) *An.* II. 3–4 makes it clear why Aristotle refers to discussions of 'generation and nourishment' together, for he argues there that these are the same capacity. *Qua* nutritive, it is the capacity to transform food into blood and then into tissues in order to maintain an already actual organism; *qua* generative, it is the capacity to transform the material that is a potential organism into a new actual organism. The inborn heat is the instrument that accomplishes these goals (cf. *GA* II. 4–7).

674a23–b17: 'animals with a complete set of teeth have one stomach'. The stomach is now integrated into the complex web of correlated differences discussed at III. 2–3, 662b23–664a11. There is a basic differentiation among the blooded live-bearing animals: those with a full set of teeth have one stomach, those lacking a full set of upper teeth have numerous stomachs (for some reason, while he lists four names, Aristotle never gives a precise number). That correlation is universal. But in addition there are two nearly universal correlations that interest Aristotle. Virtually all the animals with many stomachs and no upper incisors have horns and cloven feet, and Aristotle offered a complex material/teleological explanation for this in the discussion of horns. But there are two exceptions: the pig is cloven-hoofed but has a full set of teeth and no horns (though it has tusks (663a7), which are like horns growing from the jaw (664a11)); and the camel has the cloven hoofs, the lack of teeth, and the multiple stomachs, but is without horns (cf. 663a4, 6, and below, on the camel).

674a28–674b7: 'such as the camel'. A number of features of Aristotle's biological method are well illustrated here. The focus of *PA* is on explaining why each part belongs to all (and sometimes all and only) the group of animals to which it belongs. But these groups are often identified *only by reference to another part*—e.g. 'those with horns'. Thus the explanatory problem is often of the form 'Why do all/all and only the animals that have *X* have *Y*?' (For further discussion see 671a8–9 note.)

The possession of multiple stomachs is a case in point. There is no Greek name for all and only the animals with this feature: it is a subgroup of Aristotle's four-footed, live-bearing animals and includes a number of familiar animals with common names, like sheep, ox, and deer. Aristotle's interest is focused on noting what *other* features all the animals with this feature have—horns, cloven hoofs, and no upper incisors—and even more on their causal relationships. In this case—briefly—under constraints set by a fixed amount of earthen material, the animal's nature directs a certain amount of it to make horn (usually for the sake of defence). This limits the material available for the hoofs and the teeth, which in turn limits the ability of the teeth to break down food before it enters the stomach. This problem is dealt with by multiple stomachs that break food down further in stages.

Given this explanation, an animal that lacks the organ that is the first link in that explanatory chain, and yet possesses all the other features, is a major problem. The camel's lack of horns means that there ought to be material available for a full complement of teeth. So why does it not have them? Aristotle notes that a full complement of teeth is correlated with one stomach rather than four, and it is a 'greater necessity for it (the camel) to have that sort of stomach than the front teeth'. (Incidentally, though the camel is discussed often in *Historia Animalium*, the fact that it is the only hornless animal with four stomachs is not mentioned.)

The greater necessity of having many stomachs is eventually explained to be due to the thorny and woody nature of the camel's food. But then there is additional earthen material available (and it was not used on the hoofs, which are cloven), which Aristotle explains by noting that 'since its nourishment is thorny, while it is a necessity that the tongue be fleshy, nature makes use of the earth from the teeth for hardness in the roof of the mouth'.

Here arises a legitimate concern over *ad hoc* explanation. The camel *seems* to be a piece of strong disconfirmation of Aristotle's basic causal explanation for the correlation of four stomachs and lack of upper front teeth. The basic cause among the correlated features—the presence of horns for the sake of defence—is absent, but the other correlated features are present.

Rather than treat it as disconfirmation, however, Aristotle says that, in effect, there can be another cause of this set of features being found together. If the animal requires the four stomachs because of its diet more than a full set of teeth, and it cannot have both (on the often-invoked principle that nature does not produce redundancy), it will lack the upper front teeth. This does not account for the cloven hoofs, however.

In effect then, Aristotle is allowing two distinct causal explanations for the presence of the same features in different subjects:

(1) In camels, food that is hard to digest necessitates four stomachs, which makes a full set of upper teeth useless, and the excess hard matter is used in the roof of the mouth.
(2) In horned animals, the need for defence necessitates horns, which takes away matter for upper incisors, which in turn necessitates multiple stomachs.

This in itself does not violate his explanatory principles—see *An. Post.* II. 17, $99^b4$–6. But when combined with the weaknesses inherent in his account of horns, the camel might better have occasioned questions regarding the alleged link between horns and multiple stomachs. It would be interesting to know whether knowledge of the internal anatomy of the camel came in after this general theory had been worked out.

$674^b17$: 'owing to the same cause'. That is, the same cause that explains the presence of multiple stomachs in ruminants, i.e. a mouth which fails to concoct food adequately for digestion. The cause of the lack of teeth in birds, however, is entirely different, and the digestive tracks deal with the unconcocted nutrients in very different ways. As Aristotle goes on to state, not only do birds lack *some* teeth, they are toothless, so that the mouth does not process nutrients at all. And as the beak is simply part of their nature, an explanation for it will not be forthcoming. The rest of this inordinately long sentence lists the ways in which the birds deal with this problem.

$674^b17$: 'the bird kind also differs'. The Greek could be more literally rendered as 'the kind also has a difference'—that is, there is a differentiation within the birds regarding digestive parts. In the singular, the term 'difference' often means that the members of the group are different in a certain respect from one another. (Cf. *HA* II. 17, $508^b25$–6, where the formula is spelt out fully; and cf. $508^b25$–$509^a16$ for discussion of the differences.)

$674^b20$, 23: 'perform the work of the mouth . . . the operation of the mouth'. These and related abstract nouns (used together at $674^b9$–10 in the phrase 'the performance of the mouth's operation') refer to the processing of nutrients by the various parts of the digestive system in explicitly instrumental terms. Aristotle's theory that parts are what they are partly in virtue of the functions they perform helps to explain the contrast of the crop with the *operation* of the mouth.

$674^b30$: 'some birds—those that are long-legged and marsh-dwelling—that have none of these'. Commentators have been uncomfortable about this claim, since the crop *was* among the differences just discussed. The worry is needless, however: 'none of these' refers to the various ways of solving the digestive problem mentioned up to this point, and a long crop is a new solution, different from those already mentioned.

$674^b34$–$675^a24$: 'The fish kind'. On the relevance of fish being sawtoothed, cf. III. 1, $662^a6$–15 and notes. Only two 'species' are mentioned in this discussion, in both cases in order to point out an oddity. This is typically the only reason why Aristotle focuses on groups of such a narrow extension.

$675^a3$: 'the one called parrotfish . . . which alone among fish . . . chew[s] its cud'. The parrotfish (or 'parrot-wrasse') is often mentioned for this oddity (cf. *HA* II. 13, $505^a28$; 17, $508^b11$; VII (VIII). 2, $591^b22$; VIII (IX). 49, $632^b10$). The argument is even more condensed than usual. Lacking saw teeth (their teeth are flat), they are, like the ruminants, deficient with respect to chewing. Thus, like the ruminants, these fish chew their cud. The reason why fish in general must swallow quickly was given at III. 1, $662^a9$–15; typically, rather than repeat it, Aristotle simply makes a passing reference to the explanation.

Aristotle might have enjoyed reading the following comment. '"Parrot-wrasses" feed mostly on vegetable matter, corals, and on hard-shelled Mollusca, *for crushing which their dentition is well adapted*' (Harmer and Shipley 1904).

$675^a11$: 'the mullet'. Two different varieties are referred to often in *Historia Animalium*, identified by Thompson as the grey and red mullets (see the index to volume iii of the Loeb *Historia Animalium* under these names). Cf. Ogle (1882) 214 n. 19 for additional suggestions about identification.

$675^a11$–18: 'appendages next to the stomach'. A reference to the pyloric caeca (cf. *HA* II. 17, $508^b13$–25, $509^a16$–25). In many fish these are diffuse and numerous, and indeed 'by the stomach'; they are on either side of the anterior end of the large intestine in birds, but often rudimentary (cf. Jollie 1972: 253–70). Peck's identification of the appendages in live-bearing animals as the vermiform appendix is wrong. Many of the mammals that Aristotle dissected have a caecum positioned by the intestine as in birds, but only the apes and man have a vermiform appendix.

$675^a18$–24: 'The entire fish kind . . . .is gluttonous'. This brief comment indicates the tight connection in Aristotle between anatomical, physiological, and psychological states. The straight intestine leads to rapid excretion of poorly digested food, with correspondingly brief gustatory pleasures, and a rapid return of the desire for food. This is the underlying explanation of the gluttonous behaviour of fish. Some of the data upon which the judgement of gluttony depends may be found at *HA* VII (VIII). 2, $591^a6$–$592^a28$.

$675^a25$: 'nearly all of them fall into two differences'. For the phrase 'fall into two differences' as a way of referring to the results of a division cf. *PA* I. 3, $642^b18$, $643^a12$, $643^b14$. The order in which the blooded animals have been considered is again logical, but determined by context. The live-bearing animals are divided into those with and those without upper incisors. The latter group is considered first, followed by the birds and fish, both of which are also deficient in mastication in ways which affect their stomachs. Finally, the other side of the main division, animals with a full set of teeth, is taken up. The order of discussion is dictated by the fact that what determines the differences in the gut is how well prepared the food is by the mouth before it gets there; it is not determined by a fixed classification system.

675a31: 'the nature of the intestines'. Once again, the form of expression 'the nature of *X*' is used of a connected system of parts subserving a single goal (cf. II. 9, 654a32, and III. 1, 661a34, with notes). Notice that the object of discussion is referred to as 'this part' in the next sentence.

675a32–3: 'has many differences'. That is, the intestines are found differentiated in a variety of respects in different animals. The connectives in this passage suggest that the differences found among intestines are correlated with those found among stomachs. The broadest differentiation is into groups that have the intestinal system simple and all alike, and those in which there are variations throughout its length. The former group is hardly discussed, and the animals that have it this way are never named. (In *HA* II the intestines of some fish (508b9–13) and birds (509a16–17) are so described.) The latter group has the interesting variations, and is the focus in *PA*. Within this group, the primary differences are between 'the horn-bearers'—i.e. those with multiple stomachs—and all the others. There is no predetermined taxonomy here: the focus is on variations of the organ in question, so that those animals with similar intestines are grouped together.

675a33: 'when uncoiled'. Cf. *HA* II. 17, 509a17. This would appear to refer to an act of dissection, in which the intestines are laid out straight for examination.

675b5–22: 'In all those animals whose intestines are not straight'. These paragraphs are not specific to either the horn-bearers or their contrast class. They appear to describe portions of the large intestine. 'Blind' (675b7) is a literal rendering of the Greek, which is barely permissible because of a similar metaphor in English expressions like 'blind alley'. In establishing the reference of these various terms it would be helpful to know which animals Aristotle was using as his exemplars, but we are given no hint. Given the aim of this passage, the description has to be abstract enough to fit the entire class indifferently. A number of the details in this description indicate that Aristotle had examined the contents of the intestines at the various stages described. For example, his awareness that the residue in the large intestine is further dehydrated with respect to that in the small intestine is a vivid example of Aristotle following his recommendation to investigate even those things that cannot be looked upon without much disgust (I. 5, 645a28–30).

$675^b10$–11: 'called the rectum'. 'Rectum' actually translates *archos*, the Greek word for 'ruler' or 'leader'. It refers to the anus or rectum in a number of Hippocratic treatises as well; cf. *Aphorisms*, V. 58; *Epidemics*, V. 20. I have no explanation for this curious fact.

$675^b11$–13 'All these parts have been constructed by nature'. Here we have the plural used for the intestinal tract (cf. $675^a31$ note), but the point of this sentence is to stress that they all work 'as one' in serving a single function.

$675^b22$–3: 'more moderate regarding the production of nourishment'. Two types of digestive arrangement—a large lower stomach or a straight intestinal tract (cf. $675^a18$–24 on fish)—lead to different forms of gluttony. Either the animal must eat huge amounts all at one time or it must eat over and over again quickly. Both are to be contrasted with those animals with many coils in the intestinal tract, which eat in moderation. At *GA* I. 4, $717^a22$–30, Aristotle compares the moderation in eating habits resulting from coiled intestines to the moderation in reproductive behaviour resulting from the presence of testicles.

$675^b31$–$676^a5$: 'it is also necessary that there be some intermediate place in which it changes'. Contemporary anatomists distinguish three parts of the small intestine: duodenum, jejunum, and ileum. Most translators identify this 'intermediate' part as the jejunum. I have translated it, according to its literal meaning in Greek, as 'fasting-place'. Aristotle later notes its heightened visibility when the animal is 'fasting'; it may also, as Ogle (1882: 216 n. 36) suggests, have been so named by early anatomists because it is often empty when dissected.

The language describing its relation to the large intestine and to the upper region is similar to that of $674^a13$–19. It appears that our passage describes two three-part structures: the nourishment moves from the oesophagus, through the stomach, to the intestine; and the residue from the upper intestines, through the 'fasting-place', to the lower intestines. In each case Aristotle sees this arrangement as a way of separating the actual digestive activity from what precedes and follows it.

$676^a3$–5: 'In females . . . while the males'. Ogle (1912) claims 'This strange statement has no anatomical foundation.' ($676^a5$ n. 1; cf. 1882: 216 n. 36). Without knowing the animal models Aristotle was using, I am not prepared to be so bold. What is certainly true is, as we have seen so often, that we are provided with no evidence for this claim.

$676^a6$–18: 'what is called rennet'. See *HA* III. 20–1, $522^b2$–12. This term properly refers to milk taken from the stomachs of suckling ruminants, which is then used to curdle milk, or to a mixture of residue from fig juice and milk which has the same effect. Here Aristotle says nothing about the substance he is referring to being present only in sucklings.

*Historia Animalium* also wrongly identifies the hare as the only animal with both sets of front teeth that has rennet, and while it gives no reason for this, it does refer to the relevant fact about fig juice which is used to construct the explanation here. It is an extract from the lining of the *fourth* stomach of suckling ruminants that has this effect, not the third, as Aristotle claims.

$676^a18$: 'in the problems'. Works, generally taken to have been compiled later than Aristotle, have come down to us under the titles *Problems* and *Mechanica*, and collections of 'problems' are listed in the ancient lists of Aristotle's works; but the problem of why rennet is found in the third stomach of ruminants is not discussed in the works that have survived. These works *do*, as this tag-line suggests, state interesting facts and then offer tentative explanations for them.

# BOOK FOUR

## CHAPTER I

### $676^a23$–$^b16$

The purpose of the discussion down to $676^b16$ is not entirely clear. There is a persistent attempt to relate the snakes to the four-footed egg-layers and to the fish; but their lack of feet and possession of a lung makes it impossible to place them without qualification in either group. Do they then count as a distinct extensive kind? Aristotle never suggests this as an option. *HA* I. 6, $490^b23$–31, might suggest that the vipers (discussed below, $676^a36$–$^b3$) are the problem, since on account of them the snakes have two distinct modes of reproduction. But as is noted in our passage, this is equally true of the fish. Compare *HA* II. 17, $508^a8$–$508^b4$.

$676^a26$–36: 'all are very similar to the fish as well'. It is tempting to see this as referring to the footless nature of the snakes, and thus to see 'all' as meaning 'all the snakes'. But the reference to the bladder of the tortoise as exceptional shows that the reference is to the main subject of the first sentence, the viscera, stomach, and related parts of the four-footed, egg-laying animals. Cf. $676^b10$–15, below.

$676^a36$–$^b3$: 'The vipers'. These are differentiated from other snakes in the same way that the selachians are differentiated from other fish, by being ovo-viviparous. This implies that the same axis of division—here mode of reproduction—may be applied within different kinds, as well as to differentiate one kind from another. A distinct mode of reproduction does not, by itself, provide grounds for placing the selachia and the vipers in one group, distinct from the other fish and serpents. Thus it seems that this claim presupposes the 'multiple-difference' method of division argued for in *PA* I. 2–3.

$676^b6$–10: 'on account of the shape of their body'. Causal/mechanical priority is established for the shape of the body over the manner in which the viscera are configured; it is not clear, however, whether Aristotle thinks that this moulding process takes place during each animal's development, or is 'programmed' into the formal nature of the animal.

## CHAPTER 2

### $676^b16$–$677^b10$

The discussion of bile has special significance philosophically because it contains one of Aristotle's clearest statements that not every biological part calls for a teleological explanation. It is interesting for a number of other reasons as well: despite a long tradition among translators of hiding the fact, Aristotle marks no distinction between bile and gall bladder; further, bile is a residue produced regularly during the course of an animal's life that not only has no teleological explanation, but is actually harmful to the animals that have it; and finally this passage gives us insight into how Aristotle conceives of the relation between basic biology and medicine.

Aristotle's basic understanding of bile is remarkably accurate. He recognizes that it is a residue of blood—in fact bile pigment is a residue of spent red blood cells. He realizes that at least some bile is a secretion of the liver, and that a build-up of excessive bile in the liver is a sign of poor health. Moreover, he recognizes that this bile, once secreted, travels to the intestines. He fails to realize that it actually has a very important role to play in the digestion of fat. The irony here is that he was actually wrong to reject the need for a teleological account of bile.

$676^b16$: 'also have bile'. Despite the practice of previous translators, there is no distinction between 'bile' and 'gall-bladder' in the Greek, nor does Aristotle ever make any anatomical or physiological claims that require such a distinction. Following a suggestion of Katherine Nolan's, I have rendered *cholē* throughout as bile, and have found no difficulty in doing so. Still, Aristotle's failure to distinguish the organ from its fluid is puzzling. One possibility is that he viewed this residue as coming in more and less congealed forms, and that what we take as an organ he took to be a congealed form of bile.

$676^b22$–31: 'those who say the nature of the bile is for the sake of a certain sort of perception are mistaken'. The argument here may refer to an Academic theory (it is similar to a claim made at *Tim.* 71 D, but the subject here is plural), which ties bile teleologically to perception. Aristotle rejects this theory on two grounds: though all animals perceive, many animals lack bile; and the theory criticized presupposes that bile is always near the liver, and this is also false.

$676^b33$–$677^a5$: 'a dispute arose about the entire kind'. Even more devastating to a universal theory of bile, in a number of kinds of animals—Aristotle claims this is so with humans, sheep, goats, and mice—some members have bile and some do not. He mentions a number of differences in the amount of bile being correlated with the location of the members of kinds—Naxos was on the east coast of Sicily, Chalcis on the western Aegean island of Euboea.

$677^a5–11$: 'The circle of Anaxagoras'. Literally, 'those around Anaxagoras'. Again, their claims are rejected on the same grounds: they blame excess bile for diseases in animals that do not in fact have bile. The remark about dissections is difficult to interpret. The verb form could indicate a past or a present possibility, so that this might be a criticism of the Anaxagorians for not doing their homework, or it might be a remark about what Aristotle's audience would see, were they to observe 'the dissections'. In addition, 'the dissections' might be drawings of the results of dissections or actual dissections.

The final comment about the amount of bile associated with these diseases is unclear. Presumably the second criticism is restricted to diseased creatures with bile. But the incommensurability between the amount of bile present during the illness and the amount expelled is left entirely unexplained. Ogle (1882: 218; 1912: $677^a12$ n. 4) suggests that there is a comparison between the bilious staining of contiguous organs found upon dissection of dead animals and the amount presumed to be present during cases of jaundice, but there is no evidence in the passage for either side of this comparison.

$677^a16$: 'it is not on this account necessary to seek what something is for in every case'. While not the only passage in which Aristotle explicitly limits teleological enquiry (cf. *GA* V. 1, $778^a29–^b6$, for a similar argument), this is one of the clearest and most often cited. It is important to understand the passage in its context, however. Aristotle first rejects a teleological hypothesis regarding the existence of bile, and here concludes that it is (1) simply a residue of bodily activity, and (2) not for the sake of anything. Since Aristotle holds that some residues are 'used by nature for the sake of something', it cannot be directly inferred from the fact that it is a residue that it lacks a function (cf. Lennox 1985*b*).

*GA* V. 1 deals explicitly with the issue of when the search for a functional explanation is reasonable, and illuminates this discussion. There Aristotle argues that, for any kind *K*, if a part *p* is present for the sake of *K*, then *p* must be present in all the (normal) members of *K*. He also argues that if there is no consistent relation of *p* to other parts, there is reason to doubt whether it has a single organic function. Both conditions hold for bile; but the case against a teleological explanation for bile is even stronger, since it is harmful to life (see $677^a36–^b5$ note).

$677^a29$–35: 'So it is apparent that the bile is not for the sake of anything, but is a by-product.' Aristotle believes that a number of correlations support the conclusion that bile is not for the sake of anything. Bile is found in animals with less pure blood; those with the sweetest livers have no bile; and there is a correlation in livers between their bitterness and the presence of bile near them. It is thus concluded that bile is a by-product or residue of impure blood. This conclusion is further supported by a general correlation between longevity and absence of bile, noted even by certain 'ancients'.

$677^a36$–$^b7$: 'it is reasonable . . . in accord with our account'. An argument has been made that bile is a residue of impure blood, and this has an impact on the character of the liver. Aristotle then cites with approval those who have noted a correlation between the absence of bile and long life in certain animals, and adds some evidence of his own to strengthen this correlation. The view he now claims is reasonable is that the character of the liver is one causal factor in determining length of life. The claim that is 'in accord with our account' is less easy to determine, but it seems to be the claim that it is the bile that is the residue of the liver in particular that determines length of life. What account of Aristotle's is this in accord with? It would seem to be this:

(1) There are only two organs vital to the lives of all blooded animals, the heart and the liver. (Cf. III. 4, $666^a19$–$^b1$.)
(2) Bile cannot be found near the heart, because (cf. III. 4, $667^a33$–$^b13$) that would be immediately fatal.
(3) Bile is found near the liver, and we have just established as 'reasonable' the claim that the character of the liver is a determinate of length of life.
Therefore the residual bile from the liver is a clear indicator of length of life.

By referring to 'the residue of *this* visceral organ and none of the others', Aristotle is not implying that bile is only a residue of the liver, but that it is only this bile that is a reliable sign of length of life.

## CHAPTER 3

### $677^b14$–$678^a20$

The account of the omentum's development ($^b21$–9) depends directly on the earlier discussion of fat in *PA* II. 5, which in turn relies heavily on the 'biochemistry' of *Meteor.* IV. The explanatory language used hints at a lack of commitment to providing a full-blooded teleological explanation for it, and in this light it is interesting to contrast it with the explanation for the mesentery which immediately follows.

677$^b$14–16: 'hard fat . . . soft fat'. The omentum is the outer, membranous result of the heating of a dry/moist mixture, its fatty character being due to the fatty nature of the bloody nutrient from which it is formed. The dense membrane through which fatty material (being thin) emerges must be the stomach wall, rather than the omentum itself.

677$^b$20: 'in both land-dwelling and water-dwelling blooded animals'. As Ogle notes (1882: 219 n. 2; 1912: 677$^b$22 n. 2), among Aristotle's blooded groups, only live-bearing two-footed and four-footed animals have an omentum.

677$^b$21–9: 'The generation of this part occurs of necessity'. In the discussion of the omentum, Aristotle asserts that its *generation is by necessity* while nature *makes use of it for something*. This is importantly different from his more typical assertion that a part comes to be and is both *by necessity* and *for the sake of something*. Further, Aristotle does not say that nature uses the omentum for the sake of (*heneka*) nutrition, but for (*pros*) nutrition. The latter preposition does overlap in meaning with the former in ordinary Greek, but in every case where Aristotle discusses teleology philosophically, it is the former term that is nominalized as one of four kinds of cause. The use of *pros* suggests a weaker form of teleology, as Kullmann (1985) 173–4 notes.

How might Aristotle distinguish these two sorts of cases? He could do so by focusing on the way the part develops, on the manner of its functioning, and on whether or not it is a functional necessity for the animal. In this light, it is significant that the account of the omentum's role in food preparation is mechanical in the extreme: being fat, it is hot, and heat aids in digestion. Its function is served simply by dint of its material nature. Furthermore, as a mere aid to digestion it does not seem even to be *conditionally* necessary. Contrast the mesentery, on all counts.

There is a parallel distinction within evolutionary biology today. A trait that is present within a population owing to past and continued selection for the genes for that trait can be given complementary selection and biochemical explanations for its presence. But the presence of a new trait that arises by a genetic mutation can only be given a biochemical/developmental explanation for its presence, though rarely one might observe that 'by chance' such a trait confers an advantage on its possessor. In this case, it is appropriate to say that the trait makes the animal better adapted, but inappropriate to say that the trait is an adaptation (since the latter phrase is reserved for traits that are present owing to selection). For Aristotle, the issue would have to be whether the animal's formal nature *directed* a part's formation for an end or not—if not, it might still be *used* by the animal's nature towards an end though it did not come to be for the sake of that end.

