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THE WORKS OF ARISTOTLE

TRANSLATED INTO ENGLISH
UNDER THE EDITORSHIP

OF

J. A. SMITH M.A.
WAYNFLETE PROFESSOR OF MORAL AND METAPHYSICAL PHILOSOPHY
FELLOW OF MAGDALEN COLLEGE

W. D. ROSS M.A.
FELLOW OF ORIEL COLLEGE

VOLUME V

DE PARTIBUS ANIMALIUM
By WILLIAM OGLE

DE MOTU AND DE INCESSU ANIMALIUM
By A. S. L. FARQUHARSON

DE GENERATIONE ANIMALIUM
By ARTHUR PLATT

OXFORD
AT THE CLARENDON PRESS
1912

HENRY FROWDE, M.A.
PUBLISHER TO THE UNIVERSITY OF OXFORD
LONDON, EDINBURGH, NEW YORK, TORONTO
MELBOURNE AND BOMBAY

PREFACE

It was the desire of the late Master of Balliol, Dr. Benjamin Jowett, as formulated in his will, that the proceeds from the sale of his works, the copyright in which he bequeathed to Balliol College, should be used to promote the study of Greek Literature, especially by the publication of new translations and editions of Greek authors. In a codicil to his will he expressed the hope that the translation of Aristotle's works begun by his own translation of the *Politics* should be proceeded with as speedily as possible. The College resolved that the funds thus accruing to them should, in memory of his services to the College and to Greek letters, be applied to the subvention of a series of translations of the works of Aristotle. Through the co-operation, financial and other, of the Delegates of the University Press it has now become possible to begin the realization of this design. By agreement between the College and the Delegates of the Press the present editors were appointed to superintend the carrying out of the scheme. The series is published at the joint expense and risk of the College and the Delegates of the Press.

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The editors, while retaining a general right of revision and annotation, will leave the responsibility for each translation to its author.

J. A. S.
W. D. R.

DE PARTIBUS ANIMALIUM

DE PARTIBUS ANIMALIUM

TRANSLATED BY

WILLIAM OGLE M.A., M.D., F.R.C.P.
SOMETIME FELLOW OF CORPUS CHRISTI COLLEGE, OXFORD

OXFORD
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HENRY FROWDE, M.A.
PUBLISHER TO THE UNIVERSITY OF OXFORD
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TORONTO AND MELBOURNE

TO

THE MEMORY

OF

EDWARD POSTE

PREFACE

THIS translation is a revised version of one made by me very many years ago and published in 1882, with introductory essays and very copious annotation. Exigencies of space have necessitated the omission of the former and a very great abridgement of the latter, while the translation itself has been largely altered and corrected. It still, however, remains as before, a very free version; for it is not intended to meet the linguistic requirements of the critical Greek scholar so much as those of the student of biological history, to whom a treatise that is the earliest extant attempt to assign its function to each several organ of the animal body cannot but be of great interest. Such being my main object, I have not hesitated to transfer clauses, or even an entire sentence, when by such transposition the argument can be made less obscure or more consecutive, and have ventured in no few cases to suggest new readings or adopt new readings suggested by others, when such readings are in my judgement called for by the context.

Bekker's text has been followed as a rule, and any departure from it is mentioned in a note. If there be MS. authority for the departure the letter designating the MS. is added, as 'omitting *ψυχρόν* (Z)'. If the new reading be one suggested by some other person, the name of that person is given, as 'For *συστάν* read *συνιστάν* (Platt)'. For other new readings I am myself responsible.

My sincere thanks are due to Mr. W. D. Ross of Oriel College and to Professor Platt of University College, London, for many valuable criticisms and suggestions made in the course of revision.

SYNOPSIS

BOOK I

1 Every[1] systematic science, the humblest and the noblest alike, seems to admit of two distinct kinds of proficiency; one of which may be properly called scientific knowledge of the subject, while the other is a kind of educational acquaintance with it. For an educated man should be able to form a fair off-hand judgement as to the goodness or badness of the method used by a professor in his exposition. To be educated is in fact to be able to do this; and even the man of universal education we deem to be such in virtue of his having this ability. It will, however, of course, be understood that we only ascribe universal education to one who in his own individual person is thus critical in all or nearly all branches of knowledge, and not to one who has a like ability merely in some special subject. For it is possible for a man to have this competence in some one branch of knowledge without having it in all. 639a

It is plain then that, as in other sciences, so in that which inquires into nature, there must be certain canons, by reference to which a hearer shall be able to criticize the method of a professed exposition, quite independently of the question whether the statements made be true or false. Ought we, for instance (to give an illustration of what I mean), to begin by discussing each separate species—man, lion, ox, and the like—taking each kind in hand independently of the rest, or ought we rather to deal first

[1] This treatise, known to us as 'On the Parts of Animals', is referred to by A. himself (*G. A.* v. 3. 782a 21) as 'On the Causes of the Parts of Animals'. It is professedly (ii. 1. 646a 11) an inquiry as to how far the existence and structure of each part are due to Necessity and how far to Design. Owing, however, to the giant share ascribed by A. to the latter cause, the treatise becomes one on the functions of the parts rather than on their causes, and might almost be styled, as was Galen's later work, a treatise *De Usu Partium*.

with the attributes which they have in common in virtue of some common element of their nature, and proceed from this as a basis for the consideration of them separately? For genera that are quite distinct yet oftentimes present many identical phenomena, sleep, for instance, respiration, growth, decay, death,[1] and other similar affections and conditions, which may be passed over for the present, as we are not yet prepared to treat of them with clearness and precision. Now it is plain that if we deal with each species independently of the rest, we shall frequently be obliged to repeat the same statements over and over again; for horse and dog and man present, each and all, every one of the phenomena just enumerated. A discussion therefore of the attributes of each such species separately[2] would necessarily involve frequent repetitions as to characters, themselves identical but recurring in animals specifically distinct. (Very possibly also there may be other characters
639b which, though they present specific differences, yet come under one and the same category. For instance, flying, swimming, walking, creeping, are plainly specifically distinct, but yet are all forms of animal progression.) We must, then, have some clear understanding as to the manner in which our investigation is to be conducted; whether, I mean, we are first to deal with the common or generic characters, and afterwards to take into consideration special peculiarities; or whether we are to start straight off with the ultimate species. For as yet no definite rule has been laid down in this matter. So also there is a like uncertainty as to another point now to be mentioned. Ought the writer who deals with the works of nature to follow the plan adopted by the mathematicians in their astronomical demonstrations, and after considering the phenomena presented by animals, and their several parts, proceed subsequently to treat of the causes and the reason why; or ought he to follow some other method? And when these

[1] All of these, be it noted, as also the modes of progression mentioned a few sentences later on, were made subjects of special treatises by A.

[2] Reading τὰ συμβεβηκότα for τῶν συμβεβηκότων.

questions are answered, there yet remains another. The causes concerned in the generation of the works of nature are, as we see, more than one. There is the final cause and there is the motor cause. Now we must decide which of these two causes comes first, which second. Plainly, however, that cause is the first which we call the final one. For this is the Reason, and the Reason forms the starting-point, alike in the works of art and in works of nature. For consider how the physician or how the builder sets about his work. He starts by forming for himself a definite picture, in the one case perceptible to mind, in the other to sense, of his end—the physician of health, the builder of a house—and this he holds forward as the reason and explanation of each subsequent step that he takes, and of his acting in this or that way as the case may be. Now in the works of nature the good end and the final cause is still more dominant than in works of art such as these, nor is necessity a factor with the same significance in them all; though almost all writers, while they try to refer their origin to this cause, do so without distinguishing the various senses in which the term necessity is used. For there is absolute necessity, manifested in eternal phenomena; and there is hypothetical necessity, manifested in everything that is generated by nature as in everything that is produced by art, be it a house or what it may. For if a house or other such final object is to be realized, it is necessary that such and such material shall exist; and it is necessary that first this and then that shall be produced, and first this and then that set in motion, and so on in continuous succession, until the end and final result is reached, for the sake of which each prior thing is produced and exists. As with these productions of art, so also is it with the productions of nature. The mode of necessity, however, and the mode of ratiocination are different in natural science[1] from what 640a
they are in the theoretical sciences;[2] of which we have

[1] We might add, 'and in art.'

[2] A. divides the sciences into three groups (*Metaph.* E. 1). Firstly, the *Theoretical*, which are purely intellectual and not concerned with action. In this are comprised Metaphysics, Physics, and Mathematics. Secondly the *Practical*; and thirdly, the *Constructive or Artistic*.

spoken elsewhere. For in the latter the starting-point is that which is; in the former that which is to be. For it is that which is yet to be—health, let us say, or a man—that, owing to its being of such and such characters, necessitates the pre-existence or previous production of this and that antecedent: and not this or that antecedent which, because it exists or has been generated, makes it necessary that health or a man is in, or shall come into, existence. Nor is it possible to trace back the series of necessary antecedents to a starting-point, of which you can say that, existing itself from eternity, it has determined their existence as its consequent. These however, again, are matters that have been dealt with in another treatise. There too it was stated in what cases absolute and hypothetical necessity exist; in what cases also the proposition expressing hypothetical necessity is simply convertible, and what cause it is that determines this convertibility.[1]

The Practical and the Artistic comprehend action as well as intelligence; but differ from each other, in that the Practical have no other result than the action itself; whereas the Constructive or Artistic, when the action is over, leave as its result a substantial product.

The contrast in the text is between the theoretical and the constructive sciences; among which latter, A. here inconsistently includes ἡ φυσική; and the points of contrast are as follows. The theoretical philosopher starts from certain eternal facts or verities (τὸ ὄν)—the mathematician for instance from his axioms—and proceeds to deduce from these those consequences which are linked to them by absolute necessity. The artist, on the other hand, or nature, the chief of artists, starts from an ideal conception, not yet existent in matter, but to be realized in the future (τὸ ἐσόμενον). Starting from this, he reasons backwards through the antecedent steps that are necessary, if the conception is to be realized. The realization of my conception *E*, he says, requires first the realization of *D*; if *D* is to be produced, there must previously be *C*; *C* again requires *B* for its production; and so farther and farther back, until he reaches a link in the chain of antecedents, let us say *A*, the material production of which is within his power. Here the ratiocination ceases, and construction begins. He produces *A*; then by means of *A* produces *B*, from *B* produces *C*, and so on, retracing his previous steps, until he reaches *E*, the conception of which was his starting-point, as its material realization is his end.

[1] (Cf. *De G. et C.* ii. 9-11.) The following is a brief abstract of A.'s views. The only motion capable of being eternal is motion in a circle; and the only element endowed with a rotatory motion is the celestial aether. The heavenly bodies consist of this; and they alone are individually eternal. The Divinity, however, wishing to give the things of earth as near an approach to eternity as is compatible with their being made of other elements than aether, caused their motions

Another matter which must not be passed over without consideration is, whether the proper subject of our exposition is that with which the ancient writers concerned themselves, namely, what is the process of formation of each animal; or whether it is not rather, what are the characters of a given creature when formed. For there is no small difference between these two views. The best course appears to be that we should follow the method already mentioned, and begin with the phenomena presented by each group of animals, and, when this is done, proceed afterwards to state the causes of those phenomena, and to deal with their evolution. For elsewhere, as for instance in house building, this is the true sequence. The plan of the house, or the house, has this and that form; and because it has this and that form, therefore is its construction carried out in this or that manner. For the process of evolution is for the sake of the thing finally evolved, and not this for the sake of the process. Empedocles, then, was in error when he said that many of the characters presented by animals were merely the results of incidental occurrences during their development; for in-

to be so affected by that of the celestial bodies as to simulate rotation in the only way possible, namely by a cyclical arrangement of their serial phenomena. Not only is this manifested in the periodicity of many phenomena (*G. A.* iv. 10. 777b 16), but still more in the successive stages of the evolution of organisms, these stages being so arranged as to form a circle. Germ, foetus, infant, man, and then germ again, and so on in eternal succession. Thus a simulacrum of eternity is impressed on even perishable things in the only way possible for them (*De An.* ii. 4. 415b 4; *G. A.* ii. 1. 731b 32); an eternity, however, which differs from that of the celestial bodies, in that it does not attach to the individual but to the species. For in the cycle—germ, foetus, man, germ—it is not the same germ, but only a similar one, in which the circle is completed. Each term in such a cycle is at once the antecedent and the consequent of all the rest. Man necessarily presupposes germ, and germ as necessarily presupposes man. Any hypothetical proposition then that states the necessary relation of any two of the terms—e.g. if there is to be a man there must necessarily be a germ—is capable of simple conversion—viz. if there is to be a germ there must necessarily be a man.

By the 'propositions expressing hypothetical necessity and capable of simple conversion' A. means, then, all those in which two stages in the cyclical evolution of an organism are placed as antecedent and consequent. By the 'cause which determines this' he may mean either the action of the heavenly bodies upon terrestrial bodies; or possibly, going a stage farther back, the purpose of the Divinity in the construction of the world.

stance, that the backbone was divided as it is into vertebrae, because it happened to be broken owing to the contorted position of the foetus in the womb. In so saying he overlooked the fact that propagation implies a creative[1] seed endowed with certain formative properties. Secondly, he neglected another fact, namely, that the parent animal pre-exists, not only in idea, but actually in time. For man is generated from man; and thus it is the possession of certain characters by the parent that determines the development of like characters in the child. The same statement holds good also for the operations of art, and even for those which are apparently spontaneous.[2] For the same result as is produced by art may occur spontaneously. Spontaneity, for instance, may bring about the restoration of health. The products of art, however, require the pre-existence of an efficient cause homogeneous with themselves, such as the statuary's art, which must necessarily precede the statue; for this cannot possibly be produced spontaneously. Art indeed consists in the conception of the result to be produced before its realization in the material. As with spontaneity, so with chance:[3] for

[1] For συστάν read συνιστάν (Platt).

[2] No reason is here given as to how the desirable result of Chance or Spontaneity can be said to occur for the sake of such end. The explanation seems to be as follows:—

In the living body there are series of concatenated motions, established by nature or habit, to produce each some desirable end. If any one of these motions be set a-going, the rest of the series follow automatically in due succession till the end is attained (ὅταν ἀρχὴ γένηται κινήσεως, ὥσπερ ἐν τοῖς αὐτομάτοις θαύμασι, συνείρεται τὸ ἐφεξῆς, *G. A.* ii. 5. 741 ᵇ 8). Such a series is that which terminates in Health, and its final terms are Heat, Uniform bodily condition (ὁμαλότης), Health. The man of Art, i. e. the physician, says, in order to restore Health I must obtain ὁμαλότης; to obtain this Heat is required; Heat again will follow on Friction. Here then he has come to something within his power. He applies Friction, and Heat, Equable Condition, Health follow in due order. But Friction may be applied by mere Chance and set the mechanism going that ends in Health. In such case the result may be said to be produced *intentionally*, as it is produced by machinery intentionally set up by nature with a view to that end. It is only in the case of bodies that possess such inherent capacity for self-motion (οἷα κινεῖσθαι ὑφ' αὑτῆς) that chance can do the work of Art. Results that Art produces from a purely inert material, e.g. a statue, are quite beyond the power of Chance. Cf. *Phys.* ii. 4-6, *Metaph.* Z. 7-9.

[3] Accident is called Chance – or preferably Luck – when the accidental

this also produces the same result as art, and by the same process.

The fittest mode, then, of treatment is to say, a man has such and such parts, because the conception of a man includes their presence, and because they are necessary conditions of his existence, or, if we cannot quite say this, which would be best of all, then the next thing to it, namely, that it is either quite[1] impossible for him to exist without them, or, at any rate, that it is better for him that they should be there; and their existence involves the existence of other antecedents. Thus we should say, because man 640b
is an animal with such and such characters, therefore is the process of his development necessarily such as it is; and therefore is it accomplished in such and such an order, this part being formed first, that next, and so on in succession; and after a like fashion should we explain the evolution of all other works of nature.

Now that with which the ancient writers, who first philosophized about Nature, busied themselves, was the material principle and the material cause. They inquired what this is, and what its character; how the universe is generated out of it, and by what motor influence, whether, for instance, by antagonism or friendship, whether by intelligence or spontaneous action, the substratum of matter being assumed to have certain inseparable properties; fire, for instance, to have a hot nature, earth a cold one; the former to be light, the latter heavy. For even the genesis of the universe is thus explained by them. After a like fashion do they deal also with the development of plants and of animals. They say, for instance, that the water[2] contained in the body causes by its currents the formation of the stomach and the other receptacles of food or of excretion; and that the breath by its passage breaks open the outlets of the nostrils; air and water being the materials of which

agent acts with intention, though not with the intention of producing the result that actually occurs. It is called Spontaneity when the agent has no intention at all. It is the intermixture of semi-intention that gives force to the line *τύχη τέχνην ἔστερξε καὶ τέχνη τύχην*.

[1] For ὅλως ὅτι read ὅτι ὅλως (Z).

[2] Omitting ὅτι.

bodies are made; for all represent nature as composed of such or similar substances.

But if men and animals and their several parts are natural phenomena, then the natural philosopher must take into consideration not merely the ultimate substances of which they are made, but also flesh, bone, blood, and all the other homogeneous parts; not only these, but also the heterogeneous parts, such as face, hand, foot; and must examine how each of these comes to be what it is, and in virtue of what force. For to say what are the ultimate substances out of which an animal is formed, to state, for instance, that it is made of fire or earth, is no more sufficient than would be a similar account in the case of a couch or the like. For we should not be content with saying that the couch was made of bronze or wood or whatever it might be, but should try to describe its design or mode of composition in preference to the material; or, if we did deal with the material, it would at any rate be with the concretion of material and form. For a couch is such and such a form embodied in this or that matter, or such and such a matter with this or that form; so that its shape and structure must be included in our description. For the formal nature is of greater importance than the material nature.

Does, then, configuration and colour constitute the essence of the various animals and of their several parts? For if so, what Democritus says will be strictly correct. For such appears to have been his notion. At any rate he says that it is evident to every one what form it is that makes the man, seeing that he is recognizable by his shape and colour. And yet a dead body has exactly the same configuration as a living one; but for all that is not a man. So also no hand of bronze or wood or constituted in any but the appropriate way can possibly be a hand in more than name.
641a For like a physician in a painting, or like a flute in a sculpture, in spite of its name it will be unable to do the office which that name implies. Precisely in the same way no part of a dead body, such I mean as its eye or its hand, is really an eye or a hand. To say, then, that shape and colour constitute the animal is an inadequate statement,

and is much the same as if a woodcarver were to insist that the hand he had cut out was really a hand. Yet the physiologists, when they give an account of the development and causes of the animal form, speak very much like such a craftsman. What, however, I would ask, are the forces by which the hand or the body was fashioned into its shape? The woodcarver will perhaps say, by the axe or the auger; the physiologist, by air and by earth. Of these two answers the artificer's is the better, but it is nevertheless insufficient. For it is not enough for him to say that by the stroke of his tool this part was formed into a concavity, that into a flat surface; but he must state the reasons why he struck his blow in such a way as to effect this, and what his final object was; namely, that the piece of wood should develop eventually into this or that shape. It is plain, then, that the teaching of the old physiologists is inadequate, and that the true method is to state what the definitive characters are that distinguish the animal as a whole; to explain what it is both in substance and in form, and to deal after the same fashion with its several organs; in fact, to proceed in exactly the same way as we should do, were we giving a complete description of a couch.

If now this something that constitutes the form of the living being be the soul, or part of the soul, or something that without the soul cannot exist; as would seem to be the case, seeing at any rate that when the soul departs, what is left is no longer a living animal, and that none of the parts remain what they were before, excepting in mere configuration, like the animals that in the fable are turned into stone; if, I say, this be so, then it will come within the province of the natural philosopher to inform himself concerning the soul, and to treat of it, either in its entirety, or, at any rate, of that part of it which constitutes the essential character of an animal; and it will be his duty to say what this soul or this part of a soul is; and to discuss the attributes that attach to this essential character, especially as nature is spoken of in two senses, and the nature of a thing is either its matter or its essence; nature as essence including both the motor cause and the final cause. Now it is in the latter of these two senses that either the whole soul or some part of it constitutes the nature of an animal; and inasmuch as it is the presence of the soul that enables matter to constitute the animal nature, much more than it is the presence of matter which so enables the soul, the inquirer into nature is bound on every ground to treat of the soul rather than of the matter. For though the wood of which they are made constitutes the couch and the tripod, it only does so because it is capable of receiving such and such a form.

What has been said suggests the question, whether it is the whole soul or only some part of it, the consideration of which comes within the province of natural science. Now if it be of the whole soul that this should treat, then there
641b is no place for any other philosophy beside it. For as it belongs in all cases to one and the same science to deal with correlated subjects—one and the same science, for instance, deals with sensation and with the objects of sense—and as therefore the intelligent soul and the objects of intellect, being correlated, must belong to one and the same science, it follows that natural science will have to include the whole universe in its province. But perhaps it is not the whole soul, nor all its parts collectively, that constitutes the source of motion; but there may be one part, identical with that in plants, which is the source of growth, another, namely the sensory part, which is the source of change of quality, while still another, and this not the intellectual part, is the source of locomotion. I say not the intellectual part: for other animals than man have the power of locomotion, but in none but him is there intellect. Thus then it is plain that it is not of the whole soul that we have to treat. For it is not the whole soul that constitutes the animal nature, but only some part or parts of it. Moreover, it is impossible that any abstraction can form a subject of natural science, seeing that everything that Nature makes is means to an end. For just as human creations are the products of art, so living objects are manifestly the products of an analogous cause or principle, not external but internal,

derived like the hot and the cold[1] from the environing universe. And that the heaven, if it had an origin, was evolved and is maintained by such a cause, there is therefore even more reason to believe, than that mortal animals so originated. For order and definiteness are much more plainly manifest in the celestial bodies than in our own frame; while change and chance are characteristic of the perishable things of earth. Yet there are some who, while they allow that every animal exists and was generated by nature, nevertheless hold that the heaven was constructed to be what it is by chance and spontaneity; the heaven, in which not the faintest sign of hap-hazard or of disorder is discernible! Again, whenever there is plainly some final end, to which a motion tends should nothing stand in the way, we always say that such final end is the aim or purpose of the motion; and from this it is evident that there must be a something or other really existing, corresponding to what we call by the name of Nature. For a given germ does not give rise to any chance living being, nor spring from any chance one; but each germ springs from a definite parent and gives rise to a definite progeny. And thus it is the germ that is the ruling influence and fabricator of the offspring. For these it is by nature, the offspring being at any rate that which in nature will spring from it. At the same time the offspring is anterior[2] to the germ; for germ and perfected progeny are related as the developmental process and the result.[3] Anterior, however, to both germ and product is the organism from which the germ was derived. For every germ implies two organisms, the parent and the progeny. For germ or seed is both the seed of the organism from which it came, of the horse, for instance, from which it was derived, and the seed of the organism that will eventually arise from it, of the mule, for example, which is developed from the seed of the horse. The same seed then is the seed both of the horse and of the mule, though in different ways as here set forth.

[1] And the other material elements of our bodies.
[2] That is to say, in the order of thought.
[3] And result is in thought anterior to evolution.

Moreover, the seed is potentially that which will spring from it, and the relation of potentiality to actuality we know.[1]

642a There are then two causes, namely, necessity and the final end. For many things are produced, simply as the results of necessity. It may, however, be asked, of what mode of necessity[2] are we speaking when we say this. For it can be of neither of those two modes which are set forth in the philosophical treatises.[3] There is, however, the third mode, in such things at any rate as are generated. For instance, we say that food is necessary; because an animal cannot possibly do without it. This third mode is what may be called hypothetical necessity. Here is another example of it. If a piece of wood is to be split with an axe, the axe must of necessity be hard; and, if hard, must of necessity be made of bronze or iron. Now exactly in the same way the body, which like the axe is an instrument—for both the body as a whole and its several parts individually have definite operations for which they are made—just in the same way, I say, the body, if it is to do its work, must of necessity be of such and such a character, and made of such and such materials.

It is plain then that there are two modes of causation, and that both of these must, so far as possible, be taken into account in explaining the works of nature, or that at any rate an attempt must be made to include them both;[4] and that those who fail in this tell us in reality

[1] We know, that is, to be that of consequent to antecedent.

[2] As A. has fully explained what he means by Hypothetical Necessity only a few pages back, it is strange that he should now deal with it again in terms that seem to imply that he is stating something quite new. Very possibly the whole of this long paragraph is an interpolation.

[3] Elsewhere (*Metaph.* iv. 5) A. speaks of three kinds of necessity, Absolute necessity, Necessity of coercion (as when a weaker agent is constrained by a stronger one), and Hypothetical necessity. There is also another passage (*Phys.* ii. 9) in which he deals with necessity, and distinguishes, as in the text, two kinds, Absolute and Hypothetical. Plainly, however, it can be to neither of these passages that he is now referring. The passage wherever it is, or was, must have been one in which the two modes of necessity distinguished from each other were Absolute and Coercive necessity. It may perhaps have been contained in the lost dialogue on Philosophy; concerning which see Heitz, *Die verlor. Schrift. d. Arist.* 179.

[4] Reading εἰ δὲ μή, πειρᾶσθαί γε ποιεῖν τοῦτο, δῆλον.

nothing about nature. For primary [1] cause constitutes the nature of an animal much more than does its matter. There are indeed passages in which even Empedocles hits upon this, and following the guidance of fact, finds himself constrained to speak of the ratio (ὁ λόγος) as constituting the essence and real nature of things. Such, for instance, is the case when he explains what is a bone. For he does not merely describe its material, and say it is this one element, or those two or three elements, or a compound of all the elements, but states the ratio (ὁ λόγος) of their combination.[2] As with a bone, so manifestly is it with the flesh and all other similar parts.

The reason why our predecessors failed in hitting upon this method of treatment was, that they were not in possession of the notion of essence, nor of any definition of substance. The first who came near it was Democritus, and he was far from adopting it as a necessary method in natural science, but was merely brought to it, spite of himself, by constraint of facts. In the time of Socrates a nearer approach was made to the method. But at this period men gave up inquiring into the works of nature, and philosophers diverted their attention to political science and to the virtues which benefit mankind.

Of the method itself the following is an example. In dealing with respiration we must show that it takes place for such or such a final object; and we must also show that this and that part of the process is necessitated by this and that other stage of it. By necessity we shall sometimes mean hypothetical necessity, the necessity, that is, that the requisite antecedents shall be there, if the final end is to be reached; and sometimes absolute necessity, such necessity as that which connects substances and their inherent properties and characters. For the alternate discharge and re-

[1] i. e. the final cause; for, as said earlier in the chapter, 'that cause is the first which we call the final.'

[2] Both Empedocles and Aristotle can speak of the λόγος of a bone, but in different senses; Empedocles meaning no more than the proportion or ratio of the several component parts of bone; while Aristotle means the reason or cause of such composition, and professes to believe that Empedocles meant something of the same kind.

entrance of heat and the inflow of air are necessary if we are to live. Here we have at once a necessity in the former of
642b the two senses. But the alternation of heat and refrigeration produces of necessity an alternate admission and discharge of the outer air, and this is a necessity of the second kind.[1]

In the foregoing we have an example of the method which we must adopt, and also an example of the kind of phenomena, the causes of which we have to investigate.

Some[2] writers propose to reach the definitions of the 2
ultimate forms of animal life by bipartite division. But this method is often difficult, and often impracticable.

Sometimes the final differentia of the subdivision is sufficient by itself, and the antecedent differentiae are mere surplusage. Thus in the series Footed, Two-footed, Cleft-footed,[3] the last term is all-expressive by itself, and to append the higher terms is only an idle iteration.

Again it is not permissible to break up a natural group, Birds for instance, by putting its members under different bifurcations, as is done in the published dichotomies, where some birds are ranked with animals of the water, and others placed in a different class. The group Birds and the group Fishes happen to be named, while other natural groups have no popular names; for instance, the groups that we may call Sanguineous and Bloodless are not known popularly by any designations. If such natural groups are not to be broken up, the method of Dichotomy cannot be employed, for it necessarily involves such breaking up and dislocation. The group of the Many-footed, for instance,

[1] This passage defies all other than a paraphrastic rendering with some expansion.

[2] Alluding to Plato's method of dividing downwards until by successive bifurcations the infima species is at last reached. Examples of this method, *abscissio infiniti*, will be found in the *Sophistes* and *Politicus*. These are apparently the 'published dichotomies' of which A. speaks; and it is to them that his criticisms in this and the two next chapters have immediate reference. The main interest of these chapters to the biologist lies in the evidence they give that the idea of natural classification had occurred to Aristotle, their whole drift indeed being to uphold the claims of natural as opposed to artificial systems.

[3] Omitting *ἄπουν*.

would, under this method, have to be dismembered, and some of its kinds distributed among land animals, others among water animals.

3 Again, privative terms inevitably form one branch of dichotomous division, as we see in the proposed dichotomies. But privative terms in their character of privatives admit of no subdivision. For there can be no specific forms of a negation, of Featherless for instance or of Footless, as there are of Feathered and of Footed. Yet a generic differentia must be subdivisible; for otherwise what is there that makes it generic rather than specific? There are to be found generic, that is specifically subdivisible, differentiae; Feathered for instance and Footed. For feathers are divisible into Barbed and Unbarbed, and feet into Manycleft, and Twocleft, like those of animals with bifid hoofs, and Uncleft or Undivided, like those of animals with solid hoofs. Now even with differentiae capable of this specific subdivision it is difficult enough so to make the classification, as that each animal shall be comprehended in some one subdivision and in not more than one; but far more difficult, nay impossible, is it to do this, if we start with a dichotomy into two contradictories. (Suppose for instance we start with the two contradictories,[1] Feathered and Unfeathered; we shall find that the ant,[2] the glow-worm, and some other animals fall under both divisions.) For each differentia must be presented by some species. There must be some species, therefore, under the privative heading. Now specifically distinct animals cannot 643a
present in their essence a common undifferentiated element, but any apparently common element must really be differentiated. (Bird and Man for instance are both Two-footed, but their two-footedness is diverse and differentiated. So any two sanguineous groups must have some difference in their blood, if their blood is part of their essence.) From

[1] For *ἄναιμα* read *ἐναντία*.

[2] The wing of an insect was held by A. to be a feather (*πτερόν*, not *πτέρυξ*), differing, however, from the feather of a bird in being without barbs and without shaft (*ἄσχιστον* and *ἄκαυλον*) and also in its mode of origin (cf. iv. 6. 682b 18).

this it follows that a privative term, being insusceptible of differentiation, cannot be a generic differentia; for, if it were, there would be a common undifferentiated element in two different groups.

Again, if the species are ultimate indivisible groups, that is, are groups with indivisible differentiae, and if no differentia be common to several groups, the number of differentiae must be equal to the number of species. If a differentia though not divisible could yet be[1] common to several groups, then it is plain that in virtue of that common differentia specifically distinct animals would fall into the same division. It is necessary then, if the differentiae, under which are ranged all the ultimate and indivisible groups, are specific characters, that none of them shall be common; for otherwise, as already said, specifically distinct animals will come into one and the same division. But this would violate one of the requisite conditions, which are as follows. No ultimate group must be included in more than a single division; different groups must not be included in the same division; and every group must be found in some division. It is plain then that we cannot get at the ultimate specific forms of the animal, or any other, kingdom by bifurcate division. If we could, the number of ultimate differentiae would equal the number of ultimate animal forms.[2] For assume an order of beings whose prime differentiae are White and Black.[3] Each of these branches will bifurcate, and their branches again, and so on till we reach the ultimate differentiae, whose number will be four or some other power of two, and will also be the number of the ultimate species comprehended in the order.

(A species is constituted by the combination of differentia and matter.[4] For no part of an animal is purely material or purely immaterial; nor can a body, independently of its condition, constitute an animal or any of its parts, as has repeatedly been observed.)[5]

[1] Omitting μή with Titze.
[2] And that, he implies, is inconceivable.
[3] For τὰ λευκά read τὸ λευκὸν καὶ τὸ μέλαν (Edit. nonnulli).
[4] Reading ἐν τῇ ὕλῃ τὸ εἶδος (Y).
[5] e.g. at i. 1. 641a 19.

Further, the differentiae must be elements of the essence, and not merely essential attributes. Thus if Figure is the term to be divided, it must not be divided into figures whose angles are equal to two right angles, and figures whose angles are together greater than two right angles. For it is only an attribute of a triangle and not part of its essence that its angles are equal to two right angles.

Again, the bifurcations must be opposites, like White and Black, Straight and Bent; and if we characterize one branch by either term, we must characterize the other by its opposite, and not, for example, characterize one branch by a colour, the other by a mode of progression, swimming for instance.

Furthermore, living beings cannot be divided[1] by the functions common to body and soul, by Flying, for instance, and Walking, as we see them divided in the dichotomies already referred to. For some groups, Ants for instance, 643b
fall under both divisions, some ants flying while others do not. Similarly as regards the division into Wild and Tame; for it also would involve the disruption of a species into different groups. For in almost all species in which some members are tame, there are other members that are wild. Such, for example, is the case with Men, Horses, Oxen, Dogs in India, Pigs, Goats, Sheep; groups which, if double, ought to have what they have not, namely, different appellations; and which, if single, prove that Wildness and Tameness do not amount to specific differences. And whatever[2] single element we take as a basis of division the same difficulty will occur.

The method then that we must adopt is to attempt to recognize the natural groups, following the indications afforded by the instincts of mankind, which led them for instance to form the class of Birds and the class of Fishes, each of which groups combines a multitude of differentiae, and is not defined by a single one as in dichotomy. The method of dichotomy is either impossible (for it would put a single group under different divisions or contrary groups

[1] Reading *οὐ δεῖ διαιρεῖν* (Gaza).
[2] Reading *ὁποιαοῦν* (Y) and *διαφορᾷ* (EY).

under the same division), or it only furnishes a single ultimate differentia for each species, which either alone or with its series of antecedents has to constitute the ultimate species.

If, again, a new differential character be introduced at any stage into the division, the necessary result is that the continuity of the division becomes merely a unity and continuity of agglomeration, like the unity and continuity of a series of sentences coupled together by conjunctive particles. For instance, suppose we have the bifurcation Feathered and Featherless, and then divide Feathered into Wild and Tame, or into White and Black. Tame and White are not a differentiation of Feathered, but are the commencement of an independent bifurcation, and are foreign to the series at the end of which they are introduced.

As we said then, we must define at the outset by a multiplicity of differentiae. If we do so, privative terms will be available, which are unavailable to the dichotomist.

The impossibility of reaching the definition of any of the ultimate forms by dichotomy of the larger group, as some propose, is manifest also from the following considerations. It is impossible that a single differentia, either by itself or with its antecedents, shall express the whole essence of a species. (In saying a single differentia by itself I mean such an isolated differentia as Cleft-footed; in saying a single differentia with antecedent I mean, to give an instance, Many-cleft-footed preceded by Cleft-footed.[1] The very continuity of a series of successive differentiae in a division is intended to show that it is their combination that expresses the character of the resulting unit, or ultimate group. But one is misled by the usages of language into imagining that it is merely the final term of the series, Many-cleft-footed for instance, that constitutes the whole differentia, and that the antecedent terms, Footed, Cleft-
644a footed, are superfluous.[2] Now it is evident that such a

[1] For πρὸς τὸ σχιζόπουν read πρὸς τῷ σχιζόπουν (Platt).

[2] In the text as it stands the terms of several distinct series of differentiae are mixed together with much confusion. If, however, we omit ἢ τὸ δίπουν, and substitute σχιζόπουν for πολύπουν, as I have ventured to do in the translation, the terms of only one series—

series cannot consist of many terms. For if one divides and subdivides, one soon reaches the final differential term, but for all that will not have got to the ultimate division, that is, to the species.) No single differentia, I repeat, either by itself or with its antecedents, can possibly express the essence of a species. Suppose, for example, Man to be the animal to be defined; the single differentia will be Cleft-footed, either by itself or with its antecedents, Footed and Two-footed.[1] Now if man was nothing more than a Cleft-footed animal, this single [2] differentia would duly represent his essence. But seeing that this is not the case, more differentiae than this one will necessarily be required to define him; and these cannot come under one division; for each single branch of a dichotomy ends in a single differentia, and cannot possibly include several differentiae belonging to one and the same animal.

It is impossible then to reach any of the ultimate animal forms by dichotomous division.

4 It deserves inquiry why a single name denoting a higher group was not invented by mankind, as an appellation to comprehend the two groups of Water animals and Winged animals. For even these have certain attributes in common.[3] However, the present nomenclature is just. Groups that only differ in degree, and in the more or less of an identical element that they possess, are aggregated under a single class; groups whose attributes are not identical but analogous are separated. For instance, bird differs from bird by gradation, or by excess and defect; some birds have long feathers, others short ones, but all are feathered. Bird and Fish are more remote and only agree

Footed, Cleft-footed, Many-cleft-footed—are used, and the passage becomes intelligible and clear.

[1] If the text be correct, which the many different readings make doubtful, A. is speaking carelessly; for Many-cleft-footed clearly does not imply Two-footed, seeing that many quadrupeds are *πολυσχιδῆ*. Much alteration would be required to make the passage logically accurate. It might, however, be done by reading *ἢ τὸ πολυσχιδὲς μόνον* instead of *ἢ τὸ σχιζόπουν μόνον*, and for *ὑπόπουν δίπουν σχιζόπουν* reading *ὑπόπουν σχιζόπουν πολυσχιδές*; and then *πολυσχιδές* after *ἄνθρωπος*.

[2] Read *αὕτη ἡ μία*.

[3] Omit *καὶ τοῖς ἄλλοις*.

in having analogous organs: for what in the bird is feather, in the fish is scale. Such analogies can scarcely, however, serve universally as indications for the formation of groups, for almost all animals present analogies in their corresponding parts.

The individuals[1] comprised within a species, such as Socrates and Coriscus, are the real existences; but inasmuch as these individuals possess one common specific form, it will suffice to state the universal attributes of the species, that is, the attributes common to all its individuals, once for all, as otherwise there will be endless reiteration, as has already been pointed out.[2]

But as regards the larger groups—such as Birds—which comprehend many species, there may be a question. For on the one hand it may be urged that as the ultimate species represent the real existences, it will be well, if practicable, to examine these ultimate species separately, just as we examine the species Man separately; to examine, that is, not the whole class Birds collectively, but the Ostrich, the Crane, and the other indivisible groups or species belonging to the class.

On the other hand, however, this course would involve repeated mention of the same attribute, as the same attribute is
644b common to many species, and so far would be somewhat irrational and tedious. Perhaps, then, it will be best to treat generically the universal attributes of the groups that have a common nature and contain closely allied subordinate forms, whether they are groups recognized by a true instinct of mankind, such as Birds and Fishes, or groups not popularly known by a common appellation, but withal composed of closely allied subordinate groups; and only to deal individually with the attributes of a single species, when such species—man, for instance, and any other such, if such there be—stands apart from others, and does not constitute with them a larger natural group.

[1] By τὰ ἔσχατα εἴδη, if such be the true reading, must here be meant 'the ultimate forms', i.e. the individuals comprised in a species, as rendered above. This, however, seems a scarcely tenable translation of the words, and I prefer, as a possible emendation, that we should read τὰ ἔσχατα without εἴδη.

[2] Cf. i. 1. 639a 27.

It is generally similarity in the shape of particular organs, or of the whole body, that has determined the formation of the larger groups. It is in virtue of such a similarity that Birds, Fishes, Cephalopoda,[1] and Testacea have been made to form each a separate class. For within the limits of each such class, the parts do not differ in that they have no nearer resemblance than that of analogy—such as exists between the bone of man and the spine of fish—but differ merely in respect of such corporeal conditions as largeness smallness, softness hardness, smoothness roughness, and other similar oppositions, or, in one word, in respect of degree.

We have now touched upon the canons for criticizing the method of natural science, and have considered what is the most systematic and easy course of investigation; we have also dealt with division, and the mode of conducting it so as best to attain the ends of science, and have shown why dichotomy is either impracticable or inefficacious for its professed purposes.

Having laid this foundation, let us pass on to our next topic.

5 Of things constituted by nature some are ungenerated, imperishable, and eternal, while others are subject to generation and decay. The former are excellent beyond compare and divine, but less accessible to knowledge. The evidence that might throw light on them, and on the problems which we long to solve respecting them, is furnished but scantily by sensation; whereas respecting perishable plants and animals we have abundant information, living as we do in their midst, and ample data may be collected concerning all their various kinds, if only we are willing to take sufficient pains. Both departments, however, have their special charm. The scanty conceptions to which we can attain of celestial things give us, from their excellence, more pleasure than all our knowledge of the

[1] A.'s *μαλάκια* do not correspond to our Mollusca, though often so rendered, but to the limited and well-defined group of Cephalopoda; and the term is so translated in the rest of this treatise.

world in which we live; just as a half glimpse of persons that we love is more delightful than a leisurely view of 645a other things, whatever their number and dimensions. On the other hand, in certitude and in completeness our knowledge of terrestrial things has the advantage. Moreover, their greater nearness and affinity to us balances somewhat the loftier interest of the heavenly things that are the objects of the higher philosophy. Having already treated of the celestial world, as far as our conjectures could reach, we proceed to treat of animals, without omitting, to the best of our ability, any member of the kingdom, however ignoble. For if some have no graces to charm the sense, yet even these, by disclosing to intellectual perception the artistic spirit that designed them, give immense pleasure to all who can trace links of causation, and are inclined to philosophy. Indeed, it would be strange if mimic representations of them were attractive, because they disclose the mimetic skill of the painter or sculptor, and the original realities themselves were not more interesting, to all at any rate who have eyes to discern the reasons that determined their formation. We therefore must not recoil with childish aversion from the examination of the humbler animals. Every realm of nature is marvellous: and as Heraclitus, when the strangers who came to visit him found him warming himself at the furnace in the kitchen and hesitated to go in, is reported to have bidden them not to be afraid to enter, as even in that kitchen divinities were present, so we should venture on the study of every kind of animal without distaste; for each and all will reveal to us something natural and something beautiful. Absence of haphazard and conduciveness of everything to an end are to be found in Nature's works in the highest degree, and the resultant end of her generations and combinations is a form of the beautiful.

If any person thinks the examination of the rest of the animal kingdom an unworthy task, he must hold in like disesteem the study of man. For no one can look at the primordia of the human frame—blood, flesh, bones, vessels, and the like—without much repugnance. Moreover, when any one of the parts or structures, be it which it may, is under discussion, it must not be supposed that it is its material composition to which attention is being directed or which is the object of the discussion, but the relation of such part to the total form. Similarly, the true object of architecture is not bricks, mortar, or timber, but the house; and so the principal object of natural philosophy is not the material elements, but their composition, and the totality of the form, independently of which they have no existence.

The course of exposition must be first to state the 645b
attributes common to whole groups of animals, and then to attempt to give their explanation. Many groups, as already noticed,[1] present common attributes, that is to say, in some cases absolutely identical affections, and absolutely identical organs,—feet, feathers, scales, and the like; while in other groups the affections and organs are only so far identical as that they are analogous. For instance, some groups have lungs, others have no lung, but an organ analogous to a lung in its place; some have blood, others have no blood, but a fluid analogous to blood,[2] and with the same office. To treat of the common attributes in connexion with each individual group would involve, as already suggested, useless iteration. For many groups have common attributes. So much for this topic.

As every instrument and every bodily member subserves some partial end, that is to say, some special action, so the whole body must be destined to minister to some plenary sphere of action. Thus the saw is made for sawing, for sawing is a function, and not sawing for the saw. Similarly, the body too must somehow or other be made for the soul, and each part of it for some subordinate function, to which it is adapted.

[1] Cf. i. 1. 639a 18 and 27.

[2] A. divides animals into those with and those without blood, meaning exclusively *red* blood. This division into Sanguineous and Bloodless tallies closely with that into Vertebrates and Invertebrates, but not completely. For in Amphioxus, usually classed as vertebrate, the blood is colourless, while it is red in no few invertebrates, e.g. in Planorbis, Arca, Pectunculus, Solen legumen, &c., &c. Possibly it was the red blood in some worms, e.g. those common in pond-mud, that led A. to consider worms generally to be immature eels (*G. A.* iii. 11. 762b 26, *H. A.* vi. 16. 570a 15).

We have, then, first to describe the common functions, common, that is, to the whole animal kingdom, or to certain large groups, or to the members of a species. In other words, we have to describe the attributes common to all animals, or to assemblages, like the class of Birds, of closely allied groups differentiated by gradation, or to groups like Man not differentiated into subordinate groups. In the first case the common attributes may be called analogous, in the second generic, in the third specific.

When a function is ancillary to another, a like relation manifestly obtains between the organs which discharge these functions; and similarly, if one function is prior to and the end of another, their respective organs will stand to each other in the same relation. Thirdly, the existence of these parts involves that of other things as their necessary consequents.[1]

Instances of what I mean by functions and affections are Reproduction, Growth, Copulation, Waking, Sleep, Locomotion, and other similar vital actions. Instances of what I mean by parts are Nose, Eye, Face, and other so-called 646a members or limbs, and also the more elementary parts[2] of which these are made. So much for the method to be pursued. Let us now try to set forth the causes of all vital phenomena, whether universal or particular, and in so doing let us follow that order of exposition which conforms, as we have indicated, to the order of nature.

[1] Reading ἃ τούτων for τῶν. The meaning is plain from other passages. Thus: 'we must not always expect to find such a final cause; for granted the existence in the body of this or that constituent with such and such properties, many results must ensue as necessary results of these properties' (iv. 2. 677^{a} 17); and again, 'everything given by nature is either itself given for an end, or is the incidental accompaniment of something else that is so given' (*De An.* iii. 12. 434^{a} 31). A.'s triple division may be illustrated by an example. (1) The alimentary canal, as a whole, has the elaboration of food for its plenary function. (2) The teeth, gullet, stomach, and intestines, with their several offices, are ancillary to the last. (3) The fatty omentum is held by A. (iv. 3. 677^{b} 22) to be the necessary consequent of the above parts, and to have no distinct function of its own.

[2] Such appears to be the meaning of τῶν ἄλλων; μόρια that are not μέρη; that is homogeneous as contrasted with heterogeneous parts. Cf. ii. 1. 646^{a} 20 note.

BOOK II

1 The nature and the number of the parts of which animals are severally composed are matters which have already been set forth in detail in the book of Researches about Animals. We have now to inquire what are the causes that in each case have determined this composition, a subject quite distinct from that dealt with in the Researches.[1]

Now there are three degrees of composition; and of these the first in order, as all will allow, is composition out of what some call the elements, such as earth, air, water, fire. Perhaps, however, it would be more accurate to say composition out of the elementary forces;[2] nor indeed out

[1] In the *Hist. Animalium* (Books i.–iv. 7) the parts were *described*; their *causes* are now to be considered—a very different subject.

[2] The so-called elements, says A. elsewhere (*De G. et C.* ii. 2), are not simple bodies but compounds, being produced by combinations of the primary forces or active properties of matter. Tangible objects differ from each other in endless ways, as regards colour, taste, smell, &c. (*Meteor.* iv. 10); but they are all either fluid or solid, and all either hot or cold. Everything tangible presents two of these properties; it is either solid or fluid, and either hot or cold. There are then four main elementary properties, and each object possesses two of them. Now among four things there may be six combinations of two and two (συζεύξεις); but the pairing of two directly opposite properties, as of cold and hot, causes them both to disappear; for they neutralize each other. Thus only four combinations remain, and these correspond to the four apparently simple bodies, fire, air, water, earth; solid and hot forming fire; hot and fluid forming air, for air corresponds to vapour; fluid and cold forming water; cold and solid forming earth.

It is evident then why A. holds it more accurate to say composition from the elementary forces rather than from the elements, the former being the components of the latter. It is plain also that when he says 'nor out of all of them', he means to exclude all other properties excepting the four main ones, two of which belong to every tangible object. From these four primary properties, he says, all others are derived, and in contrast to them may be called secondary. As to the mode in which the secondary properties are deducible from the primary ones, cf. *De G. et C.* ii. 2.

It will be noticed that A. uses the adjectival forms, hot, cold, solid, fluid, and not the substantives, heat, fluidity, &c. For he is speaking not of abstract properties, but of concrete substances. His views (*De G. et C.* ii. 1) were as follows. There is one ultimate matter, of all of these, but out of a limited number of them, as defined in previous treatises. For fluid and solid,[1] hot and cold, form the material of all composite bodies;[2] and all other differences are secondary to these, such differences, that is, as heaviness or lightness, density or rarity, roughness or smoothness, and any other such properties of matter as there may be. The second degree of composition is that by which the homogeneous[3] parts of animals, such as bone,

which forms the universal substratum of all terrestrial things. This matter, however, has no existence in a condition of isolation, but is invariably combined with some or other of the primary properties, heat, fluidity, &c. Thus we have fluid matter, hot matter, solid matter, cold matter; but there is no such thing as simple matter by itself, any more than there is such a thing as fluidity by itself. By hot, cold, solid, fluid, A. means then the universal substratum in a state of heat, coldness, solidity, or fluidity.

[1] The traditional rendering of *ὑγρόν* and *ξηρόν* is Wet or Moist and Dry. They are here rendered Fluid and Solid. For though these terms are, as A. says (ii. 3. 649^b 9), used in several senses, the definitions he gives of them (*De G. et C.* ii. 2. 329^b 30) are distinctly definitions of Fluid and Solid. He defines *ὑγρόν* (fluid) as 'that which has no definite boundary of its own but readily has one imposed upon it', meaning, of course, by the receptacle into which it is poured; while *ξηρόν* (solid) is 'that which has a definite boundary of its own and resists the imposition of another'.

[2] By compound substances A. means all substances made by combinations of the elements. Every such compound, that is every actually existing substance, contains, says A. (*De G. et C.* ii. 8), some proportion of every one of the four elementary substances. The differences between substances depended therefore, not on differences in the elements of which they were made, but on differences in the ever-varying proportions in which these were combined to form them.

A. distinguished clearly enough between chemical combination and mere mixture. In the former, he says (*De G. et C.* i. 10), the combining substances disappear with their properties, and a new substance with new properties arises from their unification. In the latter the mixed substances remain with all their properties, and it is merely the imperfection of our vision which prevents us from seeing the particles of each lying side by side and separate. Had we the eyes of Lynceus we should do so, however intimate the mixture might be. But though A. thus distinguished chemical combination from mechanical mixture, he had no notion of preferential affinities, nor, of course, of combination in definite proportions. The elementary bodies combined with each other with perfect indifference, and in any chance proportions. There was thus no such thing as definite composition, and consequently no such thing as definite properties, in substances. One piece of matter might resemble another more or less, but that it should be identical with it in composition and therefore in properties was, in the infinity of possibilities, so improbable as to be out of the question. It was to this *ἀοριστία τῆς ὕλης* (*G. A.* iv. 7. 778^a 6) that A. ascribed the apparent imperfections in Nature's handiwork.

[3] The division into Homogeneous and Heterogeneous parts corre-

flesh, and the like, are constituted out of the primary substances. The third and last stage is the composition which forms the heterogeneous parts, such as face, hand, and the rest.

Now the order of actual development and the order of logical existence are always the inverse of each other. For that which is posterior in the order of development is antecedent in the order of nature, and that is genetically last which in nature is first.

(That this is so is manifest by induction; for a house does not exist for the sake of bricks and stones, but these materials for the sake of the house; and the same is the case with the materials of other bodies. Nor is induction required to show this. It is included in our conception of generation. For generation is a process from a something to a something; that which is generated having a cause in which it originates and a cause in which it ends. The originating cause is the primary efficient cause, which is something already endowed with tangible existence, while the final cause is some definite form or similar end; for man generates man, and plant generates plant, in each case out of the underlying material.)[1]

In order of time, then, the material and the generative process must necessarily be anterior to the being that is
generated; but in logical order the definitive character and 646b
form of each being precedes the material. This is evident if one only tries to define the process of formation. For the definition of house-building includes and presupposes that of the house; but the definition of the house does not

sponds in a general way to the later division into Tissues and Organs; the former, however, including much that we should not call tissue, e. g. the blood, and, in short, any constituent of the body which A. held to be incapable of further structural analysis, being formed directly out of the compound, i. e. the chemical, substances. These Homogeneous parts again were of two kinds, (a) simple tissues or stuffs, without any notion of size or shape, e. g. cartilaginous or osseous tissues, and (β) simple organs, that is, organs made of a single tissue but with definite form and size, e. g. a cartilage or a bone. In this sense even the heart was homogeneous, being made of a single tissue, viz. flesh, while it was heterogeneous as having a definite shape.

[1] The material substratum is of comparatively small importance; the form is derived from the parent.

include nor presuppose that of house-building; and the same is true of all other productions. So that it must necessarily be that the elementary material exists for the sake of the homogeneous parts, seeing that these are genetically posterior to it, just as the heterogeneous parts are posterior genetically to them. For these heterogeneous parts have reached the end and goal, having the third degree of composition, in which degree generation or development often attains its final term.[1]

Animals, then, are composed of homogeneous parts, and are also composed of heterogeneous parts. The former, however, exist for the sake of the latter. For the active functions and operations of the body are carried on by these: that is, by the heterogeneous parts, such as the eye, the nostril, the whole face, the fingers, the hand, and the whole arm. But inasmuch as there is a great variety in the functions and motions not only of aggregate animals but also of the individual organs, it is necessary that the substances out of which these are composed shall present a diversity of properties. For some purposes softness is advantageous, for others hardness; some parts must be capable of extension, others of flexion. Such properties, then, are distributed separately to the different homogeneous parts, one being soft another hard, one fluid another solid, one viscous another brittle; whereas each of the heterogeneous parts presents a combination of multifarious properties. For the hand, to take an example, requires one property to enable it to effect pressure, and another and different property for simple prehension. For this

[1] The first degree of composition was that of the compound substances; the second that of the homogeneous parts or tissues; the third that of the heterogeneous parts or organs. The evolution, then, of an individual organ has reached its final term when this third stage is attained. But in an animal or a plant, as a rule, there is yet a fourth degree of composition. For the entire organism is made up of a multiplicity of organs. This, however, is not the case with all organisms. The simpler kinds (Aristotle would probably have instanced the Sponge, the Actinia, the Medusa and, among plants, Lichens and Fungi) present no such distinction of parts as allows us to say that they are made up of organs. They are constructed not of organs, but directly out of tissues. Their evolution, therefore, as that of a single organ, ends with the third degree of composition. They are aggregates of the third, not of the fourth, degree.

reason the active or executive parts of the body are compounded out of bones, sinews, flesh, and the like, but not these latter out of the former.

So far, then, as has yet been stated, the relations between these two orders of parts are determined by a final cause. We have, however, to inquire whether necessity may not also have a share in the matter; and it must be admitted that these mutual relations could not from the very beginning have possibly been other than they are. For heterogeneous parts can be made up out of homogeneous parts, either from a plurality of them, or from a single one, as is the case with some of the viscera which, varying in configuration, are yet, to speak broadly, formed from a single homogeneous substance; but that homogeneous substances should be formed out of a combination of heterogeneous parts is clearly an impossibility. For these 647a causes, then, some parts of animals are simple and homogeneous, while others are composite and heterogeneous; and dividing the parts into the active or executive and the sensitive, each one of the former is, as before said, heterogeneous, and each one of the latter homogeneous. For it is in homogeneous parts alone that sensation can occur, as the following considerations show.

Each sense is confined to a single order of sensibles, and its organ must be such as to admit the action of that kind or order. But it is only that which is endowed with a property *in posse* that is acted on by that which has the like property *in esse*, so that the two are the same in kind, and if[1] the latter is single so also is the former. Thus it is that while no physiologists ever dream of saying of the hand or face or other such part that one is earth, another water, another fire, they couple each separate sense-organ with a separate element, asserting this one to be air and that other to be fire.

Sensation, then, is confined to the simple or homogeneous parts. But, as might reasonably be expected, the organ of

[1] Reading καὶ εἰ ἐκεῖνο ἕν. If the organ were not a simple homogeneous substance it would be acted on by more than one order of sensibles, which is not the case.

touch, though still homogeneous, is yet the least simple of all the sense-organs. For touch more than any other sense appears to be correlated to several distinct kinds of objects, and to recognize more than one category of contrasts, heat and cold, for instance, solidity and fluidity, and other similar oppositions. Accordingly, the organ which deals with these varied objects is of all the sense-organs the most corporeal,[1] being either the flesh, or the substance which in some animals takes the place of flesh.

Now as there cannot possibly be an animal without sensation, it follows as a necessary consequence that every animal must have some homogeneous parts; for these alone are capable of sensation, the heterogeneous parts serving for the active functions. Again, as the sensory faculty, the motor faculty, and the nutritive faculty are all lodged in one and the same part of the body, as was stated in a former treatise,[2] it is necessary that the part which is the primary seat of these principles shall on the one hand, in its character of general sensory recipient, be one of the simple parts; and on the other hand shall, in its motor and active character, be one of the heterogeneous parts. For this reason it is the heart which in sanguineous animals constitutes this central part, and in bloodless animals it is that which takes the place of a heart. For the heart, like the other viscera, is one of the homogeneous parts; for, if cut up, its pieces are homogeneous in substance with each other. But it is at the same time heterogeneous in virtue of its definite configuration. And the same is true of the other so-called viscera, which are indeed formed from the
647^b same material as the heart. For all these viscera have a sanguineous character owing to their being situated upon vascular ducts and branches. For just as a stream of water deposits mud, so the various viscera, the heart excepted,[3] are, as it were, deposits from the stream of blood in the vessels. And as to the heart, the very starting-point of the vessels, and the actual seat of the force by

[1] Cf. ii. 8. 653^b 30 note.

[2] Cf. *De Somno*, 2. 455^b 34, 456^a 5.

[3] The heart is excepted, because A. thought that it was formed earlier than the blood, which is true if by blood be meant a red fluid.

which the blood is first fabricated, it is but what one would naturally expect, that out of the selfsame nutriment of which it is the recipient its own proper substance shall be formed. Such, then, are the reasons why the viscera are of sanguineous aspect; and why in one point of view they are homogeneous, in another heterogeneous.

2 Of the homogeneous parts of animals, some are soft and fluid, others hard and solid; and of the former some are fluid permanently, others only so long as they are in the living body.[1] Such are blood, serum, lard, suet, marrow, semen, bile, milk when present, flesh,[2] and their various analogues. For the parts enumerated are not to be found in all animals, some animals only having parts analogous to them. Of the hard and solid homogeneous parts bone, fish-spine, sinew, blood-vessel, are examples. The last of these points to a sub-division that may be made in the class of homogeneous parts. For in some[3] of them the whole and a portion of the whole in one sense are designated by the same term—as, for example, is the case with blood-vessel and bit of blood-vessel—while in another sense they are not; but a portion of a heterogeneous part, such as face, in no sense has the same designation as the whole.

The first question to be asked is what are the causes to which these homogeneous parts owe their existence? The causes are various; and this whether the parts be solid or fluid. Thus one set of homogeneous parts represent the material out of which the heterogeneous parts are formed; for each separate organ is constructed of bones, sinews, flesh, and the like; which are either essential elements in its formation, or contribute to the proper discharge of its function. A second set are the nutriment of the first, and are invariably fluid, for all growth occurs at the expense of

[1] Or 'the system'. For φύσις in this sense cf. ii. 3. 649^b 28–32.

[2] Flesh is presumably called fluid as being potentially blood (iii. 5. 668^a 27); a view which very possibly derived support from its cadaveric rigidity.

[3] Namely the simple organs. Cf. ii. 1. 646^a 21 note. Blood-vessel and bit of blood-vessel are both vascular tissue, but a bit of blood-vessel is not a blood-vessel.

fluid matter; while a third set are the residue of the second. Such, for instance, are the faeces and, in animals that have a bladder, the urine; the former being the dregs of the solid nutriment, the latter of the fluid.

Even the individual homogeneous parts present variations, which are intended in each case to render them more serviceable for their purpose. The variations of the blood may be selected to illustrate this. For different bloods differ in their degrees of thinness or thickness, of clearness or turbidity, of coldness or heat; and this whether we compare the bloods from different parts of the same individual or the bloods of different animals. For, in the individual, all the differences just enumerated distinguish the blood of
648a the upper and of the lower halves of the body; and, dealing with classes, one section of animals is sanguineous, while the other has no blood, but only something resembling it in its place. As regards the results of such differences, the thicker and the hotter blood is, the more conducive is it to strength, while in proportion to its thinness and its coldness is its suitability for sensation and intelligence. A like distinction exists also in the fluid which is analogous[1] to blood. This explains how it is that bees and other similar creatures are of a more intelligent nature than many sanguineous animals; and that, of sanguineous animals, those are the most intelligent whose blood is thin and cold. Noblest of all are those whose blood is hot, and at the same time thin and clear. For such are suited alike for the development of courage and of intelligence. Accordingly, the upper parts are superior in these respects to the lower, the male superior to the female, and the right side to the left.[2] As with the blood so also with the other parts,

[1] Reading *τὸ ἀνάλογον ὑπάρχον*.

[2] It was the unquestioning belief of Aristotle that the right was in nature superior to the left, the upper to the lower, the front to the back. He also held that 'Nature, when no more important purpose stands in the way, places the more honourable part in the more honourable position' (iii. 4. 665^{b} 20). This dogma he uses as an axiom beyond dispute, and has recourse to it on numerous occasions in explanation of the relative positions of organs and other phenomena. The stomach, for instance, is placed where it is and not nearer the mouth because otherwise it would be above the heart, a nobler organ than itself (iv. 10. 686^{a} 13). Man's nobility is shown by his upper part

homogeneous and heterogeneous alike. For here also such variations as occur must be held either to be related to the essential constitution and mode of life of the several animals, or, in other cases, to be merely matters of slightly better or slightly worse. Two animals, for instance, may have eyes. But in one these eyes may be of fluid consistency, while in the other they are hard; and in one there may be eyelids, in the other no such appendages. In such a case, the fluid consistency and the presence of eyelids, which are intended to add to the accuracy of vision, are differences of degree.

As to why all animals must of necessity have blood or something of a similar character, and what the nature of blood may be, these are matters which can only be considered when we have first discussed hot and cold. For the natural properties of many substances are referable to these two elementary principles; and it is a matter of frequent dispute what animals or what parts of animals are hot and what cold. For some[1] maintain that water animals are hotter than such as live on land, asserting that their natural heat counterbalances the coldness of their medium; and again, that bloodless animals are hotter than those with blood, and females than males. Parmenides, for instance, and some others declare that women are hotter than men, and that it is the warmth and abundance of their blood which causes their menstrual flow, while Empedocles maintains the opposite opinion. Again, comparing the blood and the bile, some speak of the former as hot and of the latter as cold, while others invert the description. If there be this endless disputing about hot and cold, which of all things that affect our senses are the most distinct, what are we to think as to our other sensory impressions?

The explanation of the difficulty appears to be that the term 'hotter' is used in several senses; so that different 648^{b}

being turned towards the upper part of the universe (ii. 10. 656^{a} 11). The front of man is chosen in preference to the back, for the growth of hair (ii. 14. 658^{a} 23). The nictitating membrane comes from the canthus in front, rather than the canthus on the side (ii. 13. 657^{b} 22). The heart, being the noblest part, is in front and in the upper half of the body (iii. 4. 665^{b} 18), and so on.

[1] Empedocles, cf. *De Resp.* 14.

statements, though in verbal contradiction with each other, may yet all be more or less true. There ought, then, to be some clear understanding as to the sense in which natural substances are to be termed hot or cold, solid or fluid. For it appears manifest that these are properties on which even life and death are largely dependent, and that they are moreover the causes of sleep and waking, of maturity and old age, of health and disease; while no similar influence belongs to roughness and smoothness, to heaviness and lightness, nor, in short, to any other such properties of matter. That this should be so is but in accordance with rational expectation. For hot and cold, solid and fluid, as was stated in a former treatise,[1] are the foundations of the physical elements.

Is then the term hot used in one sense or in many? To answer this we must ascertain what special effect is attributed to a hotter substance, and if there be several such, how many these may be. A body then is in one sense said to be hotter than another, if it impart a greater amount of heat to an object in contact with it. In a second sense, that is said to be hotter which causes the keener sensation when touched, and especially if the sensation be attended with pain. This criterion, however, would seem sometimes to be a false one; for occasionally it is the idiosyncrasy of the individual that causes the sensation to be painful. Again, of two things, that is the hotter which the more readily melts a fusible substance, or sets on fire an inflammable one. Again, of two masses of one and the same substance, the larger is said to have more heat than the smaller. Again, of two bodies, that is said to be the hotter which takes the longer time in cooling, as also we call that which is rapidly heated hotter than that which is long about it; as though the rapidity implied proximity and this again similarity of nature, while the want of rapidity implied distance and this again dissimilarity of nature. The term hotter is used then in all the various senses that have been mentioned, and perhaps in still more. Now it is impossible for one body to be hotter than another in all these different

[1] *De G. et C.* ii. 2–3, *Meteor.* iv.

fashions. Boiling water for instance, though it is more scalding than flame, yet has no power of burning or melting combustible or fusible matter, while flame has. So again this boiling water is hotter than a small fire, and yet gets cold more rapidly and completely. For in fact fire never becomes cold; whereas water invariably does so. Boiling water, again, is hotter to the touch than oil; yet it gets cold and solid more rapidly than this other fluid. Blood, again, is hotter to the touch than either water or oil, and yet coagulates before them. Iron, again, and stones and other similar bodies are longer in getting heated than water, but when once heated burn other substances with a much greater intensity. Another distinction is this. In some of the bodies which are called hot the heat is derived from without, while in others it belongs to the bodies themselves; and it 649a
makes a most important difference whether the heat has the former or the latter origin. For to call that one of two bodies the hotter, which is possessed of heat, we may almost say, accidentally and not of its own essence, is very much the same thing as if, finding that some man in a fever was a musician, one were to say that musicians are hotter than healthy men. Of that which is hot *per se* and that which is hot *per accidens*, the former is the slower to cool, while not rarely the latter is the hotter to the touch. The former again is the more burning of the two—flame, for instance, as compared with boiling water—while the latter, as the boiling water, which is hot *per accidens*, is the more heating to the touch. From all this it is clear that it is no simple matter to decide which of two bodies is the hotter. For the first may be the hotter in one sense, the second the hotter in another. Indeed in some of these cases it is impossible to say simply even whether a thing is hot or not. For the actual substratum may not itself be hot, but may be hot when coupled with heat as an attribute, as would be the case if one attached a single name to hot water or hot iron. It is after this manner that blood is hot.[1] In such cases, in those, that is, in which the substratum owes its heat to an external

[1] Because in A.'s opinion it derives its heat from the heart, or from the celestial heat which has its main seat in the heart.

influence, it is plain that cold is not a mere privation, but an actual existence.

There is no knowing but that even fire may be another of these cases. For the substratum of fire may be smoke or charcoal, and though the former of these is always hot, smoke being an uprising vapour, yet the latter becomes cold when its flame is extinguished, as also would oil and pinewood under similar circumstances. But even substances that have been burnt nearly all possess some heat, cinders, for example, and ashes, the dejections also of animals, and, among the excretions, bile; because some residue of heat has been left in them after their combustion. It is in another sense that pinewood and fat substances are hot; namely, because they rapidly assume the actuality of fire.

Heat appears to cause both coagulation and melting. Now such things as are formed merely of water are solidified by cold, while such as are formed of nothing but earth are solidified by fire. Hot substances again are solidified by cold, and, when they consist chiefly of earth, the process of solidification is rapid, and the resulting substance is insoluble; but, when their main constituent is water, the solid matter is again soluble. What kinds of substances, however, admit of being solidified, and what are the causes of solidification, are questions that have already been dealt with more precisely in another treatise.[1]

In conclusion, then, seeing that the terms hot and hotter
649b are used in many different senses, and that no one substance can be hotter than others in all these senses, we must, when we attribute this character to an object, add such further statements as that this substance is hotter *per se*, though that other is often hotter *per accidens*; or again, that this substance is potentially hot, that other actually so; or again, that this substance is hotter in the sense of causing a greater feeling of heat when touched, while that other is hotter in the sense of producing flame and burning. The term hot being used in all these various senses, it plainly follows that the term cold will also be used with like ambiguity.

[1] Cf. *Meteor.* iv. 6–8, 10.

So much then as to the signification of the terms hot and cold, hotter and colder.

3 In natural sequence we have next to treat of solid and fluid. These terms are used in various senses. Sometimes, for instance, they denote things that are potentially, at other times things that are actually, solid or fluid. Ice for example, or any other solidified fluid, is spoken of as being actually and accidentally solid, while potentially and essentially it is fluid. Similarly earth and ashes and the like, when mixed with water, are actually and accidentally fluid, but potentially and essentially are solid. Now separate the constituents in such a mixture and you have on the one hand the watery components to which its fluidity was due,[1] and these are both actually and potentially fluid, and on the other hand the earthy components, and these are in every way[2] solid; and it is to bodies that are solid in this complete manner that the term 'solid' is most properly and absolutely applicable. So also the opposite term 'fluid' is strictly and absolutely applicable to that only which is both potentially and actually fluid. The same remark applies also to hot bodies and to cold.

These distinctions, then, being laid down, it is plain that blood is essentially hot in so far as that heat is connoted in its name; just as if boiling water were denoted by a single term, boiling would be connoted in that term. But the substratum of blood, that which it is in substance while it is blood in form, is not hot. Blood then in a certain sense is essentially hot, and in another sense is not so. For heat is included in the definition of blood, just as whiteness is included in the definition of a white man, and so far therefore blood is essentially hot. But so far as blood becomes hot from some external influence, it is not hot essentially.

[1] The distinctive character of a fluid is that it is ἀναπληστικόν, that is, that it has no shape of its own but takes that of the vessel which it fills up as a mould (*De G. et C.* ii. 2. 329b 34). To say then that a constituent of a mixture is ἀναπληστικόν is to say that it confers fluidity on the mixture.

[2] That is, 'both potentially and actually'. Ἅπαντα, if the true reading, must be taken as adverbial and as used though 'de duobus tantum agitur' (Bonitz, 571b 51); but I suggest πάντως as a preferable reading.

As with hot and cold, so also is it with solid and fluid. We can therefore understand how some substances are hot and fluid so long as they remain in the living body, but become perceptibly cold and coagulate so soon as they are separated from it; while others are hot and consistent while in the body, but when withdrawn undergo a change to the opposite condition, and become cold and fluid. Of the former blood is an example, of the latter bile; for while blood solidifies when thus separated, yellow bile under the same circumstances becomes more fluid. We must attribute to such substances the possession of opposite properties in a greater or less degree.

650a In what sense, then, the blood is hot and in what sense fluid, and how far it partakes of the opposite properties, has now been fairly explained. Now since everything that grows must take nourishment, and nutriment in all cases consists of fluid and solid substances, and since it is by the force of heat that these are concocted and changed, it follows that all living things, animals and plants alike, must on this account, if on no other, have a natural source of heat. This natural heat, moreover, must belong to many parts,[1] seeing that the organs by which the various elaborations of the food are effected are many in number. For first of all there is the mouth and the parts inside the mouth, on which the first share in the duty clearly devolves, in such animals at least as live on food which requires disintegration. The mouth, however, does not actually concoct the food, but merely facilitates concoction; for the subdivision of the food into small bits facilitates the action of heat upon it. After the mouth come the upper and the lower abdominal cavities,[2] and here it is that concoction is

[1] A. looked on the heart as the main but not the exclusive seat of vital heat. 'The whole body and all its parts have a certain connate natural heat. But in sanguineous animals the main seat of this heat must be the heart. For, though the other parts by their natural heat can effect the concoction of the food, yet chief and foremost in this office is the heart. The rest of the body then may become cold, and yet life continue; but should the heart cease to be hot, all life is at an end; for no longer does there remain a source whence the rest of the body may derive heat' (*De Juv. et Sen.* 4. 469^b 12).

[2] The upper cavity is of course the stomach. By the lower is meant

effected by the aid of natural heat. Again, just as there is a channel for the admission of the unconcocted food into the stomach, namely the mouth, and in some animals the so-called oesophagus, which is continuous with the mouth and reaches to the stomach, so must there also be other and more numerous channels by which the concocted food or nutriment shall pass out of the stomach and intestines into the body at large, and to which these cavities shall serve as a kind of manger. For plants get their food from the earth by means of their roots; and this food is already elaborated when taken in, which is the reason why plants produce no excrement,[1] the earth and its heat serving them in the stead of a stomach. But animals, with scarcely an exception, and conspicuously all such as are capable of locomotion, are provided with a stomachal sac, which is as it were an internal substitute for the earth. They must therefore have some instrument which shall correspond to the roots of plants, with which they may absorb their food from this sac, so that the proper end of the successive stages of concoction may at last be attained. The mouth then, its duty done, passes over the food to the

the large intestine, or rather its caecal enlargement. This is sometimes, as here, spoken of by A. as a seat of digestion, that is as a second stomach, and sometimes merely as a receptacle of residual matter, as though all digestion were over before this part was reached. We may fairly suppose that A. in the different passages is speaking of different animals; for while the caecum in some animals, as in the horse, really acts as a second stomach, in others, as in man, its contents are almost entirely faecal.

[1] Περίττωμα, like the nutriment (*G. A.* i. 18. 725^a 4) of which it is the surplus, is of two kinds, the useless (ἄχρηστον) and the serviceable (χρήσιμον). The former is eliminated, mainly by the bowels and kidneys, and may be called the excremental residue. The latter is such of the nutriment reduced to blood as remains after the nobler parts, such as the sense-organs and flesh, have taken what they require (*G. A.* ii. 6. 744^b 23). This surplus is utilized in various ways. Some is spent on the inert parts, such as nails, hairs, sinews, bones (744^b 25); some is stored up as fat (ii. 5. 651^a 21); and some forms useful secretions and notably the generative (iv. 10. 689^a 8-13). All these products of the περίττωμα are themselves called περιττώματα. The χρήσιμον περίττωμα in the blood contrasts with the σύντηγμα or product of body-waste (*G. A.* i. 18. 724^b 26 sq.); and when A. says of anything, other than excrement, that it is περίττωμα, he means that it derives from the serviceable residue, not from the effete matter. Plants, he says above, have no excremental residue, while their serviceable residue forms their fruit and seeds (ii. 10. 655^b 35).

stomach, and there must necessarily be something to receive it in turn from this. This something is furnished by the blood-vessels, which run throughout the whole extent of the mesentery from its lowest part right up to the stomach. A description of these will be found in the treatises on Anatomy and Natural History.[1] Now as there is a receptacle for the entire matter taken as food, and also a receptacle for its excremental residue, and again a third receptacle, namely the vessels, which serve as such for the blood, it is plain that this blood must be the final nutritive material in such animals as have it; while in bloodless animals the same is the case with the fluid which represents the blood. This explains why the blood diminishes in quantity when no food is taken, and increases

650^{b} when much is consumed, and also why it becomes healthy and unhealthy according as the food is of the one or the other character. These facts, then, and others of a like kind, make it plain that the purpose of the blood in sanguineous animals is to subserve the nutrition of the body. They also explain why no more sensation is produced by touching the blood than by touching one of the excretions or the food, whereas when the flesh is touched sensation is produced. For the blood is not continuous nor united by growth with the flesh, but simply lies loose in its receptacle, that is in the heart and vessels. The manner in which the parts grow at the expense of the blood, and indeed the whole question of nutrition, will find a more suitable place for exposition in the treatise on Generation, and in other writings.[2] For our present purpose

[1] Cf. *H. A.* i. 16; iii. 4. 514^{b} 12.

[2] A. often refers to a treatise which he was going to write on Nutrition. It has been generally supposed that the *De Generatione Animalium*, in which (ii. 4. 740^{a} 21–^{b} 12, ii. 6. 743^{a} 8–7. 746^{a} 28) nutrition is handled to a certain extent, is the treatise thus promised. But this view seems incompatible with the fact that a similar reference to a future treatise 'on growth and nutrition' is made in the *De Generatione* itself (v. 4. 784^{b} 3). The present passage, moreover, speaks of 'other writings' besides the *De Generatione*. The promised treatise is not extant; perhaps was never written; for no mention of such is to be found in Diogenes Laertius. Heitz (*Die verlor. Schrift. d. Arist.* 61) thinks it probable that a short separate treatise was written, such as those massed together in the *Parva Naturalia*, and that some portions of it have come down to us merged in the *De Generatione*;

all that need be said is that the blood exists for the sake of nutrition, that is the nutrition of the parts; and with this much let us therefore content ourselves.

4 What are called fibres are found in the blood of some animals but not of all. There are none, for instance, in the blood of deer and of roes;[1] and for this reason the blood of such animals as these never coagulates. For one part of the blood consists mainly of water[2] and therefore does not coagulate, this process occurring only in the other and earthy constituent, that is to say in the fibres, while the fluid part is evaporating.

Some at any rate of the animals with watery blood have a keener intellect than those whose blood is of an earthier nature. This is due not to the coldness of their blood, but rather to its thinness and purity; neither of which qualities belongs to the earthy matter. For the thinner and purer its fluid is, the more easily affected is an animal's sensibility. Thus it is that some bloodless animals, notwithstanding their want of blood, are yet more intelligent than some among the sanguineous kinds. Such for instance, as already said,[3] is the case with the bee and the tribe of ants, and whatever other animals there may be of a like nature. At the same time too great an excess of water makes animals timorous. For fear chills the body; so that in animals whose heart contains so watery a mixture the way is prepared for the operation of this emotion. For water is congealed by cold. This also explains why bloodless animals are, as a general rule, more timorous than such as have blood, so that they remain motionless, when frightened, and discharge their excretions, and in some

and there is in fact in the *De Somno* (3. 456b 6) a passage which apparently refers to a treatise on Nutrition as already written. The subject is treated in *De G. et C.* i. 5. 321a 32 – 322a 33, ii. 8. 335a 10, *Meteor.* iv. 2. 379b 23.

[1] Elsewhere (*H. A.* iii. 6. 515b 34) to these animals are added the Bubalis (antelope) and hare. It will be noted that all these are animals that are hunted: and the blood of animals hunted to death coagulates so imperfectly that J. Hunter was led to suppose erroneously that it did not coagulate at all (Hunter's *Works*, i. 234). A. (*H. A.* iii. 6. 516a 1) admits an imperfect coagulation of such blood.

[2] Omitting ψυχρόν (Z).

[3] Cf. ii. 2. 648a 6.

instances change colour.[1] Such animals, on the other hand, as have thick and abundant fibres in their blood are of a more earthy nature, and of a choleric temperament, and liable to bursts of passion. For anger is productive of heat; and solids, when they have been made hot, give off more heat
651a than fluids. The fibres therefore, being earthy and solid, are turned into so many hot embers in the blood, like the embers in a vapour-bath, and cause ebullition in the fits of passion.

This explains why bulls and boars are so choleric and so passionate. For their blood is exceedingly rich in fibres,[2] and the bull's at any rate coagulates more rapidly than that of any other animal.[3] If these fibres, that is to say if the earthy constituents of which we are speaking, are taken out of the blood, the fluid that remains behind will no longer coagulate; just as the watery residue of mud will not coagulate after removal of the earth. But if the fibres are left the fluid coagulates, as also does mud, under the influence of cold. For when the heat is expelled by the cold, the fluid, as has been already stated, passes off with it by evaporation, and the residue is dried up and solidified, not by heat but by cold.[4] So long, however, as the blood is in the body, it is kept fluid by animal heat.

[1] The bloodless animals that remain motionless when frightened are beetles, moths, &c. (iv. 6. 682^{b} 25). Those that discharge their excreta are various insects and cephalopods (iv. 5. 679^{a} 6); and it is these latter that change colour (iv. 5. 679^{a} 13).

[2] Elsewhere (*H. A.* iii. 19. 521^{a} 5) the ass is instanced as well as the bull. Bovine animals (but still more swine and horses) have a larger proportion of fibrine in their blood than men (Andral, *Ann. de Chimie*, 1842, p. 306); and from such scanty observations as exist it would seem that the blood of bulls is richer in fibrine than that of cows or oxen (*ibid.* p. 307). Thackrah seems to have arrived at much the same general conclusion as Aristotle. 'Although my experiments are far from evincing a disparity uniform in its reference to the classes of animals, yet it appears probable that a more complete examination would prove *the crassamentum to bear a proportion to the strength and ferocity of the animal*, since I never found the serum in such quantity as in the timid sheep, nor the crassamentum so abundant as in the predatory dog' (*On the Blood*, 1834, p. 154).

[3] Thackrah says (*On the Blood*, p. 154) that 'from my observations the general inference may be drawn that coagulation commences sooner in small and weak animals than in large and strong'. This seems in contradiction with A.'s statement.

[4] Cf. *Meteor.* iv. 6–8, where A. discusses at length the questions of coagulation, liquefaction, &c.

The character of the blood affects both the temperament and the sensory faculties of animals in many ways. This is indeed what might reasonably be expected, seeing that the blood is the material of which the whole body is made. For nutriment supplies the material, and the blood is the ultimate nutriment. It makes then a considerable difference whether the blood be hot or cold, thin or thick, turbid or clear.

The watery part of the blood is serum; and it is watery, either owing to its not being yet concocted, or owing to its having become corrupted; so that one part of the serum is the resultant of a necessary process,[1] while another part is material intended to serve for the formation of the blood.

5 The differences between lard and suet correspond to differences of blood.[2] For both are blood concocted into these forms as a result[3] of abundant nutrition, being that surplus blood that is not expended on the fleshy part of the body, and is of an easily concocted and fatty character. This is shown by the unctuous aspect of these substances; for such unctuous aspect in fluids is due to a combination of air and fire.[4] It follows from what has been said that no non-sanguineous animals have either lard or suet; for they have no blood. Among sanguineous animals those whose blood

[1] By the 'necessary process' is meant the waste of the body (σύντηξις) that is constantly going on, but is increased by toil (*De Somno*, 3. 456b 34). The effete matter (σύντηγμα) that results from this necessary process, passing into the blood on its way to elimination by the various emunctories, is there commingled with nutritive material (*χρήσιμον περίττωμα*) that is on its way to repair the body-waste. This *σύντηγμα*, to use modern terms, is catabolic matter, while the *χρήσιμον περίττωμα* is anabolic.

[2] A. calls the softer kinds of fat *πιμελή* and the harder kinds *στέαρ*, terms corresponding to the Pinguedo and Sevum of later times. These are here rendered Lard and Suet, 'lard' being used in want of a better word for any soft fat, not merely that of swine. J. Hunter made four divisions—Oil, Lard, Tallow, Spermaceti, also taking consistency as the basis of distinction.

[3] A. held that in over-fed or well-fed animals the blood was of such a character as favoured its conversion by further concoction into fat rather than into generative secretions; just as vines in rich soil run to leaf rather than to fruit. *G. A.* i. 18. 725b 26 sq., ii. 7. 746b 27; *H. A.* v. 14. 546a 1.

[4] This clause seems so inconsecutive that one may suspect it to be an interpolation.

is dense have suet rather than lard. For suet is of an earthy nature, that is to say, it contains but a small proportion of water and is chiefly composed of earth; and this it is that makes it coagulate, just as the fibrous matter of blood coagulates, or broths which contain such fibrous matter. Thus it is that in those horned animals that have no front teeth in the upper jaw the fat consists of suet. For the very fact that they have horns and huckle-bones [1] shows that their composition is rich in this earthy element; for all such appurtenances are solid and earthy in character. On the other hand in those hornless animals that have front teeth in both jaws, and whose feet are divided into toes, there is no suet, but in its place lard; [2] and this, not being of an earthy character, neither coagulates nor dries up into a friable mass.

Both lard and suet when present in moderate amount are beneficial: for they contribute to health and strength, while
651b they are no hindrance to sensation. But when they are present in great excess, they are injurious and destructive. For were the whole body formed of them it would perish. For an animal is an animal in virtue of its sensory part, that is in virtue of its flesh, or of the substance analogous to flesh.[3] But the blood, as before stated, is not sensitive; as therefore is neither lard nor suet, seeing that they are nothing but concocted blood. Were then the whole body composed of these substances, it would be utterly without sensation. Such animals, again, as are excessively fat age rapidly. For so much of their blood is used in forming fat, that they have but little left; and when there is but little blood the way is already open for decay.[4] For decay may be said to be deficiency of blood, the scantiness of which renders it

[1] Cf. iv. 10. 690a 13 note.

[2] i.e. Swine. Elsewhere (*H. A.* iii. 17. 520a 9) A. says correctly that the horse as well as the hog has soft fat.

[3] Cf. ii. 8. 653b 30 note.

[4] Cf. Thackrah, *On the Blood*, p. 131: 'Fat animals have I believe considerably less blood in proportion to their weight than lean ones; and in the fat human subject venesection shows the veins to be comparatively small, and the quantity of blood, even when two or three vessels are opened, is less than flows from one vein of a lean person' etc.

liable, like all bodies of small bulk, to be injuriously affected by any chance excess of heat or cold. For the same reason fat animals are less prolific than others. For that part of the blood which should go to form semen and seed is used up in the production of lard and suet, which are nothing but concocted blood; so that in these animals there is either no reproductive excretion at all, or only a scanty amount.[1]

6 So much then of blood and serum, and of lard and suet. Each of these has been described, and the purposes told for which they severally exist.

The marrow also is of the nature of blood, and not, as some [2] think, the germinal force of the semen. That this is the case is quite evident in very young animals. For in the embryo the marrow of the bones has a blood-like appearance, which is but natural, seeing that the parts are all constructed out of blood, and that it is on blood that the embryo is nourished.[3] But, as the young animal grows up and ripens into maturity, the marrow changes its colour, just as do the external parts and the viscera.[4] For the viscera also in animals, so long as they are young, have each and all a blood-like look, owing to the large amount of this fluid which they contain.

The consistency of the marrow agrees with that of the fat. For when the fat consists of lard, then the marrow also is unctuous and lard-like; but when the blood is converted by concoction into suet, and does not assume the form [5] of lard, then the marrow also has a suety character.

[1] 'On dirait qu'il y a un rapport constant et rigoureux entre la sécrétion de la semence et l'exhalation de la graisse; que ces deux fluides sont en raison inverse l'un de l'autre' (Bichat, *Anat. Gén.* i. 55). That over-fat animals are bad breeders is known to every farmer. So also it is well known that castrated animals grow fat.

[2] Alluding to Plato, who expresses this view in the *Timaeus* (73 c).

[3] 'The bones of the foetus are void of a distinct medullary canal, and present merely a reddish homogeneous vascular pulp, somewhat consistent but presenting soft portions. This state continues for some time after birth' (Todd, *Cyclop. Anat. and Phys.* i. 60). So also Virchow's *Cellularpath.* 369.

[4] In the foetus and infant there is less pigment in the body generally than in the adult. The skin, hair, eyes (*G.A.* v. 1. 779^a 26), and olfactory region, are all lighter-coloured than in later life.

[5] For *ὅμοιος* read *ὅμοιον* (Z).

In those animals, therefore, that have horns and are without upper front teeth, the marrow has the character of suet; while it takes the form of lard in those that have front teeth in both jaws, and that also have the foot divided into toes. What has been said hardly applies to the spinal marrow. For it is necessary that this shall be continuous and extend without break through the whole backbone, inasmuch as this bone consists of separate vertebrae. But were the spinal marrow[1] either of unctuous fat or of suet, it could not hold together in such a continuous mass as it does, but would either be too fluid or too frangible.

There are some animals that can hardly be said to have any marrow. These are those whose bones are strong and
652a solid, as is the case with the lion. For in this animal the marrow is so utterly insignificant that the bones look as though they had none at all. However, as it is necessary that animals shall have bones or something analogous to them, such as the fish-spines of water-animals, it is also a matter of necessity that some of these bones shall contain marrow: for the substance contained within the bones is the nutriment out of which these are formed. Now the universal nutriment, as already stated,[2] is blood; and the blood within the bone, owing to the heat which is developed in it from its being thus surrounded, undergoes concoction, and self-concocted[3] blood is suet or lard; so that it is perfectly intelligible how the marrow within the bone comes to have the character of these substances. So also it is easy to understand why, in those animals that have strong and compact bones, some of these should

[1] That the spinal cord is the marrow of the vertebrae is an error, the memory of which is still preserved in the popular term 'spinal marrow'.

[2] Cf. ii. 4. 651a 14.

[3] This passage is of importance; for it indicates the answer to the obvious objection, that many of the phenomena attributed by A. to heat are manifestly not so producible. For, in using the term 'self-concoction', A. means to draw a distinction between ordinary heat and the heat of the blood or body. Mere cooking with fire of course does not convert blood into fat, nor digest food, nor the like. But the heat of the body, as the heat of the sun, says A. (*G. A.* ii. 3. 737a 1), is something very different from this. It has a vivifying influence, which simple fire has not, and produces effects far beyond the power of this element.

be entirely void of marrow, while the rest contain but little of it;[1] for here the nutriment is spent in forming the bones.

Those animals that have fish-spines in place of bones have no other marrow than that of the chine.[2] For in the first place they have naturally but a small amount of blood; and secondly the only hollow fish-spine is that of the chine. In this then marrow is formed; this being the only spine in which there is space for it, and, moreover, being the only one which owing to its division into parts requires a connecting bond. This too is the reason why the marrow of the chine, as already mentioned, is somewhat different from that of other bones. For, having to act the part of a clasp, it must be of glutinous character, and at the same time sinewy so as to admit of stretching.

Such then are the reasons for the existence of marrow, in those animals that have any, and such its nature. It is evidently the surplus of the sanguineous nutriment apportioned to the bones and fish-spines, which has undergone concoction owing to its being enclosed within them.

7 From the marrow we pass on in natural sequence to the brain. For there are many[3] who think that the brain itself consists of marrow, and that it forms the commencement of that substance, because they see that the spinal marrow is continuous with it. In reality the two may be said to be utterly opposite to each other in character. For of all the parts of the body there is none so cold as the brain; whereas the marrow is of a hot nature, as is plainly shown by its fat and unctuous character. Indeed this is the very reason why the brain and spinal marrow are continuous with each other. For, wherever the action of any part is in excess, nature so contrives as to set by it another part with an excess of contrary action, so that the excesses of the two may counterbalance each other. Now that the marrow is hot is clearly shown by many indications. The

[1] Reading ὀλίγος for ὀλίγοις (U).

[2] No fish has a medullary canal in its bones, though there are some, as the trout, in which the bony tissue is more or less penetrated by an oily fluid (Todd, *Cyclop. of An. and Phy.* iii. 958).

[3] As Plato in the *Timaeus* (73 c).

coldness of the brain is also manifest enough.[1] For in the first place it is cold even to the touch; and, secondly, of all the fluid parts of the body it is the driest[2] and the one that has the least blood; for in fact it has no blood
652b at all in its proper substance. This brain is not residual matter, nor yet is it one of the parts which are anatomically continuous[3] with each other; but it has a character peculiar to itself, as might indeed be expected. That it has no continuity with the organs of sense is plain from simple inspection, and is still more clearly shown by the fact, that, when it is touched, no sensation is produced; in which respect it resembles the blood of animals and their excrement. The purpose of its presence in animals is no less than the preservation of the whole body. For some[4] writers assert that the soul is fire or some such force. This, however, is but a rough and inaccurate assertion; and it would perhaps be better to say that the soul is incorporate in some substance of a fiery character. The reason for this being so is that of all substances there is none so suitable for ministering to the operations of the soul as that which is possessed of heat. For nutrition and the imparting of motion are offices of the soul, and it is by heat that

[1] There are three strange statements in this chapter as to the brain—that it is cold; that it is bloodless; that it is fluid. (α) The belief that the brain is cold lasted from the time of Hippocrates into the sixteenth or even the seventeenth century. For, as Dr. Payne states in his Harveian Oration, it was taught by Harvey in his MS. Praelectiones of 1616, and this though an anatomist of the preceding century is quoted by himself as having placed one hand on the heart and the other on the brain of a recently killed animal and found them equally hot. (β) Most of the blood that goes to the brain goes to the superficial gray matter. This, differing as it does from the mass below in colour and general aspect, was considered by A. to be part of the highly vascular *Pia mater*, from which indeed he can hardly have learnt to separate it mechanically. He appears to have overlooked the small vessels which penetrate the white mass, and which, though numerous, only appear as bloody puncta. (γ) A. uses the term 'fluid' with much latitude; and may mean no more than that the brain is, as Galen calls it, 'nearly fluid.' At any rate he qualifies his statement very much by saying that of all the fluids it is the least fluid (*αὐχμηρότατον*), that is, the most consistent, and that it is only fluid in the young and becomes consolidated afterwards (*G. A.* ii. 6. 744a 17).

[2] i. e. the most consistent.

[3] Such as the vascular or osseous systems. See ii. 9. 654a 33.

[4] Democritus (*De An.* i. 2. 403b 31).

these are most readily effected. To say then that the soul is fire is much the same thing as to confound the auger or the saw with the carpenter or his craft, simply because the work is wrought by the two in conjunction. So far then this much is plain, that all animals must necessarily have a certain amount of heat. But as all influences require to be counterbalanced, so that they may be reduced to moderation and brought to the mean (for in the mean, and not in either extreme, lies the true and rational position), nature has contrived the brain as a counterpoise to the region of the heart with its contained heat, and has given it to animals to moderate the latter, combining in it the properties of earth and water.[1] For this reason it is, that every sanguineous animal has a brain; whereas no bloodless creature has such an organ, unless indeed it be, as the Poulp, by analogy.[2] For where there is no blood, there in consequence there is but little heat. The brain, then, tempers the heat and seething of the heart. In order, however, that it may not itself be absolutely without heat, but may have a moderate amount, branches run from both blood-vessels,[3] that is to say from the great vessel and from what is called the aorta, and end in the membrane which surrounds the brain;[4] while at the same time, in order to prevent any injury from the heat, these encompassing vessels, instead of being few and large, are numerous and small, and their blood scanty and clear, instead of being abundant and thick. We can now understand why defluxions have their origin in the head, and occur whenever the parts about the brain have more than a due propor-

[1] And therefore causing it to be cold; for both earth and water are compounds of cold matter, the former with solid, the latter with fluid matter. (Cf. ii. 1. 646a 16 note.)

[2] Elsewhere (*H. A.* i. 16. 494b 27) A. speaks of Cephalopods in general, and not only of the Poulp, as having a brain. The cephalic ganglia in these animals are so large as to rival the brains of vertebrates in size and importance.

[3] Cf. iii. 5. 667b 16 note.

[4] i.e. the *pia mater*. A. (*H. A.* i. 16) describes the brain as having two membranes, an outer and stronger one next to the bone (*dura mater*), and an inner one in contact with the brain itself (*pia mater*). This latter is the vascular one, so often mentioned by Aristotle. This membrane consists in great part of a plexus of extremely numerous and very minute vessels, as A. says.

tion of coldness. For when the nutriment steams upwards 653^a through the blood-vessels, its refuse portion is chilled by the influence of this region, and forms defluxions of phlegm and serum. We must suppose, to compare small things with great, that the like happens here as occurs in the production of showers. For when vapour steams up from the earth and is carried by the heat into the upper regions, so soon as it reaches the cold air that is above the earth, it condenses again into water owing to the refrigeration, and falls back to the earth as rain. These, however, are matters which may be suitably considered in the Principles of Diseases,[1] so far as natural philosophy has anything to say to them.

It is the brain again—or, in animals that have no brain, the part analogous to it—which is the cause of sleep. For either by chilling the blood that streams upwards after food, or by some other similar influences, it produces heaviness in the region in which it lies (which is the reason why drowsy persons hang the head), and causes the heat to escape downwards in company with the blood. It is the accumulation of this in excess in the lower region that produces complete sleep, taking away the power of standing upright from those animals to whom that posture is natural, and from the rest the power of holding up the head. These, however, are matters which have been separately considered in the treatises on Sensation and on Sleep.[2]

That the brain is a compound of earth and water is shown by what occurs when it is boiled. For, when so treated, it turns hard and solid, inasmuch as the water is evaporated by the heat, and leaves the earthy part behind. Just the same occurs when pulse and other fruits are boiled. For these also are hardened by the process, because the water which enters into their composition is driven off and leaves the earth, which is their main constituent, behind.

Of all animals, man has the largest brain in proportion to

[1] As to the question whether the promised treatise on the Principles of Diseases was ever written, see Heitz, *Die verlor. Schrift. d. Arist.* p. 58.

[2] *De Somno*, 2. 455^b 28 – 3. 458^a 32. I find nothing in *De Sensu*.

his size; and it is larger in men than in women. This is because the region of the heart and of the lung is hotter and richer in blood in man than in any other animal; and in men than in women. This again explains why man, alone of animals, stands erect. For the heat, overcoming any opposite inclination, makes growth take its own line of direction, which is from the centre of the body upwards. It is then as a counterpoise to his excessive heat that in man's brain there is this superabundant fluidity and coldness; and it is again owing to this superabundance that the cranial bone, which some call the Bregma,[1] is the last to become solidified; so long does evaporation[2] continue to occur through it under the influence of heat. Man is the only sanguineous animal in which this takes
place. Man, again, has more sutures in his skull than any 653b
other animal,[3] and the male more than the female.[4] The explanation is again to be found in the greater size of the brain, which demands free ventilation, proportionate to its bulk. For if the brain be either too fluid or too solid, it will not perform its office, but in the one case will freeze the blood, and in the other will not cool it at all; and thus will cause disease, madness, and death. For the cardiac heat and the centre of life is most delicate in its sympathies, and is immediately sensitive to the slightest change or affection of the blood on the outer surface of the brain.[5]

[1] i. e. the anterior fontanel, considered by A. to be a separate bone (*H. A.* i. 7. 491a 31).

[2] The erroneous notion that the use of the sutures is to ventilate the brain is repeated by Galen (*De Inst. Odor.* 2; *De Sanit. tuenda*, i. 13).

[3] This is an error. A. was probably led to it by the fact that in numerous animals the sutures become more or less effaced at a very early age. This is notably the case with birds, fishes, and, of mammals, with the cetacea and elephants.

[4] The sutures in the female skull are really identical with those of the male. Still it is not impossible that A.'s statement may have been founded on some single observation. For it is by no means uncommon for the sutures on the vertex to become more or less effaced in pregnant women; so common indeed is it, that the name 'puerperal osteophyte' has been given to the condition by Rokitansky (*Path. Anat.* iii. 208, Syd. Soc. Transl.).

[5] A. is ridiculed by Galen for having made the brain no more than a spongeful of cold water. It is plain, however, that in reality he assigned to it an office scarcely less important than that he attached to the heart. It is true he made this latter the actual sensory centre,

The fluids which are present in the animal body at the time of birth have now nearly all been considered. Amongst those that appear only at a later period are the residua of the food, which include the deposits of the belly and also those of the bladder. Besides these there is the semen and the milk, one or the other of which makes its appearance in appropriate animals. Of these fluids, the excremental residua of the food may be suitably discussed by themselves, when we come to examine and consider the subject of nutrition. Then will be the proper time to explain in what animals they are found, and what are the reasons for their presence. Similarly all questions concerning the semen and the milk may be dealt with in the treatise on Generation,[1] for the former of these fluids is the very starting-point of the generative process, and the latter has no other ground of existence than generative purposes.

We have now to consider the remaining homogeneous 8
parts, and will begin with flesh, and with the substance that, in animals that have no flesh, takes its place. The reason for so beginning is that flesh forms the very basis of animals, and is the essential constituent of their body. Its right to this precedence can also be demonstrated logically. For an animal is by our definition something that has sensibility and chief of all the primary sensibility, which is that of Touch;[2] and it is the flesh, or analogous substance, which is the organ of this sense. And it is the organ, either in the same way as the pupil is the organ of sight, that is it constitutes the primary organ of the sense; or it is the organ and the medium through which the object acts com-

but he represented it as so directly dependent upon the brain for the discharge of its functions, and as so instantaneously affected by any change which occurs in this organ, that heart and brain came as it were to form one consolidated organ.

[1] *G. A.* i. 17 – ii. 3, iv. 8.

[2] Not meaning that the other special senses are only modifications of touch or general sensibility. For this view, entertained by Democritus, is expressly repudiated by A. (*De Sensu*, 4. 442^a 29). Touch is to A. the primary sense, firstly because it is the most universally distributed of the senses; no animals being without it, though they may be without any other (*De An.* iii. 13. 435^b 1; ii. 3. 415^a 3; *H. A.* i. 3. 489^a 17); and secondly, because it is by touch that we are able to recognize the four primary properties of matter (*De An.* ii. 11).

bined, that is it answers to the pupil with the whole transparent medium attached to it. Now in the case of the other senses it was impossible for nature to unite the medium with the sense-organ, nor would such a junction have served any purpose; but in the case of touch she was compelled by necessity to do so. For of all the sense-organs that of touch is the only one that has corporeal substance, or at any rate it is more corporeal than any other, and its medium must be corporeal like itself.[1]

It is obvious also to sense[2] that it is for the sake of the flesh that all the other parts exist. By the other parts I mean the bones, the skin, the sinews, and the blood-vessels, and, again, the hair and the various kinds of nails, and anything else there may be of a like character. Thus the bones are a contrivance to give security to the soft parts,[3] to which purpose they are adapted by their hardness; and in animals that have no bones the same office is fulfilled by some analogous substance, as by fish-spine in some fishes, and by cartilage in others.

Now in some animals this supporting substance is situated within the body, while in some of the bloodless species it is 654a

[1] A.'s statements as to the relation of the flesh to Touch are by no means clear. The flesh is sometimes (ii. 1. 651a 20) spoken of as the Sense-organ (αἰσθητήριον) of Touch; sometimes this is strenuously denied (ii. 10., 656b 25) and it is said to be the medium (τὸ μεταξὺ τοῦ ἁπτικοῦ). Here it is suggested that it is medium and organ combined; and this seems to be the view to which A. inclines, the outer mass of flesh being the medium and some undefined and purely hypothetical part of it, situated internally in close proximity to the heart (ἔνδον, πρὸς τῇ καρδίᾳ), being the organ. Medium, organ, and heart being thus in continuity with each other, any motion of the medium affects organ and heart not in succession but simultaneously, just as a blow on a shield in immediate contact with the body affects shield and body together. A. held (*De G. et C.* i. 7) that nothing could be set in motion except by an agent generically homogeneous with itself. In sensation the object of sense sets the medium in motion, and then the motion of the medium is communicated to the sense-organ (*De An.* ii. 7). The medium then and the sense-organ must be generically alike. Now, wherever an animal may be, its eye and ear find media of corresponding nature to themselves in the external air or water; but the sense-organ of Touch being a corporeal, that is a solid, substance requires a solid medium, and this it can only have if attached to itself and carried about as part of the body.