$677^b30$–4: 'the omentum is hot'. Again the argument is transparently syllogistic:

> That which is hot is able to concoct.
> Fat is hot.
> Fat is able to concoct.
> The omentum is fat.
> The omentum is able to concoct.

As is so often the case, however, in order to draw the conclusion Aristotle draws—that the omentum is used to aid in concoction—one needs to assume that nature does what is best, given the possibilities.

$678^a3$–5: '⟨the mesentery's⟩ generation is . . . of necessity; and owing to what cause it is present'. The mesentery is not said merely to be *used* by nature, but to be *present* ('exist'), for the sake of something ($678^a15$–16), though its *generation* is from necessity.

$678^a9$–15: 'there needs to be something through which the nutrient will proceed, as if through roots'. There is an extended analogy with plants here—stomach : earth :: mesentery : roots (cf. II. 3, $650^a20$–7). On this model the mesentery is necessary in order to transport nutrient in its final form (blood or its analogue) to the blood vessels, for which it is precisely suited in its structure and its connection to the intestines on one side and to the major vessels on the other. Here the necessity constantly stressed is quite clearly conditional necessity—nutrients must be ingested, these must be converted to final nutrient, and this must be transported to the blood vessels, if the organism is to survive.

$678^a19$–20: 'the works on generation and on nutrition'. Compare *PA* III. 14, $674^a20$–1. For various other apparent references to a work on nutrition by Aristotle, see Bonitz (1870) $104^b16$–28.

## $678^a21$–$685^b27$

From here to $685^b27$, Aristotle turns to the bloodless animals, noting (as he does also in *HA* IV. 1, $523^b1$–17) that the internal/external distinction is less clear in them, and that they lack viscera entirely (cf. $678^a29$–31, $^a34$–$^b6$). Since, with the exception of the head and neck, Aristotle has not yet discussed the external parts of the blooded animals, beginning the discussion of the bloodless animals here forces him to return to the blooded ones at 685$^b$28. And as noted earlier (665$^a$27–665$^b$9 note), Aristotle never explains why, after the discussion of the head and its external parts concludes in III. 2, he proceeds to the *innards* of blooded animals in III. 3–IV. 4, rather than to the remaining external parts. The order of these sections lacks any justification, and could well be the work of a later editor. In a later note I shall give reasons for supposing that the material from 685$^b$28 on is organized according to a somewhat different plan from the earlier discussion.

The chapters dealing with the bloodless animals are entirely devoid of Aristotle's usual language of teleology—where one would expect *heneka* or *charin* Aristotle uses other prepositions in ways that encourage their translation with a teleological nuance (*pros*, *eis*, *dia*). The rare, apparent exceptions will be discussed in the notes. Though I have no plausible explanation for this, it may be worth noting that a number of the bloodless animals, including all the hard-shelled, were thought by Aristotle to be spontaneously generated (see 640$^a$27–30 and note). The model of teleological causation defended in *PA* I. 1 does not, at least not obviously, apply to such organisms.

## CHAPTER 5

678$^a$28–9: 'the nature of the viscera'. On this form of expression, cf. 654$^a$32 note, and compare 659$^b$20, 28, 661$^a$34. The viscera's dependence on blood is argued at 647$^a$34–$^b$9.

678$^a$32: 'For none of these animals has blood'. The discussion begins by noting that the bloodless animals have no viscera, which is initially argued to be a consequence of their lack of blood. *PA* I. 2, 642$^b$15–16, says that the blooded and the bloodless are unnamed; and *PA* I. 4, 644$^b$1–15, says that the groups of bloodless animals identified here are also not 'named kinds', which probably means that there is no commonly used name that covers the entire extension of any of his groups. The names adopted by Aristotle for them here are nominalized adjectival constructions that refer to some obvious feature of their physical appearance. They do, however, meet I. 4's criteria for constituting a kind, of having one nature and embracing forms whose parts vary only in degree.

The bloodless kinds are: the soft-bodied animals (extensionally equivalent to our group cephalopoda; literally, 'the softies'), the soft-shelled animals (i.e. crustacea, literally 'the soft earthenwares'), the hard-shelled animals (i.e. testacean molluscs, literally 'the earthenware-skinned'), and the insects (i.e. insecta, literally 'the insected').

$678^a32$, 34: 'constitutive of their being . . . in the account defining their substantial being'. At least three distinct claims are made here.

(1) Since the visceral nature is composed of blood, and no bloodless animal has blood, they cannot possess viscera.
(2) No bloodless animal has blood, because being bloodless is an aspect of the substantial being of bloodless animals.
(3) The defining account of the substantial being of blooded and bloodless animals will include mention of the fact that one is blooded and the other is bloodless.

All three claims are problematic:

(1) The first argument has an air of a priorism to it, but this can be dispelled. Internal organs are certain sorts of materials shaped in characteristic ways for various functions. Aristotle first reminds us that the material nature of viscera is 'bloody' (cf. $647^a35$–$^b1$); and then goes on to note that the various functions for which viscera are present in blooded animals are also absent in bloodless animals (see below).

(2) I am supposing that 'some such affection' here refers to being bloodless. This supposition is suggested by the Greek and supported by point (3) below. At any rate, metaphysical puzzles about whether privative characteristics can be definitive are made explicit in (3), so that stretching for a less natural reading merely puts off the inevitable.

(3) Can Aristotle seriously maintain that a privative characteristic is part of the defining account of the being of a certain class of organisms? Do bloodless animals constitute a class defined by this privative characteristic, or is that simply an illusion fostered by the appearance of the word?

A central criticism of dichotomous division articulated in *PA* I. 2–3 was its inability to deal with the appearance of privative differences. Aristotle claimed that one virtue of the multiple-difference method is that it permits the use of privations in division. So Aristotle has nothing in principle against privations being part of the defining being of something. Indeed, 'the blooded' and 'the bloodless' are said to refer to unnamed groups (I. 2, $642^b16$), and distributing animals into bloodless groups is used as an example of the problems faced by dichotomy.

But a privative predicate may appear in a definition only if the group possesses a number of other positive differences that can be traced down through the various groups, in this case the bloodless kinds of animals. And here we get into difficulty. Aristotle tends to restrict the process of characterizing kinds by many general differences to his 'extensive kinds'—in this case, the four mentioned here at the outset, corresponding to our cephalopods, crustaceans, testaceans, and insects. It is doubtful whether Aristotle recognizes kinds above this level that meet the standards for a kind set out in *PA* I. 4—a common nature, with numerous forms varying by more and less. Certainly the class of bloodless animals does not meet these standards. This suggests that blooded/bloodless is not a division of kinds, but of attributes only; and in fact Aristotle says only that some animals will have 'bloodless', others 'blooded', in their definition. It is important, then, to recall that bloodless animals have an analogue of blood: there is a nutritive fluid in all animals.

The most plausible view of this claim, and one consistent with what is said in *PA* I, is that certain animals, specifically, those within the groups mentioned here, are bloodless; but this privative *term* does not signal a mere absence of blood. Rather, it signals the presence of an unnamed ($678^a8$) blood analogue. This cannot, clearly, be a *differentiating* feature of any of these kinds, since it is common to all of them (cf. $643^a1–5$); but it *can* serve to distinguish any of them from any of the blooded kinds. And it *is* explanatorily fundamental, in the sense that it is at the root of many of the differences between the blooded and bloodless kinds, which involve the absence in the latter of something present in the former. Nevertheless, that many explanations actually rest on a *privation* (absence of blood) may account for Aristotle's unusual claim that this defining feature is an *affection* of their being.

$678^a35–^b1$: 'none of those things for the sake of which the blooded animals have the viscera'. The heart is the source of the blood vessels ($665^b12–17$); the kidneys are present for the sake of aiding the bladder ($670^a22–3$, $671^b15–28$); the lung is for the sake of cooling blood; and all the viscera below the diaphragm are 'for the sake of the blood vessels' ($670^a8–19$). The bloodless creatures thus lack *both* the material cause and the final cause of viscera.

$678^b1–4$: 'for them it is only necessary to have the analogue to the heart'. The heart analogue is necessary because even bloodless animals perceive and move. It is not claimed to be the source of a system analogous to the blood vessels. Aristotle's attempt to locate and describe it runs from $681^b12$ to $682^a8$. Note that while Aristotle notes the absence of blood vessels, bladder, and breathing, he has *not* said why the bloodless animals need no *analogue* to these parts.

$678^b4–6$: 'have the parts for nutrition of necessity'. Since nutrition is a function common to all living things, nutritive parts must belong to all bloodless animals. Most of the discussion, however, will focus on the differences in the ways they feed, and Aristotle then quickly introduces the key idea that different ways of feeding are associated with different ways of life (cf. *HA* VII (VIII). 2, $589^a10–591^a6$). Differences in the nutritive structures of the bloodless kinds are discussed at 678b6–681b12, while 681b12–682a8 discusses those in the 'heart analogue'.

678b6–26: 'two teeth . . . in place of a tongue they have something fleshy'. On the biological details Ogle (1882: 220) is still valuable. The discussion of the internal parts of the soft-bodied animals should be compared with *HA* IV. 1, 524b1–525a30; certain passages are what Balme refers to as 'doublets' of those in *PA*—passages identical in phrasing and even some incidental details of syntax. There are, however, subtle disagreements in the two accounts, and *Historia Animalium* provides information not found in *PA*.

It is puzzling that the fleshy organ of taste discrimination is viewed as an *analogue* to the tongue, while the 'teeth' are straightforwardly treated as teeth. Yet the 'teeth' in the invertebrates are no more like teeth in vertebrates than are their 'tongues'. This may be because the teeth were so designated, while the fleshy organ of taste was not referred to as a tongue.

Methodologically, the discussion of these parts is organized as before: the most widely shared parts are taken up first. Where there are comparisons to be made between kinds, they are made without hesitation.

678b22: 'as we also stated in our initial accounts'. Cf. 682a2 and note. Peck and Ogle cite *HA* IV. 4, 528b30 ff., as the obvious reference; but this structure is discussed in detail at *PA* III. 2, 661a20–4, and typically the references to *Historia Animalium* are by name, so there is no reason to prefer it. A complete list of such references is given in Düring (1943) 14–15.

678b23–6: 'a long gullet . . . a crop . . . a stomach, and following it a simple intestine extending to the anus'. More detail regarding the differences between the cuttlefish and octopus on the one hand, and the squid on the other, are provided in *HA* IV. 1—the explanation for the difference is vague.

679a1–30: 'For protection and self-preservation these animals have what is called the "ink"'. The general explanation comes at the end of the passage, a25–30: the expulsion of ink is an automatic fear response, which the animal's nature makes use of as a protective device. Again we see an 'indirect' teleology, in which a mechanically necessitated residue is *turned to a use*, rather than being a part which developed *for the sake of a use* (cf. 677b21–9 note).

The ink belongs to all and only the soft-bodied animals but is differentiated in the different subkinds, and most of the passage is focused on these differences, and their explanation. The cuttlefish have more of it, differently located, than the other two kinds both because they live nearer to shore (and thus are more susceptible to predation?) and are otherwise defenceless, and because they are more earthen (witness the nature of their skeletal part), ink being an earthen residue.

679$^a$23–4: 'Owing to what cause some have it while some do not, and what sort each of them has, has been said.' This refers to the discussion of these structures in *PA* II. 8, 654$^a$12–26. Aristotle can refer in this manner well back in a treatise (or even to another treatise) without a temporal adverb (compare the various references at 668$^b$9, 669$^a$4, $^a$19, 671$^a$35, 671$^b$26, 672$^a$12, 672$^b$8, $^b$13, 673$^a$33).

679$^a$30–$^b$2. 'The soft-shelled animals too'. The discussion of their internal parts is extremely brief; their external parts are discussed somewhat more fully in IV. 8.

679$^a$32–7: 'two primary teeth . . . another set of teeth'. While the precise references, both to groups and parts, are inevitably difficult to establish, the general claim is accurate. 'Crayfish, for example, have three large gastric teeth which meet medially and are manipulated by a complex set of muscles' (Meglitsch 1972: 583). Though Aristotle mentions a 'crop-like' structure in soft-bodied animals and again in the hard-shelled animals (679$^b$9), he apparently failed to recognize a similar structure in the foregut of the soft-shelled animals.

## 679$^b$2–681$^b$12

This subsection focuses primarily on the nutritive system of the hard-shelled animals. Four philosophically interesting claims about kinds are made here: there are many kinds and forms of hard-shelled animals (679$^b$15); certain groups are 'outside the divided kinds': some of these 'tend towards animals in certain respects and plants in others' (681$^b$1–2); and finally, there are many kinds of sea urchins, a statement defended on the ground that there is no single form shared by all of them (680$^a$15). Each of these claims will be discussed in its context.

No comprehensive notes on comparative anatomy will be attempted. Again, the notes in Ogle (1882) are sometimes useful, though often over-confident both about the class of animal and about the anatomical feature being discussed. For those wishing to work on these sorts of problems, a good text on invertebrate zoology such as Meglitsch (1972) is indispensable. Roughly speaking, Aristotle's 'trumpet-shells' and 'univalves' would today be classified as different orders of gastropod molluscs (limpets begin development with a spiral shell which gradually deteriorates); the 'bivalves' as pelecypod molluscs; ascidians as a class of chordates; and sea urchins (as well as starfish) as echinoderms (after their designation in Greek).

679b6, 8: 'hard, sharp teeth, as was said previously . . . They also have, as was said, a proboscis'. 678b11, 23–4, and 661a15, respectively.

679b10–11: 'the *mēkōn* as it is called'. Commentators usually assume that this term refers to the invertebrate liver. Peck identifies it with the *mutis* of the soft-bodied animals discussed at 679a9, but gives no reason for doing so. Aristotle, at any rate, would have no reason to suspect a liver in these animals, given his view of the liver's function. He treats it rather as a digestive residue. Since there is no modern equivalent, I have followed the standard practice of transliterating the Greek.

679b15: 'many kinds and forms of hard-shelled animals'. This is a good example of the level-neutral semantics of Aristotle's terms 'kind' (*genos*) and 'form' (*eidos*) discussed in the notes to *PA* I. 2–5. At 678a30 the hard-shelled animals themselves were said to constitute a single kind (*genos*) with five forms. Here it is said that there are many kinds (*genē*) of hard-shelled animals. These claims are consistent if all that it takes for a group of animals to be a kind is for it to be differentiable into a number of similar subkinds, or 'forms'. In that case, the hard-shelled animals will be a kind that embraces the trumpet-shells and the bivalves; and the trumpet-shells will be one of many hard-shelled kinds embracing the various trumpet-shelled forms. (For another example see 680a15 note. In general, see Pellegrin 1986: 83–107; and on this passage, 102.)

679b31–2: 'The nature of the soft- and hard-shelled animals has been constituted'. Most previous uses of the verb 'to be constituted' refer to animals or parts being constituted from something (cf. Bodson 1990: 226–7), not to their *natures*. However, see 'blood, out of which the nature of the viscera is constituted', 678a31; the same point is made at 665b6, 668a13 by simply saying 'the viscera'. The reference may be to the material nature in both cases—the difference consists in whether the hard material is on the inside or the outside.

679b35: 'as was said'. Cf. 679b2–5.

679b37: 'each part differs in position and size'. One criterion that Aristotle consistently uses to identify different animals as a single kind is whether there is a significant number of organs shared by them all, but differentiated in position, size, or 'perceptual affections' (e.g. colour, texture, taste, shape). Cf. *HA* II. 15, $506^a1$–8.

$680^a1$–3: 'studied with the help of the enquiries about animals and of the dissections. For some of these things need to be clarified by an account, others rather by visual inspection.' Peck (n. b) takes this latter remark to suggest that 'diagrams or illustrations accompanied the treatises', following Ogle (1882: 223 n. 34). To be more precise, this remark suggests a work like our *Historia Animalium* providing further *discussion* and 'the dissections' providing *visual aids*. But it is entirely possible that we are being directed, not to illustrations, but to actual dissections. One passage in *Historia Animalium* suggests that it had its own illustrations (cf. *HA* III. 1, $510^a29$–35, with Peck's or Thompson's attempted reconstructions—Peck 1965: 236, Thompson 1910: 510b). Just previously, however, at $509^b22$–3, readers are referred to 'the dissections', and throughout the rest of *Generation of Animals*, *PA*, *De Incessu Animalium*, and *Historia Animalium* the references indicate that there are two distinct 'works' to be consulted with respect to the same fact.

$680^a4$–15: 'The sea urchins'. On this passage and the corresponding discussion in *HA* IV, including contemporary anatomical illustrations, cf. Lennox (1983) 147–51.

$680^a14$: 'certain dark masses which have no name'. Discussed more extensively in *HA* IV. 4, $529^a22$, $530^a34$, $^b13$, $^b31$.

$680^a15$: 'Though there are several kinds (for there is not one form of all sea urchins), all of them have these parts'. Aristotle occasionally refers to the sea urchins as a single kind (e.g. $683^b14$), based on the fact that they all have certain (generic) parts. However, those parts are differentiated 'by the more and less' (i.e. they vary significantly in their sensible affections), and these differences give rise to different kinds of sea urchin. Much confusion about this passage has been engendered by translating *genos* as 'genus' and *eidos* as 'species' (cf. Pellegrin 1986: 104, 195 n. 45). If we translate *genos* as 'kind' and *eidos* as 'form', the point here is clear. If there were but one, undifferentiated form, then there would only be a single kind of sea urchin. But there are various differentiated forms of sea urchin and each group of individuals alike in form is a distinct kind of sea urchin. Aristotle does not mention any significant *functional* differences between the various forms. For details on the several kinds, cf. *HA* IV. 5, $530^a32$–$531^a7$.

$680^a25$: 'the "egg", as it is called'. It is commonly assumed that the reference is to the gonadal bodies (cf. Ogle 1882: 224 n. 39). On Aristotle's views about their seasonal variations and lunar waxing and waning, compare *HA* VI. 12, $544^a16$–24; and on the sea urchins in the Strait of Pyrrha in particular, $544^a21$. The migratory patterns of the Strait of Pyrrha's fish are discussed at *HA* VI. 15, $548^a9$, and VIII (IX). 37, $621^b9$–15.

$680^b3$: 'All the sea urchins have both an equal—and odd—number of eggs'. The long, poorly organized argument down to $681^a1$ aims to show that the fivefold character of these various structures is necessitated by the sea urchin's nature.

The argument proceeds in stages. First the sea urchin must have this material, since it is common to all hard-shelled animals. From the fact that all other such animals have these 'eggs' in a discontinuous manner, Aristotle concludes that the sea urchin must have a number of these 'eggs'. From the fact that the sea urchin, unlike other members of its class, is spherical, combined with the requirements that the distribution of objects on a sphere must be balanced, and that the distribution of these 'eggs' in sea urchins should not violate their general manner of distribution in hard-shelled animals, it is concluded that the number of 'eggs' must be odd.

So then, the number must be three, five, or some odd number greater than five. Now it looks as if the necessity that there be five is deduced from the premisses that three would be too far apart and more than five would, *contra* the first conclusion, lead to continuity of the 'eggs'. But when one asks *why* three eggs would be 'too distant' and more than five continuous, there is no immediate answer. In a body divided into five segments, however, three would leave segments without any 'egg' (which is not good, $^b25$) and more than five would require more than one per segment, which Aristotle might plausibly think of as producing continuity (which is not possible, $^b26$). From $680^b28$–36 the pentamerous structure of the 'eggs', teeth, and stomach is made to follow directly from the pentamerous character of the animal. But it is likely that Aristotle feels licensed to make such an argument only because the previous argument has ruled out continuous organs throughout the segments and segments without organs.

$681^a8$: 'for they use their spines for feet'. Cf. *HA* IV. 5, $530^b15$–17. These two passages constitute a good example of what David Balme means by 'doublet' passages in *PA* and *Historia Animalium*. *PA* gives an explanation for the evidence, and by doing so also makes the claim a little clearer.

### $681^a9$–$681^b12$

This subsection should be compared with *HA* VII (VIII). 1, $588^b4$–$589^a1$ (and Balme 1991: 60–72 nn.), which contains a number of exact doublets of lines which occur here. These two passages are often cited, out of context, as the source for the *scala naturae* concepts found in later naturalists such as Buffon and Linnaeus. They stress that, while certain attributes (living attached to another object, lacking residue, locomotion, or perception) are characteristic of plants, and others (perception, locomotion, predation, expelling residue) are characteristic of animals, these characteristics differ in degree. Certain animals will have the distinguishing features of animals to a minimal extent, or behave like plants in certain respects. The fact that the defining characteristics of plants and animals vary in degree leads to a continuum from lifeless objects, to plants, to animals, rather than to sharply discontinuous classes. Thus Aristotle's stress is *not* on the idea of a hierarchy or scale in nature, but on the difficulty of determining the status of borderline creatures. (For a detailed discussion of this passage and its focus on the problem of such borderlines, see Lloyd 1996: 73–82.)

681$^{a}$10, $^{a}$15–17: 'the sponges'. This agrees with *HA* VII (VIII). 1, 588$^{b}$21, but appears to disagree with 487$^{b}$9, 548$^{b}$10, 549$^{a}$8 (see Balme 1991: 23, 64 n. b; 1987*a*: 15; Lennox 1996*a*: 239; Lloyd 1996: 75–6). These last three passages discuss the sponge's ability to perceive, while our passage (and its companion) are focused on its inability to survive when detached—but nevertheless, our passage says that sponges are plant-like *in every respect*, and makes no mention of their ability to perceive though it is clearly relevant, since it is precisely this that qualifies the attached ascidians as animals (681$^{a}$25–8).

On the other hand, why say that sponges are plant-*like*, and not *plants*? This passage seems to imply that sponges are sufficiently like ascidians for there to be some doubt as to whether they are plants or animals. 'Potentiality of a plant' refers, I take it, to 'second potentialities', i.e. the soul capacities of plants—nutritive and reproductive, but not perceptive and locomotive.

But continuity is further produced because not all bloodless animals are both perceptive *and* locomotive. Holothurians and 'lungs' (called sea cucumbers since Pliny) are said to lack perception but to be 'detached' creatures (681$^{a}$17–18). Sponges are attached and do not perceive; and ascidians are attached and perceive. Aristotle also mentions a plant which, though it cannot perceive, can live detached for some time—that is, it is like the holothurians and lungs, though they are animals and it is a plant (Lloyd 1996: 77–80).

681$^{b}$1–2: 'fall outside the divided kinds'. There is a somewhat richer discussion of anemones at *HA* IV. 6, 531$^{a}$32–531$^{b}$18. The phrase 'outside the divided kinds' is ambiguous between 'outside the kinds to be divided' and 'outside the kinds created by division'. The syntax suggests the former.

There are two distinct points made in the passage. Being outside the divided kinds is intended to explicate the fact that the anemones are not among the hard-shelled animals, which is one of Aristotle's bloodless extensive kinds. The rest of the passage focuses on the second point made here—that anemones are in their nature both animal- and plant-like (see next note).

That they fall outside these kinds does not prevent Aristotle from referring to them as a kind (cf. 'the kind consisting of anemones', *HA* IV. 6, 531a31)—but he never subjects the kind to division, which is consistent with what is said here.

681b1–2: 'tend in their nature towards both plant and animal'. I follow Balme's suggestions (cf. 1991: 60–1 n. a) for translating *epamphoterizein* as 'to tend towards both', rather than Peck's popular 'to dualize', adopted by Lloyd (1996: 74). With such animals, Aristotle's typical practice is not to claim that they belong to both kinds, but to claim, as he does here, that they are distinctive, but tend towards one kind—here animal—in some respects and towards another kind—here plant—in other respects.

A number of features are noted in virtue of which they are like animals, and a number in virtue of which they are like plants.

681b8–9: 'the starfish kind'. There is a claim here that starfish are, in their mode of feeding, like anemones. But the reference to *other* soft-bodied, soft-shelled animals is unclear.

### 681b12–682a30

Aristotle now returns to the four extensive kinds, and in particular to the question of the heart analogue in bloodless animals, as the origin of the perceptual capacity.

681b12: 'the same account holds for the hard-shelled animals as well'. It is not entirely clear to which account Aristotle is referring. The most general possibility is the account of being animal-like in certain respects, plant-like in others. But since that discussion began with the ascidians, and these *are* hard-shelled animals, this remark would be superfluous. The narrowest construal is 'the account of the likenesses among starfish'. This is plausible, given the many ways in which starfish *are* like sea urchins.

681b14–16: 'there is a need to have some part analogous to those present in the blooded animals to govern the modes of perception; for this part must be present in all animals'. Nutritional parts are necessary for all *organisms* and were discussed first; perceptual parts are a requirement of all *animals*. But Aristotle is currently explaining the *internal* parts, and thus the discussion is not of the sense-organs *per se*, but of the internal part which plays the perceptual role analogous to the heart in blooded animals—which he here refers to as 'the authority over the senses'. The part Aristotle has in mind in the case of the soft-bodied animals is pretty certainly the part today identified as their liver; the similarly named part in the crustacea is harder to identify. The crustacea that Aristotle refers to have an extremely short oesophagus and a two-chambered stomach, with the heart lying above the first chamber—it is thus just possible that what he refers to as the *mutis* in this case is the cardiac region. The rest of the anatomy in this paragraph is restricted to the soft-bodied animals, as the reference to the ink near the intestine makes clear.

$681^b28$: 'the analogue of the heart'. Aristotle's argument for the *mutis* being the heart's analogue rests primarily on its location. The second piece of evidence, the sweetness of its fluid, could have led him to identify it as a liver analogue (cf. $677^a21–5$ on the sweetness of the liver). Aristotle's theory of animal functions, however, dictates that bloodless animals have a heart analogue, not a liver analogue.

The instructions regarding where to look for the origin of animal functions rest on fundamental theoretical premisses defended at *PA* III. 4, $665^b17–27$. But some bloodless animals are sessile; and since the right/left distinction is based on the origination and direction of motion, their midpoint can be established only by reference to the 'top/bottom' dimension—and in Aristotle's functional account of dimensionality, top = point of nutritional ingestion and bottom = location of residual expulsion (cf. *IA* 4, and the note, with references, to $656^a13$).

At $682^a1–4$ Aristotle extends this to accommodate the intermediate 'thorax' segment of insect bodies.

$682^a2–3$: 'as stated in the initial accounts'. Cf. the almost identical phrasing at $678^b22$ (and Düring 1943: 14–15, discussed at $678^b22$ note). There is in this case no earlier reference in *PA*, while there are parallel discussions in *Historia Animalium* (in this case IV. 7, $531^b26–532^a5$). Michael of Ephesus, Peck, Ogle, and Düring all take this to be the reference. However, we have seen that references to *Historia Animalium* are usually by name. Bonitz (1870: $103^b36$, 40) suggests *Juv.* 2, $468^a21–^b16$, or *Resp.* 8 (=*Juv.* 14), $474^b1$. Both of these passages are in content preferable (especially the latter), though without giving a reason Düring rejects these suggestions out of hand.

$682^a7–8$: 'only one in actuality, but in potentiality more than one'. A number of texts throughout the corpus make related claims about the *souls* of these insects:

(1) *An.* I. 5, $411^b19$–22, says that the souls of the parts after division are one in form though not in number.
(2) *An.* II. 2, $413^b17$–20, cites living when divided as evidence that their souls are 'one in complete actuality, but potentially more than one'.
(3) *Long.* 6, $467^a19$–23, while conceding that each section has a source, notes that, unlike plants, this source cannot regenerate the organs necessary to live for a long time.
(4) *Juv.* 2, $468^a25$–$^b5$, says that the source of their nutritive soul, and then the nutritive and perceptive soul itself ($468^b2$–5), is actually one but potentially many.
(5) *Met.* *Z* 16, $1040^b10$–14, has an enigmatic reference to animals living when divided in a discussion of the unity of the parts of living things.

These passages are consistent, but each makes a different claim. What is clear is that the heart or its analogue is viewed as a crucial centre of all the basic potentialities of the soul. There is no reason to argue, as Nuyens (1948) did, that this shows Aristotle's theory of the soul at an early stage of development. However 'dispositional' his theory of the soul is, the heart or its analogue is critical to those dispositions, such that if there are organisms that can be sectioned and the segments separated from the 'origin' continue to react to stimuli and move in place, they must, after division, have an origin. Note that one of the key passages on this subject comes in the midst of the discussion Nuyens takes to be most sophisticated, *An.* II. Thus to defend this view he is forced to dissect treatises into layers, the usual result of trying to defend such chronologies.

$682^a10$: 'the sting, as it is called'. Aristotle's discussion is at so high a level of generality that it is hard to identify the referents. In a number of insect families there are outer, teeth-like mandibles, and behind these a sucking tube formed as an extension of the pharynx. There is slightly more detail provided at $678^b13$–21, where the ants are identified with the second group mentioned here.

$682^a26$–7: 'the ephemeral animals (these arise around the Pontus)'. The Black Sea by Aristotle's time was routinely referred to simply as 'the Pontus' (i.e. 'the Sea'), as was the region on its south-eastern shore. The so-called 'dayfly' is presumably the referent. David Balme claimed that the reference to it at *HA* I. 5, $490^a26$, 'defeats the theory of both *IA* and *PA* that all bloodless animals must have more than four feet' (Balme 1987*a*: 15; Lennox 1996*a*: 239–40). The reference here does not help to resolve the question of potential conflict between *Historia Animalium* and *PA* on this issue, however, since limbs are not discussed.

### 682a30–685b28

This passage accurately reflects the structure of *PA* II. 10–IV. 14. Up to this point the basic structure of the discussion is the following:

(1) II. 3–10: uniform parts of blooded and bloodless animals;
(2) II. 10–III. 3: external parts of head of blooded animals;
(3) III. 3–IV. 4: all internal parts of blooded animals;
(4) IV. 5: all internal parts of bloodless animals.

And the remainder of *PA* IV is, in a general way, as promised here:

(5) IV. 6–10: all external parts of bloodless animals;
(6) IV. 10–14: the rest of the external parts of blooded animals.

What this overview *fails* to do is to provide an explanation for this structure. In particular, no rationale is provided for the transition from external to internal organs at III. 3, or for placing the discussion of the bloodless animals in the middle of the discussion of the blooded.

## CHAPTER 6

682a35: 'The insected animals do not consist of a large number of parts'. Compare 683b25 on the hard-shelled animals. The point seems to be that while there will not be a large number of different sorts of parts to discuss, there is considerable differentiation of the parts that there are.

682a36–7: 'all are many-footed'. The fact that insects have more than four legs—Aristotle counts limbs 'none, two, four, many' (cf. *IA* 1, 704a13)—is accounted for as a means of making up for a sluggish tendency due to their coldness. Hence the longer ones, being colder, have the most feet. These are also the highly segmented insects with many 'origins' which can live when divided—but Aristotle never gives explanatory priority to either coldness or multiple origins, and their large number of feet seems to be explained on both grounds.

682b4: 'on account of having many origins'. This remark should probably be taken to be restricted to the very long 'insected animals' with the most feet, just referred to, since the next sentence, marked by a particle of balanced contrast, discusses those with *fewer* feet. In these (but clearly not in most other insects) it is Aristotle's view that the segments correspond to the number of origins, and that the number of legs corresponds to the number of segments.

682$^b$6–17: 'and those flyers'. The discussion of the external parts of insects focuses primarily on three parts: wings, feet, stings. The Greek word translated 'foot' (*pous*) can also refer to the entire leg with the foot, and even to the appendages of the octopus. There is a broad division among insects into many and few (six) feet, six feet being correlated with wings. There is then a broad division of wing type by number (4, 2), the four-winged group being further divided into those with sheaths and without them. Other correlations are brought in to explain the differences: for example, some four-winged insects have sheaths for their wings *because* they are sedentary and thus their wings are easily destroyed (682$^b$12–17). Note again the absence of Aristotle's usual teleological language throughout these explanations: sedentary, winged insects have sheaths *so that* the capacity of the wings may be preserved—but the sheaths are not said to be present *for the sake of* preserving the wings.

682$^b$7, $^b$12: 'those . . . whose way of life is nomadic . . . lead sedentary lives'. Cf. *PA* II. 16, 659$^a$2; III. 1, 662$^b$5, and notes. The Greek term *bios* refers to an organism's way of life, not to the fact that it is alive. The determinants of way of life that Aristotle typically stresses are the nature of the environment, where the animal spends most of its time, and its feeding habits. It is one of the four basic forms of difference in the *Historia Animalium* (cf. *HA* I. 1, 487$^a$11–488$^b$11), though in practice Aristotle tends to discuss differences in activity and way of life together (cf. *HA* VII (VIII). 1, 588$^a$16–17, 588$^b$23–4, 589$^a$2–5).

682$^b$17: 'Their wing [*to pteron*] . . . is not a feather [*pteron*]'. The same Greek word can be used to refer to feathers and to wings, which creates inevitable problems for translation. Peck translates 'An insect's wing is not divided, and it has no shaft. In fact, it is not a wing at all'. Rather than have Aristotle say 'a wing is not a wing', it seems preferable to suppose that the reference shifts. What lends plausibility to this suggestion is that the negative claims made here about the insect wing point out its differences from a feather, which are then explicated by saying it is not a feather but a skin-like membrane. The contrast with a membrane also supports the idea of a shift in reference, since Aristotle contrasts feathered wings with membranous wings in a number of texts (cf. *HA* I. 5, 490$^a$5–10).

682$^b$27–32: 'having many origins is present in their substantial being'. Cf. 682$^a$7 and note for other references to this doctrine. As at 682$^b$2–5, this claim appears to be restricted to the long, multi-segmented insects, though Aristotle is never entirely clear on the extension, within the insects, of the ability to live when divided. Here this is especially important, since he is claiming that having (potentially) many origins is a defining feature of the group under consideration. The kinship to plants is here given the same restriction made at *Long.* 6, $467^a19$–23 (see $682^a7$ note).

$683^a16$: 'just barely able to strike by means of things in front'. Assuming that the Greek term *molis* here means 'scarcely', Ogle, followed by Thurot, suggested altering the text to say 'to the rear' rather than 'in front'. But *molis* here probably means 'just barely' and his point is that if it were in the rear it would be *completely* useless.

$683^a19$: 'it is better, where possible'. The example mentioned here indicates that this teleological principle applies as well to the situation described at $682^b36$–$683^a3$, where the sting is compared to the elephant's trunk in that it is used for taste perception, food conveyance, and strength. The comparison goes back to *PA* II. 17, $661^a26$–9, where, however, the tongues of certain insects are said to *take the place* of stings. Here ($683^a1$–2) 'the sting has been positioned by the tongue; for they both perceive their nourishment by this part, and take hold of it and convey it'. Note that while the opening of this sentence suggests two organs in proximity, it closes as if discussing one organ, not two.

What does Aristotle see as the constraints on nature doing the better thing in such cases? To my knowledge he never addresses this important question at the philosophical level, but by taking Aristotle's repeated admonition to consider the case of the elephant (*PA* II. 16, $658^b35$–$659^a36$; 17, $661^a26$–9; IV. 6, $682^b36$–$683^a4$; IV. 12, $692^b15$–19), we can see the outlines of an answer. In that case, there is a principal function for the part—the trunk is a nostril used for breathing—and this, given the elephant's way of life, accounts for its physical character. In addition, basic physical constraints prevent the elephant from using its front limbs to convey food, and nature makes use of the trunk 'in place of hands'.

The general pattern then, seems to be this.

(1) Part *p1* is present for a primary function *f1*.
(2) Another function (*f2*) required by the organism cannot be performed by the part (*p2*) typically used for *f2* in the (wider) kind.
(3) *p1* is *capable* of performing both *f1* and *f2*.
(4) The animal's nature uses *p1* for both *f1* and *f2*.

$683^a25$: 'spit-and-lampstand'. An *obeliskoluchnion* was a device used in military encampments as a spit to cook over a fire and as a lampholder. Cf. *Pol.* IV. 15, $1299^b8$–12.

## CHAPTER 7

683$^b$5–7: 'more composite, on account of their activities'. This is an application of two general theses argued at 645$^b$14–20 and 646$^b$14–27: that the body of an organism with a life involving multiple activities must be complex, and that this will involve organs, and not merely tissues. The hard-shelled animals are among the least active of animals, and thus have a simple body.

683$^b$10: 'for self-preservation'. The absence of the standard teleological connectives, and their replacement with more neutral expressions, is obvious here. For other examples see 683$^b$15, $^b$20, $^b$32–3, $^b$36, 684$^a$4, $^a$7, $^a$12–13, $^a$19, $^a$23, $^a$31.

683$^b$17: 'fused on both sides, e.g. the pipe kind'. The 'razorfish', class *Scaphopoda* in modern classifications, is related, as Aristotle astutely realizes, to the bivalve molluscs such as the clams. This is the only reference in *PA*; but see *HA* 528$^a$18–22, 535$^a$14, 547$^b$13, 548$^a$5, 588$^b$15. The two parts of the shell fuse during development, giving it the appearance of a 'pipe' in the mature stage, to which Aristotle's word refers.

683$^b$21: 'the below above, and the above below'. A common bit of cleverness, used most often with reference to plants (cf. Bonitz 1870: 68$^b$19–34). The idea is to stress an opposition between directional and functional meanings of up and down, where the functionally 'up' is defined by reference to ingestion of nutrients (cf. 656$^a$10–13 note, and 686$^b$32–687$^a$2; *IA* 4, 705$^a$26–$^b$6). The same phrase is used of the crocodile's jaws (660$^b$27–34), where again the concept of a 'lower' jaw includes the idea that it is the movable one, which the crocodile alone violates.

683$^b$21: 'the head is in a membrane'. The subject of the verb has to be supplied. Both Peck and Ogle take it to be 'the body'; but the sentence is in the midst of a discussion of their heads, and it is false to say that the body of testaceans is enclosed in a membrane, while not at all obviously false to say this of their heads.

## CHAPTER 8

683$^b$25, 32, 684$^a$7, 18, $^b$1: '"locomotive", "locomotion" "walkers"'. The Greek terms here (*poreutikos, poreia*) have both a narrower meaning applying to movement on land and a wider meaning referring to locomotion in general—Aristotle's treatise on the subject, *De Incessu Animalium*, discusses all forms of locomotion. The wider sense is occasionally inappropriate, however, as at 684$^a$18, where it is contrasted with swimming, and where it is used to explain the possession of numerous feet. There I translated 'not more swimmers than walkers'.

683$^b$26–8: 'four extensive kinds . . . of each . . . many forms'. This text provides additional evidence for the 'context-sensitivity' of Aristotle's concepts of 'kind' and 'form'. (Cf. 679$^b$15, 680$^a$15, 681$^b$1–10 and notes; Pellegrin 1986: 94–107.) While in some key texts he uses the term 'extensive kind' (*megiston genos*) for the widest classes of blooded and bloodless animals, he treats the background class here as the *soft-shelled*, bloodless animals, so that the widest groups of these are the 'extensive kinds'. In accord with the minimal prescriptions of *PA* I. 4, 644$^b$1–15, each kind has many forms, differing in shape, size, and sensible properties. The vocabulary is level neutral, but is used consistently.

683$^b$31–684$^a$18: 'The ones that are crab-like and crayfish-like'. This is a nicely balanced example of Aristotle's divisional method. 683$^b$31–684$^a$1 points out the fundamental likeness of the crabs and crayfish—claws, used not for locomotion but in relation to nutrition. Next (684$^a$1–5) they are differentiated by reference to presence or absence of tail, both presence and absence being given a functional explanation (though again without the language of *to hou heneka*). Finally (684$^a$5–11), there is a subdifferentiation of crabs into deep-sea and non-deep-sea varieties, two deep-sea types being actually discussed, along with a small, unnamed variety.

Aristotle then ($^a$11–17) moves on to characterize the shrimp by differentiating them from the crabs (they have tails) and from the crayfish (they lack claws). The balanced contrast is somewhat odd, since lacking claws also differentiates them from crabs. He is apparently assuming the shared similarity of crayfish and shrimp, a tail, which differentiates them from crabs.

684$^a$16: 'the growth from one place has been used up elsewhere'. Compare the discussion of horns, hoofs, and teeth at III. 2, 663$^b$22–664$^a$3 and note, for Aristotle's doctrine of the animal's formal nature shifting the material around for different uses. And see 684$^a$24–30 and note.

684$^a$18: 'The parts on the underside and around the head are in some cases gill-like'. In fact they are gills, but Aristotle treats them as having a nutritive rather than a cooling function, thus 'gill-like'. The 'in some cases' may be due to the locational restriction, for in a number of crustacea these structures are abdominal rather than thoracic.

$684^a23–4$: 'they deposit their eggs towards them, rather than expelling them'. Again, Aristotle is an astute observer: 'In some of the Malacostraca, medial plates are attached to the thoracic appendages. These are the oöstegites, and form a ventral brood chamber' (Meglitsch 1972: 548).

$684^a32–684^b1$: 'The lobsters alone'. There are two unusual and important features of this passage. First, there is the attempt to explain the chance variation in a structure, which one might think to be outside the purview of explanation for Aristotle. Second, there is the odd contrast between what an organ does naturally and what it is for in this case.

(1) Aristotle takes it that two facts need to be explained: why lobsters have claws, and why they have the larger one on either left or right, apparently at random. The first explanation is unsatisfactory in the same way as that of the horns of female deer ($664^a1–8$): lobsters have claws because they are in a claw-possessing kind. This is dissatisfying no matter how one takes it. If the kind referred to is just the lobsters, it is vacuous. If it refers to the obvious wider kind—soft-shelled animals—it is false, since that kind is *not* universally clawed, as we have just been told. If Aristotle is simply treating all the clawed soft-shelled animals as a kind, it is *ad hoc*.

(2) The random distribution of the larger claw (factually accurate) is explained as a deformity. Aristotle goes on to say—and the Greek leaves it unclear whether this is an additional fact about lobsters or part of the explanation by reference to deformity—that they are not used for their natural function but 'for the sake of locomotion'. This was, of course, denied to be the function of claws in crayfish and crabs, and had Aristotle stopped after saying that lobsters are deformed and do not use their claws naturally, these discussions would be consistent. But it is hard to understand the claim that they are used *for the sake of* locomotion, especially given the general avoidance of teleological explanation in these chapters even for universally possessed features performing their natural functions. Now it is true that Aristotle uses the locution associated with what I have been calling 'indirect' teleology—'used for the sake of'—here. But it is unprecedented for nature to use an organ, which in other members of the kind has one function, solely for a secondary function. Indeed, in one of the other rare uses of this term in these chapters, at $683^b32$, Aristotle notes that the crab- and crayfish-like animals have claws '*not* for the sake of locomotion, but in relation to grasping and holding'. Judged by his own philosophical standards, then, this explanation is problematic.

$684^b4–5$: 'studied with the help of the dissections and the enquiries about animals'. Cf. *HA* IV. 2, $525^a30–527^a35$, which does take up the topics mentioned and is a good deal more detailed than this discussion, but without separating the treatment into one of internal and one of external parts.

## $684^b6$–$685^b28$

This lengthy discussion of the soft-bodied animals, and that of their internal parts (see $684^b6$ note), provides some of the strongest evidence for David Balme's thesis that many of the data reported in our *Historia Animalium* were unknown to the author of our *PA*. In particular, *HA* IV. 1 makes a number of claims that it is hard to imagine Aristotle not discussing in *PA*—the small brain at $524^b4$; the special octopus arm used in copulation ($524^a3$–9; cf. $541^b9$, $544^a12$, where he cautiously attributes the idea to others), the use of the siphon to discharge sea water as well as ink ($524^a9$–10; cf. $589^b19$–20). In addition, many more varieties of all kinds are discussed, including the nautilus, which even though it has a hard shell is treated as a cephalopod (cf. $525^a20$–1; cf. $621^b29$–$622^b18$ on cephalopod behaviour, especially the 'sailing' of the nautilus). As Balme would put it, 'the *HA* knows more'. The crucial point is that it knows a good deal about important structures that one would expect to be discussed in *PA* IV.

### CHAPTER 9

$684^b6$: 'The *internal* parts . . . spoken of previously'. Especially at $678^a26$–$679^a31$, but with scattered comparisons as well through to $682^a29$.

$684^b8$: 'between the eyes'. Literally 'within' or 'inside' the eyes; but this is not colloquial English for Aristotle's point, which is that the eyes are on either side of the cephalopod head, between which are the tentacles.

$684^b12$–14: 'the soft-bodied kind is, when compared with these, distinctive'. It is possible that 'these' refers to all the animals with feet, or just to the many-footed and bloodless, a group which includes the soft-bodied kind, their distinctive (*idios*) feature being that they have their many feet in front. Contemporary comparative anatomists deal with these creatures in a way Aristotle would find congenial: 'In discussing the cephalopods, functional rather than morphological axes will be used; head and tentacles will be considered anterior, and the funnel ventral' (Meglitsch 1972: 354).

$684^b15$–16: 'just like the cone-shaped, hard-shelled animals'. Aristotle here recognizes the similarity of structure between cephalopods and testacea, which is today embodied in our classification of them as two classes within the phylum Mollusca.

$684^b19$–$685^a3$: 'the configuration of the body'. Commentators have found this passage surprisingly problematic—the Loeb translator goes so far as to replace the Greek of our manuscripts with Michael Scot's Latin translation of an Arabic manuscript in two places. But as Düring (1943: 185–7) noted, such desperate measures really are unnecessary. I have followed most of his suggestions in the translation, though I see no need to replace *to E* of the manuscripts at $685^{a}2$.

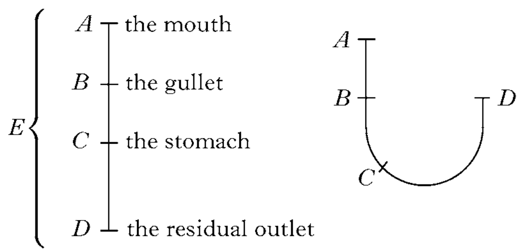


DIAGRAM 3 (*after Düring*)

Düring (1943: 186) provides the diagram that presumably was available to Aristotle's students (here Diagram 3). The basic point is fairly obvious: if one imagines the digestive tract of most animals as a straight line, with mouth defining 'upper extreme' and residual vent 'lower extreme', then the soft-bodied and hard-shelled kinds are similar to each other and distinct from the rest in having the lower extreme bent round so that the vent is either beneath or beside the mouth. This apparently out-of-place internal anatomy is introduced to explain ($^{b}14$) why the feet are in front, and is thus perfectly apposite.

$684^{b}30$: 'nature has added . . . for the sake of'. An exceptional use of the technical language of teleological explanation in these chapters on the bloodless animals which proves (evidences) the rule, since the reference is in fact to the *blooded* animals.

$685^{a}9$–12: 'because of this the residue . . . exits in the region of the mouth'. 'Because of this' refers broadly to the similarly bent structure of the body. Earlier this was introduced as the cause of the feet (i.e. the tentacles) being in front (as we are reminded at $685^{a}12$), but it also causes the mouth (*A*) and residual vent (*D*) to be side by side.

$685^{a}14$–21: 'The cuttlefish and squids are unlike the octopuses'. From this point on the discussion turns to 'within-group' differences among soft-bodied animals and their explanation. Many of these differences can be traced back to the one mentioned here, that the octopus can walk as well as swim, whereas the cuttlefish and squid cannot. But see the note to

685$^a$25–30, below. The differences in the tentacle structures are accurately characterized—keeping in mind that Aristotle treats the two elongated arms of the squid and cuttlefish as distinct structures, focusing as he does on their function, discussed at 685$^a$30–$^b$3.

685$^a$25–30: 'nature takes from the body'. The distinctive natures of these animals distribute common materials differently, and that accounts for the relatively small legs in the squid and cuttlefish compared with the octopus. But does this anatomical difference explain why the first two groups are only swimmers while the octopus can both swim and walk, or vice versa? This functional difference, at any rate, then accounts for the two added 'proboscises' of the squid and cuttlefish, since their tentacles are useless for grasping, conveying, and holding. Thus among the most fundamental differences in these groups is a difference of *structure*, itself due to the natural distribution of materials between the trunk and the legs. That the animal's nature distributes the material in distinct ways may be an 'unexplained explainer', a starting-point. On the other hand, this may be accounted for by reference to the locomotive differences discusssed at 685$^a$14–21. It is worth noting that the basic explanations here are not obviously teleological, though it is possible that, were Aristotle to turn to the control of development by means of the animal's formal nature, the explanation for this distribution would turn out to be teleological (i.e. for the sake of producing an octopus, i.e. a walker *and* swimmer).

685$^a$32–$^b$3: 'for these reasons they have two long proboscises'. This term, which we have seen Aristotle use of insects' sucking-tubes and stings and the elephant's trunk, appears always to apply to a long forward projection used for feeding and often turned to other uses. Here he is referring to specially adapted tentacles, but by treating them as distinct organs Aristotle achieves a universal generalization over the soft-bodied animals regarding the number of 'feet'. They are certainly used, as Aristotle claims, for capturing prey and feeding, but I have found no reliable modern discussion that claims these structures are used for mooring the animal in stormy weather. Nevertheless, Aristotle has often been vindicated in his claims about animal behaviour, and there is nothing inherently preposterous in this one.

685$^b$4–12: 'the plaited tube in which the ancient doctors set fingers'. See Ogle (1882) 235 n. 16. The image is apparently of these animals wrapping themselves around their prey and contracting to ingest everything within. Commentators usually take the analogue to be a device described in the Hippocratic treatise *On Joints* (iv. 318–20 Littré), which has a plaited character and which is used to grasp a finger when setting a dislocation.

Aristotle is careful to restrict the analogy to 'potential and constitution', i.e. to its contracting ability and its 'plaited' fine structure, so that too much should not be read into the comparison.