[2] Besides having its right to precedence logically demonstrable, as stated a few sentences back.

[3] Reading τοῦ μαλακοῦ.

placed on the outside. The latter is the case in all the Crustacea,[1] as the Carcini (*Crabs*) and the Carabi (*Prickly Lobsters*); it is the case also in the Testacea, as for instance in the several species known by the general name of oysters. For in all these animals the fleshy substance is within, and the earthy matter, which holds the soft parts together and keeps them from injury, is on the outside. For the shell not only enables the soft parts to hold together, but also, as the animal is bloodless and so has but little natural warmth, surrounds it, as a chaufferette does the embers, and keeps in the smouldering heat. Similar to this seems to be the arrangement in another and distinct tribe of animals, namely the Tortoises, including the Chelone and the several kinds of Emys.[2] But in Insects and in Cephalopods the plan is entirely different, there being moreover a contrast between these two themselves. For in neither of these does there appear to be any bony or earthy part, worthy of notice, distinctly separated from the rest of the body. Thus in the Cephalopods the main bulk of the body consists of a soft flesh-like substance, or rather of a substance which is intermediate to flesh and sinew, so as not to be so readily destructible as actual flesh. I call this substance intermediate to flesh and sinew, because it is soft like the former, while it admits of stretching like the latter.[3] Its cleavage, however, is such that it splits not longitudinally, like sinew, but into circular segments, this being the most advantageous condition, so far as strength is concerned. These animals have also a part inside them corresponding to the spinous bones of fishes. For instance, in the Cuttle-fishes there is what is known as the *os sepiae*, and in the Calamaries there is the so-called *gladius*. In the Poulps,[4] on the other hand, there is no such internal part, because the body, or, as it is termed in them, the head,[5] forms but a short sac, whereas it is of considerable length in the other two; and it was this length which led

[1] Cf. iv. 8. 683b 25 note.

[2] Cf. iii. 9. 671a 32 note.

[3] Cf. iii. 4. 666b 13 note.

[4] Read τό for τά and γένος after πολυπόδων (Platt).

[5] Cf. iv. 9. 685a 5 note.

nature to assign to them their hard support, so as to ensure their straightness and inflexibility; just as she has assigned to sanguineous animals their bones or their fish-spines, as the case may be. To come now to Insects. In these the arrangement is quite different from that of the Cephalopods; quite different also from that which obtains in sanguineous animals, as indeed has been already stated. For in an insect there is no distinction into soft and hard parts, but the whole body is hard, the hardness, however, being of such a character as to be more flesh-like than bone, and more earthy and bone-like than flesh. The purpose of this is to make the body of the insect less liable to get broken into pieces.

9 There is a resemblance between the osseous and the vascular systems; for each has a central part in which it begins, and each forms a continuous whole. For no bone in the body exists as a separate thing in itself, but each is either a portion of what may be considered a continuous whole, or at any rate is linked with the rest by contact and by attachments; so that nature may use adjoining bones either as though they were actually continuous and formed 654b
a single bone, or, for purposes of flexure, as though they were two and distinct. And similarly no blood-vessel has in itself a separate individuality; but they all form parts of one whole. For an isolated bone, if such there were, would in the first place be unable to perform the office for the sake of which bones exist; for, were it discontinuous and separated from the rest by a gap, it would be perfectly unable to produce either flexure or extension; nor only so, but it would actually be injurious, acting like a thorn or an arrow lodged in the flesh. Similarly if a vessel were isolated, and not continuous with the vascular centre, it would be unable to retain the blood within it in a proper state. For it is the warmth derived from this centre that hinders the blood from coagulating; indeed the blood, when withdrawn from its influence, becomes manifestly putrid. Now the centre or origin of the blood-vessels is the heart, and the centre or origin of the bones, in all

animals that have bones, is what is called the chine. With this all the other bones of the body are in continuity; for it is the chine that holds together the whole length of an animal and preserves its straightness. But since it is necessary that the body of an animal shall bend during locomotion, this chine, while it is one in virtue of the continuity of its parts, yet by its division into vertebrae is made to consist of many segments. It is from this chine that the bones of the limbs, in such animals as have these parts, proceed, and with it they are continuous, being fastened together by the sinews where the limbs admit of flexure, and having their extremities[1] adapted to each other, either by the one being hollowed and the other rounded,[2] or by both being hollowed and including between them a hucklebone,[3] as a connecting bolt, so as to allow of flexure and extension. For without some such arrangement these movements would be utterly impossible, or at any rate would be performed with great difficulty. There are some joints, again, in which the lower end of the one bone and the upper end of the other are alike in shape. In these cases the bones are bound together by sinews, and cartilaginous pieces are interposed in the joint, to serve as a kind of padding, and prevent the two extremities from grating against each other.

Round about the bones, and attached to them by thin fibrous bands, grow the fleshy parts, for the sake of which the bones themselves exist. For just as an artist, when he is moulding an animal out of clay or other soft substance, takes first some solid body as a basis, and round this moulds the clay, so also has nature acted in fashioning the animal body out of flesh. Thus we find all the fleshy parts, with one exception, supported by bones, which serve, when the parts are organs of motion, to facilitate flexure, and, when the parts are motionless, act as a protection. The

[1] Read *συνεχῆ πρὸς αὐτὴν τὰ τούτων ὀστᾶ τῶν μορίων* (Z) *ἐστίν, ᾗ ἔχει τὰ κῶλα κάμψιν συνδεδεμένα τοῖς* (SU) *νεύροις κτλ.*

[2] i. e. Ball and socket joints, as of hip and shoulder. The next form, containing an astragalus, is the ankle joint. The third kind mentioned includes arthrodial joints, e. g. the sterno-clavicular, carpal, &c., but probably refers more especially to the knee-joint with its semilunar cartilages.

[3] Cf. iv. 10. 690a 10 note.

ribs, for example, which enclose the chest are intended to ensure the safety of the heart and neighbouring viscera. The exception of which mention was made is the belly. 655a
The walls of this are in all animals devoid of bones; in order that there may be no hindrance to the expansion which necessarily occurs in this part after a meal, nor, in females, any interference with the growth of the foetus, which is lodged here.

Now the bones of viviparous animals, of such, that is, as are not merely externally but also internally viviparous,[1] vary but very little from each other in point of strength, which in all of them is considerable. For the Vivipara in their bodily proportions are far above other animals, and many of them occasionally grow to an enormous size, as is the case in Libya and in hot and dry countries generally. But the greater the bulk of an animal, the stronger, the bigger, and the harder, are the supports which it requires; and comparing the big animals with each other, this requirement will be most marked in those that live a life of rapine. Thus it is that the bones of males are harder than those of females; and the bones of flesh-eaters, that get their food by fighting, are harder than those of Herbivora. Of this the Lion is an example; for so hard are its bones, that, when struck, they give off sparks, as though they were stones. It may be mentioned also that the Dolphin, inasmuch as it is viviparous, is provided with bones and not with fish-spines.

In those sanguineous animals, on the other hand, that are oviparous, the bones present successive slight variations of character. Thus in Birds there are bones, but these are not so strong as the bones of the Vivipara. Then come the Oviparous fishes, where there is no bone, but merely fish-spine. In the Serpents too the bones have the character of fish-spine, excepting in the very large species, where the solid foundation of the body requires to be stronger, in order that the animal itself may be strong, the same reason prevailing as in the case of the Vivipara. Lastly, in the

[1] i.e. Of the truly viviparous, not the ovo-viviparous such as the Selachia, whose bones are cartilaginous. Cf. iv. 1. 676b 3 note.

Selachia, as they are called, the fish-spines are replaced by cartilage. For it is necessary that the movements of these animals shall be of an undulating character; and this again requires the framework that supports the body to be made of a pliable and not of a brittle substance. Moreover, in these Selachia [1] nature has used all the earthy matter on the skin; and she is unable to allot to many different parts one and the same superfluity of material.[2] Even in viviparous animals many of the bones are cartilaginous. This happens in those parts where it is to the advantage of the surrounding flesh that its solid base shall be soft and mucilaginous. Such, for instance, is the case with the ears and nostrils; for in projecting parts, such as these, brittle substances would soon get broken. Cartilage and bone are indeed fundamentally the same thing, the differences between them being merely matters of degree. Thus neither cartilage nor bone, when once cut off, grows again.[3] Now the cartilages of these land animals are without marrow, that is without any distinctly separate marrow. For the marrow, which in bones is distinctly separate, is here mixed up with the whole mass, and gives a soft and mucilaginous consistence to the cartilage. But in the Selachia
655b the chine, though it is cartilaginous, yet contains marrow; for here it stands in the stead of a bone.

Very nearly resembling the bones to the touch are such parts as nails, hoofs, whether solid or cloven, horns, and the

[1] The skin of the fishes called Selachia by A. is studded with numerous tubercles, granules, or spines, of bony matter; a peculiarity designated as 'placoid' by modern ichthyologists.

[2] It has been a matter of question whether the credit of being the first to put forth the law of organic equivalents should be assigned to Geoffroi St. Hilaire or to Goethe; the former of whom spoke of it as 'la loi de balancement organique', while the latter expressed it in these terms, 'Nature must save in one part in order to spend in another.' As a matter of fact, the law, whether true or false, is perfectly recognized by Aristotle, and is used by him over and over again in explanation of morphological phenomena.

[3] So also Hippocrates (*Aphor.* vii. 28); where, as also in the *Coacae Praenotiones* (Kühn i. 319), the word used is, as in this passage and *H. A.* iii. 8. 516b 33, ἀποκοπῇ, i. e. excised. But διακοπῇ—cut through—is used in another Aphorism (vi. 19) and is the object of the hostile criticism from which Galen somewhat weakly defends Hippocrates (Kühn xviii, Part i. 30).

beaks of birds, all of which are intended to serve as means of defence. For the organs which are made out of these substances, and which are called by the same names as the substances themselves, the organ hoof, for instance, and the organ horn, are contrivances to ensure the preservation of the animals to which they severally belong. In this class too must be reckoned the teeth, which in some animals have but a single function, namely the mastication of the food, while in others they have an additional office, namely to serve as weapons; as is the case with all animals that have sharp interfitting teeth or that have tusks. All these parts are necessarily of a solid and earthy character; for the value of a weapon depends on such properties. Their earthy character explains how it is that all such parts are more developed in four-footed vivipara than in man. For there is always more earth in the composition of these animals than in that of the human body. However, not only all these parts but such others as are nearly connected with them, skin for instance, bladder, membrane, hairs, feathers, and their analogues, and any other similar parts that there may be, will be considered farther on with the heterogeneous parts.[1] There we shall inquire into the causes which produce them, and into the objects of their presence severally in the bodies of animals. For, as with the heterogeneous parts, so with these, it is from a consideration of their functions that alone we can derive any knowledge of them. The reason for dealing with them at all in this part of the treatise, and classifying them with the homogeneous parts, is that under one and the same name are confounded the entire organs and the substances of which they are composed. But of all these substances flesh and bone form the basis. Semen and milk were also passed over when we were considering the homogeneous fluids. For the treatise on Generation[2] will afford a more suitable place for their examination, seeing that the former

[1] Cf. as to Bladder, iii. 8; Membrane, iii. 11; Hairs, ii. 14; Feathers, iv. 12. 692b 10 sq.; Nails, iv. 10. 687b 23 sq.; Hoofs, iv. 10. 690a 4; Horns, iii. 2; Beaks, iii. 1. 662a 29 sq.; Teeth, iii. 1. 661a 34 sq.

[2] *G. A.* i. 17–ii. 3, iv. 8.

of the two is the very foundation of the thing generated, while the latter is its nourishment.

Let us now make, as it were, a fresh beginning, and con- 10
sider the heterogeneous parts, taking those first which are the first in importance. For in all animals, at least[1] in all the perfect kinds, there are two parts more essential than the rest, namely the part which serves for the ingestion of food, and the part which serves for the discharge of its residue. For without food growth and even existence is impossible. Intervening[2] again between these two parts there is invariably a third, in which is lodged the vital principle. As for plants, though they also are included by us among things that have life, yet are they without any part for the discharge of waste residue. For the food which they absorb from the ground is already concocted, and they give off as its equivalent their seeds and fruits.
656a Plants, again, inasmuch as they are without locomotion, present no great variety in their heterogeneous parts. For, where the functions are but few, few also are the organs required to effect them. The configuration of plants is a matter then for separate consideration. Animals, however, that not only live but feel, present a greater multiformity of parts, and this diversity is greater in some animals than in others, being most varied in those to whose share has fallen not mere life but life of high degree. Now such an animal is man. For of all living beings with which we are acquainted man alone partakes of the divine, or at any rate partakes of it in a fuller measure than the rest. For this reason, then, and also because his external parts and their forms are more familiar to us than those of other animals, we must speak of man first; and this the more fitly, because in him alone do the natural parts hold the natural position; his upper part being turned towards that which is upper in the universe. For, of all animals, man alone stands erect.

In man, then, the head is destitute of flesh; this being

[1] For καί read τοῖς γε.
[2] This sentence is transposed from ll. 36–37.

the necessary consequence of what has already been stated[1] concerning the brain. There are, indeed, some[2] who hold that the life of man would be longer than it is, were his head more abundantly furnished with flesh; and they account for the absence of this substance by saying that it is intended to add to the perfection of sensation. For the brain they assert to be the organ of sensation; and sensation, they say, cannot penetrate to parts that are too thickly covered with flesh. But neither part of this statement is true. On the contrary, were the region of the brain thickly covered with flesh, the very purpose for which animals are provided with a brain would be directly contravened. For the brain would itself be heated to excess and so unable to cool any other part; and, as to the other half of their statement, the brain cannot be the cause of any of the sensations, seeing that it is itself as utterly without feeling as any one of the excretions.[3] These writers see that certain of the senses are located in the head, and are unable to discern the reason for this; they see also that the brain is the most peculiar of all the animal organs; and out of these facts they form an argument, by

[1] Cf. ii. 7.

[2] e.g. Plato in the *Timaeus* (75 B), who probably borrowed the opinion, as Galen says he did his physiology generally, from Hippocrates. Democritus also had taught that the sovereign part of the soul was in the head; and Diogenes of Apollonia, more directly, had held that the brain was the seat of sensation, being surrounded by a layer of hot dry air, which was in connexion with the sense-organs by means of the blood-vessels, and so sympathized with their motions and affections (cf. Grote's *Plato*, i. 65).

[3] A.'s chief reasons for refusing to admit that the brain was the sensory centre were as follows. (1) It was insensible to touch (ii. 10. 656^{a} 23; ii. 7. 652^{b} 5). (2) There was no brain or analogous organ in any of the bloodless animals, cephalopods excepted (ii. 7. 652^{b} 25). (3) It was cold and bloodless (ii. 7. 652^{a} 33). (4) It was not anatomically connected with the sense-organs, notably with those of touch and taste (ii. 7. 652^{b} 3).

On the other hand, the heart (1) was palpably affected in emotion or when pain or pleasure was felt (iii. 6. 669^{a} 19); (2) was present, or an analogous organ, in all animals (iii. 4. 665^{b} 10; *G. A.* iv. 4. 771^{a} 3); (3) was the source of heat and of the blood (iii. 5. 667^{b} 26); (4) was in anatomical connexion, through the blood-vessels, with all the sense-organs (*G. A.* ii. 6. 744^{a} 3); (5) was the first part to be formed in the embryo, the 'primum vivens, ultimum moriens' (*G. A.* ii. 5. 741^{b} 20); (6) was in a central position befitting the supreme organ (iii. 7. 670^{a} 24).

The brain in all animals that have one is placed in the front part of the head; because the direction in which sensation acts is in front; and because the heart, from which sensation proceeds, is in the front part of the body; and lastly because the instruments of sensation are the blood-containing parts, and the cavity in the posterior part of the skull is destitute of blood-vessels.

As to the position of the sense-organs, they have been arranged by nature in the following well-ordered manner. The organs of hearing are so placed as to divide the circumference of the head into two equal halves; for they have to hear not only sounds which are directly in a line with themselves, but sounds from all quarters. The organs of vision are placed in front, because sight is exercised only in a straight line, and moving as we do in a forward direction it is necessary that we should see before us, in the direction of our motion. Lastly, the organs of smell are placed with good reason between the eyes. For as the body consists of two parts, a right half and a left, so also each organ of sense is double. In the case of touch this is not apparent, the reason being that the primary organ of this sense is not the flesh or analogous part, but lies internally.[1] In the case of taste, which is merely a modification of touch and which is placed in the tongue, the fact is more apparent than in the case of touch, but still not
657a so manifest as in the case of the other senses. However, even in taste it is evident enough; for in some animals the tongue is plainly forked. The double character of the sensations is, however, more conspicuous in the other organs of sense. For there are two ears and two eyes, and the nostrils, though joined together, are also two. Were these latter otherwise disposed, and separated from each other as

blood-vessels outside the brain, and blood itself is insensible. The channels from the ears end in the void space, where there are no blood-vessels; and no part without blood-vessels is sensitive. Neither the sensibility of the eyes nor that of the ears can therefore be explained simply by their connexion with the interior of the cranium.

A short sentence is here omitted, as being partly unintelligible, partly empty iteration. Part of it, moreover, is wanting in E, one of the best MSS.

[1] Cf. ii. 8. 653b 30 note.

are the ears, neither they nor the nose in which they are placed would be able to perform their office. For in such animals as have nostrils olfaction is effected by means of inspiration, and the organ of inspiration is placed in front and in the middle line. This is the reason why nature has brought the two nostrils together and placed them as the central of the three sense-organs, setting them side by side on a level with each other, to avail themselves of the inspiratory motion. In other animals than man the arrangement of these sense-organs is also such as is adapted in
11 each case to the special requirements. For instance, in quadrupeds the ears stand out freely from the head and are set to all appearance above the eyes. Not that they are in reality above the eyes; but they seem to be so, because the animal does not stand erect, but has its head hung downwards. This being the usual attitude of the animal when in motion, it is of advantage that its ears shall be high up and movable; for by turning themselves about they can the better take in sounds from every quarter.
12 In birds, on the other hand, there are no ears, but only the auditory passages. This is because their skin is hard and because they have feathers instead of hairs, so that they have not got the proper material for the formation of ears. Exactly the same is the case with such oviparous quadrupeds as are clad with scaly plates, and the same explanation applies to them. There is also one of the viviparous quadrupeds, namely the seal, that has no ears but only the auditory passages. The explanation of this is that the seal, though a quadruped, is a quadruped of stunted formation.

13 Men, and Birds, and Quadrupeds, viviparous and oviparous alike, have their eyes protected by lids. In the Vivipara there are two of these; and both are used by these animals not only in closing the eye, but also in the act of blinking; whereas the oviparous quadrupeds, and the heavy-bodied birds[1] as well as some others, use only

[1] That is the Gallinaceous birds (*H. A.* ii. 8. 613b 6).

the lower lid to close the eye;[1] while birds blink by means of a membrane that issues from the canthus. The reason for the eyes being thus protected is that nature has made them of fluid consistency, in order to ensure keenness of vision. For had they been covered with hard skin, they would, it is true, have been less liable to get injured by anything falling into them from without, but they would not have been sharp-sighted. It is then to ensure keenness of vision that the skin over the pupil is fine and delicate: while the lids are superadded as a protection from injury. It is as a still further safeguard that all these animals blink, 657b and man most of all; this action (which is not performed from deliberate intention but from a natural instinct) serving to keep objects from falling into the eyes; and being more frequent in man than in the rest of these animals, because of the greater delicacy of his skin. These lids are made of a roll of skin; and it is because they are made of skin and contain no flesh that neither they, nor the similarly constructed prepuce, unite again when once cut.[2]

As to the oviparous quadrupeds, and such birds as resemble them in closing the eye with the lower lid, it is the hardness of the skin of their heads which makes them do so. For such birds as have heavy bodies are not made for flight; and so the materials which would otherwise have gone to increase the growth of the feathers are diverted thence, and used to augment the thickness of the skin. Birds therefore of this kind close the eye with the lower lid; whereas pigeons and the like use both upper and lower lids for the purpose. As birds are covered with feathers, so oviparous quadrupeds are covered with scaly plates; and these in all

[1] In birds, as a rule, as also in Chelonia, in crocodiles, and in frogs, the lower lid is much larger and more movable than the upper, and it is with it therefore that the eye is closed in sleep. There are, however, some few exceptions, and of these the owl is one, as noticed by A. elsewhere (*H. A.* ii. 12. 504^{a} 26). A few sentences later it is said that pigeons use both lids to close the eye, which is also a correct observation.

[2] This is an unfortunate statement, borrowed however from Hippocrates (Kühn's ed. i. 319; iii. 752). Firstly, the presence of flesh, i.e. of muscular tissue, is not essential for reunion after section; secondly, the eyelid does contain muscular tissue; and, lastly, cuts both in it and the prepuce can be made to unite by proper appliances.

their forms are harder than hairs, so that the skin also to which they belong is harder than the skin of hairy animals. In these animals, then, the skin on the head is hard, and so does not allow of the formation of an upper eyelid, whereas lower down the integument is of a flesh-like character, so that the lower lid can be thin and extensible.

The act of blinking is performed by the heavy-bodied birds[1] by means of the membrane already mentioned, and not by this lower lid. For in blinking rapid motion is required, and such is the motion of this membrane, whereas that of the lower lid is slow. It is from the canthus that is nearest to the nostrils that the membrane comes. For it is better to have one starting-point for nictitation than two; and in these birds this starting-point is the junction of eye and nostrils, an anterior starting-point being preferable to a lateral one. Oviparous quadrupeds do not blink in like manner as the birds;[2] for, living as they do on the ground, they are free from the necessity of having eyes of fluid consistency and of keen sight, whereas these are essential requisites for birds, inasmuch as they have to use their eyes at long distances. This too explains why birds with talons, that have to search for prey by eye from aloft, and therefore soar to greater heights than other birds, are sharp-sighted; while common fowls and the like, that live on the ground and are not made for flight, have no such keenness of vision. For there is nothing in their mode of life which imperatively requires it.

Fishes and Insects and the hard-skinned Crustacea present certain differences in their eyes, but so far resemble each other as that none of them have eyelids.[3] As for the hard-skinned Crustacea it is utterly out of the question that they should have any; for an eyelid, to be of use, requires the action of the skin[4] to be rapid. These animals then have

[1] And by all other birds also (cf. *H. A.* ii. 12. 504a 26).

[2] A. both here and elsewhere speaks erroneously of a nictitating membrane as peculiar to birds. For, though it is especially well developed in birds, yet it is to be found in numerous reptiles, amphibia, and sharks, not to mention some mammals.

[3] There are exceptions among fishes, particularly in sharks.

[4] Read *ταχεῖαν τὴν δερματικὴν ἔχει ἐργασίαν.*

no eyelids and, in default of this protection, their eyes are hard, just as though the lid were attached to the surface of the eye, and the animal saw through it. Inasmuch, however, as such hardness must necessarily blunt the sharpness of vision, nature has endowed the eyes of Insects, and
658a still more those of Crustacea,[1] with mobility (just as she has given some quadrupeds movable ears), in order that they may be able to turn to the light and catch its rays, and so see more plainly. Fishes, however, have eyes of a fluid consistency. For animals that move much about have to use their vision at considerable distances. If now they live on land, the air in which they move is transparent enough. But the water in which fishes live is a hindrance to sharp sight, though it has this advantage over the air, that it does not contain so many objects to knock against the eyes. The risk of collision being thus small, nature, who makes nothing in vain, has given no eyelids to fishes, while to counterbalance the opacity of the water she has made their eyes of fluid consistency.

All animals that have hairs on the body have lashes on 14
the eyelids; but birds and animals with scale-like plates, being hairless, have none.[2] The Libyan ostrich, indeed, forms an exception; for, though a bird, it is furnished with eyelashes. This exception, however, will be explained hereafter. Of hairy animals, man alone has lashes on both lids. For in quadrupeds there is a greater abundance of hair on the back than on the under side of the body; whereas in man the contrary is the case, and the hair is more abundant on the front surface than on the back. The reason for this is that hair is intended to serve as a protection to its possessor. Now, in quadrupeds, owing to

[1] A.'s knowledge of Crustacea was confined, or nearly so, to Podophthalmata, in which the eyes are supported on movable peduncles. Insects have, almost invariably, sessile and motionless eyes; and though in a few instances the eyes are on peduncles, these peduncles are not movable like those of Crustacea.

[2] Birds, as a rule, have no eyelashes. There are, however, a few exceptions, and of these the Ostrich is one.—Casaubon rightly explains the construction—'voluit dicere et scripsisset alius, *ὄρνιθες δὲ οὐκ ἔχουσιν οὐδὲ τῶν φολιδωτῶν οὐδέν*'.

their inclined attitude, the under or anterior surface does not require so much protection as the back, and is therefore left comparatively bald, in spite of its being the nobler of the two sides. But in man, owing to his upright attitude, the anterior and posterior surfaces of the body are on an equality as regards need of protection. Nature therefore has assigned the protective covering to the nobler of the two surfaces;[1] for invariably she brings about the best arrangement of such as are possible. This then is the reason that there is no lower eyelash in any quadruped; though in some a few scattered hairs sprout out under the lower lid.[2] This also is the reason that they never have hair in the axillae, nor on the pubes, as man has. Their hair, then, instead of being collected in these parts, is either thickly set over the whole dorsal surface, as is the case for instance in dogs, or, sometimes, forms a mane, as in horses and the like, or as in the male lion, where the mane is still more flowing and ample. So, again, whenever there is a tail of any length, nature decks it with hair, with long hair if the stem of the tail be short, as in horses, with short hair if the stem be long, regard also being had to the condition of the rest of the body. For nature invariably gives to one part what she subtracts from another. Thus when she has covered the general surface of an animal's body with an excess of hair, she leaves a deficiency in the region of the tail. This, for instance, in the case with 658b
bears.

No animal has so much hair on the head as man. This, in the first place, is the necessary result of the fluid character of his brain, and of the presence of so many sutures in his skull. For wherever there is the most fluid and the most heat, there also must necessarily occur the

[1] Cf. ii. 2. 648^{a} 13 note.

[2] So far as I can ascertain it is true that man is the only mammal with a distinct marginal lower eyelash, with the exception of some monkeys, an exception elsewhere (*H. A.* ii. 8. 502^{a} 31) recognized by A., and some few antelopes. In very many mammals, especially the smaller kinds, there are no eyelashes at all. In the larger kinds, as a rule, the upper lash is well developed and marginal, while the lower lash is represented, as A. rightly says, by some long straggling hairs set below the lid, not on its margin.

greatest outgrowth. But, secondly, the thickness of the hair in this part has a final cause, being intended to protect the head, by preserving it from excess of either heat or cold. And as the brain of man is larger and more fluid than that of any other animal, it requires a proportionately greater amount of protection. For the more fluid a substance is, the more readily does it get excessively heated or excessively chilled, while substances of an opposite character are less liable to such injurious affections.

These, however, are matters which by their close connexion with eyelashes have led us to digress from our real topic, namely the cause to which these lashes owe their existence. We must therefore defer any further remarks we may have to make on these matters till the proper occasion arises and then return to their consideration.

Both eyebrows and eyelashes exist for the protection of the eyes; the former that they may shelter them, like the eaves of a house, from any fluids that trickle down from the head;[1] the latter to act like the palisades which are sometimes placed in front of enclosures, and keep out any objects which might otherwise get in. The brows are placed over the junction of two bones, which is the reason that in old age they often become so bushy as to require cutting. The lashes are set at the terminations of small blood-vessels. For the vessels come to an end where the skin itself terminates; and, in all places where these endings occur, the exudation of moisture of a corporeal character necessitates the growth of hairs,[2] unless there be some operation of nature which interferes, by diverting the moisture to another purpose.

[1] The explanation and the comparison are borrowed from Xenophon (*Mem.* i. 4. 6), who puts them into the mouth of Socrates.

[2] A. knew that the blood passed from the heart to the various parts by the vessels, but scarcely recognized its returning. Thus when the blood reached the peripheral ends of the vessels, it had to be disposed of in some form or other; that which escaped internally formed the viscera, that which escaped externally formed hair and the like. Thus the hair was in a certain sense an excretion (ii. 650^a 22 note). So also was it regarded by Bacon (*Nat. Hist.* cent. i, sect. 58) and Shakespeare— 'Your bedded hair, like life in excrements,
Starts up, and stands on end' (*Hamlet* iii. 4).

16 Viviparous quadrupeds, as a rule, present no great variety of form in the organ of smell. In those of them, however, whose jaws project forwards and taper to a narrow end, so as to form what is called a snout, the nostrils are placed in this projection, there being no other available plan; while, in the rest, there is a more definite demarcation between nostrils and jaws. But in no animal is this part so peculiar as in the elephant, where it attains an extraordinary size and strength. For the elephant uses its nostril as a hand; this being the instrument with 659a
which it conveys food, fluid and solid alike, to its mouth. With it, too, it tears up trees, coiling it round their stems. In fact it applies it generally to the purposes of a hand. For the elephant has the double character of a land animal, and of one that lives in swamps. Seeing then that it has to get its food from the water,[1] and yet must necessarily breathe, inasmuch as it is a land animal and has blood; seeing, also, that its excessive weight prevents it from passing rapidly from water to land, as some other sanguineous vivipara that breathe can do, it becomes necessary that it shall be suited alike for life in the water and for life on dry land. Just then as divers are sometimes provided with instruments for respiration, through which they can draw air from above the water, and thus may remain for a long time under the sea,[2] so also have elephants been furnished by nature with their lengthened nostril; and, whenever they have to traverse the water, they lift this up above the surface and breathe through it.[3] For the elephant's proboscis, as already said, is a nostril. Now it would have

[1] The elephant is much given to bathing: but A. appears to have entertained an exaggerated idea of its aquatic habits, and to have misinterpreted its reasons for betaking itself to the water; imagining that it went there not merely to slake its thirst or for the luxury of a cold bath, but because it depended, of course in its wild state, on water-plants for its sustenance!

[2] From this curious passage it would appear that the ancients were already acquainted with some form of diving apparatus corresponding to the submarine helmet and tubes in use at the present time. It may, however, have been some very simple instrument, such as the reed by means of which Australian natives (Tylor, *Anthrop.* p. 208) are said to be able to swim for a distance under water, so as to approach a flock of ducks without being seen.

[3] Cf. *H. A.* ix. 46. 630b 27. The elephant does in fact use its trunk in the way described when crossing a deep river (cf. Tennent, *Ceylon*, ii. 310).

been impossible for this nostril to have the form of a proboscis, had it been hard and incapable of bending. For its very length would then have prevented the animal from supplying itself with food, being as great an impediment as the horns of certain oxen, that are said [1] to be obliged to walk backwards while they are grazing. It is therefore soft and flexible, and, being such, is made, in addition to its own proper functions, to serve the office of the fore-feet; nature in this following her wonted plan of using one and the same part for several purposes. For in polydactylous quadrupeds the fore-feet are intended not merely to support the weight of the body, but to serve as hands. But in elephants, though they must be reckoned [2] polydactylous, as their foot has neither cloven nor solid hoof, the fore-feet, owing to the great size and weight of the body, are reduced to the condition of mere supports; and indeed their slow motion and [3] unfitness for bending make them useless for any other purpose. A nostril, then, is given to the elephant for respiration, as to every other animal that has a lung, and is lengthened out and endowed with its power of coiling because the animal has to remain for considerable periods of time in the water, and is unable to pass thence to dry ground with any rapidity. But as the feet are shorn of their full office, this same part is also, as already said, made by nature to supply their place, and give such help as otherwise would be rendered by them.

As to other sanguineous animals, the Birds, the Serpents,
659b and the Oviparous quadrupeds, in all of them there are the nostril-holes, placed in front of the mouth; but in none are there any distinctly formed nostrils, nothing in fact which can be called nostrils except from a functional point of view. A bird at any rate has nothing which can properly be called a nose. For its so-called beak is a substitute for jaws. The reason for this is to be found in the natural conformation of birds. For they are winged bipeds; and

[1] This story comes from Herodotus (iv. 183).

[2] Although the toes are not separate nor clearly defined, *ἀσχίστους καὶ ἠρέμα διηρθρωμένους*. (Cf. *H. A.* iii. 9. 517a 32.)

[3] A. does not mean that the elephant has no joints in its legs, for he specially repudiates this vulgar error (*H. A.* ii. 1. 498a 9).

this makes it necessary that their head and neck shall be of light weight; just as it makes it necessary that their breast[1] shall be narrow. The beak therefore with which they are provided is formed of a bone-like substance, in order that it may serve as a weapon as well as for nutritive purposes, but is made of narrow dimensions to suit the small size of the head. In this beak are placed the olfactory passages. But there are no nostrils; for such could not possibly be placed there.

As for those animals that have no respiration, it has already been explained[2] why it is that they are without nostrils, and perceive odours either through gills, or through a blow-hole, or, if they are insects, by the hypozoma;[3] and how the power of smelling depends, like their motion, upon the innate spirit of their bodies, which in all of them is implanted by nature and not introduced from without.

Under the nostrils are the lips, in such sanguineous animals, that is, as have teeth. For in birds, as already has been said, the purposes of nutrition and defence are fulfilled by a bone-like beak, which forms a compound substitute for teeth and lips. For supposing that one were

[1] Cf. iv. 12. 693b 17 note.

[2] Perhaps this refers to *De Sensu* 5. 444b 6 sq.

[3] By *hypozoma* A. designates no distinct organ or structure, but the indefinite mid part of the trunk, that in the human body is called the waist, but in other animals has no name. In insects this region is marked by a narrow constriction, but A. also speaks of a hypozoma in fishes where there is no such constriction (*G. A.* i. 8. 718b 1). It is not difficult to understand why A. located the sense of smell in or near this region of the insect's body. Arguing by analogy from the higher animals, A. believed that the organ of smell was inseparable from the organ of respiration, or, in the lower animals, of refrigeration. He accordingly located smell in the gills of fishes, in the blowpipe of Cetacea, and in insects, in a specially thin part of the integument, covering a fissure just below the *hypozoma*, and serving, as he thought, for escape of heat and production of sounds (*De Resp.* 9. 475a 1–19; *H. A.* iv. 9. 535b 8). This refers to the so-called 'drums' of cicadae and the 'tympana' of grasshoppers, to which A. apparently supposed there was something correspondent in other insects; meaning perhaps the thinner integument between the successive rings of the abdomen. The alternate contractions and dilatations, which are visible in an insect's abdomen, and which are in reality respiratory, were attributed by him to the refrigerating motion of the 'connate spirit'. It must be by inadvertence that the blowpipe of Cetacea is mentioned, for A. is speaking of animals that have no lungs, and he well knew that Cetacea were not of these.

to cut off a man's lips, unite his upper teeth together, and similarly his under ones, and then were to lengthen out the two separate pieces thus formed, narrowing them on either side and making them project forwards, supposing, I say, this to be done, we should at once have a bird-like beak.

The use of the lips in all animals except man is to preserve and guard the teeth; and thus it is that the distinctness with which the lips are formed is in direct proportion to the degree of nicety and perfection with which the teeth are fashioned. In man the lips are soft and flesh-like and capable of separating from each other. Their purpose, as in other animals, is to guard the teeth, but they are more especially intended to serve a higher office, contributing in common with other parts to man's faculty of speech. For just as nature has made man's tongue unlike that of other animals, and, in accordance
660a with what I have said [1] is her not uncommon practice, has used it for two distinct operations, namely for the perception of savours and for speech, so also has she acted with regard to the lips, and made them serve both for speech and for the protection of the teeth. For vocal speech consists of combinations of the letters, and most of these it would be impossible to pronounce, were the lips not moist, nor the tongue such as it is. For some letters are formed by closures of the lips and others by applications of the tongue. But what are the differences presented by these and what the nature and extent of such differences, are questions to which answers must be sought from those who are versed in metrical science.[2] It was necessary that the two parts which we are discussing should, in conformity with the requirements, be severally adapted to fulfil the office mentioned above, and be of appropriate character. Therefore are they made of flesh, and flesh is softer in man than in any other animal, the reason

[1] Cf. 659a 21.

[2] The so-called Metrical Science had for its province everything relating to words considered merely as sounds, and ranged therefore from prosody and the laws of versification back to the elementary vocal sounds and the mechanism of their production. Cf. *Poetics* 20.

for this being that of all animals man has the most delicate sense of touch.

17 The tongue is placed under the vaulted roof of the mouth. In land animals it presents but little diversity. But in other animals it is variable, and this whether we compare them as a class with such as live on land, or compare their several species with each other. It is in man that the tongue attains its greatest degree of freedom, of softness, and of breadth; the object of this being to render it suitable for its double function. For its softness fits it for the perception of savours, a sense which is more delicate in man than in any other animal, softness being most impressionable by touch, of which sense taste is but a variety. This same softness again, together with its breadth, adapts it for the articulation of letters and for speech. For these qualities, combined with its freedom from attachment, are those which suit it best for advancing and retiring in every direction. That this is so is plain, if we consider the case of those who are tongue-tied in however slight a degree. For their speech is indistinct and lisping; that is to say there are certain letters which they cannot pronounce. In being broad is comprised the possibility of becoming narrow; for in the great the small is included, but not the great in the small.

What has been said explains why, even among birds, those that are most capable of pronouncing letters are such as have the broadest tongues;[1] and why the viviparous and sanguineous quadrupeds, where the tongue is hard and thick and not free in its motions, have a very limited vocal articulation. Some birds have a considerable variety of notes. These are the smaller kinds.[2] But it is the birds with talons that have the broader tongues. All birds use their tongues to communicate with each other. But some do this in a greater degree than the rest; so that in some 660b
cases it even seems as though actual instruction were

[1] In parrots, included by A. among the birds with talons, the tongue is 'épaisse, charnue et arrondie; deux circonstances qui leur donnent la plus grande facilité à imiter la voix humaine' (Cuvier, *Reg. An.* i. 461).
[2] Cf. *H. A.* iv. 9. 536a 24.

imparted from one to another by its agency. These, however, are matters which have already been discussed in the Researches concerning Animals.[1]

As to those oviparous and sanguineous animals that live not in the air but on the earth, their tongue in most cases is tied down and hard, and is therefore useless for vocal purposes; in the serpents, however, and in the lizards it is long and forked, so as to be suited for the perception of savours. So long indeed is this part in serpents, that though small while in the mouth it can be protruded to a great distance. In these same animals it is forked and has a fine and hair-like extremity, because of their great liking for dainty food. For by this arrangement they derive a twofold pleasure from savours, their gustatory sensation being as it were doubled.

Even some bloodless animals have an organ that serves for the perception of savours; and in sanguineous animals such an organ is invariably present. For even in such of these as would seem to an ordinary observer to have nothing of the kind, some of the fishes for example, there is a kind of shabby representative of a tongue,[2] much like what exists in river crocodiles. In most of these cases the apparent absence of the part can be rationally explained on some ground or other. For in the first place the interior of the mouth in animals of this character is invariably spinous. Secondly, in water animals there is but short space of time for the perception of savours, and as the use of this sense is thus of short duration, shortened also is the separate part which subserves it. The reason for their food being so rapidly transmitted to the stomach is that they cannot possibly spend any time in sucking out the juices; for were they to attempt to do so, the water would make its way in during the process. Unless therefore one pulls their mouth very widely open, the projection of this part is quite invisible. The region exposed by thus

[1] Cf. *H. A.* ii. 12. 504b 1; iv. 9. 536a 20–b 19; ix. 1. 608a 17.

[2] Cf. *H. A.* ii. 13. 505a 31. Many fishes have no tongue. In none is it protrusible, being at best an insignificant ligamentary or cellular body, scarcely projecting from the glosso-hyoid. Cf. Owen (*Vert.* i. 411), Cuvier (*An. Comp.* ii. 681), Günther (*St. of Fishes*, p. 119).

opening the mouth is spinous; for it is formed by the close apposition of the gills, which are of a spinous character.

In crocodiles the immobility of the lower jaw also contributes in some measure to stunt the development of the tongue. For the crocodile's tongue is adherent to the lower jaw. For its upper and lower jaws are, as it were, inverted, it being the upper jaw which in other animals is the immovable one. The tongue, however, of this animal is not attached to the upper jaw, because that would interfere with the ingestion of food, but adheres to the lower jaw, because this is, as it were, the upper one which has changed its place.[1] Moreover, it is the crocodile's lot, though a land animal, to live the life of a fish, and this again necessarily involves an indistinct formation of the part in question.

The roof of the mouth resembles flesh, even in many of the fishes; and in some of the river species, as for instance in the fishes known as Cyprini,[2] is so very flesh-like and soft as to be taken by careless observers for a tongue. The 661a
tongue of fishes, however, though it exists as a separate part, is never formed with such distinctness as this, as has been already explained. Again, as the gustatory sensibility is intended to serve animals in the selection of food, it is not diffused equally over the whole surface of the tongue-like organ, but is placed chiefly in the tip; and for this reason it is the tip which is the only part of the tongue separated in fishes from the rest of the mouth. As all animals are sensible to the pleasure derivable from food, they all feel a desire for it. For the object of desire is the pleasant. The part, however, by which food produces the sensation is not precisely alike in all of them, but while in some it is free

[1] The exact drift of this passage is not very evident. I take it that A. thinks it necessary to explain why the tongue, if it adheres to one jaw, does not adhere to that which in his view is the nobler, namely the upper (ii. 2. 648^a 11 note). His explanation is that in reality the tongue does adhere to the upper jaw; but that the upper jaw has been brought into the position of the lower one, as its immobility testifies, lest the adherence of the tongue to it should interfere with deglutition.

[2] In the Cyprinoids the palate is cushioned with a thick soft vascular substance, remarkable for its great irritability. This is still commonly known in France as 'langue de carpe' (Cuvier, *R. An.* ii. 270).

from attachments, in others, where it is not required for vocal purposes, it is adherent. In some again it is hard, in others soft or flesh-like. Thus even the Crustacea, the Carabi for instance and the like, and the Cephalopods, such as the Sepias and the Poulps, have some such part inside the mouth. As for the Insects, some of them have the part which serves as tongue inside the mouth, as is the case with ants, and as is also the case with many Testacea, while in others it is placed externally. In this latter case it resembles a sting, and is hollow and spongy, so as to serve at one and the same time for the tasting and for the sucking up of nutriment. This is plainly to be seen in flies and bees and all such animals, and likewise in some of the Testacea. In the Purpurae,[1] for instance, so strong is this part that it enables them to bore holes through the hard covering of shell-fish, of the spiral snails, for example, that are used as bait to catch them. So also the gad-flies and cattle-flies[2] can pierce through the skin of man, and some of them even through the skins of other animals. Such, then, in these animals is the nature of the tongue, which is thus as it were the counterpart of the elephant's nostril. For as in the elephant the nostril is used as a weapon, so in these animals the tongue serves as a sting.

In all other animals the tongue agrees with the description already given.

[1] Under Purpura are probably included all the various species of Murex and Purpura from which purple dye was obtainable. Of these the most important seem to have been *M. trunculus* and *M. brandaris* (Woodward, *R. & F. Shells*, p. 106). As to the power possessed by *P. lapillus* of boring through shells by means of its armed tongue, see Forbes and Hanley, *Brit. Mollusca*, iii. 385.

[2] By Oestri and Myopes, translated vaguely as Gad-flies and Cattle-flies, are probably meant some species or other of Tabanus.

BOOK III

1 We have next to consider the teeth, and with these the mouth, that is the cavity which they enclose and form. The teeth have one invariable office, namely the reduction 661b of food; but besides this general function they have other special ones, and these differ in different groups. Thus in some animals the teeth serve as weapons; but this with a distinction. For there are offensive weapons and there are defensive weapons; and while in some animals, as the wild Carnivora, the teeth answer both purposes, in many others, both wild and domesticated, they serve only for defence. In man the teeth are admirably constructed for their general office, the front ones being sharp, so as to cut the food into bits, and the hinder ones broad and flat, so as to grind it to a pulp; while between these and separating them are the dog-teeth, which, in accordance with the rule that the mean partakes of both extremes, share in the characters of those on either side, being broad in one part but sharp in another.[1] Similar distinctions of shape are presented by the teeth of other animals, with the exception of those whose teeth are one and all of the sharp kind. In man, however, the number and the character even of these sharp teeth have been mainly determined by the requirements of speech. For the front teeth of man contribute in many ways to the formation of letter-sounds.

In some animals, however, the teeth, as already said, serve merely for the reduction of food. When, besides this, they serve as offensive and defensive weapons, they may either be formed into tusks, as for instance is the case in swine, or may be sharp-pointed and interlock with those of the opposite jaw, in which case the animal is said to be saw-toothed. The explanation of this latter arrangement is as follows. The strength of such an animal is in its teeth, and

[1] That is 'broad below and sharp above' (*H. A.* ii. 3. 537^b 17).

these depend for their efficiency on their sharpness. In order, then, to prevent their getting blunted by mutual friction, such of them as serve for weapons fit into each other's interspaces, and are so kept in proper condition. No animal that has sharp interfitting teeth is at the same time furnished with tusks. For nature never makes anything superfluous or in vain. She gives, therefore, tusks to such animals as strike in fighting, and serrated teeth to such as bite. Sows, for instance, have no tusks, and accordingly sows bite instead of striking.

A general principle must here be noted, which will be found applicable not only in this instance but in many others that will occur later on. Nature allots each weapon, offensive and defensive alike, to those animals alone that can use it; or, if not to them alone, to them in a more marked degree; and she allots it in its most perfect state to those that can use it best; and this whether it be a sting, or a spur, or horns, or tusks, or what it may of a like kind.

Thus as males are stronger and more choleric than females, it is in males that such parts as those just mentioned are found, either exclusively, as in some species, or more fully developed, as in others. For though females are of course provided with such parts as are no less necessary to them than to males, the parts, for instance, which subserve nutrition, they have even these in an inferior degree, and the parts which answer no such necessary purpose they do
662a not possess at all. This explains why stags have horns, while does have none; why the horns of cows are different from those of bulls, and, similarly, the horns of ewes from those of rams. It explains also why the females are often without spurs in species where the males are provided with them, and accounts for similar facts relating to all other such parts.

All fishes have teeth of the serrated form, with the single exception of the fish known as the Scarus.[1] In many of them there are teeth even on the tongue and on the roof of

[1] The Scarus is doubtless the parrot-fish (*Scarus Cretensis*). This is, however, by no means the only exception to the general statement that all fishes have serrated dentition.

the mouth. The reason for this is that, living as they do in the water, they cannot but allow this fluid to pass into the mouth with the food. The fluid thus admitted they must necessarily discharge again without delay. For were they not to do so, but to retain it for a time while triturating the food, the water would run into their digestive cavities. Their teeth therefore are all sharp, being adapted only for cutting,[1] and are numerous and set in many parts,[2] that their abundance may serve in lieu of any grinding faculty, to mince the food into small bits. They are also curved, because these are almost the only weapons which fishes possess.

In all these offices of the teeth the mouth also takes its part; but besides these functions it is subservient to respiration, in all such animals as breathe and are cooled by external agency. For nature, as already said,[3] uses the parts which are common to all animals for many special purposes, and this[4] of her own accord. Thus the mouth has one universal function in all animals alike, namely its alimentary office; but in some, besides this, the special duty of serving as a weapon is attached to it; in others that of ministering to speech; and again in many, though not in all, the office of respiration. All these functions are thrown by nature upon one single organ, the construction of which she varies so as to suit the variations of office. Therefore it is that in some animals the mouth is contracted, while in others it is of wide dimensions. The contracted form belongs to such animals as use the mouth merely for nutritive, respiratory, and vocal purposes; whereas in such as use it as a means of defence it has

[1] Reading *διαίρεσιν μόνον, καί* (P).

[2] The mouth in many fishes, e. g. the pike, is beset with a countless number of sharp teeth which project from all parts of the internal surface. The object of this is not so much the comminution of the food, as A. supposes, as to enable the fish to retain hold of its slippery prey. Similarly the recurved form of the teeth, noticeable in many predatory species, serves to prevent the prey when once in the mouth from escaping, the points being all directed towards the oesophagus.

[3] Namely, at ii. 16. 658b 35, when speaking of the elephant's trunk. Similar statements are made (iv. 10. 688a 24, and 690a 2) concerning the female mammae, and the tails of animals.

[4] i. e. not of necessity.

a wide gape. This is its invariable form in such animals as are saw-toothed. For seeing that their mode of warfare consists in biting, it is advantageous to them that their mouth shall have a wide opening; for the wider it opens, the greater will be the extent of the bite, and the more numerous will be the teeth called into play.

What has just been said applies to fishes as well as to other animals; and thus in such of them as are carnivorous, and made for biting, the mouth has a wide gape; whereas in the rest it is small, being placed at the extremity of a tapering snout. For this form is suited for their purposes, while the other would be useless.

In birds the mouth consists of what is called the beak, which in them is a substitute for lips and teeth. This beak presents variations in harmony with the functions and
662b protective purposes which it serves. Thus in those birds that are called Crooked-clawed[1] it is invariably hooked, inasmuch as these birds are carnivorous, and eat no kind of vegetable food whatsoever. For this form renders it serviceable to them in obtaining the mastery over their prey, and is better suited for deeds of violence than any other. Moreover, as their weapons of offence consist of this beak and of their claws, these latter also are more crooked in them than in the generality of birds. Similarly in each other kind of bird the beak is suited to the mode of life. Thus, in woodpeckers[2] it is hard and strong, as also in crows and birds of crow-like habit, while in the smaller birds it is delicate, so as to be of use in collecting seeds and picking up minute animals. In such birds, again, as eat herbage, and such as live about marshes—those, for example, that swim and have webbed feet—the bill is broad, or adapted in some other way to the mode of life. For a broad bill enables a bird to dig into the ground with ease, just as, among quadrupeds, does the broad snout of the pig, an animal which, like the birds in question, lives

[1] i. e. the Raptores.

[2] The example is well chosen. For in woodpeckers, especially in the larger species, the beak acquires the density of ivory (cf. Owen, *Vert.* ii. 146). In the raven also, which is the bird usually meant by A. when he speaks of crows, the beak is hard and strong.

on roots. Moreover, in these root-eating birds and in some others of like habits of life, the tips of the bill end in hard points, which gives them additional facility in dealing with herbaceous food.

The several parts which are set on the head have now, pretty nearly all, been considered. In man, however, the part which lies between the head and the neck is called the face, this name (*prosōpon*) being, it would seem, derived from the function of the part. For as man is the only animal that stands erect, he is also the only one that looks directly in front (*prosō*); and the only one whose voice is emitted in that direction.

2 We have now to treat of horns; for these also, when present, are appendages of the head. They exist in none but viviparous animals; though in some ovipara certain parts are metaphorically spoken of as horns, in virtue of a certain resemblance.[1] To none of such parts, however, does the proper office of a horn belong; for they are never used, as are the horns of vivipara, for purposes which require strength, whether it be in self-protection or in offensive strife. So also no polydactylous animal[2] is furnished with horns. For horns are defensive weapons, and these polydactylous animals possess other means of security. For to some of them nature has given claws, to others teeth suited for combat, and to the rest some other adequate defensive appliance. There are horns, however, in most of the cloven-hoofed animals, and in some[3] of those that have 663a a solid hoof, serving them as an offensive weapon, and in some cases also as a defensive one. There are horns

[1] For instance, in some male fishes, lizards, and many beetles, where the horns are not weapons but mere ornaments. So A. calls the antennae of Crustacea horns (*H. A.* iv. 2. 526a 6). He alludes, however, more especially to the Egyptian snake (*H. A.* ii. 1. 500a 3): 'Thus the Egyptians speak of the snakes about Thebes as horned, because they have a kind of projection which as it were simulates a horn.' This is a reference to Herodot. ii. 74, and the snake in question was doubtless the Cerastes of Egypt.

[2] Under Polydactyla are included Carnivora, Rodentia, Insectivora, Cheiroptera, as well as man, apes, and elephants; in fact all Mammalia known to A. excepting Ruminantia, Solidungula, and Cetacea.

[3] Meaning the Indian Ass. Cf. 663a 20 note.

also in all animals that have not been provided by nature with some other means of security; such means, for instance, as speed, which has been given to horses; or great size, as in camels; for excessive bulk, such as has been given to these animals, and in a still greater measure to elephants, is sufficient in itself to protect an animal from being destroyed by others. Other animals again are protected by the possession of tusks; and among these are the swine, though they have a cloven hoof.[1]

All animals again, whose horns are but useless appendages, have been provided by nature with some additional means of security. Thus deer are endowed with speed; for the large size and great branching of their horns makes these a source of detriment rather than of profit to their possessors.[2] Similarly endowed are the Bubalus[3] and gazelle; for though these animals will stand up against some enemies and defend themselves with their horns, yet they run away from such as are fierce and pugnacious. The Bonasus[4] again, whose horns curve inwards towards each other,[5] is provided with a means of protection in the discharge of its excrement; and of this it avails itself when

[1] And therefore, he implies, might be expected to have horns, like most cloven-hoofed animals. Read διχαλὸν ὄν.

[2] It is somewhat astounding to find so determined a teleologist suddenly declaring that antlers are not merely useless but actually injurious to stags. A modern writer, however (Bailly, *Sur l'usage des cornes, Ann. d. Sc. Nat.* ii. 371), has come to the same conclusion: 'Quant aux bois du cerf, du renne, de l'élan, on sait qu'ils sont plus nuisibles qu'utiles.' The horns are, however, not so utterly useless as is here supposed, the upper antlers serving in defence, the brow antlers in attack (*Desc. of Man*, ii. 253). Still, as Darwin points out, the large branching horns do present a difficulty. For a straight point would inflict a much more serious wound than several diverging ones. Their great size and branching serve, however, as ornaments, and so give an advantage in the sexual struggle.

[3] The Bubalus must not be confounded with the Buffalo (*Bubalus*), which was known to A. as the wild ox of the Arachotae (*H. A.* i. 2. 499a 4). It is probably an Antelope, perhaps the Bubaline Antelope of N. Africa.

[4] The Bonasus (*H. A.* ix. 45) is universally admitted to be the European bison, which in the present day is almost extinct, existing only in Lithuania and in the Caucasus, but which in ancient times abounded in the forests of Europe generally. A. speaks of it (*H. A.* ii. 1. 500a 1) as living in his days in Paeonia and Medica, i. e. North Macedonia.

[5] And are therefore of no use as weapons.

frightened. There are some other animals besides the Bonasus that have a similar mode of defence. In no case, however, does nature ever give more than one adequate means of protection to one and the same animal.

Most of the animals that have horns are cloven-hoofed; but the Indian ass, as they call it, is also reported to be horned, though its hoof is solid.[1]

Again as the body, so far as regards its organs of motion, consists of two distinct parts, the right and the left, so also and for like reasons the horns of animals are, in the great majority of cases, two in number. Still there are some that have but a single horn; the Oryx,[2] for instance, and the so-called Indian ass; in the former of which the hoof is cloven, while in the latter it is solid. In such animals the horn is set in the centre of the head; for as the middle belongs equally to both extremes, this arrangement is the one that comes nearest to each side having its own horn.

Again, it would appear consistent with reason that the single horn should go with the solid rather than with the cloven hoof. For hoof, whether solid or cloven, is of the same nature as horn; so that the two naturally undergo division simultaneously and in the same animals. Again, since the division of the cloven hoof depends on deficiency of material, it is but rationally consistent, that nature, when she gave an animal an excess of material for the hoofs, which thus became solid, should have taken away something from the upper parts and so made the animal to have but one horn.

Rightly too did she act when she chose the head whereon to set the horns; and Æsop's Momus[3] is beside the mark,

[1] The account of the Indian Ass with a solid hoof, and a single horn, was taken by A. from Ctesias, who apparently did not profess himself to have seen more of the animal than its astragalus. It has been plausibly conjectured that the Indian Rhinoceros (*R. unicornis*) is the animal meant. For, though this animal has three toes, they are so indistinctly separated, that the real character of the foot might easily escape a casual observer, to whom the animal would, moreover, probably not give much leisure for observation.

[2] Probably the Leucoryx of N. Africa.

[3] The fable of Momus, the critic God, is alluded to by Lucian (*Nigrinus*, 32), and told in full by Babrius (Sir C. Lewes's ed. 59). Their account of the criticism on the bull's structure is not quite the

when he finds fault with the bull for not having its horns upon its shoulders. For from this position, says he, they would have delivered their blow with the greatest force,
663^b whereas on the head they occupy the weakest part of the whole body. Momus was but dull-sighted in making this hostile criticism. For had the horns been set on the shoulders, or had they been set on any other part than they are, the encumbrance of their weight would have been increased, not only without any compensating gain whatsoever, but with the disadvantage of impeding many bodily operations. For the point whence the blows could be delivered with the greatest force was not the only matter to be considered, but the point also whence they could be delivered with the widest range. But as the bull has no hands and cannot possibly have its horns on its feet or on its knees, where they would prevent flexion, there remains no other site for them but the head; and this therefore they necessarily occupy. In this position, moreover, they are much less in the way [1] of the movements of the body than they would be elsewhere.

Deer are the only animals in which the horns are solid throughout, and are also the only animals that cast them. This casting is not simply advantageous to the deer from the increased lightness which it produces, but, seeing how heavy the horns are, is a matter of actual necessity.

In all other animals the horns are hollow for a certain distance, and the end alone is solid, this being the part of use in a blow. At the same time, to prevent even the hollow part from being weak, the horn, though it grows out [2] of the skin, has a solid piece from the bones fitted into its cavity. For this arrangement is not only that which makes the horns of the greatest service in fighting, but that

same as Aristotle's. Momus objects that the horns are so placed as to be in the way of the animal's sight when it has its head down to attack its foe.

[1] ἀνεμπόδιστα, in spite of its form, is here supposed to be used in an active sense on the authority of Bonitz (56^a 6) and of Liddell and Scott.

[2] Omitting οὐ before πέφυκεν (EPYZ), cf. *H. A.* ii. 1. 500^a 8. For εἶναι read ἐστίν (Platt).

which causes them to be as little of an impediment as possible in the other actions of life.

Such then are the reasons for which horns exist; and such the reasons why they are present in some animals, absent from others.

Let us now consider the character of the material nature whose necessary results have been made available by rational nature for a final cause.

In the first place, then, the larger the bulk of animals, the greater is the proportion of corporeal and earthy matter which they contain. Thus no very small animal is known to have horns, the smallest horned animal that we are acquainted with being the gazelle. But in all our speculations concerning nature, what we have to consider is the general rule; for that is natural which applies either universally or generally. And thus when we say that the largest animals have most earthy matter, we say so because such is the general rule. Now this earthy matter is used in the animal body to form bone. But in the larger animals there is an excess of it, and this excess is turned by nature to useful account, being converted into weapons of defence. Part of it necessarily flows to the upper portion of the body, and this is allotted by her in some cases to the formation of tusks and teeth, in others to the formation of horns. Thus it is that no animal that has horns has also front teeth in both jaws, those in the upper jaw being deficient.[1] For 664a
nature by subtracting from the teeth adds to the horns; the nutriment which in most animals goes to the former being here spent on the augmentation of the latter. Does, it is true, have no horns and yet are equally deficient with the males as regards the teeth. The reason, however, for this is that they, as much as the males, are naturally horn-bearing animals; but they have been stripped of their

[1] 'The inverse relationship between the development of teeth and horns, exemplified by the total absence of canines in the ruminants with persistent frontal weapons, by their first appearance in the periodically hornless deer, and by their larger size in the absolutely hornless musks, is further illustrated by the presence not only of canines but of a pair of laniariform incisors in the upper jaw of Camelidae' (Owen *Vert.* iii. 348).

horns, because these would not only be useless to them but actually baneful; whereas the greater strength of the males causes these organs, though[1] equally useless, to be less of an impediment. In other animals, where this material is not secreted from the body in the shape of horns, it is used to increase the size of the teeth; in some cases of all the teeth, in others merely of the tusks, which thus become so long as to resemble horns projecting from the jaws.

So much, then, of the parts which appertain to the head.

Below the head lies the neck, in such animals as have 3
one. This is the case with those only that have the parts to which a neck is subservient. These parts are the larynx[2] and what is called the oesophagus. Of these the former, or larynx, exists for the sake of respiration, being the instrument by which such animals as breathe inhale and discharge the air. Therefore it is that, when there is no lung, there is also no neck. Of this condition the Fishes are an example. The other part, or oesophagus, is the channel through which food is conveyed to the stomach; so that all animals that are without a neck are also without a distinct oesophagus. Such a part is in fact not required of necessity for nutritive purposes; for it has no action whatsoever on the food. Indeed there is nothing to prevent the stomach from being placed directly after the mouth. This, however, is quite impossible in the case of the lung. For there must be some sort of tube common to the two divisions of the lung, by which—it being bipartite—the breath may be apportioned to their respective bronchi, and thence pass into the air-pipes; and such an arrangement

[1] In some cases.

[2] The word here rendered *larynx* is in the Greek *pharynx*. It is quite clear, however, that the part which is made of cartilage, serves for vocal and respiratory purposes, lies in front of the oesophagus, &c., can only be what we call larynx. Yet the word *larynx* was known to A., and occasionally used by him as by us. It would seem that the two words *pharynx* and *larynx* had not in his day been clearly differentiated from each other, but were used indifferently for one and the same part (*H. A.* iv. 9. 535a 29, 32, and Aristophanes, *Frogs*, 571–5), namely the larynx. What we call *pharynx* had for A. no distinct name, being nothing more than the first part of the oesophagus; which latter he says, later on in this chapter, is directly continuous with the mouth.

will be the best for giving perfection to inspiration and expiration. The organ then concerned in respiration must of necessity be of some length ; and this, again, necessitates there being an oesophagus to unite mouth and stomach.[1] This oesophagus is of a flesh-like character, and yet admits of extension like a sinew.[2] This latter property is given to it, that it may stretch when food is introduced ; while the flesh-like character is intended to make it soft and yielding, and to prevent it from being rasped by particles as they pass downwards, and so suffering damage. On the other hand, the windpipe and the so-called larynx are constructed out of a cartilaginous substance. For they have to serve 664b not only for respiration, but also for vocal purposes ; and an instrument that is to produce sounds must necessarily be not only smooth but firm. The windpipe lies in front of the oesophagus, although this position causes it to be some hindrance to the latter in the act of deglutition. For if a morsel of food, fluid or solid, slips into it by accident, choking and much distress and violent fits of coughing ensue. This must be a matter of astonishment to any of those who assert that it is by the windpipe that an animal imbibes fluid.[3] For the consequences just mentioned occur invariably, whenever a particle of food slips in, and are quite obvious. Indeed on many grounds it is ridiculous to say that this is the channel through which animals imbibe fluid. For there is no passage leading from the lung to the stomach, such as the oesophagus which we see leading thither from the mouth. Moreover, when any cause produces sickness and vomiting, it is plain enough whence the fluid is discharged. It is manifest also that fluid, when swallowed, does not pass directly into the

[1] It would probably be truer to say that there is a long trachea in order that there may be a long neck, so as to facilitate the motions of the head, than to say, as A. does, that there must be a long neck, in order to provide space for a long trachea. Still the length of the trachea is not without use ; for the air in its passage down the long canal is filtered of its dust, moistened, and warmed. In some animals the trachea is still further lengthened by being formed into a coil.

[2] Cf. iii. 4. 666b 13 note.

[3] Alluding to Plato (*Timaeus*, 70 C). Hippocrates mentions and attacks this same strange notion (*De Morbis*, iv. 30).

bladder and collect there, but goes first into the stomach. For, when red wine is taken, the dejections of the stomach are seen to be coloured by its dregs; and such discoloration has been even seen on many occasions inside the stomach itself, in cases where there have been wounds opening into that organ. However, it is perhaps silly to be minutely particular in dealing with silly statements such as this.

The windpipe then, owing to its position in front of the oesophagus, is exposed, as we have said, to annoyance from the food. To obviate this, however, nature has contrived the epiglottis. This part is not found in all sanguineous animals,[1] but only in such of them as have a lung; nor in all of these, but only in such as at the same time have their skin covered with hairs, and not either with scaly plates or with feathers. In such scaly and feathered animals there is no epiglottis, but its office is supplied by the larynx,[2] which closes and opens, just as in the other case the epiglottis falls down and rises up; rising up during the ingress or egress of breath, and falling down during the ingestion of food, so as to prevent any particle from slipping into the windpipe. Should there be the slightest want of accuracy in this movement, or should an inspiration be made during the ingestion of food, choking and coughing ensue, as already has been noticed. So admirably contrived, however, is the movement both of the epiglottis and of the tongue, that, while the food is being ground to a pulp in the mouth, the tongue very rarely gets caught between the teeth; and, while the food is passing over the epiglottis, seldom does a particle of it slip into the windpipe.

665a The animals which have been mentioned as having no epiglottis owe this deficiency to the dryness of their flesh and to the hardness of their skin. For an epiglottis made of such materials would not admit of easy motion. It would, indeed, take a longer time to shut down an epiglottis made of the peculiar flesh of these animals, and shaped

[1] For ζῳοτοκοῦντα, which is obviously wrong, read ζῷα τὰ ἔναιμα.

[2] Mammals alone have an epiglottis. In other vertebrates the opening into the larynx and trachea is closed simply by constrictor muscles.

like that of those with hairy skins, than to bring the edges of the windpipe itself into contact with each other.

Thus much then as to the reason why some animals have an epiglottis while others have none, and thus much also as to its use. It is a contrivance of nature to remedy the vicious position of the windpipe in front of the oesophagus. That position is the result of necessity. For it is in the front and centre of the body that the heart is situated, in which we say is the principle of life and the source of all motion and sensation. (For sensation and motion are exercised in the direction which we term forwards, and it is on this very relation that the distinction of before and behind is founded.) But where the heart is, there and surrounding it is the lung. Now inspiration, which occurs for the sake of the lung and for the sake of the principle which has its seat in the heart, is effected through the windpipe. Since then the heart must of necessity lie in the very front place of all, it follows that the larynx also and the windpipe must of necessity lie in front of the oesophagus. For they lead to the lung and heart,[1] whereas the oesophagus leads to the stomach. And it is a universal law that, as regards above and below, front and back, right and left, the nobler and more honourable part invariably is placed uppermost, in front, and on the right, rather than in the opposite positions, unless some more important object stands in the way.

[1] It is not necessary to infer with Frantzius from this passage, that A. thought that the windpipe communicated directly with the heart. For he supposed that air could pass without any such direct channel, as the following passages show. 'When the windpipe reaches the lung, it divides and subdivides, each division producing smaller and smaller branches, till the whole lung is permeated by them' (*H. A.* i. 16. 495^b 8). 'There are also ducts (i. e. *the pulmonary blood-vessels*) which lead from the heart to the lung; and these also divide and subdivide, their branches accompanying the branches from the windpipe. But there is no communication between the two (οὐδεὶς δ' ἐστὶ κοινὸς πόρος). Notwithstanding this, however, air can pass from the former (i. e. *the bronchial tubes*) into the latter (i. e. *the pulmonary vessels*), owing to the close contact in which the two lie (διὰ τὴν σύναψιν), and be transmitted to the heart' (*H. A.* i. 17. 496^a 28). This passage shows that A. not only had a fair knowledge of the anatomy of the lung, but also believed the air to pass from the air-passages into the blood-vessels through their unbroken walls, just as we hold the oxygen to do.

We have now dealt with the neck, the oesophagus, and the windpipe, and have next to treat of the viscera. These are peculiar to sanguineous animals, some of which have all of them, others only a part, while no bloodless animals have any at all.[1] Democritus then seems to have been mistaken in the notion he formed of the viscera, if, that is to say, he fancied that the reason why none were discoverable in bloodless animals was that these animals were too small to allow them to be seen. For, in sanguineous animals, both heart and liver are visible enough when the body is only just formed, and while it is still extremely small. For these parts are to be seen in the egg sometimes as early as the third day, being then no bigger than 4
665b a point;[2] and are visible also in aborted embryos, while still excessively minute. Moreover, as the external organs are not precisely alike in all animals, but each creature is provided with such as are suited to its special mode of life and motion, so is it with the internal parts, these also differing in different animals. Viscera, then, are peculiar to sanguineous animals; and therefore are each and all formed from sanguineous material, as is plainly to be seen in the new-born young of these animals. For in such the viscera are more sanguineous, and of greater bulk in proportion to the body, than at any later period of life, it being in the earliest stage[3] of formation that the nature of the material and its abundance are most conspicuous. There is a heart, then, in all sanguineous animals, and

[1] A. limits the term viscera to such internal parts as are so coloured as to resemble blood, of which in fact he supposes them to be formed (iii. 4. 665b 6; iii. 10. 673b 1). As the bloodless animals have merely a fluid analogous to blood, so they can only have parts analogous to viscera.

[2] Cf. *H. A.* vi. 3. 561a 11, where it is said that the heart in the bird's egg at its first appearance looks like a bloody spot, and palpitates as though endowed with life; a description which is the origin of the *punctum saliens* of later writers.

[3] The liver in the mature foetus forms $\frac{1}{18}$th of the whole body; in the adult it forms only $\frac{1}{36}$th. The heart also is larger proportionately to the whole body in the young embryo ($\frac{1}{30}$th) than in the mature foetus ($\frac{1}{120}$th), and in the foetus than in adult man ($\frac{1}{160}$th). In infancy again the lungs are of a brightish colour, 'which might be compared to blood froth; but as life advances they become darker, mottled with spots, patches, &c.' Cf. Quain's *Anat.* 1145.

the reason for this has already been given.[1] For that sanguineous animals must necessarily have blood is self-evident. And, as the blood is fluid, it is also a matter of necessity that there shall be a receptacle for it; and it is apparently to meet this requirement that nature has devised the blood-vessels. These, again, must necessarily have one primary source. For it is preferable that there shall be one such, when possible, rather than several. This primary source of the vessels is the heart. For the vessels manifestly issue from it and do not go through it.[2] Moreover, being as it is homogeneous, it has the character of a blood-vessel. Again its position is that of a primary or dominating part. For nature, when no other more important purpose stands in her way, places the more honourable part in the more honourable position; and the heart lies about the centre of the body, but rather in its upper than its lower half, and also more in front than behind. This is most evident in the case of man, but even in other animals there is a tendency in the heart to assume a similar position, in the centre of the necessary part of the body, that is to say of the part which terminates in the vent for excrement. For the limbs vary in position in different animals, and are not to be counted with the parts which are necessary for life. For life can be maintained even when they are removed; while it is self-evident that the addition of them to an animal is not destructive of it.

There are some[3] who say that the vessels commence in the head. In this they are clearly mistaken. For in the first place, according to their representation, there would be many sources for the vessels, and these scattered; and secondly, these sources would be in a region that is manifestly cold, as is shown by its intolerance of chill, whereas the region of the heart is as manifestly hot. Again, as already said, the vessels continue their course through the other viscera, but no vessel spreads through the heart.[4]

[1] Cf. iii. 3. 665^a 12. [2] See note 4.

[3] Elsewhere (*H. A.* iii. 3. 513^a 10) A. says that not only some but all his predecessors held this opinion.

[4] The terms διέχουσι and διατείνουσι, used several times in describing the relation of the blood-vessels to the viscera, present much difficulty.

From this it is quite evident that the heart is a part of the vessels and their origin ; and for this it is well suited by its structure. For its central part consists of a dense and hollow substance, and is moreover full of blood, as though 666a the vessels took thence their origin. It is hollow to serve for the reception of the blood, while its wall is dense, that it may serve to protect the source of heat. For here, and here alone in all the viscera and indeed in all the body, there is blood without blood-vessels, the blood elsewhere being always contained within vessels. Nor is this but consistent with reason. For the blood is conveyed into the vessels from the heart, but none passes into the heart from without.[1] For in itself it constitutes the origin and fountain, or primary receptacle, of the blood. It is, however, from

The natural interpretation of διέχουσι would be that the vessels traverse the viscera and pass on to some other part ; and in the case of the liver such an interpretation is neither impossible nor improbable. For A. may have well supposed that the Hepatic vein after giving numerous small branches to the liver (*H. A.* iii. 4. 514a 33) passed on as the *vena portae* to the intestinal parts ; and indeed it is difficult to see what other explanation A. could find for the *vena portae* ; if no vessel could originate in the liver and the course of all vessels was to the periphery.

But in the case of the other viscera such an interpretation is impossible ; for A. distinctly states that all the blood brought to kidneys and spleen is used up in the substance of those viscera (iii. 9. 671b 13 ; *H. A.* i. 17. 497a 9 ; iii. 4. 514b 5), the viscera being indeed mainly intended to provide means of disposing of the surplus blood.

It seems therefore impossible to give any other meaning to διέχουσι, at any rate in the case of other viscera than the liver, than 'spread through the substance', making it equivalent to διατείνουσι as indeed it apparently is at iii. 4. 665b 32. Similarly when it is said that no blood-vessel διατείνει the heart, it must be understood as meaning that no nutrient vessels are distributed through its substance (the coronary vessels being overlooked), this organ being nourished (ii. 1. 647b 6) by the blood in its own cavities. A. appears to have used διέχουσι ambiguously, applying it to the liver in a different sense from that in which he applies it to the other viscera and the heart.

[1] These words must not be interpreted too strictly ; for, though of course A. holds the main current of blood to run from the heart outwards, he admits some flow in the opposite direction. Indeed, without this the heart could have no material for elaboration. The food, absorbed from the stomach as vapour, is, he says, converted into fluid in the blood-vessels and passes on as such to the heart (*De S. et V.* 3. 456b 3). The blood-vessels that go to the head are likened by him to a narrow strait in which the current changes to and fro (*De S. et V.* 3. 456b 20) ; and the heart is distinctly stated (*De S. et V.* 3. 458b 18) to receive blood both from the great vessel and from the aorta.

dissections and from observations on the process of development that the truth of these statements receives its clearest demonstration. For the heart is the first of all the parts to be formed; and no sooner is it formed than it contains blood. Moreover, the motions of pain and pleasure, and generally of all sensation, plainly have their source in the heart, and find in it their ultimate termination. This, indeed, reason would lead us to expect. For the source must, whenever possible, be one; and, of all places, the best suited for a source is the centre. For the centre is one, and is equally or almost equally within reach of every part. Again, as neither the blood itself, nor yet any part which is bloodless, is endowed with sensation, it is plain that that part which first has blood, and which holds it as it were in a receptacle, must be the primary source of sensation. And that this part is the heart is not only a rational inference, but is also evident to the senses. For no sooner is the embryo formed, than its heart is seen in motion as though it were a living creature, and this before any of the other parts, it being, as thus shown, the starting-point of their nature in all animals that have blood. A further evidence of the truth of what has been stated is the fact that no sanguineous animal is without a heart. For the primary source of blood must of necessity be present in them all. It is true that sanguineous animals not only have a heart but also invariably have a liver. But no one could ever deem the liver to be the primary organ either of the whole body or of the blood. For the position in which it is placed is far from being that of a primary or dominating part; and, moreover, in the most perfectly finished animals there is another part, the spleen, which as it were counterbalances it. Still further, the liver contains no spacious receptacle in its substance, as does the heart; but its blood is in a vessel as in all the other viscera. The vessel, moreover, extends through it, and no vessel whatsoever originates in it; for it is from the heart that all the vessels take their rise. Since then one or other of these two parts must be the central source, and since it is not the liver which is such, it follows of necessity that it is the heart which is the source of the blood, as also the primary organ in

other respects. For the definitive characteristic of an animal is the possession of sensation; and the first sensory part is that which first has blood; that is to say is the heart, which
666b is the source of blood and the first of the parts to contain it.

The apex of the heart is pointed and more solid than the rest of the organ. It lies against the breast, and entirely in the anterior part of the body, in order to prevent that region from getting chilled. For in all animals there is comparatively little flesh over the breast, whereas there is a more abundant covering of that substance on the posterior surface, so that the heat has in the back a sufficient amount of protection. In all animals but man the heart is placed in the centre of the pectoral region; but in man [1] it inclines a little towards the left, so that it may counterbalance the chilliness of that side. For the left side is colder in man, as compared with the right, than in any other animal. It has been stated in an earlier treatise [2] that even in fishes the heart holds the same position as in other animals; and the reason has been given why it appears not to do so. The apex of the heart, it is true, is in them turned towards the head, but this in fishes is the front aspect, for it is the direction in which their motion occurs.[3]

The heart again is abundantly supplied with sinews,[4] as

[1] It is not quite true that man is the only animal in which the heart inclines to the left. A like obliquity exists in the higher quadrumana (Cuvier, *Anat. Comp.* iv. 197), and in the mole.

[2] *De Resp.* 16. 478^b 3.

[3] By the apex of the heart of fishes A. plainly means the point at the anterior extremity of the organ, where the *bulbus arteriosus* gives off the branchial artery. This, however, has no anatomical correspondence with the apex of the heart of other vertebrates. A. makes a similar statement as to the position of the fish's heart elsewhere (*H. A.* ii. 17. 507^a 3; *De Resp.* 16. 478^b 2), and accounts for it by saying that the head in other animals is moved in a vertical plane, from above downwards, whereas in fishes it has no such motion. Forwards then in a fish is in the line from tail to mouth, while in other animals it is in the line from above downwards, that is, from the back to the sternum.

[4] Under νεῦρα A. included (iii. 4. 666^b 14 note) tendons, sinews, ligaments, and all other fibrous parts; with which, moreover, were confounded any nerves which may have been noticed, without recognition of their special nature, in the course of dissection; and this accounts for the statement (*H. A.* iii. 5. 515^b 20) that numbness is never produced in a part where there are no νεῦρα. The active part in muscular contraction was taken not by the red tissue but by the νεῦρα, that is by the

might reasonably be expected. For the motions of the body commence from the heart, and are brought about by traction and relaxation. The heart therefore, which, as already said,[1] is as it were a living creature inside its possessor, requires some such subservient and strengthening parts.

In no animals does the heart contain a bone, certainly in none of those that we have ourselves inspected, with the exception of the horse and a certain kind of ox. In these exceptional cases the heart, owing to its large bulk, is provided with a bone as a support; just as the bones serve as supports for the body generally.[2]

In animals of great size the heart has three cavities;[3] in smaller animals it has two; and in all has at least one, for, as already stated,[4] there must be some place in the heart to serve as a receptacle for the first blood; which, as has been mentioned more than once, is formed in this organ. But inasmuch[5] as the main blood-vessels[6] are two in

tendinous fibres. The blood-vessels as they advanced became smaller and smaller, until at last their calibre was insufficient for the passage of blood, and the red muscular tissue consisted of a mass of small vessels thus choked up with inspissated blood (iii. 5. 668b 1). The vessels themselves, however, were continued as solid fibres (*H. A.* iii. 5. 515a 31) to form by their aggregation the tendon (*νεῦρον*), and it was to the shortening and widening of these tendinous fibres, endowed with transverse extensibility (*H. A.* iii. 5. 515b 15), that muscular action was due, the red tissue being completely inactive, and serving merely as the medium of Touch.

[1] iii. 4. 666a 22.

[2] Cf. *H. A.* ii. 15. 506a 8. It is not uncommon to find in large mammalia, especially in Pachyderms and Ruminants, a cruciform ossification in the heart, below the origin of the aorta. In the ox this is a normal formation, as also in the stag. But in Pachyderms, or at any rate in the horse, it is only found in old individuals, and appears to be the result of pathological degeneration.

[3] Commentators differ widely as to these three cavities, nor do the several passages relating to them admit of any thoroughly consistent and satisfactory interpretation. I am, however, strongly of opinion that the three are the two ventricles and the left auricle (see ch. 5. 667b 16 n.). This view was promulgated by me in a lengthy note to my former translation. I found afterwards that Huxley had already come to the same conclusion, and had set it forth in an elaborate article in *Nature* (Nov. 6, 1869); republished in *Science and Nature* (p. 180).

[4] Cf. 666a 7.

[5] Put a full stop after *εἰρήκαμεν*. Read *Διὰ δὲ τό* (ESUYZ) and put *ἑκατέρας . . . . ἐροῦμεν* in brackets with omission of *γάρ*.

[6] See first note to next chapter.

number, namely the so-called great vessel and the aorta, each of which is the origin of other vessels; inasmuch, moreover, as these two vessels present differences, hereafter to be discussed,[1] when compared with each other, it is of advantage that they also shall themselves have distinct origins. This advantage will be obtained if each side have its own blood, and the blood of one side be kept separate from that of the other. For this reason the heart, whenever it is possible, has two receptacles. And this possibility exists in the case of large animals, for in them the heart, as the body generally, is of large size. Again it is still better that there shall be three cavities, so that the middle and odd one may serve as a centre common to both sides. But this requires the heart to be of greater magnitude, so that it is only in the largest hearts that there are three cavities.

667a Of these three cavities it is the right that has the most abundant[2] and the hottest blood, and this explains why the limbs also on the right side of the body are warmer than those on the left. The left cavity has the least blood of all, and the coldest; while in the middle cavity the blood, as regards quantity and heat, is intermediate to the other two, being however of purer quality than either. For it behoves the supreme part to be as tranquil as possible, and this tranquillity can be ensured by the blood being pure, and of moderate amount and warmth.

In the heart of animals there is also a kind of joint-like division,[3] something like the sutures of the skull. This is not, however, attributable to the heart being formed by the union of several parts into a compound whole, but is rather, as already said, the result of a joint-like division. These

[1] Cf. iii. 5. 667b 15.

[2] In an animal, especially one killed by strangulation, as recommended by A. (*H. A.* iii. 3. 513a 13), the right side of the heart and the vessels connected with it would be found gorged with dark blood and contrasting strongly with the almost empty left side and vessels. It is doubtless this that makes A. say that the blood is more abundant, less pure, and denser (*H. A.* i. 17. 496b 10) on the right side than on the left.

[3] The allusion is to the transverse and longitudinal grooves which mark out on the surface the limits of auricles and ventricles. A. is quite right in saying that the heart is not formed by the union of distinct parts into a whole. It is at first a body with a single cavity, which is converted into several by the after-development of internal septa.

jointings are most distinct in animals of keen sensibility, and less so in those that are of duller feeling, in swine for instance. Different hearts differ also from each other in their sizes, and in their degrees of firmness; and these differences somehow extend their influence to the temperaments of the animals. For in animals of low sensibility the heart is hard and dense in texture, while it is softer in such as are endowed with keener feeling. So also when the heart is of large size the animal is timorous, while it is more courageous if the organ be smaller and of moderate bulk. For in the former the bodily affection which results from terror already pre-exists; for the bulk of the heart is out of all proportion to the animal's heat, which being small is reduced to insignificance in the large space, and thus the blood is made colder than it would otherwise be.

The heart is of large size[1] in the hare, the deer, the mouse, the hyena, the ass, the leopard, the marten, and in pretty nearly all other animals that either are manifestly timorous, or betray their cowardice by their spitefulness.

What has been said of the heart as a whole is no less true of its cavities and of the blood-vessels; these also if of large size being cold. For just as a fire of equal size gives less heat in a large room than in a small one, so also does the heat in a large cavity or a large blood-vessel, that is in a large receptacle, have less effect than in a small one. Moreover, all hot bodies are cooled by motions external to themselves,[2] and the more spacious the cavities and vessels are, the greater the amount of spirit they contain, and the more potent its action. Thus it is that no animal that has large cavities in its heart, or large blood-vessels, is ever fat, the vessels being indistinct and the cavities small in all or most fat animals.

The heart again is the only one of the viscera, and indeed the only part of the body, that is unable to tolerate any serious affection.[3] This is but what might reasonably be

[1] The heart is very large in the hare, nearly twice as heavy in proportion to the body-weight, as in man. As regards the other animals I can give no accurate figures.

[2] Cf. iii. 6. 669b 3 note.

[3] Cf. iv. 2. 677b 4. (Daremberg (*Galen.* i. 401) represents A. as

expected. For, if the primary or dominant part be diseased, there is nothing from which the other parts which depend
667b upon it can derive succour. A proof that the heart is thus unable to tolerate any morbid affection is furnished by the fact that in no sacrificial victim has it ever been seen to be affected with those diseases that are observable in the other viscera. For the kidneys are frequently found to be full of stones, and growths, and small abscesses, as also are the liver, the lung, and more than all the spleen. There are also many other morbid conditions which are seen to occur in these parts, those which are least liable to such being the portion of the lung which is close to the windpipe, and the portion of the liver which lies about the junction with the great blood-vessel. This again admits of a rational explanation. For it is in these parts that the lung and liver are most closely in communion with the heart. On the other hand, when animals die not by sacrifice but from disease, and from affections such as are mentioned above, they are found on dissection to have morbid affections of the heart.

Thus much of the heart, its nature, and the end and cause of its existence in such animals as have it.

In due sequence we have next to discuss the blood- 5
vessels, that is to say the great vessel and the aorta.[1] For

saying in this passage that the heart is not liable to disease, or at any rate less liable than other organs; just as Galen said that it was made of hard flesh which could not easily be injured. But in fact A. says nothing of the kind, but merely states what is fairly true, viz. that diseases of the heart are more certainly fatal, and less consistent with apparently good health, than diseases of other parts, so that when a victim, i.e. an animal supposed to be of sound health, is sacrificed, its heart is never found diseased, though such is frequently the case when an animal dies of a malady. What would A. have thought of the bull sacrificed by Caesar, which the soothsayers asserted to have no heart at all (Cicero, *De Div.* ii. 16)!

[1] The 'great vessel', as I interpret A.'s account, consists of the upper and lower Venae cavae, with the right auricle, considered by A., as by Galen and later anatomists, to be no part of the heart but merely the dilated junction of the two Venae cavae. This communicates with the largest cavity (*right ventricle*) by the wide auriculo-ventricular opening, and from this same cavity issues the pulmonary artery, regarded by A. in virtue of its connexion with the same cavity, its having a similarly thin wall, and being found after death (iii. 4. 667a 2 note) similarly gorged with dark blood, as a part of the 'great vessel', though separated from its main trunk by the interposition of the right ventricle,

it is into these two that the blood first passes when it quits the heart ; and all the other vessels are but offshoots from them. Now that these vessels exist on account of the blood has already been stated. For every fluid requires a receptacle, and in the case of the blood the vessels are that receptacle. Let us now explain why these vessels are two, and why they spring from one single source, and extend throughout the whole body.

The reason, then, why these two vessels coalesce into one centre, and spring from one source, is that the sensory soul is in all animals actually one ; and this one-ness of the sensory soul determines a corresponding one-ness of the part in which it primarily abides. In sanguineous animals this one-ness is not only actual but potential, whereas in some bloodless animals [1] it is only actual. Where, however, the sensory soul is lodged, there also and in the self-same place must necessarily be the source of heat ; and, again, where this is there also must be the source of the blood, seeing that it thence derives its warmth and fluidity. Thus, then, in the oneness of the part in which is lodged the prime source of sensation and of heat is involved the one-ness of the source in which the blood originates ; and this,

this being the cavity referred to (*H. A.* iii. 3. 513^b 4) as that ἐν ᾧ λιμνάζει τὸ αἷμα. The middle cavity from which the aorta proceeds is the left ventricle, and the smallest is the left auricle. All three cavities are connected with the lung, but in only one (*right ventricle*) is the connexion distinctly visible (*H. A.* iii. 3. 513^a 36). Thus 'the great vessel' comprises all the vessels connected with the right side of the heart, and the aorta comprises all that are connected with the left, that is all the systemic arteries and the pulmonary veins, and each side has its distinct and completely separate blood (iii. 4. 666^b 29), which is much more abundant, denser, and less pure (iii. 4. 667^a 2 note) on the right side than on the left. Lastly, the opening by which the aorta communicates with the heart is much smaller (*H. A.* iii. 3. 513^b 5) than that by which 'the great vessel' so communicates, i. e. the right auriculo-ventricular opening, not the aperture of the pulmonary artery, as stated by error in my former translation.

[1] Alluding to such Invertebrata as insects, myriapods, and annelids, which he frequently mentions as capable of living for a short time when cut into segments ; which shows that each segment must have its own centre of vitality ; the entire animal seemingly consisting of an aggregation of many animals, each with a certain individuality, which ordinarily is merged in the life of the aggregate, but is capable of asserting its existence when the segment is isolated ; the only reason, in fact, why such an isolated segment does not live more than a short time, being that it has not got the necessary organs of nutrition.

again, explains why the blood-vessels have one common starting-point.

The vessels, again, are two, because the body of every sanguineous animal that is capable of locomotion[1] is bilateral; for in all such animals there is a distinguishable before and behind, a right and left, an above and below. Now as the front is more honourable and of higher supremacy than the hinder aspect, so also and in like degree is
668a the great vessel superior to the aorta. For the great vessel is placed in front, while the aorta is behind; the former again is plainly visible in all sanguineous animals, while the latter is in some indistinct and in some not discernible at all.

Lastly, the reason for the vessels being distributed throughout the entire body is that in them, or in parts analogous to them, is contained the blood, or the fluid which in bloodless animals takes the place of blood, and that the blood or analogous fluid is the material from which the whole body is made. Now as to the manner in which animals are nourished,[2] and as to the source from which

[1] As all the sanguineous animals, i. e. vertebrates, are capable of locomotion, these words might seem surplusage. But they are not so. For A. holds that the bilateral symmetry of animals belongs to them primarily in virtue of their locomotor organs; and that the symmetrical disposition of these determines an imperfect degree of bilateral symmetry in the organs of vegetative life.

[2] A.'s general notions on the subject of nutrition were much as follows:—

The food masticated in the mouth, but not otherwise altered (ii. 3. 650a 11), reaches the stomach, where it is concocted; the heat for this purpose, which is not common heat but a heat with special powers (ii. 6. 652a 10 note), being supplied by the liver and spleen, which are hot organs in close contiguity with the stomach (iii. 7. 670a 21). The solid and indigestible portion passes off by the lower bowel, but the fluid portion, which alone can be serviceable in nutrition (ii. 2. 647b 26), is absorbed by the blood-vessels of the stomach and intestine (iv. 4. 678a 10), over the surface of which they are spread like the roots of a plant (ii. 3. 650a 25). These blood-vessels open by very minute and invisible pores into the intestine, pores like those in jars of unbaked clay that let water filter through (*G. A.* ii. 6. 743a 9). The matter thus absorbed passes up to the heart in the form of vapour (*ἀναθυμιᾶται*), not as yet being blood, but only (ii. 4. 651a 17) an imperfect serum (*ἰχώρ*). In the heart and vessels (*De Somno*, 3. 456b 4) it undergoes a second concoction, these being the hottest parts of the body, and by this second concoction the serum is converted into blood (*H. A.* iii. 19. 521a 17), the ultimate food of all the organs. The amount of blood thus formed is extremely small, as compared with the original materials they obtain nutriment and as to the way in which they absorb this from the stomach, these are matters which may be more suitably considered and explained in the treatise on Generation.[1] But inasmuch as the parts are, as already said, formed out of the blood, it is but rational that the flow of the blood should extend, as it does, throughout the whole of the body. For since each part is formed of blood, each must have blood about and in its substance.

To give an illustration of this. The water-courses in gardens are so constructed as to distribute water from one single source or fount into numerous channels, which divide and subdivide so as to convey it to all parts; and, again, in house-building stones are thrown down along the whole ground-plan of the foundation walls; because the garden-plants in the one case grow at the expense of the water, and the foundation walls in the other are built out of the stones. Now just after the same fashion has nature laid down channels for the conveyance of the blood throughout the whole body, because this blood is the material out of which the whole fabric is made. This becomes very evident in bodies that have undergone great emaciation. For in such there is nothing to be seen but the blood-vessels; just as when fig-leaves or vine-leaves or the like have dried up, there is nothing left of them but their vessels. The explanation of this is that the blood, or fluid which takes its

(*G. A.* i. 18. 725^a 18). The blood when made passes from the heart by the vessels (arteries and veins alike), being mingled with air inhaled by the lungs and thence conveyed to the heart, and is carried to all parts of the body. Each organ selects from the common stock those materials which it requires. The nobler parts, such as the flesh and the organs of sense, take the choicer elements, while the inferior parts, as bones and sinews, are fed on the inferior elements or leavings (*ὑπολείμματα*) of the former (*G. A.* ii. 6. 744^b 15). This nutrition of the parts goes on most actively at night (*De Somno*, I. 454^b 32).

Thus every part of the blood that can be turned to account is utilized; but such as from its quality is unfit for use, for instance any bitter substance, is excreted as bile, urine, sweat, etc., in company with the matter which results from the decay (*σύντηξις*) of the parts themselves.

Such surplus of nutritious matter as there may be, after all parts are satisfied, is either stored up in the body as fat or the like, or passes out to form hairs, scales, feathers, and other cutaneous appendages.

[1] *G. A.* ii. 4. 740^a 21–^{b} 12, 6. 743^a 8–7. 746^a 28.

place, is potentially body and flesh, or substance analogous to flesh. Now just as in irrigation the largest dykes are permanent, while the smallest are soon filled up with mud and disappear, again to become visible when the deposit of mud ceases; so also do the largest blood-vessels remain permanently open, while the smallest are converted actually into flesh, though potentially they are no whit less vessels than before.[1] This too explains why, so long as the flesh of an animal is in its integrity, blood will flow from any part of it whatsoever that is cut, though no vessel, however small, be visible in it. Yet there can be no blood, unless there be a blood-vessel. The vessels then are there, but are invisible owing to their being clogged up, just as the dykes for irrigation are invisible until they have been cleared of mud.

668b As the blood-vessels advance, they become gradually smaller and smaller, until at last their tubes are too fine to admit the blood. This fluid can therefore no longer find its way through them, though they still give passage to the humour which we call sweat; and especially so when the body is heated, and the mouths of the small vessels are dilated. Instances, indeed, are not unknown of persons who in consequence of a cachectic state have secreted sweat that resembled blood,[2] their body having become loose and flabby, and their blood watery, owing to the heat in the small vessels having been too scanty for its concoction. For, as was before said, every compound of earth and water—and both nutriment and blood are such—becomes thicker from concoction. The inability of the heat to effect concoction may be due either to its being absolutely small in amount, or to its being small in proportion to the quantity of food, when this has been taken in excess. This excess again may be of two kinds, either quantitative or qualitative; for all substances are not equally amenable to concoction.

The widest passages in the body are of all parts the most

[1] Cf. iii. 4. 666b 15 note.
[2] Instances of red-coloured sweat are not unknown. Cf. Todd, *Cycl. An. and Phys.* iv. 844.

liable to haemorrhage ; so that bleeding occurs not infrequently from the nostrils, the gums, and the fundament, occasionally also from the mouth.[1] Such haemorrhages are of a passive kind, and not violent as are those from the windpipe.

The great vessel and the aorta, which above lie somewhat apart, lower down exchange positions, and by so doing give compactness to the body. For when they reach the point[2] where the legs diverge, they each split into two, and the great vessel passes from the front to the rear, and the aorta from the rear to the front. By this they contribute to the unity of the whole fabric. For as in plaited work the parts hold more firmly together because of the interweaving, so also by the interchange of position between the blood-vessels are the anterior and posterior parts of the body more closely knit together. A similar exchange of position occurs also in the upper part of the body, between the vessels that have issued from the heart.[3] The details however of the mutual relations of the different vessels must be looked for in the treatises on Anatomy and the Researches concerning Animals.[4]

So much, then, as concerns the heart and the blood-vessels. We must now pass on to the other viscera and apply the same method of inquiry to them.

6 The lung,[5] then, is an organ found in all the animals of

[1] The mention of gums and mouth points to the existence of scurvy in those days.

[2] The common iliac arteries, formed by the division of the descending aorta, do in fact, as A. says, come forwards and lie in front of the common iliac veins ; whereas as a general rule the veins lie in front of the arteries.

[3] The pulmonary artery, regarded by A. as a part of the μεγάλη φλέψ, at its origin is in front of the aorta, but when it reaches the arch sends its right and larger division behind the ascending aorta. It is probably to this that A. alludes.

[4] Cf. *H. A.* i. 17 ; iii. 2–4.

[5] It will be noticed that A. always speaks of *the lung* of an animal, and not as we do of *the lungs*. He considers the two to be merely subdivisions of a single organ, because they have one common outlet, viz. the trachea. When the right and left bronchi which lead from this to either lung are of more than ordinary length, as in birds, he admits that the lung has the outward appearance of being a double organ, but still considers it really to be a single one for the above

a certain class, because they live on land. For there must of necessity be some means or other of tempering the heat of the body; and in sanguineous animals, as they are of an especially hot nature, the cooling agency must be external,
669a whereas in the bloodless kinds the innate spirit is sufficient of itself for the purpose. The external cooling agent must be either air or water. In fishes the agent is water. Fishes therefore never have a lung, but have gills in its place, as was stated in the treatise on Respiration.[1] But animals that breathe are cooled by air. These therefore are all provided with a lung.

All land animals breathe, and even some water animals, such as the whale, the dolphin, and all the spouting Cetacea. For many animals lie half-way between terrestrial and aquatic; some that are terrestrial and that inspire air being nevertheless of such a bodily constitution that they abide for the most time in the water; and some that are aquatic partaking so largely of the land character, that respiration constitutes for them the main condition of life.

The organ of respiration is the lung. This derives its motion from the heart; but it is its own large size and spongy texture that affords amplitude of space for the entrance of the breath. For when the lung rises up the breath streams in, and is again expelled when the lung collapses.[2] It has been said [3] that the lung exists as a provision

reason; though 'any one might think that there were two because the ducts from the two divisions unite at a considerable distance from them' *H. A.* ii. 17. 507a 19; *P. A.* iii. 7. 669b 24.

[1] *De Resp.* 10. 475b 15 sq.

[2] The mechanism of respiration is described elsewhere (*De Resp.* 21). The lung is compared, aptly enough, to a pair of forge bellows. When the lung is expanded, air rushes in; when it is contracted, the air is again expelled. The expansion is brought about by the heat derived from the heart; heat always causing expansion in the parts to which it extends. The lung then, heated by the heart, expands; and with it the cavity of the thorax. Cold air rushes in to fill the void, and the heat is reduced. This causes the lung and thorax to collapse, and the air is expelled.

[3] Plato (*Tim.* 70 C) regarded the lung as a soft yielding buffer, intended to receive the impact of the heart, when throbbing violently in fits of emotion. To this A. objects that animals that are not liable to such fits of emotion nevertheless have lungs; and, moreover, that the lung is not placed on the side of the heart where the impact occurs: that is, not on the sternal aspect.

to meet the jumping of the heart. But this is out of the question. For man is practically the only animal whose heart presents this phenomenon of jumping, inasmuch as he alone is influenced by hope and anticipation of the future. Moreover, in most animals the lung is separated from the heart[1] by a considerable interval and lies above it, so that it can contribute nothing to mitigate any jumping.

The lung differs much in different animals. For in some it is of large size and contains blood; while in others it is smaller and of spongy texture. In the vivipara it is large and rich in blood, because of their natural heat; while in the ovipara it is small and dry but capable of expanding to a vast extent when inflated. Among terrestrial animals, the oviparous quadrupeds, such as lizards, tortoises, and the like, have this kind of lung; and, among inhabitants of the air, the animals known as birds.[2] For in all these the lung is spongy, and like foam. For it is membranous and collapses from a large bulk to a small one, as does foam when it runs together. In this too lies the explanation of the fact that these animals are little liable to thirst and drink but sparingly, and that they are able to remain for a considerable time under water. For, inasmuch as they 669b
have but little heat, the very motion of the lung, airlike and void, suffices by itself to cool them for a considerable period.[3]

These animals, speaking generally, are also distinguished from others by their smaller bulk. For heat promotes

[1] The natural nominative to ἀπέχει, as the text stands, is ὁ πλεύμων, and this, as also the sense, requires that for τοῦ πλεύμονος should be read τῆς καρδίας; for in no sense can the heart be said to be *above* the lung, nor would such a position invalidate Plato's notion, whereas 'in most animals', that is in quadrupeds, the lung is placed above the heart, and away from the side where the heart's impact occurs.

[2] The lungs of birds, though smaller in proportion to the body than those of mammals, are highly vascular.

[3] A. seems to have had some strange notion that a fan cools a body not merely by bringing a continuous current of cold air into contact with it, but directly by its own motion, that is independently of the air. 'Every hot body,' he says, 'is cooled by the motions of bodies external to itself' (iii. 4. 667a 28). So he supposes here that when an animal is under water, its lung will continue in motion, and that, though no air is admitted, yet the motion will itself produce a certain amount of cooling in the neighbouring parts. See also *De Resp.* 9. 475a 14.

growth, and abundance of blood is a sure indication of heat. Heat, again, tends to make the body erect; and thus it is that man is the most erect of animals, and the vivipara more erect than other quadrupeds. For no viviparous animal, be it apodous[1] or be it possessed of feet, is so given to creep into holes as are the ovipara.

The lung, then, exists for respiration; and this is its universal office; but in one order of animals it is bloodless and has the structure described above, to suit the special requirements. There is, however, no one term to denote all animals that have a lung; no designation, that is, like the term Bird, applicable to the whole of a certain class. Yet the possession of a lung is a part of their essence, just as much as the presence of certain characters constitutes the essence of a bird.

Of the viscera some appear to be single, as the heart 7
and lung; others to be double, as the kidneys; while of a third kind it is doubtful in which class they should be reckoned. For the liver and the spleen would seem to lie half-way between the single and the double organs. For they may be regarded either as constituting each a single organ, or as a pair of organs resembling each other in character.[2]

In reality, however, all the organs are double. The reason for this is that the body itself is double, consisting of two halves, which are however combined together under

[1] Meaning the viper, which is apparently said to be less of a troglodyte than its congeners, because other snakes conceal themselves underground during their period of torpor, while the viper remains on the surface, hiding under stones. (*H. A.* viii. 15. 599^b 1.)

[2] It seems to have been the universal opinion of the ancients that the spleen was the left homologue of the liver. In modern times the more general view is that of Müller, that there is no such relation between them, each being an azygos organ. The ancient opinion is not, however, without its modern advocates. Dr. Doellinger, for instance (*Grundriss der Naturlehre des menschl. Organ.* 1805), supported it; and more recently Dr. Sylvester (*The Discov. of the Nature of the Spleen*, 1870) has argued with much ingenuity that 'the spleen is not a blood-gland in the mesial line of the body, having no homologous relationship with the liver,' but that 'it is the left lateral homologue of a portion of the liver, the latter being a combination of a sanguiferous gland and a biliary apparatus,' and the spleen the homologue of the former portion of it.

one supreme centre. For there is an upper and a lower half, a front and a rear, a right side and a left.

This explains why it is that even the brain and the several organs of sense tend in all animals to consist of two parts; and the same explanation applies to the heart with its cavities. The lung again in Ovipara is divided to such an extent that these animals look as though they had actually two lungs. As to the kidneys, no one can overlook their double character. But when we come to the liver and the spleen, any one might fairly be in doubt. The reason of this is, that, in animals that necessarily have a spleen,[1] this organ is such that it might be taken for a kind of bastard liver; while in those [2] in which a spleen is not an actual necessity but is merely present, as it were, by way of token, in an extremely minute form, the liver plainly consists of two parts; of which the larger tends to lie on the right side and the smaller on the left.[3] Not but what there are some even of the Ovipara in which this condition is comparatively indistinctly marked; while, on the other hand, there are some Vivipara in which the liver is manifestly divided into two parts.[4] Examples of such

[1] That is to say in the viviparous quadrupeds.

[2] Namely the Ovipara.

[3] There is some foundation for the statement that the size of the spleen and the distinctness with which the liver is divided into lobes are inversely related to each other. Thus it is in Mammalia that the spleen is largest in proportion to the body, and in them also that the liver is least distinctly lobulated. Among Mammalia it is the rodents that have the smallest spleen, and in these also it is that the liver reaches its maximum of sub-division. On the other hand, the spleen is large in ruminants and their liver at the same time presents scarcely any marks of lobulation. In the Ovipara the spleen is much smaller than in Mammalia, and the liver, as a general though not universal rule, is much more decidedly cleft into distinct lobes. In all birds, in all batrachians, and in all reptiles, excepting Ophidia, the liver is distinctly divided into two lobes. In the remaining class, fishes, the spleen varies much in size; sometimes is apparently altogether absent, sometimes excessively small, sometimes almost as large in proportion to the body as that of a mammal, and the liver is sometimes multilobed, sometimes bilobed, sometimes unilobed. In this class, however, I cannot ascertain that there is any such relation as that mentioned in the text between the two conditions.

[4] The exceptional ovipara are the Ophidia and many osseous fishes, where the liver is unilobed. The exceptional vivipara are the rodents, of which A. specially mentions the hare. Omit κἀκεῖ and ὥσπερ ἔν τισι (EY).

division are furnished by the hares of certain regions, which have the appearance of having two livers, and by the cartilaginous and some other fishes.[1]

It is the position of the liver on the right side of the
670a body that is the main cause for the formation of the spleen; the existence of which thus becomes to a certain extent a matter of necessity in all animals, though not of very stringent necessity.

The reason, then, why the viscera are bilateral is, as we have said, that there are two sides to the body, a right and a left. For each of these sides aims at similarity with the other, and so likewise do their several viscera; and[2] as the sides, though dual, are knit together into unity, so also do the viscera tend to be bilateral and yet one by unity of constitution.

Those viscera which lie below the diaphragm exist one and all on account of the blood-vessels;[3] serving as a bond, by which these vessels, while floating freely, are yet held in connexion with the body. For the vessels give off branches which run to the body through the outstretched structures,[4] like so many anchor-lines thrown out from a ship. The great vessel sends such branches to the liver and the spleen; and these viscera—the liver and spleen on either side with the kidneys behind—attach the great vessel to the body with the firmness of nails.[5] The aorta sends similar branches to each kidney, but none to the liver or spleen.[6]

These viscera, then, contribute in this manner to the compactness of the animal body. The liver and spleen assist, moreover, in the concoction of the food; for both are

[1] In cartilaginous fishes the liver consists of two distinct lobes, whereas in osseous fishes it is often unilobed.

[2] Reading *καὶ καθάπερ* (PZ).

[3] Assisting them in the mechanical way immediately mentioned, and also by providing an outlet for their surplus blood. Cf. iii. 10. 673b 1.

[4] The mesentery is meant.

[5] The introduction of nails into the metaphor is so out of place, that the temptation is strong to substitute *εὐναί*—mooring-stones—for *ἧλοι*. The metaphor would then run on all fours; the ship being the main blood-vessel; the anchor-lines its outstretching branches; the mooring-stones the liver, spleen, kidneys.

[6] The hepatic and splenic arteries seem to have escaped A.'s notice; probably because they are not given off directly from the aorta.

of a hot character, owing to the blood which they contain. The kidneys, on the other hand, take part in the separation of the excretion which flows into the bladder.

The heart then and the liver are essential constituents of every animal; the liver that it may effect concoction, the heart that it may lodge the central source of heat. For some part or other there must be which, like a hearth, shall hold the kindling fire; and this part must be well protected, seeing that it is, as it were, the citadel of the body.

All sanguineous animals, then, need these two parts; and this explains why these two viscera, and these two alone, are invariably found in them all. In such of them, however, as breathe, there is also as invariably a third, namely the lung. The spleen, on the other hand, is not invariably present; and, in those animals that have it, is only present of necessity in the same sense as the excretions of the belly and of the bladder are necessary, in the sense, that is, of being an inevitable concomitant. Therefore it is that in some animals the spleen is but scantily developed as regards size. This, for instance, is the case in such feathered animals as have a hot stomach. Such are the pigeon, the hawk, and the kite.[1] It is the case also in oviparous quad- 670b
rupeds, where the spleen is excessively minute, and in many of the scaly fishes. These same animals are also without a bladder, because the loose texture of their flesh allows the residual fluid to pass through and to be applied to the formation of feathers and scales. For the spleen attracts the residual humours[2] from the stomach, and owing to its bloodlike character is enabled to assist in their concoction. Should, however, this residual fluid be too abundant, or the heat of the spleen be too scanty, the body becomes sickly from over-repletion[3] with nutriment. Often, too, when the

[1] The spleen is small in all birds, but whether specially so in these, or in the owl, which he adds elsewhere (*H. A.* ii. 15. 506a 13) to the list, I cannot say.

[2] The notion that the spleen serves to attract superfluous humours is taken from Hippocrates, who thus expresses himself, 'I say that when a man drinks a more than ordinary amount of fluid, both the body and the spleen attract to themselves the water from the stomach' (*De Morbis*, iv. 9 and *De Morb. Mul.* i. 15).

[3] Reading πλήθει for πλήρη.

spleen is affected by disease, the belly becomes hard [1] owing to the reflux into it of the fluid; just as happens to those who form too much urine, for they also are liable to a similar diversion of the fluids into the belly. But in those animals that have but little superfluous fluid to excrete, such as birds and fishes, the spleen is never large, and in some exists no more than by way of token. So also in the oviparous quadrupeds it is small, compact, and like a kidney. For their lung is spongy, and they drink but little, and such superfluous fluid as they have is applied to the growth of the body and the formation of scaly plates, just as in birds it is applied to the formation of feathers.

On the other hand, in such animals as have a bladder, and whose lung contains blood, the spleen is watery, both for the reason already mentioned, and also because the left side of the body is more watery and colder than the right. For each of two contraries has been so placed as to go together with that which is akin to it in another pair of contraries. Thus right and left, hot and cold, are pairs of contraries; and right is conjoined with hot, after the manner described, and left with cold.

The kidneys when they are present exist not of actual necessity, but as matters of greater finish and perfection. For by their special character they are suited to serve in the excretion of the fluid which collects in the bladder. In animals therefore where this fluid is very abundantly formed, their presence enables the bladder to perform its proper office with greater perfection.[2]

Since then both kidneys and bladder exist in animals for one and the same function, we must next treat of the bladder, though in so doing we disregard the due order of succession in which the parts should be enumerated. For not a word has yet been said of the midriff, which is one of the parts that environ the viscera and therefore has to be considered with them.

[1] Also from Hippocrates (Kühn's Ed. i. 533).

[2] A. thought that the bladder was the essential agent in forming the urine, the kidneys being comparatively unimportant adjuncts, though he also admits that when the fluid leaves these organs, it already has in a measure the characters of the final excretion. Cf. iii. 9. 671[b] 24.

8 It is not every animal that has a bladder; those only being apparently intended by nature to have one, whose lung contains blood. To such it was but reasonable that 671a
she should give this part. For the superabundance in their lung of its natural constituents causes them to be the thirstiest of animals, and makes them require a more than ordinary quantity not merely of solid but also of liquid nutriment. This increased consumption necessarily entails the production of an increased amount of residue; which thus becomes too abundant to be concocted by the stomach and excreted with its own residual matter. The residual fluid must therefore of necessity have a receptacle of its own; and thus it comes to pass that all animals whose lung contains blood are provided with a bladder. Those animals, on the other hand, that are without a lung of this character, and that either drink but sparingly owing to their lung being of a spongy texture, or never imbibe fluid at all for drinking's sake but only as nutriment, insects for instance and fishes, and that are moreover clad with feathers or scales or scaly plates[1]—all these animals, owing to the small amount of fluid which they imbibe, and owing also to such residue as there may be being converted into feathers and the like, are invariably without a bladder.[2] The Tortoises, which are comprised among animals with scaly plates, form the only exception; and this is merely due to the imperfect development of their natural conformation; the explanation of the matter being that in the sea-tortoises the lung is flesh-like and contains blood, resembling the lung of the ox, and that in the land-tortoises it is of disproportionately

[1] A. distinguishes the scales of fishes from those of reptiles by giving them distinct names, but nowhere discusses their differences excepting that he says (iv. 2. 691a 16) 'these plates (φολίδες) are equivalent to scales (λεπίδες) but of a harder character'. But see iv. 13. 697a 5 note.

[2] All viviparous quadrupeds, i.e. Mammalia, have (Monotremata excepted) a urinary bladder. Birds have none. In many fishes the ureters form a small dilatation or bladder. Among reptiles, Ophidia and many Saurians have no bladder; but there is one in some Saurians and in all Chelonia, and in these latter it is of great size.

A. is mistaken in supposing that tortoises drink but little. Darwin describes them as wearing broad and well-beaten paths to the springs in Chatham Island (*Voyage of Beagle*, p. 383).

large size.[1] Moreover, inasmuch as the covering which invests them is dense and shell-like, so that the moisture cannot exhale through the porous flesh, as it does in birds and in snakes and other animals with scaly plates, such an amount of secretion is formed that some special part is required to receive and hold it. This then is the reason why these animals, alone of their kind, have a bladder, the sea-tortoise a large one, the land-tortoises an extremely small one.[2]

What has been said of the bladder is equally true of the 9
kidneys. For these also are wanting in all animals that are clad with feathers or with scales or with scale-like plates; the sea and land tortoises[3] forming the only exception. In some of the birds, however, there are flattened kidney-like bodies, as though the flesh allotted to the formation of the kidneys, unable to find one single place of sufficient size, had been scattered over several.[4]

[1] The lungs of Chelonia are of much greater size than those of most Saurians and Amphibia, and 's'étendent le long du dos jusqu'au bassin au-dessus de tous les viscères' (Cuvier, *Leçons*, iv. 347). They are, moreover, not only thus larger, but contain 'in correlation with the non-transpirable integument a much greater development of internal parenchyma' (Rolleston, *Forms of An. Life*, lx). This comparative abundance of parenchyma is more marked in marine than in other tortoises (Cuvier, *Leçons*, iv. 324 and 332).

[2] Perrault found on repeated dissections that precisely the contrary was the case, and consequently inferred 'qu'il y a faute au texte par la transposition des mots *terrestre* et *marine*' (*Mém. pour servir à l'hist. nat. des Animaux*, 2e *partie*, *p.* 403).

[3] A similar statement, that no Ovipara save the tortoises have kidneys, is made elsewhere (*H.A.* ii. 16); where also it is said that the kidney of the tortoise consists, like that of the ox, of numerous smaller parts. The chelonian kidney is, in fact, extremely subdivided on the outer surface; so that there can be no doubt that A. had examined it. But it is difficult to understand how the kidneys of other Ovipara escaped his notice. It is true they are so differently shaped from those of a mammal, or even of a tortoise, that they might appear to a careless observer to be totally different organs. But the probable explanation is that A. argued *a priori* that it was impossible for there to be a kidney if there was no bladder. For the essential organ in the formation of urine was, as he thought, not the kidney, but the bladder; and the kidneys were but adjuncts to this (iii. 7.670b 28 note). A kidney, then, in an animal without a bladder was to A. just as absurd a supposition as would be to us a urinary bladder when there was no kidney. That A. was misled by this preconception is shown by the fact that he did see the kidneys in birds, and did recognize their kidney-like aspect; but yet refused to consider them as true kidneys.

[4] In birds the kidneys, almost always trilobed, are flattened against

The Emys[1] has neither bladder nor kidneys. For the softness of its shell allows of the ready transpiration of fluid ; and for this reason neither of the organs mentioned exists in this animal. All other animals, however, whose lung contains blood are, as before said, provided with kidneys. For nature uses these organs for two separate 671b
purposes, namely for the excretion of the residual fluid, and to subserve the blood-vessels,[2] a channel leading to them from the great vessel.

In the centre of the kidney is a cavity of variable size. This is the case in all animals, excepting the seal.[3] The kidneys of this animal are more solid than those of any other, and in form resemble the kidneys of the ox. The human kidneys are of similar shape ; being as it were made up of numerous small kidneys,[4] and not presenting one unbroken surface like the kidneys of sheep and other quadrupeds.[5] For this reason, should the kidneys of a man be once attacked by disease, the malady is not easily expelled. For it is as though many kidneys were diseased and not merely one; which naturally enhances the difficulties of a cure.

The duct which runs to the kidney from the great vessel does not terminate in the central cavity, but is expended on the substance of the organ, so that there is no blood in the cavity, nor is any coagulum found there after death. A pair of stout ducts, void of blood, run, one from the cavity of each kidney, to the bladder ; and other ducts, strong and

the back, and, fitting into the deep interspaces between the bones, retain the impressions of these successive cavities or depressions.

[1] The Emys was some freshwater tortoise (*H. A.* v. 33. 558^{a} 8) ; but what species is uncertain, as there are several in Greece. None is without a bladder, but this is equally true of all known Chelonia. Neither has any animal now known as Emys a soft shell.

[2] Cf. iii. 7. 670^{a} 8 note.

[3] The cavity in the seal's kidney is very small. It is pictured in section by Buffon (*Hist. Nat.* xiii. pl. 48). The kidney consists of numerous distinct lobes, and in this respect resembles that of an ox.

[4] This is not true of adult man, excepting as an occasional anomaly. But it is true of the foetus. This is one of the statements which lead me to think that A. may have dissected the human foetus.

[5] Not all quadrupeds other than the ox have non-lobulated kidneys, though such is the general rule. The elephant, bear, otter, all have lobulated kidneys.

continuous, lead into the kidneys from the aorta.[1] The purpose of this arrangement is to allow the superfluous fluid to pass from the blood-vessel into the kidney, and the resulting renal excretion to collect, by the percolation of the fluid through the solid substance of the organ, in its centre, where as a general rule there is a cavity. (This by the way explains why the kidney is the most ill-savoured of all the viscera.) From the central cavity the fluid is discharged into the bladder by the ducts that have been mentioned, having already assumed in great degree the character of excremental residue.[2] The bladder is as it were moored to the kidneys; for, as already has been stated, it is attached to them by strong ducts. These then are the purposes for which the kidneys exist, and such the functions of these organs.

In all animals that have kidneys, that on the right is placed higher than that on the left.[3] For, inasmuch as motion commences from the right,[4] and the organs on this side are in consequence stronger than those on the left, they must all push upwards in advance of their opposite fellows: as may be seen in the fact that men even raise the right eyebrow more than the left, and that the former is more arched than the latter. The right kidney being thus drawn upwards is in all animals brought into contact with the liver; for the liver lies on the right side.

672a Of all the viscera the kidneys are those that have the most fat. This is in the first place the result of necessity, because the kidneys are the parts through which the residual matters percolate. For the blood which is left behind after this excretion, being of pure quality, is of easy concoction, and the final result of thorough blood-concoction is lard and suet. For just as a certain amount of fire is left in the ashes of solid substances after combustion, so also does a remnant of the heat that has been developed remain in

[1] The bloodless ducts are the ureters. The ducts from the aorta and great vessel are the renal arteries and veins respectively.

[2] Cf. iii. 7. 670b 28 note.

[3] This is the general but not universal rule. One of the exceptions is man, where the right kidney is usually slightly lower than the left.

[4] Cf. *De Caelo*, ii. 2. 284b 28 and *De An. Inc.* 4. 705b 29; 6. 706b 17.

fluids after concoction ; and this is the reason why oily matter is light, and floats on the surface of other fluids. The fat is not formed in the kidneys themselves, the density of their substance forbidding this, but is deposited about their external surface. It consists of lard or of suet, according as the animal's fat is of the former or latter character. The difference between these two kinds of fat has already been set forth in other passages.[1] The formation, then, of fat in the kidneys is the result of necessity; being, as explained, a consequence of the necessary conditions which accompany the possession of such organs. But at the same time the fat has a final cause, namely to ensure the safety of the kidneys, and to maintain their natural heat. For placed, as these organs are, close to the surface, they require a greater supply of heat than other parts. For while the back is thickly covered with flesh, so as to form a shield for the heart and neighbouring viscera, the loins, in accordance with a rule that applies to all bendings, are destitute of flesh ; and fat is therefore formed as a substitute for it, so that the kidneys may not be without protection. The kidneys, moreover, by being fat are the better enabled to secrete and concoct their fluid ; for fat is hot, and it is heat that effects concoction.

Such, then, are the reasons why the kidneys are fat. But in all animals the right kidney is less fat than its fellow.[2] The reason for this is, that the parts on the right side are naturally more solid and more suited for motion than those on the left. But motion is antagonistic to fat, for it tends to melt it.

Animals then, as a general rule, derive advantage from their kidneys being fat ; and the fat is often very abundant and extends over the whole of these organs. But, should the like occur in the sheep, death ensues. Be its kidneys, however, as fat as they may, they are never so fat but that some part, if not in both at any rate in the right one, is left free. The reason why sheep are the only animals that suffer in this manner, or suffer more than others, is that in

[1] Cf. ii. 5, *H.A.* iii. 17.
[2] Aubert and Wimmer say this is true of rabbits.

animals whose fat is composed of lard [1] this is of fluid consistency, so that there is not the same chance in their case of wind getting shut in and causing mischief. But it is to such an enclosure of wind that rot [2] is due. And thus even in men, though it is beneficial to them to have fat kidneys, yet should these organs become over-fat and diseased, deadly pains ensue. As to those animals whose fat consists of
672b suet, in none is the suet so dense as in the sheep, neither is it nearly so abundant; for of all animals there is none in which the kidneys become so soon gorged with fat as in the sheep.[3] Rot, then, is produced by the moisture and the wind getting shut up in the kidneys, and is a malady that carries off sheep with great rapidity. For the disease forthwith reaches the heart, passing thither by the aorta and the great vessel, the ducts which connect these with the kidneys being of unbroken continuity.

We have now dealt with the heart and the lung, as also with the liver, spleen, and kidneys. The latter are sepa- **10**
rated from the former by the midriff or, as some call it, the *Phrenes*. This divides off the heart and lung, and, as already said, is called *Phrenes* in sanguineous animals, all [4] of which have a midriff, just as they all have a heart and a liver. For they require a midriff to divide the region of the heart from the region of the stomach, so that the centre wherein abides the sensory soul may be undisturbed, and not be overwhelmed, directly food is taken, by its up-steaming vapour and by the abundance of heat then superinduced. For it was to guard against this that nature made a division,

[1] Cf. ii. 5. 651a 35.

[2] A. is plainly speaking of some disease that is compatible with accumulation of fat, and that also is, at any rate sometimes, rapidly fatal. Such seems to be the case with rot. 'In this disease there is no loss of condition, but quite the contrary. For the sheep in the early stages of rot has a great propensity to fatten' (Youatt, *Book of Farm*, ii. 386). Again, the rot is sometimes 'rapid in its course, and this season a large number of sheep have been killed very quickly by it' (Gamgee, *Pr. Counc. Rep.* v. 240).

[3] The ox and the sheep, says John Hunter, have more fat about the kidneys, the loins, and within the abdomen, than most other animals (*Museum Cat.* iii. 312).

[4] Mammals alone have a perfect diaphragm, but in most vertebrates there is something analogous to it. The description, however, given further on, applies only to the perfect diaphragm, viz. that of mammals.

constructing the midriff as a kind of partition-wall and fence, and so separated the nobler from the less noble parts, in all cases where a separation of upper from lower is possible. For the upper part is the more honourable, and is that for the sake of which the rest exists; while the lower part exists for the sake of the upper and constitutes the necessary element in the body, inasmuch as it is the recipient of the food.

That portion of the midriff which is near the ribs is fleshier and stronger than the rest, but the central part has more of a membranous character; for this structure conduces best to its strength and its extensibility. Now that the midriff, which is a kind of outgrowth from the sides of the thorax, acts as a screen to prevent heat mounting up from below, is shown by what happens, should it, owing to its proximity to the stomach, attract thence the hot and residual fluid. For when this occurs there ensues forthwith a marked disturbance of intellect and of sensation. It is indeed because of this that the midriff is called [1] *Phrenes*, as though it had some share in the process of thinking (*Phronein*). In reality, however, it has no part whatsoever itself in the matter, but, lying in close proximity to organs that have, it brings about the manifest changes of intelligence in question by acting upon them. This too explains why its central part is thin. For though this is in some measure the result of necessity, inasmuch as those portions of the fleshy whole which lie nearest to the ribs must necessarily be fleshier than the rest,[2] yet besides this there is a final cause, namely to give it as small a proportion of humour as possible; for, had it been made of flesh throughout, it 673a would have been more likely to attract and hold a large amount of this. That heating of it affects sensation rapidly and in a notable manner is shown by the phenomena of laughing. For when men are tickled they are quickly set a-laughing, because the motion quickly reaches this part,

[1] A notion still commemorated in the anatomical terms 'phrenic nerves' and 'phrenic centre'.

[2] The central part of the midriff, which is tendinous, is the 'cordiform tendon' of modern anatomists.

and heating[1] it though but slightly nevertheless manifestly so disturbs the mental action as to occasion movements that are independent of the will. That man alone is affected by tickling is due firstly to the delicacy of his skin, and secondly to his being the only animal that laughs. For to be tickled is to be set in laughter, the laughter being produced by such a motion as mentioned of the region of the armpit.

It is said also that when men in battle are wounded anywhere near the midriff, they are seen to laugh,[2] owing to the heat produced by the wound. This may possibly be the case. At any rate it is a statement made by much more credible persons than those who tell the story of the human head, how it speaks after it is cut off. For so some assert, and even call in Homer to support them, representing him as alluding to this when he wrote,[3] 'His head still speaking rolled into the dust,' instead of 'The head of the speaker'. So fully was the possibility of such an occurrence accepted in Caria, that one of that country was actually brought to trial under the following circumstances. The priest of Zeus Hoplosmios[4] had been murdered; but as yet it had not been ascertained who was the assassin; when certain persons asserted that they had heard the murdered man's head, which had been severed from the body, repeat several times the words, 'Cercidas slew man on man.' Search was thereupon made and a man of those parts who bore the name of Cercidas hunted out and put upon his trial. But it is impossible that any one should utter a word when the windpipe is severed and no motion any longer derived from the lung. Moreover, among the Barbarians, where heads are chopped off with great rapidity, nothing of the kind has ever yet occurred. Why, again, does not the like occur in

[1] Reading θερμαίνουσαν (PUY) for θερμαίνουσι, with a comma before it; but the text of this passage is too corrupt for more than conjectural interpretation.

[2] When the diaphragm is suddenly ruptured, instant death usually follows, and the face is said invariably to assume the peculiar expression or grin, called *Risus Sardonicus*. Cf. *Dict. d. Sci. Médic.* ix. 214.

[3] *Iliad* x. 457; *Odyssey* xxii. 329. In both places the reading is φθεγγομένου not φθεγγομένη.

[4] Probably meaning 'armed' Zeus. So too there was a temple of Here Hoplosmia in the Peloponnesus. (Liddell and Scott.)

the case of other animals than man? For that none of them should laugh, when their midriff is wounded, is but what one would expect; for no animal but man ever laughs. So, too, there is nothing irrational in supposing that the trunk may run forwards to a certain distance after the head has been cut off; seeing that bloodless animals at any rate can live, and that for a considerable time, after decapitation, as has been set forth and explained in other passages.[1]

The purposes, then, for which the viscera severally exist have now been stated. It is of necessity upon the inner terminations of the vessels that they are developed; for humour, and that of a bloody character, cannot but exude at these points, and it is of this, solidified and coagulated, 673^b
that the substance of the viscera is formed.[2] Thus they are of a bloody character, and in substance resemble each other while they differ from other parts.

11 The viscera are enclosed each in a membrane. For they require some covering to protect them from injury, and require, moreover, that this covering shall be light. To such requirements membrane is well adapted; for it is close in texture so as to form a good protection, destitute of flesh so as neither to attract humour nor retain it, and thin so as to be light and not add to the weight of the body. Of the membranes those are the stoutest and strongest which invest the heart and the brain;[3] as is but consistent with reason. For these are the parts which require most protection, seeing that they are the main governing powers of life, and that it is to governing powers that guard is due.

12 Some animals have all the viscera that have been enumerated; others have only some of them. In what kind of animals this latter is the case, and what is the explanation, has already been stated.[4] Moreover, the self-same viscera present differences in different possessors. For the heart is

[1] Cf. iii. 5. 677^b 27 note; *De An.* i. 5. 411^b 19; ii. 2. 413^b 20; *De Long. Vit. Iuv. et Sen.* 6. 467^a 19; *De Vita*, 2. 468^a 25, ^{b} 2; *De Resp.* 3. 471^b 20; *H. A.* iv. 7. 531^b 30 – 532^a 5; *De Inc. An.* 7. 707^a 27.

[2] Cf. ii. 15. 658^b 24 note.

[3] The pericardium and dura mater.

[4] Cf. iii. 4. 665^a 29.

not precisely alike in all animals that have one; nor, in fact, is any viscus whatsoever. Thus the liver is in some animals split into several parts, while in others it is comparatively undivided.[1] Such differences in its form present themselves even among those sanguineous animals that are viviparous, but are more marked in fishes and in the oviparous quadrupeds, and this whether we compare them with each other or with the Vivipara. As for birds, their liver very nearly resembles that of the Vivipara; for in them, as in these, it is of a pure and blood-like colour. The reason of this is that the body in both these classes of animals admits of the freest exhalation, so that the amount of foul residual matter within is but small. Hence it is that some of the Vivipara are without any gall-bladder[2] at all. For the liver takes a large share in maintaining the purity of composition and the healthiness of the body. For these are conditions that depend finally and in the main upon the blood, and there is more blood in the liver than in any of the other viscera, the heart only excepted. On the other hand, the liver of oviparous quadrupeds and fishes inclines, as a rule, to a yellow hue,[3] and there are even some of them in which it is entirely of this bad colour,[4] in accordance with the bad composition of their bodies generally. Such, for instance, is the case in the toad, the tortoise, and other similar animals.

The spleen, again, varies in different animals. For in those that have horns and cloven hoofs, such as the goat, the sheep, and the like, it is of a rounded form;[5] excepting when increased size has caused some part of it to extend its
674a growth longitudinally, as has happened in the case of the

[1] Cf. iii. 7. 669b 32, 35 notes.
[2] Cf. iv. 2. 676b 26.
[3] The liver of mammals and birds is as a rule of a brown-red colour. In reptiles it inclines to a yellow hue; and in fishes this yellow tint is often still more decided. Cf. Cuvier, *Leçons*, iv. 14-16.
[4] 'Bad' because the degree of yellowness is to A. a measure of the impurity which the liver has to separate from the blood. Perhaps also with some reference to the views of the soothsayers, who seem to have considered a pale liver to be an unfavourable omen, the lucky tint being the normal mottled red, the ποικίλη εὐμορφία of Aeschylus; in which case 'bad' would correspond to the *turpia exta* of Livy (xxvii. 26).
[5] Or perhaps 'of a broad oval form'; στρογγύλος being the term applied to a merchant vessel as distinguished from a ship of war.

ox. On the other hand, it is elongated in all polydactylous animals.[1] Such, for instance, is the case in the pig,[2] in man, and in the dog. While in animals with solid hoofs it is of a form intermediate to these two, being broad in one part, narrow in another. Such, for example, is its shape in the horse, the mule, and the ass.

13 The viscera differ from the flesh not only in the turgid aspect of their substance, but also in position; for they lie within the body, whereas the flesh is placed on the outside. The explanation of this is that these parts partake of the character of blood-vessels, and that while the former exist for the sake of the vessels, the latter cannot exist without them.[3]

14 Below the midriff lies the stomach, placed at the end of the oesophagus when there is one, and in immediate contiguity with the mouth when the oesophagus is wanting. Continuous with this stomach is what is called the gut. These parts are present in all animals, for reasons that are self-evident. For it is a matter of necessity that an animal

[1] The spleen 'is broader at one end in the cow, reindeer, and giraffe than in other ruminants' (Owen, *Verteb.* iii. 561). In the hog it is elongated; so also in Carnivora generally. In the Ungulata it is of proportionately smaller dimensions than in the Carnivora, and in the horse is 'elongated, flattened, broadest at the upper end'. A.'s account so far therefore fairly tallies with the facts. But as regards man his statement is erroneous. For though the human spleen is very variable in shape as in size, yet it cannot be said to be elongated in comparison with that of other mammalia.

[2] A. seems to have been at a loss to classify the pig. Here he reckons it with the many-toed animals in opposition to the animals with solid or cloven hoofs. In the next chapter he separates it from the many-toed, and puts it into a separate division, consisting of 'those that have a cloven hoof, but yet have front teeth in both jaws'; of course in contradistinction to the ruminants. In another place (*H. A.* ii. 1. 499^{b} 12) he says the pig lies half-way between the cloven-hoofed and the solidungulates; and, in corroboration of this, states that there are sometimes pigs with a solid hoof; an anomaly of which instances do in fact occur not very rarely.

The foot of the pig has in reality four toes; but of these the two middle ones are much longer and stouter than the others, and form a cloven hoof which is used by the animal in walking. The two lateral toes are also furnished with hoofs, but are placed at some distance above the ground, so as not to touch it.

[3] It is the viscera that exist 'for the sake of the vessels' (iii. 7. 670^{a} 8), the flesh that 'cannot exist without them' (iii. 5. 668^{a} 32).

shall receive the incoming food; and necessary also that it shall discharge the same when its goodness is exhausted. This residual matter, again, must not occupy the same place as the yet unconcocted nutriment. For as the ingress of food and the discharge of the residue occur at distinct periods, so also must they necessarily occur in distinct places. Thus there must be one receptacle for the ingoing food and another for the useless residue, and between these, therefore, a part in which the change from one condition to the other may be effected. These, however, are matters which will be more suitably set forth when we come to deal with Generation and Nutrition.[1] What we have at present to consider are the variations presented by the stomach and its subsidiary parts. For neither in size nor in shape are these parts uniformly alike in all animals. Thus the stomach is single in all such sanguineous and viviparous animals as have teeth in front of both jaws. It is single therefore in all the polydactylous kinds, such as man, dog, lion, and the rest; in all the solid-hoofed animals also, such as horse, mule, ass; and in all those which, like the pig, though their hoof is cloven, yet have front teeth in both jaws.[2] When, however, an animal is of large size, and feeds on substances of so thorny and ligneous a character as to be difficult of concoction, it may in consequence have several stomachs, as for instance is the case with the camel. A similar multiplicity of stomachs exists also in the horned animals; the reason being that horn-bearing animals have no front teeth in the upper jaw. The camel also, though it has no horns, is yet without upper front teeth.[3] The explanation of this is that it is more essential for the camel to have a multiple stomach than to have these teeth. Its stomach, then, is constructed like that of animals without
674b upper front teeth, and, its dental arrangements being such

[1] *G.A.* ii. 4. 740a 21–b 12; 6. 743a 8 – 7. 746a 28.

[2] Cf. iii. 12. 674a 3 note.

[3] The camel has in fact two incisor teeth in the upper jaw. But these are placed laterally close against the canines, so as to leave a considerable vacant space in the front of the mouth. Had A. known of the existence of these upper incisors, he would not have failed to find in their presence a striking confirmation of his views as to the inverse development of teeth and horns. Cf. iii. 2. 664a 1.

as to match its stomach, the teeth in question are wanting. They would indeed be of no service. Its food, moreover, being of a thorny character, and its tongue necessarily made of a fleshy substance, nature uses the earthy matter which is saved from the teeth to give hardness to the palate. The camel ruminates like the horned animals, because its multiple stomach resembles theirs. For all animals that have horns, the sheep for instance, the ox, the goat, the deer, and the like, have several stomachs. For since the mouth, owing to its lack of teeth, only imperfectly performs its office as regards the food, this multiplicity of stomachs is intended to make up for its shortcomings; the several cavities receiving the food one from the other in succession; the first taking the unreduced substances, the second the same when somewhat reduced, the third when reduction is complete, and the fourth when the whole has become a smooth pulp. Such is the reason why there is this multiplicity of parts and cavities in animals with such dentition. The names given to the several cavities are the paunch, the honey-comb bag, the manyplies, and the reed. How these parts are related to each other, in position and in shape, must be looked for in the treatises on Anatomy and the Researches concerning Animals.[1]

Birds also present variations in the part which acts as a recipient of the food; and the reason for these variations is the same as in the animals just mentioned. For here again it is because the mouth fails to perform its office and fails even more completely — for birds have no teeth at all, nor any instrument whatsoever with which to comminute or grind down their food—it is, I say, because of this, that in some of them what is called the crop precedes the stomach and does the work of the mouth; while in others the oesophagus is either wide throughout[2] or a part of it bulges

[1] Cf. *H. A.* ii. 17. 507a 34–b 15.

[2] The oesophagus, as a general rule, is wide and dilatable in birds, 'in correspondence with the imperfection of the oral instruments as comminutors of the food' (Owen). It is especially wide in the cormorant and other fishing birds. A. (*H. A.* ii. 17. 508b 35) gives as examples several species of crows, with which he appears (*H. A.* viii. 3. 593b 18) to have classed the cormorant.

just before it enters the stomach, so as to form a preparatory store-house for the unreduced food;[1] or the stomach itself has a protuberance in some part,[2] or is strong and fleshy,[3] so as to be able to store up the food for a considerable period and to concoct it, in spite of its not having been ground into a pulp. For nature retrieves the inefficiency of the mouth by increasing the efficiency and heat of the stomach. Other birds there are, such, namely, as have long legs and live in marshes, that have none of these provisions, but merely an elongated oesophagus.[4] The explanation of this is to be found in the moist character of their food. For all these birds feed on substances easy of reduction, and their food being moist and not requiring much concoction, their digestive cavities are of a corresponding character.

675a Fishes are provided with teeth, which in almost all of them[5] are of the sharp interfitting kind. For there is but one small section in which it is otherwise. Of these the fish called Scarus (*Parrot-fish*) is an example. And this is probably the reason why this fish apparently ruminates,

[1] Alluding to the *proventriculus* or glandular stomach. This exists in all birds, but is much larger and more glandular when there is no crop, than when this is present. Doubtless in such cases it supplies the absence of the crop (Cuvier, *Leçons*, iii. 408), and acts as a store-house of food.

[2] The example given in the *H. A.* (ii. 17. 509a 6) is a bird which Aubert and Wimmer identify with *Falco tinnunculus*. They point out that in all the diurnal birds of prey there is a peculiarity, thus described by Meckel (*Tr. Gén. d'Anat. Comp.* viii. 314): 'L'estomac folliculeux d'une ampleur peu considérable forme subitement une saillie allongée, qui est séparée par un étranglement, supérieurement de l'œsophage, et inférieurement de l'estomac musculaire.'

[3] The gizzard is strong and muscular in graminivorous birds; but thin and membranous in the carnivorous species.

[4] In the Greek text, instead of oesophagus (στόμαχος) we have crop (πρόλοβος). This must be an error; for the presence of a crop is one of the very provisions which A. has just enumerated, and which he says are wanting in the long-legged marsh-birds, i. e. the Grallatores. I therefore read στόμαχος for πρόλοβος; which is in harmony with the parallel passage in the *Hist. An.* (ii. 17. 509a 9), where it is said that these birds have a long oesophagus to match their long neck.

In the typical waders there is no crop; neither is the stomach fleshy, but has thin walls, as in piscivorous birds generally. The 'dilatation of the oesophagus before it enters the stomach', i. e. the *proventriculus*, would also seem to A. to be absent; for it forms one single cavity with the thin-walled gizzard; at least such is the case in the heron (Cuvier, *Leçons*, iii. 410).

[5] For πάντας read πάντες.

though no other fishes do so.[1] For those horned animals that have no front teeth in the upper jaw also ruminate.

In fishes the teeth are all[2] sharp; so that these animals can divide[3] their food, though imperfectly. For it is impossible for a fish to linger or spend time in the act of mastication, and therefore they have no teeth that are flat or suitable for grinding; for such teeth would be to no purpose. The oesophagus again in some fishes is entirely wanting, and in the rest is but short. In order, however, to facilitate the concoction of the food, some of them, as the Cestreus[4] (*mullet*), have a fleshy stomach resembling that of a bird; while most of them have numerous processes close against the stomach, to serve as a sort of antechamber in which the food may be stored up and undergo putrefaction[5] and concoction. There is a contrast between fishes and birds in the position of these processes. For in fishes they are placed close to the stomach; while in birds, if present at all, they are lower down, near the end of the gut.[6] Some of the Vivipara also have processes connected with

[1] Whether the parrot-fish ruminates I do not know; but A. is wrong in saying that no other fish does so. There are several species, especially of the carp tribe, in which a sort of rumination occurs. Cf. Owen, *Comp. Anat.* ii. 236.

[2] For πάντες read πάντας.

[3] Cf. iii. 1. 662a 13. The sharp teeth of fishes, however, serve rather for the retention than for the mastication of food.

[4] The Cestreus is doubtless some species of Mugil, a tribe of which our grey mullet is a familiar example. What species is meant is uncertain; the Mediterranean containing at least five. In all these Mugilidae the stomach has much the character of a true muscular gizzard. 'Of all the fish I have seen, the mullet is the most complete instance of this (the grinding) structure; its strong muscular stomach being evidently adapted, like the gizzard of birds, to the two offices of mastication and digestion.'—John Hunter.

[5] A. seems here to admit that digestion is in part due to putrefaction, a doctrine held by Pleistonicus.

[6] In most osseous fishes, though not in all, there are a variable number of caecal appendages close behind the pylorus, which have been erroneously held to be the homologues of the pancreas. Their use is not known with certainty. The Selachia are rightly stated by A. (*H. A.* ii. 17. 508b 22) to be without these caeca. In birds, as a rule, there are two caeca at the junction of small and large gut; rarely, as in the heron, a single caecum. Sometimes, however, as A. notices here and elsewhere (*H. A.* ii. 17. 508b 14), the caeca are absent. This is the case, for instance, in the wryneck, woodpecker, lark, and cormorant, among birds known to Aristotle.

the lower part of the gut [1] which serve the same purpose as that stated above.

The whole tribe of fishes is of gluttonous appetite, owing to the arrangements for the reduction of their food being very imperfect, and much of it consequently passing through them without undergoing concoction: and, of all, those are the most gluttonous that have a straight intestine. For as the passage of food in such cases is rapid, and the enjoyment derived from it in consequence but brief, it follows of necessity that the return of appetite is also speedy.[2]

It has already been mentioned that in animals with front teeth in both jaws the stomach is of small size.[3] It may be classed pretty nearly always under one or other of two headings, namely as resembling the stomach of the dog, or as resembling the stomach of the pig. In the pig the stomach is larger than in the dog, and presents certain folds of moderate size, the purpose of which is to lengthen out the period of concoction; while the stomach of the dog is of small size, not much larger in calibre than the gut, and smooth on the internal surface.[4]

Not much larger, I say, than the gut; for in all animals after the stomach comes the gut. This, like the stomach, presents numerous modifications. For in some animals it is uniform, when uncoiled, and alike throughout, while in

[1] Meaning of course the caecum and vermiform appendix. There is the greatest variety in the different mammalian orders as to the presence or absence of these. Cf. Cuvier, *Leçons*, iii. 465.

[2] Fishes, says A., do not digest their food well, because they have a short gut; and so they are ravenous. Similarly in the *Timaeus* it is said that a long intestine was given to animals to prevent insatiable gluttony. An abnormally short gut is, in fact, a sufficient cause for a ravenous appetite (cf. Schiff, *Sur la Digestion*, i. 44). The normally short gut of a fish is, however, probably to be explained by the easy digestibility of their food.

[3] What he stated before was that they had a single stomach, not a small one. The single stomach is, however, small as compared with the multiple stomach of the ruminants.

[4] The stomach of the dog, as of Carnivora generally, is of small size, somewhat elongated, and perfectly smooth within. That of the pig is of larger dimensions owing to the very ample cardiac cul-de-sac, is of globular shape, and presents on its internal surface two transverse folds on either side of the cardia. Cf. *H. A.* ii. 17. 507b 19. The two types, then, under which A. classes stomachs are the small, perfectly simple stomach of Carnivora, and the larger and less simple stomach that, beginning with the pig, culminates in the very complicated organ of the ruminants. Cf. Owen, *Anat. of Vert.* iii. 463.

others it differs in different portions. Thus in some cases it is wider in the neighbourhood of the stomach, and narrower towards the other end; and this explains by the way why dogs[1] have to strain so much in discharging their excrement. But in most animals it is the upper portion that is 675b the narrower and the lower that is of greater width.

Of greater length than in other animals, and much convoluted, are the intestines of those that have horns.[2] These intestines, moreover, as also the stomach, are of ampler volume, in accordance with the larger size of the body. For animals with horns are, as a rule, animals of no small bulk, because of the thorough elaboration which their food undergoes. The gut, except in those animals[3] where it is straight, invariably widens out as we get farther from the stomach and come to what is called the colon, and to a kind of caecal dilatation. After this it again becomes narrower and convoluted.[4] Then succeeds a straight portion which runs right on to the vent. This vent is known as the anus, and is in some animals surrounded by fat, in others not so. All these parts have been so contrived by nature as to harmonize with the various operations that relate to the food and its residue. For, as the residual food gets farther on and lower down, the space to contain it enlarges, allowing it to remain stationary and undergo conversion. Thus is it in those animals which, owing either to their large size, or to the heat of the parts concerned,[5] require more nutriment, and consume more fodder than the rest.

[1] 'Dans les chiens . . . . les gros intestins n'ont guères plus de diamètre que les grêles.' Cuvier, *Leçons*, iii. 485.

[2] The intestines, longer in Herbivora generally than in Carnivora, attain the greatest length in ruminants. In the sheep, for instance, they are twenty-eight times as long as the body; in the equally herbivorous but non-ruminating rabbit ten times; in the carnivorous dog only five times.

[3] What animals, if any, at all comparable with ruminants, A. held to have a straight intestine, I cannot surmise. Here, however, he seems to include all non-ruminants under εὐθυέντερα, as being comparatively straight-gutted. Cf. *H. A.* ii. 17. 507b 34.

[4] Referring to the spiral coil of the colon, which forms one of the characteristics of the Artiodactyla (cf. Owen, *Vert.* iii. 474). The colon becomes narrower where it assumes this spiral disposition. Later on A. calls this part the coil or helix (ἕλιξ). The straight terminal part is of course the rectum.

[5] The digestive cavities. As to τόπων compare τῶν τόπων ἀμφοτέρων, 676a 2.

Neither is it without a purpose that, just as a narrower gut succeeds to the upper stomach, so also does the residual food, when its goodness is thoroughly exhausted, pass from the colon and the ample space of the lower stomach into a narrower channel and into the spiral coil. For so nature can regulate her expenditure and prevent the excremental residue from being discharged all at once.[1]

In all such animals, however, as have to be comparatively moderate in their alimentation,[2] the lower stomach presents no wide and roomy spaces, though their gut is not straight, but has a number of convolutions. For amplitude of space causes desire for ample food, and straightness of the intestine causes quick return of appetite. And thus it is that all animals whose food receptacles are either simple or spacious are of gluttonous habits, the latter eating enormously at a meal, the former making meals at short intervals.

Again, since the food in the upper stomach, having just been swallowed, must of necessity be quite fresh, while that which has reached the lower stomach must have had its juices exhausted and resemble dung, it follows of necessity that there must also be some intermediate part, in which the change may be effected, and where the food will be neither perfectly fresh nor yet dung. And thus it is that, in all such animals as we are now considering, there is found what is called the jejunum;[3] which is a part of the small gut, of the gut, that is, which comes next to the stomach. For this jejunum lies between the upper cavity which contains the yet unconcocted food and the lower cavity which holds the residual matter, which by the time it has got here has become worthless. There is a jejunum in all these
676a animals, but it is only plainly discernible in those of large size, and this only when they have abstained from food for

[1] Why should she do so? A. probably has in mind the Bonasus (iii. 2. 663^a 16).

[2] That is, the Carnivora; whose food is only taken at comparatively long intervals (iv. 10. 688^b 4) and is not so bulky as that of Herbivora. In these the gut, though not unconvoluted, is less so than in ruminants, of which animals A. has up to now been speaking, and is without their spiral coil or their capacious caecum and colon.

[3] Jejunum (*νῆστις*) is the name given to the middle section of the small intestine, because it is usually found empty after death. The passage of the contained food through it takes place with great rapidity (cf. M. Edwards, *Leçons*, iii. 130).

a certain time. For then alone can one hit on the exact period when the food lies half-way between the upper and lower cavities; a period which is very short, for the time occupied in the transition of food is but brief. In females this jejunum may occupy any part whatsoever of the upper intestine, but in males it comes just before the caecum and the lower stomach.[1]

15 What is known as rennet[2] is found in all animals that have a multiple stomach, and in the hare[3] among animals whose stomach is single. In the former the rennet neither occupies the large paunch, nor the honeycomb bag, nor the terminal reed, but is found in the cavity which separates this terminal one from the two first, namely in the so-called manyplies.[4] It is the thick character of their milk which causes all these animals to have rennet; whereas in animals with a single stomach the milk is thin, and consequently no rennet is formed. It is this difference in thickness[5] which makes the milk of horned animals coagulate, while that of animals without horns does not. Rennet forms in the hare because it feeds on herbage that has juice like that of the fig;[6] for juice of this kind coagulates the milk in the stomach of the sucklings.[7] Why it is in the manyplies that rennet is formed in animals with multiple stomachs has been stated in the Problems.[8]

[1] This strange statement has no anatomical foundation.

[2] By rennet is usually meant the wall of the fourth stomach of a sucking ruminant, which contains a substance that has the property of coagulating milk; but the term is also used for the milk when thus coagulated, which, owing to the substance mixed with it, has the power of coagulating other milk. It is this concreted milk that A. calls rennet, attributing its formation to that convenient agent 'Vital heat' (*G. A.* ii. 4. 739^b 23; *H. A.* iii. 21. 522^b 7).

[3] So also Varro (*De Re rustica*, ii. 11).

[4] This is erroneous. It is the fourth stomach that gives rennet.

[5] The thickness of milk, as explained in *H. A.* iii. 20. 521^b 28, depends on the proportion of cheese it contains as compared with the whey. The milk of ruminants is rightly stated to contain much more cheese, i. e. caseine, than that of other animals.

[6] The leaves of the common Pinguicula contain a juice which has the power of coagulating milk, and is said by Linnaeus to be used by the Laplanders in the fabrication of cheese. The same property is possessed by *Galium Verum*, sometimes therefore called Cheese Rennet. As to fig-juice cf. *H. A.* iii. 20. 522^b 2.

[7] Ἔμβρυον seems a strange term for a suckling which not only sucks but grazes. Cf. *Odyssey* ix. 245.

[8] Not in the Problems as they have come down to us.

BOOK IV

THE account which has now been given of the viscera,[1] 1
the stomach, and the other several parts holds equally good not only for the oviparous quadrupeds, but also for such apodous animals as the Serpents. These two classes of animals are indeed nearly akin, a serpent resembling a lizard which has been lengthened out and deprived of its feet. Fishes, again, resemble these two groups in all their parts, excepting that, while these, being land animals, have a lung, fishes have no lung, but gills in its place. None of these animals, excepting the tortoise, as also no fish, has a urinary bladder.[2] For owing to the bloodlessness of their lung, they drink but sparingly; and such fluid as they have is diverted to the scaly plates, as in birds it is diverted to the feathers, and thus they come to have the same white matter on the surface of their excrement as we see on that of birds. For[3] in animals that have a bladder, its excretion when voided throws down a deposit of earthy brine in the containing vessel.[4] For the sweet and fresh elements, being light, are expended on the flesh.

676b Among the Serpents, the same peculiarity attaches to vipers, as among fishes attaches to Selachia. For both these and vipers are externally viviparous, but previously produce ova internally.[5]

[1] The stomach is not one of the viscera in A.'s sense. Cf. iii. 4. 665a 31 note.

[2] Cf. iii. 8. 671b 15 note.

[3] For διόπερ read διότι.

[4] And this earthy brine, it is implied, must, if there is no bladder, be discharged by the bowel. It is, of course, discharged with the faecal matter from the reptilian and avian cloaca.

[5] A. includes under Selachia all cartilaginous fishes, among which he erroneously classes the Lophius (cf. iv. 13. 695b 14 note). All these, he often says, with the exception of Lophius, are ovoviviparous: that is, they retain their ova within the body till hatched. In some of these ovovivipara the embryo throughout remains free from all anatomical connexion with the mother, but in some, when the nutriment supplied by the yelk is exhausted, the embryo forms a connexion with the parent's body (*G. A.* ii. 4. 727b 23; iii. 3. 754b 27). The latter part of

The stomach in all these animals is single, just as it is single in all other animals that have teeth in front of both jaws; and their viscera are excessively small, as always happens when there is no bladder. In serpents these viscera are, moreover, differently shaped from those of other animals. For, a serpent's body being long and narrow, its contents are as it were moulded into a similar form, and thus come to be themselves elongated.

All animals that have blood possess an omentum, a mesentery,[1] intestines with their appendages, and, moreover, a diaphragm and a heart; and all, excepting fishes, a lung and a windpipe. The relative positions, moreover, of the windpipe and the oesophagus are precisely similar in them all; and the reason is the same as has already been given.[2]

2 Almost all sanguineous animals have a gall-bladder. In some this is attached to the liver, in others separated from that organ[3] and attached to the intestines, being apparently in the latter case no less than in the former an appendage of the lower stomach.[4] It is in fishes that this is most

this statement applies to certain sharks, which do in fact present a rudimentary placenta. The former part of his statement is too wide a generalization; for the oviparous dogfishes and the rays present exceptions to the statement that all A.'s Selachia are, as he says, ovo-viviparous. Yet A. (*H. A.* vi. 10. 565a 22) was well acquainted with the eggs of the dogfishes and the rays. The explanation seems to be that he imagined that the young fish was fully developed in the ovum at the time when this was first laid. It is, however, very doubtful whether this is the case, unless as an exception. Cf. Meyer, *Thierkunde*, p. 281.

The osseous fishes A. states to be all oviparous. This rule, however, is not without exception; e. g. the viviparous blenny.

[1] All vertebrata have a mesentery, with the exception of the lamprey, the carp, and some other fishes, and even these have it in their embryonic stage. As to the omentum, cf. iv. 3. 677b 23 note; as to the diaphragm, cf. iii. 10. 672b 13 note.

[2] Cf. iii. 3. 664b 3, where, however, the inconvenient position is described, but no explanation proffered.

[3] In certain Ophidia the gall-bladder is, in fact, completely separated from the liver and lies close to the pylorus. This is so in all the serpents that have the tongue enclosed in a sheath (Duvernoy, *Ann. d. Sc. Nat.* xxx. 127). A similar condition is found in some fishes (Owen, *Lect. on Comp. An.* ii. 243), among others in the Lophius, the Swordfish, and the Muraena; all of which are elsewhere (*H. A.* ii. 15. 506b 15) enumerated as examples of this structure. Probably this peculiar arrangement has reference to the long narrow shape of the animals, and exists for convenience of packing.

[4] As to lower stomach, cf. ii. 3. 650a 14 note; iii. 14. 675b 19. The

clearly seen. For all fishes[1] have a gall-bladder; and in most of them it is attached to the intestine, being in some, as in the Amia,[2] united with this, like a border, along its whole length. It is similarly placed in most serpents. There are therefore[3] no good grounds for the view entertained by some writers, that the gall exists for the sake of some sensory action. For they say that its use is to affect that part of the soul which is lodged in the neighbourhood of the liver, vexing this part when it is congealed, and restoring it to cheerfulness when it again flows free. But this cannot be. For in some animals there is absolutely no gall-bladder at all—in the horse, for instance, the mule, the ass, the deer, and the roe; and in others, as the camel, there is no distinct bladder, but merely small vessels of a biliary character. Again, there is no such organ in the seal, nor, of purely sea-animals, in the dolphin.[4] Even within the limits of the same genus, some animals appear to have and others to be without it.[5] Such, for instance, is the case with mice:

exact meaning of this passage is doubtful. I understand, however, A. to mean that the bile is in all cases discharged into the intestine at a point below the upper or true stomach.

[1] Fishes are very rarely without a gall-bladder, though there are some few exceptions, e.g. sawfish, lamprey, and basking-shark.

[2] The Amia appears to be the *Scomber Sarda* of Cuvier. This fish abounds in the Mediterranean. Like the tunny, bonito, and sundry other Scombridae, it is remarkable for the extreme length and slenderness of its gall-bladder. Cuvier, *Règ. Anim.* ii. 199, and Owen, *Lect.* ii. 244.

[3] This very obscure and corrupt passage is intended to summarize Plato's views as to the gall as given in the *Timaeus* 71. For *συνιστῇ* read *συστῇ*.

[4] A. is correct in this enumeration of animals that have no gall-bladder, with the exception of the seal. The *Phoca vitulina* has a gall-bladder; but it may possibly, though improbably, be that the *Phoca monachus*, which was the species best known to the ancients (Cuvier, *Règne An.* i. 169), is without one, as Frantzius suggests.

[5] The gall-bladder is sometimes present, sometimes absent in giraffes (Owen-Joly); in the apteryx and bittern (Owen); in the guinea-fowl, &c. It is especially variable, as A. rightly says, in the different species of Mus (Cuvier, *Leçons*, iv. 36). In man a congenital absence of the gall-bladder has been noticed in rare instances (Rokitansky, ii. 155; *Phil. Trans.* 1749). This, however, could not be known to A., who says, moreover (*H. A.* i. 17. 496b 22), that *most* men are without a gall-bladder. If, as is not impossible, A. examined aborted human embryos, he might easily have been led to this erroneous opinion. For the gall-bladder is not developed at all until the third month, at a time when the liver almost entirely fills the abdominal cavity.

such also with man. For in some individuals there is a distinct gall-bladder attached to the liver, while in others there is no gall-bladder at all. This explains how the existence of this part in the whole genus has been a matter of dispute. For each observer, according as he has found it present or absent in the individual cases he has examined, has supposed it to be present or absent in the whole genus. The same has occurred in the case of sheep and of goats. For these animals usually have a gall-bladder; but, while in some 677a
localities it is so enormously big as to appear a monstrosity, as is the case in Naxos, in others it is altogether wanting, as is the case in a certain district belonging to the inhabitants of Chalcis in Euboea.[1] Moreover, the gall-bladder in fishes is separated, as already mentioned,[2] by a considerable interval from the liver.[3] No less mistaken seems to be the opinion of Anaxagoras and his followers, that the gall-bladder is the cause of acute diseases, inasmuch as it becomes over-full, and spirts out its excess on to the lung, the blood-vessels, and the ribs. For, almost invariably, those who suffer from these forms of disease are persons who have no gall-bladder at all, as would be quite evident were they to be dissected. Moreover, there is no kind of correspondence between the amount of bile which is present in these diseases and the amount which is exuded.[4] The most probable opinion is that, as the bile when it is present in any other part of the body is a mere residuum or a product of decay, so also when it is present in the region of the liver it is equally excremental and has no further use; just as is the case with the dejections of the stomach and intestines. For though even the residua are occasionally used by nature for some useful purpose, yet we must not in all cases expect to find such a final cause; for granted the existence in the body of this or that constituent, with such

[1] Cf. *H. A.* i. 17. 496b 26. [2] Cf. iv. 2. 676b 19.

[3] And therefore cannot have the action these writers attribute to it.

[4] When an animal's body is opened some time after death, the parts near the gall-bladder are often found to be stained yellow from an exudation of bile. It is probably to this overflow that reference is made, as being excessively small in comparison with the amount of bile which is apparent in the human body in cases of jaundice.

and such properties, many results must ensue merely as necessary consequences of these properties. All animals, then, whose liver is healthy in composition and supplied with none but sweet blood, are either entirely without a gall-bladder on this organ, or have merely small bile-containing vessels; or are some with and some without such parts. Thus it is that the liver in animals that have no gall-bladder is, as a rule, of good colour and sweet; and that, when there is a gall-bladder, that part of the liver is sweetest which lies immediately underneath it. But, when animals are formed of blood less pure in composition, the bile serves for the excretion of its impure residue. For the very meaning of excrement is that it is the opposite of nutriment, and of bitter that it is the opposite of sweet; and healthy blood is sweet. So that it is evident that the bile, which is bitter, cannot have any useful end, but must simply be a purifying excretion. It was therefore no bad saying of old writers that the absence of a gall-bladder gave long life. In so saying they had in mind deer and animals with solid hoofs. For such have no gall-bladder and live long. But besides these there are other animals that have no gall-bladder, though those old writers had not noticed the fact, such as the camel and the dolphin; and these also are, as it happens, long-lived.[1] Seeing, indeed, that the liver is not only useful, but a necessary and vital part in all
677b animals that have blood, it is but reasonable that on its character should depend the length or the shortness of life. Nor less reasonable is it that this organ and none other should have such an excretion as the bile. For the heart, unable as it is to stand any violent affection, would be utterly intolerant of the proximity of such a fluid: and, as to the rest of the viscera, none excepting the liver are necessary parts of an animal. It is the liver therefore that alone has this provision. In conclusion, wherever we see bile we must take it to be excremental. For to suppose

[1] The camel is said by A. (*H. A.* viii. 9. 596^{a} 10) to live for 30 years, and exceptionally for 100 years. Burckhardt gives it a life of 40 years. As to the dolphin it is stated (*H. A.* vi. 12. 566^{b} 24) that some had been marked by fishermen and let go; and that by their recapture it had been ascertained that they live at least 30 years.

that it has one character in this part, another in that, would be as great an absurdity as to suppose mucus or the dejections of the stomach to vary in character according to locality and not to be excremental wherever found.

3 So much then of the gall-bladder, and of the reasons why some animals have one, while others have not. We have still to speak of the mesentery and the omentum; for these are associated with the parts already described and contained in the same cavity. The omentum, then, is a membrane containing fat; the fat being suet or lard, according as the fat of the animal generally is of the former or latter description. What kinds of animals are so distinguished has been already set forth in an earlier part of this treatise.[1] This membrane, alike in animals that have a single and in those that have a multiple stomach, grows from the middle of that organ, along a line which is marked on it like a seam. Thus attached, it covers the rest of the stomach and the greater part of the bowels, and this alike in all sanguineous animals, whether they live on land or in water.[2] Now the development of this part into such a form as has been described is the result of necessity. For, whenever solid and fluid are mixed together and heated, the surface invariably becomes membranous and skin-like. But the region in which the omentum lies is full of nutriment of such a mixed character. Moreover, in consequence of the close texture of the membrane, that portion of the sanguineous nutriment will alone filter into it which is of a greasy character; for this portion is composed of the finest particles; and when it has so filtered in, it will be concocted by the heat of the part, and will be converted into suet or lard, and will not acquire a flesh-like or sanguineous constitution. The development, then, of the omentum is simply the result of necessity. But when once formed, it is used by nature for an end, namely, to facilitate and to hasten the concoction of food. For all that is hot aids concoction; and fat is hot, and the omentum is fat. This too explains why it hangs

[1] Cf. ii. 5. 657a 35.

[2] A similar statement is made elsewhere (iv. 1. 676b 11: *H. A.* iii. 14). It is, however, erroneous. Mammalia alone have an omentum.

from the middle of the stomach; for the upper part of the stomach has no need of it, being assisted in concoction by the adjacent liver. Thus much as concerns the omentum.

The so-called mesentery is also a membrane: and extends continuously from the long stretch of intestine to the 4
678a great vessel and the aorta. In it are numerous and close-packed vessels, which run from the intestines to the great vessel and to the aorta. The formation of this membrane we shall find to be the result of necessity, as is that of the other [similar] parts.[1] What, however, is the final cause of its existence in sanguineous animals is manifest on reflection. For it is necessary that animals shall get nutriment from without: and, again, that this shall be converted into the ultimate nutriment, which is then distributed as sustenance to the various parts; this ultimate nutriment being, in sanguineous animals, what we call blood, and having, in bloodless animals, no definite name. This being so, there must be channels through which the nutriment shall pass, as it were through roots, from the stomach into the blood-vessels. Now the roots of plants are in the ground: for thence their nutriment is derived. But in animals the stomach and intestines represent the ground from which the nutriment is to be taken. The mesentery, then, is an organ to contain the roots; and these roots are the vessels that traverse it. This then is the final cause of its existence. But how it absorbs nutriment, and how that portion of the food which enters into the vessels is distributed by them to[2] the various parts of the body, are questions which will be considered when we come to deal with the generation and nutrition of animals.

The constitution of sanguineous animals, so far as the parts as yet mentioned are concerned, and the reasons for such constitution, have now been set forth. In natural sequence we should next go on to the organs of generation, as yet undescribed, on which depend the distinctions of male and female. But, inasmuch as we shall have to deal spe-

[1] A. cannot have meant that all the parts are the necessary outcome of purely physical conditions, but only that membranes (*G. A.* ii. 4. 739b 27) so originate. Either *τοιούτοις* must be supplied before *μορίοις* or for *μορίοις* may be read *ὑμέσιν* (Platt).

[2] For *ταῦτα* read *πάντα*.

cially with generation hereafter, it will be more convenient to defer the consideration of these parts to that occasion.

5 Very different from the animals we have as yet considered are the Cephalopoda and the Crustacea. For these have absolutely no viscera[1] whatsoever; as is indeed the case with all bloodless animals, in which are included two other genera, namely the Testacea and the Insects. For in none of them does the material out of which viscera are formed exist. None of them, that is, have blood. The cause of this lies in their essential constitution. For the presence of blood in some animals, its absence from others, must be included in the conception which determines their respective essences. Moreover, in the animals we are now considering, none of those final causes will be found to exist which in sanguineous animals determine the presence of viscera. For they have no blood-vessels nor urinary bladder,[2] nor 678b
do they breathe; the only part that it is necessary for them to have being that which is analogous to a heart. For in all animals there must be some central and commanding part of the body, to lodge the sensory portion of the soul and the source of life. The organs of nutrition are also of necessity present in them all. They differ, however, in character because of differences of the habitats in which they get their subsistence.

In the Cephalopoda there are two teeth,[3] enclosing what is called the mouth; and inside this mouth is a flesh-like substance which represents a tongue and serves for the discrimination of pleasant and unpleasant food. The Crustacea have teeth corresponding to those of the Cephalopoda, namely their anterior teeth,[4] and also have the fleshy repre-

[1] Cf. iii. 4. 665a 31 note.

[2] Urinary bladder and lung (iii. 8. 671a 1) were to A. signs of abundant blood; and viscera (iii. 7. 670a 8 note) were one of the channels by which superfluous blood was eliminated.

[3] By the teeth are meant the two halves of the parrot-like beak. The so-called tongue is a large organ, and its anterior part 'very soft in texture, beset with numerous papillae, having all the characters of a perfect organ of taste' (Owen).

[4] The 'anterior teeth' are the strong shear-like mandibles; which are called anterior to distinguish them from the stomachal teeth presently to be mentioned. By the tongue is meant the bifid lower lip, which has been called a tongue by other writers than A., but is not properly comparable to such an organ. Cf. Todd, *Cycl.* i. 773.

sentative of a tongue. This latter part is found, moreover, in all Testacea,[1] and serves, as in sanguineous animals, for gustatory sensations. Similarly provided also are the Insects. For some of these, such as the Bees and the Flies, have, as already described,[2] their proboscis protruding from the mouth; while those others that have no such instrument in front have a part which acts as a tongue inside the mouth.[3] Such, for instance, is the case in the Ants and the like. As for teeth, some insects have them, the Bees and the Ants[4] for instance, though in a somewhat modified form, while others that live on fluid nutriment are without them. For in many insects the teeth are not meant to deal with the food, but to serve as weapons.

In some Testacea, as was said in the first treatise,[5] the organ which is called the tongue is of considerable strength; and in the Cochli (*Sea-snails*) there are also two teeth,[6] just as in the Crustacea. The mouth in the Cephalopoda is succeeded by a long gullet. This leads to a crop,[7] like that of a bird, and directly continuous with this is the stomach, from which a gut runs without windings to the vent. The Sepias and the Poulps resemble each other completely, so far as regards the shape and consistency of these parts. But not so the Teuthides (*Calamaries*). Here, as in the other groups, there are the two stomach-like receptacles; but the

[1] The tongue or odontophore forms a very remarkable organ in the Gasteropoda, but there is none in the Conchifera or bivalves of Aristotle.

[2] Cf. *H. A.* iv. 4. 528b 29.

[3] The so-called 'tongue' of insects is the upper portion of the labium, and is very distinct in some species. In bees and flies this tongue goes, with the rest of the labium, to form what A. calls their proboscis; so that it is only in other insects that there is a distinct tongue inside the mouth.

[4] Reading *μυρμήκων* for *μυιῶν*, the very probable emendation of Meyer. The 'modified teeth' are the mandibles. The insects that live on fluid nutriment and have no teeth are the Lepidoptera, in which the maxillae are converted into a long proboscis, while the mandibles are quite rudimentary.

[5] *H. A.* iv. 4. 528b 33.

[6] i.e. the horny jaws with which some Gasteropods are furnished.

[7] By the crop (*πρόλοβος*) and stomach of the Cephalopoda A. meant respectively what modern anatomists recognize as the stomach and the first part of the intestine; which latter is dilated and has a diverticulum that in some species is spirally convoluted so as to be aptly likened by A. (*H. A.* iv. 1. 524b 11) to the helix of a whelk. The real crop, which is present only in the poulps among dibranchiate Cephalopoda, was not noticed by A.

first of these cavities has less resemblance to a crop, and in neither is the form [or the consistency] the same as in the other kinds, the whole body indeed being made of a softer kind of flesh.

The object of this arrangement of the parts in question is the same in the Cephalopoda as in Birds; for these also are all unable to masticate their food; and therefore it is that a crop precedes their stomach.

For purposes of defence, and to enable them to escape from their foes, the Cephalopoda have what is called their ink. This is contained in a membranous pouch, which is 679a
attached[1] to the body and provided with a terminal outlet just at the point where what is termed the funnel gives issue to the residua of the stomach. This funnel is placed on the ventral surface of the animal. All Cephalopoda alike have this characteristic ink, but chief of all the Sepia, where it is more abundant than in the rest. When the animal is disturbed and frightened it uses this ink to make the surrounding water black and turbid, and so, as it were, puts a shield in front of its body.

In the Calamaries and the Poulps the ink-bag is placed in the upper part of the body, in close proximity to the *mytis*,[2] whereas in the Sepia it is lower down, against the stomach. For the Sepia has a more plentiful supply of ink than the rest, inasmuch as it makes more use of it. The reasons for this are, firstly, that it lives near the shore, and, secondly, that it has no other means of protection; whereas the Poulp has its long twining feet to use in its defence, and is, moreover, endowed with the power of changing colour.[3] This changing of colour, like the discharge of ink, occurs as

[1] For προσπεφυκότα read προσπεφυκότι.

[2] The *mytis* is identical with the *mecon*, which exists in all Crustacea (*H. A.* iv. 2. 526b 32); is a bag containing excretory matter (*H. A.* iv. 4. 529b 11); placed (680a 23) near the hinge in bivalves, and in the spiral part of the shell in Turbinata, being spiral itself, in the whelk for instance (*H. A.* iv. 4. 529a 10). This can be nothing else than the liver; and Köhler's notion that the glandular appendages of the veins are meant (Todd, *Cycl. of An. and Phy.* i. 539) is out of the question.

[3] In reality all these Cephalopods have the faculty of changing colour; but the phenomenon is most conspicuous in the poulps (cf. Cuvier, *R. An.* iii. 10).

the result of fright. As to the Calamary, it lives far out at sea, being the only one of the Cephalopoda that does so;[1] and this gives it protection. These then are the reasons why the ink is more abundant in the Sepia than in the Calamary, and this greater abundance explains the lower position; for it allows the ink to be ejected with ease even from a distance. The ink itself is of an earthy character, in this resembling the white deposit[2] on the surface of a bird's excrement, and the explanation in both cases is the same, namely, the absence of a urinary bladder. For, in default of this, it is the ink that serves for the excretion of the earthiest matter. And this is more especially the case in the Sepia, because there is a greater proportion of earth in its composition than in that of the other Cephalopoda. The earthy character of its bone is a clear indication of this. For in the Poulp there is no bone at all, and in the Calamary it is thin and cartilaginous. Why this bone should be present in some Cephalopoda, and wanting in others, and how its character varies in those that have it, has now been set forth.[3]

These animals, having no blood, are in consequence cold and of a timid character. Now, in some animals, fear causes a disturbance of the bowels, and, in others, a flow of urine from the bladder. Similarly in these it produces a discharge of ink, and, though the ejection of this ink in fright, like that of the urine, is the result of necessity, and, though it is of excremental character, yet it is used by nature for a purpose, namely, the protection and safety of the animal that excretes it.

The Crustacea also, both the Caraboid forms and the Crabs, are provided with teeth, namely their two anterior teeth; and between these they also present the tongue-like piece of flesh, as has indeed been already mentioned.[4] Directly after their mouth comes a gullet, which, if we compare relative sizes, is but small in proportion to the body:

[1] The Sepiadae, and still more the Calamaries, are pelagic; the Poulps are littoral.

[2] Cf. iv. 1. 676a 32.

[3] Or εἴρηται πρότερον (P), in which case the reference is to ii. 8. 654a 20.

[4] Cf. 678b 10.

and then a stomach, which in the Carabi and some of the Crabs is furnished with a second set of teeth, the anterior teeth being insufficient for adequate mastication. From 679b
the stomach a uniform gut runs in a direct line to the excremental vent.[1]

The parts described are to be found also in all the various Testacea. The degree of distinctness, however, with which they are formed varies in the different kinds, and the larger the size of the animal the more easily distinguishable are all these parts severally. In the Sea-snails, for example, we find teeth, hard and sharp, as before mentioned,[2] and between them the flesh-like substance, just as in the Crustacea and Cephalopoda, and again the proboscis,[3] which, as has been stated,[4] is something between a sting and a tongue. Directly after the mouth comes a kind of bird-like crop,[5] then a gullet, succeeded by a stomach, in which is the *mecon*,[6] as it is styled; and continuous with this *mecon* is an intestine, starting directly from it. It is this residual substance which appears in all the Testacea to form the most palatable morsel. Purpuras and Whelks, and all other Testacea that have turbinate shells, in structure resemble the Sea-snail. The genera and species of Testacea are very

[1] The oesophagus in Crustacea is, as stated in the text, very short. The stomach-teeth are present in all Decapoda, and not only 'in the Carabi and some of the crabs'. The intestine is remarkably straight.

[2] Bronn (*Malacozoa*, part ii. 950), and Lebert (Müller's *Archiv*, 1846, p. 463), believe that A. means the lingual teeth. But these are almost too small to be seen with the naked eye. So Lebert boldly asserts that A. must have used a lens of glass or crystal, or some magnifying instrument! Clearly, however, the jaws are meant, not the lingual teeth: for they are said to be only two in number. Cf. iv. 5. 678^b 23.

[3] In many Gasteropoda, especially the carnivorous species, there is a long retractile proboscis.

[4] Cf. *H. A.* iv. 4. 528^b 30, where, however, nothing is said as to a sting.

[5] The crop, which comes directly after the mouth, is probably the 'buccal mass'; for the dilatation now called crop in many gasteropods (e. g. Dolium, Cypraea, Voluta) is as a rule removed from the mouth by half the length of oesophagus, though exceptionally (e. g. Turbo) it may be much nearer. Cf. Bronn, *Malacozoa*, part ii. 954).

[6] The *mecon* or *mytis* is the liver. This in Gasteropods is of great size and in most of them completely envelops the stomach and first part of the intestine, which latter therefore appears to start from it. When A. says that the *mecon* is inside the stomach he must have mistaken the outer surface of the visceral mass for the wall of the stomach.

numerous. For there are those with turbinate shells, of which some have just been mentioned; and, besides these, there are bivalves and univalves. Those with turbinate shells may, indeed, after a certain fashion be said to resemble bivalves. For they all from their very birth have an operculum to protect that part of their body which is exposed to view.[1] This is the case with the Purpuras, with Whelks, with the Nerites, and the like. Were it not for this, the part which is undefended by the shell would be very liable to injury by collision with external objects. The univalves also are not without protection. For on their dorsal surface they have a shell, and by the under surface they attach themselves to the rocks, and so after a manner become bivalved, the rock representing the second valve. Of these the animals known as Limpets are an example. The bivalves, scallops and mussels, for instance, are protected by the power they have of closing their valves; and the Turbinata by the operculum just mentioned, which transforms them, as it were, from univalves into bivalves. But of all there is none so perfectly protected as the sea-urchin. For here there is a globular shell which encloses the body completely, and which is, moreover, set with sharp spines. This peculiarity distinguishes the sea-urchin from all other Testacea, as has already been mentioned.[2]

The structure of the Testacea and of the Crustacea is exactly the reverse of that of the Cephalopoda. For in the latter the fleshy substance is on the outside and the earthy substance within, whereas in the former the soft parts are inside and the hard part without. In the sea-urchin, however, there is no fleshy part whatsoever.

All the Testacea then, those that have not been mentioned

[1] That all Turbinata have opercula is of course an error. In many genera, especially those with large apertures, it is quite rudimentary or obsolete (Woodward, *R. and F. Shells*, p. 102). So also a considerable division of air-breathing gasteropods is inoperculate.

That the operculum corresponds to the second valve of bivalves is a view that has been held by some modern zoologists, erroneously. It represents their *byssus* (Woodward, *R. and F. Shells*, p. 47). Moreover, the bivalve shell is really a single shell, hardened by deposits of lime on the right and left, but with a central strip left uncalcified and soft, so as to allow the two sides to fold together.

[2] I can find no passage to which this can refer.

as well as those that have, agree as stated in possessing a mouth with the tongue-like body, a stomach, and a vent for excrement, but they differ from each other in the positions and proportions of these parts. The details, however, of these differences must be looked for in the Researches con- 680^{a} cerning Animals and the treatises on Anatomy.[1] For while there are some points which can be made clear by verbal description, there are others which are more suited for ocular demonstration.[2]

Peculiar among the Testacea are the sea-urchins and the animals known as Tethya (*Ascidians*). The sea-urchins have five teeth,[3] and in the centre of these the fleshy body which is common to all the animals we have been discussing. Immediately after this comes a gullet, and then the stomach, divided into a number of separate compartments, which look like so many distinct stomachs; for the cavities are separate and all contain abundant residual matter. They are all, however, connected with one and the same oesophagus, and they all end in one and the same excremental vent.[4] There is nothing besides the stomach of a fleshy character, as has already been stated.[5] All that can be seen are the so-

[1] Cf. *H. A.* iv. 4. 528^{b} 10 sq.

[2] This passage with others shows that the *Hist. Animalium* and the lost treatises on Anatomy were illustrated. Cuvier indeed (*Hist. d. Sc.* i. 141) says the latter contained *coloured* illustrations. I can find no authority for this statement. There is none in the twenty-eight passages referring to the ἀνατομαί collected by Heitz (*Verlor. Schr. des Arist.* p. 70).

[3] Forming what is still known as the 'lantern of Aristotle' from a comparison in the *Hist. An.* (iv. 5. 531^{a} 5). The central fleshy piece is there said (iv. 5. 530^{b} 25) to be 'in place of a tongue'. As the sea-urchin has no tongue, the pharyngeal portion of the oesophagus must be meant.

[4] The oesophagus of Echinus terminates in a much wider tube, which is continued to the anus without any distinct separation into stomach and intestine. This gastro-intestinal tube is attached, by what may be called a mesentery, to the inner surface of the shell, in such a manner as to form loops or festoons, five in each of its two coils; and it is to this appearance of subdivision that A. alludes. This is plain not only from the careful way in which he here guards himself from saying that there are actually a number of distinct stomachs, but still more from his language in *Hist. An.* (iv. 5. 530^{b} 27), where he says that all the *loops* (κόλποι) of the stomach run together to the anus; and where also he makes no mention of an intestine as distinct from the stomach.

[5] What he said (679^{b} 34) was that there was no fleshy part *at all.* Perhaps, therefore, for παρά should be read περί (with U).

called ova,[1] of which there are several, contained each in a separate membrane, and certain black bodies which have no name, and which, beginning at the animal's mouth, are scattered round its body here and there promiscuously.[2] These sea-urchins are not all of one species, but there are several different kinds, and in all of them the parts mentioned are to be found. It is not, however, in every kind that the so-called ova are edible. Neither do these attain to any size in any other species than that with which we are all familiar.[3] A similar distinction may be made generally in the case of all Testacea. For there is a great difference in the edible qualities of the flesh of different kinds; and in some, moreover, the residual substance known as the *mecon*[4] is good for food, while in others it is uneatable. This *mecon* in the turbinated genera is lodged in the spiral part of the shell, while in univalves, such as limpets, it occupies the fundus, and in bivalves is placed near the hinge, the so-called ovum lying on the right;[5] while on the opposite

[1] The 'so-called ova' which A. thought to be masses of fat, or of something analogous to the fat of sanguineous animals, are the ovaries, or in males the testes. These are five in number, and arranged symmetrically round the upper interior of the shell, and would be called by fishermen 'sea-urchins' eggs'.

[2] These mysterious black bodies are also mentioned in the *Hist. An.* (iv. 5. 530^{b} 31) and are said to be bitter and uneatable. They are further said, in one kind at any rate (530^{b} 14), to start from the mouth and run in distinct lines that converge towards the aboral aperture of the test, dividing this into segments. This plainly suggests the rows of ambulacral vesicles; and, though these do not appear to be black in any known species, there is generally a certain amount of pigment connected with them in *E. esculentus*, as I am informed by the Director of the Plymouth Laboratory, and this, though scanty in young Echini, becomes more extensive in some of the older specimens. See also Macbride (*Camb. Nat. Hist. Echinod.* pp. 527–8), as to 'masses of pigment' formed in these animals by certain degenerative processes. Admitting, however, these pigmentary deposits to be the 'black bodies' there still remains unexplained the further statement (*H.A.* iv. 5. 530^{b} 33) that analogous bodies, though of different colour, are present in Frogs, Toads, Tortoises, turbinated Testacea, and Cephalopods.

[3] Frantzius, as also Meyer (*Thierkunde*, p. 175), takes ἐπιπολάζοντα to mean 'floating on this surface'. But no sea-urchins do this, and Frantzius therefore supposes A. to be speaking of dead specimens! Possibly the word may mean 'living *near* the surface', that is in shallow water, in opposition to the deep-sea species (*G. A.* v. 3. 783^{a} 21 sq.). The most probable interpretation, however, is that given above, meaning the common edible kind.

[4] See 679^{b} 11 n.

[5] So also *H. A.* iv. 4. 529^{b} 12. What A. exactly meant by the right

side is the vent. The former is incorrectly termed ovum, for it merely corresponds to what in well-fed sanguineous animals is fat; and thus it is that it makes its appearance in Testacea at those seasons of the year when they are in good condition, namely, spring and autumn. For no Testacea can abide extremes of temperature, and they are therefore in evil plight in seasons of great cold or heat. This is clearly shown by what occurs in the case of the sea-urchins. For though the ova are to be found in these animals even directly they are born, yet they acquire a greater size than usual at the time of full moon; not, as some think, because sea-urchins eat more at that season, but because the nights are then warmer, owing to the moonlight.[1] For these creatures are bloodless, and so are unable to stand cold and require warmth. Therefore it is that they are found in better condition in summer than at any other season; and this all over the world excepting in the Pyrrhean tidal 680b
strait. There the sea-urchins flourish as well in winter as in summer. But the reason for this is that they have a greater abundance of food in the winter, because the fish desert the strait at that season.

The number of the ova is the same in all sea-urchins, and is an odd one. For there are five ova, just as there are also five teeth and five stomachs; and the explanation of this is to be found in the fact that the so-called ova are not really ova, but merely, as was said before, the result of the animal's well-fed condition. Oysters also have a so-called ovum, corresponding in character to that of the sea-urchins, but existing only on one side of their body. Now inasmuch as

and left side of a bivalve it is impossible to say. For he had not made out the position of the mouth, and therefore had no guide as to what was the front aspect. As is not surprising, he entirely failed to make out the internal structure of these animals.

[1] Cicero (*De Divin.* ii. 14) mentions, among other instances of some natural connexion existing between things apparently remote and incongruous, 'that oysters and other shell-fish increase and decrease with the growth and waning of the moon.' So also Lucilius says, 'Luna alit ostrea et implet echinos'; and again Manilius, 'Si submersa fretis, concharum et carcere clausa, Ad lunae motum variant animalia corpus.' The two last quotations I borrow from Mead (*Influence of Sun and Moon*, &c., 1748, p. 65), who accepts the statement as true; as also at the present day, as I am informed, do fishermen on the Riviera.

the sea-urchin is of a spherical form, and not merely a single disk like the oyster, and in virtue of its spherical shape is the same from whatever side it be examined, its ovum must necessarily be of a corresponding symmetry. For the spherical shape has not the asymmetry of the disk-shaped body of the oysters. For in all these animals the head is central, but in the sea-urchin the so-called ovum is above [and symmetrical, while in the oyster it is only on one side].[1] Now the necessary symmetry would be observed were the ovum to form a continuous ring. But this may not be. For it would be in opposition to what prevails in the whole tribe of Testacea; for in all the ovum is discontinuous, and in all excepting the sea-urchins asymmetrical, being placed only on one side of the body. Owing then to this necessary discontinuity of the ovum, which belongs to the sea-urchin as a member of the class, and owing to the spherical shape of its body, which is its individual peculiarity, this animal cannot possibly have an even number of ova. For were they an even number, they would have to be arranged exactly opposite to each other, in pairs, so as to keep the necessary symmetry; one ovum of each pair being placed at one end, the other ovum at the other end of a transverse diameter. This again would violate the universal provision in Testacea. For both in the oysters and in the scallops we find the ovum only on one side of the circumference. The number then of the ova must be uneven, three for instance, or five. But if there were only three they would be much too far apart;[2] while, if there were more than five, they would come to form a continuous mass. The former arrangement would be disadvantageous to the animal, the latter an impossibility. There can therefore be neither more nor less than five. For the same reason the stomach is divided into five parts, and there is a corresponding number of teeth. For seeing that the ova represent each of them a kind of body for the animal, their disposition

[1] An attempt is made in the translation to give some kind of meaning to this unintelligible passage by supposing that *τοῖς δ' ἄλλοις ἐπὶ θάτερα μόνον* should be read here, having been omitted by the copyist because of the occurrence of similar words at the end of the next sentence.

[2] Read *λίαν ἂν ἦν*.

must conform to that of the stomach,[1] seeing that it is from this that they derive the material for their growth. Now if there were only one stomach, either the ova would be too far off from it, or it would be so big as to fill up the whole cavity, and the sea-urchin would have great difficulty in moving about and finding due nourishment for its repletion. As then there are five intervals between the five ova, so are there of necessity five divisions of the stomach, one for each interval. So also, and on like grounds, there are five teeth. For nature is thus enabled to allot to each stomachal com- 681a
partment and ovum its separate and similar tooth. These, then, are the reasons why the number of ova in the sea-urchin is an odd one, and why that odd number is five. In some sea-urchins the ova are excessively small, in others of considerable size, the explanation being that the latter are of a warmer constitution, and so are able to concoct their food more thoroughly; while in the former concoction is less perfect, so that the stomach is found full of residual matter,[2] while the ova are small and uneatable. Those of a warmer constitution are, moreover, in virtue of their warmth more given to motion, so that they make expeditions in search of food, instead of remaining stationary like the rest. As evidence of this, it will be found that they always have something or other sticking to their spines, as though they moved much about; for they use their spines as feet.[3]

The Ascidians differ but slightly from plants, and yet have more of an animal nature than the sponges, which are virtually plants and nothing more. For nature passes from lifeless objects to animals in such unbroken sequence, interposing between them beings which live and yet are not animals, that scarcely any difference seems to exist between two neighbouring groups owing to their close proximity.[4]

[1] For *ζωῆς* read *κοιλίας*.

[2] Literally 'for which reason the uneatable varieties are more full of residual matter', but expanded above for clearness. *Περίττωμα* is here used not for excremental matter but for unconcocted food.

[3] The spines are really instruments of locomotion, and, Agassiz said, were the only ones; but their main function is probably protective, the chief organs of locomotion being the tube-feet, which A. had not noticed in either Echini or Star-fishes.

[4] *H.A.* viii. 588b 4 sq.

A sponge, then, as already said, in these respects completely resembles a plant, that throughout its life it is attached to a rock, and that when separated from this it dies. Slightly different from the sponges are the so-called Holothurias and the sea-lungs, as also sundry other sea-animals that resemble them. For these are free and unattached. Yet they have no feeling, and their life is simply that of a plant separated from the ground. For even among land-plants there are some that are independent of the soil, and that spring up and grow, either upon other plants, or even entirely free. Such, for example, is the plant which is found on Parnassus, and which some call the Epipetrum.[1] This you may hang up on a peg[2] and it will yet live for a considerable time. Sometimes it is a matter of doubt whether a given organism should be classed with plants or with animals. The Ascidians, for instance, and the like so far resemble plants as that they never live free and unattached,[3] but, on the other hand, inasmuch as they have a certain flesh-like substance, they must be supposed to possess some degree of sensibility.

An Ascidian has a body divided by a single septum and with two orifices, one where it takes in the fluid matter that ministers to its nutrition, the other where it discharges the surplus of unused juice, for it has no visible residual substance, such as have the other Testacea. This is itself a very strong justification for considering an Ascidian, and anything else there may be among animals that resembles it, to be of a vegetable character; for plants also never have any residuum.[4] Across the middle of the body of these Ascidians there runs a thin transverse partition, and here it is that we may reasonably suppose the part on which life depends to be situated.

[1] Probably a Sedum. There is an English species, *S. telephium*, which has gained the popular name 'Livelong' from its persistent vitality after being pulled up from the ground.

[2] Literally 'the pegs'; apparently referring to some constant household fixture. Or perhaps 'the rafters'.

[3] Aristotle's Tethya, or Ascidians, are not Tunicata generally, but only the simple solitary Ascidians, which are always sessile.

[4] Cf. ii. 3. 650a 23 note.

The Acalephae,[1] or Sea-nettles, as they are variously called, are not Testacea at all, but lie outside the recognized 681b groups. Their constitution, like that of the Ascidians, approximates them on one side to plants, on the other to animals. For seeing that some of them can detach themselves and can fasten upon their food, and that they are sensible of objects which come in contact with them, they must be considered to have an animal nature. The like conclusion follows from their using the asperity of their bodies[2] as a protection against their enemies. But, on the other hand, they are closely allied to plants, firstly by the imperfection of their structure, secondly by their being able to attach themselves to the rocks, which they do with great rapidity, and lastly by their having no visible residuum notwithstanding that they possess a mouth.

Very similar again to the Acalephae are the Starfishes. For these also fasten on their prey, and suck out its juices, and thus destroy a vast number of oysters. At the same time they present a certain resemblance to such of the animals we have described as the Cephalopoda and Crustacea, inasmuch as they are free and unattached. The same may also be said of the Testacea.

Such, then, is the structure of the parts that minister to nutrition and which every animal must necessarily possess. But besides these organs it is quite plain that in every animal there must be some part or other which shall be analogous to what in sanguineous animals is the presiding seat of sensation. Whether an animal has or has not blood, it cannot possibly be without this. In the Cephalopoda this part consists of a fluid substance contained in a membrane,

[1] *H. A.* iv. 6. 531a 32 sq. The anemones of our coasts, though richly furnished with nematocysts, very exceptionally cause irritation, when handled, to the fingers. Presumably such irritation must be more common with the Greek anemones, as otherwise they would scarcely have got the general name of Sea-nettles. In all the instances of such stinging by British anemones cited by Gosse (*Br. Sea An.*, pp. 166, xxxviii) the culprit was *Anthea cereus*. This is common in the Mediterranean, and 'would probably be one of the first species of the whole race to become popularly known' (*op. cit.*, p. 162). It was known to Rondelet as *Urtica cinerea*.

[2] More definitely called stinging (*H. A.* ix. 37. 621a 11) and ascribed to the general surface of the body.

through which runs the gullet on its way to the stomach. It is attached to the body rather towards its dorsal surface, and by some is called the *mytis*.[1] Just such another organ is found also in the Crustacea and there too is known by the same name. This part is at once fluid and corporeal and, as before said, is traversed by the gullet. For had the gullet been placed between the *mytis* and the dorsal surface of the animal, the hardness of the back would have interfered with its due dilatation in the act of deglutition. On the outer surface of the *mytis* runs the intestine; and in contact with this latter is placed the ink-bag, so that it may be removed as far as possible from the mouth and its obnoxious fluid be kept at a distance from the nobler and sovereign part. The position of the *mytis* shows that it corresponds to the heart of sanguineous animals; for it occupies the self-same place. The same is shown by the sweetness of its fluid, which has the character of concocted matter and resembles blood.

In the Testacea the presiding seat of sensation is in a corresponding position, but is less easily made out.[2] It should, however, always be looked for in some midway position; namely, in such Testacea as are stationary, midway between the part by which food is taken in and the channel through which either the excrement or the spermatic fluid[3] is voided, and, in those species which are capable
682a of locomotion, invariably midway[4] between the right and left sides.

In Insects this organ, which is the seat of sensation, lies, as was stated in the first treatise,[5] between the head and the cavity which contains the stomach. In most of them it consists of a single part; but in others, for instance in such as have long bodies and resemble the Juli (*Millipedes*), it is

[1] The *mytis*, which in cephalopods is traversed by the oesophagus, is the liver, not the heart (cf. 679a 9 n.). The real heart of cephalopods, as of all other invertebrates, escaped Aristotle.

[2] A. does not profess to have seen the heart of a mollusc, but only to say where it is likely to be found on *a priori* grounds.

[3] 'or the spermatic fluid' is probably an interpolation. For A. (*G. A.* iii. 11. 761b 25) denied the existence of any distinct generative secretion in bivalves.

[4] Read ἐν τῷ μέσῳ (P).

[5] *H. A.* iv. 7. 531b 34.

made up of several parts, so that such insects continue to live after they have been cut in pieces. For the aim of nature is to give to each animal only one such dominant part; and when she is unable to carry out this intention she causes the parts, though potentially many, to work together actually as one. This is much more clearly marked in some insects than in others.

The parts concerned in nutrition are not alike in all insects, but show considerable diversity. Thus some have what is called a sting in the mouth, which is a kind of compound instrument that combines in itself the character of a tongue and of lips. In others that have no such instrument in front there is a part inside the mouth that answers the same sensory purposes. Immediately after the mouth comes the intestine, which is never wanting in any insect. This runs in a straight line[1] and without further complication to the vent; occasionally, however, it has a spiral coil. There are, moreover, some insects in which a stomach succeeds to the mouth, and is itself succeeded by a convoluted intestine, so that the larger and more voracious insects may be enabled to take in a more abundant supply of food. More curious than any are the Cicadae. For here the mouth and the tongue are united so as to form a single part, through which, as through a root, the insect sucks up the fluids on which it lives.[2] Insects are always small eaters, not so much because of their diminutive size as because of their cold temperament. For it is heat which requires sustenance; just as it is heat which speedily concocts it. But cold requires no sustenance. In no insects is this so conspicuous as in these Cicadae. For they find enough to live on in the moisture which is depo-

[1] In most Myriapoda, included by A. among insects, the alimentary canal is a simple tube running in a straight line from mouth to anus. But in some, e. g. Glomeris, the tube, though still simple, is convoluted. In true insects the canal varies much in complexity; but in many is a long convoluted organ divided into a varying number of distinct compartments.

[2] Alluding to the so-called 'rostrum' of Hemipterous insects. This is a suctorial tube formed by the upper and lower lips, within which are the mandibles and maxillae converted into lancet-shaped needles.

sited from the air. So also do the Ephemera[1] that are found about the Black sea. But while these latter only live for a single day, the Cicadae subsist on such food for several days, though still not many.

We have now done with the internal parts of animals, and must therefore return to the consideration of the external parts which have not yet been described. It will be better to change our order of exposition and begin with the animals we have just been describing, so that proceeding from these, which require less discussion, our account may have more time to spend on the perfect kinds of animals, those namely that have blood.

We will begin with Insects. These animals, though they 6
present no great multiplicity of parts, are not without diversities when compared with each other. They are all many-footed; the object of this being to compensate their
682b natural slowness and frigidity, and give greater activity to their motions. Accordingly we find that those which, as the Juli (*Millipedes*), have long bodies, and are therefore the most liable to refrigeration, have also the greatest number of feet. Again, the body in these animals is insected[2]—the reason for this being that they have not got one vital centre but many—and the number of their feet corresponds to that of the insections[3].

Should the feet fall short of this, their deficiency is compensated by the power of flight. Of such flying insects some live a wandering life, and are forced to make long expeditions in search of food. These have a body of light weight, and four feathers, two on either side, to support it. Such are bees and the insects akin to them. When, however, such insects are of very small bulk, their feathers are

[1] The Ephemera of A. are presumably the insects still so named. They are said, however (*H. A.* i. 5. 490^a 34), to have only four legs, which is neither true of Ephemera nor of any other insects.

[2] That is, are divided into segments. The ἐντομαί or insections are the more or less complete belts of softer and more pliable integument that form joints between the successive segments, being visible on the upper or under surface of the body or on both; and it is to these ἐντομαί or insections that ἔντομα or insects owe their name (*H. A.* i. 1. 487^a 33; iv. 1. 523^b 13).

[3] Read κατὰ ταύτας.

reduced to two, as is the case with flies. Insects with heavy[1] bodies and of stationary habits, though not polypterous in the same way as bees, yet have sheaths to their feathers to maintain their efficiency.[2] Such are the Melolonthae[3] and the like. For their stationary habits expose their feathers to much greater risks than are run by those of insects that are more constantly in flight, and on this account they are provided with this protecting shield. The feather of an insect has neither barbs nor shaft.[4] For, though it is called a feather, it is no feather at all, but merely a skin-like membrane that, owing to its dryness, necessarily[5] becomes detached from the surface of the body, as the fleshy substance grows cold.

These animals then have their bodies insected, not only for the reasons already assigned,[6] but also to enable them to curl round in such a manner as may protect them from injury[7]; for such insects as have long bodies[8] can roll themselves up, which would be impossible were it not for the

[1] For βραχέα read βαρέα, and in the next line for ἔχει δέ read ἔχει γάρ.

[2] If the Greek text as it stands is correct, we must suppose that A. thought that beetles have elytra—that is shards, *in addition to* their multiple πτερά. But it is scarcely credible that A. should have thought this to be the case. I have therefore adopted a suggestion made by Prof. Platt, and read οὐκ after μελίτταις. This alteration not only makes the passage intelligible, but, moreover, gives its proper significance to ὁμοίως.

[3] Probably Cockchafers. But, if so, the statement as to their development (*H. A.* v. 19. 552a 16) is quite erroneous.

[4] Frantzius, as also Aubert and Wimmer, renders πτερόν when applied to insects as 'wing'. But this part of an insect is never termed πτέρυξ by A., but always πτερόν or πτίλον; and, moreover, is said to contrast with other πτερά in being ἄσχιστον and ἄκαυλον, which can only mean 'without barbs or shaft'. It must, however, be admitted that A. calls bats δερμόπτερα, in which title πτερόν can only mean 'wing'.

[5] Cf. iv. 5. 677b 23; 678a 3 note; *G. A.* ii. 4. 739b 27.

[6] Or rather 'reason', for only one αἰτία was assigned.

[7] Liddell and Scott (7th ed.) interpret δι' ἀπάθειαν as 'without suffering pain', which makes admirable sense but seems scarcely tenable. If the reading be correct, the words must apparently be taken as equivalent to πρὸς τὸ ἀπαθῆ εἶναι (iii. 11. 673b 5), διά being used in the sense, exceptional in A., of 'for the sake of' as in διὰ τὴν ἰσχύν (iv. 10. 687b 17). Conjecturally, however, the reading may be δι' ἀκινησίαν, 'curl round and derive security from remaining motionless'.

[8] The Juli when alarmed coil themselves up in a spiral form, with the feet entirely concealed. The Glomeridæ roll themselves into a perfect ball. Not only long-bodied insects, but some others, roll themselves up. For instance, the ant known as *Myrm. Latreillii* is said by Sir J. Lubbock to do so.

insections; and those that cannot do this can yet draw their segments up into the insected spaces, and so increase the hardness of their bodies. This can be felt quite plainly by putting the finger on one of the insects, for instance, known as Canthari.[1] The touch frightens the insect, and it remains motionless, while its body becomes hard. The division of the body into segments is also a necessary result of there being several supreme organs in place of one; and this again is a part of the essential constitution of insects, and is a character which approximates them to plants. For as plants, though cut into pieces, can still live, so also can insects. There is, however, this difference between the two cases, that the portions of the divided insect live only for a limited time, whereas the portions of the plant live on and attain the perfect form of the whole, so that from one single plant you may obtain two or more.

Some insects are also provided with another means of protection against their enemies, namely a sting. In some this is in front, connected with the tongue, in others behind at the posterior end. For just as the organ of smell in elephants answers several uses, serving alike as a weapon
683a and for purposes of nutrition, so does also the sting, when placed in connexion with the tongue, as in some insects, answer more than one end. For it is the instrument through which they derive their sensations of food, as well as that with which they suck it up and bring it to the mouth. Such of these insects as have no anterior sting are provided with teeth, which serve in some of them for biting the food, and in others for its prehension and conveyance to the mouth. Such are their uses, for instance, in ants and all the

[1] The description of the Canthari in the *Hist. An.* (v. 19. 552^{a} 17), where they are said to roll dung into balls, in which they deposit their progeny, seems to identify them with the Scarabaei of Egypt (*Ateuchus sacer*). Many beetles when touched assume attitudes more or less such as here described. 'The common dung-chaffer, when touched or in fear, sets out its legs as stiff as if they were made of iron wire; which is their posture when dead; and, remaining perfectly motionless, thus deceives,' &c., &c. The pill-beetles 'pack their legs so close to the body, and lie so entirely without motion when alarmed, that they look like a dead body'. Still nearer to A.'s description is the action of certain caterpillars. 'The body is kept stiff and immovable with the separation of the segments scarcely visible' (Kirby and Spence).

various kinds of bees.[1] As for the insects that have a sting behind, this weapon is given them because they are of a fierce disposition. In some of them the sting is lodged inside the body, in bees, for example, and wasps. For these insects are made for flight, and were their sting external and of delicate make it would soon get spoiled;[2] and if, on the other hand, it were of thicker build,[3] as in scorpions, its weight would be an incumbrance. As for scorpions that live on the ground and have a tail, their sting must be set upon this, as otherwise it would be of no use as a weapon. Dipterous insects never have a posterior sting. For the very reason of their being dipterous is that they are small and weak, and therefore require no more than two feathers to support their light weight; and the same reason which reduces their feathers to two causes their sting to be in front; for their strength is not sufficient to allow them to strike efficiently with the hinder[4] part of their body. Polypterous insects, on the other hand, are of greater bulk—indeed it is this which causes them to have so many feathers; and their greater size makes them stronger in their hinder parts. The sting of such insects is therefore placed behind. Now it is better, when possible, that one and the same instrument shall not be made to serve several dissimilar uses; but that there shall be one organ to serve as a weapon, which can then be very sharp, and a distinct one to serve as a tongue, which can then be of spongy texture and fit to absorb nutriment. Whenever, therefore, nature is able to provide two separate instruments for two separate uses, without the one hampering the other, she does so,[5] instead

[1] Ants, bees, and Hymenoptera of all kinds have biting jaws or mandibles. It is these that A. calls their 'modified' teeth (iv. 5. 678b 18 note). These mandibles, however, are not used merely or principally for the prehension of food, as stated in the text, but 'comme instruments de sculpture dans les travaux architecturaux de ces animaux' (M. Edwards, *Leçons*, v. 520).

[2] Read εὔφθαρτα ἂν ἦν.

[3] For ἀπεῖχεν read παχέα ἦν (Platt); and two lines down for κέντρον read κέρκον, and for ἐπὶ ταῦτα read ἐπὶ ταύτῃ.

[4] For τοῖς ἔμπροσθεν read τοῖς ὄπισθεν.