$685^b12$–16: 'a single row . . . necessary owing to the distinctive account of their substantial being'. The octopus kind referred to here is called the *heledōnē* at *HA* IV. 1, $525^a16$–17 (for ancient references see Thompson 1910: $525^a19$ n. 2). Gotthelf (1985*b*: 41, 44–5) has pointed out that this passage attributes dimensions—thinness and length—to the definition (i.e. the *idion logon tēs ousias*, $685^b16$) of this kind. He notes one other such attribution to the definition of snakes (*IA* 8, $708^a9$–20), the dimensions again being width and length. At the very least, this indicates a willingness to include characteristics other than function in biological definitions, and perhaps even characteristics other than parts.

The explanatory contrast is, as *PA* I. 1 would lead us to predict, between a feature being present because it is best and a feature which is 'definitionally necessary' (cf. $640^a33$–4 note). The *heledōnē* lacks a second row of suckers because, given its slim nature, it must; there is no particular value to its having one row of suckers rather than two. Again a physical parameter built into the being of a kind is the explanatorily basic feature (cf. $685^a24$–30 and note).

$685^b16$–26: 'All these have a fin . . . so that they may swim, and for steering'. Aristotle appears unaware of the role of the siphon in cephalopod propulsion; it is nevertheless true that they use their collars and fins to some extent for swimming, but more for steering. Octopuses have no such structure, so Aristotle is certainly correct to claim that it is 'least visible' in them.

## $685^b29$–$697^b30$

This section opens by outlining the contents of the remainder of *PA* IV. Again, the structure of the overall discussion is correctly described, but not justified; cf. $682^a30$–4 and note. Chapter 10 ($685^b29$–$690^b12$) focuses on the external, non-uniform parts of blooded, live-bearing animals (since it includes human beings in the discussion, he cannot use the grouping 'four-footed live-bearing'). From there to $697^a15$ the blooded egg-layers are under consideration; chapter 11 ($690^b12$–$692^b3$) is generally focused on the land-dwellers, both four-footed and footless (snakes); chapter 12 ($692^b3$–$695^b2$) on birds; and most of chapter 13 ($695^b2$–$697^a15$) on fish. At $697^a15$ a discussion of the differences between the cetaceans and fish opens up into a general discussion of 'ambiguous' animals that seem to have traits of more than one of Aristotle's 'extensive kinds'. Having said that, it is important to recall that Aristotle's method of discussing differentiae at different levels of generality leads him constantly to refer to animals other than the 'focus group'—as just one example, during the long discussion of the relative proportions of upper and lower body during growth in live-bearing animals, Aristotle comments that 'the bird and fish kind, and every blooded kind, are, as has been said, dwarf-like' ($686^b21$).

## $685^b29–690^b12$

Aristotle acknowledges, with many backward references, that the discussion of the head and neck is reviewing territory covered more thoroughly in *PA* II. 10–III. 3. But this is no *mere* review. The divine and upright nature of humans is given as a reason for beginning with them in the earlier discussion, but no explanation for this posture is there provided—a lack that Aristotle now corrects. In the earlier discussion an explanation is provided for why the sense-organs that are on the head are there, and is therefore quickly reviewed here; but while functional explanations of the mouth and each of its parts (lips, tongue, teeth) were given earlier, the reason for the mouth being on the head was not, and again Aristotle attempts such an explanation now. Thus if one compares these two passages, there is very little overlap, and what little there is typically is acknowledged as such.

### CHAPTER 10

$685^b33–4$: 'previously discussed'. Very broadly this refers to $655^b28–664^a20$. The word translated 'throat' (*trachulos*) is rare in Aristotle—this is its only appearance in *PA*, and in particular it does *not* occur in the passage to which we are here referred. It is occasionally a synonym for the word here translated 'neck' (*auchēn*), but sometimes these terms appear to differentiate the front from the back of the neck.

$686^a1$: 'All live-bearing'. Aristotle provides a quick review of the information on necks at $664^a12–20$, though not the explanations. In divisional terms, it is the oviparous and viviparous breathers that have a neck and a lung.

But the commensurate universality of lung and neck is never made clear in our passage; when Aristotle says 'for those that have a lung also have a neck', he is delineating the *egg-laying* animals that have necks from those that do not—primarily fish.

$686^a5–6$: 'The head is present above all for the sake of the brain'. This is not a claim made previously; and even with the qualification 'above all', we must assume that the background class is the blooded, since only blooded animals have a brain (according to *PA*; but see $652^b23$–6 note, and references), while many bloodless animals have heads. Note that one part is said to be for the sake of another, sanctioned in theory at I. 5, $645^b28$–33.

$686^a7$: 'the causes stated previously'. The claims reiterated here combine those made at $652^b16$–26, which discusses the role of the brain in the moderation of the heat generated around the heart, and $656^a19$–$656^b7$, which discusses the value of placing certain sense-organs near the brain.

$686^a11$–17: 'nature has added a third part . . . most suitably placed there'. This passage has defied reasonable interpretation. Aristotle is trying to explain why the mouth is placed on the head, and in a manner quite typical of the *PA* he approaches this question by performing thought experiments in which he imagines the alternatives and derives consequences from these alternative arrangements which are less suitable than the actual arrangement. The alternatives considered are (1) the stomach above the heart and (2) the mouth below the heart. No argument against (1) is provided; it is simply said to be impossible. But if a reader has followed Aristotle to this point, the idea of having the digestive organs weighing down on the heart, and not separated from it by the diaphragm, will seem self-evidently inappropriate. A more troublesome feature of (1) is that having the stomach above the heart does not self-evidently require that the mouth be located differently.

Arrangement (2) is said to be impossible because 'the length of the body would be great, and the mouth would be very distant from the moving and concocting origin'. Both Ogle and Peck translate this sentence as if the subject of the second clause is 'the stomach'. This is grammatically implausible, and, as Ogle points out, does not provide Aristotle with a reasonable argument. If one supposes him to be thinking (as Ogle does) that, since the mouth is connected to the stomach by the oesophagus, there will be a great distance created between the heart and stomach by having the mouth below the heart, then Aristotle must have forgotten that the oesophagus is only there because of the windpipe ($664^a21$–4), and would thus not be necessary on this new arrangement. On the other hand, if he is not thinking this, then why does the mouth have to be placed so as to create any additional separation between heart and stomach at all?

But at any rate, as already indicated, there is no good reason to read 'the stomach' as the subject of the second clause. Short of unsupported textual emendation I can think of no way to salvage this argument.

$686^a17$–18: 'The head . . . for the sake of these things . . . the neck is for the sake of the windpipe'. Cf. III. 3, $664^a14$–17, where the neck is said to be for the sake of the windpipe and oesophagus. An additional case (see

686$^a$5–6 and note, above) of *parts being for the sake of parts* (about which see *PA* I. 5, 645$^b$28–33). Behind teleological relations between parts there is, of course, an implied functional hierarchy—the neck is present in order to protect the windpipe, and the windpipe is for the sake of respiration.

686$^a$21–2: 'wolves and lions have a single bone in their neck'. This falsehood about lions is repeated at *HA* II. 1, 497$^b$16–17; *Historia Animalium* makes no such claim about wolves, however.

686$^a$25–31: 'Mankind . . . has arms and what are called hands'. Of all passages in Aristotle's biology, this more than any other echoes the spirit of Plato's *Timaeus* (see also 686$^b$28–31 note). The arrangement of limbs in humans is the standard against which other arrangements are compared, and thus explained. And there is an uncharacteristic tone of historical narrative in the explanation of the limbs of four-footed animals which reminds one of the following:

> Land animals came from men who had no use for philosophy and paid no heed to the heavens because they had lost the use of the circuits in the head and followed the guidance of those parts of the soul that are in the breast. By reason of these practices they let their forelimbs and heads be drawn down to earth by natural affinity and there supported. (*Timaeus*, 91 E 2–92 A 1, trans. Cornford)

Aristotle's ultimate *explananda* here are the differences in limb number and structure in the viviparous animals—as the summary at 687$^a$2–5 makes clear. The passage currently under consideration seeks to explain the last-mentioned fact, which can then be used to explain further the possession of hands, which follows (687$^a$5–23). As stated, the argument has a number of lacunae; the following provides a minimal expansion (additions in brackets) which gives Aristotle the desired conclusion:

(1) Humans are divine in nature.
(2) Reason is a function of what is most divine.
(3) [Therefore reason is a function of humans.]
(4) Reason would be hampered by having a great deal of 'bodily' matter pressing down on its organ.
(5) [Therefore humans do not have bodily nature pressing down.]
(6) [Things which do not have a great deal of bodily matter pressing down are upright.]
(7) Therefore humans are upright.
Thus human uprightness is in essence a consequence of humans being properly constructed for reasoning.

This argument needs to be integrated with an earlier one, at 653$^a$9–32.

There Aristotle claims that man's upright nature is due to the great heat around the human heart, which causes growth in an upward direction (repeated at III. 6, $669^b5$). This argument is alluded to later in our passage, at $686^b27$–31. Thus normal, adult humans are upright because of the heat around the heart sending elevating heat upward. This is fitting for a rational being, since the region around the heart is then not pressed down upon from above.

A number of the premisses in this argument stand unsupported, and when one looks elsewhere for support it is not forthcoming. Take the first two premisses, and the fact that uprightness and rationality seem to be based on our divine nature. The closest Aristotle comes is to defend the reverse implication, that humans are, in virtue of their ability to reason, essentially divine. *EN* X. 8, $1177^b26$–8, for example, first asserts that the life of theoretical virtue would not be a human life but a life lived according to something divine in humans; but then ($1177^b31$–$1178^a7$) Aristotle urges us to live life in accordance with this divine element in us, even suggesting that we should *identify* with such an element in ourselves. In a similar vein, *Met.* *Λ* 7, $1072^b22$–30, treats the act of contemplation as the best state to be in, and asserts that this is a state we are sometimes capable of and in which God always is. Finally, in *An.* III. 5–6 a productive or active reason is discussed which is 'distinct, unaffected, and unmixed' ($430^a16$–17) and which 'in separation is immortal and eternal' ($430^a23$–4). None of these passages, however, provides support for the doctrine asserted here.

Similarly, it is never explained why humans have a less heavy upper region than four-legged animals, or how soul functions are hampered by having bodily material above, or why reason is localized where it is. These last two questions raise broader issues of how Aristotle conceives of the material basis of reason and the common sense in this discussion.

Some useful detail is provided by *Som.* 3, since Aristotle sees sleep as a temporary dulling of cognitive functions due to just those causes referred to here. Briefly: excessive nutrient, in the form of ill-concocted blood, rises owing to the heat of the heart, but then presses down as it is cooled by the brain ($456^b18$–29). We 'nod off' because of this heavy nutrient in our heads, and children sleep a great deal because their growth, which is in the upward direction, carries much nutrient upward, which leads to the regular recurrence of the above dormative process ($456^b32$–$457^a6$). This constant excess of nutrient above also accounts for the 'dwarfish' nature of children ($457^a6$–7) that in our *PA* IV passage is also connected to their relative lack of reason. This discussion is thus consistent with the account in *PA* IV, and provides some grounds for the premisses in this argument.

$686^b2$–5: 'dwarf-like . . . upper'. This passage stipulates Aristotle's scientific use of these terms, necessary since he is extending them beyond their usual meanings. The upper body in this context means everything from head to anus—thus only the rear haunches and limbs are excluded. If one thinks of a dog standing on its hind limbs, one can see why Aristotle thinks of viviparous quadrupeds as 'dwarf-like'—upper body larger relative to lower body. With these meanings stipulated, the claims at 686b6–16 follow straightforwardly.

The term 'dwarf-like' is thus descriptive, referring to a type of bodily proportion, though these passages are often cited to show Aristotle using evaluative concepts to 'devalue' other animals by comparison with humans (cf. Lloyd 1983: 40–1). There are, as noted at 686b26, ways in which human dwarfs are said to be deficient compared with the norm, but that is not indicated by the term 'dwarf'. That term refers to the property of having the upper body proportionately larger than the lower—this is unusual in adult humans, typical of infants and other quadrupeds.

686b19–20: 'the growth of the lower parts relative to the upper parts is proportional to the deficiency'. This is a remarkable mathematical generalization (recalling that Greek arithmetic is largely the theory of ratios and proportions). Aristotle's claim is that the *rate* of growth of the lower parts is determined by the ratio of the lower to the upper parts—the greater the ratio, the greater the rate of growth of the lower parts (an instance of the boldness of Aristotle's mathematical reasoning discussed in Hussey 1991: 213–42). That Aristotle intends this as an explicitly mathematical law is suggested by the use of the phrase 'proportional to their deficiency': ratios in Greek arithmetic are expressed as an excess or deficiency of one magnitude relative to another. I take it that the specific claim here is that all the viviparous quadrupeds are dwarf-like, but the hornless and toed ones are less so than those with hoofs.

686b27: 'the origin of the soul is . . . sluggish and bodily'. Presumably this refers either to the heart or to its blood.

686b28–31: 'as the heat which rises becomes less and the earthen material becomes greater'. Compare the following passage from the *Timaeus*:

> On this account their kind was born with four feet or with many, God giving to the more witless the greater number of points of support, that they might be all the more drawn earthward. The most senseless, whose whole bodies were stretched at length upon the earth, since they had no further need of feet, the gods made footless, crawling over the ground. (92 A 2–92 B 1, trans. Cornford)

The language descriptive of the *explananda* is strikingly similar, though the explanation is quite different. There is the common theme relating reason to upright posture. But, while Aristotle does account for human uprightness teleologically—it is beneficial to reason to have relatively little weight above the heart, and it is this which produces uprightness—he provides a 'mechanics' of posture which the Platonic account lacks. There is less heat to raise the animal up, relatively more earthen material, and thus the animal becomes more 'earthbound'.

One can, and lacking any other evidence of evolutionary tendencies in Aristotle should, interpret the 'narrative' character of this discussion as metaphorical—one is 'proceeding through' the various blooded kinds. Nevertheless, here is yet another similarity between this passage and the *Timaeus*—Aristotle's language sounds as if he is describing a process by which the four-footed and then the footless animals are a result of certain degenerative changes in a human prototype (cf. Clark 1975; Lloyd 1983: 41–2). Indeed, in one sense Aristotle goes further, in that there is a transition from the lowest level of animals to plants, again described as something which 'finally comes to be' (cf. $683^b21$ and note; *IA* 4, $705^a26$–$^b6$).

$687^a8$: 'Anaxagoras said'. Cf. 59 A 102 DK. We have no independent confirmation that Anaxagoras held this view, but it is broadly consistent with an evolutionary perspective expressed at 59 A 1 DK (Hippolytus, *Ref.* I. viii. 12), that animals first arose from the moist, and then began to reproduce. So here Aristotle may be claiming that (as the Epicureans later insisted) first the organ arises, then the ability to use it. Aristotle gives causal priority to functional ability: 'Surely it is more fitting to give flutes to the flautist than to provide the ability to play flutes to one who has them'.

$687^a11$: 'nature, like an intelligent human being'. Surely a bit of humour: nature provides hands to humans because humans are the most intelligent animals and thus is acting like an intelligent human.

$687^a15$: 'nature does, among the possibilities, what is best'. On the role of this principle in *PA* see $663^b20$–4 and note; and Lennox (1996*c*; 1997). In contrast to Anaxagoras, Aristotle insists that instruments are provided based on the organism's ability to use them. Thus the ability to use hands is causally prior to having them, and the passage which follows explains that hands, as instruments for instruments, have an enormous range of uses—for a being with the ability to make intelligent choices. But this is merely a special application of the governing causal priority of *PA*: the form of an animal, its soul—its nutritive, reproductive, locomotive, and cognitive abilities—is that for the sake of which its body is constituted. The argument for this at *PA* I. 1, $641^a14$–32, stresses that each particular capacity demands specific parts arranged in specific ways. The argument of *PA* II. 1 for the teleological priority of organs over tissues ($646^b10$–35) uses the hand's need for many opposing material potentials for squeezing and grasping as its principal example. Nor at this point is there anything startling in the claim that, where better and worse arrangements are possible, nature organizes this in the best way possible. The cash value, then, is as it has been all along—the formal nature has priority over the material, and arranges the body in the best way possible for the animal's life.

687$^a$31–$^b$6: 'But for mankind . . . he may choose'. This I take to be the central point of connection between mankind's greater intelligence and the possession of hands: the structure of the hand, which Aristotle next goes on to discuss in detail, allows for an indefinite range of instrumental activities, but only if we can choose intelligently among them can we take advantage of this fact.

687$^b$4–5: 'it will be all these'. The reference of 'all these' is somewhat unclear, but I take it to be 'any weapon or instrument'.

687$^b$6–25: 'the form of the hand has been adapted by nature'. The discussion of the hand's structure is generally straightforward—Aristotle correctly identifies the 'opposable thumb' as crucial to the hand's grasping ability, and attempts to argue that its size and shape give it the strength necessary to 'oppose' the other four fingers. He assumes that the natural direction of the thumb's movement is upward. Perhaps this is because he takes the arm's natural position to be palm backward, so that when the arm is raised the thumb's grasping position is below the fingers.

687$^b$22: 'The form of the nails too has been well arranged'. 'Form' is not in the Greek, only a definite article. But the adverbial *kai* ('too') suggests continuation of an earlier point, and the root of the verb here is the same as that at $^b$6, indicating that 'form' is the noun to be supplied. Another possibility, though without an antecedent in this passage, is 'kind', since Aristotle will use the expression 'the kind consisting of the nails' (cf. 690$^b$8).

The distinction between the nails of humans and other animals is not entirely clear. The Greek I have rendered 'service' could also mean 'advantage' or even 'practice', but in any event it is hard to see why being a protective covering for the fingertips is *contrasted* with providing a service. Perhaps Aristotle has in mind a distinction between an *active* use of nails (e.g. as weapons) and a merely *passive* use as a covering.

687$^b$26–688$^a$11: 'in a manner opposite to the four-footed animals'. The first problem with this passage is to understand Aristotle's attempt to distinguish the limbs of humans from those of the other live-bearing animals. A fuller discussion is provided in *IA* 12–14 and *HA* II. 1, 498$^a$3–31. There we find a twofold distinction: (1) human limbs do not bend inward, since they do not serve as bodily supports, while the limbs of four-footed animals do; (2) in live-bearing, four-footed animals the front limbs bend backward, the hind limbs forward (relative to direction of motion), while in humans it is just the opposite. Though hardly as cut and dried as Aristotle makes it sound here, this is a generally accurate division. The only 'bend' referred to in our passage is 'inward', i.e. toward the body. It is surprising not to see a mention of the elephant here, however—at *IA* 13 Aristotle claims that the elephant's joints are, alone among the four-footed animals, like those of humans (712$^a$10–13; cf. *HA* II. 1, 498$^a$4; at 709$^a$10 we are told that 'the ancient account' claimed falsely that the elephant's hind limbs did not bend at all). I take it that this comparison refers not to anterior/posterior bending, but to concave or convex curvature relative to the animal's body (see Peck 1961: 433).

Aristotle introduced the idea that four-footed animals with many toes tend to use their front feet like hands at *PA* II. 16, 659$^a$24–36—the elephant being an exception to this rule as well.

688$^a$23–4: 'while in females nature has turned them to another function as well'. It should be stressed that Aristotle views the lactating function of the breast as a secondary function, even in females, as is clear both from the idiom of 'nature turning' them to this function and from the adverbial *kai* ('as well'). In humans generally the primary function is the protection of the cardiac region. Aristotle never faces the obvious problem for this claim posed by the male *nipples*.

688$^a$35–$^b$1: 'in other cases have only two, around mid-belly, e.g. lion'. Once again Aristotle's information about the lion is wrong, whatever its source. Without notice, the explanation for mammae in four-footed animals is solely in terms of their nutritional function, and no mention is made of the male. A related issue is briefly mentioned at 688$^b$30–3, where an explanation of why, in some species, some males have mammae and others do not is hinted at—those that do are those that 'resemble their mother'. The only example provided is of horses, and the issue is not nipples, but mammae. Notice also that this is an explanation of within-species variation, of the sort found in *GA* IV and V.

688$^b$5–9: 'The elephant'. Three facts about the elephant's mammae are given three distinct types of explanation in a remarkable piece of compression. That they are *two* is accounted for by reference to the fact that they bear only one offspring at a time—it is assumed that the animal's nature provides nothing superfluous. That they are *not between the thighs* is explained directly by reference to the elephant's nature as a many-toed animal—no reference to the needs or good of the animal is involved. That they are *forward* is accounted for by noting that when there are more than two, the most forward are the primary ones (688$^b$10–14 gives evidence in favour of this claim). The missing premiss is that if an animal can have only two, it is either necessary or best that they be the *primary* two.

688$^b$16–21: 'those with many offspring have the mammae around the belly'. Again, the explanation is highly compressed, and in this case there is an organic need—large litters require many mammae—and a set of physical constraints—relatively narrow width, right and left side, and lengthy belly—that jointly explain the location of the multiple mammae.

688$^b$34–689$^a$3: 'the stomach, which is unenclosed by the ribs owing to the aforementioned cause'. Cf. *PA* II. 9, 655$^a$1–4.

689$^a$7–8: 'with few exceptions'. Aristotle is apparently claiming that, with few exceptions, blooded animals have a common passage for copulation and venting of moist residue in both males and females. As Ogle notes (1882: 239 n. 32), this conflicts with Aristotle's insistence that most oviparous blooded animals do not vent moist residue (cf. *GA* I. 13, 719$^b$29–720$^a$33). If the Greek for 'the moist' were omitted, this passage would be in line with others on the same topic, and two other details support such removal. First, the word order in the Greek is atypical for Aristotle (not surprisingly, MS Y has a different reading). Second, the previous line has a similar expression, making a scribal insertion of this sort quite possible.

689$^a$9–10, 689$^a$12–13: 'let this be assumed for now . . . for now let it only be assumed'. The references are presumably to the enquiry into the male and female contributions to generation at *GA* I. 18–20, 724$^b$21–729$^a$33. The language of 'assumption', 'proof', and 'definition' is noteworthy, especially as we have the causal explanations of certain parts of animals resting on assumptions which are not immediate, but are to be proven and defined in the causal investigation of animal generation. Aristotle had a difficult decision to make regarding these organs. He treats the study of animal generation as a distinct causal investigation. Given his views about the importance of defining organs by reference to their functional capacities, and of explaining their material and structural make-up by reference to their functional capacities, it is appropriate for him to set aside the discussion of generative organs and residues for that investigation. But if the same organs are also used essentially for the removal of nutritive residues, they must also be discussed here.

689a18–20: 'apparent with the help of the enquiry about animals and the dissections, and will be stated later in the works on generation'. *HA* III. 1, 510a29–35, refers, with a demonstrative pronoun, to drawings with lettered designations, suggesting the presence of the illustrations along with the text, or lecture. *GA* I. 3, 716b32, and 4, 717a34, both refer to the *HA* III discussion, while 719a10 refers to it and accompanying drawings of dissections. The division of labour suggests that providing the phenomena, even in written form, is to be distinguished from an account (*logos*) of a subject.

689a27–9: 'this part has been naturally constituted from things of a sort that allows for both changes to happen'. This is an example of the philosophical approach recommended at *PA* I. 1, 640b36–641a3: in order for a bodily organ to perform its functions, and thus fully to be such an organ, it must be constituted of the appropriate uniform parts. More specifically, *PA* II. 1, 646b11–27, argues that organs with diverse functions require the powers associated with a number of different uniform parts, which is one reason why organs are composed of tissues. So here the penis's ability to contract or become erect depends on its being constituted of both sinew and cartilage.

689b12: 'nature, taking that which is bodily from the upper parts'. The nature of the animal apportions the material, accomplishing two valuable functions at the same time. The nature of the haunches refers to the character of the part under discussion. Cf. *PA* III. 2, 663b20–35 and notes.

690a6–8: 'a secretion to use for the nature of the nails instead of horns and teeth'. Cf. *PA* III. 2, 663a18–33 and notes. This account of the hoof, as 'one big nail', accords with the current evolutionary understanding of the limb structure of hoofed animals.

690a13: 'while the knuckle-bone, being a fastener'. Cf. *PA* II. 9, 654b20–3, on the types of joints and the role of the knuckle-bone.

690a30–1: 'the size of the digits in the feet is opposite to that in the hands, which is in accordance with our account'. The last clause includes the phrase *kata logon*, which can carry the connotation either of an account or of proportionality, depending on context. Here the context is able to accommodate either meaning. The functional account Aristotle gives of hand and foot in humans implies that the digits of the hand should be long and those of the foot short. But by the same token there is a straightforward proportional relation expressed as well: as fingers are long in the hand, so are toes short in the foot. I have favoured the first suggestion in the translation because it seems that Aristotle's stress is on the causal explanation for the difference in each case, rather than on the proportion itself.