[5] Here we have a distinct statement of the advantage of division of labour in the animal body; a truth which Milne Edwards thought he was the first to enunciate. 'Dans les créations de la Nature, de même que dans l'industrie des hommes, c'est surtout par la division du

of acting like a coppersmith who for cheapness makes a spit and lampholder in one.[1] It is only when this is impossible that she uses one organ for several functions.

The anterior legs are in some cases longer[2] than the others, that they may serve to wipe away any foreign matter that may lodge on the insect's eyes and obstruct its sight, which already is not very distinct owing to the eyes being made of a hard substance. Flies and bees and the like may be constantly seen thus dressing themselves with crossed forelegs. Of the other legs, the hinder are bigger than the middle pair, both to aid in running and also that the insect, when it takes flight, may spring more easily from the ground. This difference is still more marked in such insects as leap, in locusts for instance, and in the various kinds of fleas.[3]

travail, que ce perfectionnement s'obtient,' and in a note he adds, 'Ce principe de physiologie générale qui aujourd'hui est adopté par presque tous les zoologistes a été formulé pour la première fois dans un article que j'ai publié en 1827' (M. Edwards, *Leçons*, i. 16).

[1] This strange implement with a double purpose is also mentioned in the *Politics* (iv. 15. 1299^b 10); where A. likens it to a board of magistrates charged with a multitude of distinct functions. Among the Graeco-Roman antiquities in the British Museum is a lampholder, to which my attention was directed by Mr. Arthur Smith, and which I think may very probably be an actual ὀβελισκολύχνιον. This holder is a bronze rod, some sixteen inches long, formed at one end into a horse-shoe, within which a small detachable oil-lamp swings freely, so as to have its face uppermost in all positions of the holder. A little way from the other end is a hook, obviously for suspension; while the end itself—and this is the distinctive character—is a spike, intended, as I conjecture, to allow the holder to be stuck in the ground when the lamp was used out of doors or in a tent, as by soldiers, for whose use it was meant (Theopomp. Εἰρήνη, quoted by Pollux, x. 118). When the soldier wanted the holder for cooking purposes, he would detach it from the lamp and fix the meat on the spike as on a toasting-fork, possibly, if the piece was large, further securing it by aid of the hook. In the passage of Theopompus cited above the ὀβελισκολύχνιον is coupled with ξιφομάχαιρα, sword and knife in one. So sergeants in our own army used to carry sword-bayonets, which served both purposes indicated by the name.

[2] The anterior pair of legs are remarkably long in some insects; (Kirby, *Bridg. Tr.* ii. 180); with what use it is difficult to say. Sometimes, at any rate, it seems to be a provision to enable the male to secure the female, the peculiarity being confined to, or most marked in, the former sex. The explanation given by A. can hardly be the correct one; for the anterior pair are not specially elongated in ants or bees, though these are insects that use their legs to dress themselves.

[3] In such insects as are slow walkers all the legs are, as a rule, of much the same length; in those that run quickly all the legs are elongated, the hinder pair being the largest; in swimming insects, and still more in leapers, the hind legs are much longer than the rest. In

For these first bend and then extend the legs, and, by doing so, are necessarily shot up from the ground. It is only the hind legs of locusts, and not the front ones, that resemble the steering oars[1] of a ship. For this requires that the joint 683b
shall be deflected inwards, and such is never the case with the anterior limbs. The whole number of legs, including those used in leaping, is six in all these insects.

7 In the Testacea the body consists of but few parts, the reason being that these animals live a stationary life. For such animals as move much about must of necessity have more numerous parts than such as remain quiet; for their activities are many,[2] and the more diversified the movements the greater the number of organs required to effect them. Some species of Testacea are absolutely motionless, and others not quite but nearly so. Nature, however, has provided them with a protection in the hardness of the shell with which she has invested their body. This shell, as already has been said,[3] may have one valve, or two valves, or be turbinate. In the latter case it may be either spiral, as in whelks, or merely globular,[4] as in sea-urchins. When it has two valves, these may be gaping, as in scallops and mussels, where the valves are united together on one side only, so as to open and shut on the other; or they may be united together on both sides, as in the Solens[5] (*razor-fishes*). In all cases alike the Testacea have, like plants, the head downwards.[6] The reason for this is, that they take in their

fleas the difference is not so marked as in grasshoppers; nor do fleas jump, like the latter, exclusively from the hind legs; for, having placed one in a glass tube under a microscope, I have seen it hop with the anterior legs.

[1] The resemblance of these legs to the long lateral rudder-oars of ancient ships includes not only position but function. 'Whoever,' says Kirby, 'has seen any grasshopper take flight or leap from the ground will find that they stretch out their legs, and like certain birds use them as a rudder' (*Bridg. Treat.* ii. 162).

[2] For διὰ τὸ εἶναι read διὰ τὸ πολλὰς εἶναι (Platt).

[3] Cf. iv. 5. 679^b 16.

[4] A. reckons Echinus, though globular, with Turbinata (στρομβώδη).

[5] Probably *Solen marginatus*, see Forbes and Hanley (*Brit. Mollusca*, i. 240).

[6] The ordinary position of most living bivalves is not on their side but vertical, with the opening between the valves downwards. This probably led A. to the conclusion that the head, or what answered to it, was downwards, so as to take in food from below.

nourishment from below, just as do plants with their roots. Thus the under parts come in them to be above, and the upper parts to be below. The body is enclosed in a membrane, and through this the animal filters fluid free from salt and absorbs its nutriment. In all there is a head; but none of the parts, excepting this recipient of food, has any distinctive name.

All the Crustacea[1] can crawl as well as swim, and accord- 8
ingly they are provided with numerous feet. There are four main genera, viz. the Carabi, as they are called, the Astaci, the Carides, and the Carcini. In each of these genera, again, there are numerous species, which differ from each other not only as regards shape, but also very considerably as regards size. For, while in some species the individuals are large, in others they are excessively minute. The Carcinoid and Caraboid Crustacea resemble each other in possessing claws. These claws are not for locomotion, but to serve in place of hands for seizing and holding objects; and they are therefore bent in the opposite direction to the feet, being so twisted as to turn their convexity towards the body, while their feet turn towards it their concavity. For in this position the claws are best suited for laying hold of
684a the food and carrying it to the mouth. The distinction between the Carabi and the Carcini (*Crabs*) consists in the former having a tail while the latter have none. For the Carabi swim about and a tail is therefore of use to them, serving for their propulsion like the blade of an oar. But it would be of no use to the Crabs; for these animals live habitually close to the shore, and creep into holes and corners. In such of them as live out at sea, the feet are much less adapted for locomotion than in the rest, because they are little given to moving about but depend for protection on their shell-like covering. The Maiae[2] and the

[1] For a more detailed account of Crustacea see *H. A.* iv. 2. A. divides those known to him into four groups (1) Carcini—our Brachyura or Crabs. (2) Carabi—our Palinuridae or Spiny Lobsters. (3) Astaci—comprising the Smooth Lobsters and the River Crawfish. (4) Carides—among which are included Prawns, Shrimps, Squills, and other small species.

[2] The very large (*H. A.* iv. 2. 525^b 4), hard-shelled (*H. A.* viii. 17.

crabs known as Heracleotic are examples of this; the legs in the former being very thin, in the latter very short.

The very minute crabs that are found among the small fry at the bottom of the net have their hindermost feet flattened out into the semblance of fins or oar-blades, so as to help the animal in swimming.[1]

The Carides are distinguished from the Carcinoid species by the presence of a tail; and from the Caraboids by the absence of claws. This is explained by their large number of feet, on which has been expended the material for the growth of claws. Their feet again are numerous to suit their mode of progression, which is mainly by swimming.

Of the parts on the ventral surface, those near the head are in some of these animals formed like gills, for the admission and discharge of water; while the parts lower down differ in the two sexes. For in the female Carabi these are more laminar than in the males,[2] and in the female crabs the flap is furnished with hairier appendages. This gives ampler space for the disposal of the ova, which the females retain in these parts instead of letting them go free, as do fishes and all [3] other oviparous [4] animals. In the Carabi and in the Crabs the right claw is invariably the larger and the stronger.[5] For it is natural to every animal in active

601a 18), thin-legged Maia, with eyes placed close together near the central line (*H. A.* iv. 3. 527b 13), is doubtless the Spiny Spider-crab (*M. squinado*). There are no sufficient data for determining what are meant by the 'Heracleotic crabs'.

[1] In most crabs the four hinder pairs of feet are formed exclusively for running; but in some few they are flattened out so as to serve in swimming. These swimming crabs are all small. Rondelet mentions several species as found in the Mediterranean.

[2] 'In the Podophthalma, the lamelliform ciliated appendages of the abdominal segments include similar marsupial or incubatory recesses for the ova. The female lobster and other Macrura are distinguished from the male by the greater development of these appendages' (Owen, *Lect.* i. 185). Similarly Cuvier (*Règ. An.* iv. 28), speaking of the flap or tail of the Brachyura, says, 'Triangulaire dans les mâles et garnie seulement à sa base de quatre ou deux appendices, elle s'arrondit, s'élargit et devient bombée dans les femelles. Son dessous offre quatre paires de doubles filets velus, destinés à porter les œufs. Plusieurs de ces filets existent dans les mâles, mais dans un état rudimentaire.'

[3] There are exceptions. Thus some spiders, toads, and even at least one fish carry their ova about with them after extrusion.

[4] For τίκτοντα read ᾠοτοκοῦντα.

[5] This is too absolute a statement; and elsewhere (*H. A.* iv. 3.

operations to use the parts on its right side in preference to those on its left; and nature, in distributing the organs, invariably assigns each, either exclusively or in a more perfect condition, to such animals as can use it. So it is with tusks, and teeth, and horns, and spurs, and all such defensive and offensive weapons.

In the Lobsters alone it is a matter of chance which claw is the larger, and this in either sex.[1] Claws they must have, because they belong to a genus in which this is a constant character; but they have them in this indeterminate way, owing to imperfect formation and to their not using them
684b for their natural purpose, but for locomotion.

For a detailed account of the several parts of these animals, of their position and their differences, those parts being also included which distinguish the sexes, reference must be made to the treatises on Anatomy and to the Researches concerning Animals.[2]

We come now to the Cephalopoda.[3] Their internal 9
organs have already been described[4] with those of other animals. Externally there is the trunk of the body, not distinctly defined, and in front of this the head surrounded by feet, which form a circle about the mouth and teeth, and are set between these and the eyes. Now in all other animals the feet, if there are any, are disposed in one of two ways; either before and behind or along the sides, the latter being the plan in such of them, for instance, as are bloodless and have numerous feet. But in the Cephalopoda there is a peculiar arrangement, different from either of these.

527b 6) A. speaking more carefully says that the rule is general but not universal. There are some grounds for his statement. 'In many species (of the higher Crustacea) the chelae on the opposite sides of the body are of unequal size, the right-handed one being, as I am informed by Mr. C. Spence Bate, generally though not invariably the largest. This inequality is often much greater in the male than in the female' (Darwin, *Desc. of Man*, i. 330). There are, however, some small Crustacea in which the right claw appears to be invariably the bigger. Such, for instance, is the case in some, but not all, species of Hermit-crabs.

[1] This is apparently correct, but not so the further statement that lobsters use their claws only for locomotion and not for prehension.

[2] *H. A.* iv. 2, 3; v. 7. 541b 29.

[3] For a fuller account of Cephalopoda see *H. A.* iv. 1. 523b 21 sq.

[4] Cf. iv. 5. 678b 24 – 679a 31.

For their feet are all placed at what may be called the fore end. The reason for this is that the hind part of their body has been drawn up close to the fore part,[1] as is also the case in the turbinated Testacea. For the Testacea, while in some points they resemble the Crustacea, in others resemble the Cephalopoda. Their earthy matter is on the outside, and their fleshy substance within. So far they are like the Crustacea. But the general plan of their body is that of the Cephalopoda; and, though this is true in a certain degree of all the Testacea, it is more especially true of those turbinated species that have a spiral shell.[2] Of this general plan, common to the two,[3] we will speak presently. But let us first consider the case of quadrupeds and of man, where the arrangement is that of a straight line. Let *A* at the upper end [4] of such a line be supposed to represent the mouth, then *B* the gullet, and *C* the stomach, and the intestine to run from this *C* to the excremental vent where *D* is inscribed. Such is the plan in sanguineous animals; and round this straight line as an axis are disposed the head and so-called trunk; the remaining parts, such as the anterior and posterior limbs, having been superadded by nature, merely to minister to these and for locomotion.

In the Crustacea also and in Insects there is a tendency to a similar arrangement of the internal parts in a straight line; the distinction between these groups and the sanguineous animals depending on differences of the external organs

[1] A similar idea concerning the cuttlefish, viz. that it is comparable to a vertebrate animal bent double, with the approximated arms and legs extending forwards, was advanced in a paper read before the Academy of Sciences in 1830. This paper was referred to Geoffroy St.-Hilaire and Latreille; was reported on most favourably, and its position in fact almost entirely adopted by them. This was the starting-point in the famous controversy between G. St.-Hilaire and Cuvier as to unity of type; the controversy which excited Goethe more than the revolution of 1830 (see Lewes, *Goethe*, ii. 436).

[2] Excluding, that is, the Echini, which A. reckons among Turbinata, notwithstanding their more or less globular shell.

[3] What A. means in this passage is perfectly clear, but the transcribers have evidently misunderstood him and the text consequently requires very free handling.

[4] The manifestly corrupt text may be conjecturally amended as follows: *πρῶτον μὲν ἐπὶ ἄκρῳ τῷ ἄνω τῆς εὐθείας κατὰ τὸ* Α *τὸ στόμα, ἔπειτα κατὰ τὸ* Β *τὸν στόμαχον, τὸ δὲ* Γ *τὴν κοιλίαν, ἀπὸ δὲ τούτου τὸ ἔντερον* (Platt).

which minister to locomotion. But the Cephalopoda and the turbinated Testacea have in common an arrangement
685a which stands in contrast with this. For here the two extremities are brought together by a curve, as if one were to bend the straight line marked *E* until *D* came close to *A*. Such, then, is the disposition of the internal parts; and round these, in the Cephalopoda, is placed the sac (in the Poulps alone called a head),[1] and, in the Testacea, the turbinate shell which corresponds to the sac. There is, in fact, only this difference between them, that the investing substance of the Cephalopoda is soft while the shell of the Testacea is hard, nature having surrounded their fleshy part with this hard coating as a protection because of their limited power of locomotion. In both classes, owing to this arrangement of the internal organs, the excrement is voided near the mouth; at a point below this orifice in the Cephalopoda, and in the Turbinata on one side of it.[2]

Such, then, is the explanation of the position of the feet in the Cephalopoda, and of the contrast they present to other animals in this matter. The arrangement, however, in the Sepias and the Calamaries is not precisely the same as in the Poulps, owing to the former having no other mode of progression than by swimming, while the latter not only swim but crawl. For in the former six[3] of the feet are above the teeth and small, the outer one on either side being the biggest; while the remaining two, which make up the total eight, are below the mouth and are the biggest of all, just as the hind limbs in quadrupeds are stronger than the fore limbs. For it is these that have to support the weight,[4]

[1] The head and body in the Poulps are connected by a broad cervical band. This, and the comparatively small size of the body, doubtless caused the entire mass to be looked on as a head by the vulgar.

[2] In Gasteropoda the mouth and anus are near each other, but never in the same median plane.

[3] After ὀδόντων read ἓξ μικρούς (Gaza) and for μεγίστους τούτων read μεγίστους πάντων.

[4] A. is not quite correct in his view of the part taken by the posterior limbs, at least in Mammalia. For though these take the chief part in the propulsion of the body, it is on the fore limbs that devolves the greater share in its support; and it is, says Owen, this difference in function that explains the different conformation of *manus* and *pes*. Cf. Owen, *Nature of Limbs*, p. 26, and *Archet. of the Skeleton*, p. 167.

and to take the main part in locomotion. And the outer two of the upper six are bigger than the pair which intervene between them and the uppermost of all, because they have to assist the lowermost pair in their office. In the Poulps, on the other hand, the four central feet are the biggest.[1] Again, though the number of feet is the same in all the Cephalopoda, namely eight,[2] their length varies in different kinds, being short in the Sepias and the Calamaries, but greater in the Poulps. For in these latter the trunk of the body is of small bulk, while in the former it is of considerable size ; and so in the one case nature has used the materials subtracted from the body to give length to the feet, while in the other she has acted in precisely the opposite way, and has given to the growth of the body what she has first taken from the feet.[3] The Poulps, then, owing to the length of their feet, can not only swim but crawl, whereas in the other genera the feet are useless for the latter mode of progression, being small while the bulk of the body is considerable. These short feet would not enable their possessors to cling to the rocks and keep themselves from being torn off by the waves when these run high in times of storm ; neither would they serve to lay hold of objects at all remote and bring them in ; but, to supply these defects, the animal is furnished with two long proboscises, by which it can moor itself and ride at anchor like a ship in rough weather. These same processes serve also to catch prey at 685b

[1] There does not seem any very certain rule as to the comparative lengths of the different arms in Sepia and Loligo. The general rule, however, is that there is a gradual increase in length from the dorsal to the ventral pair ; and the statement in the text that the ventral pair are the biggest, and the third pair the next in size, accords with this. Neither does there seem to be any certain rule in this matter in Poulps. Cuvier (*Règ. An.* iii. 11) says that their arms are all much of the same length. Owen (*Lect. on Comp. Anat.* i. 344) says that in most of them the dorsal pair are the longest, which accords with *H. A.* iv. 1. 524^{a} 4.

[2] A. does not reckon the two long retractile tentacles or 'proboscises' of sepias and calamaries as feet ; so that he is correct in saying that all Cephalopoda are octopodous.

[3] Cf. ii. 9. 655^{a} 28 n. 'The development of the eight external arms bears an inverse proportion to that of the body ; they are therefore longer in the short round-bodied Octopi, and shortest in the lengthened calamaries and cuttlefishes, in which the two elongated retractile tentacles are superadded by way of compensation' (Owen, *Lect.* i. 344).

a distance and to bring it to the mouth. They are so used by both the Sepias and the Calamaries. In the Poulps the feet are themselves able to perform these offices, and there are consequently no proboscises. Proboscises[1] and twining tentacles,[2] with acetabula set upon them, act in the same way and have the same structure as those plaited instruments[3] which were used by physicians of old to reduce dislocations of the fingers. Like these they are made by the interlacing of their fibres, and[4] they act by pulling upon pieces of flesh and yielding substances. For the plaited fibres encircle an object in a slackened condition, and when they are put on the stretch they grasp and cling tightly to whatever it may be that is in contact with their inner surface. Since, then, the Cephalopoda have no other instruments with which to convey anything to themselves from without, than either twining tentacles,[5] as in some species, or proboscises as in others, they are provided with these to serve as hands for offence and defence and other necessary uses.

[1] As the Greek text stands A. likens the entire cephalopod, and not merely its various tentacles with their suckers, to a *πλεγμάτιον* and, moreover, entirely leaves out of account the most important of the instruments he is discussing, namely, the *προβοσκίδες* of sepias and calamaries; for these are not counted by him as *πόδες*. I venture therefore to suggest that for *ὅσοις* should be read *ὅσαις* and *προβοσκίσι* for *πρὸς τοῖς πόσι*.

[2] The term *πλεκτάναι*, though sometimes used to denote the feet of any cephalopod without distinction, is applied more precisely to the long twining tentacles of the poulps, as contrasted with the comparatively short tentacles of the sepias and calamaries. These *πλεκτάναι*, and especially the dorsal pair (*H. A.* iv. 1. 524a 4), are held by A. to combine with their common office of feet the function of the long retractile tentacles (*προβοσκίδες*) of the sepias and calamaries, that is, to lay hold of prey at a distance and draw it to the mouth.

[3] These are the 'Saurae' mentioned by Hippocrates (Kühn's ed. iii. 266). The 'Saura' was a short tube of plaited palm-fibres, in size like the finger of a glove but open at both ends. Placing one end round the dislocated finger, the operator introduced his own finger into the other end, and, on pulling, the tube grasped both fingers tightly and enabled the surgeon to reduce the dislocation. A. likens the *προβοσκίς* to a Saura; Owen (*Cycl. An. and Phys.* i. 529, fig. 215) with equal aptness to obstetrical forceps. [4] For *αἷς ἕλκουσι* read *καὶ ἕλκουσι*.

[5] Though A. uses carelessly the general term *ποσί*, he plainly means *πλεκτάναις*. For parts special to some species of cephalopods, not parts common to all, are clearly indicated; and it is the *πλεκτάναι* of the poulps that serve like the proboscises of sepias and calamaries to bring objects in from without. After *ἄλλην* read *χρείαν καί* (Y).

The acetabula are set in double line in all the Cephalopoda excepting in one kind of poulp, where there is but a single row.[1] The length and the slimness which is part of the nature of this kind of poulp explain the exception. For a narrow space cannot possibly admit of more than a single row. This exceptional character, then, belongs to them, not because it is the most advantageous arrangement, but because it is the necessary consequence of their essential specific constitution.

In all these animals there is a fin, encircling the sac. In the Poulps and the Sepias this fin is unbroken and continuous, as is also the case in the larger calamaries known as Teuthi.[2] But in the smaller kind, called Teuthides, the fin is not only broader than in the Sepias and the Poulps, where it is very narrow, but, moreover, does not encircle the entire sac, but only begins in the middle of the side. The use of this fin is to enable the animal to swim, and also to direct its course. It acts, that is, like the rump-feathers in birds, or the tail-fin in fishes. In none is it so small or so indistinct as in the Poulps.[3] For in these the body is of small bulk and can be steered by the feet sufficiently well without other assistance.

The Insects, the Crustacea, the Testacea, and the Cephalopoda, have now been dealt with in turn; and their parts have been described, whether internal or external.

10 We must now go back to the animals that have blood, and consider such of their parts, already enumerated, as were before passed over. We will take the viviparous animals[4] first, and, when we have done with these, will pass on to the oviparous, and treat of them in like manner.

The parts that border on the head, and on what is known as the neck and throat, have already been taken into con-

[1] The poulp with a single row of suckers is some species of Eledone (*H. A.* iv. 1. 525^{a} 16), *E. cirrhosa* according to Owen.

[2] For the distinctive characters of Teuthi and Teuthides see *H. A.* iv. 1. 524^{a} 29. It is sufficient here to consider them as large and small calamaries without attempting precise identification, as to which zoologists differ greatly.

[3] The Octopodidae have in fact no body-fin at all.

[4] i. e. the Mammalia.

sideration.[1] All animals that have blood have a head; 686a whereas in some bloodless animals, such as crabs, the part which represents a head is not clearly defined. As to the neck, it is present in all the Vivipara, but only in some of the Ovipara; for while those that have a lung also have a neck, those that do not inhale the outer air have none.[2]

The head exists mainly for the sake of the brain. For every animal that has blood must of necessity have a brain; and must, moreover, for reasons already given,[3] have it placed in an opposite region to the heart. But the head has also been chosen by nature as the part in which to set some of the senses; because its blood is mixed in such suitable proportions as to ensure their tranquillity and precision, while at the same time it can supply the brain with such warmth as it requires. There is yet a third constituent superadded to the head, namely the part which ministers to the ingestion of food. This has been placed here by nature, because such a situation accords best with the general configuration of the body. For the stomach could not possibly be placed above the heart, seeing that this is the sovereign organ; and if placed below, as in fact it is, then the mouth could not possibly be placed there also. For this would have necessitated a great increase in the length [4] of the body; and the stomach, moreover, would have been removed too far from the source of motion and of concoction.[5]

The head, then, exists for the sake of these three parts; while the neck, again, exists for the sake of the windpipe.

[1] Cf. ii. 10–iii. 3.

[2] i.e. Fishes. Serpents, though they have a lung, have no neck. This exception, though not noted here, is dealt with in the next chapter.

[3] Cf. ii. 7. 652b 17.

[4] Read πολὺ γὰρ ἂν τὸ μῆκος ἦν (P).

[5] The argument is this. 'The stomach cannot be placed above the heart, for such a position would be inconsistent with the dignity of the chief organ (cf. ii. 2. 648a 13 n.); it must therefore be placed below it. But if the mouth were also placed below the heart, the stomach, owing to the length of the oesophagus, would be removed so far from the heart, that digestion, which is due to heat derived from the heart, would not be possible.' A. forgets that elsewhere (iii. 3. 664a 23) he has said that the oesophagus is only necessary, because there is a neck, and that, but for this, the stomach might come immediately after the mouth.

For it acts as a defence to this and to the oesophagus, encircling them and keeping them from injury. In all other animals this neck is flexible and contains several vertebrae; but in wolves and lions it contains only a single bone.[1] For the object of nature was to give these animals an organ which should be serviceable in the way of strength, rather than one that should be useful for any of the other purposes to which necks are subservient.[2]

Continuous with the head and neck is the trunk with the anterior limbs. In man the forelegs and forefeet are replaced by arms and by what we call hands. For of all animals man alone stands erect, in accordance with his god-like nature and essence. For it is the function of the god-like to think and to be wise; and no easy task were this under the burden of a heavy body, pressing down from above and obstructing by its weight the motions of the intellect and of the general sense.[3] When, moreover, the weight and corporeal substance become excessive, the body must of necessity incline towards the ground. In such cases therefore nature, in order to give support to the body, has replaced the arms and hands by forefeet, and has thus converted the animal into a quadruped. For, as every animal that walks must of necessity have the two hinder feet, such 686b
an animal becomes a quadruped, its body inclining downwards in front from the weight which its soul cannot sustain.

[1] Though there were lions in N. Greece in A.'s time they were rare and confined to a small locality (*H. A.* vi. 31. 579^{b} 6), and A. clearly was scantily informed about them; for nearly all his statements about their structure are erroneous. Here he says that they have only one cervical vertebra; a little later on he says they have but two dugs; elsewhere that their bones are without medullary cavity, &c.

[2] Such uses, for instance, as turning round quickly to guard the hinder part against a foe (iv. 11. 692^{a} 5); picking up food from the bottom of the water, as do web-footed and other water-birds (iv. 12. 693^{a} 8); or catching prey at a distance, the long neck serving as a fishing rod (iv. 12. 693^{a} 23).

[3] There are some perceptions, says A., that are peculiar to one sense, e. g. colour to vision, hardness and temperature to touch, &c. But there are others not peculiar to one sense, but appreciable by several, or at any rate by vision and by touch. Such are motion, rest, number, figure, magnitude. These, then, are common sensibles, and that which perceives them is the one common or general sense, of which the five senses are special forms. Cf. *De An.* iii. 1 and 2; *De Som.* 2; *De Sens.* 4. 442^{b} 4.

For all animals, man alone excepted, are dwarf-like in form. For the dwarf-like is that in which the upper part is large, while that which bears the weight and is used in progression is small. This upper part is what we call the trunk,[1] which reaches from the mouth to the vent. In man it is duly proportionate to the part below, and diminishes much in its comparative size as the man attains to full growth. But in his infancy the contrary obtains, and the upper parts are large, while the lower part is small; so that the infant can only crawl, and is unable to walk; nay, at first cannot even crawl, but remains without motion. For all children are dwarfs in shape, but cease to be so as they become men, from the growth of their lower part; whereas in quadrupeds the reverse occurs, their lower parts being largest in youth, and advance of years bringing increased growth above, that is in the trunk, which extends from the rump to the head. Thus it is that colts are scarcely, if at all, below full-grown horses in height; and that while still young they can touch their heads with the hind legs, though this is no longer possible when they are older. Such, then, is the form of animals that have either a solid or a cloven hoof. But such as are polydactylous and without horns, though they too are of dwarf-like shape, are so in a less degree; and therefore the greater growth of the lower parts as compared with the upper is also small, being proportionate to this smaller deficiency.[2]

Dwarf-like again is the race of birds and fishes; and so in fact, as already has been said, is every animal that has blood. This is the reason why no other animal is so intelli-

[1] In the Greek text 'thorax' (*θώραξ*); this term not being as yet restricted to the cavity above the diaphragm, cf. *H. A.* i. 7. 491^{a} 29.

[2] Cf. *H. A.* ii. 1. 500^{b} 26 sq. This statement as to the alteration that occurs in the human body in the relative proportions of the upper and lower parts is correct. 'After birth, the proportions of the body alter in consequence of the legs growing faster than the rest of the body. In consequence, the middle point of the height of the body—which at birth is situated about the umbilicus—becomes gradually lower until, in the adult male, it is as low as the symphysis pubis' (Huxley, *Vert.* p. 488). On the other hand, every one is familiar with the preponderant length of a colt's legs as compared with that of its body. Lastly, if one compares a kitten with a cat, one finds no such contrast of proportions.

gent as man. For even among men themselves if we compare children with adults, or such adults as are of dwarf-like shape with such as are not, we find that, whatever other superiority the former may possess, they are at any rate deficient as compared with the latter in intelligence. The explanation, as already stated, is that their psychical principle is corporeal, and much impeded in its motions. Let now a further decrease occur in the elevating heat, and a further increase in the earthy matter, and the animals become smaller in bulk, and their feet more numerous, until at a later stage they become apodous, and extended full length on the ground. Then, by further small successions of change, they come to have their principal organ below; and at last their cephalic part becomes motionless and destitute of sensation. Thus the animal becomes a plant, that has its upper parts downwards and its lower parts above. For in plants the roots are the equivalents of mouth and head, while the seed has an opposite significance,[1] for it is 687a
produced above at the extremities of the twigs.

The reasons have now been stated why some animals have many feet, some only two, and others none; why, also, some living things are plants and others animals; and, lastly, why man alone of all animals stands erect. Standing thus erect, man has no need of legs in front, and in their stead has been endowed by nature with arms and hands. Now it is the opinion of Anaxagoras that the possession of these hands is the cause of man being of all animals the most intelligent. But it is more rational to suppose that his endowment with hands is the consequence rather than the cause of his superior intelligence. For the hands are instruments or organs, and the invariable plan of nature in distributing the organs is to give each to such animal as can make use of it; nature acting in this matter as any prudent man would do. For it is a better plan to take a person who is already a flute-player and give him a flute, than to take one who possesses a flute and teach him the art of flute-playing. For nature adds that which is less to that which

[1] Answers, that is to say, to the residual nutriment of animals. Cf. ii. 3. 650a 20 n.

is greater and more important, and not that which is more valuable and greater to that which is less. Seeing then that such is the better course, and seeing also that of what is possible nature invariably brings about the best, we must conclude that man does not owe his superior intelligence to his hands, but his hands to his superior intelligence. For the most intelligent of animals is the one who would put the most organs to use; and the hand is not to be looked on as one organ but as many; for it is, as it were, an instrument for further instruments.[1] This instrument, therefore,—the hand—of all instruments the most variously serviceable, has been given by nature to man, the animal of all animals the most capable of acquiring the most varied handicrafts.

Much in error, then, are they who say that the construction of man is not only faulty, but inferior to that of all other animals; seeing that he is, as they point out, barefooted, naked, and without weapon of which to avail himself. For other animals have each but one mode of defence, and this they can never change; so that they must perform all the offices of life and even, so to speak, sleep with sandals on, never laying aside whatever serves as a protection to their bodies, nor changing such single weapon as they may chance to possess. But to man numerous modes of defence
687b are open, and these, moreover, he may change at will; as also he may adopt such weapon as he pleases, and at such times[2] as suit him. For the hand is talon, hoof, and horn, at will. So too it is spear, and sword, and whatsoever other weapon or instrument you please; for all these can it be from its power of grasping and holding them all. In harmony with this varied office is the form which nature has contrived[3] for it. For it is split into several divisions, and these are capable of divergence. Such capacity of divergence does not prevent their again converging so as to form a single compact body, whereas had the hand been an undivided mass, divergence would have been impossible.

[1] Cf. *Polit.* i. 4. 1253b 33.

[2] Read ὁπόταν for ὅπου ἄν.

[3] For συμμεμηχανῆσθαι read συμμεμηχάνηται and omit καί before τῇ φύσει.

The divisions also may be used singly or two together and in various combinations.[1] The joints, moreover, of the fingers are well constructed for prehension and for pressure. One of these also, and this not long like the rest but short and thick, is placed laterally. For were it not so placed all prehension would be as impossible, as were there no hand at all. For the pressure of this digit is applied from below upwards, while the rest act from above downwards; an arrangement which is essential, if the grasp is to be firm and hold like a tight clamp. As for the shortness of this digit, the object is to increase its strength, so that it may be able, though but one, to counterbalance its more numerous[2] opponents. Moreover, were it long it would be of no use. This is the explanation[3] of its being sometimes called the great digit, in spite of its small size; for without it all the rest would be practically useless. The finger which stands at the other end of the row is small, while the central one of all is long, like a centre oar[4] in a ship. This is rightly so; for it is mainly by the central part of the encircling grasp that a tool must be held when put to use.

No less skilfully contrived are the nails. For, while in man these serve simply as coverings to protect the tips of the fingers, in other animals they are also used for active purposes; and their form in each case is suited to their office.

The arms in man and the fore limbs in quadrupeds bend in contrary directions, this difference having reference to the

[1] If the text be correct, by *ἑνί* must be meant one of the divisions implied in *διαιρετή*, viz. one of the fingers. Not only is this a very strange construction, but *τῶν δακτύλων* in the next sentence seems to mark that as the beginning of the account of the fingers. We should also expect *πλείοσι* rather than *πολλαχῶς* if fingers are meant. May it not be that for *ἑνί* should be read *μιᾷ*, the transcriber having been led to make this mistake by the *ἔνι* that begins the preceding sentence? 'The hands also may be used singly or together and in various combinations.'

[2] Transposing *ἵνα . . . πολλοῖς* to follow *τὴν ἰσχύν*.

[3] Transpose *καὶ διά . . . ἄνευ τούτου* to come after *εἰ μακρός*.

[4] For *μέσον νέως* read *μεσόνεως* (Schneider). According to Dr. Warre (Badminton, *Boating*, p. 14) the midship oars in an ancient Greek vessel were longer and heavier than those nearer stern and prow; and consequently it was these centre oars that poets put in the hands of heroes, see Apoll. Rhodius, *Argon.* i. 395–400.

ingestion of food and to the other offices which belong to these parts. For quadrupeds must of necessity bend their anterior limbs inwards that they may serve in locomotion, for they use them as feet.[1] Not but what even among quadrupeds there is at any rate a tendency for such as are polydactylous to use their forefeet not only for locomotion 688a but as hands. And they are in fact so used, as any one may see. For these animals seize hold of objects, and also repel assailants with their anterior limbs; whereas quadrupeds with solid hoofs use their hind legs for this latter purpose. For their fore limbs are not analogous to the arms and hands of man.[2]

It is this hand-like office of the anterior limbs which explains why in some of the polydactylous quadrupeds, such as wolves, lions, dogs, and leopards, there are actually five digits on each forefoot, though there are only four on each hind one. For the fifth digit of the foot corresponds to the fifth digit of the hand,[3] and like it is called the big one. It is true that in the smaller polydactylous quadrupeds the hind feet also have each five toes. But this is because these animals are creepers; and the increased number of nails serves to give them a tighter grip, and so enables them to creep up steep places with greater facility,[4] or even to run head downwards.

In man between the arms, and in other animals between the forelegs, lies what is called the breast. This in man is broad, as one might expect; for as the arms are set laterally on the body, they offer no impediment to such expansion in this part. But in quadrupeds the breast is

[1] Reading ὡς (P) before ποσίν, and substituting a comma for the colon after κῶλα.

[2] Analogous is here used in the modern sense, i. e. having similar functions, and not as equivalent to homologous.

[3] And therefore is not wanted, as the hind foot has no hand-like office such as that of the corresponding forefeet.

[4] In Canidae and Felidae, from which A.'s examples are taken, there are only four toes to the hind foot, while the forefeet have each five, as in most Unguiculata. The smaller quadrupeds, that are described as having five hind toes and as creeping or even running head downwards, are such animals as rats, squirrels, moles, martens, weasels. It is, however, not only small quadrupeds and creepers that have five hind toes; for the same is the case with elephants and bears.

narrow, owing to the legs having to be extended in a forward direction in progression and locomotion.

Owing to this narrowness the mammae of quadrupeds are never placed on the breast. But in the human body there is ample space in this part; moreover, the heart and neighbouring organs require protection, and for these reasons this part is fleshy and the mammae are placed upon it separately, side by side, being themselves of a fleshy substance in the male and therefore of use in the way just stated; while in the female, nature, in accordance with what we say is her frequent practice, makes them minister to an additional function, employing them as a store-place of nutriment for the offspring. The human mammae are two in number, in accordance with the division of the body into two halves, a right and a left. They are somewhat firmer than they would otherwise be, because the ribs [1] in this region are joined together; while they form two separate masses, because their presence is in no wise burdensome.[2] In other animals [3] than man, it is impossible for the mammae to be placed on the breast between the forelegs, for they would interfere with locomotion; they are therefore disposed of otherwise, and in a variety of ways.[4] Thus in such animals as produce but few at a birth, whether horned quadrupeds or those with solid hoofs, the mammae are placed in the region of the thighs, and are two in number,[5] while in such as produce litters, or such as are polydactylous, the dugs

[1] The upper or true ribs which are united to the sternum, in opposition to the false ribs below. Thus there is firmness given to the mammae by the firm substratum. For ἀλλήλας read ἀλλήλαις.

[2] As the arms are not used for locomotion, the mammae are not in the way, and so there is no disadvantage in there being two of them; otherwise they would be made to form a single mass.

[3] Elsewhere (*H. A.* ii. 8. 502a 34), apes, as well as man, are excepted. Pectoral mammae are by no means confined, however, to man and apes. In bats, for instance, the two mammae are pectoral; so also in elephants, as indeed is presently mentioned.

[4] Omit ἤδη before πολλούς.

[5] The horned animals which produce few at a birth and have only two mammae are sheep and goats. For in other horned animals, e.g. the cow, there are four, as A. elsewhere (*H. A.* ii. 1. 499a 19) mentions. Even in sheep and goats there are really four; but two of these are usually rudimentary. The Solidungula have, as correctly stated, only two mammae and these inguinal.

are either numerous and placed laterally on the belly, as in swine and dogs, or are only two in number, being set, however, in the centre [1] of the abdomen, as is the case in the lion.[2]
688b The explanation of this latter condition is not that the lion produces few at a birth, for sometimes it has more than two cubs at a time, but is to be found in the fact that this animal has no plentiful supply of milk. For, being a flesh-eater, it gets food at but rare intervals, and such nourishment as it obtains is all expended on the growth of its body.

In the elephant also there are but two mammae, which are placed under the axillae of the fore limbs. The mammae are not more than two, because this animal has only a single young one at a birth; and they are not placed in the region of the thighs, because they never occupy that position in any polydactylous animal such as this. Lastly, they are placed above, close to the axillae, because this is the position of the foremost dugs in all animals whose dugs are numerous, and the dugs so placed give the most milk. Evidence of this is furnished by the sow. For she always presents these foremost dugs to the first-born of her litter. A single young one is of course a first-born, and so such animals as only produce a single young one must have these anterior dugs to present to it; that is they must have the dugs which are under the axillae. This, then, is the reason why the elephant has but two mammae, and why they are so placed. But, in such animals as have litters of young, the dugs are disposed about the belly; the reason being that more dugs are required by those that will have more young to nourish. Now it is impossible that these dugs should be set transversely in rows of more than two, one, that is, for each side of the body, the right and the left [3]; they must therefore be

[1] In opposition to the general rule in bi-mammary animals, whose mammae, as said a few lines back, are set *ἐν τοῖς μηροῖς*, that is are inguinal, or are pectoral as in man.

[2] The number and position of the mammae are given correctly by A. in the other instances; but as usual he is in error as regards the lion; for though its mammae are, as stated, abdominal, they are four, not two, in number. The lion produces not unfrequently four, and occasionally even five or six, at a birth (*G. A.* iii. 10. 760^b 23).

[3] The *διά . . . δεξιόν* must refer in sense to the preceding *δύο*, not to the *μόνους*. There must be two in each row because of the require-

placed lengthways, and the only place where there is sufficient length for this is the region between the front and hind legs. As to the animals that are not polydactylous but produce few at a birth, or have horns, their dugs are placed in the region of the thighs.[1] The horse, the ass, the camel are examples; all of which bear but a single young one at a time, and of which the two former have solid hoofs, while in the last the hoof is cloven. As still further examples may be mentioned the deer, the ox, the goat, and all other similar animals.

The explanation is that in these animals growth takes place in an upward direction;[2] so that there must be an abundant collection of residual matter and of blood in the lower region, that is to say in the neighbourhood of the orifices for efflux, and here therefore nature has placed the mammae. For the place in which the nutriment is set in motion must also be the place whence nutriment can be derived by them. In man there are mammae in the male as well as in the female; but some of the males of other animals are without them. Such, for instance, is the case with horses, some stallions being destitute of these parts, while others that resemble their dams have them.[3] Thus much then concerning the mammae.

Next after the breast comes the region of the belly, which is left unenclosed by the ribs for a reason which has already 689a
been given;[4] namely that there may be no impediment to the swelling which necessarily occurs in the food as it gets heated, nor to the expansion of the womb in pregnancy.

ments of bilateral symmetry (cf. 688a 26), and not more than two, because of the narrow space.

[1] Omit *καί* before *ἐν τοῖς μηροῖς*.

[2] i. e. in the direction from tail to head. This upward growth implies, he says, the accumulation of nutriment in the part from which the growth proceeds, for otherwise there would be no material for the growth; and it is in this land of plenty that the mammae are placed. In the human body the growth takes place in the contrary direction, and the seat of plenty and location of the mammae is accordingly at the opposite or pectoral end. As to direction of growth cf. 686b 32 note.

[3] Linnaeus counted the horse among those exceptional quadrupeds in which the male has no teats; but John Hunter discovered vestiges of them in the stallion. Possibly what A. says may be true, and thus the discrepancy between these two modern authorities explained.

[4] Cf. ii. 9. 655a 2.

At the extreme end of what is called the trunk are the parts concerned in the evacuation of the solid and also of the fluid residue. In all sanguineous animals with some few exceptions,[1] and in all Vivipara without any exception at all, the same part which serves for the evacuation of the fluid residue is also made by nature to serve in sexual congress, and this alike in male[2] and female. For the semen is a kind of fluid and residual matter.[3] The proof of this will be given hereafter,[4] but for the present let it be taken for granted. (The like holds good of the menstrual fluid in women, and of the part where they[5] emit semen. This also, however, is a matter of which a more accurate account will be given hereafter. For the present let it be simply stated as a fact, that the catamenia of the female like the semen of the male are residual matter.[6] Both of them, moreover,

[1] This passage is translated as it stands; but the text cannot but be corrupt. For it makes A. say that all oviparous vertebrates with some few exceptions form urine, in contradiction of his repeated and distinct statement (e.g. iii. 8 and 9, iv. 13. 697^{a} 13; *H. A.* ii. 16) that none of them do so or have either kidneys or bladder, except tortoises. I have no doubt that what A. really said here was as follows: '*In all such sanguineous animals as are viviparous and in some few of those that are oviparous, the same part*,' &c.; the 'some few' being the various tortoises, as to whose coitus see *H. A.* v. 3, v. 5. 541^{a} 8. For ἔξω . . . ἐναίμοις, therefore, I would read ἐν ὀλίγοις τισὶν τῶν ᾠοτόκων.

[2] For τῶν ἀρρένων read τοῖς ἄρρεσιν.

[3] See note 6 and ii. 14. 658^{a} 23 note.

[4] *G. A.* i. 18. 724^{b} 21–726^{a} 25.

[5] If the reading be correct, A. apparently attributes to females the secretion of γονὴ *in addition to* the καταμήνια. So also in the *H. A.* (i. 3. 489^{a} 9–13) he attributes to them the secretion of σπέρμα. But when he considers the question more fully in the *G. A.* he again and again (e.g. *G. A.* i. 19. 727^{a} 1 and 28) maintains that the καταμήνια are themselves the female equivalent of γονὴ or σπέρμα. Prof. Platt, however, ingeniously suggests that the reading should be εἰ προΐενταί τινα γονήν, 'and of the semen if so be that they emit any.'

[6] Hippocrates (Kühn ed. i. 551) had said, in partial anticipation of Darwin's doctrine of pangenesis, that the semen was formed by contributions from all parts of the parent's body; and he explained on this hypothesis the resemblance of the offspring to the parent, which extended occasionally even to accidental or acquired peculiarities of structure. This opinion is combated by A. (*G. A.* i. 17, 18), who insists, among other arguments, that it would imply that the semen was a product of dissolution or decay (σύντηξις), which is clearly inadmissible. He argues that the semen can be nothing else in substance than part of that surplus or residue of sound nutriment, which, after conversion into blood, has not been required for the growth or maintenance of the bodily fabric. This, he says, explains why no semen is formed either when the growth is active, as in

being fluid, it is only natural that the parts which serve for voidance of the urine should give issue to residues which resemble it in character.[1]) Of the internal structure of these parts, and of the differences which exist between the parts concerned with semen and the parts concerned with conception, a clear account is given in the book of Researches concerning Animals and in the treatises on Anatomy. Moreover, I shall have to speak of them again when I come to deal with Generation.[2] As regards, however, the external shape of these parts, it is plain enough that they are adapted to their operations, as indeed of necessity they must be. There are, however, differences in the male organ corresponding to differences in the body generally. For all animals are not of an equally sinewy nature. This organ, again, is the only one that, independently of any morbid change, admits of augmentation and of diminution of bulk. The former condition is of service in copulation, while the other is required for the advantage of the body at large. For, were the organ constantly in the former condition, it would be an incumbrance. The organ therefore has been formed of such constituents as will admit of either state. For it is partly sinewy, partly cartilaginous,[3] and thus is enabled either to contract or to become extended, and is capable of admitting air.[4]

childhood, or when the power of concocting nutriment is small, as in old age or sickness; and also why those animals whose surplus nutriment is turned into fat are not prolific (ii. 5. 651^{b} 13). The semen, then, instead of being, as Hippocrates would have it, something which comes from each and every part of the parent, is something which might have gone to each and every part of the parent. To the semen of the male corresponds the menstrual discharge of the female; but, in accordance with the colder nature of females, their generative secretion is less concocted (*G. A.* iv. 5. 774^{a} 2), and therefore retains a greater resemblance to blood.

[1] Omitting τῶν αὐτῶν καί.

[2] *H. A.* i. 13, 14, i. 17. 497^{a} 27, iii. 1; *G. A.* i. 2–16.

[3] Elsewhere (*H. A.* ii. 1. 500^{b} 22) sundry Carnivora are correctly stated to have a bone in the penis; the camel and stag to have no such bone, but a sinewy organ, also correctly; and man to have cartilage in the part, which chances to be true of some negroes. In no other case, however, does the penis contain cartilage. As to the presence of sinew conferring the power of contraction, cf. iii. 4. 666^{b} 14 note.

[4] Erection was attributed to air, not to blood (*Probl.* xxx. 1. 953^{b} 34); as also emission (*H. A.* vii. 7. 586^{a} 16).

All female quadrupeds void their urine backwards, because the position of the parts which this implies is useful to them in the act of copulation. This is the case with only some few males, such as the lynx, the lion, the camel, and the hare.[1] No quadruped with a solid hoof is retromingent.

689ᵇ The posterior portion of the body and the parts about the legs are peculiar in man as compared with quadrupeds. Nearly all these latter have a tail, and this whether they are viviparous or oviparous. For, even if the tail be of no great size, yet they have a kind of scut, as at any rate a small representative[2] of it. But man is tail-less. He has, however, buttocks, which exist in none of the quadrupeds. His legs also are fleshy (as too are his thighs and feet);[3] while the legs in all other animals that have any, whether viviparous or not, are fleshless, being made of sinew and bone and spinous substance. For all these differences there is, so to say, one common explanation, and this is that of all animals man alone stands erect. It was to facilitate the maintenance of this position that Nature made his upper parts light, taking away some of their corporeal substance, and using it to increase the weight of the parts below, so that the buttocks, the thighs, and the calves of the legs were all made fleshy. The character which she thus gave to the buttocks renders them at the same time useful in

[1] The camel, the cats, and many rodents including the hare, are retromingent.

[2] For σμικροῦ read σημείου (Bonitz).

[3] For κνήμας read πόδας (Y).

A. uses the term σκέλος, as we use 'leg', to designate not only the entire limb, but also that lower part of it which lies between thigh and foot; but, as he shares the popular misconception which identifies the knee-joint of man with what is really the tarsal joint of other vertebrates, the tibial segment in man with its fleshy calf (κνήμη and γαστροκνημία) and the scraggy metatarsal segment of quadrupeds and birds come to be the σκέλη which he supposes to correspond anatomically and compares with each other.

The same misconception as to the knee-joint causes him to find the counterpart of the human femur in the tibial segment of the other vertebrates; but this leaves him in the case of these vertebrates with an extra limb-segment (the femur) unaccounted for. The human femur is jointed to the pelvic ischium, and therefore A. calls this extra segment an ischium, though it is a separate bone, and looks, he is bound to admit, when detached from its surroundings, just like a femur (*H. A.* ii. 12. 503ᵇ 35).

resting the body. For standing causes no fatigue to quadrupeds, and even the long continuance of this posture produces in them no weariness; for they are supported the whole time by four props, which is much as though they were lying down. But to man it is no easy task to remain for any length of time on his feet, his body demanding rest in a sitting position. This, then, is the reason why man has buttocks and fleshy legs; and the presence of these fleshy parts explains why he has no tail. For the nutriment which would otherwise go to the tail is used up in the production of these parts, while at the same time the existence of buttocks does away with the necessity of a tail. But in quadrupeds and other animals the reverse obtains. For they are of dwarf-like form, so that all the pressure of their weight and corporeal substance is on their upper part, and is withdrawn from the parts below.[1] On this account they are without buttocks and have hard legs. In order, however, to cover and protect that part which serves for the evacuation of excrement, nature has given them a tail of some kind or other, subtracting for the purpose some of the nutriment which would otherwise go to the legs. Intermediate in shape between man and quadrupeds is the ape, belonging therefore to neither or to both, and having on this account neither tail nor buttocks; no tail in its character of biped, no buttocks in its character of quadruped. There is
a great diversity of so-called tails; and this organ like others 690^a
is sometimes used by nature for by-purposes, being made to serve not only as a covering and protection to the fundament, but also for other uses and advantages of its possessor.

There are differences in the feet of quadrupeds. For in some of these animals there is a solid hoof, and in others a hoof cloven into two, and again in others a foot divided into many parts.

The hoof is solid when the body is large and the earthy matter present in great abundance; in which case the earth, instead of forming teeth and horns, is separated in the character of a nail, and being very abundant forms one

[1] i. e. the hind legs, *H. A.* ii. 1. 500^b 29.

continuous nail, that is a hoof, in place of several. This consumption of the earthy matter on the hoof explains why these animals, as a rule, have no [1] huckle-bones; a second reason [2] being that the presence of such a bone in the joint of the hind leg somewhat impedes its free motion. For extension and flexion can be made more rapidly in parts that have but one angle than in parts that have several. But the presence of a huckle-bone, as a connecting bolt, is the introduction as it were of a new limb-segment between the two ordinary ones. Such an addition adds to the weight of the foot, but renders the act of progression more secure. Thus it is that in such animals as have a huckle-bone, it is only in the posterior and not in the anterior limbs that this bone is found. For the anterior limbs, moving as they do in advance of the others, require to be light and capable of ready flexion, whereas firmness and extensibility are what are wanted in the hind limbs. Moreover, a huckle-bone adds weight to the blow of a limb, and so renders it a suitable weapon of defence; and these animals all use their hind legs to protect themselves, kicking out with their heels against anything which annoys them. In the cloven-hoofed quadrupeds the lighter character of the hind legs admits of there being a huckle-bone; and the presence of the huckle-bone prevents them from having a solid hoof, the bony substance remaining in the joint, and therefore being deficient in the foot. As to the polydactylous quadrupeds, none of them have huckle-bones. For if they had they would not be polydactylous, but the divisions of the foot would only extend to that amount of its breadth which was covered by the huckle-bone.[3] Thus it is that most [4] of the animals that have huckle-bones are cloven-hoofed.

[1] Not every tarsal bone, which modern anatomists call astragalus, was so called by A., but only such as in size and shape were suitable for the ancient game which has come down to us as the game of huckle-bone or knuckle-bone. Such are the astragali of the smaller ruminants.

[2] Read *καί* before *διὰ τὸ δυσκινητοτέραν* (S U).

[3] A. probably means that, if there were an astragalus, there would be much earthy matter; and, if much earthy matter, then the hoof would be a solid mass; excepting in that part of its breadth where the earthy matter was used up in making the astragalus.

[4] As to the supposed exceptions see *H. A.* ii. 1. 499^b 20.

Of all animals man has the largest foot in proportion to the size of the body.[1] This is only what might be expected. For seeing that he is the only animal that stands erect, the two feet which are intended to bear all the weight of the body must be both long and broad. Equally intelligible is it that the proportion between the size of the fingers and that of the whole hand should be inverted in the case of the toes and feet. For the function of the hands is to take hold of objects and retain them by pressure; so that the fingers require to be long. For it is by its flexed portion that the hand grasps an object. But the function of 690b
the feet is to enable us to stand securely, and for this[2] the undivided part of the foot requires to be of larger size than the toes. However, it is better for the extremity to be divided than to be undivided. For in an undivided foot disease of any one part would extend to the whole organ; whereas, if the foot be divided[3] into separate digits, there is not an equal liability to such an occurrence. The digits, again, by being short would be less liable to injury. For these reasons the feet in man are many-toed, while the separate digits are of no great length. The toes, finally, are furnished with nails for the same reason as are the fingers, namely because such projecting parts are weak and therefore require special protection.

We have now done with such sanguineous animals as live on land and bring forth their young alive;[4] and, having dealt with all their main kinds, we may pass on to such
11 sanguineous animals as are oviparous. Of these some have four feet, while others have none. The latter form a single genus, namely the Serpents; and why these are apodous has been already explained in the dissertation on Animal

[1] 'L'homme a les pieds plus larges, et il peut les écarter l'un de l'autre plus que les autres animaux . . . . La grandeur de la surface du pied de l'homme tient à ce qu'il appuye le tarse, le métatarse et tous les doigts à terre, ce qu'aucun animal ne fait aussi parfaitement' (Cuvier, *Leçons*, i. 474).

[2] For ὥστε read πρὸς δέ. For νομίζειν read μεῖζον (Platt).

[3] For ἐσχισμένων read ἐσχισμένου. For συμβλάπτοιντο read ἂν βλάπτοιντο (Platt).

[4] That is, all the Mammalia known to him, with the exception of Cetacea.

Progression.[1] Irrespective of this absence of feet, serpents resemble the oviparous quadrupeds in their conformation.

In all these animals there is a head with its component parts; its presence being determined by the same causes[2] as obtain in the case of other sanguineous animals: and in all, with the single exception of the river crocodile, there is a tongue inside the mouth.[3] In this one exception there would seem to be no actual tongue, but merely a space left vacant for it. The reason is that a crocodile is in a way a land-animal and a water-animal combined. In its character of land-animal it has a space for a tongue; but in its character of water-animal it is without the tongue itself. For in some fishes, as has already been mentioned,[4] there is no appearance whatsoever of a tongue, unless the mouth be stretched open very widely indeed; while in others it is indistinctly separated from the rest of the mouth. The reason for this is that a tongue would be of but little service to such animals, seeing that they are unable to chew their food or to taste it before swallowing, the pleasurable sensations they derive from it being limited to the act of deglutition.[5] For it is in their passage down the gullet that solid edibles cause enjoyment, while it is by the tongue that the savour of fluids is perceived. Thus it is during deglutition that the oiliness, the heat, and other such qualities of food are

[1] *De An. Inc.* 8. 708a 9–20. See also iv. 13. 696a 10, where the explanation is repeated.

[2] Cf. iv. 10. 686a 5–18.

[3] There are, as a matter of fact, some oviparous quadrupeds without a tongue; but these are species which were unknown to Aristotle, such as the Carinthian Proteus, the Surinam Pipa, and the Dactylethra of South Africa. The crocodile really has a tongue; but it is flat, destitute of papillae, and united by its whole extent to the floor of the mouth. This seems to be recognized in other passages (*H. A.* ii. 10. 503a 1; *P. A.* ii. 17. 660b 15).

[4] Cf. ii. 17. 660b 13.

[5] That the sense of taste must be very dull in fishes is admitted by all naturalists (cf. Yarrell, *Brit. Fishes*, i. xvii); for, as A. justly observes, they do not chew their food, and thus the juices, which alone can excite true taste, are not expressed. Moreover, the inside of the mouth is being constantly washed over with water, which must of itself interfere with the possibility of any delicate gustation. Still they are probably not entirely without this sense, as is elsewhere (*H. A.* iv. 8. 533a 30) admitted; for, as there pointed out, they manifest certain preferences for one food rather than another.

recognized; and,[1] in fact, the satisfaction from most solid edibles and dainties is derived almost entirely from the dilatation of the oesophagus during deglutition.[2] This 691a sensation, then, belongs even to animals that have no[3] tongue, but while other animals have in addition the sensations of taste, tongueless animals have, we may say, no other[4] satisfaction than it. What has now been said explains why intemperance as regards drinks and savoury fluids does not go hand in hand with intemperance as regards eating and solid relishes.

In some oviparous quadrupeds, namely in lizards, the tongue is bifid,[5] as also it is in serpents,[6] and its terminal divisions are of hair-like fineness, as has already been described.[7] (Seals also have a forked tongue.) This it is which accounts for all these animals being so fond of dainty food.[8] The teeth in the four-footed Ovipara are of the sharp interfitting kind, like the teeth of fishes.[9] The organs of all the senses are present and resemble those of other animals. Thus there are nostrils for smell, eyes for vision, and ears for hearing. The latter organs, however, do not project from the sides of the head, but consist simply of the

[1] Transposing ἔχει . . . αἴσθησιν to after ἡ χάρις, and διό . . . ἐδωδήν to after ἡ ἑτέρα.

[2] 'On which account a certain gormandizer wished that his throat were longer than a crane's, implying that his pleasure was derived from the sense of touch' (*Ethics*, iii. 13. 1118a 32). The same notion led Spenser, in describing Gluttony, to say, 'And like a crane, his neck was long and fyne' (*Faëry Queen*, i. 4. 21).

[3] For ζῳοτόκα, substitute ἄγλωττα, as imperatively demanded by the context. A. did not suppose any vertebrate to be absolutely tongueless, not even the crocodile (ii. 17. 660b 25) though he calls it ἄγλωττος. In fishes, however, this part was almost rudimentary (ii. 17. 660b 14 note) and their sense of taste consequently very feeble.

[4] For ὡσπερανεί read ὥσπερ μόνη (Y).

[5] Cf. *H. A.* ii. 17. 508a 23. The tongue in Ophidia is bifid, as also it is in one great division of Sauria (hence called Fissilinguia or Leptiglossa), but not in all; not, for instance, in the chameleon nor in the wall gecko, or scarcely so, among species known to Aristotle. In the seal the tongue is deeply notched. See Buffon, *Nat. Hist.* xiii. pl 50.

[6] Read καί before οἱ ὄφεις (Y).

[7] Cf. ii. 17. 660b 9.

[8] For ἰσχνά read λίχνα (Karsch).

[9] The teeth of Saurian reptiles are usually acutely conical and slightly hooked. In some cases they are blade-like, and occasionally dentated on the edges. Rarely, as in Cyclodus, they have broad crushing crowns. In Chelonia there are no teeth whatsoever.

duct, as also is the case in birds. This is due in both cases to the hardness[1] of the integument; birds having their bodies covered with feathers, and these oviparous quadrupeds with horny plates. These plates are equivalent to scales, but of a harder character. This is manifest in tortoises and river crocodiles, and also in the large serpents. For here the plates become stronger than the bones,[2] being seemingly of the same substance as these.

These animals have no upper eyelid, but close the eye with the lower lid.[3] In this they resemble birds, and the reason is the same as was assigned in their case.[4] Among birds there are some[5] that can not only thus close the eye, but can also blink by means of a membrane which comes from its corner. But none of the oviparous quadrupeds blink;[6] for their eyes are harder than those of birds.[7] The reason for this is that keen vision and far-sightedness[8] are of very considerable service to birds, flying as they do in the air, whereas they would be of comparatively small use to the oviparous quadrupeds, seeing that they are all of troglodytic habits.

Of the two separate portions which constitute the head, namely the upper part and the lower jaw, the latter in man[9] and in the viviparous quadrupeds moves not only upwards and downwards, but also from side to side;[10] while in fishes,

[1] Cf. ii. 12; and ii. 13. 657^b 5.

[2] All reptiles have horny epidermal scales, but not so such Amphibia as the frog and toad, which A. included in the same group. In the Chelonia and the crocodiles these scales are combined with bony scutes, and these animals are therefore known as Loricata. But nothing of the kind occurs in the large serpents, none of which were actually known to Aristotle, but of which he had probably heard fabulous accounts from some of Alexander's companions; from Nearchus, for instance, whose statement as to the existence of monstrous serpents in the East is quoted by Arrian in his *Indica*.

[3] Most reptiles have an upper eyelid, though they use the lower lid exclusively or preferentially. In Ophidia, however, and some Lacertilia, there are no lids at all, or rather the two lids are transparent and continuous with each other in front of the eye; a condition of things which A. supposed (ii. 13. 657^b 32) to exist in Crustacea.

[4] Cf. ii. 13. 657^b 5.

[5] Not some but all, as more correctly stated, *H. A.* ii. 12. 504^a 26.

[6] This is an error (cf. ii. 13. 657^b 23 note).

[7] And therefore, he implies, do not require so much protection.

[8] Reading *ὀξυωπία καὶ τὸ πόρρω προϊδεῖν* (U Y). [9] Omitting *οὖν* (Y).

[10] The Carnivora are an exception, their teeth being adapted for

and birds and oviparous quadrupeds, the only movement is up and down. The reason is that this latter movement is the one required in biting and dividing food, while the 691b
lateral movement serves to reduce substances to a pulp. To such animals, therefore, as have grinder-teeth this lateral motion is of service; but to those animals that have no grinders it would be quite useless, and they are therefore invariably without it. For nature never makes anything that is superfluous. While in all other animals it is the lower jaw that is movable, in the river crocodile it is exceptionally the upper.[1] This is because the feet in this creature are so excessively small as to be useless for seizing and holding prey; on which account nature has given it a mouth that can serve for these purposes in their stead. For that direction of motion which will give the greater force to a blow will be the more serviceable one in holding or in seizing prey; and a blow from above is always more forcible than one from below. Seeing, then, that both the prehension and the mastication of food are offices of the mouth, and that the former of these two is the more essential in an animal that has neither hands nor suitably formed feet, these crocodiles will derive greater benefit from a motion of the upper jaw downwards than from a motion of the lower jaw upwards. The same considerations explain why crabs also move the upper division of each claw and not the lower. For their claws are substitutes for hands, and so require to be suitable for the prehension of food, and not for its comminution; for such comminution and biting is the office of teeth. In crabs, then, and in such other animals as are able to seize their food in a leisurely manner, inasmuch as their mouth is not called on to perform its office while they are still in the water, the two functions are assigned to

cutting and not for grinding. This exception, though not mentioned here, is recognized presently, when it is said that lateral motion goes with grinding teeth only, and therefore not with the serrated dentition of Carnivora.

[1] This was the common belief of the ancients (cf. Herodotus, ii. 68). Cuvier thus accounts for the error: 'Les mâchoires inférieures se prolongeant derrière le crâne, il semble que la supérieure soit mobile, et les anciens l'ont écrit ainsi; mais il ne se meut qu'avec la tête toute entière' (*Règ. An.* ii. 18).

different parts, prehension to the hands or feet, biting and comminution of food to the mouth. But in crocodiles the mouth has been so framed by nature as to serve both purposes, the jaws being made to move in the manner just described.

Another part present in these animals is a neck, this being the necessary consequence of their having a lung. For the windpipe by which the air is admitted to the lung is of some length.[1] If, however, the definition of a neck be correct, which calls it the portion between the head and the shoulders, a serpent can scarcely be said with the same right as the rest of these animals to have a neck, but only to have something analogous to that part of the body. It is a peculiarity of serpents, as compared with other animals
692a allied to them, that they are able to turn their head backwards without stirring the rest of the body. The reason of this is that a serpent, like an insect, has a body that admits of being curled up, its vertebrae being cartilaginous and easily bent.[2] The faculty in question belongs then to serpents simply as a necessary consequence of this character of their vertebrae; but at the same time it has a final cause, for it enables them to guard against attacks from behind. For their body, owing to its length and the absence of feet, is ill-suited for turning round and protecting the hinder parts; and merely to lift the head, without the power of turning it round, would be of no use whatsoever.

The animals with which we are dealing have, moreover, a part which corresponds to the breast; but neither here nor elsewhere in their body have they any mammae, as neither has any bird or fish. This is a consequence of their having no milk; for a mamma is a receptacle for milk and, as it were, a vessel to contain it. This absence of milk is not peculiar to these animals, but is common to all such as are not internally viviparous.[3] For all such produce eggs, and the

[1] Cf. iii. 3. 664a 30 note.

[2] The vertebrae of Ophidia are not cartilaginous but osseous. The great flexibility of the spine is due to its division into excessively numerous segments, and to the existence of a perfect ball and socket joint between each of these and that which precedes and follows it.

[3] 'Internally viviparous' is equivalent to Mammalia, whose ovum

nutriment which in Vivipara has the character of milk is in them engendered in the egg. Of all this, however, a clearer account will be given in the treatise on Generation.[1] As to the mode in which the legs[2] bend, a general account, in which all animals are considered, has already been given in the dissertation on Progression.[3] These animals also have a tail, larger in some of them, smaller in others, and the reason for this has been stated in general terms in an earlier passage.[4]

Of all oviparous animals that live on land there is none so lean as the Chamaeleon. For there is none that has so little blood. The explanation of this is to be found in the psychical temperament of the creature. For it is of a timid nature, as the frequent changes it undergoes in its outward aspect testify.[5] But fear is a refrigeration, and results from deficiency of natural heat and scantiness of blood.

We have now done with such sanguineous animals as are 692b
quadrupedous and also such as are apodous, and have stated with sufficient completeness what external parts they possess, and for what reasons they have them.

12 The differences of birds compared one with another are differences of magnitude, and of the greater or smaller development of parts. Thus some have long legs, others short legs; some have a broad tongue, others a narrow tongue; and so on with the other parts. There are few of their parts that differ save in size,[6] taking birds by themselves. But when birds are compared with other animals the parts present differences of form also. For in some animals these are

was unknown to Aristotle; it excludes ovoviviparous animals, which A. called 'externally viviparous but internally oviparous.'

[1] *G. A.* iii. 2. 752b 15 sqq.

[2] For καμπύλων read σκελῶν (P).

[3] Cf. *De An. Inc.* 13.

[4] Cf. iv. 10. 689b 3–690a 4.

[5] Alluding of course to the well-known changes of colour that occur in this animal (cf. Owen, *Verteb.* i. 556), which are apparently determined not only by variations in the temperature, the amount of light, and the tints of surrounding objects, but also by emotions, as fear, anger, and the like.

[6] The sense requires πλὴν κατὰ μέγεθος or equivalent words after ἀλλήλων. The class Aves is remarkably homogeneous. 'The structural modifications which they present are of comparatively little importance' (Huxley).

hairy, in others scaly, and in others have scale-like plates, while birds are feathered.

Birds, then, are feathered,[1] and this is a character common to them all and peculiar to them. Their feathers, too, are split and distinct in kind from the undivided feathers of insects; for the bird's feather is barbed, these are not; the bird's feather has a shaft, these have none.[2]

A second strange peculiarity which distinguishes birds from all other animals is their beak. For as in elephants[3] the nostril serves in place of hands, and as in some insects the tongue serves in place of mouth, so in birds there is a beak, which, being bony,[4] serves in place of teeth and lips. Their organs of sense have already been considered.[5]

All birds have a neck extending from the body; and the purpose of this neck is the same as in such other animals as have one. This neck in some birds is long, in others short; its length, as a general rule, being pretty nearly determined by that of the legs. For long-legged birds have a long neck, short-legged birds a short one, to which rule, however,
693a the web-footed birds form an exception. For to a bird perched up on long legs a short neck would be of no use whatsoever in collecting food from the ground; and equally useless would be a long neck, if the legs were short. Such birds, again, as are carnivorous would find length in this part interfere[6] greatly with their habits of life. For a long neck is weak, and it is on their superior strength that carnivorous birds depend for their subsistence. No bird, therefore, that has talons ever has an elongated neck. In web-footed birds, however, and in those other birds[7] belonging

[1] Transpose πτερωτοί . . . τῶν ἄλλων, placing it after the next sentence.

[2] Cf. iv. 6. 682b 17 note.

[3] Cf. ii. 16. 658b 33.

[4] Read ὀστινον ὄν (Y). Not, however, actually bony, but resembling bone in being hard. Cf. ii. 9. 655b 3.

[5] Cf. ii. 12–17.

[6] Read ὑπεναντίον ἂν ἦν τό (P Y b).

[7] Read καὶ τὰ διῃρημένους, and for ὡς ἐν τῷ read καὶ ἐν τῷ. The birds alluded to are the Grebes, Phalaropes, and Coots (the Pinnatipedes of Temminck), in which the toes, as described more distinctly farther on, are bordered with broad membranous lobes. The word in the Greek text (σεσιμωμένους), rendered 'with flat marginal lobes', is literally 'snub-nosed'; the main stem of the toe answering to the ridge of the nose, and the lobes on either side to the flattened nostrils.

to the same class, whose toes though actually separate have flat marginal lobes, the neck is elongated, so as to be suitable for collecting food from the water; while the legs are short, so as to serve in swimming.

The beaks of birds, as their feet, vary with their modes of life. For in some the beak is straight, in others crooked; straight, in those who use it merely for eating; crooked, in those that live on raw flesh. For a crooked beak is an advantage in fighting; and these birds must, of course, get their food from the bodies of other animals, and in most cases by violence. In such birds, again, as live in marshes and are herbivorous the beak is broad and flat, this form being best suited for digging and cropping, and for pulling up plants. In some of these marsh birds, however, the beak is elongated, as too is the neck, the reason for this being that the bird gets its food from some depth below the surface. For most birds of this kind, and most of those whose feet are webbed, either in their entirety or each part separately,[1] live by preying on some of the smaller animals that are to be found in water, and use these parts for their capture, the neck acting as a fishing-rod, and the beak representing the line and hook.

The upper and under sides of the body, that is of what in quadrupeds is called the trunk, present in birds one unbroken surface, and they have no arms[2] or forelegs attached to it, but in their stead wings, which are a distinctive peculiarity of these animals; and, as these wings are sub- 693b
stitutes for arms, their terminal segments lie on the back in the place of a shoulder-blade.[3]

The legs are two in number, as in man; not however, as in man, bent outwards, but bent inwards like the [hind] legs of a quadruped.[4] The wings are bent like the forelegs of

[1] The sense is obvious (see last note), but the true meaning doubtful. I suggest omitting *τό* with Y and for *ταὐτό* reading *τούτοις*, meaning the elongated neck and beak.

[2] Read *καὶ ἔχουσι ἀπηρτημένας*, omitting *ἔχουσι* after *προσθίων* (Y b).

[3] The scapula in birds is a simple elongated bone, not flattened out into a plate or blade, and so was not recognized by A. as a 'blade-bone', just as he did not recognize the astragalus unless it had the form suiting it for use as a 'huckle-bone'.

[4] Cf. *H. A.* ii. 1. 498a 27; *De An. Inc.* 15. 712b 22 sq. A. uses two sets

a quadruped, having their convexity turned outwards. That the feet should be two in number is a matter of necessity. For a bird is essentially a sanguineous animal, and at the same time essentially a winged animal; and no sanguineous animal has more than four points for motion.[1] In birds, then, as in those other sanguineous animals that live and move upon the ground, the limbs attached to the trunk are four in number. But, while in all the rest these four limbs consist of a pair of arms and a pair of legs,[2] or of four legs as in quadrupeds, in birds the arms or forelegs are replaced by a pair of wings, and this is their distinctive character. For it is of the essence of a bird that it shall be able to fly; and it is by the extension of wings that this is made possible. Of all arrangements, then, the only possible, and so the necessary, one is that birds shall have two feet; for this with the wings will give them four points for motion. The breast in all birds is sharp-edged, and fleshy.[3] The sharp edge is to minister to flight, for broad surfaces move with considerable difficulty, owing to the large quantity of air which they have to displace; while the fleshy character

of terms to describe the bendings of the limbs: (1) Forwards and backwards, (2) Inwards and outwards. A limb is said to be bent forwards or backwards when its convexity is turned forwards or backwards; e.g. the leg of a man is bent forwards; so is the foreleg of a horse. But the hind leg of a horse is bent backwards; the arm of a man is bent backwards with a slight inclination to the side. A limb is bent inwards, when its concavity is turned in the direction in which the main bulk of the body lies; outwards when the concavity is turned away from this. Thus both the fore and hind legs of a horse are bent inwards. So also the leg of a bird is bent inwards; but the leg of a man is bent outwards. Cf. *H. A.* ii. 1. 498^a 3–31; *De An. Inc.* 12–15.

It must be remembered that A. knows nothing of the homologies of the various joints. He simply takes the limbs as wholes, and compares the general direction of their main curvature in different animals.

[1] A. rightly says that no sanguineous animal has more than four organs of locomotion, that is, more than four limbs. There are passages from which it might be inferred that he imagined, less correctly, that they never have less than four. But in the *De An. Inc.* (10. 709^b 22) he expressly repudiates such a statement.

[2] Reading *σκέλη τοῖς δὲ τετράποσι σκέλη* (PY).

[3] A. had clearly neither dissected, nor seen the skeleton of, an ostrich. In all other birds known to him the sternum is provided with a keel, and is compared by him (*De An. Inc.* 10. 710^a 31) to the sharp prow of a felucca, reminding one of the term 'Carinatae' now applied to birds with a keeled sternum. By the fleshy covering is of course meant the mass of pectoral muscles.

acts as a protection, for the breast, owing to its form, would be weak, were it not amply covered.

Below the breast lies the belly, extending, as in quadrupeds and in man, to the vent and to the place where the legs are jointed to the trunk.

Such, then, are the parts which lie between the wings and the legs. Birds like all other animals, whether produced viviparously or from eggs, have an umbilicus during their development, but, when the bird has attained to fuller growth, no signs of this remain visible. The cause of this is plainly to be seen during the process of development; for in birds the umbilical cord unites with the intestine, and is not a portion of the vascular system, as is the case in viviparous animals.[1]

Some birds, again, are well adapted for flight, their wings being large and strong. Such, for instance, are those that 694a
have talons and live on flesh. For their mode of life renders the power of flight a necessity, and it is on this account that their feathers are so abundant and their wings so large. Besides these, however, there are also other genera of birds that can fly well; all those, namely, that depend on speed for security, or that are of migratory habits. On the other hand, some kinds of birds have heavy bodies and are not constructed for flight. These are birds that are frugivorous and live on the ground, or that are able to swim and get

[1] It might be supposed from this passage that A. imagined a bird to be developed without an allantois and merely with an umbilical vesicle. But from other passages (*G. A.* iii. 3. 754^b 4; *G. A.* iii. 2. 753^b 20 sq.; *H. A.* vi. 3. 561^b 5) it is plain that this was not the case. He describes the foetal bird and reptile as differing from fishes in having two umbilical appendages, one going to the membrane surrounding the yelk, and serving to introduce the nutriment thence derived, the other (*allantois*) to the membranous expansion which lines the inner surface of the shell. This latter appendage, he says, collapses as the embryonic bird enlarges; while the former with the yelk is drawn back into the abdominal cavity, the walls of which unite together behind it. He had not observed the umbilical vesicle of mammals, which is comparatively small, and shrivels up at an early period of foetal life, and erroneously supposed their allantois to correspond to the umbilical vesicle of birds and reptiles. This error was not corrected till 1667, when Needham discovered the umbilical vesicle of mammals, and recognized its correspondence to that of birds. Neither had A. observed that Amphibia in this matter resemble fishes and not reptiles, with which latter he grouped them.

their living in watery places. In those that have talons the body, without the wings, is small; for the nutriment is consumed in the production of these[1] wings, and of the weapons and defensive appliances; whereas in birds that are not made for flight the contrary obtains, and the body is bulky and so of heavy weight. In some of these heavy-bodied birds the legs are furnished with what are called spurs, which replace the wings as a means of defence. Spurs and talons never co-exist in the same bird. For nature never makes anything superfluous; and if a bird can fly, and has talons, it has no use for spurs; for these are weapons for fighting on the ground, and on this account are an appanage of certain heavy-bodied birds. These latter, again, would find the possession of talons not only useless but actually injurious; for the claws would stick into the ground and interfere with progression. This is the reason why all birds with talons walk so badly, and why they never settle upon rocks.[2] For the character of their claws is ill-suited for either action.

All this is the necessary consequence of the process of development. For the earthy matter in the body issuing[3] from it is converted into parts that are useful as weapons. That which flows upwards gives hardness or size to the beak; and, should any flow downwards, it either forms spurs upon the legs or gives size and strength to the claws upon the feet. But it does not at one and the same time produce both these results, one in the legs, the other in the claws; for such a dispersion of this residual matter would destroy all its efficiency. In other birds this earthy residue furnishes
694b the legs with the material for their elongation; or sometimes, in place of this, fills up the interspaces between the

[1] For *ἐνταῦθα* read *εἰς ταύτας* (Q S U Z); and read *καί* before *εἰς τὰ ὅπλα*.

[2] Birds of prey are awkward movers on the ground or other flat surface, because of their talons, and help themselves along by flapping their wings. But the statement made here and elsewhere (*H. A.* ix. 32. 619b 7) that they very seldom or never settle on rocks is erroneous; they often do so, and indeed rocks are the usual resting-place of many. Moreover, in the Falconidae the claws are retractile, so that they can be elevated at pleasure, and their sharp ends kept from being blunted by contact with any hard body on which the bird may perch.

[3] If the strange word *ἔξορμον* be kept, we may read *ἔξορμον ἐκ τούτου τά* (Y), and suppose the earthy matter making its way out of the body to be compared metaphorically to a ship making its way out of a harbour, but Langkavel's suggested reading *ἔξω ῥυέν* is very probable.

toes. Thus it is simply a matter of necessity,[1] that such birds as swim shall either be actually web-footed, or shall have a kind of broad blade-like margin running along the whole length of each distinct toe. The forms, then, of these feet are simply the necessary results of the causes that have been mentioned. Yet at the same time they are intended for the animal's advantage. For they are in harmony with the mode of life of these birds, who, living on the water, where their wings[2] are useless, require that their feet shall be such as to serve in swimming. For these feet are so developed as to resemble the oars of a boat, or the fins[3] of a fish; and the destruction of the foot-web has the same effect as the destruction of the fins; that is to say, it puts an end to all power of swimming.

In some birds the legs are very long, the cause of this being that they inhabit marshes. I say the cause, because nature makes the organs for the function, and not the function for the organs. It is, then, because these birds are not meant for swimming that their feet are without webs, and it is because they live on ground that gives way under the foot that their legs and toes are elongated, and that these latter in most of them have an extra number of joints.[4] Again, though all birds have the same material composition, they are not all made for flight; and in these, therefore, the nutriment that should go to their tail-feathers is spent on the legs and used to increase their size. This is the reason why these birds when they fly make use of their legs as a tail, stretching them out behind, and so rendering them serviceable, whereas in any other position they would be simply an impediment.[5]

[1] Because the earthy matter has not been used in any other manner, and must be disposed of in some way or other.

[2] For πτερῶν read πτερύγων (Y b).

[3] Read καί before τὰ πτερύγια τοῖς ἰχθύσιν (Y b).

[4] This is erroneous. The number of phalanges is the same in the several toes of Waders as in other birds, though the toes are as a rule longer.

[5] 'These water birds fly with their legs stretched out behind, using them in place of a tail to steer their course.' In the heron, for instance, the tail is short, and the long legs, stretched out in flight, 'seem, like the longer tails of some birds, to serve as a rudder' (Bewick's *Birds*, p. 11).

In other birds, where the legs are short, these are held close against the belly during flight. In some cases this is merely to keep the feet out of the way, but in birds that have talons the position has a further purpose, being the one best suited for rapine. Birds that have a long and a thick neck keep it stretched out during flight; but those whose neck though long is slender fly with it coiled up. For in this position it is protected, and less likely to get broken, should the bird fly against any obstacle.[1]

695a In all birds there is an ischium,[2] but so placed and of such length that it would scarcely be taken for an ischium, but rather for a second thigh-bone; for it extends as far as to the middle of the belly. The reason for this is that the bird is a biped, and yet is unable to stand erect. For if its ischium extended but a short way from the fundament, and then immediately came the leg, as is the case in man and in quadrupeds, the bird would be unable to stand up at all.[3] For while man stands erect, and while quadrupeds have their heavy bodies propped up in front by the forelegs, birds can neither stand erect owing to their dwarf-like shape, nor have anterior legs to prop them up, these legs being replaced by wings.[4] As a remedy for this Nature has given them a long ischium, and brought it to the centre of the body, fixing it firmly; and she has placed the legs under this central point, that the weight on either side may be equally balanced, and standing or progression rendered possible. Such then is the reason why a bird, though it is a biped, does not stand erect. Why its legs[5] are destitute of flesh has also already been stated;[6] for the reasons are the same as in the case of quadrupeds.

[1] The heron in flight rests its very slender neck and head on the back, so that the bill appears to issue from the chest; while the stork, the ibis, the goose, &c., fly with the comparatively stout neck outstretched.

[2] A. uses the term 'ischium' in two senses; firstly, for the fleshy buttocks, and it is with this meaning that he says (iv. 10. 690a 25) that man alone has ischia; secondly, for the bone with which the femur in man, and what he mistakes for the femur in other vertebrates, is articulated at its upper end; and it is with this meaning that he says that birds have long ischia. (Cf. iv. 10. 689b 7 note.)

[3] For ὀρθόν read ὅλως (P Q U).

[4] Read διὰ τοῦτο, πτέρυγας δὲ ἀντ' αὐτῶν (Y).

[5] By σκέλη here are plainly meant not the whole legs, but their tarso-metatarsal segments.

[6] Cf. iv. 10. 689b 7.

In all birds alike, whether web-footed or not, the number of toes in each foot is four.[1] For the Libyan ostrich may be disregarded for the present, and its cloven hoof and other discrepancies of structure as compared with the tribe of birds will be considered further on.[2] Of these four toes three are in front, while the fourth points backwards, serving, as a heel, to give steadiness. In the long-legged birds this fourth toe is much shorter[3] than the others, as is the case with the Crex,[4] but the number of their toes is not increased.[5] The arrangement of the toes is such as has been described in all[6] birds with the exception of the wryneck. Here only two of the toes are in front,[7] the other two behind; and the reason for this is that the body of the wryneck is not inclined forward so much as that of other birds. All birds have testicles; but they are inside the body. The reason for this will be given in the treatise on the Generation of Animals.[8]

13 Thus then are fashioned the parts of birds. But in fishes 695b
a still further stunting has occurred in the external parts. For here, for reasons already given,[9] there are neither legs nor hands nor wings, the whole body from head to tail presenting one unbroken surface. This tail differs in different fishes, in some approximating in character to the fins,[10] while in others, namely in some of the flat kinds, it is spinous and elongated, because the material which should have gone to

[1] This is a general but not universal rule. In some birds, as the great bustard, the Otis of Aristotle, the toes are reduced to three by suppression of the hallux, as in the ostrich they are reduced to two by suppression of both hallux and second digit.

[2] Cf. iv. 14.

[3] The hind toe varies very much in its development in Waders. Usually it is short, as A. correctly says, but sometimes it is as long as, or even longer than, the others.

[4] The Crex was doubtless some bird that derived its name, as does our corn-crake, from its note. But it is uncertain what exact species was thus designated. Cf. D'Arcy Thompson, *Greek Birds*, p. 103.

[5] Although such increase might perhaps have been expected by way of compensation.

[6] Elsewhere (*H. A.* ii. 12. 504a 11) A. says, more correctly, that there are several exceptions besides the wryneck.

[7] Transpose ὄπισθεν and ἔμπροσθεν (Karsch).

[8] *G. A.* i. 4. 717b 4, i. 12.

[9] I cannot say to what passage A. refers. But his explanation of the substitution of fins for limbs is given a little further on in this chapter. See 695b 17.

[10] After παραπλησίαν, by itself unmeaning, read τοῖς πτερυγίοις.

the tail has been diverted thence and used to increase the breadth of the body. Such, for instance, is the case with the Torpedos,[1] the Trygons, and whatever other Selachia there may be of like nature. In such fishes, then, the tail is spinous and long; while in some others it is short and fleshy, for the same reason which makes it spinous and long in the Torpedo. For to be short and fleshy comes to the same thing as to be long and less amply furnished with flesh.

What has occurred in the Fishing-frog[2] is the reverse of what has occurred in the other instances just given. For here the anterior and broad part of the body is not of a fleshy character, and so all the fleshy substance which has been thence diverted has been placed by nature in the tail and hinder portion[3] of the body.

In fishes there are no limbs attached to the body. For in accordance with their essential constitution they are swimming animals; and nature never makes anything superfluous or void of use. Now inasmuch as fishes are made for swimming they have fins,[4] and as they are not made for

[1] The electric rays or Torpedos are found abundantly in the Mediterranean, and must have been well known to A., who frequently speaks of them. Yet in these the tail is far from being spinous and elongated, as compared, that is, with other rays. Frantzius suggests therefore that some error has got into the text, and that perhaps Batos should be read instead of Torpedo. A similar correction would have to be made a few lines farther on. The Trygon is doubtless the *Trygon Pastinaca* or sting-ray, which is abundant in the Mediterranean.

[2] The Fishing-frog (*Lophius piscatorius* or *L. budegassa*) was erroneously classed by A. with Selachia, confounding it with the rays. Into this error he was doubtless led by the somewhat ray-like form of this fish, by the semi-cartilaginous character of its skeleton (Cuvier, *R. An.* iii. 250), and by its naked skin, rough with warts and tubercles. A. did not, however, fail to observe that this fish differed in many important points from the rest of the group; in being, for instance, oviparous (*G. A.* iii. 3. 754a 25); and in having an operculum for its gills, which are themselves placed laterally, not ventrally as in true rays (*H. A.* ii. 13. 505a 5).

[3] For *αὐτό* read *αὐτῶν* (U).

[4] Although A. recognizes the correspondence of the paired fins (i. e. pectorals and ventrals) of fishes to the four limbs of other vertebrates, this recognition is not based on any serious anatomical grounds, as is plain from what he says of the Rays. For he fails to see that the marginal parts of the flattened bodies of these fishes are really the pectorals, but supposes these to have been moved back and to be represented by the (*dorsal*) fins on the tail, which in many rays are two in number. So also he speaks of the serpents, which have no limbs at all, as still resembling the other sanguineous animals, i. e. in having four points of motion. 'For,' says he, 'their flexures are four,' while

walking they are without feet; for feet are attached to the body that they may be of use in progression on land. Moreover, fishes cannot have feet, or any other similar limbs, as well as four fins; for they are essentially sanguineous animals. The Cordylus,[1] though it has gills, has feet, for it has no fins but merely has its tail flattened out and loose in texture.[2]

Fishes, unless, like the Batos and the Trygon, they are broad and flat, have four fins, two on the upper and two on 696a
the under side of the body; and no fish ever has more than these. For, if it had, it would be a bloodless animal.

The upper pair of fins is present in nearly all fishes, but not so the under pair;[3] for these are wanting in some of those fishes that have long thick bodies, such as the eel, the conger, and a certain kind of Cestreus that is found in the lake at Siphae. When the body is still more elongated, and resembles that of a serpent rather than that of a fish, as is the case in the Smuraena,[4] there are absolutely no fins at all; and locomotion is effected by the flexures of the body, the water being put to the same use by these fishes as is the ground by serpents. For serpents swim in water exactly in the same way as they glide on the ground. The reason for these serpent-like fishes being without fins is the same as that which causes serpents to be without feet; and what

in such fishes as have only two fins 'the flexures are two, to replace the missing pair' (cf. *H. A.* i. 5. 490a 30).

[1] Cf. *H. A.* viii. 2. 589b 26. The Cordylus must presumably be the larval form of some triton or newt which retains its gills for a longer period than the generality of tadpoles. Such, says Prof. D'Arcy Thompson, are *Triton alpestris* and *Salamandra atra*. It is strange that A. should not have known that tadpoles are the larval forms of frogs and newts.

[2] Destitute, that is, of fin-rays.

[3] The pectoral fins are, as rightly stated in the text, much more constant than the ventral pair. Even in those elongated eels in which no pectorals are visible externally, rudiments of them are to be found on dissection; whereas not only are the ventral fins more often externally wanting than the pectorals, but their absence is often complete, no rudiment of them appearing on dissection, e. g. in Muraena, Muraenophis, Gymnotus, &c. There are pectoral, but no ventral, fins in the eel, the conger, and the rest of the so-called Apodal Physostomatous fishes. As to the Cestreus, it is impossible to say what fish is here meant. It can scarcely be one of the Mugilidae, though these are the fishes usually called Cestreus by Aristotle.

[4] The Smuraena and Muraena are probably one and the same fish, namely the *Muraena Helena*, common in the Greek seas, and still, according to Erhard, called Smurna or Sphurna.

this is has been already stated in the dissertations on the Progression and the Motion of Animals.[1] The reason was this. If the points of motion were four, motion would be effected under difficulties; for either the two pairs of fins would be close to each other, in which case motion would scarcely be possible, or they would be at a very considerable distance apart, in which case the long interval between them would be just as great an evil. On the other hand, to have more than four such motor points would convert the fishes into bloodless animals. A similar explanation applies to the case of those fishes that have only two fins. For here again the body is of great length and like that of a serpent, and its undulations[2] do the office of the two missing fins. It is owing to this that such fishes can even crawl on dry ground, and can live there for a considerable time; and do not begin to gasp until they have been for a considerable time out of the water, while others, whose nature is akin to that of land-animals, do not even do as much as that.[3] In such fishes as have but two fins it is the upper pair (*pectorals*) that is present, excepting when the flat broad shape of the body prevents this. The fins in such cases are placed at the head, because in this region there is no elongation, which might serve in the absence of fins as a means of locomotion; whereas in the direction of the tail there is a considerable lengthening out in fishes of this conformation. As for the Bati and the like, they use the marginal part of their flattened bodies in place of fins for swimming.[4]

In the Torpedo and the Fishing-frog the breadth of the anterior part of the body is not so great as to render locomotion by fins impossible, but in consequence of it the upper pair (*pectorals*) are placed further back and the under pair (*ventrals*) are placed close to the head, while to compensate for this advancement they are reduced in size so as to be smaller than the upper ones.[5] In the Torpedo the

[1] Cf. *De An. Inc.* 7. 709b 7 sqq. There is no corresponding passage in the *De Motu.* Moreover, that treatise is universally admitted to be spurious. Possibly A. is merely using a longer title than usual to designate his treatise on Progression.

[2] See 695b 20 note.

[3] The text here is so corrupt as only to admit of somewhat conjectural rendering.

[4] The Rays swim as here described. See, however, 695b 20 note.

[5] In the Fishing-frog the ventral fins are, as stated, in advance of

two upper fins (*pectorals*) are placed on the tail,[1] and the fish uses the broad expansion of its body to supply their place, each lateral half of its circumference serving the office of a fin.

The head, with its several parts, as also the organs of sense, have already come under consideration.[2]

There is one peculiarity which distinguishes fishes from all other sanguineous animals, namely, the possession of gills. Why they have these organs has been set forth in **696b**
the treatise on Respiration.[3] These gills are in most fishes covered by opercula, but in the Selachia, owing to the skeleton being cartilaginous, there are no such coverings. For an operculum requires fish-spine for its formation, and in other fishes the skeleton is made of this substance, whereas in the Selachia it is invariably formed of cartilage. Again, while the motions of spinous fishes are rapid, those of the Selachia are sluggish, inasmuch as they have neither fish-spine nor sinew; but an operculum requires rapidity of motion, seeing that the office of the gills is to minister as it were to expiration.[4] For this reason in Selachia the branchial orifices themselves effect their own closure, and thus there is no need for an operculum to ensure its taking place with due rapidity.[5] In some fishes the gills are numerous, in others few in number; in some again they are double, in others single. The last gill in most cases is single.[6] For

the pectorals and smaller than these. It is quite true that when the ventrals are advanced forwards, so as to become jugular, they are as a rule, if not invariably, reduced in size; and they are also, as a rule, modified in such a way as to serve new purposes, to act, for instance, as instruments of touch. Cf. *Ann. d. Sci. Nat.*, 1872, t. xvi. p. 93.

[1] Cf. 695b 20 note.

[2] Namely, in the latter part of the second book and beginning of the third book.

[3] *De Resp.* 10. 476a 1 sq., and 21. 480b 13.

[4] A. says, minister 'as it were' to expiration; for expiration is limited by him to the expulsion of air from a lung after inspiration. The expulsion of water through gills is analogous to this, but not the same thing.

[5] In these cartilaginous fishes there is no gill-cover; the gills being placed in a series of distinct sacs or pouches, each of which has its own separate slit-like aperture, which is closed during inhalation by its own muscular sphincter.

[6] In the Elasmobranchii or cartilaginous fishes there are five, and in osseous fishes four, gills on either side as a rule. But the number is subject to some variations. Each gill consists, as a rule, of a double row of leaflets. But it is by no means uncommon for the last, that is the fourth, gill in an osseous fish to be, as A. says, furnished with only a single row, e.g. Scarus, Scorpaena, Cottus, most Labroids, &c.

a detailed account of all this, reference must be made to the treatises on Anatomy, and to the book of Researches concerning Animals.[1]

It is the abundance or the deficiency of the cardiac heat which determines the numerical abundance or deficiency of the gills. For, the greater an animal's heat, the more rapid and the more forcible does it require the branchial movement to be;[2] and numerous and double gills act with more force and rapidity than such as are few and single. Thus, too, it is that some fishes that have but few gills, and those of comparatively small efficacy, can live out of water for a considerable time; for in them there is no great demand for refrigeration. Such, for example, are the eel and all other fishes of serpent-like form.

Fishes also present diversities as regards the mouth. For in some this is placed in front, at the very extremity of the body, while in others, as the dolphin[3] and the Selachia, it is placed on the under surface; so that these fishes turn on the back in order to take their food. The purpose of Nature in this was apparently not merely to provide a means of salvation for other animals, by allowing them opportunity of escape during the time lost in the act of turning—for all the fishes with this kind of mouth prey on living animals—but also to prevent these fishes from giving way too much to their gluttonous ravening after food.[4] For had they been

[1] Cf. *H. A.* ii. 13. 504^b 28–505^a 20.

[2] Because the hotter an animal is, the more perfect must be the arrangements for its refrigeration.

[3] Seeing that dolphins abound in the Mediterranean, and that the main points in their structure, and their habits of life, are accurately enough described by Aristotle, it seems to me quite impossible either that he can have imagined their mouth to be underneath their body, or, as has been suggested, confounded them with the larger sharks. I agree therefore with Frantzius that the word dolphins in the text is probably an interpolation; and this notwithstanding the objection to that view taken by Meyer, namely, the fact that the same false statement occurs elsewhere (*H. A.* viii. 2. 591^b 26). The same transcriber who made the addition to the text in the one place may very possibly have made it in the other.

[4] This is, so far as I know, the only place where A. speaks of the structure of an animal as intended for the advantage of other animals than itself. Elsewhere he always speaks of the organs as given to animals to be of service to themselves. 'Nature never gives an organ to an animal except when it is able to make use of it.' Even here he considers the habit in question to be of use to its possessor, and only speaks doubtfully of its being intended as a means of salvation to others.

able to seize their prey more easily than they do, they would soon have perished from over-repletion. An additional reason is that the projecting extremity of the head in these fishes is round and small, and therefore cannot admit of a wide opening.

Again, even when the mouth is not placed on the under surface, there are differences in the extent to which it can open. For in some cases it can gape widely, while in others it is set at the point of a small tapering snout; the former 697a being the case in carnivorous fishes, such as those with sharp interfitting teeth, whose strength lies in their mouth, while the latter is its form in all such as are not carnivorous.

The skin is in some fishes covered with scales (the scale of a fish is a thin and shiny film, and therefore easily becomes detached from the surface of the body[1]). In others it is rough, as for instance in the Rhine, the Batos[2], and the like. Fewest of all are those whose skin is smooth. The Selachia have no scales, but a rough skin. This is explained by their cartilaginous skeleton. For the earthy material which has been thence diverted is expended by nature upon the skin.

No fish has testicles[3] either externally or internally; as indeed have no apodous animals, among which of course are

[1] This parenthesis appears to be a note introduced to point out the difference between the scale of a fish (λεπίς) and the scale of a reptile (φολίς); the former thin and quite superficial, so as to be easily rubbed off, the latter thicker and set more firmly in the skin. It is strange that λαμπρότης should be assigned as a cause of easy detachment, unless 'shiny' is supposed to connote 'superficial'. Perhaps, however, for λαμπρότητα should be read **μαλακότητα**.

[2] The Batus is indisputably a Ray. The Rhine is usually identified with the Angel-fish (*R. Squatina*), but much more probably is some other shark in shape like a dog-fish; while the Angel-fish is the Rhinobates, said (*H. A.* vi. 11. 566a 28) to be in the fore part like the Batus and in the hind part like the Rhine, and supposed to be a cross between the two. It 'has a form and appearance intermediate between the Sharks and Rays' (Seeley).

[3] That is to say they have no solid organ of the globular or ovoid shape which characterizes the testes of Mammalia, birds, and most reptiles. This is all that A. can mean; for he was perfectly aware that the milt was an organ from which the male fish secreted sperm; and he states, in opposition to those who held that there were no males among osseous fishes, that the ova of the female fish come to nothing unless the male voids the secretion of this milt upon them (*G. A.* iii. 1. 750b 15; *H. A.* vi. 14. 568b 6). He refuses, however, to call these saccular organs 'testes', because of their shape and of their being hollow, and styles them spermatic tubes (πόροι) or roe (θορικά). He supposed (*G. A.* i. 4) that these saccular spermatic tubes or roe, as

included the serpents. One and the same orifice serves both for the excrement and for the generative secretions,[1] as is the case also in all other oviparous animals, whether two-footed or four-footed,[2] inasmuch as they have no urinary bladder and form no fluid excretion.[3]

Such then are the characters which distinguish fishes from all other animals. But dolphins and whales and all such Cetacea are without gills; and, having a lung, are provided with a blow-hole; for this serves them to discharge the sea-water which has been taken into the mouth.[4] For, feeding as they do in the water, they cannot but let this fluid enter into their mouth, and, having let it in, they must of necessity let it out again. The use of gills, however, as has been explained in the treatise on Respiration,[5] is limited to such animals as do not breathe; for no animal can possibly possess gills and at the same time be a respiratory animal. In order, therefore, that these Cetacea may discharge the water, they are provided with a blow-hole. This

also the elongated testes of serpents, corresponded not to the solid globular or ovoid organs of birds, reptiles, and mammals, but to the tubular *vasa deferentia*; and it was to these latter that he erroneously ascribed the seminal secretion. The ovoid or globular bodies he thought were merely parts superadded, when the secreting spermatic tubes became very long and complicated, for certain mechanical purposes, which are set forth by him. His account of the seminal organs of fishes seems to have been taken from osseous fishes; for in the rays and sharks, that is to say in his Selachia, the testes are compact oval bodies (cf. Huxley, *Vert.* p. 135).

[1] In birds, reptiles, amphibians, there is a cloaca, i. e. a common chamber into which open the rectum and the genital organs, as also the urinary, though the latter escaped A.'s notice. Thus in these animals the faeces and the generative products are voided by one and the same orifice. There is also a cloaca in the Plagiostomous fishes, or Selachia of Aristotle. But though the statement in the text so far is true, it is erroneous as regards other fishes. For in these the anus is distinct from the generative orifice or abdominal pore.

[2] Read *καὶ δίποδα καὶ τετράποδα*.

[3] The meaning must be: 'If there were urinary organs and external urinary orifice, the generative secretions would be discharged by this. But as there is none, these secretions are discharged by the anus.'

[4] The like statement is often enough made nowadays, but is incorrect. The sea-water taken into the mouth has no access to the respiratory passages and blow-hole, owing to the peculiar arrangement by which the elongated trachea and larynx are continuous with the tubular prolongation of the nasal passage formed by the soft palate. The 'spouting' is due to the sudden condensation of expired vapour, and to spray driven up by the force of the expiration, when this begins before the animal has quite reached the surface.

[5] *De Resp.* 10. 476a 1 sq.; 21. 480b 13.

is placed in front of the brain; for otherwise it would have cut off the brain from the spine.[1] The reason for these animals having a lung and breathing, is that animals of large size require an excess of heat, to facilitate[2] their motion. A lung, therefore, is placed within their body, and is fully supplied with blood-heat. These creatures are after a fashion land and water animals in one. For so far as they are inhalers of air they resemble land-animals, while they resemble water-animals in having no feet and in deriving their food from the sea. So also seals lie half-way between 697b
land and water animals, and bats half-way between animals that live on the ground and animals that fly; and so belong to both kinds or to neither. For seals, if looked on as water-animals, are yet found to have feet; and, if looked on as land-animals, are yet found to have fins.[3] For their hind feet are exactly like the fins of fishes; and their teeth also are sharp and interfitting[4] as in fishes. Bats again, if regarded as winged animals, have feet; and, if regarded as quadrupeds, are without them.[5] So also they have neither the tail of a quadruped nor the tail of a bird; no quadruped's tail, because they are winged animals; no bird's tail, because they are terrestrial. This absence of tail is the result of necessity. For bats fly by means of a membrane, but no animal, unless it has barbed feathers, has the tail of a bird; for a bird's tail is composed of such feathers.

[1] As to continuity of brain and spinal cord, and its supposed purpose, cf. ii. 7. 652a 30.