### 690$^{b}$12–697$^{a}$28

The discussion now moves from the blooded live-bearing animals to the blooded *egg-layers*. Modes of locomotion and reproduction continue to be the differences used for initial identification of the animals being discussed, with explanatory context determining whether mode of locomotion is used to differentiate a wider reproductive group (as here), or is simply used in conjunction with a reproductive group in order to identify a group such as the four-legged egg-layers.

## CHAPTER 11

690$^{b}$12–16: 'Of the blooded animals that lay eggs, some are four-footed while others are footless.' There is a clear slip-up here that most commentators ignore: if the background class is blooded egg-layers, snakes are not the only footless ones—so are fish. Cf. *HA* II. 14, 505$^{b}$11–12: 'The snakes, just like the kind consisting of fish, are footless.' And not only are there four-footed and footless ones, there are two-footed ones (birds) as well. Since 695$^{b}$1–697$^{a}$28 is devoted to fish, it is likely that Aristotle imagines the background class to be blooded, *land-dwelling* egg-layers; but that is not in fact what he says.

690$^{b}$15–16: 'stated in those works that provide definitions of animal locomotion'. The footlessness of snakes is discussed at *IA* 8, 708$^{a}$9–20; cf. 696$^{a}$10–11, below. Briefly stated: the greatest number of feet a blooded animal may possess by nature is four, which would be useless for an animal of the relative length of a snake—and nature produces nothing useless.

690$^{b}$17: 'to the four-footed, egg-laying animals'. The manuscripts read *ōotokois* ('egg-laying') here; Bekker and Langkavel print *zōiotokois* ('live-bearing'), but most later editors and translators have not followed them. Following Peck, I have dealt with the problem by rendering *ta d' alla* at line $^{b}$16 adverbially ('in other respects') rather than taking it to refer to a contrasting group.

690$^{b}$20: 'except for the river crocodile'. The explanatory structure and strategy of *PA* are such that Aristotle will say little here about features shared with other blooded animals or other blooded, four-footed animals.

He will refer to the prior explanations for those features, and focus on features peculiar to the blooded egg-layers and their subkinds, since these are features that of necessity will have no explanation at these more general levels. These explanations often appeal to comparative structures and functions in other animals—the tongues of fish and seals, the scales of fish and feathers of birds, the claws of crabs, the ears, eyelids, and nictitating membranes of birds, the ability of insects to roll themselves up, and so on. These apparent asides provide insight into the cause of the part that Aristotle is explaining.

The crocodile has two peculiarities in need of special explanation—the virtual absence of a tongue and the peculiar structure of its jaw (cf. $691^b6$–26). Both explanations appeal to the creature's dual nature, as both a land and a water-dweller (at $690^b22$–3 and $691^b20$–5). It is assured the *place* for a tongue in virtue of its land-dwelling character; but tongues are for savouring the juices of foods that remain in the mouth while they are being chewed. Animals that take in their food underwater cannot, as Aristotle has already explained, do this. Rather, they tend to swallow their food quickly, and whole. For such creatures, a tongue is a useless appendage, and thus nature has not provided one for them. For the background explanation and more on the river crocodile, see *PA* II. 17, $660^b12$–33 and notes.

$691^a5$: 'the other way of perceiving'. The untrustworthy MS Y has the Greek for 'only' here, which admittedly is helpful. But in context, as Düring (1943: 196) points out, it is not necessary—there are only two modes of taste perception being considered, and the contrasting group is said to have, in addition to the mode associated with swallowing, that associated with the tongue. This is just the sort of 'helpful' addition which is characteristic of MS Y.

$691^a5$–8: 'the lizards, like the snakes, have a forked tongue'. Cf. *PA* II. 17, $660^b5$–11, where, however, the seal is not mentioned. The causal explanation, absent here, is provided there; they are voracious eaters, and the forked tongue provides them with a double dose of pleasure. All the manuscripts read *ischna* (thin) rather than *lichna* (gluttonous); the latter is a conjecture of the German translator Anton Karsch, which is printed by Peck and accepted by Düring. Since this would be an easy copying error, and since 'thin' makes no descriptive or explanatory sense, while 'gluttony' is the explanatory concept used earlier at $660^b9$, this conjecture seems compelling.

$691^a9$–19: 'razor-toothed . . . nostrils . . . eyes . . . ears . . . scales'. $662^a7$–16 discusses the razor-teeth of fishes; $657^a18$–23 has a similar discussion of the ears of birds and oviparous quadrupeds; $657^b5$–7 of the eyelids; and $659^b1$–5 of the nostrils.

$691^a25$: 'for the birds, being flyers, sharpness of vision is more useful to their way of life'. A few lines previously, the lack of external ears in both birds and four-footed egg-layers was accounted for by a common hardness of skin; here, a variation between the same groups in hardness of eyes is explained by the differential needs imposed by differences in each animal's way of life (*bios*). Thus in the one case a common hardness of a uniform part explains the shared absence of a structure, and in turn is explained by noting (perhaps more fundamental) differences in way of life. The discussion of variations in keenness of vision in *GA* V. 1, $780^a1$–$781^a11$, does not invoke relative hardness of eyes at all.

$691^a27$–$^b3$: 'the lower jaw'. This passage draws a perceptive distinction between the jaws of human beings and live-bearing four-legged animals, on the one hand, and of fish, birds, and egg-laying four-legged animals on the other; and an equally perceptive adaptive connection between the mammalian jaw and the presence of molars.

$691^b5$–17: 'the river crocodile alone moves the upper'. Another peculiarity of the river crocodile in need of explanation; Aristotle provides a functional one, by noting (correctly—it kills lunged prey by holding them under water until they drown) that the crocodile uses its jaws for grasping and holding its food, not merely for chewing it. Thus he appeals to analogies with other grasping devices (e.g. the crab's claw) to account for its peculiar structure. As is typical, there is a complex web of functional explanation here, since the need to use the jaw in this manner derives from the fact that the crocodile's feet are poorly designed to do so.

$691^b18$–25: 'For the same reason the crabs also move the upper part of their claw, not the lower'. Claws were discussed earlier; at $683^b31$–$684^a1$ claws were cited as a differentia of crabs and crayfish, and as organs for grasping and holding, not locomotion (though lobsters unnaturally so use them ($684^a33$–$^b1$)). It might be argued that this discussion is out of place, since the issue of which part of the crab's claw was the mobile part should have been covered in the discussion of the external parts of the crustacea. But 'For the same reason' indicates that Aristotle is here going for an abstract, functional explanation for a peculiarity common to human hands, crocodile jaws, and crab claws.

The remark about 'all animals able to grasp at their leisure' appears to refer to those which do not feed underwater, but is too vague to interpret with any assurance.

**The Y-recension**

From 691b28 to 695a28 one of the *PA* manuscripts diverges systematically from all the others. This has been handled in a variety of ways over the years. Bekker (1831) devalues its testimony, but continues to use it cautiously as a source for textual reconstruction. Langkavel (1868) prints a text based solely on MS Y, and another based solely on the others, on facing pages. Düring (1943) provides a preliminary version of a new text 'to cleanse the text from all vestiges of the activity of the writer of Y' (196) as well as a carefully argued evaluation of the 'Y-recension' (67–80). Most of its idiosyncrasies are stylistic, and I agree with Düring's conclusion that it has little merit as a source for reconstructing Aristotle's Greek. I have based the translation on Düring's reconstruction, though I have continuously compared this with Bekker. Departures from Düring's version are noted in the Textual Notes at the end of the volume. Peck shows a clear preference for Y in this section of the text.

691b28: 'the snake would seem least of all such animals to have a neck'. A neck is defined as that which is between head and shoulders; given this definition, creatures without shoulders do not have one. The closing, cautious hypothetical perhaps reflects the fact that snakes *do* have windpipes and oesophaguses, so that if one were to define the neck functionally, as the part of the body that protects these organs, then they could be said to have a neck. In fact at 664a14–17 Aristotle claims that *only* animals with these organs, for the sake of which the neck is present, have a neck (though not '*all* and only', so the snakes are not necessarily included). On the other hand, Aristotle sometimes uses the term 'analogue' for items which are structurally completely different but functionally the same (gills and lung, for example), a usage that fits the snake's 'neck' precisely.

692a3–5: 'of necessity . . . owing to this cause . . . also for the better, i.e. for the sake of guarding'. I take 'this cause' to refer to the dispositional character of the backbone: Given a backbone made of flexible cartilaginous materials, it (must) have the capacity to coil. That it has this capacity is also for the sake of the better. The capacity thus *both* is a necessary consequence of the materials out of which the backbone is made *and* is present because it contributes to the snake's well-being.

692a13–15: 'nor any of the others that do not bear live young internally'. Aristotle adds 'internally' to leave room for the vipers (see 676a36–b3), which, like the selachian fishes, are ovo-viviparous. Only true live-bearing animals lactate; in egg-layers the milky nourishment is found inside the egg.

$692^a16$–18: 'in the works on generation . . . in the works on locomotion'. *GA* III. 1–7 provides an account of oviparous reproduction, but the four-legged egg-layers are hardly discussed at all. Likewise, while more than half of *HA* VI (which this remark could just as easily refer to) is devoted to birds and fish, the oviparous quadrupeds and serpents are relegated to a brief appendage to *HA* V at $558^a1$–$^b3$. The claim here is thus true only if it refers to the discussion of the production of eggs and the presence or absence of breasts in general. *IA* 13 discusses the bending of the joints in four-footed creatures; but in the introductions to *De Incessu Animalium* and to *De Motu Animalium*, it is the latter that is said to provide 'the common cause of animal locomotion', so the reference here is also unclear. Cf. *MA* 1, $698^a1$–7, and *IA* 1, $704^a4$–9.

$692^a18$: 'Such animals also have a tail . . . the general cause of this we have stated previously.' $689^b28$–31 gives the general cause; at $690^a1$–4 it is noted that besides this general cause, tails are differentiated for a variety of additional uses.

$692^a20$–4: 'The chameleon'. *HA* II. 11, $503^a15$–$^b28$, constitutes a long discussion of the characteristics of the chameleon, organized atypically for *Historia Animalium*, all of its internal and external parts being discussed together. That it has little flesh and blood is briefly mentioned there, along with a large number of things not taken up here. This is the only reference to the chameleon in *PA*, which is further evidence that our *Historia Animalium*, as Balme suggests, includes information not available when *PA* was composed. On the other hand, with respect to the few facts that *PA* mentions, the different purposes of the two discussions are clearly displayed. *Historia Animalium* notes the small amount of flesh, the small amount of blood, and the ability to change colour, but makes no attempt, as our discussion does, to explain these facts. By contrast, our passage causally links both lack of flesh and colour change to lack of blood; and lack of blood to a timorous soul.

The concluding statement, that 'fear is cooling because of paucity of blood and want of warmth', should be read in conjunction with *An.* I. 1, $403^a3$–$^b19$, which discusses how the naturalist is to study affections such as anger and fear. Since the character of the chameleon's soul is basic in these explanations, they are in line with the methodology defended in *An.* I, and also with *PA* II (see $648^a14$–19 and notes).

## CHAPTER 12

$692^b3$: 'differentiation of one from another is by means of excess or deficiency of their parts, and according to the more and less'. Cf. *PA* I. 4,

$644^a16$–$23$, $644^b7$–$15$ with notes; *HA* I. 1, $486^a16$–$487^a10$, VII (VIII). 1, $588^a25$–$588^b10$. The two examples of differentiation in degree given here are *dimensional*—differences in length and breadth. These are the variations stressed throughout the discussion. They are usually explained by reference to variations in the animals' way of life (*bios*).

$692^b12$–$15$: 'the birds are feathered . . . the feather is split and not alike in form to the whole-winged insects'. As noted previously ($682^b17$ note), the Greek language makes it difficult for Aristotle to express himself precisely here. The word for 'feather' is also used to refer to the wing, and here what I have translated as 'whole-winged' could just as easily be 'whole-feathered'. He is referring to winged insects, and I suppose that he thinks of an insect's wing as somewhat like a feather that lacks a stock running up the centre and that is not split into fibres as a bird's feather is.

$692^b15$–$18$: 'the nature of the beak, an odd and distinctive feature . . . in place of teeth and lips'. As in the discussion of many other parts, the subject is *not* 'the beak', but 'the *nature* of the beak'. The suggestion that it replaces 'teeth and lips', as well as virtually everything said here about variations in beaks due to differences in way of life, can be found in the course of the discussions of nostrils ($659^b4$–$13$), of lips ($659^b20$–$28$), and of 'the nature of the teeth' ($662^a34$–$^b16$). To refer to it as 'distinctive' (*idion*) is to say that it belongs to all and only birds, but not necessarily that it is a defining feature. Cf. *HA* II. 12, $504^a20$–$2$.

$692^b19$: 'Their sense-organs have been spoken of previously.' The reference is to $656^a3$–$661^a30$. Since *PA* is organized 'part by part', each of the sense-organs of birds has been taken up within the general discussion of a particular sense-organ.

$692^b19$–$693^a5$: 'Birds have a neck'. (1) The variations are 'by the more and less'—long/short, thick/thin. (2) The variations in neck and legs are correlated. (3) The causal principle that explains the variations is the 'way of life' (*bios*) of the particular sort of bird—not merely what is *useful* to them, but rather what is useful *given their way of life*. This concept plays a crucial role in these chapters. Today it would be seen as an 'ecological' concept, rather like the modern concept of a 'niche'. It refers to facts about an animal's environment with implications for nutritive, perceptual, and locomotive activities, and thus for the character of the organs that perform these activities. Three passages ($693^a11$–$17$, $694^a1$–$8$, $694^b6$–$22$) display the concept in explanatory action, and I shall leave detailed discussion to the notes on those passages.

$693^a6–10$: 'Those that are web-footed'. The web-footed birds had been excepted from the generalization about long necks going with long legs ($692^b24$), and the exception to the rule is here explained (and a related group of aquatic birds added). Though the term 'way of life' is not explicitly used here, the explanatory pattern is the same—given the way of life of these birds, the long neck is useful for feeding, while short legs are useful for locomotion. Aristotle seems to think it is self-evident that shorter legs are better for swimming—at any rate, he does not justify it.

$693^a10–23$: 'Their beaks differ in accordance with their ways of life.' The only variation explicitly mentioned here is straight/curved; long and flat beaks are discussed, but not short or non-flat ones. In each case the trait is accounted for by noting (1) that it is correlated with a different sort of environment, and (2) that it is of use for procuring food in its environment. In contemporary terms, these are 'adaptation explanations' (cf. Brandon 1985; Lennox 1987*b*). The explicit description of the environment may or may not be free of reference to the animal's diet. To say that a bird is carnivorous, for example, puts all the stress on what it eats, though it implicitly refers to the environment; but to say that a bird lives in a swamp or is a water-dweller puts the stress on abiotic features of the environment, though again a certain sort of diet is implied.

$693^a26–{}^b5$: 'instead of arms and forelimbs, feathered wings—a distinctive part . . . their legs are two, as with mankind'. As with the beak, feathered wings and their peculiar type of bipedalism are distinctive features of birds, and thus, on the *Analytics* model of explanation, should be explained *qua* bird, rather than *qua* egg-layer or blooded. Cf. *HA* II. 12, $503^b32–5$ and next note.

$693^b5$: 'They are two-footed of necessity'. The necessity here referred to is that of *PA* I. 1, $640^a34–6$: 'Since this is what it is to be a human being [substitute bird], on account of this it has these things; for it is not possible to be without these parts.' That is, the aim is to demonstrate that birds must be bipedal from fundamental truths about their being. The substantial being (*ousia*) of birds is said to be 'that of the blooded animals' and 'that of the winged animals', and the ability to fly is later said to be 'in the substantial being for bird'. (This claim leads to a potential confusion; see $693^b26$ and note.) Since it is blooded, it must have four 'points' of locomotion—that is what it is to be blooded. But on the other hand, it is by nature winged. 'So it remains for them to be, of necessity, two-footed; for in this way they will move, with their wings, by means of four points.' QED.

*IA* 6–8 should be consulted for the more basic explanation of why blooded animals have four limbs, and for the differences in the character of the legs in birds and humans. The central argument for the connection between being blooded and having four points of motion runs from 707a6 to 707a23. A number of steps in the argument are obscure, but one thing seems clear: the need for a central origin of motion places an upper limit of four on points of motion. Thus, that the heart is a single, central origin of motion, defended in *PA* III. 4, may underwrite the connection between being blooded and having four points of motion, which in these chapters is simply taken for granted.

There is, however, a fundamental problem with the claim that these two features are aspects of the substantial being of a bird. Both 'blooded' and 'winged' are predicates of wider extension than 'bird'. Thus two features that are not specific to birds are said to be in a bird's substantial being. This violates the principle stated in the theoretical discussion of division at 643a1–5 (which uses being blooded as its example), that a feature in the substantial being of an animal cannot be common to any other (sort of) animal, a principle sanctioned by the *Metaphysics*, where substantial being is denied to what is common (e.g. *Met. Z* 13, 1038b9–12). *PA* I. 3 sanctions such claims if the blood and wings of birds are 'other and different' from those of other blooded and winged animals. Aristotle could avail himself of this solution in our passage, but he does not explicitly do so.

*An. Post.* II. 13, 96a24–38, by contrast, sanctions the practice of grasping the substantial being of a kind by finding two or more features, each of which belongs to a wider kind, but which jointly belong only to the kind in question. But even this method fails in the present case, since the conjunction 'blooded flyer' captures bats as well as birds. Were one to add further differentiae, of course, such as being feathered, or having a beak, the problem would be solved.

693b24–5: 'This is made clear in the works on generation'. Cf. *GA* III. 2, 752a24–b12, esp. b11–12; 753b20–754a20; *HA* VI. 3, 561a4–562b2.

694a1–8: 'it is a necessity for them to be able to fly on account of their way of life; so for the sake of this they have both many feathers and large wings'. Though being a flyer was previously said to be in a bird's substantial being and thus primitive, here the necessity that raptors be 'able to fly' is explained by reference to their peculiar way of life. The conflict, however, is only apparent; it arises because there are two notions of 'being able to fly' used in this chapter. In the fundamental sense, all birds are flyers—the sense in which they have wings. However, there are birds that are good flyers and those that are poor flyers, and Aristotle will use the very same word to refer exclusively to the good flyers. It is in this sense that the way of life of raptors explains why they must be able to fly—though the Greek in no way sanctions it, one can be sympathetic to Ogle's translation 'well-adapted to flight'. This is confirmed by the fact that it is not the possession of feathers and wings *per se* that is here being explained, but rather having *many* feathers and *large* wings.

To what does 'this', in the phrase 'for the sake of this', refer? The two possibilities are 'way of life' and 'being able to fly'. The latter option is preferable, since being an able flyer is the immediate functional result of the parts identified. Taken this way, the explanatory structure is:

> ⟨Excellent⟩ flight belongs to the taloned birds necessarily, because of their ⟨soaring, predatory⟩ way of life; and the abundance of feathers and large wings are present for the sake of ⟨this sort of⟩ flight.

It is noted that other ways of life demand flight as well: hence, the 'raptorial' way of life is a sufficient condition for strong flight, but is not a necessary condition.

694a6: 'not able to fly'. Here again this presumably refers, not only to flightless birds, but to birds that are poor flyers.

694a9: 'on account of the nourishment being used up'. Another instance of the pattern of explanation in which a fixed amount of nutritive material is distributed differently in different kinds in accordance with their way of life. Occasionally, Aristotle makes it explicit that this distribution is under the guidance of the formal nature of the organism in question; cf. 694a14–15 note.

694a12–13: 'Some of the heavy birds have, as protection, instead of wings, things called "spurs" on their legs.' Though the Greek is ambiguous, the point is presumably that instead of using wings to fly away from danger, these heavy birds are provided with spurs to defend themselves—it does not mean that they have spurs *instead of* wings.

694a14–15: 'that is because nature makes nothing superfluous'. That is, the formal natures of the different birds distribute the earthen material for spurs and talons so that no bird has an organ that is either useless or harmful to it. We, following Darwin, may well be inclined to ask, 'Why?' Aristotle, as we have seen, treats this as an inductively grounded presupposition of natural investigation, with no deeper explanation (see *IA* 2, 704b12–18; Lennox 1996*c*; 1997).

The explanations here centre around four features: body size, wing size, spurs, and talons. The good flyers have small bodies and large wings: the bulk of nutrients are supplied to wings and talons. The heavy birds have bulky bodies, small wings, and spurs: the bulk of nutrients goes to the body and the spurs. Spurs are useless to raptors, talons harmful to ground birds—each kind thus has the defensive organ that suits its way of life, and no bird has both, 'because nature makes nothing superfluous'.

$694^a22$–$^b5$: 'It is from necessity that this difference comes about during generation.' This is a rare case in which *PA* goes into the details of how a part comes to be; cf. *PA* III. 2, $663^b20$–$664^a3$. Typically, the language of things 'happening of necessity' refers to the flow of materials needed to *maintain* a particular structure, where there are other structures within the same kind constituted of the same materials but suited to a different way of life. Behind each of *PA*'s explanations of part maintenance there presumably lies an account of the generation of these differentiated structures, although seldom does *Generation of Animals* give us one. *GA* II–III provides detailed discussion of the formation of uniform parts, but only a few sketchy discussions of the formation of non-uniform parts.

There are at least two philosophical questions raised by this passage. (1) What is it that is claimed to happen of necessity? (2) What sort of necessity is here being identified? The reference to the flow of material effluences is syntactically tied to the claimed necessity by an explanatory particle, which strongly suggests that the necessity in question is that of the materials acting according to their material natures. But no particular part is necessitated—Aristotle mentions a variety of possible outcomes.

If this earthen material necessarily flows where it is most useful given a bird's way of life, then the necessity here is conditional. Given that this sort of bird must have weapons, they must be hard; and given that they must be hard, they must be made of earthen material. Thus earthen material must flow to the appropriate place during generation. Such necessity is consistent with these materials not necessitating, on their own, which sort of structure is to be made.

$694^b5$: 'of necessity owing to these causes . . . on account of the better . . . for the sake of their way of life—in order that'. Compare the wording at $692^a3$–$5$. Aristotle is now arguing that these distributions occur as they do *because* it is better that they do. The explanatory hierarchy of *PA* I states that one begins by attempting to show that a part is present because it is necessary if the animal is to be what it is; next, either show that it cannot be otherwise, or at least that it is better the way it is ($640^a33$–$^b1$). We earlier (cf. $693^b5$ and note) saw an explanation of the first sort; the present one is clearly of the third sort. But what of the series of explanatory phrases—'on account of the better', 'for the sake of', 'in order that'? I see these as progressively richer, less abstract versions of a single explanation:

(1) The material between the swimming bird's toes is 'on account of the better'.
(2) That is, it *is for the sake of their way of life* that they have this material used for these particular structures rather than others.
(3) That is, for their *aquatic* way of life—they develop these structures *in order that* they may have feet that are suitable for swimming.

$694^b13–14$: 'nature makes the instruments to fit the function, not the function to fit the instruments'. Compare *PA* I. 5, $645^b14–20$; IV. 10, $687^a10–14$; *GA* I. 3, $716^b17–27$, for similar assertions. The organs are constructed out of the various uniform parts, which are constructed out of the blood; what is optional is the precise choice of organs to be constructed, and thus the shapes, sizes, and combinations of uniform parts to be made in particular locations. It is the functions required by the organism's way of life that put constraints on this process, constraints which define the actions of the formal nature.

$694^b18$: 'yet all birds are composed of the same matter'. One of the few passages in *PA* (cf. $657^a20$) where it is made explicit that the members of the basic kinds share a common material nature, a claim that underwrites the sort of comparisons Aristotle makes here—the material used in *A* for *X* is used in *B* for *Y*. But many questions are left unanswered. Do birds have the same *amount* of matter, or only the same *sort* of matter? One might think that the former claim is absurd (after all, Aristotle knows of both sparrows and ostriches)—but if it does *not* mean this, why does the fact that material is used for long legs mean it cannot also be used for a generous tail?

Perhaps the answer is this. In any sort of bird, there is a fixed *proportion* of a given sort of matter, such as earthen matter. It is capable of being used for legs, feathers, spurs, beak, and so on. How it is used is determined by the bird's formal nature, but the amount available for use is a fixed proportion. Thus, if a certain amount is used for one structure, it limits the amount available for others.

It is noteworthy that two of the explanations in this stretch of text are for the *absence* of a structure that a reasonable person might expect to find, e.g. webbing between the toes of shorebirds.

$695^a10$: 'nature has, by making the ischium long'. Birds' legs consist of three bones. Aristotle makes an analogy between the bone connected to the pelvis and the mammalian ischium, between the second and the femur, and between the third and the tibia. Properly an ischium is a protrusion from the base of the pelvis, not a distinct bone, and modern readers have difficulty with Aristotle's analogy because they recognize, as he apparently did not, that birds also have an ischium. Biomechanically, the bone he is referring to is set at an angle of about 45 degrees forward, ending under the belly, which has the stabilizing effect he describes.

Peck's revision of $695^a10$, to have Aristotle saying that birds lack fore-limbs because they have wings, is unnecessary. All the manuscripts have a text that explains that the bird lacks front legs and therefore has wings instead, which is entirely acceptable. Birds are blooded, and must have four limbs; they lack front legs, but satisfy their blooded nature by having wings instead. The background argument for having wings, that they are flyers ($693^b5$–14), is assumed.

$695^a13$–14: 'The cause owing to which they are two-legged though not upright has been stated.' Cf. $693^b3$–15 and note.

$695^a14$–15: 'The cause of their legs being without flesh is the same as in the four-footed animals, about which we also spoke previously.' Cf. $689^b25$–31 and note.

$695^a17$: 'We will speak about the Libyan ostrich later'. Cf. $697^b13$–26.

$695^a22$: 'the wryneck alone'. This is an interesting remark to compare with *HA* II. 12, $504^a11$–19, on the wryneck. That passage provides much more detail about the bird, all in one stretch of text. It denies that the wryneck is the only bird with the two front/two rear arrangement of toes, insisting that a few birds have this arrangement and giving the wryneck as an example. The data on the wryneck in *Historia Animalium* are not distributed under the discussion of the various parts, many of these data are in need of explanation yet go unmentioned in *PA*, and (as noted) one claim conflicts with *PA* in a way which suggests that *Historia Animalium* represents wider knowledge. All this adds up to support for David Balme's thesis that our text of *Historia Animalium* includes material unfamiliar at the time our *PA* was written (cf. Lennox 1996*a*).

$695^a26$: 'All the birds . . . have testicles . . . internally'. Since Aristotle is pointing us to a causal account, the reference must be to *GA* I. 3, $716^b17$–25, and I. 12, $719^b10$–15. It is to be discussed in the future, relative to the reading of our passage, but this need not mean that it was not yet written; more likely, as other passages suggest, the discussion of the reproductive parts is, pedagogically, to come after the discussion of the parts in general. Cf. $678^a15$–26.

## CHAPTER 13

$695^b1$–2: 'even more stunting of the external parts'. The notion of 'stunting' has only been used once before in *PA* ($671^a16$), in a very different context. The birds, however, were just described as 'dwarf-like' ($695^a8$), and this is no doubt the group to which the fish are being compared. (Both birds and fish are so described at $686^b21$–2.) Being dwarf-like is based on a comparison with the stature of a normal adult human being—the shorter the rear limbs relative to the trunk, the more dwarf-like an animal is. But the stunting here goes beyond the complete absence of rear limbs in fish—they also lack forelimbs and a neck. This may be why the wider concept is used here.

$695^b4$: 'the cause of these things was stated before'. The only discussion in *PA* of this topic follows, in this chapter. It is possible that the reference is to *IA* 18, $714^a20$–$^b8$, in which Aristotle gives an argument for why fish have no feet, and fins in place of wings—other references in *PA* to *IA* have referred to it as a previous discussion, e.g. $690^b14$–16, $692^a16$–18.

$695^b8$: 'torpedo-fishes, stingrays, and any other selachian'. Aristotle's 'selachians' include the modern suborder of that name (the sharks and angelfish) and the modern suborder 'batoidei' (torpedoes, rays, and skates); but he here in effect recognizes the modern distinction by differentiating the latter group from the sharks in virtue of the flattened body and long, thin tail characteristic of many of the batoidei group.

$695^b13$–16: 'In the fishing frogs the opposite situation arises'. That is, instead of there being a sharing of flesh between a flat upper body and a tail, these have a flat, non-fleshy, upper body and a long, fleshy tail. The underlying causal principles are the same, however—the flat upper body in this case is less fleshy than in the torpedoes and rays, the flesh being used on the tail. In all of this discussion the explanations are entirely material—Aristotle gives no teleological reason for these different distributions of fleshy material.

$695^b17$–27: 'the nature of fish, according to the account of their substantial being'. The following four demonstrative explanations are embedded in this remarkably compressed passage, though, in a sense, explanations (1) and (4) establish the same conclusion.

(1) Nature makes nothing useless or pointless. ($695^b19$)
Fish are essentially swimmers. ($695^b18$)

It is pointless for swimmers to have feet. ($695^b21$–3)[3]
Fish lack distinct limbs. ($695^b17$)

(2) Fish are essentially swimmers. ($695^b18$)
Swimmers necessarily have fins. ($695^b20$–1)
Fish have fins. ($695^b21$)

(3) Fish are essentially blooded. ($695^b20$)
Blooded animals move by four points.[4]
Fish have four fins. ($695^b23$)

(4) Fish have four fins. ($695^b23$)
Blooded animals cannot have four fins and any other limbs. ($695^b23$–5)
Fish have no other limbs.

$695^b24$–5: 'The water newts'. The relevance of the exceptional newt in this context may not be immediately obvious. Aristotle has *not*, he is stressing, ruled out the combination of gills and four feet, *provided* the gilled animal lacks fins. Thus nothing he has just said rules out the water newt. He may also be indicating that the water newt's tail fulfils the role of fins.

$695^b27$–$696^a9$: 'Those fish that are not flat . . . have four fins'. There are two obvious problems with this claim. It is manifestly false (many kinds of common Mediterranean fish have three pairs of fins) and is inconsistent with the claim made later that certain fish have only two, or even none at all. The only argument Aristotle gives is that they must have no more than four, since otherwise they would be bloodless.

$696^a5$: 'the kind of mullet found in the lake in Siphae'. Also referred to at *IA* 7, $708^a5$, and *HA* II. 13, $504^b33$.

$696^a10$–15: 'The cause has been stated in the works on locomotion and on the movement of animals.' Cf. *IA* 8, $708^a9$–20, the argument of which is repeated here. Peck and Ogle both suppose that there are two separate treatises being referred to here, but the words do not imply this and nothing in our *De Motu* answers to this reference. The two explanatory principles noted here are the length of the serpent's body and its blooded nature. The first is not *overtly* teleological, but it is the lack of value of four limbs to

[3] Only feet are explicitly mentioned here, as useful for walking (and hence presumably useless for swimming); for the point to be fully convincing Aristotle would have to indicate that all the other sorts of blooded limbs are also not useful for swimming. Penguins would have required a special explanation, presumably.

[4] This premiss is, of course, basic to the entire discussion in *De Incessu Animalium* and has already been introduced in *PA* in discussing the wings of birds, at IV. 12, $693^b6$–8.

such a body that explains their absence, not simply the body's length. On this pattern of explanation in *PA* cf. Gotthelf (1985*b*).

696$^a$26: 'their flat outer edge'. That is, they use the flexible, outer edges of their body like fins.

696$^a$27. 'The torpedo-fish and fishing frog'. The best evidence that these are the genera to which the Greek terms refer comes from *HA* VIII (IX). 37, 620$^b$11–28, where the 'fishing' and 'stinging' feeding behaviour of each is carefully described.

At this point in the text one of the manuscripts (P) reads 'Those that are less flat have fins, e.g. the torpedo-fish and the fishing frog'. Düring (1943: 214–15) provides an elaborate defence of this text (which is adopted by Langkavel and Peck), and also provides a complete reconstruction of the rest of the sentence to fit the facts about these two fish. I have gone with the majority of the manuscripts, which I find can be made tolerably sensible and not obviously inconsistent with the facts.

Let us begin with terminology. The terms 'above' and 'below' mean towards the head and towards the tail, respectively. 'On the back' and 'on the underside' mean just what they say. With regard to fins, I have maintained Aristotle's descriptive terminology in the translation, rather than trying to figure out whether he is discussing dorsal or ventral fins. Given these preliminaries, here is what we are told:

(1) These two types of fish have a pair of fins on the back, relatively toward the tail end, because the front end is flat—this is correct.
(2) They have fins on the underside of their body, relatively towards the head, but in return for having the under-fins forward, they are smaller than the fins on the back. This clearly fits the fishing frog, but not the torpedo-rays I have examined.
(3) The torpedo-fish has two fins towards the tail, but does not use them as fins, since it uses its flat body for swimming—this claim is restricted to the torpedo-fish, and is also accurate.

Ogle (1882: 247 n. 5) is critical of Aristotle for 'erroneously' classifying the fishing frog with the selachia simply because of 'the somewhat ray-like form of this fish . . . the semi-cartilaginous character of its skeleton . . . and its naked skin'. Wherein lies the error? Aristotle recognizes that it reproduces differently from sharks and rays (cf. *GA* III. 3, 754$^a$25–32; *HA* II. 13, 505$^b$4), and notes that its gills are covered (but by smooth skin, unlike the oviparous fishes: *HA* II. 13, 505$^a$6–7), but the above characteristics nevertheless qualify it for membership in his selachian group.

696$^a$32. 'The parts on the head and the sense-receptors have been spoken of previously.' Cf. *PA* II. 13, 658$^{a}$4–11 (eyes); 16, 659$^{b}$14–16 (no nostrils); 17, 660$^{b}$12–661$^{a}$6 (tongue); III. 1, 662$^{a}$7–16 (teeth); 662$^{a}$31–4 (mouth).

696$^{b}$1–2: 'the cause owing to which they have this feature has been stated in the works on respiration'. Cf. *Resp.* 10. (=*Juv.* 16) 476$^{a}$1–15; *PA* III. 6, 669$^{a}$4–5, also refers elsewhere for the explanation of gills. Briefly, Aristotle argues that gills are used to cool the region around the heart with water, as lungs do with air; and since one organ for cooling is sufficient, animals will have one or the other (since nature does nothing in vain).

696$^{b}$3–4: 'all the selachians, since they are cartilaginous, lack coverings'. Another instance of *Historia Animalium* containing data inconsistent with *PA*; the fishing frog, both here and in *Historia Animalium*, is included among the selachians; but at *HA* II. 13, 505$^{a}$6–7, Aristotle notes (correctly) that their gills are covered, though *not* with bony substance (see 696$^{a}$27 note). On gill-coverings generally, see *HA* II. 13, 504$^{b}$35–505$^{a}$8.

696$^{b}$14–16: 'For the precise details, one should study with the help of the dissections of these things and the enquiries about animals.' This passage shows how difficult it is to be confident about the nature of these references. The phrase 'the dissections of these things' suggests, not a collection of drawings, but actual dissections; but one cannot be sure that the reference is not to drawings. *HA* II. 13, 505$^{a}$8–18, does in fact give us more precise and detailed information about the distribution of the different number of gills.

696$^{b}$17: 'A cause of the number of gills being larger or smaller is a larger or smaller amount of heat in the heart'. The gills are the analogue to the lung; their function is to provide water-cooling for the heart, just as the lung provides air-cooling. That is the unexpressed reason why those with more heat must have more gills. The explicit argument is compressed syllogistic:

More/double gills provide rapid and stronger movement.
Rapid and stronger movement provides more cooling.
<u>More cooling is needed for those with more heat in the heart.</u>
(C) Hence those with more heat have more/double gills.

The basic cause of differences in gills is thus variation in the heat of the heart. Does Aristotle have direct evidence for this, or is he (circularly) inferring the heat of a particular fish's heart from the number of its gills? This passage suggests a third alternative: he is supporting a theory of variations of heat in the hearts of fish with indirect evidence independent of the number of gills a fish possesses. In the last sentence in this discussion, for example, it is noted that serpetine fish are able to live out of water longer than most fish. If fish are water-cooled, this fact suggests (given Aristotle's physiology) that serpentine fish have cooler hearts. But the ability to live for a long time out of water is strongly correlated with fewer gills, and this correlation supports (in a non-circular way) the theory that fish have fewer gills *because* they have less heat in the heart.

696$^b$27–8: 'the dolphins and selachians . . . turn belly up to seize their nourishment . . . not only for the sake of the preservation of the other animals'. This is a much-discussed example (cf. Balme 1987*c*: 278–9; 1987*d*: 299; Kullmann 1985: 173; Lennox 1997). It is rare for Aristotle to account for the feature of an animal by pointing to the way in which the animal benefits *other* animals (cf. *Pol.* I. 8, 1256$^b$15–25, for another example), since his basic teleological axiom is that nature does what is best among the possibilities for *the animal's own being*. On the other hand, the *negative* axiom, that nature does nothing in vain, is cited in the *Politics* passage to explain the existence of other animals for our use.

Two facts about this passage soften the conflict somewhat. First, Aristotle mentions two causal factors related to turning belly up to feed (which is *not*, in fact, typical of selachians or dolphins) that are *not* other-benefiting—it controls harmful gluttony and it is dictated by the nature of their snout (see next note). Second, the explanation opens with the unusually tentative phrase 'nature *appears* to do this'.

Neither of these facts, however, entirely resolves the conflict between this explanation and the theory of teleological explanation that Aristotle explicitly defends. Balme suggests that 'this account replaces a faulty teleological one [the "other-benefiting" one] with a proper ["self-benefiting"] one' (1987*c*: 279), or is 'a polite correction' (1987*b*: 299). But the form of expression suggests addition, not replacement; and the use of the verb 'to appear' covers both the 'faulty' and the 'proper' explanations.

Aristotle does occasionally mention two ways in which things may be said to be 'for the sake of something': where that something is the *beneficiary* of an action, and where it is the *goal* of an action (cf. *Phys.* II. 2, 194$^a$34–6, citing *On Philosophy* for the distinction; *An.* II. 4, 415$^b$2–3, $^b$21–2; *Met.* $\Lambda$ 7, 1072$^b$2–3). These may, of course, coincide, but they need not—the goal of the proper functioning of the heart is the maintenance of its possessor, and its possessor is the beneficiary of that proper functioning; but the rolling of the selachians to eat may *benefit* other fish while having prevention of selachian gluttony as its *goal*. Had Aristotle indicated such a distinction here, this would neatly solve the problem; unfortunately he does not.

696$^b$33–5: 'the nature of the snout'. The Greek here can be taken in a variety of ways. The phrase rendered 'on the underside' could refer to the underside of the animal in question, or of the snout. Aristotle's final point, that the shape of the snout means that it is not easily opened, suggests that the reference is specifically to the underside of the snout.

Though this is a reasonable description of the selachians, it is not of dolphins. Frantzius (1853: 117, 321) regarded it as an interpolation, and he was followed by Ogle; to that Meyer (1855: 289) rightly objected that the same claim is made at *HA* VII (VIII). 2, $591^b25–30$ (in fact, the claim is expanded to include all the cetaceans; cf. Balme 1991: 94–5 n. a). Neither passage, however, gives enough detail for us to be confident about Aristotle's meaning, and since dolphins were a commonplace in Greek figurative painting, it is unlikely that Aristotle would have been deeply confused about the placement of their mouth.

$697^a8–9$: 'on account of their being cartilaginous'. Much of the explanation is left implicit, based on the discussion of bone and cartilage at *PA* II. 9, $655^a23–655^b2$. Cartilage is less earthen than bone, and Aristotle is claiming that, by comparison with bony fishes, this provides some excess of earthen material to be transferred to the skin.

$697^a9$. 'None of the fish has testicles'. Cf. *GA* I. 6, $717^b34–718^a17$, one of the most interesting passages in the corpus concerning the distinction between explanation by reference to 'the necessary' and by reference to 'the better'.

$697^a17–20$: 'have a pipe on account of having a lung'. The word translated 'pipe' has also been translated 'flute' (cf. $687^a13$) and 'pipe' for the funnel of the cuttlefish (cf. $679^a3$). Aristotle's explanation for cetaceans having one is based on a surprising anatomical misunderstanding; the blowhole of cetaceans is connected to the windpipe, and is used for breathing, not expelling the water taken in when eating. Since dolphins were standard dietary fare in classical Athens, one would have expected Aristotle to have good anatomical data on them. Ogle (1882: 252 nn. 38, 39) conveniently reviews Aristotle's otherwise impressive knowledge of these animals.

$697^a21$. 'Gills . . . owing to which cause . . . in the works on respiration'. Cf. the notes to $696^b1–2$ and $669^a4–5$.

$697^a24–5$: 'It is placed in front of their brain'. For Aristotle the brain is naturally continuous with the marrow in the spinal column, for thermodynamic reasons; cf. *PA* II. 7, $652^a24–652^b1$.

## 697a28–697b29

The entire investigation ends by looking at various blooded animals that do not fit naturally into the four extensive kinds recognized throughout *PA* II–IV. In *Historia Animalium* the cetaceans are treated as a separate 'extensive kind', but they are not in *PA*. This decision would be based on concluding that there were many forms of cetacea varying in their parts and ways of life only in degree. Their inclusion in this closing discussion strongly indicates that the author of *PA* II–IV has *not* made this decision. This once again suggests a fundamental advance in *Historia Animalium* which would have significantly altered the explanatory structure of *PA*.

From the standpoint of classification, how does Aristotle understand these animals? The most extensive discussion of this issue in Aristotle is *HA* VII (VIII). 1–2, 588a33–590a18. As Balme (1987*b*: 85–6) points out, the approach taken there is to distinguish the various respects in which an animal is designated as, for example, a water-dweller. A water-dweller in the unqualified sense would live its entire life in the water, cool itself by water, and pursue its food in the water. Dolphins are water-dwellers in the first and third respects, seals only in the third, fish in all three respects. In essence, one would treat a cetacean's way of life as water-dweller$_{1,3}$/land dweller$_2$. This does not, however, determine their classification, since Aristotle recognized that extensive kinds are based on many differentiae related to all aspects of anatomy and behaviour.

Lloyd suggests that Aristotle's intense focus on these 'ambiguous' animals shows a pervasive and important debt on Aristotle's part to the folklore of his culture (Lloyd 1983: 44–52). This claim has been critically evaluated in Parker (1984) 183–5, and Lennox (1985*d*). Aristotle is dealing with legitimately unusual animals here, and is doing so by making explicit use of his philosophical systematics.

697b1: 'tending . . . towards both'. As I noted earlier (681b1–2 note), neither Peck's 'to dualize' nor Ogle's 'to lie half way between' captures the nuances of *epamphoterizein*; nor does the suggestion of Pellegrin that in Aristotle's biology the term 'designates animals that belong to an intermediate group' (1986: 185 n. 15). There is no suggestion in any of these cases that there is a group intermediate between, say, 'water-dweller' and 'land-dweller', to which the cetaceans belong. Rather, Aristotle always treats *ta epamphoterizonta* as distinctive groups. In fact, in *Historia Animalium* the cetaceans are elevated to the status of an extensive kind on a par with bird and fish (cf. *HA* I. 6, 490b9; II. 15, 505b30), though not in *PA*.

CHAPTER 14

$697^b13$. 'the Libyan ostrich'. For other references in Greek literature cf. Pollard (1977) 86; Thompson (1936) 159–60.

$697^b29$: 'the next step is to go through the facts about their generation'. Throughout *PA* there have been references forward to *Generation of Animals*. The manner of reference here suggests a connected series of courses. Moreover, studying the generation of the parts after reviewing their actual nature also accords with the recommendations of *PA* I. 1, $640^a11$–$^b4$, about the order of a zoological investigation.

# TEXTUAL NOTES

In the main I have adopted the Berlin Academy text prepared by I. Bekker as my base text. However, for reasons explained in the commentary I have followed the text prepared by I. Düring for $691^b28$–$695^a28$ (while continuing to consult Bekker). I have also regularly consulted the texts of Langkavel in the Teubner series, and Peck 's Loeb Classical Library edition.

Below I indicate those places where I depart from the base text, and give some indication of the grounds for so doing. For further discussion, see the notes.

## BOOK ONE

$642^b8$: Delete *ἄπουν*, with Ogle and Peck.

$645^a8$: Read *ὁμοίως* with all manuscripts.

## BOOK TWO

$649^a18$: Read *οὐ φύσις τις ἀλλά* with EJY. Bekker reads *φύσις τις ἀλλ' οὐ* with PSU.

$650^a8$: Read *καὶ αὕτη ὥσπερ* with Barnes.

$655^b31$: Read *ἀφιᾶσι* with SUY and Michael (cf. $679^a2$). Düring notes that the transition to future is just possible here, but the manuscript authority is about equal and the present indicative is more natural.

$656^a26$: Read *ἰδιώτερον* with EPSYU. As Düring comments, LSJ cites this and $658^b33$ (where it is also a minority variant) as support for the existence of *ἰδιαίτερον*, apparently unaware that it is unsupported by most manuscripts.

$658^b18$: Read *ἑργμάτων*, with Peck. Dr Friederike Berger kindly checked the microfilms of the manuscripts in the Aristoteles-Archiv of the Freie Universität in Berlin and reports (private communication) that Bekker's reading, ἐργμάτων, is found in EPSUYZ. Peck's suggestion gives a better sense, and as the breathing-marks have no ancient authority, I have followed it. Langkavel follows Bekker; Louis and Düring read ἐρυμάτων, which Dr Berger reports in one manuscript (Paris 1921 (m)), and which is found in the Aldine and Basel editions (Gotthelf, private communication). Bekker attributes it to unspecified editors, one of whom is presumably the editor of the 1550 Basel edition, from which he worked. Langkavel (pp. xi–xii) reports marginal notes in an Aldine edition owned by one G. A. Becker which record the reading ἐρυμάτων in one manuscript.

659$^{a}$20: Read παλιμπυγηδόν. The reading in Bekker, πάλιν πυγηδόν, is apparently a typographical error—see the note in Langkavel (1868) xxxi.

659$^{b}$33: Read τῷ with ESYZ. Bekker has τό.

## BOOK THREE

663$^{b}$17: Omit the ὄν with EPYZ—cf. *HA* 500$^{a}$6–10.

666$^{b}$7–8: Read παρεγκλίνουσα with most manuscripts, rather than Bekker's παρεκκλίνουσα. Düring points to *HA* 496$^{a}$16 and 498$^{a}$16, which have the same participle and adverbial accusative to make identical points.

666$^{b}$29: Read διαφόρου with most manuscripts; PZ have διαφυοῦς, which Bekker prints.

667$^{a}$6: Read διαίρεσιν with ESUYZ. Bekker follows P, which has διάρθρωσιν.

669$^{a}$10: Read τῶν with EPUY rather than τόν (Bekker and Langkavel).

669$^{a}$28: Read μεγάλην ἵστασθαι, following Düring (1943: 164), rather than Bekker's suggestion μεγάλα διίστασθαι (followed by Peck).

670$^{a}$2: Read εἶναι ἀναγκαῖον with EPYZ; ἀναγκαῖον omitted by Bekker.

670$^{a}$6: Read καὶ καθάπερ with PZ.

670$^{b}$7: Read πλήρης with EYZ. Bekker reads πλήρη.

673ᵃ17: Read ἀρκαδίαν with Z. The grounds for reading it are rehearsed in Peck (1961) 282 n. b.

674ᵃ5: Read τήν with ESUYZ. Peck and Langkavel correctly read it, and Düring defends it and shows that Michael read it. Bekker uncharacteristically goes with P's τά.

674ᵃ28: Read ὗς, πλὴν εἰ μή, suggested by Bussemaker. Bekker writes ὗς, εἰ μή.

675ᵇ15: Read ἱστάμενον with ESUY, rather than Bekker's ἱσταμένῳ, found in PZ.

## BOOK FOUR

677ᵃ13: Read εἶναι with the EPSUY, *contra* Bekker, who has ἐστιν. Düring makes the case well.

677ᵃ18–19: Read τοιαῦτα rather than Bekker's διὰ ταῦτα.

677ᵇ16, ᵇ34: Read ἦρκται following Düring (1943) 174–5, instead of Bekker's ἤρτηται.

680ᵇ4: Read πάντες after περιττά with PSUY.

680ᵇ26–7: Read αὐτοῖς with EP. SU have τούτοις, and Bekker has αὐτούς. Either of the manuscript readings is fine, as Düring shows.

683ᵇ25: Read καὶ πορευτικὰ πάντα with SUY.

684ᵃ5: Read τόν. As Peck notes, Bekker erroneously prints τό instead of τόν (see Langkavel 1868: p. L).

684ᵃ18: Read ὅτι μή with SU. See Düring (1943) 184 for a defence.

687ᵇ6: Omit the καί found in Bekker between εἶδος and τῇ φύσει. Cf. Düring (1943) 191.

690b17: Read *ᾠοτόκοις* (PUY, Michael, Düring 1943: 195) rather than *ζῳοτόκοις* (Bekker, Langkavel, Peck).

**From 691b28 to 695a28 take Düring (1943) as the base text.**

692b18: Read *χειλῶν* with QUZY.

694a23–4: Read *ἔξορμον* with the manuscripts.

694b26–7: Read *πλατύτερον . . . πέτανται* with PQSU. Bekker and Düring uncharacteristically go with Y here, reading *παχύτερον*.