[2] Heat is the instrument of the soul in motion, as in all operations. Cetacea, therefore, that move actively must have much heat; and this again necessitates a perfect organ to regulate heat, and such is the lung.

[3] For πτέρυγας read πτερύγια.

[4] *H. A.* ii. 1. 501a 21. In the seals, says Owen (*Odontog.* i. 506), 'the coadaptation of the crowns of the upper and lower teeth is more completely alternate than in any of the terrestrial Carnivora, the lower teeth always passing into the interspace anterior to its fellow in the upper jaw.'

[5] A. means that the anterior limbs of bats though they are wings yet have claws, and so resemble feet and are unlike the wings of a bird; but at the same time they do not so closely resemble the fore-limbs of a quadruped as to make the bat strictly quadrupedous. A. knew that bats are viviparous and suckle their young; for he speaks of these animals as having cotyledons in their uterus (*H. A.* iii. 1. 511a 31 sq.), and groups them with the hare and the rat among viviparous animals with teeth in both jaws.

As for a quadruped's tail, it would be an actual impediment, if present among the feathers.

Much the same may be said also of the Libyan ostrich. 14
For it has some of the characters of a bird, some of the characters of a quadruped. It differs from a quadruped in being feathered; and from a bird in being unable to soar aloft, and in having feathers that resemble hair and are useless for flight.[1] Again, it agrees with quadrupeds in having upper eyelashes,[2] which are the more richly supplied with hairs because the parts about the head and the upper portion of the neck are bare;[3] and it agrees with birds in being feathered in all the parts posterior to these. Further, it resembles a bird in being a biped, and a quadruped in having a cloven hoof; for it has hoofs and not toes.[4] The explanation of these peculiarities is to be found in its bulk, which is that of a quadruped rather than that of a bird. For, speaking generally, a bird must necessarily be of very small size. For a body of heavy bulk can with difficulty be raised into the air.

Thus much then as regards the parts of animals. We have discussed them all, and set forth the cause why each exists; and in so doing we have severally considered each group of animals. We must now pass on, and in due sequence must next deal with the question of their generation.

[1] In the ostrich and other Ratitae the barbs of the feathers are disconnected, so that they come to resemble long hairs, and, owing to their want of firmness, are useless for flight.

[2] Cf. ii. 14. 658a 13 note.

[3] The head and neck are naked, or covered with only a short downy plumage. Cf. ii. 9. 655a 28 note.

[4] The foot of the ostrich has two stout toes, connected at the base by a strong membrane. Of these toes the internal is much the larger, and is furnished with a thick hoof-like claw, but the external and smaller toe is clawless. Aristotle had probably never himself seen an ostrich; for, had he done so, he would scarcely have spoken of its foot as having two hoofs. That the ostrich is a kind of link, uniting birds with mammals, is not a fancy confined to Aristotle. The vulgar opinion in Arabia still makes it the product of a camel and a bird, as in the days when it got the name, already used for it by Pliny, of Struthio-camelus. The height of the bird, its long neck, its bifid foot, its frequentation of the desert, its patient endurance of thirst, and possibly the comparative complexity of its digestive organs, were doubtless the grounds of this strange notion.

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39^{a}—97^{b} = 639^{a}—697^{b}

The English version clearly cannot tally line for line with the Berlin Greek text; it tallies, however, pretty closely with it at the lines marked 5, 10, 15 &c. In the following Index, the matter intervening between two

ERRATA

666^{b} 10 note 4. *Before* Under νεῦρα *read* Meaning the *Chordae tendineae* (H. A. iii. 5. 515^{a} 25). *and omit reference after* A. included

680^{a} 15 note 3. *For* this surface *read* the surface

693^{a} 20 note 1. *For* true meaning *read* true reading

In Index: under Birds, at line 5 for *ib.* read 92^{b}
under Heart, at line 26 for *ib.* read 66^{b}

Aristotle Translation: de Partibus Animalium.
March 1911. (*At end*)

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DE MOTU ANIMALIUM

DE INCESSU ANIMALIUM

BY

A. S. L. FARQUHARSON

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M. S.

IOHANNIS LANGHORNE A.M.

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PREFACE

THESE translations have been made from Bekker's text (Berlin, 1831) with the help of the critical apparatus there given, of photographic facsimiles of the manuscripts E and Y for *de Motu*, and of U for *de Incessu*, as well as the C.C.C. Oxon. MS. of the latter treatise (Bekker's Z). I have noted some readings from an *antiqua uersio* of both tracts (Ball. Coll. MS. CCL) of the late XIIIth century. I refer to it as Γ, though the text on which it is based is not the same for both *de Motu* and *de Incessu*, nor is the Latin by the same translator. The pages of the Berlin edition are given in the margin.

The commentary of Michael Ephesius (Comm. in Arist. Graeca, xxii. 2, Hayduck, 1904) has been some help for the text of both treatises, occasionally for the interpretation. In a small measure this holds also of Alexander Aphrodisias' *de Anima* (Supp. Arist. ii. 1, Bruns). Of the MSS. E and Z are the oldest, Γ is independent though approaching Z very closely in the last part of *de Incessu*, U and S are akin, Y is copied from E and a MS. very like Z, P has preserved some good variants. The paraphrase of *de Motu* by Albertus Magnus (Opp. ix. 2, Borgnet, 1890), derived from a Greek original ('in Campania nobis iuxta Graeciam iter agentibus peruenit ad manus nostras libellus Aristotelis *de motibus anim*[m].'), throws some light on the text. It is referred to as A.M. in the notes. I have used with profit the Latin translation of Nicolaus Leonicus Thomaeus (ob. A.D. 1533), an Aristotelian scholar who evidently made use of more than one MS. Isaac Casaubon speaks ill of his Aristotelian labours (*de Enthusiasmo*, ch. vi), but I venture rather to agree with Wyttenbach's praise of his elegance and learning (*Opuscula*, i. 363). I have also read Bernardino Crippa's Latin translation and notes (A.D. 1566). St. Hilaire's French rendering and notes are useful for the general sense.

Authorities differ as to the genuineness of *de Motu*, the more modern opinion inclining to accept it. It certainly gives, except in one difficult passage, the exact doctrine of Aristotle, and I hope that the rather full references I have given will show this. I have defended its genuineness, with especial regard to the remarkable doctrine of ch. x, in a paper communicated to the Oxford Philological Society, a paper favourably received by the scholars then present.

I have to thank Dr. Günther, Fellow of Magdalen College, who kindly read my MSS., for valuable criticisms from the naturalist's point of view. It was difficult to resist the temptation to make the notes fuller in this connexion. Mr. W. D. Ross, Fellow of Oriel College, has done the same by the rendering of the actual Greek. I am very sensible of his patience and accuracy as well as of his learning. I have also had the advantage, in the critical estimate of the text, of one evening with the Oxford Philological, and of two with the Oxford Aristotelian Society. My thanks are also given to Mrs. New and to Mr. F. J. Routledge of New College, who made for me transcripts of the Latin Version; to my friend Monsieur R. Simeterre, for his generous labour in Paris; to Rev. H. M. Bannister of Pembroke College, who helped me in Rome; and to Corpus Christi and Balliol Colleges for the loan of MSS. The little book is dedicated to the memory of my old schoolmaster. He died just as I had finished. Whiston's successor at Rochester, the descendant of Plutarch's translator, by his stern judgement and nice taste first opened to me the Greek and Roman Classics. I could wish that this interpretation were exact enough to have disarmed his inveterate prejudice against Oxford versions.

OXFORD,
June, 1912.

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DE INCESSU ANIMALIUM

DE MOTU ANIMALIUM

1 ELSEWHERE we have investigated in detail[1] the movement of animals after their various kinds, the differences between them, and the reasons for their particular characters (for some animals fly, some swim, some walk, others move in various other ways); there remains an investigation of the common ground[2] of any sort of animal movement whatsoever. 698a

Now we have already determined (when we were discussing[3] whether eternal motion exists or not, and its definition, if it does exist) that the origin of all other motions is that which moves itself, and that the origin[4] of this is the immovable, and that the prime mover must of necessity be immovable. And we must grasp this not only generally in theory,[5] but also by reference to individuals in the world of sense, for with these in view we seek general theories, and with these we believe that general theories ought to harmonize.[6] Now in the world of sense too it is plainly impossible for movement to be initiated if there is nothing at rest, and before all else in our present subject—animal life.[7] For if one of the parts of an animal be moved,

[1] e.g. *P.A.* iv. 10–14 and *de Inc. Anim.* (the latter treatise being a section of the former work and presupposed in *de Motu Anim.*).

[2] The full title seems to have been περὶ τῆς κοινῆς κινήσεως τῶν ζῴων (704b 2), cf. the last words in some MSS. of *de Divinatione per Somnum*; or ἡ κοινὴ αἰτία τῆς τῶν ζῴων κινήσεως (782a 21), *de causa motus animalium*. That is, On animal movement in general; or The general ground of animal movement. (Cf. *P.A.* 646a 10.) Movements had been reduced in the *Physics* to a primary kind, Thrusts and Pulls, i.e. Translation; this treatise discusses the origination of such primary movements in the animate body; they are referred to a central original, the heart, and that is the organ of the soul.

[3] Cf. *de Anim.* iii. 2, 9, 10; *Physics*, viii. 5; *Metaph.* xii. 7 and 8.

[4] Leg. τούτου EYPΓ, Mich. Eph., Leonicus. (Zeller, *Arist.* Eng. trans. ii. 492.) Cf. *Physics*, 252b 1 πάντων δὲ τὸ ἀκίνητον: *Met.* 1072b 7.

[5] P and Mich. om. καθόλου, but vid. *G.A.* 729a 24.

[6] Zeller finds in this an exaggeration of A.'s empirical attitude; cf. however *Parv. Nat.* 468a 23; *G.A.* 760b 28, 788b 19. Bon. Index 177a 45.

[7] Cf. *Physics*, 259b 1 φανερῶς.

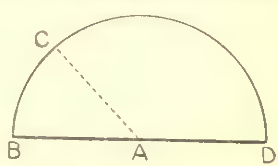
another must be at rest, and this is the purpose of their joints;[1] animals use joints like a centre,[2] and the whole member, in which the joint is, becomes both one and two,[3] both straight and bent, changing potentially and actually by reason of the joint. And when it is bending and being moved one of the points in the joint is moved and one is at rest, just as if the points A and D of a diameter were at rest, and B were moved, and DAC were generated.[4] However, in the geometrical illustration, the centre is held to be altogether indivisible (for in mathematics motion is a fiction, as the phrase goes, no mathematical entity being really moved),[5] whereas in the case of joints the centres become now one potentially and divided actually, and now one
698b actually and divided potentially. But still the origin[6] of movement, qua origin, always remains at rest when the lower part of a limb is moved; for example, the elbow joint, when the forearm[7] is moved, and the shoulder, when the whole arm; the knee when the tibia is moved, and the hip when the whole leg. Accordingly it is plain that each animal as a whole must have within itself a point at rest, whence will be the origin of that which is moved, and supporting itself upon which[8] it will be moved both as a complete whole and in its members.

[1] Cf. *de Inc. Anim.* 3 and 9.

[2] Cf. *de Anim.* 433^b 26; *P. A.* 654^b 1 (ἵνα χρῆται ἡ φύσις καὶ ὡς ἑνὶ καὶ συνεχεῖ, καὶ ὡς δυσὶ καὶ διῃρημένοις πρὸς τὴν κάμψιν), where there is an account of various types of joint.

[3] Cf. *de Anim.* 427^a 10 and *infra*, 702^a 30.

[4] Leg. γίνοιτο ἡ ΔΑΓ (Prof. J. C. Wilson). The Diagram contemplated is given by Mich. Eph.:
DB, the whole arm.
AC, the forearm (cf. radius).
DA, the humerus.
A, the elbow.



[5] Leg. κινεῖσθαι EYSΓ. Cf. *Physics*, 193^b 34; *Met.* 989^b 32, 1064^a 30, &c.

[6] ἀρχή used for *terminus a quo* or origin; source of movement or original, sometimes with a suggestion of rule or command, or seat of government. In this treatise it is most often translated 'original'.

[7] βραχίων loosely for πῆχυς. The Greeks did not speak of forearm, but lower arm. Later προπήχιον (Poll. ii. 142) was used for the ulna, by contrast with παραπήχιον (radius). A. here is thinking of the movement of the ulna.

[8] Cf. *de Inc.* 705^a 5; *Met.* 1040^b 10. For the notion of something external against which the moving body must support itself (a notion

2 But the point of rest in the animal is still quite ineffectual unless there be something without which is absolutely at rest and immovable. Now it is worth while to pause and consider what has been said, for it involves a speculation which extends beyond animals even to the motion and march of the universe.[1] For just as there must be something immovable within the animal, if it is to be moved, so even more must there be without it something immovable, by supporting itself upon which that which is moved moves. For were that something always to give way (as it does for mice[2] walking in grain or persons walking in sand) advance would be impossible, and neither would there be any walking unless the ground[3] were to remain still, nor any flying or swimming were not the air and the sea to resist. And this which resists must needs be different from what is moved, the whole of it from the whole of that, and what is thus immovable must be no part of what is moved; otherwise there will be no movement.[4] Evidence of this lies in the problem why it is that a man easily moves a boat[5] from outside, if he push with a pole, putting it against the mast or some other part, but if he tried to do this when in the boat itself he would never move it, no not giant Tityus himself nor Boreas[6] blowing from inside the ship, if he really were blowing in the way painters represent him; for they paint him sending the breath out from the boat. For

more fully developed in *de Motu* than elsewhere, though accepted in *de Inc.*) we may compare A.'s general doctrines of the moving universe, and of sense perception (e.g. *de Anim.* 417a 4 ἄνευ τῶν ἔξω οὐ ποιοῦσιν αἴσθησιν).

[1] Cf. *Met.* 1072b 14.

[2] Leg. οἷον τοῖς μυσὶ ἐν τῇ ζειᾷ ἢ τοῖς ἐν τῇ ἄμμῳ πορευομένοις (ἐν τῇ . . . E). Mich. had γῇ but did not understand it; in his Commentary to *de. Inc.* (p. 138. 18) he illustrates the same point by βάδισις εἰς ἄλω πλήρη κέγχρου.

[3] i.e. the ground beneath their feet; Mich. is mistaken here in speaking of the immobility of the Earth; cf. *de Inc.* 705a 9, where A. speaks of the *relative* stability of the ground.

[4] In all this discussion A. obviously intends 'relative' movement and 'relative' equilibrium.

[5] For the illustration of the boat cf. *Phys.* 254b 30.

[6] Cf. *Meteor.* 349b 1. Mich. says the representation of Winds in this way was very familiar. The point requires the wind-god to be *in* a boat. I cannot find any trace of such representation in ancient art, nor any other literary reference to such representation (cf. *de Inc.* 711a 2 note). Leg. αὐτοῦ, with Γ viz. τοῦ πλοίου.

whether one blew gently or so stoutly as to make a very 699a great wind, and whether what were thrown or pushed were wind or something else, it is necessary in the first place to be supported upon one of one's own members which is at rest and so to push, and in the second place for this member, either itself, or that of which it is a part, to remain at rest, fixing itself against something external to itself.[1] Now the man who is himself in the boat, if he pushes, fixing himself against the boat, very naturally does not move the boat, because what he pushes against should properly remain at rest. Now, what he is trying to move, and what he is fixing himself against is in his case the same. If, however, he pushes or pulls from outside he does move it, for the ground is no part of the boat.

3 Here we may ask the difficult question whether if something moves the whole heavens this mover must be immovable,[2] and moreover be no part of the heavens, nor in the heavens. For either it is moved itself and moves the heavens, in which case it must touch something immovable in order to create movement, and then this is no part of that which creates movement; or if the mover is from the first immovable it will equally be no part of that which is moved. In this point at least they argue correctly who say [3] that as the Sphere is carried round in a circle no single part remains still, for then either the whole would necessarily stand still or its continuity be torn asunder;[4] but they argue less well in supposing that the poles have a certain force, though conceived as having no magnitude, but as merely termini or points. For besides the fact that no such things have any substantial existence it is impossible for a single movement to be initiated by what is twofold;[5] and

[1] Curiously enough he does not in this treatise give a general reason for this; cf. *G. A.* 768b 18 *ὅλως τὸ κινοῦν ἔξω τοῦ πρώτου ἀντικινεῖταί τινα κίνησιν, οἷον τὸ ὠθοῦν ἀντωθεῖταί πως καὶ ἀντιθλίβεται τὸ θλῖβον.*

[2] Leg. *εἶναί τε δεῖ ἀκίνητον καὶ τοῦτο, καὶ μηθὲν. . . .*

[3] *οἱ λέγοντες*, probably some of the Physicists (*Phys.* 193b 29). Possibly these were Pythagoreans (*de Anim.* 405a 32; *de Caelo*, 293b 33). The Sphere is that of the fixed stars (*Met.* xii. 8; *de Caelo*, ii. 6).

[4] Cf. *de Caelo*, 290a 6.

[5] Cf. *Phys.* 259a 18.

yet they make the poles two. From a review of these difficulties we may conclude that there is something so related to the whole of Nature, as the earth is to animals and things moved by them.

And the mythologists with their fable of Atlas[1] setting his feet upon the earth appear to have based the fable upon intelligent grounds. They make Atlas a kind of diameter[2] twirling the heavens about the poles. Now as the earth remains still this would be reasonable enough, but their theory involves them in the position that the earth is no part of the universe. And further the force of that which initiates movement must be made equal to the force of that which remains at rest. For there is a definite quantity of force or power by dint of which that which remains at rest does so, just as there is of force by dint of which that which initiates movement does so; and as there is a necessary proportion between opposite motions, so there is between absences of motion. Now equal forces are unaffected by one another, but are overcome by a superiority of force. And so in their theory Atlas, or whatever similar power 699b
initiates movement from within, must exert no more force than will exactly balance the stability of the earth—otherwise the earth will be moved out of her place in the centre of things. For as the pusher pushes so is the pushed pushed, and with equal force. But the prime mover moves that which is to begin with at rest, so that the power it exerts is greater, rather than equal and like to the power which produces absence of motion in that which is moved. And similarly[3] also the power of what is moved and so moves must be greater than the power of that which is moved but does not initiate movement. Therefore the force of the earth in its immobility will have to be as great as the force of the whole heavens, and of that which moves

[1] Atlas, cf. *Met.* 1023^a 20 (where the believers in Atlas are said to be poets and some physicists). Bacon approves A.'s 'very elegant interpretation' of this ancient fable, *de Aug.* iv. 4.

[2] Diameter, rather radius. The Greeks had no word except *ἡ ἡμίσεια διάμετρος* for radius.

[3] Leg. *ἡ τοῦ κινουμένου ⟨καὶ κινοῦντος τῆς τοῦ κινουμένου⟩ μὲν μὴ κινοῦντος δέ.*

the heavens. But if that is impossible,[1] it follows that the heavens cannot possibly be moved by any force of this kind inside them.

There is a further difficulty about the motions of the parts of the heavens[2] which, as akin to what has gone before, may be considered next. For if one could overcome by force of motion the immobility of the earth he would clearly move it away from the centre. And it is plain that the power from which this force would originate will not be infinite, for the earth is not infinite[3] and therefore its weight is not. Now there are more senses than one of the word 'impossible'.[4] When we say it is impossible to see a sound, and when we say it is impossible to see the men in the moon,[5] we use two senses of the word; the former is of necessity, the latter, though their nature is to be seen, cannot as a fact be seen by us. Now we suppose that the heavens are *of necessity* impossible to destroy and to dissolve,[6] whereas the result of the present argument would be to do away with this necessity. For it is natural and possible for a motion to exist greater than the force by dint of which the earth is at rest, or than that by dint of which Fire and Aether[7] are moved. If then there are superior motions, these will be dissolved in succession by one another: and if there actually are not, but might possibly be (for the earth cannot be infinite[8] because no body can possibly be infinite), there is a possibility[9] of the heavens being dissolved. For what is 4

[1] Cf. *de Caelo*, 298a 19; *Meteor.* 340a 7, 352a 27 for the small size of the Earth by comparison with the universe.

[2] Heavens, i. e. universe; cf. Bonitz, *Index*, 541b 56.

[3] Cf. *Phys.* iii. 5.

[4] Cf. *Phys.* 204a 4; *de Anim.* 422a 27.

[5] The men in the moon were a belief of the Pythagoreans, and were connected with the fiery element. (Cf. Aet. *Plac.* ii. 30; Diels, *Doxographi*, p. 361; and Galen, *Hist. Phil.* 70.) Some Stoics thought the souls of the departed dwelt here, 'circa lunam (dormitio nostra) cum Endymionibus Stoicorum,' Tert. *de Anim.* 55. It is merely an illustration here, due perhaps to a commentator. For animals in the moon cf. *G.A.* 761b 22. A.M. uses the sun's rays to illustrate the point.

[6] Cf. *Phys.* viii. 1 et seq.; *de Caelo*, i. 10–12, ii. 1.

[7] ἄνω σῶμα, i. e. the aether. Mich. takes it to mean οὐρανός in the limited sense. Cf. *de Caelo*, 270b 22; *Meteor.* 340b 6; *de Mundo*, 392a 5; *G.A.* 736b 29.

[8] Cf. *Phys.* iii. 5; *de Caelo*, i. 12.

[9] Cf. *Phys.* 203b 30; *de Caelo*, i. 5.

to prevent this coming to pass, unless it be impossible? And it is not impossible unless the opposite is necessary. This difficulty, however, we will discuss elsewhere.[1]

To resume, must there be something immovable and at rest outside of what is moved, and no part of it, or not? And must this necessarily be so also in the case of the universe? Perhaps it would be thought strange were the origin of movement inside. And to those who so conceive it the word of Homer[2] would appear to have been well spoken:

'Nay, ye would not pull Zeus, highest of all, from heaven 700a
to the plain, no not even if ye toiled right hard; come, all ye gods and goddesses! Set hands to the chain'; for that which is entirely immovable cannot possibly be moved by anything. And herein lies the solution[3] of the difficulty stated some time back, the possibility or impossibility of dissolving the system of the heavens, in that it depends from an original which is immovable.

Now in the animal world there must be not only an immovable without, but also within[4] those things which move in place, and initiate their own movement. For one part of an animal must be moved, and another be at rest, and against this the part which is moved will support itself and be moved; for example, if it move one of its parts; for one part, as it were, supports itself against another part at rest.[5]

But about things without life which are moved one might ask the question whether all contain in themselves both that which is at rest and that which initiates movement, and whether they also, for instance fire, earth, or any other inanimate thing,[6] must support themselves against something outside which is at rest. Or is this impossible and must it not be looked for rather[7] in those primary causes by which

[1] Cf. *Phys.* Book VIII, *passim*; *de Caelo*, Book I.

[2] *Iliad*, viii. 21 (wrongly quoted *more A.* in order and words). Cf. *Met.* xii. 8; Theophrastus, *Met.* Br. 310b 16 (Usener vb 17).

[3] Mich. records a variant *δύεται* for *λύεται*, which shows that a difficulty was felt.

[4] Viz. ultimately the central part of the heart.

[5] Cf. ch. 1, *supra*; *de Inc. Anim. passim.*

[6] For a discussion of the movement of inorganic bodies cf. *Phys.* viii. 4; *de Caelo*, 311a 12.

[7] Leg. ἀλλ' ὑφ' ὧν PΓ, Mich. (Leonicus, sed).

they are set in motion? For all things without life are moved by something other, and the origin of all things so moved are things which move themselves. And out of these we have spoken[1] about animals (for they must all have in themselves that which is at rest, and without them that against which they are supported); but whether there is some higher and prime mover is not clear, and an origin of that kind involves a different discussion.[2] Animals at any rate which move themselves are all moved supporting themselves on what is outside them, even when they inspire and expire; for there is no essential difference between casting a great and a small weight, and this is what men do when they spit and cough and when they breathe in and breathe out.[3]

But is it only in that which moves itself in place that **5**
there must be a point at rest, or does this hold also of that which causes its own qualitative changes, and its own growth?[4] Now the question of original generation and decay is different; for if there is, as we hold, a primary movement,[5] this would be the cause of generation and decay,[6] and probably of all the secondary movements too. And as in the universe, so in the animal world this is the primary movement, when the creature attains maturity;[7] and therefore it is the cause of growth, when the creature becomes[8] the cause of its own growth, and the cause too of alteration. But[9] if this is not the primary movement then

[1] Mich. refers to *P. A.*, i.e. *de Inc.* ch. 3, &c.; cf. *supra*, ch. 2.

[2] e.g. *Met.* xii. 8.

[3] For respiration as movement cf. *Phys.* 243b 12 (where πτύσις is held to be cognate). Marc. Antonin. *Comm.* ii. 2 (τὸ πνεῦμα) πάσης ὥρας ἐξεμούμενον καὶ πάλιν ῥοφούμενον.

[4] i.e. does the aforesaid principle hold also of the two subordinate species of κίνησις? (ἡ κατὰ μέγεθος = αὔξησις, and ἡ κατὰ πάθος = ἀλλοίωσις). Cf. *de Anim.* 406a 10; *Phys.* viii. 7; *Met.* 1069b 12, 1088a 32.

[5] i.e. motion in place or translation; cf. *Phys.* viii. 7 et seq.; Generation and Decay are not properly motions though sometimes loosely termed such (cf. *G. A.* i. 4; *de Anim.* 406a 12). They depend upon primary movements.

[6] Del. comma after φθορᾶς (with Leonicus),—[here as elsewhere the Berlin edition misprints the Latin version], and leg. τῶν ἄλλων δή.

[7] Cf. *Phys.* 260b 33; *G. A.* 735a 13, 740a 26 (with a suggestion also of the coming to be of the perfect creature, *Phys.* 261a 17).

[8] Leg. γίνεται αὐτὸ αὑτῷ αἴτιον, καί . . .

[9] The suppressed argument is 'and if this be so these secondary

the point at rest is not necessary. However, the earliest growth and alteration in the living creature arise through another and by other channels,[1] nor can anything possibly 700^{b} be the cause of its own generation and decay, for the mover must exist before the moved, the begetter before the begotten,[2] and nothing is prior to itself.

6 Now whether the soul is moved or not, and how it is moved if it be moved, has been stated before in our treatise concerning it.[3] And since all inorganic things are moved by some other thing—and [4] the manner of the movement of the first and eternally moved, and how the first mover moves it, has been determined before in our *Metaphysics*,[5] it remains to inquire how the soul moves the body, and what is the origin of movement in a living creature. For, if we except the movement of the universe, things with life are the causes of the movement of all else, that is of all that are not moved by one another by mutual impact. And so all their motions have a term or limit, inasmuch as the movements of things with life have such. For all living things both move and are moved with some object, so that this is the term of all their movement, the end, that is, in view. Now we see that the living creature is moved by intellect, imagination, purpose, wish, and appetite. And all these are reducible to mind and desire.[6] For both imagination [7] and sensation are on common ground [8] with mind, since all three are faculties of judgement [9] though differing according to distinctions stated elsewhere.[10] Will, however, impulse,[11]

movements, depending on the primary, will *a fortiori* require a point of rest'.

[1] Viz. the embryo is nourished, the child suckled by the movement of its parent's blood, or by her changes of position.

[2] Cf. *G.A.* 735^{a} 13 ; *de Anim.* 416^{b} 17 ; *Met.* 1073^{a} 3.

[3] Cf. *de Anim.* i. 3–5, ii. 4, iii. 9–end.

[4] Leg. περὶ δὲ τοῦ πρώτου E (*sic*) SΓ.

[5] Cf. *Met.* xii. 7.

[6] Cf. *Nic. Eth.* 1139^{a} 17, 1147^{a} 31. Throughout ὄρεξις is translated by 'desire', ἐπιθυμία by 'appetite'.

[7] Cf. *de Anim.* 433^{a} 9.

[8] Perhaps there is a reference also to the heart as the seat of all these powers (cf. *Parv. Nat.* 469^{b} 1).

[9] Cf. *de Anim.* 426^{b} 10, 432^{a} 16.

[10] Cf. *de Anim.* iii. 3.

[11] i.e. θυμός.

and appetite, are all three forms of desire, while purpose[1] belongs both to intellect and to desire. Therefore the object of desire or of intellect[2] first initiates movement, not, that is, every object of intellect, only the end in the domain of conduct. Accordingly among goods that which moves is a practical end,[3] not the good in its whole extent. For it initiates movement only so far as something else is for its sake, or so far as it is the object of that which is for the sake of something else. And we must suppose that a seeming[4] good may take the room of actual good, and so may the pleasant, which is itself a seeming good.[5] From these considerations it is clear that in one regard that which is eternally moved by the eternal mover is moved in the same way as every living creature, in another regard differently, and so while it is moved[6] eternally, the movement of living creatures has a term.[7] Now the eternal beautiful, and the truly and primarily good (which is not at one time good, at another time not good), is too divine and precious to be relative[8] to anything else. The prime mover[9]
701^{a} then moves, itself being unmoved, whereas desire and its faculty are moved and so move. But it is not necessary for the last in the chain of things moved to move something else;[10] wherefore it is plainly reasonable that motion in place should be the last of what happens in the region of things happening, since the living creature[11] is moved and

[1] Cf. *Nic. Eth.* 1113^{a} 10 and vi. 2, 5 and 6; *Phys.* viii. 2. In *de Anim.* iii. 10 βούλησις is used instead of προαίρεσις.

[2] Cf. *Phys.* 253^{a} 17; *de Anim.* 433^{a} 18; *Met.* 1072^{a} 26; *Nic. Eth.* 1139^{a} 34.

[3] Cf. *de Anim.* 433^{a} 29.

[4] Cf. *de Anim.* 433^{a} 28; *Nic. Eth.* 1113^{a} 16; *Rhet.* 1369^{b} 18.

[5] Cf. *Nic. Eth.* 1146^{b} 22; *Eud. Eth.* 1227^{a} 39; *Rhet.* 1369^{b} 19.

[6] Leg. τὸ μὲν ἀεὶ κινεῖται.

[7] ὁ πρακτικὸς νοῦς διαφέρει τοῦ θεωρητικοῦ τῷ τέλει, *de Anim.* 433^{a} 14.

[8] πρὸς ἕτερον PΓ., πρότερον ESY (*sic* Mich. who interprets 'than to have anything prior to itself'). Perhaps Mich. had really ὥστ' εἶναί τι πρότερον. Leon. 'quam ut illo quicquam sit prius'. The point is that the first good has nothing beyond to move it, cf. *Phys.* 260^{a} 5 οὐδὲν αὐτὸ μεταβάλλον πρὸς τὸ κινούμενον, and *Met.* 1072^{a} 26.

πρότερον, cf. *de Caelo*, i. 12. Bywater, *Contributions*, &c., p. 15.

[9] i.e. the good aimed at or achieved in act. Cf. *de Anim.* 433^{b} 16, τὸ ὀρεκτόν is τὸ κινοῦν οὐ κινούμενον (433^{b} 12), i.e. τὸ πρακτὸν ἀγαθόν, here called τὸ πρῶτον οὐ κινούμενον κινοῦν.

[10] Cf. *de Anim.* 434^{b} 35 τὸ ἔσχατον ὠθεῖται οὐκ ὦσαν.

[11] The last in the chain of causes and effects.

goes forward by reason of desire or purpose,[1] when some alteration has been set going on the occasion of sensation or imagination.

7 But how is it that thought ⟨viz. sense, imagination, and thought proper⟩ is sometimes followed by action, sometimes not; sometimes by movement, sometimes not? What happens seems parallel to the case of thinking and inferring about the immovable objects of science. There the end is the truth seen[2] (for, when one conceives the two premisses, one at once conceives and comprehends the conclusion), but here the two premisses result in a conclusion which is an action—for example, one conceives that every man ought to walk, one is a man oneself: straightway[3] one walks; or that, in this case, no man should walk, one is a man: straightway one remains at rest. And one so acts in the two cases provided that there is nothing in the one case to compel or in the other to prevent. Again, I ought to create a good, a house is good: straightway I make a house. I need a covering, a coat is a covering: I need a coat. What I need I ought to make, I need a coat: I make a coat.[4] And the conclusion I must make a coat is an action. And the action goes back to the beginning[5] or first step. If there is to be a coat, one must first have B, and if B then A, so one gets A to begin with. Now that the action[6] is the conclusion is clear. But the premisses of action[7] are of two kinds, of the good and of the possible.[8]

And as in some cases of speculative inquiry we suppress one premise so here the mind does not stop to consider at all an obvious minor premise; for example if walking is

[1] Cf. *supra*, 700^{b} 23 and note.

[2] On the contrast between the Syllogisms of Science and of Practice see *Nic. Eth.* vii. 3. An explanation such as that before us is there described as φυσικῶς (cf. *de Anim.* 434^{a} 18; *Eud. Eth.* 1227^{b} 28).

[3] Cf. *Nic. Eth.* 1147^{a} 24.

[4] Leg. ἱμάτιον ποιεῖ E (sic).

[5] Cf. *Nic. Eth.* 1112^{b} 23, 1113^{a} 6; in a different sense the ἀρχή is the major premise (l.c. 1144^{a} 32).

[6] It is the same in art (ποίησις proper), *Met.* 1032^{b} 6; *Nic. Eth.* 1112^{b} 19.

[7] ποιητικαί = πρακτικαί: cf. *Nic. Eth.* 1147^{a} 28; *Eud. Eth.* 1227^{b} 30. In this matter the spheres of ποιεῖν and πράττειν agree.

[8] δυνατὰ δὲ ἃ δι' ἡμῶν γένοιτ' ἄν, *Nic. Eth.* 1112^{b} 27, the possible is what can be brought about by our own or our friends' agency.

good for man, one does not dwell upon the minor 'I am a man'. And so what we do without reflection, we do quickly. For when a man actualizes himself in relation to his object either by perceiving, or imagining or conceiving it, what he desires he does at once.[1] For the actualizing of desire is a substitute for inquiry or reflection. I want to drink, says appetite; this is drink, says sense or imagination or mind: straightway I drink. In this way living creatures are impelled to move and to act, and desire is the last or immediate cause of movement, and desire arises after perception or after imagination and conception. And things that desire to act now create and now act under the influence of appetite or impulse or of desire or wish.[2]

701b The movements of animals may be compared with those of automatic puppets,[3] which are set going on the occasion of a tiny movement; the levers are released, and strike the twisted strings against one another;[4] or with the toy

[1] Del. comma after ὀρέγεται (*sic* Mich.). A good instance would be what is now called ideomotor action.

[2] ὄρεξις is the kind of which ἐπιθυμία, θυμός, and βούλησις are species. Cf. *de Anim.* 414b 2.

[3] A natural illustration, much used by A. (cf. *G. A.* 734b 10; *Met.* 983a 14) as it was later by the Stoic Emperor Marcus, and his great contemporary Galen (e.g. *de Usu Part.* K. iii. 48, 262). Plato uses the θαύματα differently in the famous allegory of the cave, *Rep.* 514 B (cf. *Leges*, 782 B, &c.). The mechanism of strings in the simple toy which moved its members in answer to a pull from one governing cord (*de Mundo*, ch. 6), the *nervis alienis mobile lignum* of the Roman poet, developed into the true automata which seem to have been puppets dancing in answer to an elaborate hidden mechanism of strings, weights, and rollers. The dolls may be seen in any museum, but the automatic machinery is nowhere fully described. We may get some notion of it from the figures of surgical machines in medical MSS. (vid. Littré, *Hipp.* iv, p. 305, Hipp. *Artic.* 74, *Apoll. Cit.* (Schöne) Tab. xvii, xviii). For other automatic toys cf. *de Anim.* 416b 18; *Parv. Nat.* 461b 15; *Pol.* 1253b 35; Plato, *Euthyphro*, 11 B; *Meno*, 97 D.

[4] Leg. τῶν ξύλων καὶ κρουόντων ἀλλήλαις τὰς σ. (*infra* b 9). The sense of στρέβλαι is clear, they are the strings which agitated the limbs, though the word is not used in Hippocrates. στρεβλοῦσθαι gets its sense in this way, and we may see a play upon the double meaning in Dio Chrys. *Charidemus*, 303 M ὑπὸ τούτων κατατείνεσθαι καὶ στρεβλοῦσθαι. Philoponus (or Michael Eph.) in a gloss upon *G. A.* 734b 4 (*Comm. in Arist. Graeca*, xiv. 3, p. 77) explains that the νευροσπάστης or showman knocked one of the ξύλα and so released the mechanism, which then went off of itself, the various ξύλα somehow releasing one another: 'ὥσπερ ἐπὶ τῶν αὐτομάτων θαυμάτων ὁ μὲν θαυματοποιὸς κινήσας τόδε τι πέπαυται τοῦ κινεῖν, τοῦτο δὲ τὸ προσεχῶς ὑπ' αὐτοῦ κινηθὲν ἐκίνησεν ἄλλο, κἀκεῖνο ἕτερον', and 'ὁ θαυματοποιὸς κινεῖ τόδε μὲν τὸ ξύλον καὶ ἀπέρχεται,

wagon. For the child mounts on it and moves it straight forward,[1] and then again it is moved in a circle owing to its wheels being of unequal diameter (the smaller acts like a centre on the same principle as the cylinders[2]). Animals have parts of a similar kind, their organs, the sinewy tendons to wit and the bones; the bones are like the wooden levers in the automaton, and the iron; the tendons are like the strings, for when these are tightened or released[3] movement begins. However, in the automata and the toy wagon there is no change of quality, though if the inner wheels became smaller and greater by turns there would be the same circular movement set up. In an animal the same part has the power of becoming now larger and now smaller, and changing its form,[4] as the parts increase by warmth and again contract by cold and change their quality. This change of quality is caused by imaginations and sensa-

τοῦτο δὲ ὑπὸ τῆς ἐνδοθείσης αὐτῷ κινητικῆς δυνάμεως διά τινος μηχανῆς κινεῖ ἕτερον, κἀκεῖνο ἄλλο, κἀκεῖνο τὸ εἴδωλον.' I take it that the machine (like a rack or surgical instrument) was of cylinders with strings wound round them, and with weights suspended (cf. *συνείρεται* in *G. A.* 741^b 9 referring to the rollers strung together); the cylinders had pegs (*ξύλα*) on them which in time (*ἐφεξῆς*) set other rollers going and so made the puppets dance on the table above. Aristotle alludes to the rollers, I think, in his laconic manner in the words *καθάπερ ἐν τοῖς κυλίνδροις*. The point in both this and the following simile lies in the automatism of the body, and the manifest outward gestures which flow from a tiny internal initial motion, just as the prow swings through a wide circle on a small movement of the helm.

[1] Leg. *καὶ τὸ ἁμάξιον· ὁ γὰρ ὀχούμενος αὐτὸ κινεῖ* (*ὀχούμενος* S). The point is the change of motion in a straight line to circular movement by the automatic action of the inner wheels, as well as the slight impulse given by the child. I have often seen children in old days jumping on such little carriages in the side streets of London and then swinging round in a circle. (The emendation was suggested independently by Mr. H. P. Richards and Mr. W. D. Ross.)

[2] The reference is obscure, being apparently a brief note for Aristotle's own use. I take it to refer to the cylinders of the automatic machine. St. Hilaire illustrates from *conical* rollers which are used for crushing cement (but cf. *Probl.* 913^b 38 where the cone is expressly distinguished from the cylinder *ὁ κῶνος ὠσθεὶς κύκλῳ περιφέρεται, τῆς κορυφῆς μενούσης*). Mich. speaks vaguely of toy carriages with cylindrical wheels, 'which babies drag along in their games—very pretty playthings for the colours lavished on them by painters'!

[3] Leg. *ὧν συστελλομένων καὶ ἀνιεμένων.*

[4] i.e. the body's motions are produced physiologically (by alteration) and not mechanically. A change of temperature in the heart's region causes an alteration in the tendons (*νεῦρα*) and these pull the bones. In ch. 10 A. is gravelled by the difficulty of relating this physiological change to *φορά* or translation, in his system the necessarily primary motion (cf. notes to ch. 10; and Galen, referred to in 703^a 31 note).

tions and by ideas. Sensations are obviously a form of change of quality, and imagination and conception have the same effect as the objects so imagined and conceived. For in a measure the form conceived[1] be it of hot or cold or pleasant or fearful is like what the actual objects would be, and so we shudder and are frightened at a mere idea. Now all these affections involve changes of quality, and with those changes some parts of the body enlarge, others grow smaller. And it is not hard to see that a small change occurring at the centre[2] makes great and numerous changes at the circumference, just as by shifting the rudder a hair's breadth you get a wide deviation at the prow. And further,[3] when by reason of heat or cold or some kindred affection a change is set up in the region of the heart, even in an imperceptibly small part[4] of the heart, it produces a vast difference in the periphery of the body,—blushing, let us say, or turning white, goose-skin and shivers and their opposites.[5]

But to return, the object we pursue or avoid in the field 8
of action is, as has been explained, the original of movement, and upon the conception and imagination of this there necessarily[6] follows a change in the temperature of

[1] *Species intelligibilis* of later writers.

[2] Viz. the heart (cf. b 29 *infra*). For these small changes at or affecting the centre cf. *de Anim.* 403a 21 ; *H. A.* 590a 3 ; *G. A.* 716b 3, 788a 11.

[3] Del. full stop after *πάθος*.

[4] Cf. Hobbes, *Lev.* i. 16 'And altho' unstudied men doe not conceive any motion at all to be there, where the thing moved is invisible ; or the space it is moved in is (for the shortness of it) insensible ; yet that doth not hinder but that such motions are'; a favourite topic with Bacon, e.g. *N. O.* ii. 6 'omnis actio naturalis transigitur per illa quae sunt minora quam ut sensum feriant', and with Des Cartes, e.g. *Princ. Phil.* iv, CCI 'At multas in singulis corporibus considero, quae nullo sensu percipiuntur : quod illi fortasse non probant, qui sensus suos pro mensura cognoscibilium sumunt' et seq. For ships' rudders cf. *Mech.* ch. 5 (lever principle).

[5] Homer (*Iliad*, N 279) gives a vivid description of the motions set up by fear. Such observations developed into the Prognostics or Symptoms of physicians (vid. Hipp. *Progn.* et *Epid.* Book III) ; cf. *Prob.* 902b 37 ; the opposites are caused by *θερμότης εὔκρατος*, which *ἀνίησί τε τὸ σῶμα καὶ αὔξησιν αὐτῷ ἐμποιεῖ* (Alex. *de Anim.* 77. 1); 'and their opposites' seems a gloss, cf. Mich. 115. 22.

[6] Des Cartes' equivocal treatment of the Soul, and strong inclination to see automatism in bodily changes, present a remarkable contrast and parallel. (Vid. *Traité des Passions*, *passim*.)

the body. For what is painful we avoid, what is pleasing we pursue. We are, however, unconscious of what happens in the minute parts ;[1] still anything painful or pleasing is 702a generally speaking accompanied by a definite change of temperature[2] in the body. One may see this by considering the affections. Blind courage and panic fears, erotic motions, and the rest of the corporeal affections, pleasant and painful, are all accompanied by a change of temperature, some in a particular member, others in the body generally. So, memories and anticipations,[3] using as it were the reflected images[4] of these pleasures and pains, are now more and now less causes of the same changes of temperature. And so we see the reason of nature's handiwork[5] in the inward parts, and in the centres of movement of the organic members ; they change from solid to moist, and from moist to solid, from soft to hard and vice versa. And so when these are affected in this way, and when besides the passive and active[6] have

[1] Leon. apparently had λίαν λανθάνει, a variant not in E nor Y nor recorded in Bekker. The passage is out of place, but the sense is clear. Mich., with our reading, translates δέ as γάρ.

[2] The stress on heat and cold is connected with the doctrines of the 'hypothetical' school of Medicine ridiculed by Hippocrates (*de antiq. Med.* ch. 13). In Des Cartes a purely hypothetical change in the 'vital spirits' is the analogue to these temperature changes. The first germ of the doctrine of 'animal spirit' (ψυχικὸν πνεῦμα) is contained in ch. x, *infra*, and in *G. A.* It played a disproportionate part in subsequent physiology (e. g. in the Stoics and in Galen).

For the bodily effects of heat and cold vid. *P. A.* 600b 28, 679a 25, 692a 23 ; *infra*, 703b 15 ; *G. A.* 740b 32.

[3] Cf. *Parv. Nat.* 449b 27 ; Plato, *Phil.* 32 C 'memory of the past, anticipation of the future pleasures or pains' (τὸ μὲν πρὸ τῶν ἡδέων ἐλπιζόμενον ἡδὺ καὶ θαρραλέον, τὸ δὲ πρὸ τῶν λυπηρῶν φοβερὸν καὶ ἀλγεινόν).

[4] Viz. φαντάσματα, cf. *Parv. Nat.* 450a 13, either images, likenesses (*Parv. Nat.* 462a 11), called εἰκόνες (*Parv. Nat.* 451a 15 ; Plato, *Phil.* 39 B), and ζωγραφήματα (450a 27, Plato, *Phil.* 40 A), or reflections (*Parv. Nat.* 464b 9), dream phantoms being like forms reflected in more or less troubled water (cf. Plato, *Tim.* 72 B). The later Peripatetics called them ἀναζωγραφήματα.

[5] Cf. *G. A.* 731a 24. A., though free from the vulgar Teleology of Design, is fond of calling Nature a cunning artificer, especially in his Nat. Hist. treatises. His language becomes coloured with enthusiasm in such passages as *P. A.* 645a 9 ; *de Inc.* 711a 18 ; and *G. A.* 730b 27, 743b 23. Cf. Galen *de Usu P.* passim.

[6] Cf. *de Anim.* 417a 1 ἐν τοῖς καθόλου λόγοις περὶ τοῦ ποιεῖν καὶ πάσχειν. Some have thought there was a special treatise so named, and similarly a treatise περὶ τροφῆς. On the interrelation of agent and patient cf.

the constitution we have many times described, as often as it comes to pass that one is active and the other passive, and neither of them falls short of the elements of its essence,[1] straightway one acts and the other responds. And on this account thinking that one ought to go and going are virtually simultaneous, unless there be something else to hinder action.[2] The organic parts are suitably prepared by the affections, these again by desire, and desire by imagination.[3] Imagination in its turn depends either upon conception or sense-perception. And the simultaneity and speed are due to the natural correspondence of the active and passive.

However, that which first moves the animal organism must be situate in a definite original. Now we have said that a joint is the beginning of one part of a limb, the end of another.[4] And so nature employs it sometimes as one, sometimes as two.[5] When movement arises from a joint, one of the extreme points must remain at rest, and the other be moved (for as we explained above the mover must support itself against a point at rest); accordingly, in the case of the elbow-joint, the last point of the forearm is moved but does not move anything, while, in the flexion, one point of the elbow, which lies in the whole forearm that is being moved, is moved,[6] but there must also be a point which is unmoved, and this is our meaning when we speak of a point which is in potency one, but which becomes two in actual exercise. Now if the arm were the living animal, somewhere in its elbow-joint would be

Parv. Nat. 465^{b} 15 ; *Physics*, iii. 3 ; *Meteor.* iv ; *de Gen. et Corr.* i. 9 ; *G. A.* 740^{b} 21, 768^{b} 23 ; *Metaphysic*, ix. 5 (especially *de Gen. et Corr.* 324^{a} 9 ; *Met.* 1047^{b} 35).

[1] Or 'definition'. Cf. *Met.* 1048^{a} 2.

[2] Cf. *Met.* 1048^{a} 17.

[3] Cf. *Phys.* 253^{a} 17 ; *de Anim.* 433^{b} 28.

[4] Leg. ὅτι τοῦ μέν ἐστιν, Y, i.e. the elbow-joint is the end of the forearm, the beginning of the upper arm. The joint is ultimately two juxtaposed points (more accurately surfaces, *de Anim.* 433^{b} 22); of these one is the original, the other the end of the extremity moved. In another sense the centre point is the middle of a line, and therefore both beginning and end (*Phys.* 220^{a} 12, 262^{a} 21, &c.). This geometrical point is in potency two but in act one, the point here is potentially one, in act two, just because it is not a mathematical entity. Cf. *de Anim.* 427^{a} 10.

[5] Cf. *supra*, 698^{a} 19.

[6] ? Leg. κινεῖ καὶ κινεῖται Γ, A.M. Cf. P. and *infra* 703^{a} 14 (note).

situate the original seat of the moving soul. Since, however, it is possible for a lifeless thing to be so related to the hand as the forearm is to the upper (for example, when a man moves[1] a stick in his hand), it is evident that the soul,[2] the original of movement, could not lie in either of the two extreme points, neither, that is, in the last point of the stick which is moved, nor in the original point which causes movement. For the stick too has an end point and 702b
an originative point by reference to the hand.[3] Accordingly, this example shows that the moving original which derives from the soul is not in the stick; and if not, then not in the hand; for a precisely similar relation obtains between the hand[4] and the wrist, as between the wrist and the elbow. In this matter it makes no difference whether the part is a continuous part of the body or not; the stick[5] may be looked at as a detached part of the whole. It follows then of necessity that the original cannot lie in any individual origin which is the end of another member, even though there may lie another part outside[6] the one in question. For example, relatively to the end point of the stick the hand is the original, but the original of the hand's movement is in the wrist. And so if the true original is not in the hand, because there is still something higher up,[7] neither is the true original in the wrist, for once

[1] Leg. κινοίη τις βακτηρίαν, viz. by bending the wrist. A. speaks loosely of the wrist's function, and nowhere considers the rotation of the hand, just as in *de Inc. Anim.* he treats only implicitly of the ankle, ignoring its rotation in human progression. If A. studied, as is almost certain, only *animal* anatomy these movements would more easily escape him.

[2] ἡ ψυχή loosely for ἡ ἀπὸ τῆς ψυχῆς ἀρχή, or else the soul is carelessly spoken of as the original of bodily movement (cf. *de Anim.* 406b 24, &c.).

[3] The 'extreme' is not the outermost end of the stick or the argument would fail. It is the end point where the stick meets the hand, the 'beginning' or 'original' is the point of the wrist which is at rest, hand being, as often, used for wrist (contrast *H. A.* 493b 27). Mich. was puzzled and is more than usually unhappy in his explanation; the confusion arises from a play upon ἀρχή, most characteristic of Aristotle (cf. 702b 17 note; Newman, *The Pol. of A.* iv. 322).

[4] Lit. extremity of the hand, viz. all the hand from the wrist (regarded as part of the hand) outwards; a popular use in Greek.

[5] For the 'stick' illustration cf. *Phys.* viii. 5.

[6] Viz. further from the centre of the organism, i. e. the heart.

[7] Viz. higher up towards the shoulder—a local centre—and ultimately

more if the elbow is at rest[1] the whole part below it can be moved as a continuous whole.

Now since the left and the right sides are symmetrical,[2] 9
and these opposites are moved simultaneously,[3] it cannot be that the left is moved by the right remaining stationary, nor vice versa; the original must always be in what lies above both. Therefore, the original seat of the moving soul must be in that which lies in the middle, for of both extremes the middle is the limiting point;[4] and this is similarly related to the movements from above [and below,] those that is from the head, and[5] to the bones which spring from the spinal column, in creatures that have a spinal column.[6]

And this is a reasonable arrangement. For the sensorium[7] is in our opinion in the centre too; and so, if the region of the original of movement is altered in structure through sense-perception and thus changes, it carries with it the parts[8] that depend upon it and they too are extended or contracted, and in this way the movement of the creature necessarily follows. And the middle of the body must

towards the heart. Cf. *infra*, 702b 15; and *G. A.* 788a 14 τοῦτο γάρ ἐστι τὸ ἀρχὴν εἶναι τὸ αὐτὴν μὲν αἰτίαν εἶναι πολλῶν, ταύτης δ' ἄλλο ἄνωθεν μηθέν. Fr. 1491a 13.

[1] Viz. if the lower arm and hand be held rigid, like the stick in the illustration; similarly the ἀρχή is not in the elbow, nor yet in the shoulder.

[2] τὸ ζῷον rather than ἡ ἀρχή is the implied subject.

[3] Mich. violently turns ἅμα by κατὰ μέρος, confounding the argument.

[4] Lit. 'extreme' (ἔσχατον). Of both extremes the middle is the extreme or limit point. The paradox is very Aristotelian; cf. *de Caelo*, 312a 10 ἔστι γὰρ ὡς ἔσχατον καὶ μέσον ἀμφοτέρων ⟨ἐστὶ⟩ τὸ μεταξύ. Cf. *P. A.* 661b 11; *Prob.* 913b 36; *Met.* 1022a 12; *Nic. Eth.* 1107a 8.

[5] Leg. κεφαλῆς, καὶ πρὸς τά (τά EY). καὶ κάτω is, I think, a gloss. om. Γ.

[6] The ῥάχις is the ἀρχή of the bony system (cf. *H. A.* 516a 10; *P. A.* 654a 32, b 12; Alex. *de Anima*, 97 l. 27), τάς (sc. κινήσεις) would imply a knowledge of the nervous system of the spine which only arose much later. The heart is also centrally situate in regard to the skeletal system, radiating from the ῥάχις. It is thus the centre of the bony and vascular, of the sensory as well as of the motor organization.

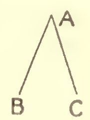
[7] Cf. *P. A.* 647a 25, 656a 28, 665a 10, 721a 22; *Parv. Nat.* 456a 4. The heart is the original of sense apprehension, though some of the πόροι αἰσθητικοί pass through the head.

[8] Viz. τὰ νεῦρα (*chordae tendineae*), the sinewy tendons that are conceived to move the limbs. The ἀρχαί or four local originals are the centres from which the limbs are moved (cf. *de Inc.* 704a 15).

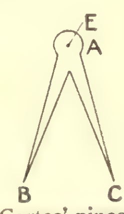
needs be in potency one but in action more than one; for the limbs are moved simultaneously from the original seat of movement, and when one is at rest the other is moved. For example, in the line BAC,[1] B is moved, and A is the mover. There must, however, be a point at rest if one is to move, the other to be moved. A ⟨AE⟩[2] then being one in potency must be two in action, and so be a definite spatial magnitude not a mathematical point.[3] Again, C may be moved simultaneously with B. Both the originals then in A must move and be moved, and so there must be something other than them which moves but is not moved. For otherwise, when the movement begins, the extremes, i.e. the originals, in A would rest upon one another, like two men putting themselves back to back 703a and so moving their legs. There must then be some one thing which moves both.[4] This something is the soul, distinct from the spatial magnitude just described and yet located therein.[5]

Although from the point of view of the definition of movement—a definition which gives the cause—desire[6] is

[1] Cf. 703b 30. The diagrams, so often mentioned (cf. *Parv. Nat.* 452b 17; *G. A.* 749b 8, 761a 10), are lost, though substitutes appear in the margins of some MSS. According to Mich. the figure contemplated is



Mich. speaks of A, or AE, as μέγεθός τι, so that A.'s drawing may have been after the similitude of a pair of compasses, E being the actual centre. On the central part of the heart cf. *P. A.* 666b 33.



[2] AE in Mich.; cf. AB in S.

[3] τὸ ἀμερὲς οὐκ ἐνδέχεται κινεῖσθαι, *Phys.* 240b 8, 258b 25; *de Anim.* 402b 1; *De Incessu*, 705a 23 (note).

[4] Leg. ἀναγκαῖον ἓν εἶναι. 'necesse esse unum' Γ, cf. A. M., l. c. p. 343.

[5] This unity is properly the organ of soul, like Des Cartes' pineal gland. He regarded this as the material centre of animal movement because it alone had no double in the brain (cf. *de Anim.* 406b 24, 415b 21 ὅθεν πρῶτον ἡ κατὰ τόπον κίνησις, ψυχή). A. did not consider the body to be moved *by* the soul but κατὰ ταύτην, as fire by its levity, or the artist by his art.

[6] The word ψυχή, at the end of last chapter, is used loosely for ἡ ὀρεκτικὴ δύναμις τῆς ψυχῆς, by reason of which organized bodies are moved. Desire, then, is the formal cause or ground of movement, it remains to find the material cause. (Cf. *de Anim.* 412b 20, where ὄψις is οὐσία ὀφθαλμοῦ ἡ κατὰ τὸν λόγον, ὁ δ' ὀφθαλμὸς ὕλη ὄψεως.)

the middle term or cause, and desire moves being moved,[1] still in the material animated body there must be some material[2] which itself moves being moved. Now that which is moved, but whose nature is not to initiate movement, is capable of being passive to an external force, while that which initiates movement must needs possess a kind of force and power. Now experience shows us that animals do both possess connatural spirit[3] and derive power from this. (How this connatural spirit is maintained in the body is explained in other passages of our works.[4]) And this spirit appears to stand to the soul-centre or original in a relation analogous to that between the point in a joint which moves being moved and the unmoved.[5] Now since this centre is for some animals in the heart, in the rest in a part analogous[6] with the heart, we further see the reason for the connatural spirit being situate where it actually is found. The question whether the spirit remains always the same or constantly changes and is renewed, like the cognate question about the rest of the parts of the body, is better postponed.[7] At all events we see that it is well disposed

[1] Cf. *de Anim.* 433^{b} 16.

[2] Cf. *de Anim.* 433^{b} 19 *ᾧ δὲ κινεῖ ὀργάνῳ ἡ ὄρεξις, ἤδη τοῦτο σωματικόν.*

[3] Aristotle heroically faces the difficulty of relating *ἀλλοίωσις* to *φορά*, since his general view of *κίνησις* involves the priority of translation to alteration. On this very obscure subject, consult among many passages *Meteor.* 366^{a} 1; *de Anim.* ii. 4; *Parv. Nat.* 474^{a} 25 et seq.; *G.A.* 728^{b} 28, 735^{b} 37, 736^{b} 37, 741^{b} 32, 781^{a} 24, 789^{b} 7.

The spirit is called *ἔμφυτον πνεῦμα* in *Parv. Nat.* 475^{a} 8; *φυτικὸν πῦρ* in 474^{b} 12.

[4] The unnecessary assumption that this is a reference to *περὶ πνεύματος*, a later work, has been used as an argument against the genuineness of *De Motu*. The reference is the other way about, as will be seen from the opening words of *de Spiritu*. The reference here is quite undetermined but we may compare *de Anim.* 416^{b} 31; *Parv. Nat.* 456^{a} 15, 474^{b} 3; *P.A.* 647^{b} 5, 651^{a} 15. Mich. refers to *περὶ τροφῆς*, a work possibly contemplated by A., but if written soon lost (cf. 702^{a} 11 note).

[5] Cf. chs. 1 and 7 *supra*. The point is here called with greater accuracy 'moving and moved'. Cf. 702^{a} 30 (note).

[6] Cf. *Parv. Nat.* 474^{b} 2 *τοῖς ἀναίμοις ἀνώνυμον* and *P.A.* 681^{b} 16; *G.A.* 721^{a} 21, 739^{a} 18.

[7] Passages are scattered about the works on this question (vid. Bonitz, *Index*, 104^{b} 16). The renewing agent is the blood, which generates by vital heat this 'spirit' in the heart, and then by help of the lungs and the cold air from without acts and reacts upon the heart's walls and so on the whole bodily frame. (Cf. *P.A.* ii. 3, iv. 4; *G.A.* ii. 6-7, v. 4;

to excite movement and to exert power;[1] and the functions of movement are thrusting and pulling.[2] Accordingly, the organ of movement must be capable of expanding[3] and contracting; and this is precisely the characteristic of spirit. It contracts and expands naturally,[4] and so is able to pull and to thrust from one and the same cause, exhibiting gravity compared with the fiery[5] element, and levity by comparison with the opposites of fire.[6] Now that which is to initiate movement without change of structure must be of the kind described, for the elementary bodies[7]

Alex. *de Anim.* 94. 17; Galen, *de Usu Part.* K. iii. 496, *de Usu Resp.* K. iv. 502.)

[1] *φαίνεται*, a reference perhaps to holding the breath when a weight is lifted. A., like gymnastic teachers to-day, supposed it gave power (cf. *de Anim.* 421^a 3; *Parv. Nat.* 456^a 15; *G.A.* 775^b 3).

[2] Cf. *de Inc.* 704^b 23; for the reduction of all movements to *ὦσις καὶ ἕλξις*, vid. *Phys.* 243^a 16, 243^b 16. Movement, it must be remembered, is not contemplated in abstraction from bodies, but taken in the sense of movement communicated by force to body.

[3] *αὐξάνεσθαι* in its vulgar sense, cf. *P. A.* 653^a 31 *ἡ γὰρ τοῦ θερμοῦ φύσις ἐνισχύουσα ποιεῖ τὴν αὔξησιν ἀπὸ τοῦ μέσου κατὰ τὴν αὐτῆς φοράν.*

[4] Leg. *ἀβιάστως συστελλομένη ⟨τε καὶ ἐκτεινομένη καὶ ἑλκτικὴ⟩ καὶ ὠ.* The emendation seems certain from Mich.'s words quoted below and from Γ 'tractiua et pulsiua'. *ἀβίαστος* is a word only found in Antoninus (*Comm.* iii. 16, &c.) and Alex. Aphr. The sense is 'naturally' (*αὐτοφυῶς* in the later Peripatetics), cf. *de Anim.* 406^b 6 *ὠσθείη γὰρ ἂν βίᾳ τὸ ζῷον.* For the omission of *ἐκτεινομένη* cf. *supra*, 701^b 15, where *συστελλομένων* is omitted by EY. Mich., probably following an older commentator, says in his notes on *P. A.* p. 88. 35 *τοῦ ἐν τῇ καρδίᾳ πνεύματος ἐκτεινομένου καὶ συστελλομένου ὡς ἐν τῇ περὶ ζ. κινήσεως δέδεικται*; cf. p. 128. 5.

Aristotle seems to have conceived the contraction of the spirit as giving a pull (*ἑλκτική*), and its expansion as loosening the sinews, whereas Des Cartes thought the vital spirits blew up the muscles and so shortened and broadened them. A. probably was thinking of such a similitude as that of an inflated wineskin or bladder, having in mind the familiar Greek mode of reducing a dislocation of the thigh by blowing up a wineskin; cf. Hipp. *Art.* 77 (Littré, iv. 310), where *ἰσχὺς* and *ἀναγκάζειν* are used of the force so applied to the injured member.

For the doctrine cf. *de Anim.* 403^a 31 where *ὄρεξις* from a physicist's point of view is said to be *ζέσις τοῦ περὶ καρδίαν αἵματος καὶ θερμοῦ*; *P. A.* 653^a 31; and for a parallel treatment of the mechanism of respiration, *P. A.* 666^b 15. We may compare also the later Stoic notions of *βία πνευματική*, &c. (cf. *H. A.* 586^a 17).

[5] *πυρώδη*, cf. *G. A.* 737^a 1 *ἀνάλογον οὖσα τῷ τῶν ἄστρων στοιχείῳ*: 'respondens elemento stellarum,' Harvey, *Treatise on Generation.*

[6] Called *θερμὸς ἀήρ* in *G. A.* 736^a 1; vital heat is not ordinary heat, and *πνεῦμα σ.* is conceived as a nice balance between the fiery and the aery.

For its volatile nature cf. *G. A.* 735^b 34; 744^a 3; and for the language *Parv. Nat.* 479^b 31 where *ζέσις* is *πνευματουμένου τοῦ ὑγροῦ.*

[7] *τὰ φυσικὰ σώματα*, viz. Earth, Air, Fire, and Water, cf. *de Caelo*, 269^a 2 and 29 (*κρατεῖν*).

prevail over one another in a compound body by dint of disproportion ; the light is overcome and kept down by the heavier, and the heavy kept up by the lighter.

We have now explained what the part is which is moved when the soul originates movement in the body, and what is the reason for this. And the animal organism must be conceived after the similitude of a well-governed commonwealth.[1] When order is once established in it there is no more need of a separate monarch to preside over each several task. The individuals each play their assigned part as it is ordered, and one thing follows another in its accustomed order. So in animals there is the same orderliness—nature taking the place of custom—and each part naturally doing his own work as nature has composed them.[2] There is no need then of a soul in each part, but she resides in a kind of central governing place of the body, and the
703^{b} remaining parts live by continuity of natural structure, and play the parts Nature would have them play.

So much then for the voluntary movements of animal II
bodies, and the reasons for them. These bodies, however, display in certain members involuntary movements too, but most often non-voluntary movements.[3] By involuntary I mean motions of the heart [4] and of the privy member ; [5] for often upon an image arising and without express mandate of the reason these parts are moved. By non-voluntary I

[1] Cf. Plato, *Tim.* 70 A ; *P.A.* 670^{a} 26 where the head or heart as seat of government is termed ἀκρόπολις. In *Nic. Eth.* 1113^{a} 8 the comparison is with the Homeric monarchy, in *Pol.* 1254^{b} 5 the relation of soul and body is that of master to slave (δεσποτική). The simile is worked out elaborately in *de Mundo*, 400^{b} 14 et seq. For the Stoic view vid. Seneca, *Epist. Mor.* 113. 23. Galen, *de Usu P.* K. iii. 268.

Galen, *de Placitis*, vii. 4 (K. v. 611) states the conflicting views about πνεῦμα. Does it pass through the body, or does a message go from the brain and produce alteration in the local nerves, or does the brain act by force without matter ? This last view he illustrates from the power of the sun, who stays in his own seat and yet warms and brightens the atmosphere.

[2] Leg. ἕκαστον τῶν οὕτω (i.e. φύσει) συστάντων, cf. *Phys.* 250^{b} 14 ; *de Anim.* 416^{a} 16.

[3] Cf. the division of acts into voluntary, non-voluntary, and involuntary, *Nic. Eth.* iii. 1.

[4] Palpitation, cf. *Parv. Nat.* 476^{b} 22, 479^{b} 19, 480^{a} 14 ; *P. A.* 669^{a} 20 (πήδησις connected with ἐλπίς).

[5] Cf. *de Anim.* 432^{b} 28 ; *P. A.* 666^{b} 17.

mean sleep and waking and respiration,[1] and other similar organic movements. For neither imagination nor desire is properly mistress of any of these; but since the animal body must undergo natural changes of quality,[2] and when the parts are so altered some must increase and others decrease, the body must straightway be moved and change with the changes that nature makes dependent upon one another. Now the causes of the movements are natural changes of temperature,[3] both those coming from outside[4] the body, and those taking place within it.[5] So the involuntary movements which occur in spite of reason in the aforesaid parts occur when a change of quality supervenes.[6] For conception and imagination, as we said above, produce the conditions necessary to affections, since they bring to bear the images or forms[7] which tend to create these states. And the two parts aforesaid display this motion more conspicuously than the rest, because each is in a sense a separate vital organism,[8] the reason being that each contains vital moisture.[9] In the case of the heart the cause is plain, for[10] the heart is the seat of the senses, while an indication that the generative organ too is vital is that there flows from it the seminal potency, itself a kind of organism.

[1] Cf. *Phys.* 259^{b} 9, growth, decay, respiration. A. does not seem to contemplate here such semi-voluntary movements as winking (*P. A.* 657^{b} 1 *οὐκ ἐκ προαιρέσεως*, and compare what is said of tickling in *P. A.* 673^{a} 6).

[2] Mich. puts a full stop after *ἀλλοίωσιν*, but the apodosis is *καὶ αἱ παρὰ τὸν λόγον δὴ* . . .

[3] For effect of heat and cold cf. *P. A.* 679^{a} 26 ; *Probl.* 902^{b} 37.

[4] *αἱ θύραθεν*, cf. *Phys.* 253^{a} 15 ; *P. A.* 653^{a} 1.

[5] Insert comma after *ὑπάρχουσαι*.

[6] Sleep, &c., are non-voluntary movements ; we set ourselves upon going to sleep and then the changes occur, largely owing to heat generated in digestion. Similarly, A. argues (like Des Cartes), the involuntary movements are bye-products of natural changes. Cf. *Parv. Nat.* 455^{b} 28 ; *P. A.* 653^{a} 10.

[7] *τὰ γὰρ εἴδη*, cf. 701^{b} 20, *supra*.

[8] I do not know any other references to this individuality of organs. For the heart cf. *P. A.* 666^{a} 21, ^{b} 17 ; for the other member, Plato, *Tim.* 91 B *οἷον ζῷον ἀνυπήκοον τοῦ λόγου*, and (of the *σπέρμα*) *ἀόρατα ζῷα*. The *θαύματα* emphasized this individuality of the *αἰδοῖον*, Hdt. ii. 48 ; Luc. *de Dea Syria*, Reitz, iii. 463.

[9] Cf. *Parv. Nat.* 466^{a} 18 *τὸ ζῷόν ἐστι φύσει ὑγρὸν καὶ θερμόν*, *G. A.* 742^{a} 15 ; Galen, *Defin. Med.* (K. xix. 370) *σπέρμα ἐστὶ πνεῦμα ἔνθερμον ἐν ὑγρῷ ἐξ ἑαυτοῦ κινούμενον* et seq.

[10] Leg. *τὰς γὰρ ἀρχάς* (PS Γ), and insert comma after *αἰτίαν*.

Again, it is a reasonable arrangement that the movements arise in the centre upon movements in the parts, and in the parts upon movements in the centre, and so reach one another. Conceive A to be the centre or starting-point. The movements then arrive at the centre from each letter in the diagram [1] we have drawn, and flow back again from the centre which is moved and changes, (for the centre is potentially [2] multiple) the movement of B goes to B, that of C to C, the movement of both to both ; but from B to C [3] the movements [4] flow by dint of going from B to A as to a centre, and then from A to C as from a centre.

Moreover [5] a movement contrary to reason sometimes does and sometimes does not arise in the organs on the occasion of the same [6] thoughts ; the reason is that some-
704a times the matter which is passive [7] to the impressions is there in sufficient quantity and of the right quality and sometimes not.

And so we have finished our account of the reasons [8] for
704b the parts of each kind of animal, of the soul, and further of sense-perception, of sleep, of memory,[9] and of movement in general ; it remains to speak of animal generation.

[1] Cf. *supra*, 702^b 29.

[2] δυνάμει—one would expect ἐνεργείᾳ (702^a 31, &c.). The other and more ordinary sense of potentiality has slipped in here.

[3] Omit ἀρχή a gloss on preceding words, with which Γ actually places it.

[4] Leg. semicolon after ἄμφω, a comma after Γ, and delete δέ after τῷ (*sic* E Γ).

[5] Leg. ἔτι EP for ὅτι (Mich. and Γ had ὅτι) and οὗ αἴτιον τὸ (ὅτε δ' οὗ αἴτιον ὅτο μὲν E *sic*).

[6] Leg. ταὐτά (τὰ αὐτά P). Cf. Bywater, *Contributions, &c.*, *N. E.* vi. 4. 1140^a 18.

[7] Cf. *de Anim.* 403^a 19; *Parv. Nat.* 447^a 16, 450^b 1 τοῖς μὲν ἐν κινήσει πολλῇ διὰ πάθος ἢ δι' ἡλικίαν οὖσιν οὐ γίνεται μνήμη et seq.

[8] Reasons, grounds or causes—cf. *supra*, 698^a 4 ; *G. A.* 782^a 22.

[9] This was the position of the Treatise in Mich.'s MSS. and is the place it occupies in E S and P. The traditional order of the two treatises was for *de Incessu* to follow *de Partibus* immediately (as it now follows in U Y b), and for *de Motu* with *de Gen. Anim.* to be interposed amid the treatises often called *Parva Naturalia* or *Minuta Naturalia*. These two followed *de Div. per Somnum* (cf. Themistius, *Parva Naturalia*) and preceded *de long. et brev. Vitae*. The equivocal position of *de Motu* is explained by its subject-matter (ἐν τοῖς κοινοῖς σώματος καὶ ψυχῆς ἔργοις, *de Anim.* 433^b 20). We may compare Ptolemy's list of the works, where it follows immediately after *de Somno*. Compare also the MS. ending of *de Div.* (omitted in Bekker) and the similar words in Themistius (p. 105 v) and Mich. Eph. p. 103. (Vid. Note at end of *de Incessu.*)

DE INCESSU ANIMALIUM

704a

We have now to consider the parts which are useful to animals for movement in place (locomotion); first, why each part is such as it is and to what end they possess them; and second, the differences[1] between these parts both in one and the same creature, and again by comparison of the parts of creatures of different species with one another. First then let us lay down how many questions we have to consider.

The first is what are the fewest points of motion necessary to animal progression, the second why sanguineous animals have four points[2] and not more, but bloodless animals more than four, and generally why some animals are footless, others bipeds, others quadrupeds, others polypods, and why all have an even number of feet, if they have feet at all; why in fine the points on which progression depends are even in number.

Next, why are man and bird bipeds, but fish footless; and why do man and bird, though both bipeds, have an opposite curvature of the legs. For man bends his legs convexly,[3] a bird has his bent concavely; again, man bends

[1] It should rather have been 'the reasons for the differences . . .' On the subject generally cf. Galen, *de Usu Partium*, iii. 2.

[2] The four points in a quadruped (Bacon's quaternion) are the points of attachment of the limbs, cf. *infra*, 712ª 19.

[3] Convexly and concavely, that is forwards and backwards (*H.A.* 498ª 6, &c.), or as it is sometimes expressed outwards and inwards (*P.A.* 693ᵇ 3; *G.A.* 728ᵇ 9, where ἐντός is correct). The terms seem chosen in this treatise to avoid confusion with the fore and hind limbs and to be later in date than *de Partibus* (vid. *P.A.* 693ᵇ 35). Forwards and backwards are clear enough, since the front of an animal is determined by the senses, especially by vision (τοῖς ὄμμασι διώρισται τὸ πρόσθιον, *infra*, 712ᵇ 17, cf. 705ᵇ 16). The next step is to call these flexions outwards and inwards (ἔξω of man's legs, *P.A.* 693ᵇ 3 εἴσω of a bird's). Man is the norm, and his knees bend away from the centre of his figure or outwards, that is ἐπὶ τὴν περιφέρειαν towards the circumference. This somewhat equivocally is then treated as towards the convex, and ἐπὶ τὸ κοῖλον used as its opposite. The Americans have coined the barbarous words cephalads and caudads, i. e. headwards and tailwards, for a similar purpose.

his arms and legs in opposite directions, for he has his arms bent convexly, but his legs concavely. And a viviparous quadruped[1] bends his limbs in opposite directions to a man's, and in opposite directions to one another; for he has his forelegs bent convexly, his hind legs concavely.
704^{b} Again, quadrupeds which are not viviparous but oviparous[2] have a peculiar curvature of the limbs laterally[3] away from the body. Again, why do quadrupeds move their legs criss-cross[4]?

We have to examine the reasons for all these facts, and others cognate to them; that the facts are such is clear from our Natural History,[5] we have now to ask reasons for the facts.

At the beginning of the inquiry we must postulate the 2
principles[6] we are accustomed constantly to use for our

[1] Except the elephant; *H. A.* 498^{a} 8; *infra*, 712^{a} 11.

[2] e. g. lizards. The flexion of Ovipara is said in *H. A.* 498^{a} 15 to be forwards for both pairs of limbs, but *infra*, ch. 13, their flexion is considered the same as that of Viviparous Quadrupeds except for the lateral inclination. A. speaks only superficially as he did not grasp the homology of the parts of the limbs. In the case of lizards and crocodiles (as in frogs) the superficial appearance is that the forelegs bend backwards, the hind legs forwards, though in some positions both look backwards bent, never both forwards. The text of *H. A.* 498^{a} 15 seems therefore corrupted, though the general drift shows that A. there *contrasted* viviparous and oviparous quadrupeds in this regard (cf. 498^{a} 23).

[3] Cf. *H. A.* 498^{a} 16 μικρὸν εἰς τὸ πλάγιον παρεγκλίνοντα.

[4] Cf. *H. A.* 490^{b} 4 lit. diagonally, i. e. the normal contrary movement of a trotting horse's feet, near fore with off hind (cf. *infra*, ch. 14). In the trot the pairs come down exactly together. A. considers a galop forcé to be abnormal, not progression but jumping (cf. ch. 14). In *H. A.* 498^{b} 6 he records another kind, the amble of the camel, as normal to it (and to the lion!) In ch. 14 he does not seem to remember about the camel, which achieves what he there regards as dynamically impossible.

[5] ἱστορία φυσική, cf. *P. A.* 650^{a} 32, the original of our term Natural History. The reference is to the work called usually αἱ περὶ τῶν ζῴων ἱστορίαι, vid. *H. A.* 490^{b} 4, 498^{a} 3 seq.; cf. *P. A.* 646^{a} 9.

[6] Unfortunately A. instances only the principles of Purpose, and of Selection of the Best Possible (Bonitz, *Index*, 836^{a} 48); cf. Leibniz, *Opp.* (ed. Erdmann) p. 106, 'Bien loin d'exclure les causes finales et la considération d'un Etre agissant avec sagesse, c'est de là qu'il faut tout déduire en Physique.' In the following few pages A. appeals also to:

(2) Economy or Organic Equivalents, 710^{a} 32, 716^{a} 16, cf. *P. A.* 652^{a} 31, 658^{a} 34, 694^{b} 18 et passim, a species of Compensation, *H. A.* 487^{b} 26, 504^{b} 7 et saepe.

(3) Bilateral Symmetry, 710^{b} 3, cf. *P. A.* 656^{b} 31, 663^{a} 22, 669^{b} 17, 686^{a} 12.

(4) Specialized Differentiation, viz. one organ for one primary purpose, 706^{a} 18, cf. *Pol.* 1252^{b} 3, &c.

scientific investigation of nature, that is we must take for granted principles of this universal character which appear in all Nature's work. Of these one is that Nature creates nothing without a purpose, but always the best possible in each kind of living creature by reference to its essential constitution. Accordingly if one way is better than another that is the way of Nature.[1] Next we must take for granted the different species of dimensions[2] which inhere in various things; of these there are three pairs of two each, superior and inferior, before and behind, to the right and to the left. Further we must assume that the originals of movements in place are thrusts and pulls.[3] (These are the essential place-movements, it is only accidentally that what is carried by another is moved; it is not thought to move itself, but to 705^{a}
be moved by something else.[4])

3 After these preliminaries, we go on to the next questions in order.

Now of animals which change their position some move with the whole body at once, for example jumping animals, others move one part[5] first and then the other, for example walking ⟨and running⟩ animals. In both these changes the moving creature always changes its position by pressing against what lies below it. Accordingly if what is below gives way[6] too quickly for that which is moving upon it to

(5) Secondary Adaptation, 714^{a} 11, cf. *P. A.* 688^{a} 24.
(6) Utility: (*a*) for preservation in environment, 710^{a} 27, 713^{b} 28, cf. *P. A.* 693^{a} 4; (*b*) of mechanical structure, 710^{b} 21, 711^{b} 32, 713^{b} 20, cf. *P. A.* 694^{b} 13.
(7) Homology of organs and members, 709^{b} 30, 714^{b} 3, et passim (cf. *P. A.* I. ch. 1).
(8) Serial Homology, 707^{b} 2.
(9) Analogy between the parts and works of Nature, 705^{b} 5.
(10) Sovereignty, the principle of subordination running through Creation (*Pol.* 1254^{a} 31: (*a*) man's superiority to the rest of the animal kingdom, cf. *P. A.* 656^{a} 7; (*b*) of the right to the left, of upper to lower, 706^{b} 10 et seq., cf. *P. A.* 686^{a} 25; (*c*) the 'gradual scale' from lifeless things to the highest animate beings, cf. *P. A.* 681^{a} 12.

[1] Leg. τὰ κατὰ φύσιν Z, cf. *Nic. Eth.* 1099^{b} 23 (Bywater).
[2] Cf. ch. 4, *infra*; *Topics*, 142^{b} 34; *Phys.* 208^{b} 13, 243^{a} 16; *de Caelo*, 284^{b} 6; *Met.* 1016^{b} 25; Plato, *Leges*, 817 E, &c. For the application to organisms cf. *H. A.* 493^{b} 17, 494^{a} 20; *P. A.* 669^{b} 20.
[3] Cf. *de Motu*, 703^{a} 20 and note.
[4] Cf. *Phys.* 243^{b} 19.
[5] Leg. κατὰ μέρος Z, cf. *inf.* 708^{a} 28.
[6] Cf. *de Motu*, 698^{b} 15, &c.

lean against it, or if it affords no resistance at all to what is moving, the latter can of itself effect no movement upon it. For an animal which jumps makes its jump both by leaning against its own upper part[1] and also against what is beneath its feet; for at the joints the parts do in a sense lean upon one another, and in general that which pushes down leans upon what is pushed down. That is why athletes jump further with weights[2] in their hands than without, and runners run faster if they swing their arms; there is in extending the arms a kind of leaning against the hands and wrists. In all cases then that which moves makes its change of position by the use of at least two parts of the body; one part so to speak squeezes, the other is squeezed; for the part that is still is squeezed as it has to carry the weight, the part that is lifted strains against that which carries the weight. It follows then that nothing without parts[3] can move itself in this way, for it has not in it[4] the distinction of the part which is passive[5] and that which is active.

Again, the boundaries[6] by which living beings are 4
naturally determined are six in number, superior and inferior, before and behind, right and left. Of these all living beings have a superior and an inferior part; for superior and inferior is in plants too, not only in animals. And this distinction is one of function, not merely of position relatively to our earth and the sky above our heads. The

[1] Leg. *αὐτὸ* UΓ Mich.; cf. *H. A.* 567a 8, *infra*, 709b 8. It is most remarkable that A. nowhere refers in this treatise to the vertebrae of the back, though they are presupposed here and certainly in his discussion of snakes; cf. *P. A.* 654b 14 *ἀνάγκῃ κινουμένου τοῦ ζῴου κάμπτεσθαι τὸ σῶμα*: Galen, *de Usu Part.* xii. 10. Prof. Platt (*J. of Phil.* xxxii. 63) suggests *τῷ ἄνω* (τω S).

[2] Pieces of wood or metal, shaped either as half disks or like our dumb-bells, used by Greek athletes to give the body additional momentum in the long-jump (cf. *Prob.* 881b 3; *Nic. Eth.* 1123b 31). They are illustrated in Dubois-Villeneuve, *Int. à l'Etude des Vases antiques*, Plate xvi.

[3] PSU and Mich. *ἀμελές*, viz. without limbs; but cf. *supra*, line 20; *de Motu*, 702b 31 (note); *infra*, 705b 22. Γ read *ἀσκελές*.

[4] Leg. *αὐτῷ* Z. (sic).

[5] Cf. *de Motu*, 702a 11 (note).

[6] Cf. *de Motu*, 703b 18 (note). *διάστασις* might almost be turned by 'dimension', but A. uses it only of body (a line is defined by Proclus, *μέγεθος ἐφ' ἓν διάστατον*). Cf. *de Caelo*, 284b 24, where 'up' is the principle of length, 'right' of breadth, and 'front' of depth.

superior is that from which flows in each kind the distribution of nutriment and the process of growth ; the inferior is that 705b
to which the process flows and in which it ends. One is a starting-point, the other an end, and the starting-point is the superior. And yet it might be thought[1] that in the case of plants at least the inferior is rather the appropriate starting-point, for in them the superior and inferior are in position other than in animals.[2] Still they are similarly situated from the point of view of function, though not in their position relatively to the universe. The roots are the superior part[3] of a plant, for from them the nutriment[4] is distributed to the growing members, and a plant takes it with its roots as an animal does with its mouth.[5]

Things that are not only alive but are animals have both a front and a back, because they all have sense,[6] and front and back are distinguished by reference to sense.[7] The front is the part in which sense is innate, and whence each thing gets its sensations, the opposite parts are the back.

All animals which partake not only in sense, but are able of themselves to make a change of place,[8] have a further distinction of left and right besides those already enumerated; like the former these are distinctions of function and not of position. The right[9] is that from which change of position

[1] Leg. *καίτοι δόξειε γ' ἂν τοῖς φυτοῖς* U, cf. Mich.

[2] Plato calls Man *φυτὸν οὐκ ἔγγειον ἀλλ' οὐράνιον*, plant not of earth but of the firmament (*Tim.* 90 A). Among animals Testacea are inverted like plants (*P. A.* 683b 20); Molluscs (Cephalopods) have no superior and inferior (*G. A.* 741b 33), cf. *infra*, 706b 1. Linnaeus said 'Planta est animal inversum'; Bacon (*N. O.* ii. 27) 'homo sit tanquam planta inversa'.

[3] Cf. *de Anim.* 416a 5 ; *Parv. Nat.* 468a 1 ; *H. A.* 494a 26, 500b 28 ; *P. A.* 650a 20, 656a 10.

[4] Cf. *de Gen. et Corr.* 335a 13 ; *G. A.* 762b 12.

[5] Cf. *de Anim.* 412b 3 ; *P. A.* 686b 28.

[6] Cf. *de Anim.* 413b 1 ; *Parv. Nat.* 467b 23 ; *P. A.* 666a 34 ; *G. A.* 731b 4 ; *Met.* 980a 28.

[7] Cf. *de Caelo*, 284b 29 *ἔμπροσθεν ἐφ' ὃ αἱ αἰσθήσεις*, 285a 24 *τὸ δὲ [εἰς τὸ] πρόσθεν ἐφ' ὃ* (sc. *ἡ κίνησις*).

[8] Sensation (*de Anim.* 414b 3 ; *Parv. Nat.* 454b 25 ; *P. A.* 653b 22) and movement in Place (*Pol.* 1290b 26) are the proper characteristics of animals (*Phys.* 265b 34). Some of the Testacea (e.g. mussels) are almost sedentary, and are therefore akin to both plants and animals (*H. A.* 487b 6 ; *P. A.* 683b 4 ; *G. A.* 731b 8). Cf. what is said of Sponges, *P. A.* 681a 11, and of Ascidians, 681a 26. Contrast *de Caelo*, 284b 32.

[9] Cf. *de Caelo*, 285a 25, b 16.

naturally begins, the opposite which naturally depends upon this is the left.

This distinction (of right and left) is more articulate and detailed in some than in others. For animals which make the aforesaid change (of place) by the help of organized parts (I mean feet for example, or wings or similar organs) have the left and right distinguished in greater detail, while those which are not differentiated into such parts, but make the differentiation [1] in the body itself and so progress, like some footless animals (for example snakes and caterpillars after their kind, and besides what men call earth-worms [2]), all these have the distinction spoken of, although it is not made so manifest to us. That the beginning of movement is on the right [3] is indicated by the fact that all men carry burdens on the left [4] shoulder; in this way they set free the side which initiates movement and enable the side which bears the weight to be moved. And so men hop easier on the left leg; for the nature of the right is to initiate movement, that of the left to be moved. The burden then must rest on the side which is to be moved, not on that which is going to cause movement, and if it be set on the moving side, which is the original of movement, it will either not be moved at all or with more labour. Another indication that the right is the source of movement is the way we put our feet forward; all men lead off with the left, and after standing still prefer to put the left foot forward, unless something happens to prevent it. The reason is that their

[1] Viz. by undulations, cf. *infra*, 707b 7.

[2] Lit. earth-entrails.

[3] Cf. *H. A.* 498b 7; *infra*, 712a 25. Man is the standard, he moves his left leg first, the right being the original of motion (ἀρχὴ κινήσεως). It is strange that A. nowhere considers the effect of the bilateral structure in this connexion; since the determining cause seems to be the development of the right hand and arm; in quadrupeds it would follow naturally that the near hind should move first (and so in fact is the tendency in most horses), but *infra*, 712a 25, he says that the off fore moves first, and that strictly should correspond to man's right hand.

[4] Many curious observations might be made. Beginners in skating exhibit a painful tendency to strike off with the left (706a 5); fencing and boxing seem adverse to A.'s doctrine. In Testacea (e. g. Snails) A. says the spiral runs from left to right; their movement being from the spiral is from right to left, accordingly they carry their shell on the right, contrary to the usual position of a burden (cf. *infra*, 706a 13).

movement comes from the leg they step off, not from the one put forward. Again, men guard themselves with their right. And this is the reason why the right is the same in all, for that from which motion begins is the same for all, and has its natural position in the same place, and for this reason the spiral-shaped Testaceans have their shells on the right,[1] for they do not move in the direction of the spire, but all go forward in the direction opposite to the spire. Examples are the murex and the ceryx.[2] As all animals then start movement from the right, and the right moves in the same direction as the whole, it is necessary for all to be alike right-handed. And man has the left limbs detached[3] more than any other animal because he is natural in a higher degree than the other animals; now the right is naturally both better[4] than the left and separate from it, and so in man the right is more especially the right, more dextrous that is, than in other animals. The right then being differentiated it is only reasonable that in man the left should be most movable,[5] and most detached.[6] In man, too, the other starting-points[7] are found most

[1] Cf. *H.A.* 528^b 9; *infra*, 714^b 8; *G.A.* 763^a 22.

[2] The Trumpet-shell.

[3] Except the elephant, cf. *H.A.* 497^b 22.

[4] For the principle of Sovereignty, obtaining between each pair, cf. Plato, *Tim.* 45; *P.A.* 648^a 11, 665^a 22, 672^b 22; *G.A.* 742^b 16. The idea is of Pythagorean origin, *de Caelo*, 284^b 7, *fr.* 1513^a 24; the superior being in their view prior to the right, and to the front, *de Caelo*, 285^a 21. On the physiological ground for the sovereignty of the right, cf. *P.A.* 667^a 21, ^{b} 35; *G.A.* 765^b 1.

Pliny, *N.H.* xviii. 24 (54) makes a suggestive remark on sowing: 'Manus utique congruere debet cum gradu semperque cum dextro pede,' and this action may be seen in medals and other plastic representations of sowing. Some modern writers connect the Saturnian metre with this beat of the right foot.

[5] Leg. εὐκινητότατα, which appears to be Z's original reading. Two letters are erased and α written in a later hand. Man is the only ambidextrous animal, *H.A.* 497^b 31; *Nic. Eth.* 1134^b 34. Plato held that at birth he was nearly ambidextrous, only dextrous by habit (*Leges*, 794 E). The determining influence of habit is recognized in *Mag. Mor.* 1194^b 30, but even for the ambidextrous the right is still φύσει βελτίω. Hippocrates (*de Aër.* 17) makes some interesting remarks upon the effect of mutilation and habit upon the right side of Sauromatian women.

[6] The reasoning seems *a priori*. Feline creatures have their left forelimbs more detached than men; in *H.A.* 497^b 22 the elephant is said to be the equal of man in this respect.

[7] ἀρχαί, as usual, hard to render adequately. The superior, front and right, are said to be ἀρχαί in two senses in *de Caelo*, 284^b 20.

naturally and clearly distinct, the superior part that is and the front.

Animals which, like men and birds, have the superior part distinguished from the front are two-footed (biped). In them, of the four points of motion, two are wings in the one, hands and arms in the other. Animals which have the superior and the front parts[1] identically situated are four-footed, many-footed, or footless (quadruped, polypod, limbless). I use the term foot[2] for a member employed for movement in place[3] connected with a point on the ground, for the feet appear to have got their name from the ground under our feet.

706b Some animals, too, have the front and back parts identically situated, for example Cephalopods (molluscs) and spiral-shaped Testaceans, and these we have discussed elsewhere in another connexion.[4]

Now there is in place[5] a superior, an intermediate, and an inferior; in respect to place bipeds have their superior part corresponding to the superior part of the universe;[6] quadrupeds,[7] polypods, and footless animals to the intermediate part,[8] and plants to the inferior. The reason is that these have no power of locomotion, and the superior

[1] Cf. *P.A.* 686a 33; man is the norm, his arms are superior limbs; a quadruped's forelegs are homologous with man's arms, and are therefore strictly 'superior', and so the superior and front are in quadrupeds identical.

[2] ποῦς ποδός, derived ἀπὸ τοῦ πέδου; cf. foot and pad in English, as if we related pad to path etymologically; cf. *P.A.* 695b 22 ἡ τῶν ποδῶν πρόσθεσις πρὸς τὴν ἐπὶ τῷ πέδῳ κίνησιν χρήσιμος (leg. πέδῳ with PSU).

[3] Leg. κινητικόν (with Γ), cf. last note.

[4] e.g. *H.A.* 523b 21; cf. *P.A.* 684b 14, b 34 seq. (πάντας ἔχουσι τοὺς πόδας ἐπὶ τὸ καλούμενον ἔμπροσθεν· τούτου δ' αἴτιον ὅτι συνῆκται αὐτῶν τὸ ὄπισθεν πρὸς τὸ ἔμπροσθεν).

[5] Cf. *supra*, 705b 4 (note). The passage is almost unique in doctrine. It would be more characteristic to consider the middle or intermediate to be the best, as in *P.A.* 666a 15 εὐφυέστατος τῶν τόπων ὁ μέσος (cf. *Pol.* 1327b 29; Plato, *Epin.* 987 D; Theoph. *Met.* Br. 321).

In this connexion A. generally uses only superior and inferior, and τὸ μέσον is ἔσχατον, cf. *de Caelo*, 308a 23, in which treatise there is a parallel to our passage. 312a 7 οἱ τόποι δύο, τὸ μέσον (the centre) καὶ τὸ ἔσχατον. ἔστι δὲ δή τι καὶ [τὸ] μεταξὺ τούτων . . . τὸ μεταξύ (viz. region of water and air).

[6] τοῦ ὅλου, cf. *de Motu*, 699a 12 for the complete term ὅλος οὐρανός.

[7] Leg. τὰ δὲ ⟨τετράποδα ἢ⟩ πολύποδα . . .

[8] τὸ μεταξύ. Cf. *Parv. Nat.* 468a 7, and for the Universe, *Meteor.* 340a 5, 18 ὁ μεταξὺ γῆς καὶ οὐρανοῦ τόπος.

part is determined relatively to the nutriment, and their nutriment is from the earth. Quadrupeds, polypods, and footless animals again have their superior part corresponding to the intermediate, because they are not erect. Bipeds have theirs corresponding to the superior part of the universe because they are erect, and of bipeds, man *par excellence*; for man is the most natural of bipeds. And it is reasonable for the starting-points to be in these parts; for the starting-point[1] is honourable, and the superior is more honourable[2] than the inferior, the front than the back, and the right than the left. Or we may reverse the argument and say quite well that these parts are more honourable than their opposites just because the starting-points are in them.

6 The above discussion has made it clear that the original of movement is in the parts on the right. Now every continuous whole,[3] one part of which is moved while the other remains at rest must, in order to be able to move as a whole while one part stands still, have in the place[4] where both parts have opposed movements[5] some common part which connects the moving parts with one another. Further in this common part the original of the motion (and similarly of the absence of motion) of each of the parts must lie.

Clearly[6] then if any of the opposite pairs of parts (right and left, that is, superior and inferior, before and behind) have a movement of their own, each of them has for common original of its movements the juncture[7] of the parts in question.

Now before and behind are not distinctions relatively to

[1] Cf. *Post. An.* 88a 5; *Nic. Eth.* 1102a 3.
[2] Cf. *supra*, 706a 20 and note.
[3] Cf. *H.A.* iii. 7.
[4] Viz. at the joints, particularly at the four 'points' of an organized body.
[5] The opposed movements are motion, and privation of motion, regarded as contraries by A. He does not realize that the stationary limb is so kept by muscular contraction, though this would chime with his general doctrine.
[6] Leg. δῆλον ὅτι (Γ) and insert comma after στάσεως.
[7] Or perhaps leg. κατὰ τὴν τῶν εἰρ. PΓ (*sic* Mich.), viz. 'has a common original by reason of the natural interconnexion of the parts in question'. The common original is the joint.

that which sets up its own motion,[1] because in nature nothing has a movement backwards,[2] nor has a moving animal any division whereby it may make a change of position towards its front or back; but right and left, superior and inferior are so distinguished. Accordingly, all
707a animals which progress by the use of distinct members have these members distinguished not by the differences of before and behind, but only of the remaining two pairs; the prior difference dividing these members into right and left (a difference which must appear as soon as you have division into two), and the other difference appearing of necessity where there is division into four.

Since then these two pairs, the superior and inferior and the right and left, are linked to one another by the same common original[3] (by which I mean that which controls their movement), and further, everything which is intended to make a movement in each such part properly must have the original cause of all the said movements arranged in a certain definite position relatively to the distances from it of the originals of the movements of the individual members (and these centres of the individual parts are in pairs arranged co-ordinately or diagonally,[4] and the common centre is the original from which the animal's movements of right and left, and similarly of superior and inferior, start); each animal must have this original at a point[5]

[1] The fore and hind limbs of a quadruped are superior and inferior by homology with man; there is therefore no articulation corresponding to the dimensions 'front' and 'behind'. Cf. *H. A.* 494a 27; *P. A.* 686a 34.

[2] Apparent exceptions are cephalopods and crayfish (*H. A.* 489b 33, 490a 3). The latter is correctly described as sometimes swimming backwards, but A. only hesitatingly recognizes the use of the abdomen in that kind of progression. The crayfish also *walks* backwards.

Among quadrupeds the badger and the weasel seem to trot backwards quite easily and naturally.

[3] Viz. the heart.

[4] Co-ordinately, e.g. fore near and hind near; diagonally, fore near, hind off.

[5] Leg. *ταύτην δεῖ ἔχειν ἕκαστον ᾗ ὁμοίως ἢ παραπλησίως ἔχει πρὸς . . .*; *ἢ παραπλησίως ἐν* Y. Γ preserves *ὁμοίως*, 'eodem modo aut quasi similiter.'

ταύτην δ' ἔχειν ἑκάστῳ ᾗ παραπλησίως ἔχει πρὸς ἕκαστον τῶν Z (*-ην δ' ἔχειν ἑκάστῳ* is written above an erasure, and above that *ἀναγκαῖον*; *ἕκαστον* has been altered to *ἑκάστην* much later) and Mich. *ὁμοίως*, p. 148. 19.

ταύτην, i. e. *τὴν ἀρχήν, τὸ τῶν κινήσεων αἴτιον*, the heart; cf. *P. A.* 666a 15 *τὸ μέσον* (the heart) *ἐπὶ πᾶν ἐφικτὸν ὁμοίως ἢ παραπλησίως . . .*

where it is equally or nearly equally related to each of the centres in the four parts described.

7 It is clear then how locomotion belongs to those animals only which make their changes of place by means of two or four points in their structure, or to such animals *par excellence.* Moreover, since this property[1] belongs almost peculiarly to Sanguineous animals, we see that no Sanguineous animal can progress at more points than four,[2] and that if it is the nature of anything so to progress at four points it must of necessity be Sanguineous.

What we observe[3] in the animal world is in agreement with the above account. For no Sanguineous animal if it be divided into more parts can live for any appreciable length of time, nor can it enjoy the power of locomotion which it possessed while it was a continuous and undivided whole. But some bloodless animals and polypods can live a long time,[4] if divided, in each of the severed parts, and can move in the same way as before they were dismembered. Examples are what is termed the centipede[5] and other insects that are long in shape, for even the hinder portion 707b
of all these goes on progressing in the same direction as before[6] when they are cut in two.

The explanation of their living when thus divided is that each of them is constructed like a continuous body of many separate living beings.[7] It is plain, too, from what was said above why they are like this. Animals constructed most naturally are made to move at two or four points, and even limbless Sanguinea are no exception. They too move by

The exception is man's heart, which is a little to the left and upwards; *H.A.* 496a 15, 507a 1; *P.A.* 666b 6.

[1] Viz. to have a common centre of movement or ἀρχή, lying in the middle, cf. *infra*, a 27.

[2] Cf. *H.A.* 490a 27.

[3] A. appeals, as so often in his scientific treatises, to experience for confirmation of general theory.

[4] Viz. τὰ ἔντομα, *H.A.* 531b 30; cf. *de Anim.* 409a 9, 411b 19, 413b 20; *Parv. Nat.* 467a 19, 468a 25, 471b 20; *P.A.* 667b 27, 673a 30.

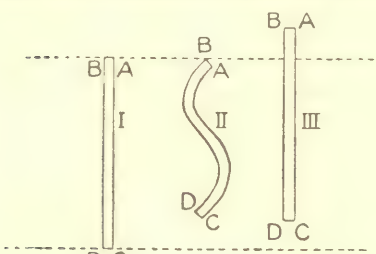
[5] Scolopendra, cf. *H.A.* 505b 13, 532a 5, 621a 7.

[6] Leg. κατὰ ταὐτὸ (καὶ Z) and τῷ πρόσθεν. Cf. *H. A.* 532a 4, where the several parts are said to move either way (cf. Prof. Platt, l. c. p. 40).

[7] On this point and its relation to the many limbs A. seems in advance of Galen (cf. *de Usu Partium*, iii. 2).

dint of four points, whereby they achieve progression. They go forward by means of two flexions.[1] For in each of their flexions there is a right and a left, both before and behind in their flat surface,[2] in the part towards the head a right and a left front point, and in the part towards the tail the two hinder points.[3] They look as if they moved at two points only, where they touch before and behind, but that is only because they are narrow in breadth. Even in them the right is the sovereign part,[4] and there is an alternate correspondence behind,[5] exactly as in quadrupeds. The reason of their flexions is their great length, for just as tall men walk with their spines bellied (undulated) forward, and when their right shoulder is leading in a forward direction their left hip is rather inclined backwards, so that their middle becomes hollow and bellied[6] (undulated), so we

[1] The doctrine is somewhat different from that of *H. A.* 490^{a} 31. There the snake is said to progress by means of four bends (cf. the same theory as to eels, 708^{a} 5 *infra*). Here the philosopher seems to intend the theory expressed in the translation, which the diagram below will make clear. Had A. compared the progression of snakes with that of lizards his theory of four points would have been exactly exemplified. I am not certain that the snake or lizard *alternates* the curves, though a fish necessarily does so in order to keep straight. The point is not discussed in Cuvier. A., though he describes their great number (*H. A.* 508^{b} 3), did not realize the function of the ribs of the snake which, with their remarkable ball and socket joints, make the snake a polypod rather than a quadruped, though if he had he would have doubtless referred them to four original points (of course the ribs are not strictly feet). He does not remark upon the function of the tail of fish or lizard in this connexion, though in *H. A.* 490^{a} 4 he says that the newt's tail is used for progression (cf. *P. A.* 684^{a} 3). Vid. A. M. *Opp.* ix, p. 298.