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# ENGLISH–GREEK GLOSSARY

| | | |
|---|---|---|
| abstract (adj.) | *ex aphaireseōs* | ἐξ ἀφαιρέσεως |
| account (n.) | *logos* | λόγος |
| accuracy | *akribeia* | ἀκρίβεια |
| action | *praxis* | πρᾶξις |
| activity | *ergasia* | ἐργασία |
| actuality | *energeia* | ἐνέργεια |
| actuality, complete | *entelecheia* | ἐντελέχεια |
| actually | *energeiai, kat' energeian* | ἐνεργείᾳ, κατ' ἐνέργειαν |
| add | *hypographein* | ὑπογράφειν |
| advantage | *ophelos* | ὄφελος |
| affection | *pathēma, pathos* | πάθημα, πάθος |
| air | *aēr* | ἀήρ |
| alteration | *alloiōsis* | ἀλλοίωσις |
| always | *aei* | ἀεί |
| analogous(ly) | *analogon* | ἀνάλογον |
| analogy | *analogia* | ἀναλογία |
| ancients | *archaioi* | ἀρχαιοί |
| animal | *zōion* | ζῷον |
| animals with a complete set of teeth | *amphōdonta* | ἀμφώδοντα |
| aorta | *aortē* | ἀορτή |
| appear, be apparent | *phainesthai* | φαίνεσθαι |
| appendage | *apophuas* | ἀποφυάς |
| appraise | *apodeiknunai* | ἀποδεικνῦναι |
| appropriate | *oikeios* | οἰκεῖος |
| appropriately | *orthōs* | ὀρθῶς |
| art | *technē* | τέχνη |
| artefacts | *technasta* | τεχναστά |
| articulate sound | *gramma* | γράμμα |
| assume | *hupolambanein* | ὑπολαμβάνειν |
| attribute | *sumbebēkos* | συμβεβηκός |
| attribute, proper | *kath' hauto sumbebēkos* | καθ' αὑτὸ συμβεβηκός |
| backbone | *rhachis* | ῥαχίς |
| beak | *rhunchos* | ῥύγχος |
| because | *dia* | διά |
| begin | *archein* | ἄρχειν |
| best | *beltiston* | βέλτιστον |
| better | *beltion* | βέλτιον |
| between | *metaxu* | μεταξύ |
| bile | *cholē* | χολή |
| bile, without | *achola* | ἄχολα |
| bipartite | *dimerēs* | διμερής |

| | | |
|---|---|---|
| bird | *ornis* | ὄρνις |
| bladder | *kustis* | κύστις |
| blend (n.) | *krāsis* | κρᾶσις |
| blood | *haima* | αἷμα |
| blooded | *enhaimos* | ἔναιμος |
| bloodless | *anhaimos* | ἄναιμος |
| bloodless character | *anhaimotēs* | ἀναιμότης |
| blood vessel | *phleps* | φλέψ |
| bodily | *sōmatōdēs* | σωματωδής |
| body | *sōma* | σῶμα |
| bone | *ostoun* | ὀστοῦν |
| brain | *enkephalos* | ἐγκέφαλος |
| breasts | *mastoi* | μαστοί |
| breath | *pneuma* | πνεῦμα |
| breathing | *anapnoē* | ἀναπνοή |
| carnivorous | *sarkophagos* | σαρκοφάγος |
| cause (n.) | *aitia* | αἰτία |
| chance (n.) | *tuchē* | τύχη |
| chance (adj.) | *ek tou tuchontos* | ἐκ τοῦ τυχόντος |
| change (n.) | *kinēsis* | κίνησις |
| character | *ēthos* | ἦθος |
| chest cavity | *thōrax* | θώραξ |
| choice | *prohaeresis* | προαίρεσις |
| coition | *ocheia* | ὀχεία |
| cold | *psuchros* | ψυχρός |
| coldness | *psuchrotēs* | ψυχρότης |
| common | *koinos* | κοινός |
| common sense, the | *koinē aisthēsis* | κοινὴ αἴσθησις |
| complete | *teleios* | τέλειος |
| complex (n.) | *sumplexis* | σύμπλεξις |
| composite | *sunthetos*, *sunthesis* | συνθετός, σύνθεσις |
| composition | *sunthesis*, *sustasis* | σύνθεσις. σύστασις |
| concoct | *pettein* | πέττειν |
| concocted | *pettomenon* | πεττόμενον |
| concoction | *pepsis* | πέψις |
| conditionally (i.e. conditionally necessary) | *ex hupotheseōs* | ἐξ ὑποθέσεως |
| configuration | *schēma* | σχῆμα |
| conjunction | *sundesmos*, *sunthesis* | συνδεσμός, σύνθεσις |
| consideration of cases | *epagōgē* | ἐπαγωγή |
| constitute, be constituted | *sunhistanai* | συνιστάναι |
| constituted | *sunhistamenos* | συνιστάμενος |
| constitution | *sustasis* | σύστασις |
| constitution, bodily | *sōmatos krāsis* | σώματος κρᾶσις |
| continuous | *sunechēs* | συνεχής |
| convert (v.) | *antistrephein* | ἀντιστρέφειν |

| | | |
|---|---|---|
| corpse | *tethneōs* | τεθνεώς |
| correctly | *orthōs* | ὀρθῶς |
| correlative | *pros allēla* | πρὸς ἄλληλα |
| courage | *andreia* | ἀνδρεία |
| craft (v.) | *dēmiourgein* | δημιουργεῖν |
| creepers | *herpustika* | ἑρπυστικά |
| crocodile | *krokodeilos* | κροκόδειλος |
| crook-taloned | *gampsōnux* | γαμψῶνυξ |
| deep-sea dweller | *pelagios* | πελάγιος |
| deer | *elaphos* | ἔλαφος |
| define | *horizein* | ὁρίζειν |
| definite | *hōrismenon* | ὡρισμένον |
| degree | *huperochē* | ὑπεροχή |
| degree, by | *kath' huperochēn* | καθ' ὑπεροχήν |
| demarcate | *horizein* | ὁρίζειν |
| demonstration | *apodeixis* | ἀπόδειξις |
| derivative | *allotrios* | ἀλλότριος |
| desire | *epithumia* | ἐπιθυμία |
| determine | *diorizein* | διορίζειν |
| diaphragm | *hupozōma* | ὑπόζωμα |
| dichotomize | *dichotomein* | διχοτομεῖν |
| dichotomy, dichotomous division | *dichotomia* | διχοτομία |
| differ | *diapherein* | διαφέρειν |
| difference, differentiation | *diaphora* | διαφορά |
| difference, contrary | *antikeimenē diaphora* | ἀντικειμένη διαφορά |
| difference, final | *eschatē diaphora* | ἐσχάτη διαφορά |
| discerning | *phronimos* | φρόνιμος |
| discernment | *phronēsis* | φρόνησις |
| discover | *heuriskein* | εὑρίσκειν |
| disposition | *diathesis* | διάθεσις |
| dissection | *anatomē* | ἀνατομή |
| distension | *diastasis* | διάστασις |
| distinctive | *idion* | ἴδιον |
| divide | *diairein* | διαιρεῖν |
| divine | *theios* | θεῖος |
| division | *diastasis, diairesis* | διάστασις, διαίρεσις |
| double-natured | *diphuēs* | διφυής |
| draw | *hupographein* | ὑπογράφειν |
| dry | *xēron* | ξηρόν |
| due to | *dia* | διά |
| earth | *gē* | γῆ |
| earthen | *geōdēs* | γεώδης |
| educatedness | *paideia* | παιδεία |
| egg | *ōion* | ᾠόν |
| egg-laying animals | *ōiotoka* | ᾠοτόκα |

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|---|---|---|
| element | *stoicheion* | στοιχεῖον |
| elephant | *elephas* | ἐλέφας |
| embrace (v.) | *periechein* | περιέχειν |
| embryo | *embruon* | ἔμβρυον |
| end (n.) | *telos* | τέλος |
| enquiry | *historia* | ἱστορία |
| ensouled things | *empsucha* | ἔμψυχα |
| entire universe, the | *to pan* | τὸ πᾶν |
| ephemeral animals | *ephēmera* [*zōia*] | ἐφήμερα [ζῷα] |
| epiglottis | *epiglōssis* | ἐπίγλωσσις |
| equal (in number) | *isos* | ἴσος |
| equipment | *skeuē* | σκεύη |
| esteem, of greater | *timiōteros* | τιμιώτερος |
| esteem, of less | *atimoteros* | ἀτιμότερος |
| eternal, eternity | *aidion* | ἀΐδιον |
| examination | *episkepsis, skepsis* | ἐπίσκεψις, σκέψις |
| examine | *skeptein* | σκέπτειν |
| examined, to be | *episkepteos* | ἐπισκεπτέος |
| excess | *huperochē* | ὑπεροχή |
| explain | *deiknunai* | δεικνῦναι |
| extreme, extremity | *to eschaton* | τό ἔσχατον |
| eye | *ophthalmos* | ὀφθαλμός |
| face | *prosōpon* | πρόσωπον |
| fat (n.) | *piōn* | πίων |
| fat, hard | *stear* | στέαρ |
| fat, soft | *pimelē* | πιμελή |
| feather | *pteron* | πτερόν |
| female | *thēlus* | θῆλυς |
| fibres | *ines* | ἶνες |
| figure | *schēma* | σχῆμα |
| final | *eschatos, teleutaios* | ἔσχατος, τελευταῖος |
| finger | *daktulos* | δάκτυλος |
| fire | *pur* | πῦρ |
| first | *prōton* | πρῶτον |
| fish | *ichthus* | ἰχθύς |
| flesh | *sarx* | σάρξ |
| fleshy, flesh-like | *sarkōdēs* | σαρκώδης |
| fluctuating | *allot' allōs* | ἄλλοτ' ἄλλως |
| flute | *aulos* | αὐλός |
| flyers | *ptēna* | πτηνά |
| foot | *pous* | πούς |
| footless | *apous* | ἄπους |
| form | *eidos* | εἶδος |
| for the sake of | *charin* | χάριν |
| for the sake of something | *heneka tou* | ἕνεκά του |
| four-footed animals | *tetrapoda* | τετράποδα |

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|---|---|---|
| friendship | *philia* | φιλία |
| from outside, from without | *thurathen* | θύραθεν |
| function (n.) | *ergon* | ἔργον |
| fuse together | *sumphuein* | συμφύειν |
| general (adj.) | *katholou* | καθόλου |
| generally | *holōs, katholou* | ὅλως, καθόλου |
| generation | *genesis* | γένεσις |
| gills | *branchia* | βράγχια |
| good (n.) | *to kalon* | τὸ καλόν |
| grasp (v.) | *lambanein* | λαμβάνειν |
| growth | *auxēsis* | αὔξησις |
| grow together | *sumphuein* | συμφύειν |
| hand | *cheir* | χείρ |
| haphazard | *tuchon* | τυχόν |
| hard | *sklēros* | σκληρός |
| hard scale | *pholis* | φολίς |
| hard-scaled animals | *pholidōta* | φολιδωτά |
| hard-shelled animals | *ostrakoderma, ostreia* | ὀστρακόδερμα, ὄστρεια |
| head | *kephalē* | κεφαλή |
| health | *hugieia* | ὑγίεια |
| hearing | *akoē* | ἀκοή |
| heart | *kardia* | καρδία |
| heat | *thermotēs* | θερμότης |
| heaven | *ouranos* | οὐρανός |
| heaviness | *baros* | βάρος |
| hole-dweller | *trōglodutēs* | τρωγλοδύτης |
| homonymously | *homōnumōs* | ὁμωνύμως |
| honourable, more | *timiōteros* | τιμιώτερος |
| horn | *keras* | κέρας |
| horn-bearing animal | *keratophoron* | κερατοφόρον |
| hot | *thermos* | θερμός |
| human being | *anthrōpos* | ἄνθρωπος |
| impede | *empodizein* | ἐμποδίζειν |
| impossible | *adunaton* | ἀδύνατον |
| inborn | *sumphutos* | σύμφυτος |
| incidental(ly) | *kata sumbebēkos* | κατὰ συμβεβηκός |
| indivisible | *atomos* | ἄτομος |
| in order that | *hina* | ἵνα |
| insects | *entoma* | ἔντομα |
| instrument | *organon* | ὄργανον |
| instrumental | *organikon* | ὀργανικόν |
| intercourse | *sunduasmos* | συνδυασμός |
| interweaving | *sumplokē* | συμπλοκή |
| intestine | *enteron* | ἔντερον |
| in vain | *matēn* | μάτην |

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|---|---|---|
| investigation | *methodos* | μέθοδος |
| investigation, the way of, the mode of | *tropos tēs methodou* | τρόπος τῆς μεθόδου |
| in virtue of | *kata* | κατά |
| in virtue of itself | *kath' hauto* | καθ' αὑτό |
| judge (v.) | *krinein* | κρίνειν |
| kidney | *nephros* | νεφρός |
| kind (n.) | *genos* | γένος |
| kind, extensive | *megiston genos* | μέγιστον γένος |
| know | *eidenai, gnōrizein* | εἰδέναι, γνωρίζειν |
| knowledge | *gnōsis* | γνῶσις |
| knuckle-bone | *astragalos* | ἀστράγαλος |
| land-dweller | *pezon* | πεζόν |
| language | *dialektos* | διάλεκτος |
| larynx | *pharunx* | φάρυγξ |
| last | *eschatos, teleutaios* | ἔσχατος, τελευταῖος |
| laughter | *gelōs* | γέλως |
| left (as opposed to right) | *aristeros* | ἀριστερός |
| leg | *skelos* | σκέλος |
| less valuable | *atimoteron* | ἀτιμότερον |
| life, way of | *bios* | βίος |
| likeness | *eikōn* | εἰκών |
| limb | *kōlon* | κῶλον |
| limit (n.) | *peras* | πέρας |
| live-bearing | *zōiotokos* | ζῳοτόκος |
| liver | *hēpar* | ἧπαρ |
| location | *topos, chōra* | τόπος, χώρα |
| locomotion | *phora, poreia* | φορά, πορεία |
| locomotive (adj.) | *poreutikos* | πορευτικός |
| lung | *pleumōn* | πλεύμων |
| male | *arrhēn* | ἄρρην |
| mammae | *mastoi* | μαστοί |
| mankind | *anthrōpos* | ἄνθρωπος |
| many (n.) | *hoi polloi* | οἱ πολλοί |
| many-footed | *polupous* | πολύπους |
| many-toed | *poluschidēs* | πολυσχιδής |
| many-winged | *poluptera* | πολύπτερα |
| marrow | *muelos* | μυελός |
| matter | *hulē* | ὕλη |
| menstrual discharges | *gunaikeia* | γυναικεῖα |
| mesentery | *mesenterion* | μεσεντέριον |
| midriffs | *phrenes* | φρένες |
| milk | *gala* | γάλα |
| mixture | *mikton* | μικτόν |
| moist | *hugros* | ὑγρός |
| moistness | *hugrotēs* | ὑγρότης |

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|---|---|---|
| more and less, the | *to mallon kai hētton* | τὸ μᾶλλον καὶ ἧττον |
| motion | *kinēsis* | κίνησις |
| mouth | *stoma* | στόμα |
| movement(s) | *kinēsis* | κίνησις |
| nameless | *anōnumos* | ἀνώνυμος |
| naturally present | *sumphutos* | σύμφυτος |
| natural philosopher | *phusikos* | φυσικός |
| natural philosophers | *phusiologoi* | φυσιόλογοι |
| natural science | *phusikē epistēmē* | φυσικὴ ἐπιστήμη |
| nature | *phusis* | φύσις |
| nature, by | *phusei* | φύσει |
| necessary | *anankaios* | ἀναγκαῖος |
| necessity | *anankē* | ἀνάγκη |
| neck | *auchēn* | αὐχήν |
| need (n.) | *chreia* | χρεία |
| non-uniform | *anhomoiomeres* | ἀνομοιομερές |
| nose | *rhis* | ῥίς |
| nostril | *muktēr* | μυκτήρ |
| nourishment | *trophē* | τροφή |
| number | *arithmos* | ἀριθμός |
| nutrients, nutrition | *trophē* | τροφή |
| octopus | *polupous* | πολύπους |
| oesophagus | *oisophagos* | οἰσοφάγος |
| offspring, the | *ta gennōmena* | τὰ γεννώμενα |
| omentum | *epiploon* | ἐπίπλοον |
| on account of | *dia* | διά |
| one by one | *kath' hekaston* | καθ' ἕκαστον |
| operation | *ergasia* | ἐργασία |
| opposite | *enantios* | ἐναντίος |
| opposites | *antikeimena* | ἀντικείμενα |
| opposition | *enantiōsis* | ἐναντίωσις |
| ordered | *tetagmenos* | τεταγμένος |
| origin | *archē* | ἀρχή |
| originate | *archein* | ἄρχειν |
| outermost | *eschatos* | ἔσχατος |
| outlet | *exodos* | ἔξοδος |
| owing to | *dia* | διά |
| oyster | *ostreion* | ὄστρειον |
| part | *morion, meros* | μόριον, μέρος |
| participate in, partake of | *metechein* | μετέχειν |
| participation | *to metechein* | τὸ μετέχειν |
| particular (n.) | *to kath' hekaston* | τὸ καθ' ἕκαστον |
| perceptible objects | *aisthēta* | αἰσθητά |
| perception, perceptive ability | *aisthēsis* | αἴσθησις |
| perceptual phenomena | *phanera kata tēn aisthēsin* | φανερά κατὰ τὴν αἴσθησιν |

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|---|---|---|
| perishing | *phthora* | φθορά |
| phenomenon | *phainomenon* | φαινόμενον |
| philosophize | *philosophein* | φιλοσοφεῖν |
| philosophy | *philosophia* | φιλοσοφία |
| pipe | *aulos* | αὐλός |
| place | *chōra* | χώρα |
| plants | *phuta* | φυτά |
| point | *sēmeion* | σημεῖον |
| possibilities | *endechomena* | ἐνδεχόμενα |
| potential, potency, power | *dunamis* | δύναμις |
| predicate (n.) | *katēgoria* | κατηγορία |
| preparation | *ergasia* | ἐργασία |
| preservation | *sōtēria* | σωτηρία |
| primary | *prōton* | πρῶτον |
| prior | *proteros* | πρότερος |
| privation | *sterēsis* | στέρησις |
| problem | *problēma* | πρόβλημα |
| proboscis | *epiboskis, proboskis* | ἐπιβοσκίς, προβοσκίς |
| producer | *to poiēsan* | τὸ ποιῆσαν |
| productive capacity | *to poiētikon* | τὸ ποιητικόν |
| proof | *deixis* | δεῖξις |
| proportional | *kata logon* | κατὰ λόγον |
| proportionate | *summetros* | σύμμετρος |
| protection | *boētheia, phulakē* | βοήθεια, φυλακή |
| prove | *deiknunai* | δεικνῦναι |
| puzzle (v.) | *aporein* | ἀπορεῖν |
| qualification, without | *haplōs* | ἁπλῶς |
| random | *hōs etuche* | ὡς ἔτυχε |
| reason | *nous* | νοῦς |
| reasonable | *eulogos* | εὔλογος |
| reasonably | *eulogōs* | εὐλόγως |
| reason, objects of | *noēta* | νοητά |
| reason why, the | *to dia ti* | τὸ διά τι |
| receptacle | *hupodochē* | ὑποδοχή |
| region | *topos* | τόπος |
| remedy (v.) | *iatreuein* | ἰατρεύειν |
| research | *zētēsis* | ζήτησις |
| residue | *perittōma* | περίττωμα |
| respiration | *anapnoē* | ἀναπνοή |
| right (as opposed to left) | *dexios* | δεξιός |
| river-dwelling | *potamios* | ποτάμιος |
| root | *rhiza* | ῥίζα |
| rudder-like legs | *pēdaliōdē* | πηδαλιώδη |
| say | *legein* | λέγειν |
| science | *epistēmē* | ἐπιστήμη |
| sea creatures | *thalattia* | θαλάττια |

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| search (v.) | *zētein* | ζητεῖν |
| sea urchin | *echinos* | ἐχῖνος |
| secretion | *ikmas* | ἰκμάς |
| seed | *sperma, gonē* | σπέρμα, γονή |
| self-preservation | *sōtēria* | σωτηρία |
| semen | *gonē* | γονή |
| sensation, sense | *aisthēsis* | αἴσθησις |
| sense-receptor | *aisthētērion* | αἰσθητήριον |
| separate (v.) | *chōrizein* | χωρίζειν |
| separately | *chōris* | χωρίς |
| serum | *ichōr* | ἰχώρ |
| shape | *morphē* | μορφή |
| shell | *ostrakon* | ὄστρακον |
| shielding | *boētheia, phulakē* | βοήθεια, φυλακή |
| sickness | *nosos* | νόσος |
| sign | *sēmeion* | σημεῖον |
| signify | *sēmainein* | σημαίνειν |
| simple | *haplous* | ἁπλοῦς |
| sinew | *neuron* | νεῦρον |
| sleep (n.) | *hupnos* | ὕπνος |
| smell (sense) | *osphrēsis* | ὄσφρησις |
| soft | *malakos* | μαλακός |
| soft-bodied animals | *malakia* | μαλακία |
| soft scale | *lepis* | λεπίς |
| soft-scaled animals | *lepidōtoi* | λεπιδωτοί |
| soft-shelled animals | *malakostraka* | μαλακόστρακα |
| solid | *stereos* | στερεός |
| solid-hoofed animals | *mōnucha* | μώνυχα |
| soul | *psuchē* | ψυχή |
| soulless | *apsucha* | ἄψυχα |
| speak | *legein* | λέγειν |
| speech | *logos* | λόγος |
| spleen | *splēn* | σπλήν |
| spontaneously | *apo tautomatou* | ἀπὸ ταὐτομάτου |
| standard | *horos* | ὅρος |
| state (n.) | *hexis* | ἕξις |
| state (v.) | *legein* | λέγειν |
| stomach | *koilia* | κοιλία |
| stomach, third | *echinos* | ἐχῖνος |
| stomachs, animals with multiple | *ta polukoilia* | τὰ πολυκοίλια |
| strength | *alkē* | ἀλκή |
| strife | *neikos* | νεῖκος |
| study (n.) | *theōria* | θεωρία |
| study (v.) | *theōrein* | θεωρεῖν |
| substantial being | *ousia* | οὐσία |

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| sucker (e.g. on the tentacles of the octopus) | *kotulēdōn* | κοτυληδών |
| surface | *to eschaton* | τό ἔσχατον |
| swamp-dweller | *helōdes* | ἑλῶδες |
| syllogism | *sullogismos* | συλλογισμός |
| synonymous | *sunōnumon* | συνώνυμον |
| taste (n.) | *geusis* | γεῦσις |
| tend towards both | *epamphoterizein* | ἐπαμφοτερίζειν |
| tentacle | *plektanē* | πλεκτάνη |
| thinking | *to phronein* | τὸ φρονεῖν |
| thorax | *thōrax* | θώραξ |
| thought | *dianoia* | διάνοια |
| throat | *trachēlos* | τράχηλος |
| through (local) | *dia* (+gen.) | διά (+gen.) |
| time | *chronos* | χρόνος |
| token | *sēmeion* | σημεῖον |
| tongue | *glōtta* | γλῶττα |
| tooth | *odous* | ὀδούς |
| touch (n.) | *haphē* | ἁφή |
| transformation | *metabolē* | μεταβολή |
| transition, to make a | *parallattein* | παραλλάττειν |
| trunk (of body) | *kutos* | κύτος |
| trunk (of elephant) | *proboskis, muktēr* | προβοσκίς, μυκτήρ |
| truth | *alētheia* | ἀλήθεια |
| two-footed | *dipous* | δίπους |
| umbilical cord | *sumphusis* | σύμφυσις |
| underlying, underlying subject | *hupokeimenon* | ὑποκείμενον |
| understanding | *epistēmē* | ἐπιστήμη |
| undifferentiated | *adiaphoron* | ἀδιάφορον |
| ungenerated | *agenētos* | ἀγένητος |
| uniform | *homoiomeres* | ὁμοιομερές |
| unite | *sumphuein* | συμφύειν |
| unperishable | *aphthartos* | ἄφθαρτος |
| unreasonable | *paralogon* | παράλογον |
| uppermost | *eschatos* | ἔσχατος |
| upright (adj.) | *orthos* | ὀρθός |
| upright (adv.) | *orthōs* | ὀρθῶς |
| use (n.) | *chreia, chrēsis* | χρεία, χρῆσις |
| use (v.) | *chrēsthai* | χρῆσθαι |
| uterus | *hustera* | ὑστέρα |
| valuable, more | *timiōteros* | τιμιώτερος |
| vase (third stomach) | *echinos* | ἐχῖνος |
| vein | *phleps* | φλέψ |
| vertebra | *sphondulos* | σφόνδυλος |

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|---|---|---|
| viscera | *splanchna* | σπλάγχνα |
| visible character | *idea* | ἰδέα |
| vision | *opsis* | ὄψις |
| waking | *egrēgorsis* | ἐγρήγορσις |
| water | *hudōr* | ὕδωρ |
| water-dwellers | *enhudra* | ἔνυδρα |
| weight | *baros* | βάρος |
| 'what it is to be' | *to ti ēn einai* | τὸ τί ἦν εἶναι |
| whole, the | *to holon* | τὸ ὅλον |
| why | *dioti* | διότι |
| windpipe | *artēria, pharunx* | ἀρτηρία, φάρυγξ |
| wing | *pteron* | πτερόν |
| work (n.) | *ergon* | ἔργον |
| work (i.e. written work) | *logos* | λόγος |