[2] Leg. καὶ ⟨τὸ⟩ ὀπίσθιον PY. Lit. 'in the breadth'.

[3] Mich. forcing the Greek takes this to describe *four* flexions.

[4] ἡγεῖται has the pre-eminence, viz. initiates movement, not necessarily goes first or leads, which is ἡγεῖσθαι τῇ θέσει, 711^{a} 23.

[5] Viz. the opposed response is made behind, i. e. motion of the left side.

[6] A.'s observation about tall men is just. λορδός is opposed to κυφός (710^{b} 18); it was a medical term strictly used of the spine, viz. hollow backed)(hunched. Hipp. *de Artic.* 807 B; λορδωτὸν . . . ἐναντίον τῷ κυρτῷ Erotiani *Glossaria*, p. 242 (Franzius).

ought to conceive snakes as moving in concave curves (undulations) upon the ground. And this is evidence that they move themselves like the quadrupeds, for they make the concave in its turn convex and the convex concave. When in its turn the left of the forward parts is leading, the concavity is in its turn reversed, for the right becomes the inner. (Let the right front point be A, the left B, the right hind C, the left D.[1])

Among land animals this is the character of the movement of snakes, and among water animals of eels, and conger-eels and also lampreys, in fact of all that have their form snakelike.[2] However, some marine animals of this shape have no fin, lampreys[3] for example, but put the sea 708a
to the same use[4] as snakes do both land and water (for snakes swim precisely as they move on the ground).[5] Others have two fins only, for example conger-eels and eels and a kind of cestreus[6] which breeds in the lake of Siphae. On this account too those that are accustomed to live on land, for example all the eels, move with fewer flexions in a fluid than on land,[7] while the kind of cestreus which has two fins, by its flexion in a fluid makes up the remaining
8 points.[8] The reason why snakes are limbless[9] is first that nature makes nothing without purpose, but always regards what is the best possible for each individual, preserving the

[1] Cf. 707b 10 (note) and 702b 29 (note). Probably Z's cyclic order is correct.

[2] Cf. *H. A.* 489b 26; *P. A.* 696a 3 (and Dr. Ogle's note), and *infra*, 709b 12.

[3] Cf. *H. A.* 489b 28, 504b 34.

[4] *Muraena helena*, cf. *H. A.* 489b 29, where the lamprey and other similar creatures are said to use the sea as snakes do the earth, and to swim in the watery medium in a manner similar to the movements of serpents.

[5] Cf. *P. A.* 696a 9.

[6] Cf. *H. A.* 504b 33; *P. A.* 694a 4. The features are not those of a mullet. Perhaps it is a fish akin to the Bichir of the Nile, and the Reed fish of Old Calabar. The latter has no ventral fins.

[7] Eels appear to be regarded here as land fishes. The true reason of their fewer flexions in water is the greater ease of their progress there, not the fins, which are practically of no help.

[8] Leg. τὰ λοιπὰ σημεῖα Z. I. e. inasmuch as they have two fins they use fewer flexions in the water than a snake, and thus preserve Nature's balance of four points of motion; cf. *H. A.* 490a 32 δύο ⟨καμπαὶ⟩ σὺν τοῖς πτερυγίοις, and *infra*, 709b 13 (τὴν λοιπὴν κίνησιν).

[9] Cf. *P. A.* 690b 14, 692a 16.

peculiar essence of each and its intended character, and secondly the principle we laid down above that no Sanguineous creature can move itself at more than four points. Granting this it is evident that Sanguineous animals like snakes, whose length is out of proportion to the rest of their dimensions, cannot possibly have limbs; for they cannot have more than four (or they would be bloodless), and if they had two or four they would be practically stationary; so slow and unprofitable would their movement necessarily be.[1]

But every limbed animal has necessarily an even number of such limbs. For those which only jump and so move from place to place do not need limbs[2] for this movement at least, but those which not only jump but also need to walk, finding that movement not sufficient for their purposes, evidently either are better able to progress with even limbs or cannot otherwise progress at all,[3] [for[4] every animal which has limbs must have an even number], for as this kind of movement is effected by part of the body at a time, and not by the whole at once[5] as in the movement of leaping, some of the limbs must in turn remain at rest, and others be moved, and the animal must act in each of these cases with opposite limbs, shifting the weight from the limbs that are being moved to those at rest. And so[6]
708b nothing can walk on three limbs or on one;[7] in the latter

[1] Cf. *P. A.* 696a 11, where the present passage is referred to.

[2] Viz. do not need limbs in the specific sense of locomotory organs. Elsewhere A. relates the movement of jumping to the abnormally developed hind legs (e.g. in ἀκρίδες and ψύλλαι), cf. *H. A.* 532a 27; *P. A.* 683a 23.

A. nowhere recognizes the uses of the tail in leaping, nor does he appear to mention the Elateridae (Skipjacks).

[3] Leg. δῆλον ὅτι οὕτως μὲν βέλτιον τοῖς δ' ὅλως ἀδύνατον ⟨ἄλλως⟩ πορεύεσθαι. My emendation gives the necessary sense, that polypods though they can succeed in progressing on odd limbs (cf. *infra*, b 14–16) do so *better* on even limbs; quadrupeds cannot walk at all on odd limbs. Γ seems to have read ὡς εἰ οὗτος μὲν βέλτιον τοῖς δὲ ἀδύνατον ὅλως. Necessity in the organic world manifests itself in a distribution of organs which is ἐκ τῶν ἐνδεχομένων βέλτιστον (best of possible arrangements) or necessary and inevitable because of some τέλος, cf. *P. A.* 640a 36 ἢ ὅτι ὅλως ἄδύνατον ἄλλως ἢ καλῶς γε οὕτως.

[4] Clearly a gloss on the whole paragraph (om. PSU).

[5] Cf. *supra*, 705a 5.

[6] Viz., on account of this opposition.

[7] Leg. τρισὶ μὲν οὐθὲν οὐδ' ἑνί. τρεῖς μὲν οὐθ' ἑνὶ οὐδέν Z. Cf. Mich. 151. 27 ἢ δι' ἑνὸς ἢ διὰ τριῶν. 'nullum neque uno' Γ.

case it has no support at all on which to rest the body's weight, in the former only in respect of one pair of opposites, and so it must necessarily fall in endeavouring so to move. Polypods however, like the Centipede,[1] can indeed make progress on an odd number of limbs, as may be seen by the experiment of wounding one of their limbs; for then the mutilation of one row of limbs is corrected by the number of limbs which remain on either side. Such mutilated creatures, however, drag the wounded limb after them with the remainder, and do not properly speaking walk. Moreover, it is plain that they, too, would make the change of place better[2] if they had an even number, in fact if none were missing and they had the limbs which correspond to one another. In this way they could[3] equalize their own weight, and not oscillate to one side, if they had corresponding supports instead of one section of the opposite sides[4] being unoccupied by a limb. A walking creature advances from each of its members alternately,[5] for in this way it recovers the same figure that it had at first.

The fact that all animals have an even number of feet,
9 and the reasons for the fact have been set forth. What follows will explain that if there were no point at rest flexion and straightening would be impossible. Flexion[6] is a change from a right line to an arc or an angle, straightening a change from either of these to a right line. Now in all such changes the flexion or the straightening must be relative to one point.[7] Moreover, without flexion there could not be walking or swimming or flying. For since limbed[8] creatures stand and take their weight alternately on one or other of the opposite legs, if one be thrust

[1] Scolopendra, vid. 707a 30 note.

[2] βέλτιον, cf. *supra*, 708a 26 note.

[3] Leg. δύναιτ' ἂν (δύναιντο PSUY, cf. 709a 12 reading of PY).

[4] Om. τήν after χώραν PSUY.

[5] He is thinking of quadrupeds as typical, and their movement κατὰ διάμετρον (cf. ch. 14 *infra*). ἐναλλάξ as in *Euclid*, i. 27 αἱ ἐναλλὰξ γωνίαι, the alternate angles, the angles there being taken, like the limbs here, in cyclic order.

[6] Cf. *Meteor.* 386a 2.

[7] Cf. *de Motu*, ch. 1; *supra*, ch. 3.

[8] μέν refers to δέ in 709a 24.

forward the other must of necessity be bent. For the opposite limbs are naturally of equal length, and the one which is under the weight must be a kind of perpendicular[1] at right angles to the ground.

When then one leg is advanced it becomes the hypo-
709a tenuse of a right-angled triangle. Its square then is equal to the square on the other side together with the square on the base.[2] As the legs then are equal, the one at rest must bend either at the knee or, if there were any kneeless animal which walked, at some other articulation. The following experiment exhibits the fact. If a man were to walk parallel to a wall in sunshine,[3] the line described ⟨by the shadow of his head[4]⟩ would be not straight but zigzag,[5] becoming lower as he bends, and higher when he stands and lifts himself up.

It is, indeed, possible to move oneself even if the leg be not bent, in the way in which children[6] crawl. This was the old though erroneous account of the movement of elephants.[7] But these kinds of movements involve a flexion in the shoulders[8] or in the hips. Nothing at any rate[9] could walk upright continuously and securely without flexions at the knee, but would have to move like men in the wrestling schools who crawl forward through the sand on their knees. For the upper part of the upright creature is long so that its leg has to be correspondingly long; in

[1] Cf. *Mech.* 857b 27 ἀνάγκη τὸν ἑστῶτα κάθετον εἶναι πρὸς τὴν γῆν.

[2] The base, i. e. the line between the point where the advanced leg touches the ground and the stationary foot.

[3] Leg. ἐν αὐγῇ ἡλίου: ἐν γῇ PSUY: ἐν . . .⌒. . . . Z with ΓΗ in later hand (the space is for about 9 letters). Cf. Plut. *Conviv.* iii. 1 (ii. 658 F). It should be evening light. Γ seems to have read ἐν γειτόνων (uicinus). Perhaps this belongs to the alternative in Mich. p. 155.

[4] Not in the Greek.

[5] Arist., like many Greek geometers, regards a zigzag as a kind of line, cf. *Met.* 1016a 2, 12. The line traced is ⩘⩘⩘ as Mich. says.

[6] To judge from Mich.'s note some words like καὶ οἱ ἀνάπηροι λεγόμενοι are missing here, viz. seals and bats, cf. *infra*, 714b 12.

[7] It was reported (perhaps by Ctesias of Cnidos, *G. A.* 736a 22) that the elephant had no knee-joints. A. corrects this mistake in *H. A.* 498a 8, and *infra*, 712a 11. He appears to be incorrectly informed in *P. A.* 659a 29, where he speaks of their legs as bending with difficulty (ἀφυῖαν τῆς κάμψεως), unless that means the exceptional bending.

[8] Scapula, cf. *H. A.* 498a 31 ἡ δὲ φώκη ὥσπερ πεπηρωμένον . . . εὐθὺς ἔχει μετὰ τὴν ὠμοπλάτην τοὺς πόδας.

[9] Leg. ὀρθόν γε.

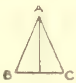
consequence there must be flexion. For since a stationary position is perpendicular, if that which moves cannot bend[1] it will either fall forward as the right angle becomes acute or will not be able to progress. For if one leg is at right angles to the ground and the other is advanced, the latter will be at once equal and greater. For it will be equal to the stationary leg and also equivalent to the hypotenuse of a right-angled triangle.[2] That which goes forward therefore must bend, and while bending one, extend the other leg simultaneously, so as to incline forward and make a stride and still remain above the perpendicular; for the legs form an isosceles triangle, and the head sinks lower when it is perpendicularly above the base on which it stands.[3]

Of limbless animals, some progress by undulations (and this happens in two ways, either they undulate on the ground, like snakes, or up and down, like caterpillars), and undulation is a flexion; others by a telescopic[4] action, like what are called earthworms and leeches. These go forward, first one part leading and then drawing the whole of the rest of the body up to this, and so they change from place to place. It is plain too that if the two curves were not greater than the one line[5] which subtends them undulating animals could not move themselves; when the flexure 709b
is extended they would not have moved forward at all if

[1] Inser. εἰ ἄκαμπτον ἔσται τὸ κινούμενον Y (cf. Z); the words do not seem a gloss. (Prof. Platt agrees, l. c. p. 42.)

[2] δυνήσεται, not here used in the mathematical sense as *supra*, 709a 1, but in the ordinary sense. The leading leg is both equal to the back leg, because a man's legs are equal, and greater because (in the figure made necessary by the inflexibility hypothesis) it subtends the right angle.

[3] βαίνειν, as in Euclid iii, Def. 9, an angle stands on the arc below it (not in L. and S. or Bonitz in this sense). As the man moves, his head drops lower until it is the perpendicular of an isosceles triangle, where AB and AC are his legs. The brachylogy is easier in Greek because isosceles means 'with equal *legs*'.



[4] ἰλύσπασις, cf. *H. A.* 487b 22; telescopic suggests the movement of earthworms, which is concertina-like. L. and S. wrongly translate 'wriggling', which is not a worm's normal movement. A.'s account of the fact is characteristically accurate; characteristically too he does not ask how it squares with his theory of movement.

[5] Viz. the two arcs are together greater than the chord which subtends them.

the flexure or arc were equal to the chord subtended; as it is, it reaches further when it is straightened out, and then this part stays still and it draws up what is left behind.

In all the changes described that which moves now extends itself in a straight line to progress, and now is hooped; it straightens itself in its leading part, and is hooped in what follows behind. Even jumping animals all make a flexion in the part of the body which is underneath,[1] and after this fashion make their leaps. So too flying and swimming[2] things progress, the one straightening and bending their wings to fly, the other their fins to swim. Of the latter some have four fins,[3] others which are rather long, for example eels, have only two. These swim by substituting a flexion of the rest of their body for the ⟨missing⟩ pair of fins to complete the movement, as we have said before.[4] Flat fish use two fins, and the flat of their body as a substitute for the absent pair of fins.[5] Quite flat fish, like the Ray,[6] produce their swimming movement with the actual fins and with the two extremes or semicircles of their body, bending and straightening themselves alternately.

A difficulty might perhaps be raised about birds. How, **10**
it may be said, can they, either when they fly or when they walk, be said to move at four points? Now we did not say that all Sanguinea move at four points, but merely at not more than four. Moreover, they cannot as a fact fly if

[1] Cf. *supra*, 705a 12.

[2] A. nowhere in this treatise recognizes the use of the tail in swimming; he treats the tail as a rudder throughout (cf. 710a 1); by fins he means the pectoral and ventral fins, and these he considers the sole organs of locomotion in the normal fish (cf. 709b 9 and note).

[3] Cf. *H.A.* 489b 24.

[4] Cf. 708a 7 and note.

[5] A. seems to think that fish like the plaice use their flat edges for swimming, as the rays do. Correct about the rays, he is wrong about these flat fish.

[6] Cf. *H.A.* 489b 32; *P.A.* 696a 26. A. gives there a remarkably accurate account of the Rays, distinguishing those that have no obvious fins from the Torpedo fish which has two (regarded by A. as pectorals) on the tail. It is this fish which uses ἑκατέρῳ τῷ ἡμικυκλίῳ, to supply the other two points of movement. This is what he is describing here, though he does not realize that these processes are the true pectoral fins.

their legs be removed, nor walk without their wings. Even a man does not walk without moving his shoulders. Everything indeed, as we have said, makes a change of place by flexion and straightening, for all things progress by pressing upon[1] what being beneath them up to a point[2] gives way as it were gradually; accordingly, even if there be no flexion in another member, there must be at least in the point whence motion begins, that is in feathered[3] (flying) insects at the base of the 'scale-wing',[4] in birds at the base of the wing, in others at the base of the corresponding member, the fins, for instance, in fishes. In others, for example snakes, the flexion begins in the joints of the body. 710a

In winged creatures the tail[5] serves, like a ship's rudder, to keep the flying thing in its course. The tail then must like other limbs be able to bend at the point of attachment.[6] And so flying insects, and birds (Schizoptera) whose tails are ill-adapted for the use in question, for example peacocks, and domestic cocks, and generally birds that hardly fly,[7] cannot steer a straight course.[8] Flying insects have absolutely no tail, and so drift along like a rudderless[9] vessel, and

[1] *ἀποστηριζόμενα* or a similar word must be supplied, and has perhaps dropped out after *γάρ*. Cf. *supra*, 705a 7 (reading of Z).

[2] Cf. 705a 9 and *de Motu* 698b 15; up to a point, because in the case of water and air the resisting medium is not regarded as quite stationary like the earth.

A. does not discuss the results upon flying and swimming creatures of the fact that the medium is all round them.

[3] Holoptera, lit. with whole feathers (viz. what we call wings in Lepidoptera, &c.), in contrast with birds which have wings divided into feathers (Schizoptera, 710a 5).

[4] Leg. *πτιλοῦ* Z (*sic*), cf. *infra*, 713a 10.

[5] *οὐροπύγιον* (cf. *H. A.* 504a 32; *P. A.* 697b 11), viz. the tail with the tail feathers.

[6] *πρόσφυσις*, viz. the caudal vertebrae, which, as A. says, are freely movable, and do not anchylose like those of the trunk.

[7] Lit. that are not made for flight.

[8] A. does not recognize the function of the tail in keeping the flying body horizontal, and in helping the bird to rise and sink. He thinks of it apparently only as subserving a direct course. Contrast A. M. ix. p. 296.

[9] A. did not detect the uses of the abdomen in an insect's flight. Movements to right and left are governed primarily by deflexion of the abdomen. The drifting flight (e. g. of butterflies) is perhaps protective, and in the case of the chafers, &c., is due less to the causes A. suggests than to the imperfect balance produced by the relatively excessive weight of the hind parts. We may compare the erect flight of moorhens and coots, among birds, where the wings are set too far forward.

beat against anything they happen upon; and this applies equally to sharded[1] insects, like the scarab-beetle[2] and the chafer,[3] and to unsharded, like bees and wasps. Further, birds that are not made for flight have a tail that is of no use; for instance the purple coot[4] and the heron[5] and all water-fowl. These fly stretching out their feet[6] as a substitute for a tail, and use their legs instead of a tail to direct their flight. The flight of insects is slow and frail because the character of their feathery wings[7] is not proportionate to the bulk of their body; this is heavy, their wings small and frail, and so the flight they use is like a cargo boat attempting to make its voyage with oars; now the frailty both of the actual wings and of the outgrowths[8] upon them contributes in a measure to the flight described. Among birds, the peacock's tail is at one time useless because of its size, at another because it is shed.[9] But birds are in general at the opposite pole to flying insects as regards their feathers, but especially the swiftest flyers among them. (These are the birds with curved talons,[10] for swiftness of wing is useful to their mode of life.[11]) The rest of their bodily structure is in harmony with their peculiar movement, the small head, the slight[12] neck,

[1] Coleoptera.

[2] Cf. *N.H.* 552a 17; *P.A.* 682b 26, perhaps *Scarabaeus pilularius*.

[3] Cf. *N.H.* 490a 14; *P.A.* 682b 14. The kind is uncertain, but the descriptions tally with our May-bug or cockchafer.

[4] Or Purple Gallinule, a bird akin to our water-hen (*Porphyrio hyacinthus* or *coeruleus*). This is Dr. Thompson's identification (*Glossary of Greek Birds*). Bonitz, with Aubert, thinks it may be the Flamingo (*Phoenicopterus roseus*), and certainly the remark about its legs would then be more pointed. Why should it not be the Purple Heron (*Ardea Purpurea*)?

[5] Gilbert White remarks (*Selborne*, Letter xlii) 'herons seem encumbered with too much sail for their light bodies'.

[6] Cf. *P.A.* 694b 20.

[7] Cf. *supra*, 709b 30.

[8] Omit ἢ, Z. ἔκφυσις seems here to refer to the scales which form the surface of the wings; cf. *P.A.* 658b 5 where the word is used for hair growing as a covering.

[9] Cf. *H.A.* 564a 32. This so-called tail is not a true tail, the feathers in the οὐροπύγιον are only about 6 in. long.

[10] i.e. Raptores.

[11] Cf. *P.A.* 694a 2 πλῆθος ἔχουσι πτερῶν and διὰ τὸν βίον.

[12] Leon. omits οὐ, but A. is now speaking of birds generally, not of Raptores. The head and neck are relatively small and light; cf. *P.A.* 659b 8, 692b 20 (τεταμένος). In *P.A.* 694b 26 he is speaking of a *relatively* thick neck.

the strong and acute breastbone (acute[1] like the prow of a clipper-built vessel, so as to be well-girt,[2] and strong by dint of its mass of flesh[3]), in order to be able to push away 710b the air that beats against it,[4] and that easily and without exhaustion. The hind-quarters, too, are light and taper again, in order to conform to the movement of the front and not by their breadth to suck[5] the air.

11 So much then for these questions. But why an animal that is to stand erect must necessarily be not only a biped, but must also have the superior parts of the body lighter, and those that lie under these heavier, is plain.[6] Only if situated like this could it possibly carry itself easily. And so man, the only erect animal, has legs[7] longer and stouter relatively to the upper parts of his body than any other animal with legs. What we observe in children also is evidence of this. Children[8] cannot walk erect because they are always dwarf-like, the upper parts of their bodies being longer and stouter than the lower. With advancing

[1] Referring to the sternal crest or *keel* of Carinate Birds; cf. *P. A.* 659^b 9, 693^b 16.

[2] εὔτονον, well-girt, cf. *Prob.* 885^a 6 θέοντες εὐτόνως. Lucian. *Anach.* R. ii. 906, κοῦφα καὶ εὔτονα καὶ τὰ αὐτὰ βαρέα. (Leon. translates εὔπορον, ut bene viam paret.)

[3] περιφύσει, if correct (φύσει PSUY and Mich.), seems to be an instance of the Principle of Compensation (cf. *P. A.* 689^b 30, 695^b 7, and note to 704^b 12).

A.'s language describes the great mass of pectoral muscles in a bird, but he does not realize the function of muscles, nor the use of these to support the wings.

In *P. A.* 693^b 18 he gives a different explanation, 'to protect the breast-bone,' just as he explains a man's breasts and pectoral muscles in that way.

[4] ἵν' ἀπωθεῖν δύνηται, &c., depends upon both adjectives, cf. *P. A.* 693^b 16; the intermediate words are parenthetic.

[5] This word was used by a rustic in conversation with me to explain the lumbering flight of a heavy bird. The Greek means 'to draw the air', and is a similarly popular explanation. Cf. *P. A.* (loc. cit.) τὰ πλατέα πολὺν ἀέρα ὠθοῦντα δυσκίνητά ἐστι. The first airships were wrongly constructed with the greatest width in the centre; the later have, like a bird, a blunt forecastle from which the lines gradually taper to the stern.

[6] Cf. the interesting discussion in *P. A.* iv. 10.

[7] Cf. *P. A.* 690^a 27.

[8] Cf. *P. A.* 686^b 8, where children are contrasted with colts, calves, and other young, and *Parv. Nat.* 453^b 6; *H. A.* 500^b 33. Birds are said to be not erect because of their dwarfishness, *P. A.* 686^b 21, 695^a 8.

For the subject generally, and its connexion with A.'s embryology, vid. *G. A.* 741^b 27, 742^b 14, 779^a 24.

years the lower increase disproportionately, until the children get their appropriate size, and then and not till then they succeed in walking erect. Birds are hunchbacked [1] yet stand on two legs because their weight is set back, after the principle of horses fashioned in bronze with their fore-legs prancing.[2] But their being bipeds and able to stand is above all due to their having the hip-bone shaped like a thigh, and so large that it looks as if they had two thighs,[3] one in the leg before the knee-joint, the other joining this part to the fundament. Really this is not a thigh but a hip, and if it were not so large the bird could not be a biped. As in a man or a quadruped, the thigh and the rest of the leg would be attached immediately to quite a small hip; consequently the whole body would be tilted forward. As it is, however, the hip is long and extends right along to the middle of the belly, so that the legs are attached at that point and carry as supports the whole frame. It is also evident from these considerations that a bird cannot possibly be erect in the sense in which man is. For as it holds its body now the wings are naturally
711a useful to it, but if it were erect they would be as useless as the wings of Cupids [4] we see in pictures. It must have been clear as soon as we spoke that the form of no human nor any similar being permits of wings; not only because it would, though Sanguineous, be moved at more than four

[1] Leg. κυφοί Z (cf. 707b 21 note). The spine of a bird is hunched, and this gives it a top-heavy appearance (dwarfish); in spite of this Nature sets the weight back like a skilful statuary.

[2] Cf. 711b 2 (note).

[3] A. intends by ἰσχίον the true femur, by the 'other bone' the tibia and fibula. Cf. *H.A.* ii. 12 and *P.A.* 694b 29. In his note to the latter passage Dr. Ogle expresses the opinion that A. correctly identified the ἰσχίον with the elongated pelvis of a bird. This is certainly favoured by the language of *P.A.*, and in that case A. may have been writing with a bird's skeleton before him; here and in *H.A.* he certainly seems to take his normal view of the segments of the limb, a view which is incorrect.

[4] The language suggests that Greek artists gave their Cupids long wings, like those of Love in Watts's pictures. Perhaps, however, the stress is merely on the incorrect anatomy of six points of movement. The question is part of a favourite quarrel between the natural philosopher and the artist, in which Galen takes a share (Galen, *de Usu Part.* iii, ch. 1; Aristotle, *Meteor.* 349b 1; *de Motu*, 698b 25). Bell's criticism (*Bridgewater Treatise*, ed. 4, p. 324) is similarly directed to the relations between structure and locomotion.

points, but also because to have wings would be useless to it when moving naturally. And Nature makes nothing contrary to her own nature.

12 We have stated above[1] that without flexion in the legs or shoulders and hips no Sanguineous animal with feet could progress, and that flexion is impossible except some point be at rest, and that men and birds, both bipeds, bend their legs in opposite directions, and further that quadrupeds bend theirs in opposite directions, and each pair in the opposite way to a man's limbs. For men bend their arms backwards,[2] their legs forwards; quadrupeds their forelegs forwards, their back legs backwards, and in like manner also birds bend theirs. The reason is that Nature's workmanship is never purposeless, as we said above, but everything for the best possible in the circumstances. Inasmuch, therefore, as all creatures which naturally have the power of changing position by the use of limbs, must have one leg stationary with the weight of the body on it, and when they move forward the leg which has the leading position must be unencumbered, and the progression continuing the weight must shift and be taken off on this leading leg, it is evidently necessary for the back leg from being bent to become straight again,[3] while the point of movement of the leg thrust forward and its lower part remain still. And so the legs must be jointed.[4] And it is possible for this to take place and at the same time for the animal to go forward, if the leading leg has its articulation forwards, impossible if it be backwards. For, if it be forwards, the stretching out of the leg will be while the body is going forwards, but, if the other way, while it is going backwards. And again, if the flexion were backwards, the placing of the foot would be made by two movements and those contrary to one another, one, that is, backwards and 711b
one forwards; for in the bending together of the limb

[1] Cf. ch. 9, *supra*.
[2] Lit. 'concavely'. Cf. note on 704a 19.
[3] Om. τε after αὖθις with YZ (Mich.'s text had it), cf. 709a 20, *supra*.
[4] This is the suppressed conclusion, the next paragraph shows which way the joints must bend in order to progression.

the lower end of the thigh would go backwards, and the shin would move the foot forwards away from the flexion: whereas, with the flexion forwards, the progression described will be performed not with contrary motions, but with one forward motion.

Now man, being a biped and making his change of position in the natural way with his two legs, bends them forward for the reasons set forth, but his arms bend backwards reasonably[1] enough. If they bent the opposite way they would be useless for the work of the hands,[2] and for taking food. But quadrupeds which are also viviparous necessarily bend their front legs forwards. For these lead off first[3] when they move, and are also in the fore-part of their body. The reason that they bend forward is the same as in the case of man, for in this respect[4] they are like mankind. And so quadrupeds as well as men bend these legs forward in the manner described. Moreover, if the flexion is like this, they are enabled to lift their feet high; if they bent them in the opposite way they would only lift them a little way from the ground, because the whole thigh and the joint from which the shin-bone springs would lie under the belly as the beast moved forward. If, however, the flexion of the hind legs were forwards the lifting of these feet would be similar to that of the forefeet (for the hind legs, too, would in this case have only a little room for their lifting inasmuch as both the thigh and the knee-joint would fall under the position of the belly); but the flexion being backwards, as in fact it is, nothing comes in the way of their progression with this mode of moving the feet. Moreover, it is necessary or at least better[5] for

[1] Cf. *P. A.* 687a 6, &c., for a remarkable discussion of the hand as a mark of humanity.

[2] Cf. *P. A.* 687b 31, where A. recognizes the secondary uses of the forelimbs in some quadrupeds for manual purposes.

[3] ἡγεῖται; *or* 'govern their movement', because the front is superior to the back.

[4] Viz. the forelegs play the chief part in movement (cf. a bird's wings, 712b 27), and so are analogous in function (and in curvature) to man's legs.

In truth the hind legs play the chief part in quadruped progression, and this is recognized in *P. A.* 685a 20 where theory is not involved.

[5] A. shows often how a secondary purpose affects Nature's handi-

their legs to bend thus when they are suckling their young, with a view to such ministrations. If the flexion were inwards it would be difficult to keep their young under them and to shelter them.[1]

13 Now there are four modes of flexion if we take the combinations in pairs.[2] Fore and hind may bend either both backwards, as the figures[3] marked A, or in the opposite way both forwards, as in B, or in converse ways and not in the same direction, as in C where the fore bend forwards and the hind bend backwards, or as in D, the opposite way to C, where the convexities are turned towards one another[4] and the concavities outwards. Now no biped or quadruped bends his limbs like the figures A or B, but the quadrupeds like C, and like D only the elephant[5] among quadrupeds and man if you consider his arms as well as his legs. For he bends his arms concavely and his legs convexly. 712a

In man, too, the flexions of the limbs are always alternately[6] opposite, for example the elbow bends back, but

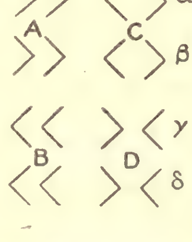
work, just as a part (in spite of the Platonic principle of specialization) is sometimes adapted to secondary uses. Cf. *P. A.* 688a 24.

[1] A somewhat different solution is offered in *P. A.* (688a 15, 688a 31) of the problem of the position of the lacteal glands in the animal creation. There A. thinks that the lateral attachment of man's arms enables his chest to be broad, and so furnishes room to the breasts; the forelegs of a quadruped, on the other hand, dictate a narrow chest and have no room for udders. The considerations here put forward would have explained very well the forward position of the elephant's udder (cf. *H. A.* 498a 1, 500a 19) since his hind legs bend forward in A.'s view. A. gives a farfetched *a priori* explanation of the fact in *P. A.* 688b 6.

[2] Leg. *κατὰ τοὺς συνδυασμούς* Z Γ (cf. *Pol.* 1290b 35, 1317a 1), the other reading seems to have arisen from the loss of *τῆς κάμψεως* (cf. Mich.'s *τρόπων κατὰ τοὺς συνδέσμους*).

[3] Mich. gives the figures which are lacking in the text of our MSS.

[4] The full expression is used in *H. A.* 498a 7 *τὰ κοῖλα τῆς περιφερείας πρὸς ἄλληλα ἀντεστραμμένα*; lit. are conversely related to one another, *ἀντιστροφή* being used of geometrical as well as of logical conversion.



[5] Does not the elephant bend like B? Cf. *H. A.* 498a 12. The MSS. are much confused.

[6] Elsewhere A. explains that similarly man has his flexions alternate and opposite to those of an animal throughout.

In the above diagram *α* and *γ* are alternate and opposite, and so the wrist of the hand forwards, and again the shoulder forwards. In like fashion, too, in the case of the legs, the hip backwards, the knee forwards, the ankle in the opposite way backwards. And plainly the lower limbs are opposed in this respect to the upper, because the first[1] joints are opposites, the shoulder bending forwards, the hip backwards; wherefore also the ankle bends backwards, and the wrist of the hand forwards.

This is the way then the limbs bend, and for the reasons 14
given. But the hind limbs move criss-cross with the fore limbs; after the off fore they move the near hind, then the near fore, and then the off hind. The reason is that (*a*) if they moved the forelegs together and first, the animal would be wrenched, and the progression would be a stumbling forwards with the hind parts as it were dragged after. Again, that would not be walking but jumping, and it is hard to make a continuous change of place, jumping all the time. Here is evidence of what I say; even as it is, all horses that move in this way soon begin to refuse,[2] for example the horses in a religious procession.[3]
712b For these reasons the fore limbs and the hind limbs move in this separate way.[4] Again, (*b*) if they moved both the right legs first the weight[5] would be outside the supporting limbs and they would fall. If then it is necessary to move in one or other of these ways or criss-cross fashion, and neither of these two is satisfactory, they must move criss-cross; for moving in the way we have said they cannot possibly experience either of these untoward results. And this is why horses and such-like animals stand still with

necessarily the remaining joints which follow in succession (cp. *H.A.* 498a 24).

[1] ἀρχή: sc. τῆς κινήσεως, principle of motion. The superior joint in each limb is regarded as the initial point in animal progression.

[2] ἀπαγορεύουσι. It is remarkable that A. says nothing of hopping birds in this treatise. After a few hops, they have recourse to a short flight.

[3] i.e. prancing, caracoling, Xen. *Equ.* xi. Admirably expressed by the artists of the Parthenon frieze. I can find only one genuine trot there represented.

[4] Del. οὐ with ZUSYΓ.

[5] Lit. 'they would be'. In later terminology, the centre of gravity would lie outside the limbs, and so produce unstable equilibrium.

their legs put forward criss-cross, not with the right or the left put forward together at once. In the same fashion animals with more than four legs make their movements; if you take two consecutive pairs of legs the hind move criss-cross with the forelegs; you can see this if you watch them moving slowly. Even crabs move in this way, and they are polypods. They, too, always move criss-cross in whichever[1] direction they are making progress. For in direction this animal has a movement all its own; it is the only animal that moves not forwards, but obliquely.[2] Yet since forwards is a distinction relative to the line of vision,[3] Nature has made its eyes able to conform to its limbs, for its eyes can move themselves obliquely,[4] and therefore after a fashion crabs are no exception but in this sense move forwards.

15 Birds bend their legs in the same way as quadrupeds.[5] For their natural construction is broadly speaking nearly the same.[6] That is, in birds the wings are a substitute for the forelegs;[7] and so they are bent in the same way as the forelegs[8] of a quadruped, since when they move to progress the natural beginning[9] of change is from the wings ⟨as in quadrupeds from the forelegs⟩. Flight in fact is their appropriate[10] movement. And so if the wings be cut off a bird can neither stand still nor go forwards.

Again, the bird though a biped is not erect,[11] and has the forward parts of the body lighter than the hind, and so it is necessary (or at least preferable for the standing posture) to have the thigh so placed below the body as it actually is,

[1] Leg. *ἐφ' ὁπότερ' ἂν* Z (*sic*).
[2] Cf. *supra*, 706^{b} 30 and note.
[3] Cf. 705^{b} 12 and note (vision is here taken as the typical sense).
[4] Cf. *H. A.* 526^{a} 10, 527^{b} 8, 529^{b} 27; a different reason is given in *P. A.* 658^{a} 2.
[5] Viz. as quadrupeds bend their hind legs; perhaps *τὰ ὄπισθεν* has dropped out, though the sense is made certain by the context.
[6] Leg. *τοῖς τετράποσι* (YZ) *αἱ γάρ* (Z) a reading which may be traced by the side of Bekker's in Mich. (p. 166. 26). So also reads Γ.
[7] Cf. *P. A.* 693^{b} 12, 695^{a} 9.
[8] Cf. *H. A.* 498^{a} 28; *P. A.* 693^{b} 5.
[9] Cf. *supra*, 711^{b} 13 and note.
[10] Cf. *P. A.* 693^{b} 14.
[11] Cf. *P. A.* 695^{a} 3.

I mean growing towards the back.[1] If then it must have this situation the flexion of the leg must be backwards, as 713a in the hind legs of quadrupeds. The reasons are the same as those given in the case of viviparous quadrupeds.

If now we survey generally birds and winged insects,[2] and animals which swim in a watery medium, all I mean that make their progress in water by dint of organs of movement, it is not difficult to see that it is better to have the attachment of the parts in question oblique to the frame, exactly as in fact we see it to be both in birds and insects. And this same arrangement obtains also among fishes. Among birds the wings are attached obliquely; so are the fins[3] in water animals, and the feather-like wings of insects. In this way they divide the air or water most quickly[4] and with most force and so effect their movement. For the hinder[5] parts in this way would follow forwards as they are carried along in the yielding medium, fish in the water, birds in the air.

Of oviparous quadrupeds all those that live in holes, like crocodiles, lizards, spotted lizards,[6] freshwater tortoises,[7] and turtles,[8] have their legs attached obliquely[9] as their whole body sprawls over the ground,[10] and bend them

[1] Cf. *P.A.* 695a 11 *εἰς μέσον.*

[2] Holoptera.

[3] Put a comma for the full stop after *πτερύγια.*

[4] A. nowhere grasps the mechanical purpose of the forwards-upwards, backwards-downwards movement of the wings. His description of the movements themselves is only superficial.

[5] Leg. *καὶ τὰ ὄπισθεν μόρια* Y, cf. *supra*, 710b 3. The MSS. are much confused, and the argument not satisfactory. Mich. has the Bekker reading, but gives a ludicrous explanation. I do not know whether there may not be concealed a reference to the patent fact that the motion of a bird's wings as of the fins of a fish is simultaneous. It is extraordinary that A. nowhere refers to this except *sub silentio.* It was adverted to by the mediaeval naturalist Albertus Magnus, *de motibus An.* ii. 2, ch. 3.

[6] i.e. *Lacerta mauretanica*; the ocellated lizard or gecko (tarantula) of S. Europe and N. Africa.

[7] i.e. *Emys lutaria.*

[8] i. e. Sea tortoises. There are two kinds in the Mediterranean; *Dermochelys coriacea* and *Thalassochelys caretta* (*Tartaruga de mari*, Sardinia; *Tartuca de mari*, Sicily).

[9] Cf. *H.A.* 498a 15 though there the joints are differently described. We may add the chameleon (*H.A.* 503a 21).

[10] Leg. *ἔχει, ἐπὶ τῇ γῇ κατατεταμένα ὅλα* (*καί* om. YZ, *κατεταγμένα ὅλα* Z ordinata tota Γ). Mich. has *τεταμένα* (p. 166. 27), the loss of *κατά*

obliquely. The reason is that this is useful for ease in creeping into holes, and for sitting upon their eggs[1] and guarding them. And as they are splayed outwards[2] they must of necessity tuck in[3] their thighs and put them under them in order to achieve the lifting of the whole body. In view of this they cannot bend them otherwise than outwards.

16 We have already stated the fact[4] that non-sanguineous animals with limbs are polypods and none of them quadrupeds. And the reason why their legs, except the extreme pairs, were necessarily attached obliquely and had their flexions upwards, and the legs themselves were somewhat turned under (bandy-shape)[5] and backwards is plain.[6] In all such creatures the intermediate legs both lead and follow.[7] If then they lay under them, they must have 713^b
had their flexion both forwards and backwards; on account of leading, forwards; and on account of following, back-

accounting for the *καί* in S and U. He explains 'let down to the ground' as compared with birds' wings!

[1] Cf. *H. A.* v. 33.

[2] Not as Mich. takes it 'when they are out of their holes', cf. *infra*, 713^a 25. YZ add the explanatory gloss (or true reading) αὐτῶν ⟨τοῦ σώματος⟩.

[3] Leg. προσστέλλοντα, as Mich.'s words indicate, and the sense demands.

[4] *Supra*, 704^a 11.

[5] There are three several characters correctly described from nature:
(*a*) the intermediate legs are attached laterally, cf. *H. A.* 525^b 25; *P. A.* 683^a 33;
(*b*) the principal flexion is upwards (as in a fly's legs);
(*c*) the limbs are bent under, or bandy, cf. *P. A.* 683^b 35.
In the text as it stands no explanation is offered of the upward bending, while the phrase 'bend laterally' is used as equivalent to 'laterally attached' (quite a different feature), that is the plane of the bent limb is oblique to the plane of progression and vision. His examples are crayfish, &c., and again flying insects, not centipedes, millipedes, &c.

[6] The interpretation of βλαισότης is very difficult, and the various uses not consistent. The word means 'bandiness', and sometimes expresses an actual curvature of a bone or segment of a limb, sometimes the general lie of a whole limb. For example the elbow-joint (in A.'s sense) normally lies further outside the line of progression than the hand or shoulder, and so a man's arms are bandied as they hang normally. εἰς τὸ ὄπισθεν seems to mean here that the foot is also behind a plane drawn through the knee at right angles to the plane or axis of progression (unless it could mean that the elbow is up and back, cf. *H. A.* 498^a 21). L. and S. seem wrongly to take βλαισότης to mean 'bent inwards at the joint', through misinterpretation of Hippocrates, *de art.* 53 (L. iv. 234).

[7] Cf. *H. A.* 498^a 17 τὰ μεταξὺ τῶν ἐσχάτων ἀεὶ ἐπαμφοτερίζει καὶ τὴν καμπὴν ἔχει εἰς τὸ πλάγιον μᾶλλον. (Not, certainly, true of centipedes.)

wards. Now since they have to do both, for this reason their limbs are turned under[1] and bent obliquely, except the two extreme pairs. (These two are more natural in their movement, the front leading and the back following.[2]) Another reason for this kind of flexion is the number of their legs; arranged in this way they would interfere less with one another in progression and not knock together. But the reason that they are bandy[3] is that all of them or most of them live in holes, for creatures living so cannot possibly be high above the ground.[4]

But crabs are in nature the oddest[5] of all polypods; they do not progress forwards except in the sense explained above,[6] and they are the only animals which have more than one pair of leading limbs.[7] The explanation of this is the hardness of their limbs, and the fact that they use them not for swimming but for walking; they always keep on the ground. However, the flexion of the limbs of all polypods is oblique, like that of the quadrupeds which live in holes—for example lizards and crocodiles and most of the oviparous quadrupeds. And the explanation is that some of them in their breeding periods, and some all their life, live in holes.

Now the rest[8] have bandy legs because they are soft- **17**
skinned, but the crayfish is hard-skinnèd and its limbs are

[1] The explanation is of the oblique bending, clearly not of the bandiness; of the latter an explanation is attempted in 713b 9.

[2] i.e. the leading feet bend forwards, the hind backwards (with a slight turn outwards, *H. A.* 498a 16).

[3] *Infra*, b 20, this troglodyte habit is used to explain the lateral situation of the limbs.

[4] Leg. τὰ ζῶντα τὸν τρόπον τοῦτον (Z) as Mich. evidently read p. 168. 20, p. 169. 9. So also Γ reads.

[5] Leg. περιττότατοι YZ, Mich. The passage looks like a dittograph of 24 seq. *infra*. In b 26 the hardness is used to explain why crabs are not bandy.

[6] *Supra*, 712b 20.

[7] It has four front legs, two pairs. Cf. *H. A.* 490b 6.

[8] The argument seems to have been that, by contrast with other polypods, crayfish and crabs are not bandy; crayfish both because their skin is hard, and because they would swim worse if bandy; crabs because of their hard skin, even though they live on the ground and in holes (*P. A.* 684a 5). I think that the true text is lost beyond recovery.

for swimming and not for walking ⟨and so are not bandy⟩.[1] Crabs, too, have their limbs bent obliquely, but not bandy[2] like oviparous quadrupeds and non-sanguineous polypods, because their limbs have a hard and shell-like skin, although they don't swim but live in holes; they live in fact on the ground. Moreover, their shape is like a disk,[3] as compared with the crayfish which is elongated, and they haven't a tail[4] like the crayfish; a tail is useful to the crayfish for swimming, but the crab is not a swimming creature. Further, it alone has its side equivalent to a hinder part,[5] because it has many leading feet. The explanation of this is that its flexions are not forward nor its legs turned in 714^a
under (bandy). We have given above the reason why its legs are not turned in under, that is the hardness and shell-like character of its integument.

For these reasons then it must lead off with more than one limb,[6] and move obliquely; obliquely, because the flexion is oblique;[7] and with more than one limb, because otherwise the limbs that were still would have got in the way of those that were moving.

[1] These words, *καὶ διὰ ταῦτα οὐ βεβλαίσωται*, are necessary to the sense (Mich. *διὰ ταῦτα οὐ βλαισοῦνται*, p. 169.14) and were perhaps in the MSS. which Mich. used.

[2] The MSS. evidently are confused through a desire to omit *οὐ*; that the negative is correct is shown by 714^a 1. Mich.'s reading was equivalent in sense though he gives an absurd explanation by which A. is made to mean that crabs were born bandy and do not (like soft-skinned creatures) bend bandy as they walk (cf. *H.A.* 498^a21). Can the explanation be that since a crab is odd enough to walk sideways, its legs are not bandy as they appear to be if you take the line of progression to be through the eyes?

[3] Cf. *H.A.* 525^b 33 where *στρογγύλον* and *πρόμηκες* are contrasted.

[4] Cf. *H.A.* 525^b 31; *P.A.* 684^a 2.

[5] This obscure remark seems to mean that since a crab progresses *εἰς τὸ πλάγιον*, its hind pairs of legs lie on its *πλάγια*, and thus its *πλάγιον* or flank is equivalent to a hinder part (cf. for *πλάγιον* in this sense *P.A.* 657^b 21, 670^a 14).

[6] Leg. *πλείοσι* in place of the repeated *πᾶσι* (*κάμψις πλεῖον* Z, *πλείοσι* Y). It leads with two pairs criss-cross with the relatively hinder pairs (*supra*, 712^b 13). The sense may have been originally that this leading makes it go sideways, as is the truth, I think, apart from deeper grounds; or that its going sideways demands this leading, otherwise the legs would obstruct one another. Γ embodied both, 'pluribus omnibus.'

[7] This lateral bending would according to A.'s normal theory be explained as an arrangement to prevent obstruction (cf. *supra*, 713^b 8).

Fishes of the flat kind swim with their heads twisted, as one-eyed men walk; they have their natural shape distorted. Web-footed birds swim with their feet; because they breathe the air and have lungs[1] they are bipeds,[2] but because they have their home in the water they are webbed;[3] by this arrangement their feet serve them instead of fins.[4] They have their legs too, not like the rest of birds in the centre of their body, but rather set back. Their legs are short, and being set back are serviceable for swimming. The reason for their having short legs is that nature[5] has added to their feet by subtracting from the length of their limbs; instead of length she gives stoutness to the legs and breadth to the feet. Broad feet[6] are more useful than long for pushing away the water when they are swimming.

There is reason, too, for winged creatures having feet, but 18
fish none. The former have their home in the dry medium, and cannot remain always in mid air; they must therefore have feet. Fish on the contrary live in the wet medium,[7]
714^{b} and take in water, not air. Fins[8] are useful for swimming, but feet not. And if they had both they would be non-sanguineous. There is a broad similarity between birds and fishes in the organs of locomotion. Birds have their wings on the superior part, similarly fish have two pectoral fins; again, birds have legs on their under parts and near

[1] Lit. 'respire'; πάντα τὰ ἀναπνέοντα ἔχει πλεύμονα, *P.A.* 669^{a} 6.

[2] Because they must not have more than a quaternion of points of motion, cf. *P.A.* 693^{b} 5.

[3] Cf. *P.A.* 693^{a} 6, 694^{b} 1.

[4] Cf. *P.A.* 694^{b} 10.

[5] According to the natural principle of organic equivalents, cf. *P.A.* 694^{a} 27, ^{b} 18; *supra*, 710^{a} 32; and note to 704^{b} 12.

[6] Leg. πλατεῖς Z as the concord requires; cf. *P.A.* 694^{b} 5.

[7] A. does not pause to ask why a fish can remain balanced in the watery medium whereas a bird cannot so remain in the air. He accepts the fact that a fish floats at any chosen point. Again, he says nothing of the surface presented to the water by the fish, though he has touched on the parallel question in respect of birds (*supra*, 710^{b} 1). In *P.A.* 695^{b} 4 he states that he has raised this question elsewhere, so that perhaps it is missing here by some mischance.

[8] Cf. *P.A.* 695^{b} 21. (Strictly of course these are feet, cf. ch. 5.)

the wings;[1] similarly, most[2] fish have two fins[3] on the under parts and near the pectorals. Birds, too, have a tail and fish a tail-fin.

19 A difficulty may be suggested as to the movements of molluscs,[4] that is, as to where that movement originates; for they have no distinction of left and right. Now observation shows them moving. We must, I think, treat all this class as mutilated,[5] and as moving in the way in which limbed creatures do when one cuts off their legs, or as analogous with the seal and the bat. Both the latter are quadrupeds but misshapen. Now molluscs do move, but move in a manner contrary to nature. They are not moving things, but are moving if as sedentary creatures[6] they are compared with zoophytes,[7] and sedentary if classed with progressing animals.

As to right and left, crabs, too, show the distinction poorly, still they do show it. You can see it in the claw; the right[8] claw is larger and stronger, as though the right and left sides were trying[9] to get distinguished.[10]

[1] Leg. *καὶ τοῖς μὲν οἱ πόδες ἔν τε τοῖς ὑπτίοις καὶ ἐγγὺς ⟨τῶν πτερύγων⟩ τοῖς δὲ τὰ πτερύγια ἐγγὺς τῶν πρανῶν τοῖς πλείστοις* (Z except the words *τῶν πτερύγων*). I think Z preserves the original words. The point is: (*a*) the external similarity of the positions of the bird's limbs and the fish's paired fins (by contrast with quadrupeds); (*b*) that *most* fish have ventral fins, and those near the pectorals, cf. *P. A.* 696^{a} 3. A. might have added the lateral attachment of both wings and fins (*supra*, 713^{a} 10). Bacon refers to the passage with approval, *Nov. Org.* ii. 27.

For a bird's legs cf. *P. A.* 695^{a} 11; *supra*, 714^{a} 12; for *πρανῶν* (sc. *πτερυγίων*) cf. *H. A.* 514^{a} 2. Γ is mutilated but confirms Z.

[2] Cf. *H. A.* 489^{b} 24, 504^{b} 30; *P. A.* 696^{a} 3, 21; *supra*, 707^{a} 31, 708^{b} 3.

[3] Viz. the ventral fins. A. uses *πτερυγία* only for the paired fins.

[4] i.e. Mollusca, excluding Cephalopoda.

[5] Cf. the discussion of Seals and Bats as intermediate and mutilated species in *H. A.* 498^{a} 31; *P. A.* 697^{b} 1 et seq.

[6] Leg. *ὡς μὲν μόνιμα καὶ πρὸς τὰ πεφυκότα.* SUZ have *πεφυκότα.* Mich. has *ὡς μὲν τὰ μόνιμα καὶ πεφυκότα*, and *πρὸς τὰ π. κινητικά.*

[7] Lit. 'growing things' (or if *προσπεφυκότα* be kept, cf. *H. A.* 487^{b} 8, 531^{a} 32; *G. A.* 715^{b} 17, 'attached things'), of which the sponge is the typical species (cf. *P. A.* 681^{a} 16). In *H. A.* 548^{b} 8 *φυόμενα*, usually equivalent to *τὰ φυτά* (plants) is by a natural extension made to include sponges, the lowest of animals.

[8] Cf. *H. A.* 527^{b} 5, 590^{b} 25; *P. A.* 684^{a} 26, 691^{b} 16; Darwin's *Descent of Man*, i. 330.

[9] *βούλεσθαι.* A. says 'intend' where the modern says 'tend'. Nature is often spoken of as trying without necessarily succeeding (cf. *P. A.* 665^{b} 22).

[10] A.'s speculations upon the commensal habits of some of the so-called

INDEX

DE GENERATIONE ANIMALIUM

BY

ARTHUR PLATT M.A.

PROFESSOR OF GREEK IN UNIVERSITY COLLEGE LONDON
LATE FELLOW OF TRINITY COLLEGE CAMBRIDGE

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TO

WILLIAM OGLE M.D.

μετὰ δὲ τριτάτοισιν ἀνάσσει

PREFACE

THIS translation has been made from Bekker's octavo text, Oxford, 1837. I have also used Aubert and Wimmer's edition, with German translation and notes, Leipzig, 1860, referred to by me as 'AW.'. I must confess to finding this work somewhat disappointing; the translation often fails to make the connexion of thought intelligible, and the notes are very scanty and sometimes incorrect. Much greater is my debt to Dr. Ogle's *Aristotle on the Parts of Animals*, London, 1882; without this model before me I should never have ventured on so hazardous an enterprise. References to his Introduction are given with his name and the Roman numeral of the page (e.g. 'see Ogle, p. xxix'), to his notes with the pages and lines of the Berlin edition (e.g. 'Ogle on 641^b 17'). References to the work of G. H. Lewes, named *Aristotle*, are given as 'Lewes' with the sections of the book, which I take this opportunity of remarking to be full of scandalous blunders and thoroughly untrustworthy, at least where Aristotle's meaning is concerned. The Greek medical writers are referred to by the volume and page of Kühn's edition, the question of their exact authorship being of course left open. My endeavour has been throughout to represent as exactly as possible what Aristotle said or meant to say; to this I have sacrificed all graces of style, comforted a little by knowing that the author himself would have been the last man in the world to complain.

Whenever Bekker's reading has been deserted the reading preferred is given in a note; if it has MS. authority I say e.g. 'reading *ἄλλο*', if it is a conjecture by another scholar the name of the author is added, if it be a new conjecture I say 'Read' or 'I read' whatever it may be.

The pleasant duty remains of thanking many friends and others who have assisted me in various ways. In particular

Professor J. P. Hill has read through the proofs and helped me on zoological questions, Dr. George Blacker made me several communications on medical points, and Dr. Ogle has made me still further his debtor by talking over some passages with me and correcting some errors. My obligations to others are acknowledged in the proper places in the notes. From the Aristotelian point of view Mr. W. D. Ross has gone through the translation minutely and caused me to improve it in many places. The Index has been made by Mr. A. W. Kappel.

With regard to the information in the notes, I have been thankful to get it wherever I could. If some of it is not exactly up to date, it is all at any rate two thousand years later than Aristotle, and compared to that interval of time what are a few years more or less? And, should any man of science come fresh to the reading of this treatise, he will, I think, be amazed and delighted to see what grasp and insight Aristotle displays in handling questions which still absorb us after all that time. If we smile at some parts, and those very considerable parts, of the discussion, especially at all the importance attached to 'form' and 'matter', and at the curious depreciation of the female sex, let us remember that most of these oddities were accepted by no less a man than William Harvey, and that Darwin wrote with generous enthusiasm concerning another of the zoological works: 'Linnaeus and Cuvier have been my two gods, though in very different ways, but they were mere schoolboys to old Aristotle' (*Life and Letters*, vol. iii, p. 252).

CONTENTS

The arrangement of this treatise is somewhat confused and there is much repetition in it. But the following table may give the reader a view of the course of the discussion and of the more important subjects discussed.

There are four main parts :—

PART I (Books I, II down to 737^{b}24)

General view of the subject.

Section I. The generative organs.

II. The generative secretions, and the Aristotelian theory of sex-generation.

III. Miscellaneous, partly developing questions already raised, partly introductory to Part II.

PART II (Book II 737^{b}25 to end of Book III)

Detailed account of generation in the different classes of animals.

PART III (Book IV)

Essays on various questions connected with generation.

PART IV (Book V)

Development after birth, and distinctions between individuals of the same species.

These four parts are laid out as follows :—

PART I

SECTION I

SECTION II

SECTION III

PART II

PART III

PART IV

BOOK I

1 WE have now discussed the other parts[1] of animals, both generally and with reference to the peculiarities of each kind,[2] explaining how each part exists on account of such a cause, and I mean by this the final cause.[3] 715a

There are four causes underlying everything: first, the final cause, that for the sake of which a thing exists; secondly, the formal cause, the definition of its essence (and these two we may regard pretty much as one and the same)[4]; thirdly, the material; and fourthly, the moving principle or efficient cause.

We have then already discussed the other three causes, for the definition and the final cause are the same, and the material of animals is their parts—of the whole animal the non-homogeneous parts, of these again the homogeneous, and of these last the so-called elements of all matter.[5] It remains to speak of those parts which contribute to the generation of animals and of which nothing definite has yet been said,[6] and to explain what is the moving or efficient cause. To inquire into this last and to inquire into the generation of each animal is in a way the same thing; and, therefore, my plan has united them together, arranging

[1] i. e. the parts not concerned in generation.

[2] i. e. each kind of animals (see *de Partibus*, *ad fin.*), *kind* meaning sometimes what we should now call a species, sometimes a class of any wider extent.

[3] This is equal to saying: 'the final cause corresponding to each part.'

[4] The final and formal causes are the same in an animal since its final cause is simply to exist in the most perfect form possible.

[5] A. assumes all parts to be homogeneous which appear such to the naked eye. His division into homogeneous and non-homogeneous corresponds to Bichat's distinction of tissues and organs. Bone e. g. is homogeneous; a hand is composed of the homogeneous parts, flesh, sinew, bone, &c., and is thus itself heterogeneous.

[6] Much has been said of them in *H. A.* however.

the discussion of these parts last,[1] and the beginning of the question of generation next to them.

Now some animals come into being from the union of male and female, i.e. all those kinds of animal which possess the two sexes. This is not the case with all of them; though in the sanguinea[2] with few exceptions the creature, when its growth is complete, is either male or female, and though some bloodless animals have sexes so that they generate offspring of the same kind, yet other bloodless animals generate indeed, but not offspring of the same kind; such are all that come into being not from a union of the sexes, but from decaying earth and excrements. To speak generally, if we take all animals which change their locality, some by swimming, others by flying, others by walking, we find in these the two sexes,[3] not only in the sanguinea but also in some of the bloodless animals; and this applies in the case of the latter sometimes to the whole class, as the
715b cephalopoda and crustacea, but in the class of insects only to the majority. Of these, all which are produced by union of animals of the same kind generate also after their kind, but all which are not produced by animals, but from decaying matter, generate indeed, but produce another kind, and the offspring is neither male nor female; such are some of the insects.[4] This is what might have been expected, for if those animals which are not produced by parents had themselves united and produced others, then their offspring must have been either like or unlike to themselves. If like, then their parents ought to have come into being in the same way; this is only a reasonable postulate to make, for it is plainly the case with other animals. If unlike, and yet able to copulate, then there would have come into being again from them another kind of creature and again another from these, and this would

[1] i.e. after the other parts, discussed in the *de Incessu* and *de Partibus*.

[2] Animals with red blood. If we exclude red-blooded worms, the modern term *vertebrates* exactly corresponds to the Aristotelian class. See Ogle, pp. xxvi, xxvii. The 'few exceptions' are some fishes which will be discussed later.

[3] The text is corrupt; I give what Aristotle must have meant.

[4] See Ogle, pp. xxvii, xxviii, and ii. 1, iii. 9 of this treatise.

have gone on to infinity. But Nature flies from the infinite, for the infinite is unending or imperfect, and Nature ever seeks an end.

But all those creatures which do not move, as the testacea and animals that live by clinging to something else,[1] inasmuch as their nature resembles that of plants, have no sex any more than plants have, but as applied to them the word is only used in virtue of a similarity and analogy. For there is a slight distinction of this sort, since even in plants we find in the same kind some trees which bear fruit and others which, while bearing none themselves, yet contribute to the ripening of the fruits of those which do, as in the case of the fig-tree and caprifig.[2]

The same holds good also in plants, some coming into being from seed and others, as it were, by the spontaneous action of Nature, arising either from decomposition of the earth or of some parts in other plants, for some are not formed by themselves separately but are produced upon other trees, as the mistletoe. Plants, however, must be 716a
investigated separately.

2 Of the generation of animals we must speak as various questions arise in order in the case of each, and we must connect our account with what has been said. For, as we said above, the male and female principles[3] may be put down first and foremost as origins of generation, the former as containing the efficient cause of generation,[4] the latter the material of it. The most conclusive proof of this is

[1] Sponges, sessile ascidians, barnacles, &c.

[2] For the fascinating phenomena connected with 'caprification' see e.g. Kerner and Oliver, *Natural History of Plants*, vol. ii, pp. 160–2; for the little known or guessed about the sexes of plants before Camerarius (1665–1721), Sachs, *History of Botany*, pp. 376–85 (English translation, Oxford, 1890). That the palm in particular was male and female was a familiar notion, though not resting on any exact basis; a quaint reference to this which has escaped the notice of the historian is to be found in Nonnus, *Dionysiaca*, iii. 142 καὶ ἄρσενα φύλλα πετάσσας | θηλυτέρῳ φοίνικι πόθον πιστώσατο φοῖνιξ.

[3] 'The male' and 'the female' are throughout in the neuter, and it is impossible to convey their force precisely in English.

[4] Lit. 'the beginning of the movement and of the generation.' The female contributes the matter which is set in motion and so put into form by the semen of the male.

drawn from considering how and whence comes the semen; for there is no doubt that it is out of this that those creatures are formed which are produced in the ordinary course of Nature[1]; but we must observe carefully the way in which this semen actually comes into being from the male and female. For it is just because the semen is secreted from the two sexes, the secretion taking place *in* them and *from* them, that they are first principles of generation. For by a male animal we mean that which generates in another, and by a female that which generates in itself; wherefore men apply these terms to the macrocosm also, naming[2] Earth *mother* as being female, but addressing Heaven and the Sun and other like entities as *fathers*, as causing generation.[3]

Male and female differ in their essence[4] by each having a separate ability or faculty, and anatomically[5] by certain parts; essentially the male is that which is able to generate in another, as said above; the female is that which is able to generate in itself and out of which comes into being the offspring previously existing in the parent. And since they are differentiated by an ability or faculty and by their function, and since instruments or organs are needed for all functioning, and since the bodily parts are the instruments or organs to serve the faculties, it follows that certain parts must exist for union of parents and production of offspring. And these must differ from each other, so that consequently the male will differ from the female. (For even though we

[1] As opposed to spontaneous generation and parthenogenesis. A. speaks here very loosely, not having yet developed his own view. We shall see presently that animals are not formed 'out of' the semen at all. If we construed σπέρμα by 'seed' and took it to mean the fertilized germ, we should correct the meaning in this sentence, but only to wreck upon the next.

[2] Reading ὀνομάζουσιν.

[3] The influence of the Sun and other heavenly bodies was supposed to cause generation of plants, &c., in the earth. Thus the Sun generates in another, Earth in herself, and A. supposes that this accounts for poets and others calling them father and mother.

[4] λόγον, their definition, which is also their final cause or *raison d'être*, the law of their being. This is the important thing, the variation of parts being only consequent upon it.

[5] Lit. 'according to sense-perception.' The λόγος is not visible or tangible, but the organ, which corresponds to it, is.

speak of the animal as a whole as male or female, yet really it is not male or female in virtue of the whole of itself,[1] but only in virtue of a certain faculty and a certain part—just as with the part used for sight or locomotion—which part is also plain to sense-perception.)

Now as a matter of fact such parts are in the female the so-called uterus, in the male the testes and the penis,[2] in all the sanguinea; for some of them have testes and others the corresponding passages. There are corresponding differences of male and female in all the bloodless animals also which 716b
have this division into opposite sexes. But if in the sanguinea it is the parts concerned in copulation that differ primarily in their forms, we must observe that a small change in a first principle is often attended by changes in other things depending on it.[3] This is plain in the case of castrated animals, for, though only the generative part is disabled, yet pretty well the whole form of the animal changes in consequence so much that it seems to be female or not far short of it, and thus it is clear that an animal is not male or female in virtue of an isolated part or an isolated faculty. Clearly, then, the distinction of sex is a first principle; at any rate, when that which distinguishes male and female suffers change, many other changes accompany it, as would be the case if a first principle is changed.[4]

3 The sanguinea are not all alike as regards testes and uterus. Taking the former first, we find that some of them

[1] The text is corrupt. Qu. *κατὰ πᾶν γε τὸ αὑτοῦ ⟨σῶμα⟩* for *κατὰ πᾶν γε τὸ αὐτό?*

[2] *περίνεος.* Liddell and Scott need correction on this word.

[3] Lit. 'a small principle being changed, many of the things after the principle are wont to change with it.' We see here stated clearly enough the distinction between primary and secondary sexual characteristics.

[4] Turning Aristotle's phraseology about 'first principles' into modern language, we should say that the phenomenon of secondary sex-characteristics varying in consequence of injury to the primary proves that the primary sex-distinction is deeply rooted in the organism, and that the secondary characteristics have been acquired later in consequence of and in connexion with it. The physical cause of the secondary characteristics is probably certain chemical substances called 'hormones' which are secreted by the testes and getting into the blood act as a stimulus upon the other parts concerned, making the beard to grow, &c.

have not testes at all, as the classes of fish and of serpents, but only two spermatic ducts.[1] Others have testes indeed, but internally by the loin in the region of the kidneys, and from each of these a duct, as in the case of those animals which have no testes at all; these ducts unite also as with those animals; this applies (among animals breathing air and having a lung) to all birds and oviparous quadrupeds.[2] For all these have their testes internal near the loin, and two ducts from these in the same way as serpents; I mean the lizards and tortoises and all the scaly reptiles. But all the vivipara have their testes in front[3]; some of them inside at the end of the abdomen, as the dolphin,[4] not with ducts but with a penis projecting externally from them[5]; others outside, either pendent as in man or towards the fundament as in swine.[6] They have been discriminated more accurately in the *Enquiries about Animals*.[7]

The uterus[8] is always double, just as the testes are always two in the male. It is situated either near the pudendum (as in women, and all those animals which bring forth alive
717a not only externally but also internally, and all fish that

[1] These spermatic ducts or tubes (πόροι) really are testes, but A. refuses to call them so, 'because of their shape and their being hollow,' see Ogle, note on *de Partibus*, iv. 697a 9. And cf. next chapter of this work. It is clear, however, that A. knew nothing of the testes of the cartilaginous fish, which are not simple hollow tubes but oval firm bodies.

[2] By oviparous quadrupeds are meant Reptilia and Amphibia, which A. does not separate from each other. (It is a curious thing, however, that in this work he never says a word which suggests any reference to amphibia, though he must surely have known that frog's eggs are altogether different from those of reptiles; in this respect (as in others) the amphibia must be classed with the fishes. Of the oviparous monotremes, duck-bill and echidna, he was naturally ignorant.)

[3] i.e. they would be in front if the creature stood up like a man.

[4] 'Ils restent constamment dans l'abdomen, placés à côté des reins, dans . . . les Cétacés.' Cuvier, *Leçons*, xxxiii, *art.* i. B.

[5] I omit the corrupt or interpolated words καθάπερ οἱ βόες.

[6] 'Ils sont serrés sous la peau du périnée . . . chez les Pachydermes'. Cuvier, ibid.

[7] *H. A.* iii. 1.

[8] This term in A. includes the oviducts. He is wrong in regarding either oviduct or true uterus as analogous to the testes, and of the ovaries he knew nothing. The uterus (in the modern sense) is single in the higher mammalia and in some of the Edentates, but as the oviducts are included in the Aristotelian conception of the word the statement in the text is verbally correct.

lay eggs externally) or up towards the hypozoma[1] (as in all birds and in viviparous fishes). The uterus is also double in the crustacea and the cephalopoda, for the membranes which include their so-called eggs are of the nature of a uterus. It is particularly hard to distinguish in the case of the poulps, so that it seems to be single, but the reason of this is that the bulk of the body is everywhere similar.[2]

It is double also in the larger insects ; in the smaller the question is uncertain owing to the small size of the body.

Such is the description of the aforesaid parts of animals.

4 With regard to the difference[3] of the spermatic organs in males, if we are to investigate the causes of their existence, we must first grasp the final cause of the testes.[4] Now if Nature makes everything either because it is necessary or because it is better so, this part also must be for one of these two reasons. But that it is not necessary for generation is plain ; else had it been possessed by all

[1] The hypozoma is the division between the thorax and the abdomen, equivalent to the diaphragm in the mammalia, its analogue in other vertebrates, the waist of insects, and so on. In fish, however, it would be only an imaginary line.

[2] Cf. *de Partibus*, ii. 654a 13, 'the mass of the body consists of a soft flesh-like substance.' A. means that the parts are difficult to make out, because the whole body is comparatively homogeneous. The cephalopoda have only one ovary, but the poulps (octopods) and some calamaries have two oviducts ; the sepia and common calamary have, however, only one oviduct. For their eggs 'on sait que les œufs du poulpe et du calmar sont rassemblés en petits boudins, par une matière gélatineuse, et ceux de la seiche en grosses grappes comparables à celles des raisins, par une matière ductile'. Cuvier, *Leçons*, xxxvi, *art.* i.

[3] This means the difference observed between males of various kinds, especially in that some have testes and others not.

[4] Lit. 'of the systasis of the testes,' which I think is only a periphrasis. Lewes (§ 425) sneeringly remarks of this that 'Aristotle's anatomical knowledge was imperfect ; this imperfection stimulated his readiness to explain phenomena by final causes'. A. is so far absolutely right, and as Lewes published five years after the *Origin of Species* there is really no excuse for him. It is true that A. is amusingly wrong in this case ; I have seen his theory ascribed to Hippocrates, but have failed to find any reference to it in him ; Lewes says it comes from Plato's *Timaeus*, which it does not ; Galen (vol. iv, p. 564) attributes it entirely to Aristotle himself. Harvey told Boyle that he was led to his discovery of the circulation by considering the *final cause* of the valves in the veins.

creatures that generate, but as it is neither serpents have testes nor have fish; for[1] they have been seen uniting and with their ducts full of milt.[2] It remains then that it must be because it is somehow better so. Now it is true that the business of most animals is, you may say, nothing else than to produce young,[3] as the business of a plant is to produce seed and fruit. But still as,[4] in the case of nutriment, animals with straight intestines are more violent in their desire for food,[5] so those which have not testes but only ducts, or which have them indeed but internally, are all quicker in accomplishing copulation. But those which are to be more temperate[6] in the one case have not straight intestines, and in the other have their ducts twisted to prevent their desire being too violent and hasty. It is for this that the testes are contrived; for they make the movement of the spermatic secretion steadier, preserving the folding back of the passages[7] in the vivipara, as horses and the like, and in man. (For details see the *Enquiries about Animals*.[8]) For the testes are no part of the ducts but are only attached to them, as women fasten stones to the loom when weaving[9]; if they are removed
717b the ducts are drawn up internally, so that castrated animals are unable to generate; if they were not drawn up they would be able, and before now a bull mounting immedi-

[1] The connexion of thought is: 'nor have fish, and fish *do* generate sexually (though some deny this), for,' &c.

[2] These ducts *are* the testes; see above on chap. 3, and for the serpent, on chap. 7. On the alleged copulation of all fishes see note on chap. 6.

[3] So says Harvey: 'The egg is the terminus from which all fowls have sprung and to which all their lives tend—it is the result which nature has proposed to herself in their being.'

[4] The connexion is: 'still it is advisable that there should be some check upon this process, and as,' &c.

[5] This is true (Ogle, pp. 215, 216), but the analogy is hardly convincing.

[6] That A. should ascribe 'temperance' to an animal is startling, but on the virtues of animals see *H. A.* i. 1, *ad fin.*, a passage clearly written with Plato's *Laches* xxv in mind. And cf. *de Partibus*, iii. 675b 22.

[7] i.e. they keep the duct down in a bent and twisted state, thus retarding the passage of semen. Cf. Galen, vol. iv, p. 575. The ducts are the epididymis and vasa deferentia.

[8] *H. A.* iii. 1, which was illustrated by A. with a diagram.

[9] In order to keep the warp steady.

ately after castration has caused conception in the cow[1] because the ducts had not yet been drawn up. In birds and oviparous quadrupeds the testes receive the spermatic secretion, so that its expulsion is slower than in fishes. This is clear in the case of birds, for their testes are much enlarged at the time of copulation, and all those which pair at one season of the year have them so small when this time is past that they are almost indiscernible, but during the season they are very large.[2] When the testes are internal the act of copulation is quicker than when they are external, for even in the latter case the semen is not emitted before the testes are drawn up.

5 Besides, quadrupeds have the organ of copulation, since it is possible for them to have it,[3] but for birds and the footless animals it is not possible,[4] because the former have their legs under the middle of the abdomen and the latter have no legs at all; now the penis depends from that region and is situated there. (Wherefore also the legs are strained in intercourse, both the penis and the legs being sinewy.) So that, since it is not possible for them to have this organ, they must necessarily either have no testes also, or at any rate not have them there, as those animals that have both penis and testes have them in the same situation.

Further, with those animals at any rate that have external testes, the semen is collected together before emission, and emission is due to the penis being heated by its movement; it is not ready for emission at immediate contact as in fishes.[5]

[1] This is perfectly possible for a week or two after castration, as Prof. Starling tells me. Was it not this unlucky observation which led A. to deny the testes their true function?

[2] e.g. 'chez le moineau, son diamètre longitudinal est douze fois aussi grand à l'époque du rut qu'avant cette époque.' Cuvier, *Leçons*, xxiii, *art.* i. C.

[3] And Nature always provides means to an end if it is possible.

[4] This is wrong; some birds have a penis, e.g. the goose, and on serpents see chapter 7. A. himself had correctly ascribed a penis to the goose in *H. A.* iii. 509b 30, but apparently had either forgotten about it or changed his mind.

[5] Apparently A. means that it is an advantage for some reason to have the semen collected first, and that this is another final cause

All the vivipara have their testes in front, internally or externally, except the hedgehog; he alone has them near the loin. This is for the same reason as with birds, because their union must be quick, for the hedgehog does not, like the other quadrupeds, mount upon the back of the female, but they conjugate standing upright because of their spines.[1]

So much for the reasons why those animals have testes which have them, and why they are sometimes external and sometimes internal.

All those animals which have no testes are deficient in **6**
this part, as has been said, not because it is better to be so but simply because of necessity,[2] and secondly because it is necessary that their copulation should be speedy. Such
718a is the nature of fish and serpents. Fish copulate throwing themselves alongside of the females and separating again quickly.[3] For as men and all such creatures[4] must hold their breath before emitting the semen, so fish at such times must cease taking in the sea-water, and then they perish easily. Therefore they must not mature the semen during copulation, as viviparous land-animals do, but they have it all matured together before the time,[5] so as not to be maturing it[6] while in contact but to emit it ready matured. So they have no testes, and the ducts are

of the existence of testes. The theory that emission is due to heat and the movement of the body is Hippocratic (vol. i, p. 321). A. held wrongly that fish copulate by throwing themselves alongside of one another. See chap. 6.

[1] It is true that the testes of a hedgehog, as of several other insectivora, which have no spines, are 'near the loin.' I do not know whether the statement about the hedgehog's attitude is true; from Dobson's *Monograph of the Insectivora* it appears that nobody knows very much about their breeding; Professor Hill, however, tells me that the spiny echidna is believed to copulate *ventre à ventre*, and it seems probable that this is true also of the hedgehog. Cf. *H. A.* v. 2. See *Addenda*.

[2] Referring to the first argument in chap. 5.

[3] A. often repeats this, but it is of course totally untrue of the great majority of fish, in which the female deposits the eggs unfertilized and the male fertilizes them afterwards by shedding his milt upon them. A. knew of this latter process, but regarded it as merely supplementary to the supposed original copulation.

[4] i. e. air-breathers.

[5] Qu. ἀλλὰ πρὸ τῆς ὥρας for ἀλλ' ὑπὸ τῆς ὥρας?

[6] Reading πέττειν for ποιεῖν (AW.).

straight and simple. There is a small part similar to this connected with the testes in the system of quadrupeds, for part of the reflected duct is sanguineous and part is not; the fluid is already semen when it is received by and passes through this latter part, so that once it has arrived there it is soon emitted in these quadrupeds also.[1] Now in fishes the *whole* passage resembles the last section of the reflected part of the duct in man and similar animals.

7 Serpents copulate twining round one another, and, as said above, have neither testes nor penis,[2] the latter because they have no legs, the former because of their length,[3] but they have ducts like fish; for on account of their extreme length the seminal fluid would take too long in its passage and be cooled if it were further delayed by testes. (This happens also if the penis is large; such men are less fertile than when it is smaller because the semen, if cold, is not generative, and that which is carried too far is cooled.) So much for the reason why some animals have testes and others not. Serpents intertwine because of their inaptitude to cast themselves alongside of one another. For they are too long to unite closely with so small a part and have no organs of attachment, so they make use of the suppleness of their bodies, intertwining. Wherefore also they seem to be slower in copulation than fish, not only on account of the length of the ducts but also of this elaborate arrangement in uniting.

8 It is not easy to state the facts about the uterus in female animals, for there are many points of difference. The vivipara are not all alike in this part; women and all

[1] This is more clearly expressed in *H. A.* iii. 1 'The liquid is still sanguineous in the duct adhering to the testis, though less so than in the passages above from the aorta, but in the ducts reflected into the channel of the penis the liquid is white.'

[2] So far from having none, they have *two*. Cuvier, *Leçons*, xxxiv, *sect.* 3, *art.* i. Treviranus took them to be urinary vessels in the chamaeleon; perhaps A. made some similar mistake.

[3] The testis of course is elongated along with the rest of the body, and, as it was just because of this elongation that A. refused to recognize it as a testis, his statement is in a sort of way correct.

the vivipara with feet have the uterus low down by the
718b pudendum, but the cartilaginous viviparous fish have it higher up near the hypozoma. In the ovipara, again, it is low in fish (as in women and the viviparous quadrupeds), high in birds and all oviparous quadrupeds.[1] Yet even these differences are on a principle. To begin with the ovipara, they differ in the manner of laying their eggs, for some produce them imperfect, as fishes whose eggs increase and are finally developed outside of them.[2] The reason is that they produce many young, and this is their function as it is with plants. If then they perfected the egg in themselves they must needs be few in number, but as it is, they have so many that each uterus seems to be an egg, at any rate in the small fishes.[3] For these are the most productive, just as with the other animals and plants whose nature is analogous to theirs,[4] for the increase of size turns with them to seed.[5]

But the eggs of birds and the quadrupedal ovipara [6] are perfect when produced. In order that these may be preserved they must have a hard covering (for their envelope is soft so long as they are increasing in size), and the shell is made by heat squeezing out the moisture from the earthy material; consequently the place must be hot in which this is to happen. But the part about the hypozoma *is* hot, as is shown by that being the part which concocts the food. If then the eggs must be within the uterus, then the uterus must be near the hypozoma in those creatures which produce their eggs in a perfect form. Similarly it must be low down in those which produce them imperfect, for it is profitable that it should be so. And it is more natural for the uterus to be low down than high up, when Nature has

[1] *High* and *low* in A. generally mean towards the head and away from it.

[2] The eggs do increase after oviposition, but it is only due to imbibition of water.

[3] i. e. each oviduct is so filled with roe that it seems a solid mass.

[4] This means 'small compared with other members of the same class'. Cp. iv. 771b 25.

[5] i. e. that which goes to increase the bulk of the larger is diverted to producing seed in the smaller. An instance of the so-called 'law of organic equivalents'; see Ogle, p. xvi.

[6] True of Reptilia. As usual A. ignores Amphibia.

no other business in hand to hinder it; for its end is low down, and where is the end, there is the function, and the uterus itself is naturally where the function is.[1]

9 We find differences in the vivipara also as compared with one another. Some produce their young alive, not only externally, but also internally,[2] as men, horses, dogs, and all those which have hair,[3] and among aquatic animals, dolphins, whales, and such cetacea.[4]

10 But the cartilaginous fish and the vipers produce their young alive externally, but first produce eggs internally. The egg is perfect,[5] for so only can an animal be generated from an egg, and nothing comes from an imperfect one. It is because they are of a cold nature, not hot as some assert,[6] that they do not lay their eggs externally.

11 At least they certainly produce their eggs in a soft envelope, the reason being that they have but little heat and so their nature does not complete the process of drying

[1] i. e. the function of the uterus is to give birth to young, but this function is performed low down in the body; therefore naturally the uterus is low. But if Nature finds it desirable to cover the egg with a hard shell, she moves the uterus or oviducts higher up to secure the heat required for this purpose. Therefore the uterus of fish may remain low in its natural position, but with birds and reptiles it must go higher up.

'End,' πέρας. Does A. mean 'end' in a physical sense or does he mean 'aim and object'? He appears to be quibbling on both meanings.

[2] This odd phrase is often used to denote animals which are viviparous without first producing an egg internally.

[3] i. e. all mammalia except the cetacea.

[4] δελφῖνές τε καὶ φάλαιναι καὶ τὰ τοιαῦτα κήτη. Cf. *H. A.* vi. 566^{b} 2. The exact meaning is uncertain; the obvious thing is to suppose that δελφῖνες is a generic term for the smaller, φάλαιναι for the larger cetaceans; but then what are the others, τὰ τοιαῦτα? As a specific term, it is agreed that δελφίς is *Delphinus delphis*, but φάλαινα is supposed by AW. to be *Delphinus tursiops*, by Ogle the sperm-whale, while Sundevall declines to decide on anything definite.

[5] i. e. does not increase after oviposition.

[6] No doubt somebody had said the cartilaginous fishes (sharks and rays) were hot *because* they were viviparous. A. liked to test theory by fact, though he may leave much to be desired himself. His own views on the heat and cold of various animals are excessively strange; see Ogle, pp. xxii seqq.

the egg-shell. Because, then, they are cold they produce
719a soft-shelled eggs, and because the eggs are soft they do not produce them externally; for that would have caused their destruction.

The process is for the most part the same as in birds, for the egg descends and the young is hatched from it near the vagina, where the young is produced in those animals which are viviparous from the beginning.[1] Therefore in such animals the uterus is dissimilar to that of both the vivipara and ovipara, because they participate in both classes; for it is at once near the hypozoma and also stretching along downwards in all the cartilaginous fishes. But the facts about this and the other kinds of uterus must be gathered from inspection of the drawings of dissections and from the *Enquiries*.[2] Thus, because they are oviparous, laying perfect eggs, they have the uterus placed high, but, as being viviparous, low, participating in both classes.

Animals that are viviparous from the beginning all have it low, Nature here having no other business to interfere with her, and their production having no double character. Besides this, it is impossible for animals to be produced alive near the hypozoma, for the foetus must needs be heavy and move, and that region in the mother is vital and would not be able to bear the weight and the movement. Thirdly, parturition would be difficult because of the length of the passage to be traversed; even as it is there is difficulty with women if they draw up the uterus in parturition by yawning or anything of the kind, and even when empty it causes a feeling of suffocation if moved upwards. For if a uterus is to hold a living animal it must be stronger than in ovipara, and therefore in all the vivipara it is fleshy, whereas when the uterus is near the hypozoma it is membranous. And this is clear also in the case of the animals which produce young by the mixed method, for their eggs are high up and sideways, but the living young are produced in the lower part of the uterus.

[1] i. e. which produce young without any egg at all. A. of course knew nothing of the mammalian ovum.

[2] *H. A.* iii. 1, where we are again referred to the drawing.

So much for the reason why differences are found in the uterus of various animals, and generally why it is low in some and high in others near the hypozoma.

12 Why is the uterus always internal, but the testes sometimes internal, sometimes external? The reason for the uterus always being internal is that in this is contained the egg or foetus,[1] which needs guarding, shelter, and maturation by concoction, while the outer surface of the body is easily injured and cold. The testes vary in position[2] because they also need shelter and a covering to preserve them and 719b
to mature the semen; for it would be impossible for them, if chilled and stiffened, to be drawn up and discharge it. Therefore, whenever the testes are visible, they have a cuticular covering known as the scrotum. If the nature of the skin is opposed to this, being too hard to be adapted for enclosing them or for being soft like a true 'skin', as with the scaly integument of fish and reptiles, then the testes must needs be internal. Therefore they are so in dolphins and all the cetacea which have them,[3] and in the oviparous quadrupeds among the scaly animals. The skin of birds also is hard so that it will not conform to the size of anything and enclose it neatly. (This is another reason with all these animals for their testes being internal besides those previously mentioned[4] as arising necessarily from the details of copulation.) For the same reason they are internal in the elephant and hedgehog, for the skin of these, too, is not well suited to keep the protective part separate.[5]

[The position[6] of the uterus differs in animals viviparous within themselves and those externally oviparous, and in the latter class again it differs in those which have the uterus low and those which have it near the hypozoma, as

[1] *τὸ γινόμενον*, lit. 'the thing that is coming into being'.

[2] Supply 'but if external are specially provided for'.

[3] A. seems not to be certain whether all cetacea have testes; perhaps he only knew of them in the dolphin and thought it unsafe to generalize.

[4] See chap. 5 of this book.

[5] Another reason has been already given for the hedgehog, chap. 5.

[6] This paragraph is an incorrect reminiscence of preceding chapters, and should be ejected.

in fishes compared with birds and oviparous quadrupeds. And it is different again in those which produce young in both ways, being oviparous internally and viviparous externally. For those which are viviparous both internally and externally have the uterus placed on the abdomen, as men, cattle, dogs, and the like, since it is expedient for the safety and growth of the foetus that no weight should be upon the uterus.]

The passages also are different through which the solid 13
and liquid excreta pass out in all the vivipara. Wherefore both males and females in this class all have a part whereby the urine is voided, and this serves also for the issue of the semen in males, of the offspring in females. This passage is situated above[1] and in front of the passage of the solid excreta.[2] The passage is the same as that of the solid nutriment[3] in all those animals that have no penis, in all the ovipara, even those of them that have a bladder, as the tortoises.[4] For it is for the sake of generation, not for the evacuation of the urine, that the passages are double; but because the semen is naturally liquid, the liquid excretion also shares the same passage.[5] This is clear from the fact

[1] Perhaps this means that the bladder is nearer the head than is the anus. But I suspect confusion of the text in all this passage.

[2] Reading ⟨τοῦ⟩ τῆς ξηρᾶς τροφῆς with the Aldine (AW.). Here follows in the MSS. another interpolation connected with that at the end of chap. 12. 'Ovipara laying imperfect eggs, as the oviparous fishes, have the uterus not under the abdomen but near the loin. For the growth of the egg does not hinder this, because the growing creature is perfected and develops externally.'

[3] Omitting *καί* and reading *τῷ* (AW.).

[4] A. held wrongly that no animals have a bladder except mammals and tortoises. Therefore he would expect the tortoises to have a separate urinary passage, like the mammals, and is surprised that they have not.

[5] See Flower and Lydekker, *Mammals*, p. 118. 'The canal,' of the penis in the monotremata or lowest mammalia, 'is open at the base and brought only temporarily in contact with the termination of the vasa deferentia, *so as to form a seminal urethra* when required; *but it never transmits the urinary secretion.* This condition is a distinct advance on that of the Sauropsida' (birds and reptiles) 'in the direction of the more complex development of these parts in most of the other mammalia', i. e. the penis has been developed 'for the sake of generation' and only took on the transmission of the urine as an afterthought. Though the reason A. gives for his statement in the

that all animals produce semen,[1] but all do not void liquid excrement. Now the spermatic passages of the male must be fixed and must not wander, and the same applies to the uterus of the female, and this fixing must take place at either the front or the back of the body. To take the uterus first, it is in the front of the body in vivipara because of the foetus, but at the loin and the back in ovipara. All animals which are internally oviparous and externally viviparous are in an intermediate condition because they participate in both classes, being at once oviparous and viviparous. For the upper part of the uterus, where the eggs are produced, is under the hypozoma by the loin and the back, but as it advances is low at the abdomen;[2] for it is in that part that the animal is viviparous. In these also the passage for solid excrement and for copulation is the same, for none of these, as has been said already, has a separate pudendum.

The same applies to the passages in the male, whether they have testes or no, as to the uterus of the ovipara. For in all of them, not only in the ovipara, the ducts adhere to the back and the region of the spine. For they must not wander but be settled, and that is the character of the region of the back, which gives continuity and stability. Now in those which have internal testes, the ducts are fixed from the first, and they are fixed in like manner[3] if the testes are external;[4] then they meet together towards the region of the penis.

The like applies to the ducts in the dolphins, but they have their testes hidden under the abdominal cavity.

We have now discussed the situation of the parts contributing to generation, and the causes thereof. 720b

14 The bloodless animals do not agree either with the sanguinea or with each other in the fashion of the parts

next sentence is quaint enough, yet how astonishing that he should have hit upon the truth!

[1] A. is here thinking of the higher animals.

[2] The text appears corrupt. Qu. προϊοῦσα or προϊόντων for προϊούσης?

[3] Only not from the first.

[4] By omitting ἅμα τοῖς πόροις I hope I have restored sense to Aristotle; to combine Greek and sense in the received text would puzzle Diels himself.

contributing to generation. There are four classes still left to deal with, first the crustacea, secondly the cephalopoda, thirdly the insects, and fourthly the testacea. We cannot be certain about all of them, but that most of them copulate[1] is plain; in what manner they unite must be stated later.

The crustacea copulate like the retromingent quadrupeds,[2] fitting their tails to one another, the one supine and the other prone. For the flaps attached to the sides of the tail[3] being long prevent them from uniting with the belly against the back. The males have fine spermatic ducts, the females a membranous uterus alongside the intestine, cloven on each side, in which the egg is produced.[4]

The cephalopoda entwine together at the mouth, pushing against one another and enfolding their arms. This attitude is necessary, because Nature has bent backwards the end of the intestine and brought it round near the mouth, as has been said before in the treatise on the parts of animals.[5] The female has a part corresponding to the uterus, plainly to be seen in each of these animals, for it contains an egg which is at first indivisible to the eye[6] but afterwards splits up into many; each of these eggs is imperfect when deposited, as with the oviparous fishes. In the cephalopoda (as also in the crustacea) the same passage serves to void the excrement and leads to the part like a uterus, for the male discharges the seminal fluid through this passage.[7] And it is on the lower surface of the body, where the mantle is open and the sea-water enters the

[1] Reading *ὅτι συνδυάζεται*.

[2] Cf. *H. A.* vi. 31, 33. But the statement there made about retromingent quadrupeds is neither true nor, if it were, does it illustrate the crustacea. For A. did not hold that one of these quadrupeds is supine and the other prone.

[3] i. e. in the female. Cf. *de Partibus*, iv. 684a 20.

[4] This description applies only to the macrurous crustacea: of the crabs a separate account is given in *H. A.* v. 7.

[5] *de Partibus*, iv. 9.

[6] The eggs of the poulps and calamaries are compacted together in the ovary so that they look like a homogeneous mass (J. P. Hill). Similarly A. speaks elsewhere of the roe of a fish as an egg.

[7] Reading provisionally *τὸ γὰρ ἄρρεν τὸν θορὸν ἀφίησι διὰ τοῦ πόρου τούτου, ἐστὶ δ'* (AW.).

cavity. Hence the union of the male with the female takes place at this point, for it is necessary, if the male discharges either semen or a part of himself or any other force, that he should unite with her at the uterine passage. But the insertion, in the case of the poulps, of the arm of the male into the funnel of the female, by which arm the fishermen say the male copulates with her, is only for the sake of attachment, and it is not an organ useful for generation, for it is outside the passage in the male and indeed outside the body of the male altogether.[1]

[1] This passage refers to one of the most astonishing phenomena in zoology, the so-called 'hectocotylization' of the di-branchiate cephalopoda. The fishermen were right and Aristotle is wrong. The male has one arm modified to form a generative organ, which is charged with spermatophores and thrust into the funnel of the female; in three genera of the Octopodidae (poulps) it actually comes off from the male altogether and remains within the mantle of the female. See Lewes, pp. 197–201; *Cambridge Natural History*, vol. iii, pp. 137–40. Lewes has an easy task in demolishing the moderns who asserted that A. knew all about the hectocotylus, but he knew nothing of this decisive passage in which A. definitely says the fishermen are wrong. The *Cambridge Nat. Hist.* is also misleading on this point.

Aristotle's argument against the fishermen, however, is apparently conclusive, and he seems justified on the evidence before him. To this day it is not known how the spermatophores ever get into the arm (Arnold Lang, *Textbook of Comparative Anatomy*, Eng. ed., Pt. ii, p. 242). A. saw the apparent impossibility involved; the arm does not connect with the vasa deferentia or with the funnel of the male through which the generative product must pass, and it is no wonder that he thought this decisive against the theory of the fishermen. He only deserves credit for doing so.

It will be seen that several important words have to be supplied in the last sentence of the translation. The obvious meaning would be that the arm is outside the 'uterine passage' or body of the *female.* But A. does not deny that it is thrust into the funnel of the female; he knows that it *is* but thinks this is only to attach the male to the female. His position is this: the male and female unite by embracing mouth to mouth; in this position the funnels of both come in contact and the generative fluid passes from the vasa deferentia through the funnel of the male into that of the female and then into her oviducts. But the hectocotylus arm is outside this passage altogether, it does not connect with the funnel of the male, and therefore though it is thrust into the funnel of the female it cannot convey the fluid into it, because, as he means to say, it is not in the funnel or passage *of the male* nor in the male *body* at all but only an outgrowth from the *head.*

The words 'or a part of himself' certainly seem to imply the actual detachment of the hectocotylized arm, the 'peculiar marvel' which Lewes denies that A. had ever heard of. The loss of the arm accounts for the fact that ancient representations of octopods sometimes have only seven arms.

Sometimes also cephalopoda unite by the male mounting
721a on the back of the female, but whether for generation or some other cause has not yet been observed.

Some insects copulate and the offspring are produced 16
from animals of the same name, just as with the sanguinea; such are the locusts, cicadae, spiders,[1] wasps, and ants. Others unite indeed and generate; but the result is not a creature of the same kind, but only a scolex,[2] and these insects do not come into being from animals but from putrefying matter, liquid or solid; such are fleas, flies, and cantharides. Others again are neither produced from animals nor unite with each other; such are gnats, 'conopes',[3] and many similar kinds. In most of those which unite the female is larger than the male. The males do not appear to have spermatic passages. In most cases the male does not insert any part into the female, but the female from below upwards into the male; this has been observed in many cases[4] (as also that the male mounts the female), the opposite in few cases; but observations are not yet comprehensive enough to enable us to make a distinction of classes. And generally it is the rule with most of the oviparous fish and oviparous quadrupeds that the female is larger than the male because this is expedient in view of the increase of bulk in conception by reason of the eggs. In the female the part analogous to the uterus is cleft and extends along the intestine, as with the other animals; in this are produced the results of conception. This is clear in locusts and all other large insects whose nature it is to unite: most insects are too small to be observed in this respect.

Such is the character of the generative organs in animals

[1] Spiders were included among insects until the time of Lamarck (1800).

[2] See iii. 9 and notes.

[3] *ἐμπίδες τε καὶ κώνωπες*. One cannot say exactly what insects are meant.

[4] Though A. often insists on this, it is scarcely necessary to say that there is not a word of truth in it, any more than in the statements about spontaneous generation of insects. All insects copulate in the usual way, and the males have 'spermatic passages' which A. could not make out.

which were not spoken of before.[1] It remains now to speak of the homogeneous parts concerned, the seminal fluid and milk. We will take the former first, and treat of milk afterwards.[2]

17 Some animals manifestly emit semen, as all the sanguinea, but whether the insects and cephalopoda do so is uncertain. Therefore this is a question to be considered, whether all males do so, or not all; and if not all, why some do and some not; and whether the female also contributes any semen or not; and, if not semen, whether she 721b
does not contribute anything else either, or whether she contributes something else which is not semen. We must also inquire what those animals which emit semen contribute by means of it to generation, and generally what is the nature of semen, and of the so-called catamenia in all animals which discharge this liquid.

Now it is thought that all animals are generated out of semen, and that the semen comes from the parents. Wherefore it is part of the same inquiry to ask whether both male and female produce it or only one of them, and to ask whether it comes from the whole of the body[3] or not from the whole; for if the latter is true it is reasonable to suppose that it does not come from both parents either.[4]

[1] i.e. in the *de Partibus*. [2] iv. 8.

[3] This was the Hippocratic view, held also by Democritus, and very similar to Darwin's famous 'pangenesis'. (See his *Variation*, chap. 27, especially note 42 in the second edition.) It is particularly interesting to observe that Hippocrates like Darwin accounted by this theory for the supposed inheritance of acquired characteristics. (Hipp., vol. i, p. 551).

[4] This does not follow rigorously, but as the Hippocratic view combines two distinct theories, of which A. accepts neither the one nor the other, he thinks that if he can overset the one it will afford a presumption that the other is wrong also.

His arguments against pangenesis, if we may adopt the Darwinian term for the similar though not identical theory, are of varying validity, but he is certainly right in the main; see e.g. Wilson, *Cell in Development and Inheritance*, chap. 9; Poulton, *Essays on Evolution*, p. 127. On the other hand, when A. denies that the female contributes semen, though he may be right in a certain sense, he is in truth fundamentally wrong, for his position is that the mother does not contribute anything resembling the semen of the male, whereas the ovum is just as important as the spermatozoon and carries inheritance equally with it.

Accordingly, since some say that it comes from the whole of the body, we must investigate this question first.

The proofs from which it can be argued that the semen comes from each and every part of the body may be reduced to four. First, the intensity of the pleasure of coition; for the same state of feeling is more pleasant if multiplied, and that which affects all the parts is multiplied as compared with that which affects only one or a few. Secondly, the alleged fact that mutilations are inherited, for they argue that since the parent is deficient in this part the semen does not come from thence, and the result is that the corresponding part is not formed in the offspring. Thirdly, the resemblances to the parents, for the young are born like them part for part as well as in the whole body; if then the coming of the semen from the whole body is cause of the resemblance of the whole, so the parts would be like because it comes from each of the parts. Fourthly, it would seem to be reasonable to say that as there is some first thing from which the whole arises, so it is also with each of the parts, and therefore if semen or seed is cause of the whole so each of the parts would have a seed peculiar to itself. And these opinions are plausibly supported by such evidence as that children are born with a likeness to their parents, not only in congenital but also in acquired characteristics;[1] for before now, when the parents have had scars, the children have been born with a mark in the form of the scar in the same place, and there was a case at Chalcedon where the father had a brand on his arm and the letter was marked on the child, only confused and not clearly articulated.[2] That is pretty much the evidence on
722a which some believe that the semen comes from all the body.

[1] Lest I should be suspected of modernizing the language unduly, I give the Greek words: *οὐ μόνον τὰ σύμφυτα προσεοικότες . . . ἀλλὰ καὶ τὰ ἐπίκτητα.* The distinction between congenital and acquired characters was evidently perfectly familiar to A.

[2] Legends of this sort have always been popular; Mrs. Harris's husband's brother was 'marked with a mad bull in Wellington boots upon his left arm on account of his precious mother havin' been worrited by one into a shoemaker's shop' (*Martin Chuzzlewit*, chap. xlvi). Hippocrates, however, held such inheritance to come direct from the father.

18 On examining the question, however, the opposite appears more likely, for it is not hard to refute the above arguments and the view involves impossibilities. First, then, the resemblance of children to parents is no proof that the semen comes from the whole body, because the resemblance is found also in voice, nails, hair, and way of moving, from which nothing comes.[1] And men generate before they yet have certain characters, such as a beard or grey hair. Further, children are like their more remote ancestors from whom nothing has come, for the resemblances recur at an interval of many generations, as in the case of the woman in Elis who had intercourse with the Aethiop; her daughter was not an Aethiop but the son of that daughter was.[2] The same thing applies also to plants, for it is clear that if this theory were true the seed would come from all parts of plants also; but often a plant does not possess one part, and another part may be removed, and a third grows afterwards.[3] Besides, the seed does not come from the pericarp,[4] and yet this also comes into being with the same form as in the parent plant.

We may also ask whether the semen comes from each of the homogeneous parts only, such as flesh and bone and sinew, or also from the heterogeneous, such as face and hands. For if (1) from the former only, we object that the resemblance exists rather in the heterogeneous parts, such as face and hands and feet; if then it is not because of the

[1] A. assumes this for hair and nails because they have no blood-vessels, I suppose.

[2] It is possible that this story *may* be true; see Lawrence, *Lectures on Physiology, &c.*, 1822, pp. 260, 261. In the absence of details we cannot even say exactly what is meant here; the daughter, for instance, might have been an albino and her son a quadroon, which would be enough to start the story, and then there would be nothing remarkable about it. But such tales are recklessly invented in America to this day.

Granting it to be true in its obvious and strongest meaning, it would *not* be a case of Mendelism. For if black were the dominant character, how could the daughter be white? And if white were dominant how could her son be black? (It is obvious that A. supposes the daughter mated with a white man, and it would be asking too much of the goddess of probabilities to postulate a black 'allelomorph' in him also.)

Plutarch's similar story (*de sera numinis vindicta*, cap. 21) seems to be another version of this of Aristotle's.

[3] And yet the new plant is like its parent in all these parts.

[4] i.e. the material of the pericarp contributes nothing to the seed.

semen coming from all parts that children resemble their parents in *these*, what is there to stop the homogeneous parts also from being like for some other reason than this? If (2) the semen comes from the heterogeneous alone, then it does not come from all parts; but it is more fitting that it should come from the homogeneous parts, for they are prior to the heterogeneous which are composed of them; and as children are born like their parents in face and hands, so they are, necessarily, in flesh and nails.[1] If (3) the semen comes from both, what would be the manner of generation? For the heterogeneous parts are composed of the homogeneous, so that to come from the former would be to come from the latter and from their composition. To make this clearer by an illustration, take a written name; if anything came from the whole of it, it would be from each of the syllables, and if from these, from the letters[2] and their composition. So that if really flesh and bones are composed of fire and the like elements, the semen would come rather from the elements than anything else, for how can it come from their
722b composition? Yet without this composition there would be no resemblance. If again something creates this composition later, it would be *this* that would be the cause of the resemblance, not the coming of the semen from every part of the body.[3]

Further, if the parts of the future animal are separated in the semen, how do they live? and if they are connected, they would form a small animal.[4]

And what about the generative parts? For that which comes from the male is not similar to what comes from the female.[5]

[1] Since face and hands are composed of flesh and nails and other homogeneous parts.

[2] The word for *letter* and *element* is the same in the Greek.

[3] This something which creates the composition of the elements so as to cause the resemblance remains as great a mystery now as it was then. But how profound is Aristotle's analysis!

[4] Which is absurd. It is true that we call the carrier of the generative element in the semen the spermatozoon, but the spermatozoon of a rhinoceros is not a little rhinoceros.

[5] This objection means, I think, that we can understand how germs from the hand or foot of both mother and father (being alike) may combine to form the hand or foot of the child, but that we cannot

Again, if the semen comes from all parts of both parents alike, the result is *two* animals, for the offspring will have all the parts of both. Wherefore Empedocles seems to say what agrees pretty well with this view (if we are to adopt it),[1] to a certain extent at any rate, but to be wrong if we think otherwise. What he says agrees with it when he declares that there is a sort of tally in the male and female, and that the whole offspring does not come from either, 'but sundered is the fashion of limbs, some in man's . . .'[2] For why does not the female generate from herself if the semen comes from all parts alike and she has a receptacle ready in the uterus? But, it seems, either it does not come from all the parts, or if it does it is in the way Empedocles says, not the same parts coming from each parent, which is why they need intercourse with each other.

Yet this also is impossible, just as much as it is impossible for the parts when full grown to survive and have life in them when torn apart, as Empedocles accounts for the creation of animals; in the time of his 'Reign of Love', says he, 'many heads sprang up without necks,' and later on these isolated parts combined into animals. Now that *this* is impossible is plain, for neither would the separate parts be able to survive without having any soul or life in them, nor if they were living things, so to say, could several of them combine so as to become one animal again. Yet those who say that semen comes from the whole of the body really have to talk in that way, and as it happened then in the earth during the 'Reign of Love', so it happens according to them in the body. Now it is impossible that

understand how germs from the generative parts of both parents (being unlike) can combine to form a part which is only male or only female. The pangenesists would have answered that there is a conflict and one or other sex prevails.

[1] i. e. if we are to say that semen comes from all parts, and that is why e. g. the hand of a son is like his father's, we must understand it to mean that each part in the offspring comes from a corresponding part in *either* male *or* female parent. Your hand may come from the father, your foot from the mother, or vice versa. But we must not say that all parts come from both parents, or we shall get a double animal with two pairs of hands and feet, &c.

[2] Empedocles said something like 'some in the semen of the man, some in that of the woman.' And so Diels restores the fragment.

the parts should be united together when they come into being and should come from different parts of the parent, meeting together in one place.[1] Then how can the upper and lower, right and left, front and back parts have been 'sundered'? All these points are unintelligible. Further, some parts are distinguished by possessing a faculty, others by being in certain states or conditions; the heterogeneous, as tongue and hand, by the faculty of doing something, the homogeneous by hardness and softness and the other similar states. Blood, then, will not be blood, nor flesh flesh, in any and every state.[2] It is clear, then, that that which comes from any part, as blood from blood or
723a flesh from flesh, will not be identical with that part. But if it is something different from which the blood of the offspring comes, the coming of the semen from all the parts will not be the cause of the resemblance, as is held by the supporters of this theory. For if blood is formed from something which is not blood, it is enough that the semen come from one part only, for why should not all the other parts of the offspring as well as blood be formed from one part of the parent? Indeed, this theory seems to be the same as that of Anaxagoras, that none of the homogeneous parts come into being, except that these theorists assume, in the case of the generation of animals, what he assumed of the universe.[3]

Then, again, how will these parts that came from all the body of the parent be increased or grow? It is true that Anaxagoras plausibly says that particles of flesh out of the food are added to the flesh.[4] But if we do not say this

[1] This seems to mean that we cannot suppose as an alternative that the separate parts are somehow united, *before* they come together, in the semen of each parent.

[2] Because they, being homogeneous substances, are defined by a particular state. And that particular state does not exist in the semen.

[3] Anaxagoras postulated an infinite number of particles homogeneous in themselves, atoms of flesh, blood, &c., which by their combination make the things we see. These particles do not 'come into being' because they exist eternally. Aristotle evidently is not serious in this parallel.

[4] So if we accepted this theory we might say that once the foetus is formed it will grow by addition of such particles without the added matter undergoing any change.

(while saying that semen comes from all parts of the body), how will the foetus become greater by the addition of something else if that which is added remain unchanged? But if that which is added *can* change,[1] then why not say that the semen from the very first is of such a kind that blood and flesh can be made out of it,[2] instead of saying that it itself *is* blood and flesh? Nor is there any other alternative, for surely we cannot say that it is increased later by a process of mixing, as wine when water is poured into it. For in that case each element of the mixture would be itself *at first* while still unmixed, but the fact rather is that flesh and bone and each of the other parts *is* such *later*. And to say that some part of the semen is sinew and bone is quite above us, as the saying is.

Besides all this there is a difficulty if the sex is determined in conception (as Empedocles says: 'it is shed in clean vessels; some wax female, if they fall in with cold').[3] Anyhow, it is plain that both men and women change not only from infertile to fertile, but also from bearing female to bearing male offspring, which looks as if the cause does not lie in the semen coming from all the parent or not, but in the mutual proportion or disproportion of that which comes from the woman and the man, or in something of this kind. It is clear, then, if we are to put this down as being so, that the female sex is not determined by the semen coming from any particular part, and consequently neither is the special sexual part so determined (if really the same semen can become either a male or female child, which shows that the sexual part does not exist in the semen). Why, then, should we assert this of *this* part any more than of the others? For if semen does not come 72
from this part, the uterus, the same account may be given of the others.

Again, some creatures come into being neither from

[1] As the pangenesists, unlike Anaxagoras, hold that it can.
[2] Just as they are made out of the food later on.
[3] According to Empedocles, if the embryo began developing on the left or cold side of the uterus it became female, if on the right or hot side male. Parmenides held the same view. See Emp. frag. 67 (Diels), and my note on iv. 765a 19.

parents of the same kind nor from parents of a different kind,[1] as flies and the various kinds of what are called fleas;[2] from these are produced animals indeed, but not in this case of similar nature, but a kind of scolex. It is plain in this case that the young of a different kind are not produced by semen coming from all parts of the parent, for they would then resemble them, if indeed resemblance is a sign of its coming from all parts.

Further, even among animals some produce many young from a single coition (and something like this is universal among plants, for it is plain that they bear all the fruit of a whole season from a single movement[3]). And yet how would this be possible if the semen were secreted from all the body? For from a single coition and a single segregation of the semen scattered throughout the body must needs follow only a single secretion. Nor is it possible for it to be separated in the uterus, for this would no longer be a mere separation of semen, but, as it were, a severance from a new plant or animal.[4]

Again, the cuttings from a plant bear seed; clearly, therefore, even before they were cut from the parent plant, they bore their fruit from their own mass alone,[5] and the seed did not come from *all* the plant.

But the greatest proof of all is derived from observations we have sufficiently established on insects.[6] For, if not in all, at least in most of these, the female in the act of copulation inserts a part of herself into the male. This, as we said before, is the way they copulate, for the females manifestly insert this from below into the males above, not in all cases, but in most of those observed. Hence it seems clear that, when the males do emit semen, then also the cause of the generation[7] is not its coming from all the body, but

[1] But by spontaneous generation.

[2] Reading ψυλλῶν.

[3] A. does not mean that one plant is fertilized by another as a single act, for he knew nothing about their fertilization. He can only mean that the plant as a whole produces fruit all over itself in consequence of a single impulse at its heart, so to say.

[4] This argument is repeated in chap. 20, where see note.

[5] Lit. 'from the same size'.

[6] See above on chap. 16.

[7] *Sic*; but what have we to do in this argument with the cause of *generation*? Should it not be the cause of the *resemblance*?

something else which must be investigated hereafter. For even if it were true that it comes from all the *body*, as they say, they ought not to claim that it comes from all *parts* of it, but only from the creative part—from the workman, so to say, not the material he works in. Instead of that, they talk as if one were to say that the semen comes from the shoes, for, generally speaking, if a son is like his father, the shoes he wears are like his father's shoes.[1]

As to the vehemence of pleasure in sexual intercourse, it is not because the semen comes from all the body, but because there is a strong friction (wherefore if this intercourse is often repeated the pleasure is diminished in the 724a
persons concerned). Moreover, the pleasure is at the end of the act, but it ought, on the theory, to be in each of the parts, and not at the same time, but sooner in some and later in others.[2]

If mutilated young are born of mutilated parents,[3] it is for the same reason as that for which they are like them. And the young of mutilated parents are not always mutilated, just as they are not always like their parents; the cause of this must be inquired into later, for this problem is the same as that.

Again, if the female does not produce semen, it is reasonable to suppose it does not come from all the body of the male either.[4] Conversely, if it does not come from all the male it is not unreasonable to suppose that it does not come from the female,[5] but that the female is cause of the generation in some other way. Into this we must next inquire, since it is plain that the semen is not secreted from all the parts.

In this investigation and those which follow from it, the

[1] In modern language, the germ-cell creates the body which it wears. This body clothes the germ-cells, as shoes again clothe the body. A.'s insight in all this passage is miraculous.

[2] Because the semen would have further to travel from some than from others.

[3] Modern science simply denies the fact *in toto*.

[4] Because the young resemble the mother as well as the father.

[5] I do not follow this argument.

first thing to do is to understand what semen is, for then it will be easier to inquire into its operations and the phenomena connected with it. Now the object of semen is to be of such a nature that from it as their origin come into being those things which are naturally formed, not because there is any agent which makes them from it as . . . but simply because this is the semen.[1] Now we speak of one thing coming *from* another in many senses; it is one thing when we say that night comes *from* day or a man becomes man *from* boy, meaning that A follows B; it is another if we say that a statue is made *from* bronze and a bed *from* wood, and so on in all the other cases where we say that the thing made is made *from* a material, meaning that the whole is formed from something pre-existing which is only put into shape. In a third sense a man becomes unmusical *from* being musical, sick *from* being well, and generally in this sense contraries arise from contraries. Fourthly, as in the 'climax' of Epicharmus;[2] thus *from* slander comes railing and *from* this fighting, and all these are *from* something in the sense that it is the efficient cause.[3] In this last class sometimes the efficient cause is in the things themselves, as in the last mentioned (for the slander is a part of the whole trouble), and sometimes external, as the art is external to the work of art or the torch to the burning house.[4]

Now the offspring comes *from* the semen, and it is plainly in one of the two following senses that it does so—either the semen is the material from which it is made, or it is the
724b first efficient cause. For assuredly it is not in the sense of A being *after* B, as the voyage[5] comes *from*, i.e. after, the Panathenaea; nor yet as contraries come from contraries, for then one of the two contraries ceases to be, and a third substance must exist as an immediate underlying basis from

[1] A corrupt passage. ἀλλ' is printed before ὅτι τοῦτό ἐστι τὸ σπέρμα in the Basle edition.

[2] See Lorenz's *Epicharmus*, p. 271.

[3] Read ἔκ τινος ἡ ἀρχή.

[4] The work of art comes *from* the art which makes it, and the burning house *from* the torch which sets it afire.

[5] Of the sacred ship to Delos.

which the new thing comes into being.[1] We must discover, then, in which of the two other classes the semen is to be put, whether it is to be regarded as matter, and therefore acted upon by something else, or as a form, and therefore acting upon something else,[2] or as both at once. For perhaps at the same time we shall see clearly also how all the products of semen come into being from contraries, since coming into being from contraries is also a natural process, for some animals do so, i.e. from male and female, others from only one parent, as is the case with plants and all those animals in which male and female are not separately differentiated. Now that which comes from [3] the generating parent is called the seminal fluid, being that which first has in it a principle of generation, in the case of all animals whose nature it is to unite; semen is that which has in it the principles from *both* united parents,[4] as the first mixture which arises from the union of male and female, be it a foetus or an ovum,[5] for these already have in them that which comes from both. (Semen, or seed, and grain differ only in the one being earlier and the other later, grain in that it comes from something else, i.e. the seed, and seed in that something else, the grain, comes from *it*, for both are really the same thing.)[6]

[1] e.g. the unmusical man comes into being from the musical. Then the musical man as such ceases to exist. But for the unmusical man to come into being there must exist the substratum *man*, of which *musical* and *unmusical* are attributes. So, if the offspring came into being from the semen as opposite from opposite, the semen would cease to exist. What then would the offspring come from? We shall have to assume some third substance.

[2] Matter is inert and incapable by itself, it is acted upon by the efficient or the formal cause, which are often identified as here. But A. goes rather far when he speaks of semen as merely 'form', even though qualified by the word *τι*.

[3] Reading *ἀπιόν*.

[4] After this come in the MSS. the words *οἷον τά τε τῶν φυτῶν καὶ ἐνίων ζῴων, ἐν οἷς μὴ κεχώρισται τὸ θῆλυ καὶ τὸ ἄρρεν*, a repetition from above in almost identical words and here utterly out of place.

[5] Read *ᾠόν*. Observe that A. here defines the semen as what we should now call the fertilized ovum, though generally he means by it the same as we do. Lewes, § 443, remarks that the 'moderns call both the impregnated and unimpregnated egg an *ovum*' in like manner. 'Foetus or ovum', because A. was naturally unacquainted with the mammalian ovum.

[6] This sentence is exceedingly irrelevant and probably interpolated.

passage in the body, but a place has been set apart for all 725b the natural secretions; thus the lower intestine serves for the excretion of the solid nutriment, the bladder for that of the liquid; for the useful part of the nutriment we have the upper intestine, for the spermatic secretions the uterus and pudenda and breasts,[1] for it is collected and flows together into them.

And the resulting phenomena are evidence that semen is what we have said, and these result because such is the nature of the secretion. For the exhaustion consequent on the loss of even a very little of the semen is conspicuous because the body is deprived of the ultimate gain drawn from the nutriment. With some few persons, it is true, during a short time in the flower of their youth the loss of it, if it be excessive in quantity, is an alleviation (just as in the case of the nutriment in its first stage, if too much have been taken, since getting rid of this also makes the body more comfortable), and so it may be also when other secretions come away with it, for in that case it is not only semen that is lost but also other influences come away mingled with it,[2] and these are morbid. Wherefore, with some men at least, that which comes from them proves sometimes incapable of procreation because the seminal element in it is so small. But still in most men and as a general rule the result of intercourse is exhaustion and weakness rather than relief, for the reason given. Moreover, semen does not exist in them either in childhood or in old age or in sickness—in the last case because of weakness, in old age because they do not sufficiently concoct their food, and in childhood because they are growing and so all the nutriment is used up too soon, for in about five years, in the case of human beings at any rate, the body seems to gain half the height that is gained in all the rest of life.[3]

In many animals and plants we find a difference in this connexion not only between kinds as compared with kinds,

[1] For milk is a spermatic secretion, iv. 777a 3–15.

[2] Read τούτῳ.

[3] *Sic*; of course A. means in the *whole* of life. AW. refer to Quetelet to show that as a matter of fact half the adult height is reached in the *third* year.

but also between similar individuals of the same kind as compared with each other, e. g. man with man or vine with vine. Some have much semen, others little, others again none at all, not through weakness but the contrary, at any rate in some cases. This is because the nutriment is used up to form the body, as with some human beings, who, being in good condition and developing much flesh[1] or getting rather too fat,[2] produce less semen and are less desirous of intercourse. Like this is what happens with those vines which 'play the goat', that is, luxuriate wantonly through too much nutrition, for he-goats when fat 726a
are less inclined to mount the female; for which reason they thin them before breeding from them, and say that the vines 'play the goat', so calling it from the condition of the goats. And fat people, women as well as men, appear to be less fertile than others from the fact that the secretion when in process of concoction turns to fat[3] with those who are too well-nourished. For fat also is a healthy secretion due to good living.[4]

In some cases no semen is produced at all, as by the willow and poplar.[5] This condition is due to each[6] of the two causes, weakness and strength; the former prevents concoction of the nutriment, the latter causes it to be all consumed, as said above. In like manner other animals produce much semen[7] through weakness as well as through

[1] i. e. muscle.

[2] For *μᾶλλον* with comparatives in A. see Cope on *Rhetoric* ii. 11.

[3] A. distinguishes between *πιμελή* and *στέαρ* in *de Partibus*, ii. 5, but a comparison of that chapter will show that he uses *πιμελή* here in a general sense.

[4] 'That over-fat animals are bad breeders is known to every farmer. So also it is well known that castrated animals grow fat. These and similar facts led Bichat (*Anat. Gen.* i. 55) to express an opinion much the same as that of Aristotle. "On dirait qu'il y a un rapport constant et rigoureux entre la sécrétion de la semence et l'exhalation de la graisse; que ces deux fluides sont en raison inverse l'un de l'autre."' Ogle on *de Partibus*, ii. 5 *ad fin.*

[5] A popular delusion among the ancients. This is why the trees are connected with the dead—*ἰτέαι ὠλεσίκαρποι*, *Odyssey* x. 510.

[6] Reading *ἑκάτεραι* (AW.).

[7] *καὶ πολύχοά ἐστι καὶ πολύσπερμα.* Elsewhere *πολύχοα* means *prolific*, but that plainly cannot be the meaning here; apparently it = *πολὺ σπέρμα χέοντα.* But another reading is *πολυχρόνια* and possibly the word is corrupt.

strength, when a great quantity of a useless secretion is mixed with it; this sometimes results in actual disease when a passage is not found to carry off the impurity, and though some recover of this, others actually die of it. For corrupt humours collect here as in the urine, which also has been known to cause disease.

[Further, the same passage serves for urine and semen; and whatever animals have both kinds of excrement, that of liquid and that of solid nutriment, discharge the semen by the same passage as the liquid excrement (for it is a secretion of a liquid, since the nutriment of all animals is rather liquid than solid), but those which have no liquid excrement discharge it at the passage of the solid residua. Moreover, waste-products are always morbid, but the removal of the secretion is useful; now the discharge of the semen participates in both characteristics because it takes up some of the non-useful nutriment. But if it were a waste-product it would be always harmful; as it is, it is not so.[1]]

From what has been said, it is clear that semen is a secretion of useful nutriment, and that in its last stage, whether it is produced by all[2] or no.

After this we must distinguish of what sort of nutriment 19
it is a secretion, and must discuss the catamenia which occur in certain of the vivipara. For thus we shall make it clear (1) whether the female also produces semen like the male and the foetus is a single mixture of two semens, or whether no semen is secreted by the female, and, (2) if not, whether she contributes nothing else either to generation but only provides a receptacle, or whether she does contribute some-
726b thing, and, if so, how and in what manner she does so.

We have previously stated that the final nutriment is the blood in the sanguinea and the analogous fluid in the other animals. Since the semen is also a secretion of the nutriment, and that in its final stage, it follows that it will

[1] This incoherent and disorderly paragraph has no connexion of any sort with the context; it is a fricassee of reminiscences from what has been said before, and should be rejected from the text.

[2] '*All*' here seems to mean *both sexes*.

be either (1) blood or that which is analogous to blood, or (2) something formed from this. But since it is from the blood, when concocted and somehow divided up, that each part of the body is made, and since the semen if properly concocted is quite of a different character from the blood when it is separated from it, but if not properly concocted has been known in some cases to issue in a bloody condition if one forces oneself too often to coition,[1] therefore it is plain that semen will be a secretion of the nutriment when reduced to blood, being that which is finally distributed to the parts of the body. And this is the reason why it has so great power,[2] for the loss of the pure and healthy blood is an exhausting thing; for this reason also it is natural that the offspring should resemble the parents, for that which goes to all the parts of the body[3] resembles that which is left over.[4] So that the semen which is to form the hand or the face or the whole animal is already the hand or face or whole animal undifferentiated, and what each of them is actually such is the semen potentially, either in virtue of its own mass or because it has a certain power in itself. I mention these alternatives here because we have not yet made it clear from the distinctions drawn hitherto whether it is the matter of the semen that is the cause of generation, or whether it has in it some faculty and efficient cause thereof, for the hand also or any other bodily part is not hand or other part in a true sense if it be without soul or some other power, but is only called by the same name as the living hand.[5]

[1] Hippocrates (vol. ii, p. 512) mentions *λάγνευμα ὕφαιμον ὑποπέλιδνον* as a symptom of an internal disease. Dr. Blacker tells me that 'undoubtedly excessive coitus may lead to bleeding from the prostate gland and so the semen may contain blood.'

[2] As is shown by the exhaustion consequent upon coition.

[3] i. e. the blood.

[4] i. e. the semen.

[5] *Soul* (*ψυχή*) is the truth and reality of an organism according to A., and a dead hand, or a hand of stone, is only called *hand* by a sort of analogy. The essence of a hand is that it shall be able to grasp, which the dead hand cannot do, and it is able to grasp because it has *ψυχή* (or we should say *life*) in it.

The MSS. proceed with a passage which AW. have bracketed as out of place, but which to me is totally unintelligible anywhere. The literal translation runs thus:

And it is plain that in all cases where a spermatic humour occurs

On this subject, then, so much may be laid down.[1] But since it is necessary (1) that the weaker animal also should have a secretion greater in quantity and less concocted, and (2) that being of such a nature it should be a mass of sanguineous liquid,[2] and (3) since that which Nature endows with a smaller portion of heat is weaker, and (4) since it has already been stated that such is the character of the female[3]—putting all these considerations together we see that the sanguineous matter discharged by the female is
727a also a secretion. And such is the discharge of the so-called catamenia.[4]

It is plain, then, that the catamenia are a secretion, and that they are analogous in females to the semen in males. The circumstances connected with them are evidence that this view is correct. For the semen begins to appear

this also is a secretion. This happens when it is dissolved into that which has come to it, just as when the coating falls away at once from stucco; for that which has come away is the same as that which was applied first. In the same way also the last secretion is the same as the first humour.

[1] And we can now proceed to consider the question of what is contributed to generation by the female.

[2] The final concoction of the blood is semen, which does not appear sanguineous, but if the concoction is less thorough, as in women, it will naturally be sanguineous. For the same reason it will be greater in quantity, the weaker animal being less able to reduce it to a small and perfect form.

[3] A. held that vital heat was a sign of superiority and that man was hotter than woman. To put his argument here in a simpler form:

Woman has less vital heat than man.
∴ woman is inferior to man.
∴ the concoction is less thorough in woman.
∴ the secretion will be still sanguineous.

But we do find such a sanguineous discharge in the female.
∴ we may conclude that the catamenia are a secretion.

For A. is very anxious to prove that both the male and female discharges are secretions, not waste-products.

[4] 'True menstruation is only found in women and certain monkeys. There is, however, a slight discharge corresponding to it in other mammals at the rutting period' (G. Blacker). Blundell expresses his surprise that A. should have attempted 'to explain what is common to all animals by a circumstance peculiar to one class' (*Midwifery*, 1840, p. 903), and certainly A. made a hazardous leap when he argued from women to all vertebrata. But he several times observes that women alone have any *superfluous* catamenia, and his great mistake was rather in taking this attendant phenomenon for the important essential in generation; in assuming that the 'material contributed' by all female vertebrates was analogous he was right, but he should have called it an ovum. (In *de Somno*, 455b 33, he lays down the principle that we should argue from man to other animals.)

in males and to be emitted at the same time of life that the catamenia begin to flow in females, and that they change their voice and their breasts begin to develop. So, too, in the decline of life the generative power fails in the one sex and the catamenia in the other.

The following signs also indicate that this discharge in females is a secretion. Generally speaking women suffer neither from haemorrhoids nor bleeding at the nose nor anything else of the sort except when the catamenia are ceasing,[1] and if anything of the kind occurs the flow is interfered with because the discharge is diverted to it.[2]

Further, the blood-vessels of women stand out less than those of men, and women are rounder and smoother because the secretion which in men goes to these vessels is drained away with the catamenia. We must suppose, too, that the same cause accounts for the fact that the bulk of the body is smaller in females than in males among the vivipara, since this is the only class in which the catamenia are discharged from the body.[3] And in this class the fact is clearest in women, for the discharge is greater in women than in the other animals. Wherefore her pallor and the

[1] *ἱσταμένων* is the medical word; cf. Luke, *Evang.* viii. 44 *ἔστη ἡ ῥύσις*, Harnack, *Luke the Physician*, p. 186. We should have expected at first sight the aorist here, but A. has in mind the aphorism of Hippocrates (vol. iii, p. 743): *γυναικὶ τῶν καταμηνίων ἐκλειπόντων αἷμα ἐκ τῶν ῥινῶν ῥυῆναι ἀγαθόν.* And the present must be explained by saying that A. does not mean to say that such bleeding does not also occur at other times but only that it does not occur *along with the catamenia* except when they are ceasing.

I believe that *αἱμορροΐδες* means haemorrhoids here, not haemorrhages in general; cf. Hippocrates, vol. i, p. 325. Indeed, the wording of this passage is enough to show this. As to the fact, Dr. Blacker informs me that it is 'no doubt to some extent true. Women do not as a rule suffer from nose-bleeding &c. at their periods'.

[2] Reading *μεθισταμένης.*

[3] The explanation is ingenious though wrong. The facts are correct indeed, for the rule in the animal kingdom is that the male is smaller than the female, often as in spiders, rotifers, cirrhipedes, &c., ridiculously so, and the mammalia form the only exception. But this is due to the fighting of the males of mammals with one another for the females, in which the bigger and stronger prevail. The male of some of the eared seals may be six times as big as the female.

The pallor of women, as compared with men, was much more conspicuous among the Greeks than among us, as the women stayed at home mostly, while the men were sunburnt by constant exposure in the gymnasium.

absence of prominent blood-vessels is most conspicuous, and the deficient development of her body compared with a man's is obvious.

Now since this is what corresponds in the female to the semen in the male, and since it is not possible that two such discharges should be found together,[1] it is plain that the female does not contribute semen to the generation of the offspring. For if she had semen she would not have the catamenia; but, as it is, because she has the latter she has not the former.

It has been stated then that the catamenia are a secretion as the semen is, and confirmation of this view may be drawn from some of the phenomena of animals. For fat creatures produce less semen than lean ones, as observed before. The reason is that fat also, like semen, is a secretion, is in fact concocted blood, only not concocted in the same way as the semen. Thus, if the secretion is
727b consumed to form fat the semen is naturally deficient. And so among the bloodless animals the cephalopoda and crustacea are in best condition about the time of producing eggs, for, because they are bloodless and no fat is formed in them, that which is analogous in them to fat is at that season drawn off to form the spermatic secretion.

And a proof that the female does not emit similar semen to the male, and that the offspring is not formed by a mixture of both, as some say, is that often the female conceives without the sensation of pleasure in intercourse, and if again the pleasure is experienced by her no less

[1] Why is this 'not possible'? Because A. had found that everywhere Nature is economical, and does not use superfluous methods; it is in fact the 'law of the physiological division of labour'. And if the catamenia really were analogous to the semen it really would follow that the female did not produce semen also. The truth, however, is that the catamenia are a discharge connected with the maturation and liberation of the ovum from the Graafian vesicle. The ovum is the important factor in generation, and this does correspond to the semen; to that limited extent, therefore, A.'s doctrine is correct. Whether we are to say that the female produces semen or not depends simply on the verbal question whether we are to call the ovum semen or not. Nobody ever did, but it would not be absurd to do so, considering that the word σπέρμα means any kind of 'seed', and the ovum might as well come under that head as the semen does.

than by the male and the two sexes reach their goal together,[1] yet often no conception takes place unless the liquid of the so-called catamenia is present in a right proportion. Hence the female does not produce young if the catamenia are absent altogether, nor often when, they being present, the efflux still continues; but she does so *after* the purgation. For in the one case she has not the nutriment or material from which the foetus can be framed by the power coming from the male and inherent in the semen, and in the other it is washed away with the catamenia because of their abundance. But when after their occurrence the greater part has been evacuated, the remainder is formed into a foetus. Cases of conception when the catamenia do not occur at all, or of conception during their discharge instead of after it, are due to the fact that in the former instance there is only so much liquid to begin with as remains behind after the discharge in fertile women,[2] and no greater quantity is secreted so as to come away from the body, while in the latter instance the mouth of the uterus closes after the discharge. When, therefore, the quantity already expelled from the body is great but the discharge still continues, only not on such a scale as to wash away the semen, then it is that conception accompanies coition.[3] Nor is it at all strange that the catamenia should still continue after conception (for even after it they recur to some extent, but are scanty and do not last during all the period of gestation; this, however, is a morbid phenomenon, wherefore it is found only in a few cases and then seldom, whereas it is that which happens as a regular thing that is according to Nature).

It is clear then that the female contributes the material for generation, and that this is in the substance of the catamenia, and that they are a secretion.

[1] Omit παρά after ἰσοδρομησάντων. Cf. Ovid, *Ars Am.* ii. 727.

[2] *Sic*, but the context shows that A. means ordinary women who have catamenia, for he is not opposing barren to fertile, but the *rare* case of conception without catamenia to the *ordinary* case of conception with them.

[3] Omitting πάλιν, which possibly should go somewhere in the next sentence.

Some think that the female contributes semen in coition because the pleasure she experiences is sometimes similar to that of the male, and also is attended by a liquid discharge. But this discharge is not seminal; it is merely 728a proper to the part concerned in each case, for there is a discharge from the uterus[1] which occurs in some women but not in others. It is found in those who are fair-skinned and of a feminine type generally, but not in those who are dark and of a masculine appearance. The amount of this discharge, when it occurs, is sometimes on a different scale from the emission of semen and far exceeds it. Moreover, different kinds of food cause a great difference in the quantity of such discharges; for instance some pungently-flavoured foods cause them to be conspicuously increased. And as to the pleasure which accompanies coition it is due to emission not only of semen, but also of a spiritus,[2] the coming together of which precedes the emission. This is plain in the case of boys who are not yet able to emit semen, but are near the proper age, and of men who are impotent, for all these are capable of pleasure by attrition. And those who have been injured in the generative organs[3] sometimes suffer from diarrhoea because the secretion, which they are not able to concoct and turn into semen, is diverted into the intestine.[4] Now a boy is like a woman[5] in form, and the woman is as it were an

[1] It seems clear that A. here refers to the vulvo-vaginal discharge (Playfair, *Midwifery*[6], vol. i, p. 28). This however, as its name denotes, does not take place 'from the uterus'. In ii. 739a 37 A. says more correctly 'the region in front of the uterus'.

A. goes on however to say that this discharge may be very large; Dr. Blacker tells me that this is never true of the vulvo-vaginal secretion, but that it suggests 'leucorrhoea or whites, which at times is present in very large amount'. This also suits the statement about brunettes and blondes to some extent, as Blacker suggests, because leucorrhoea 'is present in greater quantity in anaemic women'. But again A. elsewhere speaks of leucorrhoea (738b 25) in quite a distinct manner. On the whole I am driven to conclude that there is some confusion in this passage between the two discharges.

[2] *πνεῦμα*. See ii. 3. That the semen is expelled by a *πνεῦμα* is a Hippocratic doctrine (Hipp., vol. iii, p. 748.)

[3] *διεφθαρμένοις τὴν γένεσιν.*

[4] The secretion which is turned into semen is blood. Consequently by 'diarrhoea' here A. means a flow of blood.

[5] Reading *γυναικὶ παῖς.*

impotent male, for it is through a certain incapacity that the female is female, being incapable of concocting the nutriment in its last stage into semen (and this is either blood or that which is analogous to it in animals which are bloodless owing to the coldness of their nature). As then diarrhoea is caused in the bowels by the insufficient concoction of the blood, so are caused in the blood-vessels all discharges of blood, including that of the catamenia, for this also is such a discharge, only it is natural whereas the others are morbid.

Thus it is clear that it is reasonable to suppose that generation comes from this.[1] For the catamenia are semen not in a pure state but in need of working up, just as in the formation of fruits the nutriment is present, when it is not yet sifted thoroughly,[2] but needs working up to purify it. Thus the catamenia cause generation by mixture with the semen, as this impure nutriment in plants is nutritious when mixed with pure nutriment.

And a sign that the female does not emit semen is the fact that the pleasure of intercourse is caused by touch in the same region of the female as of the male; and yet is it not from thence that this flow proceeds. Further, it is not all females that have it at all, but only the sanguinea, and not all even of these, but only those whose uterus is not near the hypozoma and which do not lay eggs; it is not found in the animals which have no blood 728b
but only the analogous fluid (for what is blood in the former[3] is represented by another fluid in the latter). The reason why neither the latter nor those sanguinea mentioned (i. e. those whose uterus is low and which do not lay eggs) have this effluxion is the dryness of their bodies; this allows but little matter to be secreted, only enough for generation but not enough to be discharged from the body. All animals that are viviparous without producing eggs first (such are man and all quadrupeds

[1] i. e. that the catamenia contain the element contributed to generation by the female.

[2] Reading διηττημένη. The meaning is that all the material is present in an unripe fruit before it is sweetened.

[3] Read ἐν ἐκείνοις for ἐνίοις or ἐν ἐνίοις.

which bend their hind-legs outwards,[1] for all these are viviparous without producing eggs)—all these have the catamenia, unless they are defective in development as the mule, only the efflux is not abundant as in women. Details of the facts in each animal have been given in the *Enquiries concerning animals*.[2]

The catamenia are more abundant in women than in the other animals,[3] and men emit the most semen in proportion to their size. The reason is that the composition of their bodies is liquid and hot compared to others, for more matter must be secreted in such a case. Further, man has no such parts in his body as those to which the superfluous matter is diverted in the other animals; for he has no great quantity of hair in proportion to his body, nor outgrowths of bones, horns, and teeth.

There is evidence that the semen is in the catamenia,[4] for, as said before, this secretion appears in the male at the same time of life as the catamenia in the female; this indicates that the parts destined to receive each of these secretions are differentiated at the same time in both sexes; and as the neighbouring parts in both become swollen the hair of puberty springs forth in both alike. As the parts in question are on the point of differentiating they are distended by the spiritus; this is clearer in males in the testes, but appears also about the breasts; in females it is more marked in the breasts, for it is when they have risen two fingers' breadth that the catamenia generally begin.

Now, in all living things in which the male and female are not separated the semen (or seed) is a sort of embryo; by embryo I mean the first mixture of male and female;[5] hence, from one semen comes one body,—for example, one stalk of wheat from one grain, as one animal from one egg

[1] Reading ἐκτός (= ἐπὶ τὸ κοῖλον, *de Incessu*, 704b 4 &c.). The quadrupedal mammalia are meant.

[2] See *H. A.* vi. 18, where, however, only a few animals are mentioned.

[3] See note on 727a 2.

[4] *Sic*, but if A. wrote this he only means that the material in question is semen not 'purified'.

[5] i. e. in the generation of the higher animals.

(for twin eggs are really two eggs). But in whatever kinds the sexes are distinguished, in these many animals may come from one emission of semen, showing that the semen differs in its nature in plants and animals. A proof of this is that animals which can bear more than one young one at a time do so in consequence of only one coition. Whereby, too, it is plain that the semen does not come from the whole of the body; for neither would the different parts of the semen already be separated as soon as discharged from the same part, nor could they be separated in the uterus if they had once entered it all together;[1] but what does happen is just what one would expect, since what the male contributes to generation is the form and the efficient cause,[2] while the female contributes the material. In fact, as in the coagulation of milk, the milk being the material, the fig-juice or[3] rennet is that which contains the curdling principle, so acts the secretion of the male, being divided into parts in the female. Why it is sometimes divided into more or fewer parts, and sometimes not divided at all, will be the subject of another discussion.[4] But because it does not differ in kind at any rate this does not matter, but what does matter is only that each part should correspond to the material, being neither too little to concoct it and fix it

[1] This is a very difficult argument to follow and it is with diffidence that I propose this explanation. On the Hippocratic theory of pangenesis the resemblance of e.g. the nose of the son to the nose of his father is due to part of the semen being drawn from the father's nose. But suppose an animal to produce a litter of six in consequence of a single impregnation; then it follows that six different 'nose-germs' (or whatever they might be called) have found their way to the six different embryos. How could they be sorted out in this way? They could not, says A., all be kept separate in the semen when emitted by the male (six different bundles each carrying countless germs corresponding to each separate part), because the semen is all discharged in one mass from one and the same part and so is all mixed up together. Nor can they be afterwards sorted out when once in the uterus, because (according to chap. 18) that would be like splitting up a single animal into several.

The latter argument is terribly inconclusive, and I imagine that the pangenesists could have held their own against A. without very great ingenuity being required. Darwin's 'gemmules' certainly suffice.

[2] Or 'principle of motion'.

[3] Reading ἢ ἡ.

[4] See book iv. 771b.

into form, nor too much so as to dry it up; it then generates a number of offspring. But from this first formative semen, if it remains one, and is not divided, only one young one comes into being.

That, then, the female does not contribute semen to generation, but does contribute something, and that this is the matter of the catamenia, or that which is analogous to it in bloodless animals, is clear from what has been said, and also from a general and abstract survey of the question. For there must needs be that which generates and that from which it generates; even if these be one,[1] still they must be distinct in form and their essence must be different; and in those animals that have these powers separate in two sexes the body and nature of the active and the passive sex must also differ. If, then, the male stands for the effective and active, and the female, considered as female, for the passive, it follows that what the female would contribute to the semen of the male would not be semen but material for the semen to work upon. This is just what we find to be the case, for the catamenia have in their nature an affinity to the primitive matter.

So much for the discussion of this question. At the 21
same time the answer to the next question we have to investigate is clear from these considerations, I mean how
729b it is that the male contributes to generation and how it is that the semen from the male is the cause of the offspring. Does it exist in the body of the embryo as a part of it from the first, mingling with the material which comes from the female? Or does the semen communicate nothing to the material body of the embryo but only to the power and movement in it? For this power is that which acts and makes, while that which is made and receives the form is the residue of the secretion in the female.[2] Now the latter alternative appears to be the right one both *a priori* and in view of the facts. For, if we consider the question on general grounds, we find that, whenever one

[1] i. e. if they are united in the same animal.
[2] i. e. as much of the catamenia as is not discharged.

thing is made from two of which one is active and the other passive, the active agent does not exist in that which is made;[1] and, still more generally, the same applies when one thing moves and another is moved; the moving thing does not exist in that which is moved. But the female, as female, is passive, and the male, as male, is active, and the principle of the movement comes from him. Therefore, if we take the highest genera under which they each fall,[2] the one being active and motive and the other passive and moved, that one thing which is produced comes from them only in the sense in which a bed comes into being from the carpenter and the wood, or in which a ball comes into being from the wax and the form. It is plain then that it is not necessary that anything at all should come away from the male, and if anything does come away it does not follow that this gives rise to the embryo as being in the embryo, but only as that which imparts the motion and as the form; so the medical art cures the patient.

This *a priori* argument is confirmed by the facts. For it is for this reason that some males which unite with the female do not, it appears, insert any part of themselves into the female, but on the contrary the female inserts a part of herself into the male; this occurs in some insects.[3] For the effect produced by the semen in the female (in the case of those animals whose males do insert a part) is produced in the case of these insects by the heat[4] and power in the male animal itself when the female inserts that part of herself which receives the secretion. And therefore such animals remain united a long time, and when they are separated the young are produced quickly. For[5] the union lasts until that which is analogous to the semen has done its work,[6] and when they separate the female produces the embryo quickly; for the young is

[1] e.g. a man, the active agent, makes a boat out of wood, the passive material; the man does not exist in the boat as a part of it.

[2] τὰ ἄκρα ἑκατέρων. *Active* and *passive* are wider and more important categories than *male* and *female*.

[3] See on chap. 16.

[4] Reading θερμότης.

[5] Reading συνδεδύασται γάρ.

[6] Lit. 'until it puts together, as the semen.'

imperfect inasmuch as all such creatures give birth to scoleces.

What occurs in birds and oviparous fishes is the greatest proof that neither does the semen come from all parts
730a of the male nor does he emit anything of such a nature as to exist within that which is generated, as part of the material embryo, but that he only makes a living creature by the power which resides in the semen (as we said in the case of those insects whose females insert a part of themselves into the male). For if a hen-bird is in process of producing wind-eggs and is then trodden by the cock before the egg has begun to whiten and while it is all still yellow,[1] then they become fertile instead of being wind-eggs. And if while it is still yellow she be trodden by another cock, the whole brood of chicks turn out like the second cock. Hence some of those who are anxious to rear fine birds act thus; they change the cocks for the first and second treading, not as if they thought that the semen is mingled with the egg or exists in it, or that it comes from all parts of the cock; for if it did it would have come from both cocks, so that the chick would have all its parts doubled. But it is by its force that the semen of the male gives a certain quality to the material and the nutriment in the female, for the second semen added to the first can produce this effect by heat and concoction, as the egg acquires nutriment so long as it is growing.[2]

The same conclusion is to be drawn from the generation of oviparous fishes. When the female has laid her eggs, the male sprinkles the milt over them, and those eggs are fertilized which it reaches, but not the others; this shows that the male does not contribute anything to the quantity but only to the quality of the embryo.

[1] i.e. while the egg consists merely of the yolk in the vitelline membrane, when it first begins its passage through the oviduct. The 'white of egg' is deposited round it as it gets further on in the oviduct.

[2] And this acquired nutriment is benefited by the semen of the second cock.

Of course the chickens can only take after the second cock if the first has failed to fertilize the ova. A. can hardly be mistaken about the habits of Greek breeders, and such people have strange fancies, but it is a very astonishing statement. Cf. *H. A.* vi. 2.

From what has been said it is plain that the semen does not come from the whole of the body of the male in those animals which emit it, and that the contribution of the female to the generative product is not the same as that of the male, but the male contributes the principle of movement and the female the material. This is why the female does not produce offspring by herself, for she needs a principle, i. e. something to begin the movement in the embryo and to define the form it is to assume. Yet in some animals, as birds, the nature of the female unassisted can generate to a certain extent, for they do form something, only it is incomplete; I mean the so-called wind-eggs.

22 For the same reason the development of the embryo takes place in the female; neither the male himself nor the female emits semen into the male,[1] but the female receives within herself the share contributed by both, because in the female is the material from which is made the resulting product. Not only must the mass of material exist there from which the embryo is formed in the first instance, but further material must constantly[2] be added that it may increase in size. Therefore the birth must take place in the female. For the carpenter must keep in close connexion with his timber and the potter with his clay, and generally all workmanship and the ultimate movement imparted to matter must be connected with the material concerned, as, for instance, architecture is *in* the buildings it makes.

From these considerations we may also gather how it is that the male contributes to generation. The male does not emit semen at all in some animals, and where he does this is no part of the resulting embryo; just so no material part comes from the carpenter to the material, i. e. the wood in which he works, nor does any part of the carpenter's art exist within what he makes, but the shape and the form are imparted from him to the material by means of the motion he sets up. It is his hands that move his tools, his

[1] Reading ἀλλ' οὐκ εἰς τὸ ἄρρεν οὔτ' αὐτὸ τὸ ἄρρεν (Didot's ed.)
[2] Reading ἀεὶ τῆς ὕλης.

tools that move[1] the material; it is his knowledge of his art, and his soul, in which is the form,[2] that move his hands or any other part of him with a motion of some definite kind, a motion varying with the varying nature of the object made. In like manner, in the male of those animals which emit semen, Nature[3] uses the semen as a tool and as possessing motion in actuality, just as tools are used in the products of any art, for in them lies in a certain sense the motion of the art. Such, then, is the way in which these males contribute to generation. But when the male does not emit semen, but the female inserts some part of herself into the male, this is parallel to a case in which a man should carry the material to the workman. For by reason of weakness in such males Nature is not able to do anything by any secondary means, but the movements imparted to the material are scarcely strong enough when Nature herself watches over them.[4] Thus here she resembles a modeller in clay rather than a carpenter, for she does not touch the work she is forming by means of tools, but, as it were, with her own hands.[5]

In all animals which can move about, the sexes are 23
separated, one individual being male and one female, though
731a both are the same in species, as with man and horse.[6] But in plants these powers are mingled, female not being separated from male. Wherefore they generate out of themselves, and do not emit semen but produce an embryo, what is called the seed.[7] Empedocles puts this well in the line: 'and thus the tall trees oviposit; first olives . . .' For as the egg is an embryo, a certain part of it giving rise

1 Reading *αἱ δὲ χεῖρες τὰ ὄργανα καὶ τὰ ὄργανα τὴν ὕλην.*

2 For soul is the 'place of forms', containing them potentially (*de Anima*, iii. 4). The carpenter's mind contains the form of the chair, into which form he seeks to bring the material wood.

3 Reading *ἡ φύσις ἐν τῷ ἄρρενι.*

4 This is shown by the length of time required in such copulation.

5 Lit. 'herself with the parts of herself.'

6 Reading *ἄνθρωπος ἢ ἵππος.*

7 An embryo is the 'first mixture of male and female' where the sexes are differentiated. Plants, having no sexes according to A., produce a germ capable of developing without fertilization by any other principle, and thus a sort of embryo ready made.

to the animal and the rest being nutriment, so also from a part of the seed[1] springs the growing plant, and the rest is nutriment for the shoot and the first root.

In a certain sense the same thing[2] happens also in those animals which have the sexes separate. For when there is need for them to generate the sexes are no longer separated any more than in plants, their nature desiring that they shall become one; and this is plain to view when they copulate and are united, that one animal is made out of both.

It is the nature of those creatures which do not emit semen to remain united a long time until the male element has formed the embryo, as with those insects which copulate. The others so remain only until the male has discharged from the parts of himself introduced something which will form the embryo in a longer time, as among the sanguinea. For the former remain paired some part of a day, while the semen forms the embryo in several days. And after emitting this[3] they cease their union.

And animals seem literally to be like divided plants, as though one should separate and divide them, when they bear seed, into the male and female existing in them.

In all this Nature acts like an intelligent workman. For to the essence of plants belongs no other function or business than the production of seed; since, then, this is brought about by the union of male and female, Nature has mixed these and set them together in plants, so that the sexes are not divided in them. Plants, however, have been investigated elsewhere. But the function of the animal is not only to generate (which is common to all living things), but they all of them participate also in a kind of knowledge,[4] some more and some less, and some very little indeed. For they have sense-perception, and this is a kind of knowledge. (If we consider the value of this we find that it is of great importance compared with the class of lifeless objects, but of little compared with the use of the intellect.

[1] Reading *καὶ ἐκ τοῦ σπέρματος μέρους*. Modern botanists talk of the 'egg' of a plant.

[2] Reading *ταὐτό* (AW.)

[3] Qu. *προέμενα*?

[4] *γνώσεως*, lit. 'getting to know.'

For against the latter the mere participation in touch and taste seems to be practically nothing, but beside absolute insensibility it seems most excellent; for it would seem a treasure to gain even this kind of knowledge rather than to lie in a state of death and non-existence.) Now it is by sense-perception that an animal differs from those organisms which have only life. But since, if it is a living animal, it must also live;[1] therefore, when it is necessary for it to accomplish the function of that which has life,[2] it unites and copulates, becoming like a plant, as we said before.

Testaceous animals, being intermediate between animals and plants, perform the function of neither class as belonging to both. As plants they have no sexes, and one does not generate in another; as animals they do not bear fruit from themselves like plants; but they are formed and generated from a liquid and earthy concretion. However, we must speak later of the generation of these animals.[3]

[1] i.e. have the simple vital principle as well as sense.
[2] i.e. to produce seed, as stated above.
[3] iii. 11.

BOOK II

1 THAT the male and female are the principles of generation has been previously stated, as also what is their power and their essence. But why is it that one thing becomes and is male, another female? It is the business of our discussion as it proceeds to try and point out (1) that the sexes arise from Necessity and the first efficient cause, (2) from what sort of material they are formed. That (3) they exist because it is better and on account of the final cause, takes us back to a principle still further remote. 731b

Now (1) some existing things are eternal and divine whilst others admit of both existence and non-existence. But (2) that which is noble and divine is always, in virtue of its own nature, the cause of the better in such things as admit of being better or worse, and what is not eternal does admit of existence and non-existence,[1] and can partake in the better and the worse. And (3) soul is better than body, and the living, having soul, is thereby better than the lifeless which has none, and being is better than not being, living than not living. These, then, are the reasons of the generation of animals. For since it is impossible that such a class of things as animals should be of an eternal nature, therefore that which comes into being is eternal in the only way possible. Now it is impossible for it to be eternal as an individual (though of course the real essence of things is in the individual)—were it such it would be eternal—but it is possible for it as a species.[2] This is why there is

[1] Read *εἶναι καὶ μὴ εἶναι.*

[2] Cf. *de Anima*, ii. 415b 3–7, without which this passage would baffle interpretation. I have corrected Bekker's punctuation. The parenthesis, the explanation of which I owe to Dr. Jackson, is a hit at Plato.

always a class of men and animals and plants.[1] But since the male and female essences are the first principles of these, they will exist in the existing individuals for the sake of generation. Again, as the first efficient or moving cause, to which belong the definition and the form, is better and more divine in its nature than the material on which it works, it is better that the superior principle should be separated from the inferior. Therefore, wherever it is possible and so far as it is possible, the male is separated from the female. For the first principle of the movement, or efficient cause, whereby that which comes into being is male, is better and more divine than the material whereby it is female.[2] The male, however, comes together and mingles with the female for the work of generation, because this is common to both.

A thing lives, then, in virtue of participating in the male and female principles, wherefore even plants have some kind of life; but the class of animals exists in virtue of sense-perception. The sexes are divided in nearly all of these that can move about, for the reasons already stated,[3] and some of them, as said before,[4] emit semen in copulation, others not. The reason of this is that the higher animals are more independent in their nature, so that they have greater size, and this cannot exist without vital heat;[5] for the greater body requires more force to move it, and heat is a motive force. Therefore, taking a general view, we may say that sanguinea are of greater size than bloodless animals, and those which move about than those which remain fixed. And these are just the animals which emit semen on account of their heat and size.

So much for the cause of the existence of the two sexes. Some animals bring to perfection and produce into the world a creature like themselves, as all those which bring their young into the world alive;[6] others produce some-

[1] Not one individual of each species.

[2] I read provisionally *ᾗ τὸ ἄρρεν ὑπάρχει τοῖς γινομένοις ἢ ἡ ὕλη ᾗ τὸ θῆλυ* for *ᾗ ἄρρεν ὑπάρχει τοῖς γινομένοις· ὕλη δὲ τὸ ᾗ θῆλυ*, partly on the suggestion of Mr. Ross.

[3] I do not know where these reasons have been given or what they are.

[4] i. 17.

[5] See Ogle, pp. xxii–xxiv.

[6] The vivipara, including the cartilaginous fishes.

thing undeveloped which has not yet acquired its own form; in this latter division the sanguinea[1] lay eggs, the bloodless animals either lay an egg or give birth to a scolex.[2] The difference between egg and scolex is this: an egg is that from a part of which the young comes into being, the rest being nutriment for it; but the whole of a scolex is developed into the whole of the young animal.[3] Of the vivipara, which bring into the world an animal like themselves, some are internally viviparous (as men, horses, cattle, and of marine animals dolphins and the other cetacea); others first lay eggs within themselves, and only after this are externally viviparous (as the cartilaginous fishes). 732b Among the ovipara some produce the egg in a perfect condition (as birds and all oviparous quadrupeds and footless animals, e.g. lizards and tortoises and most snakes;[4] for the eggs of all these do not increase when once laid). The eggs of others are imperfect; such are those of fishes, crustaceans, and cephalopods, for their eggs increase after being produced.[5]

All the vivipara[6] are sanguineous, and the sanguinea are either viviparous or oviparous, except those which are altogether infertile.[7] Among bloodless animals the insects produce a scolex, alike those that are generated by copulation and those that copulate themselves though not so generated. For there are some insects of this sort, which though they come into being by spontaneous generation are yet male and female; from their union something is produced, only it is imperfect; the reason of this has been previously stated.

[1] Birds and reptiles.

[2] Read *τὰ δ' ἄναιμα ⟨ἢ ᾠοτοκεῖ ἢ⟩ σκωληκοτοκεῖ*, or something of the sort. A. could not have said, or at least could not have meant, that *all* invertebrates produce a scolex; over and over again he speaks of the eggs of crustacea and cephalopoda.

[3] Cf. the modern distinction between meroblastic and holoblastic yolks.

[4] The exception among the snakes is the viper.

[5] The increase in size is however only due to imbibition of water; there is no further development of the egg (AW.).

[6] Omit the words *ἢ ᾠοτοκοῦντα* which are false to fact and to Aristotle himself.

[7] Mules.

These classes admit of much cross-division. Not all bipeds are viviparous (for birds are oviparous), nor are they all oviparous (for man is viviparous), nor are all quadrupeds oviparous (for horses, cattle, and countless others are viviparous), nor are they all viviparous (for lizards, crocodiles, and many others lay eggs). Nor does the presence or absence of feet make the difference between them, for not only are some footless animals viviparous, as vipers and the cartilaginous fishes, while others are oviparous, as the other fishes and serpents, but also among those which have feet many are oviparous and many viviparous, as the quadrupeds above mentioned. And some which have feet, as man, and some which have not, as the whale and dolphin, are internally viviparous. By this character then it is not possible to divide them,[1] nor is any of the locomotive organs the cause of this difference, but it is those animals which are more perfect in their nature and participate in a purer element[2] which are viviparous, for nothing is internally viviparous unless it receive and breathe out air. But the more perfect are those which are hotter in their nature and have more moisture and are not earthy in their composition. And the measure of natural heat is the lung when it has blood in it, for generally those animals which have a lung are hotter than those which have not, and in the former class again those whose lung is not spongy nor solid nor containing only
733a a little blood, but soft and full of blood. And as the animal is perfect but the egg and the scolex are imperfect, so the perfect is naturally produced from the more perfect. If animals are hotter as shown by their possessing a lung[3] but drier in their nature, or are colder but have more

[1] A hit at Plato's 'dichotomy' of animals which *was* based on this character. Aristotle's own test, the condition in which the young are produced, is of course vastly superior, foreshadowing the doctrine that embryology affords the most important evidence of affinities. And he refuses to consider even that as the sole test. Cf. Ogle, p. xxv.

[2] *ἀρχῆς*. The internally viviparous animals, including the cetacea, are air-breathers; the cartilaginous or elasmobranch fishes are only externally viviparous, laying eggs first within themselves.

[3] Lit. 'hotter on account of having a lung', but this means what is said in the text. The business of the lung is to cool, not to heat, according to A.

moisture, then they either lay a perfect egg or are viviparous after laying an egg within themselves. For birds and scaly reptiles because of their heat produce a perfect egg, but because of their dryness it is only an egg; the cartilaginous fishes have less heat than these but more moisture, so that they are intermediate, for they are both oviparous and viviparous within themselves,[1] the former because they are cold, the latter because of their moisture; for moisture is vivifying, whereas dryness is furthest removed from what has life. Since they have neither feathers nor scales such as either reptiles or other fishes have, all which are signs rather of a dry and earthy nature, the egg they produce is soft; for the earthy matter does not come to the surface in their eggs any more than in themselves. This is why they lay eggs in themselves, for if the egg were laid externally it would be destroyed, having no protection.

Animals that are cold and rather dry than moist also lay eggs, but the egg is imperfect; at the same time, because they are of an earthy nature and the egg they produce is imperfect, therefore it has a hard integument that it may be preserved by the protection of the shell-like covering. Hence fishes, because they are scaly, and crustacea, because they are of an earthy nature,[2] lay eggs with a hard integument.

The cephalopods, having themselves bodies of a sticky nature, preserve in the same way the imperfect eggs they lay, for they deposit a quantity of sticky material about the embryo.[3]

All insects produce a scolex. Now all the insects are bloodless, wherefore all creatures that produce a scolex from themselves are so.[4] But we cannot say simply that

[1] From comparison of i. 8 it seems that this should mean 'oviparous internally and viviparous externally'.

[2] *οἱ ἰχθύες* here means what are now called the teleosteans, the vast majority of fish, opposed to the cartilaginous elasmobranchs. The latter have no scales like those of the teleosteans. The crustacea are 'earthy', as shown by their exo-skeletons. But 'the eggs of all teleosteans are soft-shelled' (Günther, *Study of Fishes*, p. 160).

[3] i.e. about their eggs.

[4] Reading *καὶ τὰ σκωληκοτοκοῦντα*.

all bloodless animals produce a scolex, for the classes overlap one another, (1) the insects, (2) the animals that produce a scolex,[1] (3) those that lay their egg imperfect, as the scaly fishes, the crustacea, and the cephalopoda.[2] I say that these form a gradation, for the eggs of these latter resemble a scolex, in that they increase after oviposition, and the scolex of insects again as it develops resembles an egg; how so we shall explain later.[3]

We must observe how rightly Nature orders generation
733b in regular gradation. The more perfect and hotter animals produce their young perfect in respect of quality (in respect of quantity this is so with no animal, for the young always increase in size after birth), and these generate living animals within themselves from the first. The second class do not generate perfect animals within themselves from the first (for they are only viviparous after first laying eggs), but still they are externally viviparous. The third class do not produce a perfect animal, but an egg, and this egg is perfect. Those whose nature is still colder than these produce an egg, but an imperfect one, which is perfected outside the body, as the class of scaly fishes, the crustacea, and the cephalopods. The fifth and coldest class does not even lay an egg from itself;[4] but so far as the young ever attain to this condition at all, it is outside the body of the parent, as has been said already.[5] For

[1] Inserting *καὶ τὰ σκωληκοκοῦντα.*

[2] The classes are (A) vertebrates, (B) invertebrates, (X) laying imperfect eggs, (Y) producing a scolex. All Y are B, but we cannot convert and say all B are Y, because many B are X. The scaly fishes take us up again into another class, being both X and A.

With his usual idea of a graduated scale of Nature in his mind, Aristotle then proceeds to point out how the imperfect egg is a sort of intermediate step between scolex and perfect egg. Nature approximates to the parallel arrangement:

1. Insects.	Scolex.
2. Higher Invertebrates.	Imperfect egg.
3. Lower Vertebrates.	Perfect egg.
4. Higher Vertebrates.	Perfect animal.

But unluckily the overlapping of the classes forbids our making this neat scheme absolute.

[3] iii. 9.

[4] 'From itself', because the scolex *does* later develop into an egg, i.e. the pupa, according to A., but the parent does not lay this pupa *ἐξ αὑτοῦ.*

[5] The reference seems to be to 733a 31. *τοῦ τοιοῦτον* in the Berlin edition is a misprint for *τὸ τοιοῦτον.*

insects produce a scolex first; the scolex after developing becomes egg-like (for the so-called chrysalis or pupa is equivalent to an egg); then from this it is that a perfect animal comes into being, reaching the end of its development in the second change.[1]

Some animals then, as said before, do not come into being from semen, but all the sanguinea do so which are generated by copulation, the male emitting semen into the female; when this has entered into her the young are formed and assume their peculiar character, some within the animals themselves when they are viviparous, others in eggs.[2]

There is a considerable difficulty in understanding how the plant is formed out of the seed or any animal out of the semen.[3] Everything that comes into being or is made must (1) be made out of something, (2) be made by the agency of something, and (3) must become something. Now that out of which it is made is the material; this some animals have in its first form within themselves, taking it from the female parent, as all those which are not born alive but produced as a scolex or an egg;[4] others receive it from the mother for a long time by sucking, as the young of all those which are not only externally but

[1] In the *third* change, literally, according to the Greek way of counting.

[2] I omit the words καὶ σπέρμασι καὶ τοιαύταις ἄλλαις ἀποκρίσεσιν. They are obviously unintelligible when the question is only of vertebrates. Either they are a senseless addition or else something considerable has dropped out before them.

[3] The discussion which follows extorted the admiration of even the malignant Lewes (§§ 457–63). The battle is between 'preformation' and 'epigenesis'; the advocates of the former maintained that the young animal already existed complete in the germ and grew out of it by what was called 'evolution'; the advocates of the latter maintained that the separate parts were added one after another as Aristotle says. Harvey declared for epigenesis, but Haller himself subsequently went wrong. The preformationists were reduced to the absurdity of saying that every germ contained packed away within itself not only one perfect animal but all that animal's descendants as well, and Aristotle finally triumphed all along the line.

The controversy has, however, recently arisen again in a new and very different form (Wilson, *The Cell in Development and Inheritance*, 2nd ed., p. 432).

[4] The egg has in it nourishment derived from the female parent, to wit, the yolk; for the scolex see iii. 758b 36.

also internally viviparous.[1] Such, then, is the material out of which things come into being, but we now are inquiring not out of what the parts of an animal are made, but by what agency. Either it is something external which makes them, or else something existing in the seminal fluid and 734a the semen; and this must either be soul or a part of soul, or something containing soul.[2]

Now it would appear irrational to suppose that any of either the internal organs or the other parts is made by something external, since one thing cannot set up a motion in another without touching it, nor can a thing be affected in any way by another if it does not set up a motion in it. Something then of the sort we require exists in the embryo itself, being either a part of it or separate from it. To suppose that it should be something else separate from it is irrational. For after the animal has been produced does this something perish or does it remain in it? But nothing of the kind appears to be in it, nothing which is not a part of the whole plant or animal. Yet, on the other hand, it is absurd to say that it perishes after making either all the parts or only some of them. If it makes some of the parts and then perishes, what is to make the rest of them? Suppose this something makes the heart and then perishes, and the heart makes another organ, by the same argument either all the parts must perish or all must remain.[3] Therefore it is preserved and does not perish. Therefore it is a part of the embryo itself which exists in the semen from the beginning; and if indeed there is no part of the soul which does not exist in some part of the body, it would also be a part containing soul in it from the beginning.

How, then, does it make the other parts? Either all the parts, as heart, lung, liver, eye, and all the rest, come into being together or in succession, as is said in the verse ascribed to Orpheus, for there he says that an animal

[1] i. e. the mammalia suckle, but the cartilaginous fish do not.

[2] For soul is the form of body, and it is this form which the semen imparts.

[3] For why should not the heart perish in its turn, and so with the rest?

comes into being in the same way as the knitting of a net.[1] That the former is not the fact is plain even to the senses, for some of the parts are clearly visible as already existing in the embryo while others are not; that it is not because of their being too small that they are not visible is clear, for the lung is of greater size than the heart, and yet appears later than the heart in the original development. Since, then, one is earlier and another later, does the one make the other, and does the later part exist on account of the part which is next to it, or rather does the one come into being only *after* the other? I mean, for instance, that it is not the fact that the heart, having come into being first, then makes the liver, and the liver again another organ, but that the liver only comes into being *after* the heart, and not by the agency of the heart, as a man becomes a man *after* being a boy, not by his agency.[2] An explanation of this is that, in all the productions of Nature or of art, what already exists potentially is brought into being only by what exists actually; therefore if one organ formed another the form and the character of the later organ would have to exist in the earlier, e. g. the form of the liver in the heart. And otherwise also the theory is strange and fictitious.

Yet again, if the whole animal or plant is formed from semen or seed, it is impossible that any part of it should exist ready made in the semen or seed, whether that part be able to make the other parts or no. For it is plain that, if it exists in it from the first, it was made by that which made the semen. But semen must be made first, and that 734b
is the function of the generating parent. So, then, it is not possible that any part should exist in it, and therefore it has not within itself that which makes the parts.[3]

[1] This metaphor of the net occurs repeatedly in modern works on the subject.

[2] That is to say that one organ is formed later in time than another, by epigenesis in modern language; A. cannot and does not mean that one organ grows into another as a boy becomes a man, but the illustration is very unluckily and badly chosen, and I trust the words *ὥσπερ μετὰ τὸ παῖς ἀνὴρ γίνεται* may be an interpolation.

[3] If all the parts are made *by* the semen, it is evident that no part can exist *in* it from the first.

But neither can this agent be external,[1] and yet it must needs be one or other of the two. We must try, then, to solve this difficulty, for perhaps some one of the statements made cannot be made without qualification, e. g. the statement that the parts cannot be made by what is external to the semen. For if in a certain sense they cannot, yet in another sense they can. (Now it makes no difference whether we say 'the semen' or 'that from which the semen comes', in so far as the semen has in itself the movement initiated by the other.) It is possible, then, that A should move B, and B move C; that, in fact, the case should be the same as with the automatic machines shown as curiosities. For the parts of such machines while at rest have a sort of potentiality of motion in them, and when any external force puts the first of them in motion, immediately the next is moved[2] in actuality. As, then, in these automatic machines the external force moves the parts in a certain sense (not by touching any part at the moment, but by having touched one previously), in like manner also that from which the semen comes, or in other words that which made the semen, sets up the movement in the embryo and makes the parts of it by having first touched something though not continuing to touch it.[3] In a way it is the innate motion that does this, as the act of building builds the house. Plainly, then, while there is something which makes the parts, this does not exist as a definite object, nor does it exist in the semen at the first as a complete part.

But how is each part formed? We must answer this by starting in the first instance from the principle that, in all

[1] As we proved before.

[2] Lit. 'comes to exist in actuality.'

[3] i. e. the male parent makes the semen and somehow imparts to it a potentiality of setting up movements in the embryo; this power given to the semen is like the impulse given to a piece of clock-work by pushing a wheel. Father = watch-maker, first wheel = semen, other wheels moved by the first = the parts developed by the semen. We cannot solve the riddle any better at the present day; we can only say that no sooner has the spermatozoon penetrated the ovum than there is set up in the latter a series of movements which differentiate it and develop the parts one after another. The whole of this passage sounds amazingly modern; cf. e. g. the language of the Presidential address to the British Association, 1908, *passim*.

products of Nature or art, a thing is made by something actually existing out of that which is potentially such as the finished product. Now the semen is of such a nature, and has in it such a principle of motion, that when the motion is ceasing[1] each of the parts comes into being, and that as a part having life or soul. For there is no such thing as face or flesh without life or soul in it; it is only equivocally that they will be called face or flesh if the life has gone out of them,[2] just as if they had been made of stone or wood. And the homogeneous parts and the organic come into being together. And just as we should not say that an axe or other instrument or organ was made by the fire alone, so neither shall we say that foot or hand were made by heat alone.[3] The same applies also to flesh, for this too has a function. While, then, we may allow that hardness and softness, stickiness and brittleness, and whatever other qualities are found in the parts that have life and soul, may be caused by mere heat and cold, yet, when we come to the principle[4] in virtue of which flesh is flesh and bone is bone, that is no longer so; what makes them is the movement set up by the male parent, who is in actuality what that out of which the offspring is made is in potentiality.[5] This is what we find in the products of art; heat and cold may make the iron soft and hard, but what makes a sword is the movement of the tools 735a
employed, this movement containing the principle of the art. For the art is the starting-point and form of the product; only it exists in something else,[6] whereas the movement of Nature exists in the product itself, issuing from another nature[7] which has the form in actuality.

Has the semen soul, or not? The same argument applies

[1] παυομένης, but is the text sound? Qu. λυομένης, 'when the motion is resolving'; cf. iv. 3 *passim*, where the 'motions' which cause resemblance to a parent are said to be often 'resolved' into other motions causing resemblance to grandparents, &c.

[2] Lit. 'being spoilt', φθαρέντα. The essence of e.g. a hand is to grasp; a dead hand or a stone hand cannot grasp, and therefore is not a hand at all, strictly speaking, though still called a hand.

[3] As certain early philosophers asserted.

[4] λόγος.

[5] Omitting ἢ after δυνάμει.

[6] i.e. in the mind of the artist, and that potentially.

[7] i.e. the parent.

here as in the question concerning the parts. As no part, if it participate not in soul, will be a part except in an equivocal sense (as the eye of a dead man is still called an 'eye'), so no soul will exist in anything except that of which it is soul; it is plain therefore that semen both has soul, and is soul, potentially.[1]

But a thing existing potentially may be nearer or further from its realization in actuality, as e. g. a mathematician when asleep is further from his realization in actuality as engaged in mathematics than when he is awake, and when awake again but not studying mathematics he is further removed than when he is so studying. Accordingly it is not any part that is the cause of the soul's coming into being, but it is the first moving cause from outside. (For nothing generates itself, though when it has come into being it thenceforward increases itself.) Hence it is that only one part comes into being first and not all of them together. But that must first come into being which has a principle of increase (for this nutritive power exists in all alike, whether animals or plants, and this is the same as the power that enables an animal or plant to generate another like itself, that being the function of them all if naturally perfect). And this is necessary for the reason that whenever a living thing is produced it must grow. It is produced, then, by something else of the same name, as e.g. man is produced by man, but it is increased by means of itself. There is, then, something which increases it.[2] If this is a single part,[3] this must come into being first.[4] Therefore if the heart is first made in some animals, and what is analogous to the heart in the others which

[1] The argument is this. Every part being alive must have soul, and all the parts are formed by the semen, and that in a living state. The life or soul imparted to them must therefore come from the semen. But that soul cannot exist *in* the semen unless it is the soul *of* the semen, for 'no soul can exist in anything of which it is not the soul'. ∴ the semen has soul, at least potentially. It is not itself *actually* possessed of soul, because it is not a living animal. Modern science of course says that the spermatozoa in the semen *are* living matter.

[2] And that something must be within it. Reading ἔστιν ἄρα ὃ αὔξει.

[3] Omitting πρῶτον.

[4] And conversely that which comes into being first must be able to increase the embryo.

have no heart, it is from this or its analogue that the first principle of movement would arise.

We have thus discussed the difficulties previously raised on the question what is the efficient cause of generation in each case, as the first moving and formative power.

2 The next question to be mooted concerns the nature of semen. For whereas when it issues from the animal it is thick and white, yet on cooling it becomes liquid as water, and its colour is that of water. This would appear strange, for water is not thickened by heat; yet semen is thick when it issues from within the animal's body which is hot, and becomes liquid on cooling. Again, watery fluids freeze, but semen, if exposed in frosts to the open air, does not freeze but liquefies, as if it was thickened by the opposite of cold. Yet it is unreasonable, again, to suppose that it is thickened by heat. For it is only substances having a predominance of earth in their composition that 735b
coagulate and thicken on boiling, e. g. milk. It ought then to solidify on cooling, but as a matter of fact it does not become solid in any part but the whole of it goes like water.

This then is the difficulty. If it is water, water evidently does not thicken through heat, whereas the semen is thick and both it and the body whence it issues are hot. If it is made of earth or a mixture of earth and water, it ought not to liquefy entirely and turn to water.

Perhaps, however, we have not discriminated all the possibilities. It is not only the liquids composed of water and earthy matter that thicken, but also those composed of water and air; foam, for instance, becomes thicker and white, and the smaller and less visible the bubbles in it, the whiter and firmer does the mass appear. The same thing happens also with oil; on mixing with air it thickens, wherefore that which is whitening becomes thicker, the watery part in it being separated off by the heat and turning to air.[1] And if oxide of lead is mixed with water or even

[1] From this passage it appears that the Greeks made their oil whiter by heating it; at least A. states the fact as if that was their

with oil, the mass increases greatly and changes from liquid and dark to firm and white, the reason being that air is mixed in with it which increases the mass and makes the white shine through, as in foam and snow (for snow is foam).[1] And water itself on mingling with oil becomes thick and white, because air is entangled in it by the act of pounding them together, and oil itself has much air in it (for shininess is a property of air, not of earth or water). This too is why it floats on the surface of the water, for the air contained in it as in a vessel bears it up and makes it float, being the cause of its lightness. So too oil is thickened without freezing in cold weather and frosts[2]; it does not freeze because of its heat (for the air is hot and will not freeze), but because the air is forced together and compressed, as . . .,[3] by the cold, the oil becomes thicker. These are the reasons why semen is firm and white when it issues from within the animal; it has a quantity of hot air in it because of the internal heat; afterwards, when the heat has evaporated and the air has cooled, it turns liquid and dark; for the water, and any small quantity of earthy matter there may be, remain in semen as it dries, as they do in phlegm.

736a Semen, then, is a compound of spirit (πνεῦμα) and water, and the former is hot air (ἀήρ); hence semen is liquid in its nature because it is made of water. What Ctesias the Cnidian has asserted of the semen of elephants is manifestly untrue; he says that it hardens so much in drying

object. Sir W. Ramsay tells me that oil is whitened by exposure to sunlight and air being blown through it, and that the same effect would follow from simple exposure to sunlight, but would take longer owing to the slowness of oxidation.

[1] AW. deny this flatly, but A. is perfectly right. Snow is white, the chemists tell me, because it is mixed with air; indeed Professor Collie says: 'Snow *is* frozen foam.' The first chapter of the περὶ Χρωμάτων shows that μέλαν may include any dark colour, and that λευκόν means *transparent* as well as *white*. 'Air is naturally white,' and this 'shines through' when air is mixed with water, &c., but A. seems to confound the two notions.

[2] 'Olive-oil coagulates some seven degrees *above* the freezing-point of water, fish-oil remains fluid at a temperature considerably below' this. Ogle on *de Partibus*, ii. 648b 32. A. seems, then, to be here thinking of the latter.

[3] The MSS. variations seem to point to some loss after ὥσπερ (which is bracketed by AW., though they mark a lacuna in their translation).

that it becomes like amber.[1] But this does not happen, though it is true that one semen must be more earthy than another, and especially so with animals that have much earthy matter in them because of the bulk of their bodies. And it is thick and white because it is mixed with spirit, for it is also an invariable rule that it is white, and Herodotus does not report the truth when he says that the semen of the Aethiopians is black, as if everything must needs be black in those who have a black skin, and that too when he saw their teeth were white. The reason of the whiteness of semen is that it is a foam, and foam is white, especially that which is composed of the smallest parts, small in the sense that each bubble is invisible, which is what happens when water and oil are mixed and shaken together, as said before. (Even the ancients seem to have noticed that semen is of the nature of foam; at least it was from this they named the goddess who presides over union.[2])

This then is the explanation of the problem proposed, and it is plain too that this is why semen does not freeze; for air will not freeze.

3 The next question to raise and to answer is this. If, in the case of those animals which emit semen into the female, that which enters makes no part of the resulting embryo, where is the material part of it diverted if (as we have seen) it acts by means of the power residing in it? It is not only necessary to decide whether what is forming in the female receives anything material, or not, from that which has entered her, but also concerning the soul in virtue of which an animal is so called (and this is in virtue of the sensitive part of the soul)—does this exist originally in the semen and in the unfertilized embryo[3] or not, and if it does whence does it come? For[4] nobody would put down

[1] Ambergris *is* an internal product of a huge animal, the sperm-whale; can this be at the bottom of the statement of Ctesias?

[2] Aphrodite, the foam-born! Cf. Galen, vol. iv, p. 531.

[3] κύημα throughout this passage must mean the unfertilized embryo or germ, not as usual the 'first mixture of male and female'.

[4] The connexion of thought is: 'I raise this question about the

the unfertilized embryo as soulless or in every sense bereft of life (since both the semen and the embryo of an animal have every bit as much life as a plant), and it is productive up to a certain point.[1] That then they possess the nutritive soul is plain (and plain is it from the discussions elsewhere
736b about soul why this soul must be acquired first[2]). As they develop they also acquire the sensitive soul in virtue of which an animal is an animal. For[3] e.g. an animal does not become at the same time an animal and a man or a horse or any other particular animal. For the end is developed last, and the peculiar character of the species is the end of the generation in each individual.[4] Hence arises a question of the greatest difficulty, which we must strive to solve to the best of our ability and as far as possible. When and how and whence is a share in reason acquired by those animals that participate in this principle? It is plain that the semen and the unfertilized embryo, while still separate from each other, must be assumed to have the nutritive soul potentially, but not actually, except that (like those unfertilized embryos that are separated from the mother) it absorbs nourishment and performs the function of the nutritive soul.[5] For at first all such embryos seem to live the life of a plant. And it is clear that we must be guided by this in speaking of the sensitive and the rational

sensitive soul because the *vegetative* (or nutritive) is certainly in the embryo even before impregnation. For, &c.'

[1] Referring to wind-eggs of fowls.

[2] *de Anima*, ii. 4.

[3] The connexion of thought is: 'This is in accordance with the law of development, the more general appearing first, the particular later. For, &c.'

[4] This passage states clearly the famous law generally attributed to von Baer, the law that in development the character, e.g., of the class, is assumed before that of the genus, of the genus before that of the species. Aristotle's example may be otherwise stated thus: the embryo assumes the character which marks it out as an animal, not a plant, before it assumes the character which marks it out as a man or horse, not some other animal. And therefore it must acquire the sensitive soul before it is specialized as a member of a sub-kingdom of animals.

[5] Read *ὄντα χωριστά* for *τὰ χωριστά*, and *πλὴν εἰ* for *πρὶν ἢ* (*πλὴν ἢ* seems not to be used by A.). The parenthesis refers to wind-eggs, the only 'unfertilized embryos' which are 'separated from the mother' (or laid as eggs), within Aristotle's cognizance, by animals possessing distinction of sex. This is the best I can make of this excessively difficult passage.

soul. For all three kinds of soul, not only the nutritive, must be possessed potentially before they are possessed in actuality. And it is necessary either (1) that they should all come into being in the embryo without existing previously outside it, or (2) that they should all exist previously, or (3) that some should so exist and others not. Again, it is necessary that they should either (1) come into being in the material supplied by the female without entering with the semen of the male, or (2) come from the male and be imparted to the material in the female. If the latter, then either all of them, or none, or some must come into being in the male from outside.

Now that it is impossible for them all to pre-exist is clear from this consideration. Plainly those principles whose activity is bodily cannot exist without a body, e.g. walking cannot exist without feet. For the same reason also they cannot enter from outside. For neither is it possible for them to enter by themselves, being inseparable from a body, nor yet in a body, for the semen is only a secretion of the nutriment in process of change.[1] It remains, then,[2] for the reason alone so to enter and alone to be divine, for no bodily activity has any connexion with the activity of reason.[3]

Now it is true that the faculty of all kinds of soul seems to have a connexion with a matter different from and more divine than the so-called elements; but as one soul differs from another in honour and dishonour, so differs also the nature of the corresponding matter. All have in their semen that which causes it to be productive; I mean what is called vital heat. This is not fire nor any such force, but it is the spiritus included in the semen and the foam-like,[4] and the natural principle in the spiritus, being analogous to the element of the stars.[5] Hence, whereas fire generates 737a
no animal and we do not find any living thing forming in either solids or liquids under the influence of fire, the heat

[1] Therefore the nutritive and sensitive souls, which require bodily organs, do not enter from outside. [2] Read δή for δέ.

[3] The function of the brain being to cool the blood.

[4] For this spiritus is found in all water or liquid matter; see iii. 11.

[5] The ether, or fifth element, in which the stars move.

of the sun and that of animals does generate them. Not only is this true of the heat that works through the semen, but whatever other residuum of the animal nature there may be, this also has still a vital principle in it.[1] From such considerations it is clear that the heat in animals neither is fire nor derives its origin from fire.[2]

Let us return to the material of the semen, in and with which comes away from the male the spiritus[3] conveying the principle of soul. Of this principle there are two kinds; the one is not connected with matter, and belongs to those animals in which is included something[4] divine (to wit, what is called the reason), while the other is inseparable from matter. This material[5] of the semen dissolves and evaporates because it has a liquid and watery nature. Therefore we ought not to expect it always to come out again from the female or to form any part of the embryo that has taken shape from it; the case resembles that of the fig-juice which curdles milk, for this too changes without becoming any part of the curdling masses.

It has been settled, then, in what sense the embryo and the semen have soul, and in what sense they have not; they have it potentially but not actually.[6]

Now semen is a secretion and is moved with the same movement as that in virtue of which the body increases (this increase being due to subdivision of the nutriment in its last stage). When it has entered the uterus it puts into form the corresponding secretion of the female and moves it with the same movement wherewith it is moved itself. For the female's contribution also is a secretion, and has all the

[1] This appears e.g. from the generation of worms in manure heaps.

[2] There seems to be here a considerable lacuna. We know now that *all* three kinds of soul have vital heat, and we expect to hear of some higher material element corresponding to the higher kinds of soul. For the rest, we have now settled, more or less, how the three kinds of soul arise in the embryo, and we return abruptly to the question raised in the first words of the chapter: what happens to the material part of the semen?

On the development of the soul, compare the most masterly *résumé* of this discussion in Dante, *Purgatorio*, xxv.

[3] I read *πνεῦμα* for *σπέρμα*.

[4] Reading *τι*. The animals are man and perhaps bees (iv. 10, *ad fin.*).

[5] Reading *σῶμα* for *σπέρμα* (AW.).

[6] This sentence is misplaced, but one cannot say where it should go.

parts in it potentially though none of them actually; it has in it potentially even those parts which differentiate the female from the male, for just as the young of mutilated parents are sometimes born mutilated and sometimes not, so also the young born of a female are sometimes female and sometimes male instead. For the female is, as it were, a mutilated male, and the catamenia are semen, only not pure[1]; for there is only one thing they have not in them, the principle of soul. For this reason, whenever a wind-egg is produced by any animal, the egg so forming has in it the parts of both sexes potentially, but has not the principle in question, so that it does not develop into a living creature, for this is introduced by the semen of the male. When such a principle has been imparted to the secretion of the female it becomes an embryo.

Liquid but corporeal substances become surrounded by some kind of covering on heating, like the solid scum which forms on boiled foods when cooling. All bodies are held 737b
together by the glutinous; this quality, as the embryo develops and increases in size, is acquired by the sinewy substance, which holds together the parts of animals, being actual sinew in some and its analogue in others. To the same class belong also skin, blood-vessels, membranes, and the like, for these differ in being more or less glutinous and generally in excess and deficiency.[2]

4 In those animals whose nature is comparatively imperfect, when a perfect embryo (which, however, is not yet a perfect animal) has been formed, it is cast out from the mother, for reasons previously stated.[3] An embryo is then complete when it is either male or female,[4] in the case

[1] See i. 20.

[2] This paragraph is obviously misplaced, but there is no other place in *G. A.* to which it belongs (AW.).

[3] Chap. I of this book.

[4] From recent researches it appears that 'the male or female character is already fully developed in the fertilized egg' from the very beginning (Lock, *Variation, Heredity, and Evolution*, p. 259). 'Sex is predetermined in the fertilized ovum' (Poulton, *Essays on Evolution*, p. 133). Indeed it is probable that both ova and spermatozoa are themselves both male and female, at least in the higher animals. For

of those animals who possess this distinction, for some (i. e. all those which are not themselves produced from a male or female parent nor from a union of the two) produce an offspring which is neither male nor female. Of the generation of these we shall speak later.

The perfect animals, those internally viviparous, keep the developing embryo within themselves and in close connexion until they give birth to a complete animal and bring it to light.

A third class is externally viviparous but first internally oviparous; they develop the egg into a perfect condition, and then in some cases the egg is set free as with creatures externally oviparous, and the animal is produced from the egg within the mother's body; in other cases, when the nutriment from the egg is consumed, development is completed by connexion with the uterus, and therefore the egg is not set free from the uterus. This character marks the cartilaginous fish, of which we must speak later by themselves.[1]

Here we must make our first start from the first class; these are the perfect or viviparous animals, and of these the first is man. Now the secretion of the semen takes place in all of them just as does that of any other residual matter. For each is conveyed to its proper place without any force from the breath or compulsion of any other cause, as some assert, saying that the generative parts attract the semen like cupping-glasses, aided by the force of the breath, as if it were possible for either this secretion or [2] the residue of the solid and liquid nutriment to go anywhere else than they do without the exertion of such a force. Their reason is that the discharge of both is attended by holding the breath, but this is a common feature of all cases when it is necessary to move anything,
738a because strength arises through holding the breath. Why, even without this force the secretions or excretions are discharged in sleep if the parts concerned are full of them

evidence, however, against this in some lower animals see e. g. Wilson, *The Cell in Development and Inheritance* ^{2}, p. 144.

[1] iii. 3.

[2] Reading ἢ ταύτην . . . . ἢ τήν.

and are relaxed. One might as well say that it is by the breath that the seeds of plants are always segregated to the places where they are wont to bear fruit. No, the real cause, as has been stated already, is that there are special parts for receiving all the secretions, alike the useless (as the residues of the liquid and solid nutriment), and the blood, which has the so-called blood-vessels.

To consider now the region of the uterus in the female—the two blood-vessels, the great vessel and the aorta, divide higher up, and many fine vessels from them terminate in the uterus.[1] These become over-filled from the nourishment they convey, nor is the female nature able to concoct it, because it is colder than man's; so the blood is excreted through very fine vessels into the uterus,[2] these being unable on account of their narrowness to receive the excessive quantity, and the result is a sort of haemorrhage. The period is not accurately defined in women, but tends to return during the waning of the moon.[3] This we should expect, for the bodies of animals are colder when the environment happens to become so,[4] and the time of change from one month to another is cold because of the absence of the moon, whence also it results that this time is stormier than the middle of the month. When then the residue of the nourishment has changed into blood, the catamenia tend to occur at the above-mentioned period, but when it is not concocted a little matter at a time is always coming away, and this is why 'whites' appear in

[1] By the great vessel A. means the *vena cava* and the whole venous system, by the aorta he means the aorta and the whole arterial system. He does not distinguish between their functions, holding that both alike nourish the body by carrying the blood to all parts of it. The fine vessels are the smallest veins and arteries visible to the naked eye, *not* the capillaries, which were unknown even to Harvey.

[2] This was the theory of Coste, that 'the blood transudes through the capillaries'. But the precise nature of the process seems to be still uncertain; see Playfair, *Midwifery*[6], vol. i, p. 74.

[3] This of course is quite untrue, but the notion that the moon has something to do with it has been renewed in modern times. 'Dr. Mead was, I fancy, disposed to be a little merry, when he gravely ascribed the tides and the catamenia equally to the influence of the moon' (Blundell, *Midwifery*, 1840, p. 632). Yet probably there really is a connexion between them; see Darwin, *Descent of Man*, chap. vi, note 32. *Life of Huxley*, vol. i, p. 359.

[4] This again is untrue of the temperature of warm-blooded animals.

females while still small, in fact mere children. If both these discharges of the secretions are moderate, the body remains in good health, for they act as a purification of the secretions which are the causes of a morbid state of body; if they do not occur at all or if they are excessive, they are injurious, either causing illness or pulling down the patient; hence whites, if continuous and excessive, prevent girls from growing. This secretion then is necessarily discharged by females for the reasons given; for, the female nature being unable to concoct the nourishment thoroughly, there must not only be left a residue of the useless nutriment, but also there must be a residue in the blood-vessels, and this filling[1] the channels of the finest vessels must
738b overflow. Then Nature, aiming at the best and the end, uses it up in this place[2] for the sake of generation, that another creature may come into being of the same kind as the former was going to be, for the menstrual blood is already potentially such as the body from which it is discharged.

In all females, then, there must necessarily be such a secretion, more indeed in those that have blood and of these most of all in man, but in the others also some matter must be collected in the uterine region. The reason why there is more in those that have blood and most in man has been already given, but why, if all females have such a secretion, have not all males one to correspond? For some of them do not emit semen but, just as those which do emit it[3] fashion by the movement in the semen the mass forming from the material supplied by the female, so do the animals in question bring the same to pass and exert the same formative power by the movement[4] within themselves in that part from whence the semen is secreted.[5] This is the region about the diaphragm in all those animals which have one,[6] for the heart or its analogue is the first principle of a natural body, while the lower part is a mere

[1] Reading πληθύοντα. [2] The uterus.
[3] Reading προϊέμενα. [4] Omitting ἐν (AW.).
[5] The reference is to certain insects; see i. 16.
[6] Or the corresponding region in those which have not.

addition for the sake of it.[1] Now the reason why it is not all males that have a generative secretion, while all females do, is that the animal is a body with soul or life; the female always provides the material, the male that which fashions it, for this is the power that we say they each possess, and this is what is meant by calling them male and female. Thus while it is necessary for the female to provide a body and a material mass, it is not necessary for the male, because it is not within the work of art or the embryo that the tools or the maker must exist. While the body is from the female, it is the soul that is from the male,[2] for the soul is the reality of a particular body.[3] For this reason if animals of a different kind are crossed (and this is possible when the periods of gestation are equal and conception takes place nearly at the same season and there is no great difference in the size of the animals), the first cross has a common resemblance to both parents, as the hybrid between fox and dog, partridge and domestic fowl, but as time goes on and one generation springs from another, the final result resembles the female in form, just as foreign seeds produce plants varying in accordance with the country in which they are sown.[4] For it is the soil that gives to the seeds the material and the body of the plant. And hence the part of the female which receives the semen is not a mere passage, but the uterus has a considerable

[1] The truth is the other way about in the order of evolution, for some of the lowest animals have a digestive canal without a heart, but from A.'s point of view the heart as the seat of life is the end to which everything else is subordinate; besides it is visible to the eye before the canal in the embryo of higher animals.

[2] And it is this which gives reality to the body.

[3] A body which is not alive is not strictly speaking a body at all, any more than a statue is really one. Hence soul makes a body really to be one in the strict sense.

[4] e. g. if seed of a mountain plant is sown in a fertile plain it will grow more luxuriantly. Despite AW. the astonishing statements about dog and fox, partridge and fowl are totally wrong; the experiments of Flourens, to which they refer, only show that if you cross two species and keep on crossing the hybrids with *one of the two original species* the result will in a few generations be indistinguishable from it.

A. thought that the Laconian hounds were descended from a cross between dog and fox.

width, whereas the males that emit semen have only passages for this purpose, and these are bloodless.[1]

Each of the secretions becomes such at the moment when it is in its proper place; before that there is nothing of the sort unless with much violence and contrary to nature.[2]

We have thus stated the reason for which the generative secretions are formed in animals. But when the semen from the male (in those animals which emit semen) has entered, it puts into form the purest part of the female secretion (for the greater part of the catamenia also is useless and fluid, as is the most fluid part of the male secretion, i. e. in a single emission, the earlier discharge being in most cases apt to be infertile rather than the later, having less vital heat through want of concoction, whereas that which is concocted is thick and of a more material nature).

If there is no external discharge, either in women or other animals, on account of there not being much useless and superfluous matter in the secretion, then the quantity forming within the female altogether is as much as what is retained within those animals which have an external discharge; this is put into form by the power of the male residing in the semen secreted by him, or, as is clearly seen to happen in some insects, by the part in the female analogous to the uterus being inserted into the male.

It has been previously stated that the discharge accompanying sexual pleasure in the female contributes nothing to the embryo. The chief argument for the opposite view is that what are called bad dreams occur by night with women as with men; but this is no proof, for the same thing happens to young men also who do not yet emit semen, and to those who do emit semen but whose semen is infertile.

It is impossible to conceive without the emission of the

[1] See i. 6, *ad fin.* Stress is laid upon the bloodlessness of the ducts because this contrasts with the material of the female.

[2] e. g. the blood remains blood so long as it is in the blood-vessels, but when it enters the testes semen is secreted from it, and not before this.

male in union and without the secretion of the corresponding female material, whether it be discharged externally or whether there is only enough within the body. Women conceive, however, without experiencing the pleasure usual in such intercourse, if the part chance to be in heat and the uterus to have descended.[1] But generally speaking the opposite is the case, because the os uteri is not closed when the discharge takes place which is usually accompanied by pleasure in women as well as men, and when this is so there is a readier way for the semen of the male to be drawn into the uterus.

The actual discharge does not take place within the uterus as some think, the os uteri being too narrow, but it is in the region in front of this, where the female discharges the moisture found in some cases, that the male 739b
emits the semen.[2] Sometimes it remains in this place;[3] at other times, if the uterus chance to be conveniently placed and hot on account of the purgation of the catamenia, it draws it within itself. A proof of this is that pessaries,[4] though wet when applied, are removed dry. Moreover, in all those animals which have the uterus near the hypozoma, as birds and viviparous fishes, it is impossible that the semen should be so discharged as to enter it; it must be drawn into it.[5] This region, on account of the heat which is in it, attracts the semen. The discharge and collection of the catamenia also excite heat in this part. Hence it acts like cone-shaped vessels which, when they have been washed out with hot water, their mouth being turned downwards, draw water into themselves.[6] And this is the way things are drawn up,

[1] 'The idea', says Dr. Blacker, 'that the uterus descends is not proved, but probably some kind of movement takes place during coitus.'

[2] Omitting *ἐάν τις ἐξικμάσῃ* (AW.)

[3] I read *ἔχον* with one MS. and *τόπον* for *τρόπον* by conjecture.

[4] Reading *πρόσθετα*.

[5] It must be remembered that A. calls the ovarian passage of birds and fishes 'uterus'. 'The semen is probably carried upwards chiefly by the inherent mobility of the spermatozoa' (Playfair, *Midwifery*[6], vol. i, p. 85).

[6] For *τὰ ἀκόνιτα* I read *τὰ κωνικά* (cf. *κωνίς*). If a bottle be heated and the neck thrust into water, as the air in the bottle cools a vacuum will be formed and some water drawn up into the neck.

but some say that nothing of the kind happens with the organic parts concerned in copulation. Precisely the opposite is the case of those who say the woman emits semen as well as the man, for if she emits it outside the uterus this must then draw it back again into itself if it is to be mixed with the semen of the male. But this is a superfluous proceeding, and Nature does nothing superfluous.

When the material secreted by the female in the uterus has been fixed by the semen of the male (this acts in the same way as rennet acts upon milk, for rennet is a kind of milk containing vital heat, which brings into one mass and fixes the similar material, and the relation of the semen to the catamenia is the same,[1] milk and the catamenia being of the same nature)[2]—when, I say,[3] the more solid part[4] comes together, the liquid is separated off from it, and as the earthy parts solidify membranes form all round it; this is both a necessary result and for a final cause, the former because the surface of a mass must solidify on heating as well as on cooling,[5] the latter because the foetus must not be in a liquid but be separated from it.[6] Some of these are called membranes and others choria, the difference being one of more or less, and they exist in ovipara and vivipara alike.[7]

When the embryo is once formed, it acts like the seeds of plants. For seeds also contain the first principle of

[1] Reading *ταὐτό*.

[2] Because both are secretions of the nutriment in a late stage of its transformations.

[3] Reading *δή* (AW.)

[4] *τοῦ σωματώδους*.

[5] Cf. Hippocrates, vol. i, p. 385, where the formation of the membrane is compared to the crust on bread. *ξηραίνεσθαι* is rather *solidify* than *dry*.

[6] This is an unlucky speculation, for the first membrane which forms round the embryo, what is called the 'amnion', is filled with 'amniotic fluid'. In the chick this fluid appears on the fifth day of incubation, and A. may have been misled by examining embryos in an earlier stage.

[7] 'The difference, &c.', i. e. the choria are thicker than the other membranes. A comparison of *H. A.* vi. 3, shows pretty clearly that by the 'chorion of the ovipara' A. means the allantois, and as this does actually unite with the chorion in mammalia he is quite accurate enough.

growth in themselves, and when this (which previously exists in them only potentially) has been differentiated, the shoot and the root are sent off from it, and it is by the root that the plant gets nourishment; for it needs 740a growth. So also in the embryo all the parts exist potentially in a way at the same time, but the first principle is furthest on the road to realization. Therefore the heart is first differentiated in actuality. This is clear not only to the senses (for it is so) but also on theoretical grounds.[1] For whenever the young animal has been separated from both parents it must be able to manage itself, like a son who has set up house away from his father. Hence it must have a first principle from which comes the ordering of the body at a later stage also,[2] for if it is to come in from outside at a later period to dwell in it, not only may the question be asked at what time it is to do so, but also we may object that, when each of the parts is separating from the rest, it is necessary that this principle should exist first from which comes growth and movement to the other parts. (Wherefore all who say, as did Democritus, that the external parts of animals are first differentiated and the internal later, are much mistaken; it is as if they were talking of animals of stone or wood. For such as these have no principle of growth at all, but all animals have, and have it within themselves.) Therefore it is that the heart appears first distinctly marked off in all the sanguinea, for this is the first principle or origin of both homogeneous and heterogeneous parts, since from the moment that the animal or organism needs nourishment, from that moment does this deserve to be called its principle or origin. For the animal[3] grows, and the nutriment, in its final stage, of an animal is the blood or its analogue, and of this the blood-vessels are the receptacle,

[1] The heart may be the organ first visible to the naked eye, and A. himself so observed it (*de Iuv.* 3), but the microscope shows that the vertebral column really begins to develop earlier. In theory, however, it ought not to do so, for it was certainly evolved later in the history of the vertebrates.

[2] And this principle must be in the embryo before separation from the mother.

[3] Reading *ζῷον*.

wherefore the heart is the principle or origin of these also. (This is clear from the *Enquiries*[1] and the anatomical drawings.)

Since the embryo is already potentially an animal but an imperfect one, it must obtain its nourishment from elsewhere; accordingly it makes use of the uterus and the mother, as a plant does of the earth, to get nourishment, until it is perfected to the point of being now an animal potentially locomotive. So Nature has first designed the two blood-vessels from the heart, and from these smaller vessels branch off to the uterus.[2] These are what is called the umbilicus, for this is a blood-vessel, consisting of one or more vessels in different animals.[3] Round these is a skin-like integument,[4] because the weakness of the vessels needs protection and shelter. The vessels join on to the uterus like the roots of plants, and through them the embryo receives its nourishment. This is why the animal remains in the uterus, not, as Democritus says, that the parts of the embryo may be moulded in conformity with
740b those of the mother. This is plain in the ovipara, for they have their parts differentiated in the egg after separation from the matrix.

Here a difficulty may be raised. If the blood is the nourishment, and if the heart, which first comes into being, already contains blood,[5] and the nourishment comes from outside, whence did the first nourishment[6] enter? Perhaps

[1] *H. A.* iii. 3. The argument here is very obscurely stated and should rather run thus :—

The heart is the ἀρχή of the blood-vessels.

These vessels carry blood through the body.

The parts are nourished by the blood, and the animal grows because of this.

∴ the heart is the first cause of the growth of the animal and the formation of the parts.

∴ the heart must itself come into being first.

[2] The description shows that a comparatively late stage of growth is here in question, when the allanto-chorion is already united to the wall of the uterus. The two vessels from the heart accordingly can hardly mean anything but the circulatory system of the umbilical vesicle (corresponding to the yolk-sac in birds), and of the united allantois and placenta. Cf. *H. A.* vi. 561b 5–10, where the two φλέβες are certainly the vessels of the yolk-sac and allantois.

[3] See note on 745b 27.

[4] Omitting ὁ καλούμενος ὀμφαλός.

[5] Omitting τὸ δ' αἷμα τροφή (AW.)

[6] i.e. the blood in the heart.

it is not true that *all* of it comes from outside. Just as in the seeds of plants there is something of this nature,[1] the substance which at first appears milky,[2] so also in the material of the animal embryo the superfluous matter of which it is formed [3] is its nourishment from the first.

The embryo, then, grows by means of the umbilicus in the same way as a plant by its root, or as animals themselves when separated from the nutriment within the mother,[4] of which we must speak later at the time appropriate for discussing them. But the parts are not differentiated, as some suppose, because like is naturally carried to like.[5] Besides many other difficulties involved in this theory, it results from it that the homogeneous parts ought to come into being each one separate from the rest, as bones and sinews by themselves, and flesh by itself, if one should accept this cause. The real cause why each of them comes into being is that the secretion of the female is potentially such as the animal is naturally, and all the parts are potentially present in it, but none actually. It is also because when the active and the passive come in contact with each other in that way in which the one is active and the other passive (I mean in the right manner, in the right place, and at the right time), straightway the one acts and the other is acted upon. The female, then, provides matter, the male the principle of motion.[6] And as the products of art are made by means of the tools of the artist, or to put it more truly by means of their movement, and this is the activity of the art, and the art is the form of what is made in something else, so is it with the power of the nutritive soul. As later on in the case of mature animals and plants this soul causes growth from the nutriment, using heat and cold as its tools (for in these

[1] i. e. nutritive.
[2] The cotyledons, e. g. the white substance in the bean.
[3] i. e. that part of the matter which is superfluous in the sense that it is not used up in making the animal.
[4] Lit. 'within themselves'. *ἐν αὑτοῖς* is probably corrupt. It seems impossible to explain the words here by connexion with the previous paragraph. Qu. *ἐν ταῖς ὑστέραις* or the like?
[5] See Hippocrates, vol. i, p. 390.
[6] And the former is passive, the latter active.

is the movement of the soul), and each thing comes into being in accordance with a certain formula, so also from the beginning does it form the product of nature.[1] For the material by which this latter grows is the same as that from which it is constituted at first; consequently also the power which acts upon it is identical with that which originally generated it;[2] if then this acting power is the nutritive soul, this is also the generative soul, and this is
741a the nature of every organism, existing in all animals and plants. [But the other parts of the soul exist in some animals, not in others.[3]] In plants, then, the female is not separated from the male, but in those animals in which it is separated the male needs the female besides.[4]

And yet the question may be raised why it is that, if **5**
indeed the female possesses the same soul and if it is the secretion of the female which is the material of the embryo, she needs the male besides instead of generating entirely from herself. The reason is that the animal differs from the plant by having sense-perception; if the sensitive soul is not present, either actually or potentially, and either with or without qualification, it is impossible for face, hand, flesh, or any other part to exist; it will be no better than a corpse or part of a corpse. If then, when the sexes are separated, it is the male that has the power of making the sensitive soul, it is impossible for the female to generate an animal from itself alone, for the process in question was seen to involve the male quality.[5] Certainly that there is

[1] This passage is 'like a tangled chain, nothing impaired but all disordered'. The meaning is this. The artist makes the product of art (e. g. a statue) in material other than himself, by a movement of his tools in which his activity is manifested; he does this in accordance with a form or idea in his mind which is realized in the statue. The soul makes the product of nature (the animal) in material other than itself by movement of heat and cold (i. e. by physical forces), which it uses like tools, and in which its activity is manifested; it does this in accordance with a principle or formula or definition within it (λόγῳ τινι), which is realized in the animal.

[2] Reading ταὐτὸ τῷ ἐξ ἀρχῆς γεννήσαντί ἐστιν (AW.).

[3] This is absurd, for it implies that some animals are devoid of sense-perception. The words in brackets are either spurious or very corrupt.

[4] This sentence is also wrong, for it ought to be 'the female needs the male'.

[5] τὸ γὰρ εἰρημένον ἦν τὸ ἄρρενι εἶναι. Reading ἄρρενι with one MS. for

a good deal in the difficulty stated is plain in the case of the birds that lay wind-eggs, showing that the female can generate up to a certain point unaided. But this still involves a difficulty; in what way are we to say that their eggs live? It is neither possible that they should live in the same way as fertile eggs (for then they would produce a chick actually alive), nor yet can they be called eggs only in the sense in which an egg of wood or stone is so called, for the fact that these eggs go bad shows that they previously participate in some way in life. It is plain, then, that they have some soul potentially. What sort of soul will this be? It must be the lowest surely, and this is the nutritive, for this exists in all animals and plants alike. Why then does it not perfect the parts and the animal? Because they must have a sensitive soul, for the parts of animals are not like those of a plant. And so the female animal needs the help of the male, for in these animals we are speaking of the male is separate. This is exactly what we find, for the wind-eggs become fertile if the male tread the female in a certain space of time. About the cause of these things, however, we shall enter into detail later.