# GREEK–ENGLISH GLOSSARY

| | | |
|---|---|---|
| ἀγένητος | *agenētos* | ungenerated |
| ἀδιάφορον | *adiaphoron* | undifferentiated |
| ἀδύνατον | *adunaton* | impossible |
| ἀεί | *aei* | always |
| ἀήρ | *aēr* | air |
| ἀΐδιον | *aidion* | eternal, eternity |
| αἷμα | *haima* | blood |
| αἴσθησις | *aisthēsis* | perception, modes of perception, sensation |
| αἰσθητά | *aisthēta* | perceptible objects |
| αἰσθητήριον | *aisthētērion* | sense-receptor |
| αἰτία | *aitia* | cause (n.) |
| ἀκοή | *akoē* | hearing |
| ἀκρίβεια | *akribeia* | accuracy |
| ἀλήθεια | *alētheia* | truth |
| ἀλκή | *alkē* | strength |
| ἀλλοίωσις | *alloiōsis* | alteration |
| ἄλλοτ' ἄλλως | *allot' allōs* | fluctuating |
| ἀλλότριος | *allotrios* | derivative |
| ἀμφώδοντα | *amphōdonta* | animals with a complete set of teeth |
| ἀναγκαῖος | *anankaios* | necessary |
| ἀνάγκη | *anankē* | necessity |
| ἄναιμος | *anhaimos* | bloodless |
| ἀναιμότης | *anhaimotēs* | bloodless character |
| ἀναλογία | *analogia* | analogy |
| ἀνάλογον | *analogon* | analogous(ly) |
| ἀναπνοή | *anapnoē* | breathing, respiration |
| ἀνατομή | *anatomē* | dissection |
| ἀνδρεία | *andreia* | courage |
| ἄνθρωπος | *anthrōpos* | human being, mankind |
| ἀνομοιομερές | *anhomoiomeres* | non-uniform |
| ἀντικείμενα | *antikeimena* | opposites |
| ἀντιστρέφειν | *antistrephein* | convert |
| ἀνώνυμος | *anōnumos* | nameless |
| ἀορτή | *aortē* | aorta |
| ἁπλοῦς | *haplous* | simple |
| ἁπλῶς | *haplōs* | without qualification |
| ἀποδεικνῦναι | *apodeiknunai* | appraise |
| ἀπόδειξις | *apodeixis* | demonstration |
| ἀπορεῖν | *aporein* | puzzle (v.) |
| ἀπὸ ταὐτομάτου | *apo tautomatou* | spontaneously |

| | | |
|---|---|---|
| ἄπους | *apous* | footless |
| ἀποφυάς | *apophuas* | appendage |
| ἀριθμός | *arithmos* | number |
| ἀριστερός | *aristeros* | left (as opposed to right) |
| ἄρρην | *arrhēn* | male |
| ἀρτηρία | *artēria* | windpipe |
| ἀρχαιοί | *archaioi* | ancients |
| ἄρχειν | *archein* | begin, originate |
| ἀρχή | *archē* | origin |
| ἀστράγαλος | *astragalos* | knuckle-bone |
| ἀτιμότερον | *atimoteron* | less valuable, of less esteem |
| ἄτομος | *atomos* | indivisible |
| αὐλός | *aulos* | flute, pipe |
| αὔξησις | *auxēsis* | growth |
| αὐχήν | *auchēn* | neck |
| ἁφή | *haphē* | touch (n.) |
| ἄφθαρτος | *aphthartos* | unperishable |
| ἄχολα | *achola* | without bile |
| ἄψυχα | *apsucha* | soulless |
| βάρος | *baros* | heaviness, weight |
| βέλτιον | *beltion* | better |
| βέλτιστον | *beltiston* | best |
| βίος | *bios* | way of life |
| βοήθεια | *boētheia* | protection |
| βράγχια | *branchia* | gills |
| γάλα | *gala* | milk |
| γαμψῶνυξ | *gampsōnux* | crook-taloned |
| γέλως | *gelōs* | laughter, laughing |
| γένεσις | *genesis* | generation |
| γεννώμενα | *gennōmena* | offspring |
| γένος | *genos* | kind |
| γεῦσις | *geusis* | taste (n.) |
| γεώδης | *geōdēs* | earthen |
| γῆ | *gē* | earth |
| γλῶττα | *glōtta* | tongue |
| γνωρίζειν | *gnōrizein* | know |
| γνῶσις | *gnōsis* | knowledge |
| γονή | *gonē* | seed, semen |
| γράμμα | *gramma* | articulate sound |
| γυναικεῖα | *gunaikeia* | menstrual discharges |
| δάκτυλος | *daktulos* | finger |
| δεικνῦναι | *deiknunai* | explain, prove |
| δεῖξις | *deixis* | proof |
| δεξιός | *dexios* | right (as opposed to left) |
| δημιουργεῖν | *dēmiourgein* | craft (v.) |

| | | |
|---|---|---|
| διά (+acc.) | *dia* | due to, because, on account of, owing to |
| διά (+gen.) | *dia* | through |
| διάθεσις | *diathesis* | disposition |
| διάλεκτος | *dialektos* | language |
| διαιρεῖν | *diairein* | divide |
| διαίρεσις | *diairesis* | division, cutting |
| διάνοια | *dianoia* | thought, intelligence |
| διάστασις | *diastasis* | division |
| διά τι, τό | *dia ti, to* | the reason why |
| διαφέρειν | *diapherein* | differ |
| διαφορά | *diaphora* | difference, differentiation, feature |
| διαφορά, ἀντικειμένη | *antikeimenē diaphora* | contrary difference |
| διαφορά, ἐσχάτη | *eschatē diaphora* | final difference |
| διμερής | *dimerēs* | bipartite |
| διορίζειν | *diorizein* | determine, define |
| διότι | *dioti* | because, why |
| δίπους | *dipous* | two-footed |
| διφυής | *diphuēs* | double-natured |
| διχοτομεῖν | *dichotomein* | dichotomize |
| διχοτομία | *dichotomia* | dichotomy, dichotomous division |
| δύναμις | *dunamis* | potential, potency, power |
| ἐγκέφαλος | *enkephalos* | brain |
| ἐγρήγορσις | *egrēgorsis* | waking |
| εἰδέναι | *eidenai* | know |
| εἶδος | *eidos* | form |
| εἰκών | *eikōn* | likeness |
| ἔλαφος | *elaphos* | deer |
| ἐλεφας | *elephas* | elephant |
| ἑλώδες | *helōdes* | swamp-dweller |
| ἔμβρυον | *embruon* | embryo |
| ἐμποδίζειν | *empodizein* | impede |
| ἔμψυχα | *empsucha* | ensouled things |
| ἔναιμος | *enhaimos* | blooded |
| ἐναντίος | *enantios* | opposite |
| ἐναντίωσις | *enantiōsis* | opposition |
| ἐνδεχόμενα | *endechomena* | possibilities |
| ἕνεκά του | *heneka tou* | for the sake of something |
| ἐνέργεια | *energeia* | actuality |
| ἐνεργείᾳ | *energeiai* | actually, in actuality |
| ἐντελέχεια | *entelecheia* | complete actuality |
| ἔντερον | *enteron* | intestine |
| ἔντομα | *entoma* | insects |
| ἐντὸς θερμόν | *entos thermon* | internal heat |

| | | |
|---|---|---|
| ἔνυδρα | *enhudra* | water-dwellers |
| ἐξ ἀνάγκης | *ex anankēs* | from necessity, of necessity |
| ἐξ ἀφαιρέσεως | *ex aphaireseōs* | abstract (adj.) |
| ἕξις | *hexis* | state (n.) |
| ἔξοδος | *exodos* | outlet |
| ἐξ ὑποθέσεως [ἀνάγκη] | *ex hupotheseōs* [*anankē*] | conditionally [necessary] |
| ἐπαγωγή | *epagōgē* | a consideration of cases |
| ἐπαμφοτερίζειν | *epamphoterizein* | tend towards both |
| ἐπιβοσκίς | *epiboskis* | proboscis |
| ἐπίγλωσσις | *epiglōssis* | epiglottis |
| ἐπιθυμία | *epithumia* | desire |
| ἐπίπλοον | *epiploon* | omentum |
| ἐπισκεπτέος | *episkepteos* | to be examined |
| ἐπίσκεψις | *episkepsis* | examination |
| ἐπιστήμη | *epistēmē* | understanding, science |
| ἐργασία | *ergasia* | preparation, operation |
| ἔργον | *ergon* | work (n.), function (n.) |
| ἑρπυστικά | *herpustika* | creepers |
| ἔσχατον, τό | *eschaton, to* | surface, extreme (n.), extremity |
| ἔσχατος | *eschatos* | final, last, outermost, uppermost |
| εὔλογος | *eulogos* | reasonable |
| εὐλόγως | *eulogōs* | reasonably |
| εὑρίσκειν | *heuriskein* | discover |
| ἐφήμερα [ζῷα] | *ephēmera* [*zōia*] | ephemeral animals |
| ἐχῖνος | *echinos* | sea urchin, vase (third stomach) |
| ζητεῖν | *zētein* | search (v.), seek |
| ζήτησις | *zētēsis* | research |
| ζῷον | *zōion* | animal |
| ζῳοτόκος | *zōiōtokos* | live-bearing |
| ἦθος | *ēthos* | character |
| ἧπαρ | *hēpar* | liver |
| θαλάττια | *thalattia* | sea creatures |
| θεῖος | *theios* | divine |
| θερμός | *thermos* | hot |
| θερμότης | *thermotēs* | heat |
| θεωρεῖν | *theōrein* | to study |
| θεωρία | *theōria* | study |
| θῆλυς | *thēlus* | female |
| θύραθεν | *thurathen* | from without, from outside |
| θώραξ | *thōrax* | thorax, chest cavity |
| ἰατρεύειν | *iatreuein* | remedy (v.) |

| | | |
|---|---|---|
| *ἰδέα* | *idea* | visible character |
| *ἴδιον* | *idion* | distinctive |
| *ἰκμάς* | *ikmas* | secretion |
| *ἵνα* | *hina* | in order that |
| *ἶνες* | *ines* | fibres |
| *ἴσος* | *isos* | equal (in number) |
| *ἱστορία* | *historia* | enquiry |
| *ἰχθύς* | *ichthus* | fish |
| *ἰχώρ* | *ichōr* | serum |
| *καθ' αὑτό* | *kath' hauto* | in virtue of itself |
| *καθ' ἕκαστον* | *kath' hekaston* | one by one |
| *καθ' ἕκαστον, τό* | *kath' hekaston, to* | particular |
| *καθόλου* | *katholou* | general (adj.), generally |
| *καλόν, τό* | *kalon, to* | good (n.) |
| *καρδία* | *kardia* | heart |
| *κατ' ἐνέργειαν* | *kat' energeian* | actually |
| *κατηγορία* | *katēgoria* | predicate (n.) |
| *κέρας* | *keras* | horn |
| *κερατοφόρον* | *keratophoron* | horn-bearing animal |
| *κεφαλή* | *kephalē* | head |
| *κίνησις* | *kinēsis* | motion, change (n.), movement |
| *κοιλία* | *koilia* | stomach |
| *κοινὴ αἴσθησις* | *koinē aisthēsis* | common sense, the |
| *κοινός* | *koinos* | common, in common |
| *κοτυληδών* | *kotulēdōn* | sucker (on the tentacles of the octopus) |
| *κρᾶσις* | *krasis* | blend (n.), constitution |
| *κρίνειν* | *krinein* | judge (v.) |
| *κροκόδειλος* | *krokodeilos* | crocodile |
| *κύστις* | *kustis* | bladder |
| *κύτος* | *kutos* | trunk (of body) |
| *κῶλον* | *kōlon* | limb |
| *λαμβάνειν* | *lambanein* | grasp (v.) |
| *λέγειν* | *legein* | speak, state (v.), say |
| *λεπίς* | *lepis* | soft scale |
| *λεπιδωτός* | *lepidōtos* | soft-scaled animal |
| *λόγος* | *logos* | account, speech, work (i.e. written work) |
| *λόγον, κατά* | *logon, kata* | proportional |
| *μαλάκια* | *malakia* | soft-bodied animals |
| *μαλακός* | *malakos* | soft |
| *μαλακόστρακα* | *malakostraka* | soft-shelled animals |
| *μᾶλλον καὶ ἧττον, τό* | *mallon kai hētton, to* | the more and less |
| *μαστοί* | *mastoi* | mammae, breasts |
| *μάτην* | *matēn* | in vain |
| *μέγιστον γένος* | *megiston genos* | extensive kind |

| | | |
|---|---|---|
| *μέθοδος* | *methodos* | investigation |
| *μεθόδου, τρόπος τῆς* | *methodou, tropos tēs* | the way of, the mode of investigation |
| *μέρος* | *meros* | part |
| *μεσεντέριον* | *mesenterion* | mesentery |
| *μεταβολή* | *metabolē* | transformation |
| *μεταξύ* | *metaxu* | (intermediate) between |
| *μετέχειν* | *metechein* | participate in, partake of |
| *μετέχειν, τό* | *metechein, to* | participation |
| *μικτόν* | *mikton* | mixture |
| *μόριον* | *morion* | part |
| *μορφή* | *morphē* | shape |
| *μυελός* | *muelos* | marrow |
| *μυκτήρ* | *muktēr* | nostril, elephant's trunk |
| *μώνυχα* | *mōnucha* | solid-hoofed animals |
| *νεῖκος* | *neikos* | strife |
| *νεῦρον* | *neuron* | sinew |
| *νεφρός* | *nephros* | kidney |
| *νοητά* | *noēta* | objects of reason |
| *νόσος* | *nosos* | sickness |
| *νοῦς* | *nous* | reason |
| *ξηρός* | *xēros* | dry |
| *ὀδούς* | *odous* | tooth |
| *οἰκεῖος* | *oikeios* | appropriate (adj.), own (adj.), akin |
| *οἰσοφάγος* | *oisophagos* | oesophagus |
| *ὅλον, τό* | *holon, to* | the whole |
| *ὅλως* | *holōs* | generally |
| *ὁμοιομερές* | *homoiomeres* | uniform |
| *ὁμωνύμως* | *homōnumōs* | homonymously |
| *ὀργανικόν* | *organikon* | instrumental |
| *ὄργανον* | *organon* | instrument |
| *ὀρθός* | *orthos* | upright |
| *ὀρθῶς* | *orthōs* | correctly, appropriately, upright |
| *ὁρίζειν* | *horizein* | define, demarcate |
| *ὄρνις* | *ornis* | bird |
| *ὅρος* | *horos* | standard |
| *ὀστοῦν* | *ostoun* | bone |
| *ὀστρακόδερμα* | *ostrakoderma* | hard-shelled animals |
| *ὄστρακον* | *ostrakon* | shell |
| *ὄστρεια* | *ostreia* | hard-shelled animals, oysters |
| *ὄσφρησις* | *osphrēsis* | smell (sense) |
| *οὐρανός* | *ouranos* | heaven |
| *οὐσία* | *ousia* | substantial being |

| | | |
|---|---|---|
| ὄφελος | *ophelos* | advantage |
| ὀφθαλμός | *ophthalmos* | eye |
| ὀχεία | *ocheia* | coition |
| ὄψις | *opsis* | vision |
| πάθημα | *pathēma* | affection |
| πάθος | *pathos* | affection |
| παιδεία | *paideia* | educatedness |
| πᾶν, τό | *pan, to* | the entire universe |
| παραλλάττειν | *parallattein* | make a transition |
| παράλογον | *paralogon* | unreasonable |
| πεζός | *pezos* | land-dweller |
| πελάγιος | *pelagios* | deep-sea dweller |
| πέρας | *peras* | limit (n.) |
| περιέχειν | *periechein* | embrace (v.) |
| περίττωμα | *perittōma* | residue |
| πέττειν | *pettein* | concoct |
| πέψις | *pepsis* | concoction |
| πηδαλιώδη | *pēdaliōdē* | rudder-like legs |
| πιμελή | *pimelē* | soft fat |
| πίων | *piōn* | fat (n.) |
| πλεκτάνη | *plektanē* | tentacle |
| πλεύμων | *pleumōn* | lung |
| πνεῦμα | *pneuma* | breath |
| ποιῆσαν | *poiēsan* | producer |
| ποιητικόν | *poiētikon* | productive capacity |
| πολλοί, οἱ | *polloi, hoi* | many (n.) |
| πολυκοίλια | *polukoilia* | with multiple stomachs |
| πολύπους (adj.) | *polupous* | many-footed |
| πολύπους (n.) | *polupous* | octopus |
| πολύπτερα | *poluptera* | many-winged, with many wings |
| πολυσχιδής | *poluschidēs* | many-toed, split-footed |
| πορεία | *poreia* | locomotion |
| πορευτικός | *poreutikos* | locomotive (adj.) |
| ποτάμιος | *potamios* | river-dwelling |
| πούς | *pous* | foot |
| πρᾶξις | *praxis* | action |
| προαίρεσις | *prohairesis* | choice |
| πρόβλημα | *problēma* | problem |
| προβοσκίς | *proboskis* | proboscis, elephant's trunk |
| πρὸς ἄλληλα | *pros allēla* | correlative |
| πρόσωπον | *prosōpon* | face |
| πρότερος | *proteros* | prior |
| πρῶτος | *prōtos* | first, primary |
| πτερόν | *pteron* | wing, feather |

| | | |
|---|---|---|
| πτηνά | *ptēna* | flyers |
| πῦρ | *pur* | fire |
| ῥάχις | *rhachis* | backbone |
| ῥίζα | *rhiza* | root |
| ῥίς | *rhis* | nose |
| ῥύγχος | *rhunchos* | beak, snout |
| σαρκοφάγος | *sarkophagos* | carnivorous |
| σαρκώδης | *sarkōdēs* | fleshy, flesh-like |
| σάρξ | *sarx* | flesh |
| σημαίνειν | *sēmainein* | signify |
| σημεῖον | *sēmeion* | sign, point, token |
| σκέλος | *skelos* | leg, limb |
| σκέπτειν | *skeptein* | examine |
| σκευή | *skeuē* | equipment |
| σκέψις | *skepsis* | examination |
| σκληρός | *sklēros* | hard |
| σπέρμα | *sperma* | seed |
| σπλάγχνα | *splanchna* | viscera |
| σπλήν | *splēn* | spleen |
| στεάρ | *stear* | hard fat |
| στερεός | *stereos* | solid |
| στέρησις | *sterēsis* | privation |
| στοιχεῖον | *stoicheion* | element |
| στόμα | *stoma* | mouth |
| συλλογισμός | *sullogismos* | syllogism |
| συμβεβηκός | *sumbebēkos* | attribute (n.) |
| συμβεβηκός, κατά | *sumbebēkos, kata* | incidental(ly) |
| συμβεβηκός, καθ' αὑτό | *sumbebēkos, kath' hauto* | proper attribute |
| σύμμετρος | *summetros* | proportionate |
| σύμπλεξις | *sumplexis* | complex (n.) |
| συμπλοκή | *sumplokē* | interweaving |
| σύμφυσις | *sumphusis* | umbilical cord |
| σύμφυτος | *sumphutos* | inborn, naturally present |
| συμφύειν | *sumphuein* | unite, grow together, fuse together |
| συνδεσμός | *sundesmos* | conjunction |
| συνδυασμός | *sunduasmos* | intercourse |
| συνεχής | *sunechēs* | continuous |
| σύνθεσις | *sunthesis* | composite, composition, conjunction |
| συνθετός | *sunthetos* | composite |
| συνιστάμενος | *sunhistamenos* | constituted |
| συνιστάναι | *sunhistanai* | constitute, be constituted |
| συνώνυμον | *sunōnumon* | synonymous |
| σύστασις | *sustasis* | constitution, composition |

| | | |
|---|---|---|
| *σφόνδυλος* | *sphondulos* | vertebra |
| *σχῆμα* | *schēma* | figure, configuration |
| *σῶμα* | *sōma* | body |
| *σωματώδης* | *sōmatōdēs* | bodily |
| *σωτηρία* | *sōtēria* | preservation, self-preservation |
| *τεθνεώς* | *tethneōs* | corpse |
| *τέλειον* | *teleion* | complete |
| *τελευταῖος* | *teleutaios* | final, last |
| *τέλος* | *telos* | end |
| *τεταγμένος* | *tetagmenos* | ordered |
| *τετράποδα* | *tetrapoda* | four-footed animals |
| *τεχναστά* | *technasta* | artefacts |
| *τέχνη* | *technē* | art |
| *τιμιώτερος* | *timiōteros* | more valuable, more honourable, of greater esteem |
| *τόπος* | *topos* | location, place, region |
| *τὸ τί ἦν εἶναι* | *to ti ēn einai* | 'what it is to be' |
| *τράχηλος* | *trachēlos* | throat |
| *τροφή* | *trophē* | nourishment, nutrition, nutrients |
| *τρωγλοδύτης* | *trōglodutēs* | hole-dweller |
| *τύχη* | *tuchē* | chance |
| *τυχόν* | *tuchon* | haphazard |
| *τυχόντος, ἐκ τοῦ* | *tuchontos, ek tou* | chance (adj.) |
| *ὑγίεια* | *hugieia* | health |
| *ὑγρός* | *hugros* | moist |
| *ὑγρότης* | *hugrotēs* | moistness |
| *ὕδωρ* | *hudōr* | water |
| *ὕλη* | *hulē* | matter |
| *ὑπεροχή* | *huperochē* | excess, degree |
| *ὑπεροχήν, καθ'* | *huperochēn, kath'* | by degree |
| *ὕπνος* | *hupnos* | sleep (n.) |
| *ὑπογράφειν* | *hupographein* | add, draw |
| *ὑποδοχή* | *hupodochē* | receptacle |
| *ὑπόζωμα* | *hupozōma* | diaphragm |
| *ὑποκείμενον* | *hupokeimenon* | underlying subject, underlying |
| *ὑπολαμβάνειν* | *hupolambanein* | assume |
| *ὑστέρα* | *hustera* | uterus |
| *φαίνεσθαι* | *phainesthai* | appear, be apparent |
| *φαινόμενον* | *phainomenon* | phenomenon |
| *φανερά (κατὰ τὴν αἴσθησιν)* | *phanera (kata tēn aisthēsin)* | perceptual phenomena |
| *φάρυγξ* | *pharunx* | larynx, windpipe |

| | | |
|---|---|---|
| *φθορά* | *phthora* | perishing |
| *φιλία* | *philia* | friendship |
| *φιλοσοφεῖν* | *philosophein* | philosophize |
| *φιλοσοφία* | *philosophia* | philosophy |
| *φλέψ* | *phleps* | blood vessel, vein |
| *φολιδωτά* | *pholidōta* | hard-scaled animals |
| *φολίς* | *pholis* | hard scale |
| *φορά* | *phora* | locomotion |
| *φρένες* | *phrenes* | midriffs |
| *φρονεῖν, τό* | *phronein, to* | thinking |
| *φρόνησις* | *phronēsis* | discernment |
| *φρόνιμος* | *phronimos* | discerning, intelligent |
| *φυλακή* | *phulakē* | shielding, protection |
| *φύσει* | *phusei* | by nature |
| *φυσικὴ ἐπιστήμη* | *phusikē epistēmē* | natural science |
| *φυσικός* | *phusikos* | natural philosopher |
| *φυσιόλογοι* | *phusiologoi* | natural philosophers |
| *φύσις* | *phusis* | nature |
| *φυτά* | *phuta* | plants |
| *χάριν* | *charin* | for the sake of |
| *χείρ* | *cheir* | hand |
| *χολή* | *cholē* | bile |
| *χρεία* | *chreia* | need (n.), use |
| *χρῆσθαι* | *chrēsthai* | use (v.) |
| *χρῆσις* | *chrēsis* | use |
| *χρόνος* | *chronos* | time |
| *χώρα* | *chōra* | place (n.) |
| *χωρίζειν* | *chōrizein* | separate (v.) |
| *χωρίς* | *chōris* | separately |
| *ψυχή* | *psuchē* | soul |
| *ψυχρός* | *psuchros* | cold |
| *ψυχρότης* | *psuchrotēs* | coldness |
| *ᾠόν* | *ōion* | egg |
| *ᾠοτόκα* | *ōiotoka* | (animals) that lay eggs, egg-laying animals, egg-layers |
| *ὡρισμένον* | *hōrismenon* | definite |
| *ὡς ἔτυχε* | *hōs etuche* | random |

# INDEX LOCORUM

# GENERAL INDEX

This index contains references to the translation, in bold type, where there is an extended discussion of the subject. All other references are to the introduction and commentary.

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