If there is any kind of animal which is female and has no male separate from it, it is possible that this may generate a young one from itself without copulation.[1] No instance of this worthy of credit has been observed up to the present at any rate, but one case in the class of fishes makes us hesitate. No male of the so-called erythrinus[2] has ever yet been seen, but females, and specimens full of roe, have been seen. Of this, however, we have as yet no proof worthy of credit. Again, some members of the class of fishes are neither male nor female, as eels and a kind of mullets found 741b
in stagnant waters.[3] But whenever the sexes are separate

ἄρρεν, it may be possible to extract the translation in the text. AW. give the words up as hopeless.

[1] Reading *τοῦτο ἄνευ ὀχείας ζῷον*.

[2] Probably the *Serranus anthias*, a kind of sea-perch. This fish is hermaphrodite, and the male organs are difficult to make out, as may be judged from the fact that the riddle was not solved till near the end of the eighteenth century, and then the solution was much disputed (AW. p. 32).

[3] The truth about eels has only been quite recently discovered;

the female cannot generate perfectly by herself alone, for then the male would exist in vain, and Nature makes nothing in vain. Hence in such animals the male always perfects the work of generation, for he imparts the sensitive soul, either by means of the semen or without it.[1] Now the parts of the embryo already exist potentially in the material, and so when once the principle of movement has been imparted to them they develop in a chain one after another, as the wheels are moved one by another in the automatic machines. When some of the natural philosophers say that like is brought to like,[2] this must be understood, not in the sense that the parts are moved as changing place, but that they stay where they are and the movement is a change of quality (such as softness, hardness, colour, and the other differences of the homogeneous parts); thus they become in actuality what they previously were in potentiality. And what comes into being first is the first principle; this is the heart in the sanguinea and its analogue in the rest, as has been often said already. This is plain not only to the senses (that it is first to come into being), but also in view of its end; for life fails in the heart last of all, and it happens in all cases that what comes into being last fails first, and the first last,[3] Nature running a double course, so to say, and turning back to the point from whence she started. For the process of becoming is from the non-existent to the existent, and that of perishing is back again from the existent to the non-existent.

they do not develop generative organs except in the deep sea (about 500 fathoms), and consequently no sexes are to be observed in any fresh-water eels. (See e. g. *Nature*, vol. 75, p. 252.) There is no explanation forthcoming of the statement about the mullets, which have sexes in the usual way.

[1] Lit. *by means of himself*. The reference is to certain insects; see i. 16.

[2] And that is how the parts are developed. See Hippocrates, vol. i, p. 390.

[3] Here again A. states a law which is fully recognized in modern times, that (generally speaking) the order of appearance and disappearance of organs or characters varies inversely. Life, however, does not necessarily disappear from the heart last, and indeed A. himself knew this to be so in the tortoise (*de Juv.* 468b 15, *de Respir.* 479a 5). Nor, as already said, does it begin to develop first.

6 After this, as said already, the internal parts come into being before the external. The greater become visible before the less, even if some of them do not come into being before them. First the parts above the hypozoma are differentiated and are superior in size; the part below is both smaller and less differentiated. This happens in all animals in which exists the distinction of upper and lower,[1] except in the insects; the growth of those that produce a scolex is towards the upper part,[2] for this is smaller in the beginning. The cephalopoda are the only locomotive animals in which the distinction of upper and lower does not exist.[3] What has been said applies to plants also, that the upper portion is earlier in development than the lower, for the roots push out from the seed before the shoots.[4]

The agency by which the parts of animals are differentiated is air, not however that of the mother nor yet of the embryo itself, as some of the physicists say.[5] This is 742a
manifest in birds, fishes, and insects. For some of these are separated from the mother and produced from an egg, within which the differentiation takes place; other animals do not breathe at all, but are produced as a scolex or an egg; those which do breathe and whose parts are differentiated within the mother's uterus yet do not breathe until the lung is perfected, and the lung and the preceding parts are differentiated before they breathe.[6] Moreover,

[1] For the difference between upper and lower in plants and animals see *de Incessu*, 704a 29 seqq. That part is *upper* by which they take nourishment and which consequently causes growth, that is *lower* which is the other extremity. A. was led to this view by his assumption that 'of all animals man is most according to Nature', and so his upright attitude is the most natural, towards which other organisms approximate more or less in proportion to their dignity. Hence the roots of a plant are the upper part of it, strange as it sounds to us.

For the rest the statement in the text is correct, as may be seen by looking at any drawing of an embryo in an early stage.

[2] i.e. the head and thorax.

[3] Because the intestinal canal of a cephalopod is twisted round so that the excreta are discharged near the head.

[4] This contradicts Hippocrates, vol. i, p. 406.

[5] See Hippocrates, vol. i, p. 383, &c.

[6] The proof is this. (1) Birds are developed within an egg, and so their development is not due to the mother's breathing ⟨nor yet to their own, because they do not breathe till the lung is complete⟩. (2) Insects and fish do not breathe, and their development is from

all polydactylous quadrupeds,[1] as dog, lion, wolf, fox, jackal, produce their young blind, and the eyelids do not separate till after birth. Manifestly the same holds also in all the other parts; as the qualitative, so also the quantitative differentia comes into being, pre-existing potentially but being actualized later by the same causes by which the qualitative distinction is produced, and so the eyelids become two instead of one. Of course air must be present, because heat and moisture are present, the former acting and the latter being acted upon.[2]

Some of the ancient nature-philosophers made an attempt to state which part comes into being after which, but were not sufficiently acquainted with the facts. It is with the parts as with other things; one naturally exists prior to another. But the word 'prior' is used in more senses than one. For there is a difference between the end or final cause and that which exists for the sake of it; the latter is prior in order of development, the former is prior in reality. Again, that which exists for the sake of the end[3] admits of division into two classes, (1) the origin of the movement, (2) that which is used by the end; I mean, for instance, (1) that which can generate, (2) that which serves as an instrument to what is generated,[4] for the one of these, that which makes, must exist first, as the teacher before the learner, and the other later, as the pipes are later than he who learns to play upon them, for it is superfluous that

a scolex or egg, and so outside the mother; therefore they also are not developed by the breathing of either the mother or themselves. (3) The mammalian embryo does not breathe till the parts are all formed; but A. gives no proof that the mother's breathing has nothing to do with their formation in *this* case.

The author of the treatise *περὶ φύσιος παιδίου* (Hippocrates, vol. i, p. 419) had already contemplated the case of the egg and said that the young bird breathed through the shell, and in this he was right enough. The shell 'is sufficiently porous to allow of the interchange of gases between its interior and the external air, and thus the chemical processes of respiration . . . are carried on during the whole period of incubation'. Foster and Balfour, *Elements of Embryology*[2], p. 1.

[1] *Sic*, but A. is not thinking of reptiles; he obviously contemplates no class even of mammals except the fissiped carnivora.

[2] The heat is the vital heat in the semen, the moisture or liquid is that of the catamenia. Heat and moisture give rise to air (*de Gen. et Cor.* ii. 331b 16), and therefore air necessarily exists in the embryo.

[3] Reading *τὸ τούτου ἕνεκα*.

[4] Reading *γεννωμένῳ*.

men who do not know how to play should have pipes. Thus there are three things: first, the end, by which we mean that for the sake of which something else exists; secondly, the principle of movement and of generation, existing for the sake of the end (for that which can make and generate, considered simply as such, exists only in relation to what is made and generated); thirdly, the useful, that is to say what the end uses. Accordingly, there must first exist some part in which is the principle of movement (I say a part because this is from the first one part of the end and the most important part too);[1] next after this the whole and the end;[2] thirdly and lastly, the organic parts serving these for certain uses. Hence if there is anything of this sort which must exist in animals, containing the principle 742b
and end of all their nature, this must be the first to come into being—first, that is, considered as the moving power, but simultaneous with the whole embryo if considered as a part of the end. Therefore all the organic parts whose nature is to bring others into being must always themselves exist before them, for they are for the sake of something else, as the beginning for the sake of the end; all those parts which are for the sake of something else but are not of the nature of beginnings must come into being later. So it is not easy to distinguish which of the parts are prior, those which are for the sake of another or that for the sake of which are the former. For the parts which cause the movement, being prior to the end in order of development, come in to cause confusion, and it is not easy to distinguish these as compared with the organic parts.[3] And yet it is in accordance with this method that we must inquire what comes into being after what; for the end is later than some parts and earlier than others. And for this reason that part which contains the first principle[4] comes into being first, next to this the upper half of the body. This is why the parts about the head, and particularly the eyes,

[1] i. e. the heart must first exist, and this is from the first a part of the embryo, not something outside it.
[2] i. e. the upper half of the animal.
[3] Which are used only as instruments by the organism.
[4] The heart.

appear largest in the embryo at an early stage, while the parts below the umbilicus, as the legs, are small; for the lower parts are for the sake of the upper, and are neither parts of the end[1] nor able to form it.

But they do not say well nor do they assign a necessary cause who say simply that 'it always happens so', and imagine that this is a first principle in these cases. Thus Democritus of Abdera says that 'there is no beginning[2] of the infinite; now the cause is a beginning, and the eternal is infinite; in consequence, to ask the cause of anything of this kind is to seek for a beginning of the infinite'. Yet according to this argument, which forbids us to seek the cause, there will be no proof of any eternal truth whatever; but we see that there is a proof of many such, whether by 'eternal' we mean what always happens or what exists eternally; it is an eternal truth that the angles of a triangle are always equal to two right angles, or that the diagonal of a square is incommensurable with the side, and nevertheless a cause and a proof can be given for these truths. While, then, it is well said that we must not take on us to seek a beginning (or first principle) of all things, yet this is not well said of all things whatever that always are or always happen, but only of those which really are first principles of the eternal things; for it is by another method, not by proof, that we acquire knowledge of the first principle. Now in that which is immovable and unchanging the first principle is simply the essence of the thing,[3] but when we come to those things which come into being the principles are more than one, varying in kind and not all of the same kind; one of this number is the principle of movement, and therefore in all the sanguinea the heart is formed

[1] The lower parts of the body are a part of the body indeed as a whole, but they only exist to subserve the upper part where all the important functions of life are performed. It is this upper part then that is the true end (τέλος) of Nature, and thus the lower parts are not 'parts of the end', but fall into the third class of mere instruments for the use of the end.

[2] The word for *beginning* in the original is the same as that for *first principle*, but it seems impossible to use the same word throughout in English. I omit the words ἀεὶ καί, which throw the argument of Democritus into confusion.

[3] e.g. the definition of a triangle.

first, as was said at the beginning, and in the other animals that which is analogous to the heart. 743a

From the heart the blood-vessels extend throughout the body as in the anatomical diagrams which are represented on the walls,[1] for the parts lie round these because they are formed out of them. The homogeneous parts[2] are formed by heat and cold, for some are put together and solidified by the one and some by the other. The difference between these has already been discussed elsewhere, and it has been stated what kinds of things are soluble by liquid and fire, and what are not soluble by liquid and cannot be melted by fire.[3] The nutriment then oozes through the blood-vessels and the passages in each of the parts, like water in unbaked pottery, and thus is formed the flesh or its analogues, being solidified by cold, which is why it is also dissolved by fire. But all the particles given off which are too earthy, having but little moisture and heat, cool as the moisture evaporates along with the heat; so they become hard and earthy in character, as nails, horns, hoofs, and beaks, and therefore they are softened by fire but none of them is melted by it, while some of them, as egg-shells, are soluble in liquids.[4] The sinews and bones are formed by the internal heat as the moisture dries, and hence the bones are insoluble by fire like pottery, for like it they have been as it were baked in an oven by the heat in the process of development. But it is not anything whatever that is made into flesh or bone by the heat, but only something naturally fitted for the purpose; nor is it made in any place or time whatever, but only in a place and time naturally so fitted.[5] For neither will that which exists potentially be made except by that moving agent which possesses the actuality, nor will that which possesses the actuality make anything out of anything whatever; the carpenter would

[1] *καθάπερ οἱ τοὺς κανάβους γράφοντες ἐν τοῖς τοίχοις.* The reference apparently is to drawings on the walls of a lecture-room, showing the course of the blood-vessels.

[2] Omitting *ἐκ*.

[3] *Meteorologica*, iv. 7–10.

[4] Egg-shell is soluble in *some* liquids, as acetic acid.

[5] Reading *οὔθ' ὅπου ἔτυχεν οὔθ' ὅποτε ἔτυχεν ἀλλὰ τὸ πεφυκὸς καὶ οὗ πέφυκε κτλ.*

not make a box except out of wood, nor will a box be made out of the wood without the carpenter. The heat exists in the seminal secretion, and the movement and activity in it is sufficient in kind and in quantity to correspond to each of the parts. In so far as there is any deficiency or excess, the resulting product is in worse condition or physically defective, in like manner as in the case of external substances[1] which are thickened by boiling that they may be more palatable or for any other purpose. But in the latter case it is we who apply the heat in due measure for the motion required; in the former it is the nature of the male parent that gives it, or with animals spontaneously generated it is the movement and heat imparted by the right season of the year that it is the cause.

Cooling, again, is mere deprivation of heat. Nature makes use of both; they have of necessity the power of
743b bringing about different results,[2] but in the development of the embryo we find that the one cools and the other heats for some definite purpose, and so each of the parts is formed; thus it is in one sense by necessity, in another for a final cause, that they make the flesh soft, the sinews solid and elastic, the bones solid and brittle. The skin, again, is formed by the drying of the flesh, like the scum upon boiled substances; it is so formed not only because it is on the outside, but also because what is glutinous, being unable to evaporate, remains on the surface. While in other animals the glutinous is dry, for which reason the covering of the invertebrates is testaceous or crustaceous, in the vertebrates it is rather of the nature of fat. In all of these which are not of too earthy a nature the fat is collected under the covering of the skin, a fact which points to the skin being formed out of such a glutinous substance, for fat is somewhat glutinous. As we said, all these things must be understood to be formed in one sense of necessity, but in another sense not of necessity but for a final cause.

The upper half of the body, then, is first marked out in

[1] *External* as contrasted with the embryo within the mother.
[2] Lit. 'making one thing *this* and another *that*'. Necessity gives the fundamental properties of matter, Nature makes use of them.

the order of development; as time goes on the lower also reaches its full size in the sanguinea. All the parts are first marked out in their outlines and acquire later on their colour and softness or hardness, exactly as if Nature were a painter producing a work of art, for painters, too, first sketch in the animal [1] with lines and only after that put in the colours.

Because the source of the sensations is in the heart, therefore this is the part first formed in the whole animal,[2] and because of the heat of this organ the cold forms the brain, where the blood-vessels terminate above, corresponding to the heat of the heart.[3] Hence the parts about the head begin to form next in order after the heart, and surpass the other parts in size, for the brain is from the first large and fluid.

There is a difficulty about what happens with the eyes of animals. Though from the beginning they appear very large in all creatures, whether they walk or swim or fly, yet they are the last of the parts to be formed completely, for in the intervening time they collapse.[4] The reason is this. The sense-organ of the eyes is set upon certain passages, as are the other sense-organs.[5] Whereas those of touch and taste are simply the body itself or some part 744a
of the body [6] of animals, those of smell and hearing are

[1] *ζῷον*. This would include the human subject; cf. Plato, *Rep.* iv. 420 C.

[2] Since sensation is the characteristic of animal life.

[3] Heat and cold being the physical agents of development, the former makes the heart, the latter the brain. A. thought the brain was cold and its office was to cool the blood. It is placed where the blood-vessels from the heart terminate 'above', i. e. anteriorly, in the embryo. It is formed next after the heart because it is to correct the heart's excessive heat, and what is to correct will naturally come after what is to be corrected. In reality the brain begins to form before the heart, but this could not be discovered by the naked eye.

[4] The eyes are said to be last finished because the eyelids are reckoned a part of them, and these are not separated in many animals until after birth, all the other parts being complete before them. They shrink *relatively* to the other parts in course of development, but A. seems to think that they also shrink absolutely.

[5] This seems a strange statement; it is difficult to see how the sense-organ of touch or of taste can be said to be 'set upon' any 'passage'. The best MS. reads *πολλά* for *τὰ ἄλλα*, but that is equally difficult.

[6] i. e. the tongue.

passages connecting with the external air and full themselves of innate spiritus;[1] these passages end at the small blood-vessels about the brain which run thither from the heart. But the eye is the only sense-organ that has a bodily constitution peculiar to itself. It is fluid and cold, and does not exist from the first in the place which it occupies later in the same way as the other parts do, for they exist potentially to begin with and actually come into being later, but the eye is the purest part of the liquidity about the brain drained off through the passages which are visible running from them to the membrane round the brain.[2] A proof of this is that, apart from the brain, there is no other part in the head that is cold and fluid except the eye. Of necessity therefore this region is large at first but falls in later. For the same thing happens with the brain; at first it is liquid and large, but in course of evaporation and concoction it becomes more solid and falls in; this applies both to the brain and the eyes.[3] The head is very large at first, on account of the brain, and the eyes appear large because of the liquid in them. They are the last organs to reach completion because the brain is formed with difficulty; for it is at a late period that it gets rid of its coldness and fluidity; this applies to all animals possessing a brain,[4] but especially to man. For

[1] *συμφύτου πνεύματος*. This is not ordinary air, but a sort of 'vital air' of a mysterious nature nowhere satisfactorily explained. The passages are the nostrils and (probably) the Eustachian tube. The spiritus in them, communicating with the air, transmits an impression to the blood-vessels, which pass it on to the heart, the seat of sensation.

[2] These passages (*πόροι*) can hardly be anything but the optic nerves. A. considers the eye continuous with the brain and made of the same material in its purest form; the eye is not developed *in situ*, therefore, like the heart, &c., or the brain itself, but it is an offshoot from the brain. Consequently it does not exist potentially from the first in the part of the embryo where it is to be formed, as the heart, &c., do.

It is supposed that A. was actually the first man to discover any, if only the optic, nerves, though he had no notion what they were.

[3] Read *καὶ τὰ ὄμματα*, and omit *καὶ τὸ μέγεθος τὸ τῶν ὀμμάτων*. 'The brain completely fills the brain-case in embryonic fishes, but in the adult only occupies a small part of it' (Ogle on *de Partibus*, ii. 656^b 13). Hence, thinks Ogle, the statement about it in the text, which is untrue of other vertebrates.

[4] Reading *πάντων μὲν τῶν ἐχόντων*. A. does not allow that any animals *ὡς εἰπεῖν* except vertebrates have a brain, though he admits that the cephalopoda have something analogous to it (*de Partibus*,

this reason the 'bregma'[1] is the last of the bones to be formed; even after birth this bone is still soft in children. The cause of this being so with men more than with other animals is the fact that their brain is the most fluid and largest.[2] This again is because the heat in man's heart is purest.[3] His intellect shows how well he is tempered,[4] for man is the wisest of animals. And children for a long time have no control over their heads on account of the heaviness of the brain; and the same applies to the parts which it is necessary to move, for it is late that the principle of motion gets control over the upper parts, and last of all over those whose motion is not connected directly with it, as that of the legs is not. Now the eyelid is such a part.[5] But since Nature makes nothing superfluous nor in vain, it is clear also that she makes nothing too late or too soon, for if she did the result would be either in vain or superfluous. Hence it is necessary that the eyelids 744b
should be separated at the same time as the heart is able to move them. So then the eyes of animals are perfected late because of the amount of concoction required by the brain, and last of all the parts because the motion must be very strong before it can affect parts so far from the first principle of motion and so cold. And it is plain that such is the nature of the eyelids, for if the head is affected by

ii. 652^{b} 25). The brain is always 'cold and fluid', and so the statement here made must be understood to refer only to the *extreme* coldness and fluidity which characterize it at first in the embryo; in the adult it is 'the most consistent of all the animal fluids' (Ogle on *de Partibus*, ii. 652^{b} 1). 'Especially to man,' because A. held that in man alone the *βρέγμα* solidifies late (*de Partibus*, 653^{a} 34).

[1] There is a space on the top of the skull which does not close up for some months after birth. This space is known as the 'anterior fontanelle', and is covered by a membrane, not a bone. It is closed over finally by the bones growing over it from each side. This appears to be what is referred to; the 'bregma' is thus, properly speaking, not a bone at all, at least at first.

[2] 'Largest in proportion to his size' is what A. means probably; see *de Partibus*, ii. 653^{a} 28. This is not absolutely correct (Ogle, *ad loc.*).

[3] i.e. his temperature is highest. But in fact many birds and mammals are hotter.

[4] The extreme heat about the heart is tempered by the large brain. Thus the brain with A. has some connexion with intellect after all.

[5] i.e. upper and not connected with the heart. Therefore the heart is late in gaining control over the eyelids and moving them.

never so little heaviness through sleepiness or drunkenness or anything else of the kind, we cannot raise the eyelids though their own weight is so small. So much for the question how the eyes come into being, and why and for what cause they are the last to be fully developed.

Each of the other parts is formed out of the nutriment, those most honourable and participating in the sovereign principle[1] from the nutriment which is first and purest and fully concocted,[2] those which are only necessary for the sake of the former parts from the inferior nutriment and the residues left over from the other. For Nature, like a good householder, is not in the habit of throwing away anything from which it is possible to make anything useful. Now in a household the best part of the food that comes in is set apart for the free men, the inferior and the residue of the best for the slaves, and the worst is given to the animals that live with them. Just as the intellect acts thus in the outside world with a view to the growth of the persons concerned, so in the case of the embryo itself does Nature form from the purest material the flesh and the body of the other[3] sense-organs, and from the residues thereof bones, sinews, hair, and also nails and hoofs and the like; hence these are last to assume their form, for they have to wait till the time when Nature has some residue to spare.

The bones, then, are made in the first conformation of the parts from the seminal secretion or residue. As the animal grows the bones also grow from the natural nourishment, being the same as that of the sovereign parts,[4] but of this they only take up the superfluous residues. For everywhere the nutriment may be divided into two kinds, the first and the second;[5] the former is 'nutritious',[6] being

[1] i.e. the sense-organs, which are concerned with the principle of sense, the decisive principle of animal life.

[2] i.e. from the blood in its first form as made by the heart. (In a later form this becomes the semen.)

[3] *Other*, because the flesh also is a sense-organ, that of touch.

[4] i.e. the blood.

[5] Omitting *καί* before *τῆς τροφῆς*, but the sentence still seems corrupt.

[6] *θρεπτικόν* must here be understood as practically meaning 'formative' or 'creative'.

that which gives its essence both to the whole and to the parts; the latter is concerned with growth, being that which causes quantitative increase. But these must be distinguished more fully later on. The sinews are formed in the same way as the bones and out of the same materials, the seminal and nutritious residue. Nails, hair, hoofs, horns, beaks, the 745a
spurs of cocks, and any other similar parts, are on the contrary formed from the nutriment which is taken later[1] and only concerned with growth, in other words that which is derived from the mother, or from the outer world after birth. For this reason the bones on the one hand only grow up to a certain point (for there is a limit of size in all animals, and therefore also of the growth of the bones; if these had been always able to grow, all animals that have bone or its analogue[2] would grow as long as they lived, for these set the limit of size to animals.[3] What is the reason of their not always increasing in size must be stated later). Hair, on the contrary, and growths akin to hair go on growing as long as they exist at all, and increase yet more in diseases[4] and when the body is getting old and wasting, because more residual matter is left over, as owing to old age and disease less is expended on the important parts, though when the residual matter also fails through age the hair fails with it. But the contrary is the case with the bones, for they waste away along with the body and the other parts.[5] Hair actually goes on growing after death; it does not, however, begin growing then.[6]

[1] i.e. drawn from the mother only after the initial impulse given by the semen of the father has ceased to act.

[2] The so-called bone of cuttle-fish and the cartilage of elasmobranchs.

[3] i.e. they are the framework of the body.

[4] Not true, say AW., but it is *they* who are wrong; it is notorious and true that the hair grows more luxuriantly in consumption, and that A. is thinking of consumption especially appears from *H. A.* iii. 518b 20. Moreover hair may 'increase' in connexion with an inflamed state of the skin; see Darwin, *Descent of Man*, one vol. ed., p. 26; Erasmus Wilson, *On Healthy Skin*[2], pp. 105–6.

[5] The spinal column is contracted in old age, but this is due to shrinkage of the connective tissue of the vertebrae, and the bones themselves do not become smaller.

[6] i.e. if hair already exists, as the beard, it will grow longer after death, but new hair will not be developed on a bald spot. That hair can go on growing after death is a popular fallacy, nor is it true that it grows more in old age. (In some rare cases 'the hair has been

About the teeth a difficulty may be raised. They have actually the same nature as the bones, and are formed out of the bones,[1] but nails, hair, horns, and the like are formed out of the skin,[2] and that is why they change in colour along with it, for they become white, black, and all sorts of colours according to that of the skin. But the teeth do nothing of the sort, for they are made out of the bones in all animals that have both bones and teeth.[3] Of all the bones they alone go on growing through life,[4] as is plain with the teeth which grow out of the straight line so as no longer to touch each other. The reason for their growth, as a final cause, is their function, for they would soon be worn down if there were not some means of saving them ; even as it is they are altogether worn down in old age in some animals which eat much and have not large teeth, their growth not being in proportion to their detrition. And so Nature has contrived well to meet the case in this also, for she causes the failure of the teeth to synchronize with old age and death. If life lasted for a thousand or ten thousand years the original teeth must have been very large indeed, and many sets of them must have been produced, for even if they had grown continuously
745b they would still have been worn smooth and become useless for their work. The final cause of their growth has been now stated, but besides this as a matter of fact the growth[5] of the teeth is not the same as that of the other bones. The latter all come into being in the first formation of the embryo and none of them later, but the teeth do so later.

renewed in old age' (Darwin, *Variation*¹, vol. ii, p. 327), and it is possible that A. may have known of such a case.)

[1] Neither of these statements is correct; the teeth are formed from the mucous membrane (Foster and Balfour, *Elements of Embryology*², p. 421).

[2] This is true.

[3] This practically means all vertebrates except birds.

[4] This is so with the incisors of rodents and tusks of elephants; A. extends the principle to all teeth; indeed I fear that he invented his facts here on the grounds he proceeds to set forth. Probably he may have seen a rat or some such animal one of whose incisors had grown long owing to its no longer meeting that of the opposite jaw.

[5] *φύσιν*. A little way back, and again a little later, A. says the teeth *have* the same *nature* (*φύσιν*) as bones ; it seems that he uses *φύσιν* here in a different sense, *development*.

Therefore it is possible for them to grow again after the first set falls out, for though they touch the bones[1] they are not connate with them. They are formed, however, out of the nutriment distributed to the bones, and so have the same nature, even when the bones have their own number complete.[2]

Other animals are born in possession of teeth or their analogue (unless in cases contrary to Nature), because when they are set free from the parent they are more perfect than man; but man (also unless in cases contrary to Nature)[3] is born without them.

The reason will be stated later why some teeth are formed and fall out but others do not fall out.[4]

It is because such parts are formed from a residue that man is the most naked in body of all animals and has the smallest nails in proportion to his size; he has the least amount of earthy residue, but that part of the blood which is not concocted is the residue, and the earthy part in the bodies of all animals is the least concocted.[5] We have now stated how each of the parts is formed and what is the cause of their generation.

7 In viviparous animals, as said before, the embryo gets its growth through the umbilical cord. For since the nutritive power of the soul, as well as the others, is present in animals, it straightway sends off this cord like a root to the uterus.[6] The cord consists of blood-vessels in a sheath, more numerous in the larger animals as cattle and the like, one in the smallest, two in those of inter-

[1] Of course they do not touch them at all really.

[2] *Sc.* while the second set of teeth is still growing.

[3] Cases of children born with teeth are pretty common. The analogue to teeth means the beak of birds.

[4] v. 8.

[5] Earthy matter is least concocted. ∴ Earthy matter gives most residuum. But man has least earthy matter. ∴ Man has least residuum, hairs, nails, &c.

[6] 'Straightway' because the first thing a seed does is to send off a root. But this quaint analogy has misled Aristotle; and in point of fact the mammalian ovum is attached to the wall of the uterus and has begun developing long before the umbilical stalk begins to form at all.

mediate size.[1] Through this cord the embryo receives its nourishment in the form of blood, for the uterus is the termination of many blood-vessels. All animals with no front teeth in the upper jaw,[2] and all those which have them in both jaws and whose uterus has not one great blood-vessel running through it but many close together instead—all these have in the uterus the so-called cotyledons[3] (with which the umbilical cord connects and is closely united; for the vessels which pass through the cord run backwards and forwards between embryo and uterus and split up into smaller vessels all over the uterus; where they terminate, there are found the cotyledons).[4] Their convexity is turned towards the uterus, the concavity towards the embryo. Between uterus and embryo are
746a the chorion and the membranes.[5] As the embryo grows and approaches perfection the cotyledons become smaller and finally disappear when it is perfected.[6] For Nature sends the sanguineous nutriment for the embryo into this part of the uterus as she sends milk into the breasts, and

[1] In mammalia there are always two arteries and one, or rarely two, veins (Foster and Balfour, *Elements*², p. 348). Thus there are never less than three blood-vessels. I suppose A. made out more in large animals than in small ones because they are larger in the former. Should we not read ἐλαχίστοις for ἐσχάτοις? Cf. *H. A.* vii. 586b 17 πάμπαν μικροῖς; but the author of that spurious book is mistaken in thinking the reference is to birds, for A. is talking of vivipara only.

[2] Ruminants. But it is hard to see what A. means by the animals he goes on to describe. Prof. Hill suggests that he may be thinking of the horse.

[3] The cotyledons are pits in the modified wall of the uterus into which fit the villi of the outside membrane of the embryo. In modern works the term is applied to the tufts of villi themselves, but A. plainly uses it of the pits into which they fit, as one would expect from the derivation. They were called 'cotyledons' from the suckers on the arms of cuttle-fish (Galen, vol. iv, p. 537).

[4] The passage in this parenthesis is inserted from one MS. It was translated by Gaza. Read πρὸς ἃς at the beginning of it for πρὸς ἅ.

[5] The chorion is the outside membrane of the embryo, which unites with a modified part of the uterus of the mother to form the placenta. The other membranes would be certainly the amnion, and perhaps, as Professor Hill suggests, that part of the allantois which is not united with the chorion.

[6] In man the blood-vessels of the placenta increase during pregnancy to such an extent that the other tissues do finally almost disappear. But A. cannot be thinking of man.

because the cotyledons are gradually[1] aggregated from many into a few the body of the cotyledon becomes like an eruption or inflammation.[2] So long as the embryo is comparatively small, being unable to receive much nutriment, they are plain and large, but when it has increased in size they fall in together.

But most of the animals which have front teeth in both jaws and no horns[3] have no cotyledons[4] in the uterus, but the umbilical cord runs to meet one blood-vessel, which is large and extends throughout the uterus. Of such animals some produce one young at a time, some more than one, but the same description applies to both these classes. (This should be studied with the aid of the examples drawn in the *Anatomy* and the *Enquiries*.)[5] For the young, if numerous, are attached each to its umbilical cord, and this to the blood-vessel of the mother; they are arranged next to one another along the stream of the blood-vessel as along a canal; and each embryo is enclosed in its membranes and chorion.[6]

Those who say[7] that children are nourished in the uterus by sucking some lump of flesh or other are mistaken. If so, the same would have been the case with other animals, but as it is we do not find this (and this can easily be observed by dissection). Secondly, all embryos alike, whether of creatures that fly or swim or walk, are sur-

[1] Omitting καί before κατὰ μικρόν.

[2] By the 'body' A. means the 'caruncle' or swelling in the wall of the uterus, in which is the cotyledon. The 'gradual aggregation' is unintelligible, but the caruncle does become 'like an inflammation' (J. P. Hill).

[3] κολοβῶν certainly means 'hornless' here. A. insists often on the inverse development of horns and teeth.

[4] Reading κοτυληδόνας.

[5] *H. A.*, but where? 586^{b} 15–23 is the only passage suitable, and that is in the seventh book, which is spurious.

[6] This description looks as if it were taken from the pig. That animal has a very simple placenta, in which the cotyledons are very little developed, though not entirely absent, as A. says. But there is no decidua, a fact which explains his statement. Neither the pig, however, nor any other animal has 'one great vessel running through the uterus'.

[7] Democritus? (see Plutarch, *Plac. Phil.* v. 16). Censorinus (*de Die Natali*, 6) ascribes the theory to Diogenes and Hippo. But it was also a medical view; see Hippocrates, vol. i, p. 430, Galen, vol. xix, p. 166.

rounded by fine membranes separating them from the uterus and from the fluids which are formed in it; but neither in these themselves is there anything of the kind, nor is it possible for the embryo to take nourishment by means of any of them. Thirdly, it is plain that all creatures developed in eggs grow when separated from the uterus.

Natural intercourse takes place between animals of the same kind. However, those also unite whose nature is near akin and whose form is not very different, if their size is much the same and if the periods of gestation are equal. In other animals such cases are rare, but they occur with dogs and foxes and wolves;[1] the Indian dogs also spring from the union of a dog with some wild dog-like animal.[2]
746b A similar thing has been seen to take place in those birds that are amative, as partridges and hens.[3] Among birds of prey hawks of different form are thought to unite, and the same applies to some other birds. Nothing worth mentioning has been observed in the inhabitants of the sea, but the so-called 'rhinobates' especially is thought to spring from the union of the 'rhinè' and 'batus'.[4] And

[1] Dogs have been crossed with foxes and wolves, and the hybrids are fertile both *inter se* and with the parent stock. Dogs and wolves cross *naturally* in both hemispheres; see Darwin, *Variation*[1], vol. i, pp. 21–4. Various nearly allied species of birds have been known to cross in a wild state, especially the black grouse and the common pheasant: for other cases see Suchetet, *Des Hybrides à l'état sauvage*. Lille, 1896.

[2] The Indian dog was said by some to be descended from the union of a bitch with a tiger! (*H. A.* viii. 607a 4). AW. suggest that it was a jackal, maintaining that θώς in A. is not a jackal, most improbably. Others think the wild dog of India is meant, i.e. some or all of the species of the genus *Cyon*, familiar to readers of Kipling as the 'red dog'. At one time I thought the cheetah a very likely animal, but on comparison of *de Partibus*, i. 643b 6, Xen. *Cyn.* ix. 1, x. 1, I must conclude that it was none of those above mentioned, but probably a large brindled hound imported from the East, perhaps such a one as we see in the Assyrian bas-reliefs. See my note in the *Classical Quarterly* for 1909.

[3] As the Greeks kept both these birds in domestication there is no reason to doubt this. Pheasants and fowls will cross. The story about the hawks is only some reckless guess like that about *rhinobates*.

[4] The rhinè is probably some kind of shark, the batus a ray, the former having a thick tail, the latter a thin one. Rhinobates was a fish with thick tail but the forepart of the body like a batus (AW. *H. A.* vol. i, p. 147). It certainly did not belong to the modern genus of that name; I incline to think it was the angel fish, *Squatina vulgaris*. Hybridism is supposed to be not uncommon among fish (Gunther, *Study of Fishes*, p. 178).

the proverb about Libya, that 'Libya is always producing something new', is said to have originated from animals of different species uniting with one another in that country, for it is said that because of the want of water all meet at the few places where springs are to be found, and that even different kinds unite in consequence.[1]

Of the animals that arise from such union all except mules are found to copulate again with each other and to be able to produce young of both sexes, but mules alone are sterile, for they do not generate by union with one another or with other animals. The problem why any individual, whether male or female, is sterile is a general one, for some men and women are sterile, and so are other animals in their several kinds, as horses and sheep. But this kind, that of mules, is universally so. The causes of sterility in other animals are several. Both men and women are sterile from birth when the parts useful for union are imperfect, so that men never grow a beard but remain like eunuchs, and women do not attain puberty; the same thing may befall others as their years advance, sometimes on account of the body being too well nourished (for in men who are in too good condition and women who are too fat the seminal secretion[2] is taken up into the body, and the former have no semen, the latter no catamenia); at other times by reason of sickness men emit the semen in a cold and liquid state, and the discharges of women are bad and full of morbid secretions. Often, too, in both sexes this state is caused by injuries in the parts and regions contributory to copulation. Some such cases are curable, others incurable, but the subjects especially remain sterile if anything of the sort has happened in the first formation of the parts in the embryo, for then are produced women of a masculine and men of a feminine appear- 747a
ance, and in the former the catamenia do not occur, in the

[1] It is to be observed that A. does not guarantee this. Cf. *H. A.* viii. 606b 18 seqq. From an obscure passage in Hippocrates (vol. i, p. 549) I guess that Hippocrates originated the theory.

[2] i. e. the semen of men and the catamenia of women; the latter have no semen according to A. It is notorious that fat animals are bad breeders. Cf. Hippocrates, vol. i, pp. 475, 560, &c.

latter the semen is thin and cold. Hence it is with good reason that the semen of men is tested in water to find out if it is infertile, for that which is thin and cold is quickly spread out on the surface, but the fertile sinks to the bottom, for that which is well concocted is hot indeed, but that which is firm and thick is well concocted.[1] They test women by pessaries to see if the smells thereof permeate from below upwards to the breath from the mouth,[2] and by colours smeared upon the eyes to see if they colour the saliva. If these results do not follow it is a sign that the passages of the body, through which the catamenia are secreted, are clogged and closed. For the region about the eyes is, of all the head, that most nearly connected with the generative secretions; a proof of this is that it[3] alone is visibly changed in sexual intercourse, and those who indulge too much in this are seen to have their eyes sunken in. The reason is that the nature of the semen is similar to that of the brain,[4] for the material of it is watery (the heat being acquired later).[5] And the seminal purgations are from the region of the diaphragm, for the first principle of nature is there, so that the movements from the pudenda are communicated to the chest, and the smells from the chest are perceived through the respiration.[6]

[1] It floats because it is thin, it sinks because it is thick. It is true it is hot, but well-concocted things must be hot, and therefore thick semen is so; the thickness overcomes the heat and makes it heavy. AW. appear to me to make nonsense of this by neglecting the μέν and δέ. Heat and cold in animals are not the same as ordinary heat and cold according to A.; see Ogle on *de Partibus*, ii. 652a 9. (Of course A. could not have said that anything could sink because it is hot.)

[2] Cf. Hippocrates, vol. i, p. 468, iii. 6, 7, 747. Recipes for various pessaries given in the first of these treatises contain many fragrant herbs such as myrrh, galbanum, &c. This passage of A. suggests that men and women were tested before marriage to find out whether they were capable of having children.

[3] *Sic*, but does not A. mean the eyes themselves? 'Adspicies oculos tremulo fulgore micantes' (Ovid, *A.A.* ii. 721).

[4] This is after all no more absurd than the popular view that the semen is connected with the 'spinal marrow', as in Shakespeare's 'spending his manly marrow in her arms'. Plato, *Timaeus*, 91 A, Gomperz, *Greek Thinkers* (Eng. ed.), vol. i, p. 548.

[5] Both brain and semen are cold and watery when formed first; the former remains cold, the latter somehow acquires the vital heat at a later period of development.

[6] The pessary sets up movements which, like all movements in any part, are passed on to the centre of the body as the seat of life. As the

8 In men, then, and in other kinds, as said before, such deficiency occurs sporadically, but the whole of the mule kind is sterile. The reason has not been rightly given by Empedocles and Democritus, of whom the former expresses himself obscurely, the latter more intelligibly. For they offer their demonstration in the case of all these animals alike which unite against their affinities.[1] Democritus says that the genital passages of mules are spoilt in the mother's uterus because the animals from the first are not produced from parents of the same kind. But we find that though this is so with other animals they are none the less able to generate; yet, if this were the reason, all others that unite in this manner ought to be barren. Empedocles assigns as his reason that the mixture of the 'seeds' becomes dense, each of the two seminal fluids out of which it is made being 747b soft, for the hollows in each fit into the densities of the other, and in such cases a hard substance is formed out of soft ones, like bronze mingled with tin. Now he does not give the correct reason in the case of bronze and tin—(we have spoken of them in the *Problems*[2])—nor, to take general ground, does he take his principles from the intelligible. How do the 'hollows' and 'solids' fit into one another to make the mixing, e. g. in the case of wine and water? This saying is quite beyond us; for how we are to understand the 'hollows' of the wine and water is too far beyond our perception. Again, when, as a matter of fact, horse is born of horse, ass of ass, and mule of horse and ass in two ways according as the parents are stallion and she-ass or jackass and mare, why in the last case does there result something so 'dense' that the offspring is sterile, whereas the offspring of male and female horse, male and female ass, is not sterile? And yet the generative fluid of the male and female horse is soft.[3] But both sexes of the horse cross with both sexes

pessary is highly scented these scents pass up along with the movements, and entering the cavity of the chest are then expelled with the breath through the mouth.

[1] Whereas they ought to have considered mules only. By proving all hybrids barren they prove too much, for many hybrids are not barren.

[2] There is nothing about this in the existing collection of *Problems*.

[3] This is short for: 'The fluid of both sexes both of the horse and of

of the ass,[1] and the offspring of both crosses are barren, according to Empedocles, because from both is produced something 'dense',[2] the 'seeds' being 'soft'. If so, the offspring of stallion and mare ought also to be sterile. If one of them alone united with the ass, it might be said that the cause of the mule's being unable to generate was the unlikeness[3] of that one to the generative fluid of the ass; but, as it is, whatever be the character of that generative fluid with which it unites in the ass, such it is also in the animal of its own kind.[4] Then, again, the argument is intended to apply to both male and female mules alike, but the male does generate at seven years of age, it is said;[5] it is the female alone[6] that is entirely sterile, and even she is so only because she does not complete the development of the embryo, for a female mule has been known to conceive.[7]

Perhaps an abstract proof might appear to be more plausible than those already given; I call it abstract because the more general it is the further is it removed from the special principles involved. It runs somewhat as follows. From male and female of the same species there are born in course of nature male and female of the same species as the parents, e. g. male and female puppies from male and female dog. From parents of different species is born a young one different in species; thus if a dog is different from a lion,

the ass is soft just as much when they are mated naturally as when they are crossed'.

[1] The ordinary mule is produced by crossing a jackass with a mare; the hybrid of a stallion and a she-ass is called a jennet, but is much less used.

[2] Read πυκνόν τι for ἕν τι.

[3] For γεννᾶν ὅμοιον read γεννᾶν ἀνόμοιον ὄν (ὄν is in one MS.).

[4] This sentence appears to be hopelessly corrupt, nor can I conjecture what the argument may have been.

[5] 'It is said', but would A. have repeated it if he had not been demolishing an opponent? Obviously the story was that it fertilized a mare. 'Neither the mule nor the jennet is fertile, either among themselves or with other members of the horse family', says Captain Hayes *apud* Tegetmeier and Sunderland, *Horses, Asses, Zebras, Mules*, p. 80, where is a discussion on the subject; no certain case is known to them. 'The stallion mule is absolutely sterile', p. 150. Darwin believed at one time that 'even the mule has bred' (*Foundations of the Origin*, pp. 11, 97, 102), but apparently gave this up before 1859.

[6] I change μόνος to μόνη and transpose it to follow θήλεια.

[7] 'In warm climates it is stated that occasionally female mules become pregnant' (by a horse), 'but that pregnancy is invariably followed by abortion, and that at an early stage' (Tegetmeier, *ibid.*).

the offspring of male dog and lioness or of lion and bitch will be different from both parents. If this is so, then since (1) mules are produced of both sexes and are not different 748a
in species from one another, and (2) a mule is born of horse and ass and these are different in species from mules, it is impossible that anything should be produced from mules. For (1) another kind cannot be, because the product of male and female of the same species is also of the same species, and (2) a mule cannot be, because that is the product of horse and ass which are different in form, [and it was laid down that from parents different in form is born a different animal].[1] Now this theory is too general and empty. For all theories not based on the special principles involved are empty; they only appear to be connected with the facts without being so really. As geometrical arguments must start from geometrical principles, so it is with the others; that which is empty may seem to be something, but is really nothing. Now the basis of this particular theory is not true, for many animals of different species are fertile with one another, as was said before. So we must not inquire into questions of natural science in this fashion any more than any other questions; we shall be more likely to find the reason by considering the facts peculiar to the two kinds concerned, horse and ass. In the first place, each of them, if mated with its own kind, bears only one young one; secondly, the females are not always able to conceive from the male (wherefore breeders put the horse to the mare again at intervals[2]). Indeed, both the mare is deficient in catamenia, discharging less than any other quadruped,[3] and

[1] The argument seems to amount to this. As mules are of the same 'species', their offspring could not be any other species. But neither can it be a mule, for a mule is born of a cross between different species, and can only be so produced; therefore it cannot be produced by two mules, which are of the same species with one another! The words in brackets plainly have nothing to do with the question and are probably an addition.

[2] The MSS. here add the foolish remark 'because she cannot bear him continuously', which I have ejected altogether. A. states the fact about breeders to show that mares do not conceive so very readily; both this fact and the other, that she bears only one at a time, show that we need not wonder if such animals are easily sterilized. What follows is directed to the same end.

[3] 'Least in proportion to size,' says A. in *H.A.* vi. 573a 11, where AW.

the she-ass does not admit the impregnation, but ejects the semen with her urine, wherefore men follow flogging her after intercourse.[1] Again the ass is an animal of cold nature,[2] and so is not wont to be produced in wintry regions because it cannot bear cold, as in Scythia[3] and the neighbouring country and among the Celts beyond Iberia,[4] for this country also is cold. For this cause they do not put the jackasses to the females at the equinox, as they do with horses, but about the summer solstice, in order that the ass-foals may be born in a warm season, for the mothers bear at the same season as that in which they are impregnated, the period of gestation in both horse and ass being one year.[5] The animal, then, being, as has been said, of such a cold nature, its semen also must be cold. A proof of this is that if a horse mount a female[6] already impregnated by an ass he does not destroy the impregnation of the ass, but if the ass be the second to mount her he does destroy that of the horse because of the coldness of his own semen.[7] When,
748b therefore, they unite with each other, the generative elements are preserved by the heat of the one of them, that contributed by the horse being the hotter; for in the ass both the semen of the male and the material contributed by the female are cold, and those of the horse, in both sexes, are hotter. Now when either hot is added to cold or cold to hot so as to mix, the result is that the embryo itself arising from these is preserved and thus these animals are fertile when crossed with one another, but the animal produced by them is no longer fertile but unable to produce perfect offspring.[8]

refer to Numann as saying that they discharge ‘nur eine schleimartige Substanz’. ‘Quadruped’ here means mammal.

[1] *H. A.* vi. 577^a 22, where AW. say they do this in Germany.

[2] Either omit τό before ζῷον or ὁ ὄνος as a gloss after it.

[3] Cf. Herodotus, iv. 28.

[4] i. e. north of the Pyrenees.

[5] It is a common error to suppose the period of gestation to be the same in both animals; in reality it is eleven months in the horse, twelve or a little more in the ass (Tegetmeier, &c., pp. 2, 14).

[6] From *H. A.* vi. 577^a 13, 28 it appears that this means a mare, not a she-ass.

[7] This statement must be based on a very insufficient number of observations.

[8] This explanation is very lame, though it is superior to those of A.'s

And in general each of these animals naturally tends towards sterility. The ass has all the disadvantages already mentioned, and if it should not begin to generate after the first shedding of teeth,[1] it no longer generates at all; so near is the constitution of the ass to being sterile.[2] The horse is much the same; it tends naturally towards sterility, and to make it entirely so it is only necessary that its generative secretion should become colder; now this is what happens to it when mixed with the corresponding secretion of the ass.[3] The ass in like manner comes very near generating a sterile animal when mated with its own species. Thus when the difficulty of a cross contrary to nature is added, (when too even in the other case when united with their own species they with difficulty produce a single young one), the result of the cross, being still more sterile[4] and contrary to nature, will need nothing further to make it sterile, but will be so of necessity.

We find also that the bodies of female mules grow large[5] because the matter which is secreted in other animals to form the catamenia is diverted to growth. But since the period of gestation in such animals is a year, the mule must not only conceive, if she is to be fertile, but must also nourish the embryo till birth, and this is impossible if there are no catamenia. But there are none in the mule; the useless part of the nutriment is discharged with the excretion from the bladder[6]—this is why male mules do not smell to the pudenda of the females, as do the other

predecessors in the point he insists on; it applies only to mules, not to all hybrids. Cf. Alcmaeon, frag. 3.

[1] Ass (and horse) shed their first four teeth at thirty months, *H. A.* vi. 577a 18. Flower, *The Horse*, p. 131.

[2] Reading τοῦ ἄγονον εἶναι.

[3] This sentence can only be got to give this meaning by violence. One would also expect the consequence to be that the cross of horse and ass was infertile, instead of which it is only the result of the cross that is so.

[4] Reading ἄγονον ⟨ὄν⟩.

[5] This statement is intelligible if A. is thinking only of female mules bred from jackass and mare, for 'both mule and jennet take after their dam in size, and their sire in appearance and disposition' (Capt. Hayes, *ubi supra*). How beautifully this fits our theory that the mother gives the material, the father the 'form' and 'soul'!

[6] Instead of being converted into the catamenia as in other animals.

solid-hoofed ungulates, but only to the evacuation itself—and the rest of the nutriment is used up to increase the size of the body.[1] Hence it is sometimes possible for the female to conceive, as has been known to happen before now, but it is impossible for her to complete the process of nourishing the embryo and bringing it to birth.

The male, again, may sometimes generate, both because the male sex is naturally hotter than the female and because it does not contribute any material substance to the mixture. The result in such cases is a 'ginnus',[2] that is to say, a dwarf mule; for 'ginni' are produced also from the crossing of horse and ass[3] when the embryo is diseased
749^a in the uterus. The ginnus is in fact like the so-called 'metachoera' in swine, for a 'metachoerum' also is a pig injured in the uterus; this may happen to any pig. The origin of human dwarfs is similar, for these also have their parts and their whole development injured during gestation, and resemble ginni and metachoera.

[1] Reading *τὴν τοῦ σώματος αὔξησιν*.

[2] The ginnus is the offspring of a mule and a mare (*H. A.* vi. 577^b 21). But there is no such thing.

[3] Lit. 'also from the horse and the ass', but this must mean what I say. The cross of mule and mare produces a *γίννος without* disease; this is a dwarfed animal and is like a dwarf mule, i.e. like the ordinary mule, only smaller; A. therefore calls it a dwarf mule, *for*, &c. It would be absurd to suppose that the embryo of mule and mare, if there were such, would be invariably diseased while in the uterus, despite the confused statement in that disorderly compilation *H. A.* vi. 24. Mules are fertile of fiction if of nothing else.

BOOK III

I We have now spoken about the sterility of mules, and about those animals which are viviparous both externally and within themselves. The generation of the oviparous sanguinea is to a certain extent similar to that of the animals that walk, and all may be embraced in the same general statement; but in other respects there are differences in them both as compared with each other and with those that walk.[1] All alike are generated from sexual union, the male emitting semen into the female. But among the ovipara (1) birds produce a perfect hard-shelled egg, unless it be injured by disease, and the eggs of birds are all two-coloured.[2] (2) The cartilaginous fishes, as has been often said already, are oviparous internally but produce the young alive, the egg changing previously from one part of the uterus to another; and their egg is soft-shelled and of one colour. One of this class alone does not produce the young from the egg within itself,[3] the so-called 'frog';[4] the reason of which must be stated later.[5] (3) All other oviparous fishes produce an egg of one colour, but this is imperfect, for its growth is completed outside the mother's body by the same cause as are those eggs which are perfected within.

Concerning the uterus of these classes of animals, what

[1] The walking animals must here mean only land mammalia. The ovipara are mostly flying or swimming animals, but A. seems to forget all about the land reptiles and amphibia.

[2] This refers to the white and the yolk.

[3] Lit. 'is not viviparous within itself'.

[4] Some species of *Lophius*, either *piscatorius* or *budegassa*; perhaps we should rather say that it includes both. The popular names are 'Fishing-Frog', 'Angler', or 'Sea-Devil'. These fish are teleostean, not cartilaginous, and spawn very abundantly. See Günther, *Study of Fishes*, p. 470.

[5] 754a 25-31.

differences there are among them and for what reasons, has been stated previously. For in some of the viviparous creatures it is high up near the hypozoma, in others low down by the pudenda; the former in the cartilaginous fishes, the latter in animals both internally and externally viviparous, such as man and horse and the rest; in the ovipara it is sometimes low, as in the oviparous fish, and sometimes high, as in birds.

Some embryos are formed in birds spontaneously, which
749b are called wind-eggs and 'zephyria' by some; these occur in birds which are not given to flight nor rapine but which produce many young, for these birds have much residual matter, whereas in the birds of prey all such secretion is diverted to the wings and wing-feathers, while the body is small and dry and hot. (The secretion corresponding in hen-birds to catamenia, and the semen of the cock, are residues.) Since then both the wings and the semen are made from residual matter, nature cannot afford to spend much upon both. And for this same reason [1] the birds of prey are neither given to treading much nor to laying many eggs, as are the heavy birds and those flying birds whose bodies are bulky, as the pigeon and so forth. For such residual matter is secreted largely in the heavy birds not given to flying, such as fowls, partridges, and so on, wherefore their males tread often and their females produce much material. Of such birds some lay many eggs at a time and some lay often: for instance, the fowl, the partridge, and the Libyan ostrich [2] lay many eggs, while the pigeon family do not lay many but lay often. For these are between the birds of prey and the heavy ones; they are flyers like the former, but have bulky bodies like the latter: hence, because they are flyers and the residue is diverted that way, they lay few eggs, but they lay often because of their having bulky bodies and their stomachs being hot and very active in concoction, and because

[1] Omit *καί* after *αἰτίαν*.

[2] The partridge is one of the most prolific of birds. The ostrich is polygamous and all his wives pool their eggs, so that early observers would probably exaggerate the number laid by a female, but as it is she is believed to lay about ten.

moreover they can easily procure their food, whereas the birds of prey do so with difficulty.[1]

Small birds also tread often and are very fertile,[2] as are sometimes small plants, for what causes bodily growth in others turns in them to a seminal residuum. Hence the Adrianic fowls[3] lay most eggs, for because of the smallness of their bodies the nutriment is used up in producing young. And other birds are more fertile than game-fowl,[4] for their bodies are more fluid and bulkier, whereas those of game-fowl are leaner and drier, since a passionate spirit is found rather in such bodies as the latter. Moreover the thinness and weakness of the legs contribute to making the former class of birds naturally inclined to tread and to be fertile, as we find also in the human species; for the nourishment which otherwise goes to the legs is turned in such into a seminal secretion, what Nature takes from the one place being added at the other. Birds of prey, on the contrary, have a strong walk and their legs are thick owing to their habits, so that for all these reasons they neither tread nor lay much. The kestrel[5] is the most fertile; for this is nearly the only bird of prey which drinks, and its moisture, both innate and acquired, along with its heat is favourable to generative products. Even this bird does not lay very many eggs, but four at the outside.

The cuckoo, though not a bird of prey, lays few eggs, because it is of a cold nature, as is shown by the cowardice of the bird,[6] whereas a generative animal should be hot

[1] This last reason hits the mark. It has been suggested that the number of eggs varies inversely to the dangers incurred by the species; see on the whole subject Beebe, *The Bird*, pp. 432–44.

[2] e.g. the long-tailed tit may lay as many as twelve eggs.

[3] *H.A.* vi. 1.

[4] This is no doubt because game-fowl have been bred for other purposes.

[5] κεγχρίς, probably the kestrel, lays 'usually four or five but sometimes six' eggs. Among the accipitrines 'the number of young produced in a brood seldom exceeds four and is frequently less' (*Royal Nat. Hist.* iv. 189, 176). The keepers at the Zoological Gardens tell me that hawks, eagles, vultures, &c., scarcely drink at all, not more than once a month, though plenty of water is provided them to wash in, nor do kestrels differ from the rest. Cf. White, *Natural History of Selborne*, letter 53.

[6] See *de Partibus*, ii. 650b 27 ὁ γὰρ φόβος καταψύχει.

and moist. That it is cowardly is plain, for it is pursued by all the birds and lays eggs in the nests of others.[1]

The pigeon family are in the habit of laying two for the most part, for they neither lay one (no bird does except the cuckoo,[2] and even that sometimes lays two) nor yet many, but they frequently produce two, or three at the most, generally two, for this number lies between one and many.[3]

It is plain from the facts that with the birds that lay many eggs the nutriment is diverted to the semen.[4] For most trees, if they bear too much fruit, wither away after the crop when nutriment is not reserved for themselves,[5] and this seems to be what happens to annuals, as leguminous plants, corn, and the like. For they consume all their nutriment to make seed, their kind being prolific. And some fowls after laying too much, so as even to lay two eggs in a day, have died after this. For both the birds and the plants become exhausted, and this condition is an excess of secretion of residual matter. A similar condition is the cause of the later sterility of the lioness, for at the first birth[6] she produces five or six, then in the next year four, and again three cubs, then the next number down to one, then none at all, showing that the residue is being
750b used up and the generative secretion is failing along with the advance of years.

We have now stated in which birds wind-eggs are found,

[1] The cuckoo 'with rare exceptions lays only one egg in a nest' (Darwin, *Origin*[6], p. 213, and cf. *H. A.* vi. 7), and hence it used to be supposed that it laid but few; it is now thought, however, that it lays a considerable number in a season. Owing to its resemblance to a hawk it is mobbed by small birds. A.'s remark, 'though not a bird of prey,' is perhaps directed against those who thought it *was* a hawk (*H. A.* ibid.).

[2] This is not so; the Fulmar petrel, for instance, 'lays but one egg, yet it is believed to be the most numerous bird in the world' (Darwin, *Origin*[6], p. 52), and many other sea-birds at any rate resemble it in this.

[3] Pigeons regularly lay two eggs with a day's interval between the first and second; the first almost invariably hatches out a male, the second a female. Hence the phrase a 'pigeon-pair', of a family consisting of a boy and girl.

[4] *Sic*, but A. means the ova. One MS. reads *σῶμα*. Did A. write *τὰ ᾠά*?

[5] Lit. *for their body*.

[6] This fable is told of the Syrian lions in *H. A.* vi. 31, and appears again in this treatise, iii. 10. A. knew little about lions but a string of foolish stories.

and also what sort of birds lay many eggs or few, and for what reasons. And wind-eggs, as said before, come into being because while it is the material for generation that exists in the female of all animals, birds have no discharge of catamenia like viviparous sanguinea (for they occur in all these latter, more in some, less in others, and in some only enough in quantity just to mark the class).[1] The same applies to fish as to birds, and so in them as in birds is found an embryonic formation without impregnation, but it is less obvious because their nature is colder.[2] The secretion corresponding to the catamenia of vivipara is formed in birds at the appropriate season for the discharge of superfluous matter, and, because the region near the hypozoma is hot, it is perfected so far as size is concerned, but in birds and fishes alike it is imperfect for generation without the seminal fluid of the male; the cause of this has been previously given. Wind-eggs are not formed in the flying birds, for the same reason as prevents their laying many eggs; for the residual matter in birds of prey is small, and they need the male to give an impulse for the discharge of it.[3] The wind-eggs are produced in greater numbers than the impregnated but smaller in size for one and the same reason; they are smaller in size because they are imperfect, and because they are smaller in size they are more in number.[4] They are less pleasant for food because they are less concocted, for in all foods the concocted is more agreeable. It has been sufficiently observed, then, that neither birds' nor fishes' eggs are perfected for generation without the males. As for embryos being formed in fish also (though in a less degree) without the males, the

[1] *ἐπισημαίνειν*. If a character regularly marks a whole class of animals we expect to find some 'rudiment', as it would be now called, even in members of the class in which it is not properly developed; A. calls such a rudiment a *σημεῖον*, e. g. the tail in apes (*de Partibus*, iv. 689^{b} 5).

[2] A. thinks that the eggs of the female fish are impregnated by the male before oviposition. This passage then means that even before that impregnation rudimentary eggs may be found in them.

[3] Reading *τοῦ περιττώματος*. Something seems to have fallen out in the text, for *πτητικά* and *γαμψώνυχα* are not convertible.

[4] These eggs are in reality neither more numerous nor smaller (AW.).

fact has been observed[1] especially in river fish, for some are seen to have eggs from the first, as has been written in the *Enquiries* concerning them.[2] And generally speaking in the case of birds even the impregnated eggs are not wont for the most part to attain their full growth unless the hen be trodden continually. The reason of this is that just as with women intercourse with men draws down the
751a secretion of the catamenia (for the uterus being heated attracts the moisture and the passages are opened), so this happens also with birds; the residual matter corresponding to the catamenia advances a little at a time, and is not discharged externally, because its amount is small and the uterus is high up by the hypozoma, but trickles together into the uterus itself. For as the embryo of the vivipara grows by means of the umbilical cord, so the egg grows through this matter flowing to it through the uterus. For when once the hens have been trodden, they all continue to have eggs almost without intermission,[3] though very small ones.[4] Hence some are wont to speak of wind-eggs as not coming into being independently but as mere relics from a previous impregnation. But this is a false view, for sufficient observations have been made of their arising without impregnation in chickens and goslings. Also the female partridges which are taken out to act as decoys, whether they have ever been impregnated or not, immediately on smelling the male and hearing his call, become filled with eggs in the latter case and lay them in the former.[5] The reason why this happens is the same as in men and quadrupeds, for if their bodies chance to be in rut they emit semen at the mere sight of the female or at a slight touch. And such birds are of a lascivious and fertile nature, so that the impulse they need is but small when they are in

[1] Reading *ἑώραται τὸ συμβαῖνον* for *ἑώραται περὶ τοὺς ἐρυθρίνους συμβαῖνον*. That the erythrini have nothing to do here was pointed out by Didot; they seem to have drifted hither from *H. A.* vi. 567a 27.

[2] *H. A.* 567a 30, where *φοξῖνοι*, whatever they were, are said to have *κυήματα* as soon as they are hatched out *ὡς εἰπεῖν*.

[3] This is stated as a proof that the drawing down of the matter is due to copulation.

[4] i. e. they are small if the treading be not continued.

[5] 'A true hunter's tale!' AW.

this excited condition, and the secreting activity takes place quickly in them, wind-eggs forming in the unimpregnated and the eggs in those which have been impregnated growing and reaching perfection swiftly.

Among creatures that lay eggs externally birds produce their egg perfect, fish imperfect, but the eggs of the latter complete their growth outside as has been said before. The reason is that the fish kind is very fertile; now it is impossible for many eggs to reach completion within the mother and therefore they lay them outside. They are quickly discharged, for the uterus of externally oviparous fishes is near the generative passage. While the eggs of birds are two-coloured, those of all fish are one-coloured. The cause of the double colour may be seen from considering the power of each of the two parts, the white and the yolk. For the matter of the egg is secreted from the blood [no bloodless animal lays eggs],[1] and that the blood 751b
is the material of the body has been often said already. The one part, then, of the egg is nearer the form[2] of the animal coming into being, that is the hot[3] part; the more earthy part gives the substance of the body and is further removed. Hence in all two-coloured eggs the animal receives the first principle of generation from the white (for the vital principle is in that which is hot), but the nutriment from the yolk.[4] Now in animals of a hotter nature the part from which the first principle arises is separated off from the part from which comes the nutriment, the one being

[1] These words must be spurious, as AW. point out, for A. says over and over again that many invertebrates lay eggs. (In their case the matter would be secreted from the fluid analogous to blood.)

[2] i.e. is more nearly related to the principle which gives the form. A. gives this honour to the white, because the more fluid is hotter than the more solid. Omitting μορίων. [3] Or white.

[4] In reality the bird is developed from a spot on the surface of the yolk, the 'blastoderm' or 'cicatricula'. In development it absorbs both the white and the yolk. Here A. retrogrades, for at least one of his predecessors had said that 'the bird is formed from the yolk; the white gives growth and nourishment; this is plain to every one who has paid attention to it.' The last remark looks as if there had been disputes on the subject (Hippocrates, vol. i, p. 420). From 752b 25 it seems that Alcmaeon of Crotona perhaps first stated the Hippocratic view. The great Harvey (*Exercitationes de Generatione*, xvii) seeks to save A.'s credit on this point, I fear in vain.

white and the other yellow, and the white and pure is always more than the yellow and earthy; but in the moister and less hot the yolk is more in quantity and more fluid. This is what we find in lake birds, for they are of a moister nature and are colder than the land birds, so that the so-called 'lecithus' or yolk in the eggs of such birds is large and less yellow[1] because the white is less separated off from it. But when we come to the ovipara which are both of a cold nature and also moister (such is the fish kind) we find the white not separated at all because of the small size of the eggs and the quantity of the cold and earthy matter;[2] therefore all fish eggs are of one colour, and white compared with yellow, yellow compared with white. Even the wind-eggs of birds have this distinction of colour, for they contain that out of which will come each of the two parts, alike that whence arises the principle of life and that whence comes the nutriment; only both these are imperfect and need the influence of the male in addition; for wind-eggs become fertile if impregnated by the male within a certain period. The difference in colour, however, is not due to any difference of sex, as if the white came from the male, the yolk from the female; both on the contrary come from the female, but the one is cold, the other hot. In all cases then where the hot part is considerable it is separated off, but where it is little it cannot be so; hence the eggs of such animals, as has been said, are of one colour. The semen of the male only puts them into form;[3] and therefore at first the egg in birds appears white and small, but as it advances[4] it is all yellow as more of the sanguineous material is continually mixed with it; finally as the hot part is separated the white takes up a position all round
752a it and equally distributed on all sides, as when a liquid

[1] This is certainly true of ducks' eggs; I have found no more information on the point.

[2] I suppose A. thought the earthy nature of the yolk caused it to condense in the middle of the white as the earth itself was in the centre of the universe. The white is really deposited round the yolk in its passage through the oviduct, and so far from being heavier, as he seems to think, the yolk has less specific gravity than the white.

[3] *συνέστησε.*

[4] i. e. down the oviduct.

boils; for the white is naturally liquid and contains in itself the vital heat;[1] therefore it is separated off all round, but the yellow and earthy part is inside. And if we enclose many eggs together in a bladder or something of the kind and boil them over a fire so as not to make the movement of the heat quicker than the separation[2] of the white and yolk in the eggs, then the same process takes place in the whole mass of the eggs as in a single egg, all the yellow part coming into the middle and the white surrounding it.

We have thus stated why some eggs are of one colour and others of two.

2 The principle of the male is separated off in eggs at the point where the egg is attached to the uterus,[3] and the reason why the shape of two-coloured eggs is unsymmetrical, and not perfectly round but sharper at one end, is that the part of the white in which is contained this principle must differ from the rest.[4] Therefore the egg is harder at this point than below,[5] for it is necessary to shelter and protect

[1] 'Boiling takes place when a liquid is aerated by heat' (*de Respir.* 479b 31), and so the white is aerated by the vital heat in it and swells up all round the yolk, which being earthy cannot 'boil' in the same way. By 'boiling' A. does not necessarily imply anything like evaporation at boiling-point; his ideas about temperature were vague enough.

[2] I have translated this word for word, not being quite sure of the exact sense. I think it means that the movement imparted by the heat must not be imparted too quickly (that is, the temperature must not be raised too fast), so as to stop the separation, as would happen if the eggs were hard-boiled in a few minutes. The parallel passage, *H. A.* vi. 560a 30, does not help.

[3] i. e. the cicatricula, the spot from which development proceeds, is at the end of the egg which is attached to the ovary. A. supposes this to be the sharper end. But the cicatricula is not at either end of the egg, but at a point upon the equator of the yolk. See Addenda. Nor can we say which part of the yolk in a mature egg corresponds to the part attached to the ovary at the moment of separation.

[4] The text looks decidedly corrupt, nor is any real reason given for the shape of the egg. Gaza does not translate the words τοῦ λευκοῦ, and Bekker's stopping makes nonsense.

[5] 'Below' means the blunter end, which A. supposes to be the lower in the passage downwards, rightly according to Newton, *Dictionary of Birds*, *s. vv.*, 'Eggs, Embryology.' This was quite unknown by modern writers till recently; Dalton, e.g. in his *Physiology* (5th ed. 1871), assumes as a matter of course that the sharp end of the egg is foremost.

this principle. And this is why the sharp end of the egg comes out of the hen later than the blunt end; for the part attached to the uterus comes out later, and the egg is attached at the point where is the said principle, and the principle is in the sharp end. The same is the case also in the seeds of plants; the principle of the seed is attached sometimes to the twig, sometimes to the husk, sometimes to the pericarp.[1] This is plain in the leguminous plants, for where the two cotyledons[2] of beans and of similar seeds are united, there is the seed attached to the parent plant, and there is the principle of the seed.

A difficulty may be raised about the growth of the egg; how is it derived from the uterus? For if animals derive their nutriment through the umbilical cord, through what do eggs derive it? They do not, like a scolex, acquire their growth by their own means.[3] If there is anything by which they are attached to the uterus, what becomes of this when the egg is perfected? It does not come out with the egg as the cord does with animals; for when its egg is perfected the shell forms all round it. This problem is rightly raised, but it is not observed that the shell is at first only a soft membrane, and that it is only after the egg is perfected that it becomes hard and brittle;[4] this is so nicely adjusted that it is still soft when it comes out (for otherwise it would cause pain in laying), but no sooner has it come out than it is fixed hard by cooling, the moisture quickly evaporating
752b because there is but little of it, and the earthy part remaining. Now at first a certain part of this membrane at the sharp end of eggs resembles an umbilical cord, and projects

The blunt end is the softer, as A. says; this is because the young bird is to break its way out there.

[1] The germinal vesicle from which the young plant is developed is near the point of attachment in the Leguminosae, and generally speaking in other plants also. The seed is attached sometimes to the 'twig', as the acorn (which A. would have called a 'seed'), sometimes to a 'husk' (κέλυφος), as a bean to its pod, sometimes to the pericarp, as the pip of an apple.

[2] τὸ δίθυρον, the cotyledons rather than the seed-coats, thinks Prof. Oliver, to whom I am deeply indebted for help on this passage.

[3] See note on chap. 9, *ad fin.*

[4] It is true that the outer membrane is soft at first, but it is made hard and brittle by the addition of calcareous matter *before* it is discharged.

like a pipe from them while they are still small. It is plainly visible in small aborted eggs, for if the bird be drenched with water or suddenly chilled in any other way and cast out the egg too soon, it appears still[1] sanguineous and with a small tail[2] like an umbilical cord running through it. As the egg becomes larger this[3] is more twisted round and becomes smaller, and when the egg is perfected this end is the sharp end. Under this is the inner membrane which separates the white and the yolk from this.[4] When the egg is perfected, the whole of it is set free, and naturally the umbilical cord[5] does not appear, for it is now the extreme end of the egg itself.

The egg is discharged in the opposite way from the young of vivipara; the latter are born head-first, the part where is the first principle leading,[6] but the egg is discharged as it were feet first; the reason of this being what has been stated, that the egg is attached to the uterus at the point where is the first principle.

The young bird is produced out of the egg by the mother's incubating and aiding the concoction, the creature developing out of part of the egg, and receiving growth and completion from the remaining part. For Nature not only places the material of the creature in the egg but also the nourishment sufficient for its growth; for since the mother bird cannot perfect her young within herself she produces the nourishment in the egg along with it. Whereas the nourishment, what is called milk, is produced for the

[1] 'Still' because A. thinks the egg is formed from the hen's blood.

[2] στόλον ὀμφαλώδη. Fabricius ab Aquapendente, approved by Harvey (see his third *Exercitatio*), explained this as the *pedunculus* by which the egg hangs from the ovary before it is discharged from its follicle. But there are various difficulties fatal to this view. AW. are plainly right in supposing the στόλος to be the *chalazae* (say rather the hinder one of the two chalazae, for A. obviously does not speak of both here). When A. says 'through it', he must mean 'from the vitelline membrane to the hinder end through the white'.

[3] i.e. the chalaza takes on more and more a spiral shape, which is true; but I do not understand why it is said to become smaller.

[4] i.e. the membrane which lies outside the white and therefore separates the white plus the yolk inside it from the sharp end of the shell.

[5] Or rather what corresponds to it.

[6] i.e. the upper part, in which is the heart, is presented first.

young of vivipara in another part, in the breasts, Nature does this for birds in the egg. The opposite, however, is the case to what people think and what is asserted by Alcmaecon of Crotona. For it is not the white that is the milk, but the yolk, for it is this that is the nourishment of the chick, whereas they think it is the white because of the similarity of colour.[1]

The chick then, as has been said, comes into being by the incubation of the mother;[2] yet if the temperature of the season is favourable, or if the place in which the eggs happen to lie is warm, the eggs are sufficiently concocted without incubation, both those of birds[3] and those of oviparous quadrupeds. For these all lay their eggs upon the ground, where they are concocted by the heat in the earth. Such oviparous quadrupeds as do visit their eggs and incubate do so rather for the sake of protecting them than of incubation.[4]

753a The eggs of these quadrupeds are formed in the same way as those of birds, for they are hard-shelled and two-coloured, and they are formed near the hypozoma as are those of birds, and in all other respects resemble them both internally and externally, so that the inquiry into their causes is the same for all. But whereas the eggs of quadrupeds are hatched out by the mere heat of the weather owing to their strength, those of birds are more exposed to destruction and need the mother-bird. Nature seems to wish to implant in animals a[5] special sense of care for their young: in the inferior animals this lasts only to the

[1] As already observed, both yolk and white serve for nutrition, the only non-nutritive part being a mere speck on the yolk.

[2] In some birds (even of those known to A., as the ostrich) the male does the incubation, and some (which he did not know, the Australian Megapodiidae or brush-turkeys) do not incubate at all.

[3] This happens to be true of the Megapodiidae, but is not true of any bird known to A. Perhaps he thought, like the author of *Job*, that the ostrich did not incubate.

[4] A. means turtles and crocodiles, which bury their eggs in the sand and in some cases sleep over them, in others keep near to protect them; he is quite right in saying that they do not, strictly speaking, incubate. (The males of some frogs also look after their eggs; some serpents are the only reptiles which truly incubate, and they are not quadrupeds.) Cf. *H. A.* v. 33.

[5] Omitting τήν.

moment of giving birth to the incompletely developed animal; in others it continues till they are perfect; in all that are more intelligent, during the bringing up of the young also. In those which have the greatest portion in intelligence we find familiarity and love shown also towards the young when perfected, as with men and some quadrupeds; with birds we find it till they have produced and brought up their young, and therefore if the hens do not incubate after laying they get into worse condition,[1] as if deprived of something natural to them.

The young is perfected within the egg more quickly in sunshiny weather,[2] the season aiding in the work, for concoction is a kind of heat. For the earth aids in the concoction by its heat, and the brooding hen does the same, for she applies[3] the heat that is within her. And it is in the hot season, as we should expect, that the eggs are more apt to be spoilt and the so-called 'uria' or rotten eggs are produced;[4] for just as wines turn sour in the heats from the sediment rising (for this is the cause of their being spoilt), so is it with the yolk in eggs, for the sediment and yolk are the earthy part in each case, wherefore the wine becomes turbid when the sediment mixes with it, and the like applies to the eggs that are spoiling because of the yolk. It is natural then that such should be the case with the birds that lay many eggs, for it is not easy to give the fitting amount of heat to all, but (while some have too little) others have too much and this makes them turbid, as it were by putrefaction. But this happens none the less with the birds of prey though they lay few eggs, for often one of the two becomes rotten, and the third practically always,[5] for being of a hot nature they make the moisture in the eggs to overboil so to say. For the nature of the white is opposed to that of the yolk; the yolk congeals in frosts but liquefies on heating, and 753b

[1] This is true (AW.).

[2] Whatever the weather, the chick emerges on the same day.

[3] Reading προσέχει.

[4] Such eggs occur rarely owing to some diseased condition, whether more often in hot weather I cannot discover.

[5] Among many other absurd legends about the eagle, it was said to lay three eggs, hatch two, and rear one; the same was said of the hawk (D'Arcy Thompson's *Glossary of Greek Birds*, p. 5).

therefore it liquefies on concoction in the earth or by reason of incubation,[1] and becoming liquid serves as nutriment for the developing chick. If exposed to heat and roasted it does not become hard, because though earthy in nature it is only so in the same way as wax is; accordingly on heating too much the eggs become watery and rotten, [if they be not from a liquid residue].[2] The white on the contrary is not congealed by frost but rather liquefies (the reason of which has been stated before),[3] but on exposure to heat becomes solid. Therefore being concocted in the development of the chick it is thickened. For it is from this that the young is formed (whereas the yolk turns to nutriment) and it is from this that the parts derive their growth as they are formed one after another. This is why the white and the yolk are separated by membranes, as being different in nature. The precise details of the relation of the parts to one another both at the beginning of generation and as the animals are forming, and also the details of the membranes and umbilical cords, must be learnt from what has been written in the *Enquiries*;[4] for the present investigation it is sufficient to understand this much clearly, that, when the heart has been first formed and the great blood-vessel has been marked off from it, two umbilical cords run from the vessel, the one to the membrane which encloses the yolk, the other to the membrane resembling a chorion which surrounds the whole embryo; this latter runs round on the inside of the membrane of the shell.[5] Through the one of

[1] AW. jeer at this and talk of hard-boiled eggs, but it is a fact that the yolk does liquefy during incubation; see note on 753[b] 25.

[2] The words in brackets are corrupt and unintelligible.

[3] I do not know where, but cf. ii. 2, *ad init.*

[4] *H. A.* vi. 3. But there is no more there on the subject than in the present work. Does γεγραμμένων perhaps mean 'drawings'? Rather, I think, the present passage is an early note, written before the whole work had been expanded, and still retained when the reference to the *H. A.* had become superfluous.

[5] This description seems to be that of a chick of about the sixth to the tenth day. The great blood-vessel is the dorsal aorta running from the heart towards the tail. The 'umbilical cords' are (1) the 'umbilical stalk' by which the yolk-sac hangs from the embryo, (2) the stalk of the allantois, a sac which, growing out from the embryo, 'lies close under the shell' (Foster and Balfour, p. 279). But the description of these as 'running from the vessel' is hardly correct.

these the embryo receives the nutriment from the yolk, and the yolk becomes larger, for it becomes more liquid by heating.[1] This is because the nourishment, being of a material character in its first form, must become liquid before it can be absorbed, just as it is with plants, and at first this embryo, whether in an egg or in the mother's uterus, lives the life of a plant, for it receives its first growth and nourishment by being attached to something else.

The second umbilical cord runs to the surrounding chorion. For we must understand that, in the case of animals developed in eggs, the chick has the same relation to the yolk as the embryo of the vivipara has to the mother so long as it is within the mother (for since the nourishment of the embryo of the ovipara is not completed within the mother, the embryo takes part of it away from her).[2] So also the relation of the chick to the outermost membrane, the sanguineous one, is like that of the mammalian embryo to the uterus.[3] At the same time the egg-shell surrounds 754a
both the yolk and the membrane analogous to the uterus, just as if it should be put round both the embryo itself and the whole of the mother, in the vivipara. This is so because the embryo must be in the uterus and attached to the mother. Now in the vivipara the uterus is within the mother, but in the ovipara it is the other way about, as if one should say that the mother was in the uterus, for that

[1] Both these statements are correct. On the seventh day 'the yellow yolk has become quite fluid, and its bulk has increased owing to its having absorbed much of the rapidly diminishing white of the egg' (Newton's *Dictionary of Birds*, p. 211). These observations are admirable, though the reasons given are wrong.

[2] i.e. when the embryo in the egg leaves the mother, it takes away the yolk with it. This yolk corresponds to the nourishment the mammalian embryo continues to receive while remaining in the mother.

[3] The allantois of the chick can scarcely be compared to the uterus; the allantois serves mainly for respiration in both birds and mammals. Naturally A. knew nothing of the true mammalian homology to the yolk of birds, but how profound his insight is on this subject also may be seen from the following quotation from Foster and Balfour, p. 327: 'It is almost certain that the mammalia are descended from ancestors, the embryos of which had large yolk-sacs, but that the yolk has become reduced in quantity owing to the nutriment received from the wall of the uterus taking the place of that originally supplied by the yolk.'

which comes from the mother, the nutriment, is the yolk.[1] The reason is that the process of nourishment is not completed within the mother.

As the creature grows the umbilicus running to the chorion collapses first,[2] because it is here that the young is to come out;[3] what is left of the yolk, and the umbilical cord running to the yolk, collapse later. For the young must have nourishment as soon as it is hatched: it is not nursed by the mother and cannot immediately procure its nourishment for itself; therefore the yolk enters within it along with its umbilicus and the flesh grows round it.

This then is the manner in which animals produced from perfect[4] eggs are hatched in all those, whether birds or quadrupeds, which lay the egg with a hard shell.[5] These details are plainer in the larger creatures; in the smaller they are obscure because of the smallness of the masses concerned.

The class of fishes is also oviparous. Those among them 3
which have the uterus low down lay an imperfect egg for the reason previously given,[6] but the so-called 'selache' or cartilaginous fishes produce a perfect egg within themselves but are externally viviparous except one which they call the 'frog':[7] this alone lays a perfect egg externally. The reason is the nature of its body, for its head is many times as large as the rest of the body and is spiny and very rough. This is also why it does not receive its young again within itself nor produce them alive to begin with, for as the

[1] If the yolk stand for the mother, the allantois for the uterus, then the mother is within the uterus!

[2] This is not correct; the yolk-sac with its stalk is drawn into the abdominal cavity of the chick on the nineteenth day, but the allantois shrivels up and the umbilicus closes on the twentieth or thereabouts (Foster and Balfour, pp. 280, 303).

[3] This seems quite unintelligible; even if it means that the chick cuts its way through the allantois (which is true), still that seems no reason for the allantoic stalk collapsing first.

[4] As contrasted with the imperfect eggs of fish.

[5] Omit *τό* before *σκληρόδερμον*.

[6] i. 718^{b} 8.

[7] On the frog-fish see note on 749^{b} 23. Of the cartilaginous or elasmobranch fishes (sharks and rays, &c.) some lay eggs and others are viviparous; A. has generalized too hastily.

size and roughness of the head prevents their entering so it would prevent their exit. And while the egg of the cartilaginous fishes is soft-shelled (for they cannot harden and dry[1] its circumference, being colder than birds), the egg of the frog-fish alone is solid and firm to protect it outside, but those of the rest are of a moist and soft nature, for they are sheltered within and by the body of the mother. 754b

The young are produced from the egg in the same way both with those externally perfected (the frog-fishes) and those internally, and the process in these eggs is partly similar to, partly different from that in birds' eggs. In the first place they have not the second umbilicus which runs to the chorion[2] under the surrounding shell. The reason of this is that they have not the surrounding shell, for it is no use to them since the mother shelters them, and the shell is a protection to the eggs against external injury between laying and hatching out. Secondly, the process in these also begins on the surface of the egg but not where it is attached to the uterus, as in birds, for the chick is developed from the sharp end and that is where the egg was attached. The reason is that the egg of birds is separated from the uterus before it is perfected, but in most though not all cartilaginous fishes the egg is still attached to the uterus when perfect.[3] While the young develops upon the surface the egg is consumed by it just as in birds and the other animals detached from the uterus, and at last the umbilicus of the now perfect fish is left attached to the uterus.[4] The like is the case with all those whose eggs are detached from the uterus, for in some of them the egg is so detached when it is perfect.

The question may be raised why the development of birds and cartilaginous fishes differs in this respect. The reason is that in birds the white and yolk are separate, but fish eggs are one-coloured, the corresponding matter being

[1] Reading *σκληρύνειν καὶ ξηραίνειν*.

[2] Fish have a yolk-sac and the stalk attached to it, the 'first umbilicus' of A., but they have no allantois and consequently no 'second umbilicus'.

[3] Qu. *τέλειον* ⟨*ὄν*⟩ ?

[4] A. is thinking of *Mustelus laevis*, as we shall see directly.

completely mixed, so that there is nothing to stop the first principle being at the opposite end,[1] for the egg is of the same nature both at the point of attachment and at the opposite end, and it is easy[2] to draw the nourishment from the uterus by passages running from this principle.[3] This is plain in the eggs which are not detached, for in some of the cartilaginous fish the egg is not detached from the uterus, but is still connected with it as it comes downwards with a view to the production of the young alive; in these the young fish when perfected is still connected by the umbilicus to the uterus when the egg has been consumed.[4] From this it is clear that previously also, while the egg was still round the young, the passages[5] ran to the uterus.[6] This happens as we have said in the 'smooth hound'.[7]

In these respects and for the reasons given the development of cartilaginous fishes differs from that of birds, but
755a otherwise it takes place in the same way. For they have the one umbilicus in like manner as that of birds connecting with the yolk,—only in these fishes it connects with the whole egg (for it is not divided into white and yolk but all one-coloured),—and get their nourishment from this, and as it is being consumed the flesh in like manner encroaches upon and grows round it.[8]

Such is the process of development in those fish that produce a perfect egg within themselves but are externally viviparous.

[1] One may well ask, however, what there is to stop this in birds either. [2] Reading ῥᾴδιον.

[3] i.e. by blood-vessels running from the germinating vesicle through the egg to the uterus, corresponding to the umbilical cord of mammals and the allantoic stalk in birds.

[4] i.e. when the egg has been altogether taken up into the young fish.

[5] Blood-vessels. [6] Through the egg.

[7] *Mustelus laevis.* In this shark the young are connected with the uterus by a kind of placenta. This extraordinary fact remained unknown to modern science till Müller reaffirmed it in 1840.

[8] After the fish has left the egg the remains of the yolk-sac are still attached to it below; in course of time (with many fish) 'the abdominal walls gradually extend over it and crowd it back into the abdomen' (Dalton's *Physiology*, 5th ed., p. 617). The words might be translated from this passage of A.

4 Most of the other fish[1] are externally oviparous, all laying an imperfect egg except the frog-fish;[2] the reason of this exception has been previously stated,[3] and the reason also why the others lay imperfect eggs.[4] In these also the development from the egg runs on the same lines as that of the cartilaginous and internally oviparous fishes, except that the growth is quick and from small beginnings and the outside of the egg is harder. The growth of the egg[5] is like that of a scolex, for those animals which produce a scolex give birth to a small thing at first and this grows by itself and not through any attachment to the parent. The reason is similar to that of the growth of yeast, for yeast also grows great from a small beginning as the more solid part liquefies and the liquid is aerated. This is effected in animals[6] by the nature of the vital heat, in yeasts by the heat of the juice commingled with them. The eggs then grow of necessity through this cause (for they have in them superfluous yeasty matter), but also for the sake of a final cause, for it is impossible for them to attain their whole growth in the uterus because these animals have so many eggs. Therefore are they very small when set free and grow quickly,[7] small because the uterus is narrow for the multitude of the eggs, and growing quickly that the race may not perish, as it would if much of the time required for the whole development were spent in this growth; even as it is most of those laid are destroyed before hatching. Hence the class of fish is prolific, for Nature makes up for the destruction by numbers. Some fish actually burst because of the size of the eggs, as the fish called 'belonė',[8] for its eggs are

[1] The bony fishes or teleosteans, comprising all the ordinary fish.

[2] The frog-fish here seems to be counted among the teleosteans, though before he was reckoned to be cartilaginous.

[3] 754a 26.

[4] i. 718b 8.

[5] A. thinks erroneously that the egg of a teleostean grows after oviposition before it hatches the young fish. For the scolex see on 758a 31.

[6] Qu. read ᾠοῖς for ζῴοις?

[7] The egg swells up by imbibing water to many times its size in a very short time.

[8] Some kind of pipe-fish, probably *Syngnathus acus*, called *belonė* from its shape. In many of the Syngnathidae the males receive the eggs in a pouch and retain them there till they are hatched; the

large instead of numerous, what Nature has taken away in number being added in size.

So much for the growth of such eggs and its reason.

755b A proof that these fish also[1] are oviparous is the fact that even viviparous fish, such as the cartilaginous, are first internally oviparous, for hence it is plain that the whole class of fishes is oviparous. Where, however, both sexes exist and the eggs are produced in consequence of impregnation,[2] the eggs do not arrive at completion unless the male sprinkle his milt upon them. Some erroneously assert that all fish are female except in the cartilaginous fishes, for they think that the females of fish differ from what are supposed to be males only in the same way as in those plants where the one bears fruit but the other is fruitless, as olive and oleaster, fig and caprifig. They think the like applies to fish except the cartilaginous, for they do not dispute the sexes in these. And yet there is no difference in the males of cartilaginous fishes and those belonging to the oviparous class in respect of the organs for the milt,[3] and it is manifest that semen can be squeezed out of males of both classes at the right season. The female also has a uterus. But if the whole class were females and some of them[4] unproductive (as with mules in the class of bushy-tailed animals),[5] then not only should those which lay eggs have a uterus but also the others, only the uterus of the latter should be different

pouch then bursts and the young escape. A. evidently took the male for the female. Cf. *H. A.* vi. 567b 22, from which passage it appears that A. knew that this pouch is distinct from the 'uterus' and that the fish is none the worse for 'bursting'.

[1] Apparently the teleosteans are meant, but it has been assumed that they are oviparous throughout the work. This passage perhaps is a relic of an early discussion of the subject retained here out of place.

[2] A. erroneously supposes copulation to take place in teleosteans generally before oviposition, in spite of his knowing that the eggs have to be influenced by the male element after it.

[3] These are the 'spermatic passages' of i. 716b 17, in fact the testes, though A. declines to call them so.

[4] The supposed males.

[5] The 'bushy-tailed animals' are the genus *Equus*. Cf. Suidas s.v. *μώνυχα*. I transpose the parenthetic words hither from the end of the sentence, where they were absurd.

from that of the former. But, as it is, some of them have organs for milt and others have a uterus, and this distinction obtains in all except two, the erythrinus and the channa,[1] some of them having the milt organs, others a uterus. The difficulty which drives some thinkers to this conclusion is easily solved if we look at the facts. They say quite correctly[2] that no animal which copulates produces many young, for of all those that generate from themselves perfect animals or perfect eggs none is prolific on the same scale as the oviparous fishes, for the number of eggs in these is enormous. But they had overlooked the fact that fish-eggs differ from those of birds in one circumstance. Birds and all oviparous quadrupeds, and any of the cartilaginous fish that are oviparous,[3] produce a perfect egg, and it does not increase outside of them, whereas the eggs of fish are imperfect and do so complete their growth. Moreover the same thing applies to cephalopods also and crustacea,[4] yet these animals are actually seen copulating, for their union lasts a long time, and it is plain in these cases that the one is male and the other has a uterus. Finally, it would be strange if this distinction[5] did not 756a exist in the whole class,[6] just as male and female in all the vivipara. The cause of the ignorance of those who make this statement is that the differences in the copulation and generation of various animals are of all kinds and not obvious, and so, speculating on a small induction, they think the same must hold good in all cases.

So also those who assert that conception in female fishes is caused by their swallowing the semen of the male have

[1] For the erythrinus see on ii. 741a 36. The channa is supposed to be *Serranus scriba* (AW., p. 34).

[2] It is obvious that their argument is not correctly repeated here; it should be something like this: Mammals, birds, and reptiles copulate and produce few at a birth. Fish produce many. Therefore fish do not copulate. The correctness does not go beyond the premisses.

[3] The frog-fish is meant.

[4] i. e. they lay very many eggs.

[5] Lit. *force*.

[6] Read παντὶ τῷ γένει or τῷ π. γ. Without the article the words could only mean *every* class, which would be absurd, for A. believes whole classes to have no sex distinction. Even as it is he thinks some fish are hermaphrodite. The class here seems to mean the ovipara.

not observed certain points when they say this. For the males have their milt and the females their eggs at about the same time of year, and the nearer the female is to laying the more abundant and the more liquid is the milt formed in the male. And just as the increase of the milt in the male and of the roe in the female takes place at the same time, so is it also with their emission, for neither do the females lay all their eggs together, but gradually, nor do the males emit all the milt at once. All these facts are in accordance with reason. For just as the class of birds in some cases has eggs without impregnation, but few and seldom, impregnation being generally required, so we find the same thing, though to a less degree, in fish. But in both classes these spontaneous eggs are infertile unless the male, in those kinds where the male exists, shed his fluid upon them. Now in birds this must take place while the eggs are still within the mother, because they are perfect when discharged, but in fish, because the eggs are imperfect and complete their growth outside the mother in all cases, those outside are preserved by the sprinkling of the milt over them, even if they come into being by impregnation, and here it is that the milt of the males is used up. Therefore it comes down the ducts and diminishes in quantity at the same time as this happens to the eggs of the females, for the males always attend them, shedding their milt upon the eggs as they are laid. Thus then they are male and female, and all of them copulate (unless in any kind[1] the distinction of sex does not exist), and without the semen of the male no such animal comes into being.

What helps in the deception is also the fact that the union of such fishes is brief, so that it is not observed even by many of the fishermen, for none of them ever watches anything of the sort for the sake of knowledge. Nevertheless their copulation has been seen, for fish [when the tail part
756^{b} does not prevent it[2]] copulate like the dolphins by throw-

[1] i. e. certain sea-perch.

[2] Read ὅσοις ⟨μή⟩; cf. *H.A.* v. 540^{b} 10, but that passage shows that the words are here interpolated, for there they make sense and here they do not.

ing themselves alongside of one another.[1] But the dolphins take longer to get free again, whereas such fishes do so quickly. Hence, not seeing this, but seeing the swallowing of the milt and the eggs, even the fishermen repeat the same simple tale, so much noised abroad, as Herodotus the story-teller,[2] as if fish were conceived by the mother's swallowing the milt,—not considering that this is impossible. For the passage which enters by way of the mouth runs to the intestines, not to the uterus, and what goes into the intestines must be turned into nutriment, for it is concocted; the uterus, however, is plainly full of eggs, and from whence did they enter it?

6 A similar story is told also of the generation of birds. For there are some who say that the raven and the ibis unite at the mouth, and among quadrupeds that the weasel brings forth its young by the mouth[3]; so say Anaxagoras and some of the other physicists, speaking too superficially and without consideration. Concerning the birds, they are deceived by a false reasoning, because the copulation of ravens is seldom seen, but they are often seen uniting with one another with their beaks, as do all the birds of the raven family; this is plain with domesticated jackdaws. Birds of the pigeon kind do the same, but, because they also plainly copulate, therefore they have not had the same legend told of them. But the raven family is not amorous, for they are birds that produce few young, though this bird also has been seen copulating before now. It is a strange thing, however, that these theorists do not ask themselves how the semen enters the uterus through the intestine, which always concocts whatever comes into it, as the nutriment; and these birds have a uterus like others, and eggs are found in them near the hypozoma. And the weasel has a uterus in like manner

[1] Viviparous teleosteans, it is supposed, must copulate, but there are very few viviparous species.

[2] Hdt. ii. 93.

[3] So Agnes in *L'École des femmes* (Act I, Sc. i) inquired,

Avec une innocence à nulle autre pareille,
Si les enfants qu'on fait se faisaient par l'oreille.

to the other quadrupeds: by what passage is the embryo to get from it to the mouth? But this opinion has arisen because the young of the weasel are very small like those of the other fissipeds, of which we shall speak
757a later, and because they often carry the young about in their mouths.

Much deceived also are those who make a foolish statement about the trochus[1] and the hyena.[2] Many say that the hyena, and Herodorus the Heracleot says that the trochus, has two pudenda, those of the male and of the female, and that the trochus impregnates itself but the hyena mounts and is mounted in alternate years. This is untrue, for the hyena has been seen to have only one pudendum, there being no lack of opportunity for observation in some districts, but hyenas have under the tail a line like the pudendum of the female. Both male and female have such a mark, but the males are taken more frequently; this casual observation has given rise to this opinion. But enough has been said of this.

Touching the generation of fish, the question may be 7
raised, why it is that in the cartilaginous fish neither the females are seen discharging[3] their eggs nor the males their milt, whereas in the non-viviparous fishes this is seen in both sexes. The reason is that the whole cartilaginous class do not produce much semen, and further the females have their uterus near the hypozoma.[4] For the males and females of the one class of fish differ from the males and females of the other class in like manner, for the carti-

[1] It is impossible to guess what this animal may have been.

[2] This would be the striped hyena (*H. striata*). The story told of it probably arose from the fact that hyenas have 'a large post-anal median glandular pouch, into which the largely developed anal scent glands pour their secretion' (Flower and Lydekker, *Mammals*, p. 541). Cf. *H. A.* vi. 32, where a more accurate statement is made than here. With regard to the greater number of males caught, A. says there that a hunter declared that out of eleven only one was female, but the records of the Zoological Society show that the sexes are about equal.

[3] This only means 'do not discharge'.

[4] And therefore the eggs are perfected internally.

laginous are less productive of semen.[1] But in the oviparous fish, as the females lay their eggs on account of their number, so do the males shed their milt on account of its abundance. For they have more milt than just what is required for copulation, as Nature prefers to expend the milt in helping to perfect the eggs, when the female has deposited them, rather than in forming them at first. For as has been said both further back and in our recent discussions, the eggs of birds are perfected internally but those of fish externally. The latter, indeed, resemble in a way those animals which produce a scolex, for the product discharged by them is still more imperfect than a fish's egg. It is the male that brings about the perfection of the egg both of birds and of fishes, only in the former internally, as they are perfected internally, and in the latter externally, because the egg is imperfect when deposited; but the result is the same in both cases.

In birds the wind-eggs become fertile,[2] and those pre- 757b
viously impregnated by one kind of cock change their nature to that of the later cock.[3] And if the eggs be behindhand in growth, then, if the same cock treads the hen again after leaving off treading for a time,[4] he causes them to increase quickly, not, however, at any period whatever of their development, but if the treading take place before the egg changes so far that the white begins to separate from the yolk. But in the eggs of fishes no such limit of time has been laid down, but the males shed their milt quickly upon them[5] to preserve them.[6] The reason is that these eggs are not two-coloured, and hence there is no such limit of time fixed with them as with those of birds. This fact is what we should expect, for by the time that the white and yolk are separated off from one another, the bird's

[1] This sentence should mean that both male and female elasmobranchs have less generative secretions than teleosteans.

[2] If impregnated in time.

[3] i.e. if afterwards the hen be trodden by a cock of another kind. See on i. 730a 8.

[4] Read ἂν διαλίπῃ τὴν ὀχείαν, ὅταν ὀχεύῃ or ὀχεύσῃ πάλιν.

[5] Reading ἐπιρραίνουσιν.

[6] For if this does not happen the eggs would perish.

egg already contains the principle that comes from the male parent[1] . . . for the male contributes to this.

Wind-eggs, then, participate in generation so far as is possible for them. That they should be perfected into an animal is impossible, for an animal requires sense-perception;[2] but the nutritive faculty of the soul is possessed by females as well as males, and indeed by all living things, as has been often said, wherefore the egg itself[3] is perfect only as the embryo of a plant, but imperfect as that of an animal. If, then, there had been no male sex in the class of birds, the egg would have been produced as it is in some fishes, if indeed there is any kind of fish of such a nature as to generate without a male; but it has been said of them before that this has not yet been satisfactorily observed.[4] But as it is both sexes exist in all birds, so that, considered as a plant, the egg is perfect, but in so far as it is not a plant it is not perfect, nor does anything else result from it; for neither has it come into being simply like a real plant nor from copulation like an animal.[5] Eggs, however, produced from copulation but already separated into white and yolk take after the first cock;[6] for they already contain both principles,[7] which is why they do not change again after the second impregnation.[8]

The young are produced in the same way also by the 8

[1] And therefore a cock cannot influence them any longer after this. The spermatozoon of the male fertilizes the egg of the female before the white has begun forming round it in its passage down the oviduct. Presumably the spermatozoon could not make its way through the white, and therefore a wind-egg which had got some way down could not be fertilized; at any rate impregnation does actually occur only in the upper part of the oviduct.

There seems to be here a gap in the text, which may be filled up as follows: '⟨But with fish there is no such separation of white and yolk, and the egg after being laid acquires further growth, and so needs help from the male,⟩ for the male contributes to this growth.'

[2] And this comes from the male parent.

[3] Read αὐτό for αὐτοῦ.

[4] ii. 741a 34, 37.

[5] Read φυτόν and ζῷον for φυτοῦ and ζῴου.

[6] Even if the hen be trodden by a second cock before the egg is laid.

[7] Not only the nutritive but also the sensitive soul.

[8] I have transposed the last clause to the end of this chapter from its place in the MSS. a few lines back. The whole of this chapter looks much mutilated.

cephalopoda, e.g. sepias and the like, and by the crustacea, e.g. carabi[1] and their kindred, for these also lay eggs in consequence of copulation, and the male has often been seen uniting with the female. Therefore those who say that all fish are female and lay eggs without copulation are 758a plainly speaking unscientifically from this point of view also. For it is a wonderful thing to suppose that the former animals lay eggs in consequence of copulation and that fish do not;[2] if again they were unaware of this,[3] it is a sign of ignorance. The union of all these creatures lasts a considerable time, as in insects, and naturally so, for they are bloodless and therefore of a cold nature.

In the sepias and calamaries or squids the eggs appear to be two, because the uterus is divided and appears double, but that of the poulps appears to be single.[4] The reason is that the shape of the uterus in the poulp is round in form and spherical, the cleavage being obscure when it is filled with eggs. The uterus of the carabi is also bifid. All these animals also lay an imperfect egg for the same reason as fishes. In the carabi and their like the females produce their eggs so as to keep them attached to themselves, which is why the side-flaps of the females are larger than those of the males, to protect the eggs; the cephalopoda lay them away from themselves. The males of the cephalopoda sprinkle their milt over the females,[5] as the male fish do over the eggs, and it becomes a sticky and glutinous mass, but in the carabi and their like nothing of the sort has been seen or can be naturally expected, for the egg is under the female and is hard-shelled. Both these eggs and those of the cephalopoda grow after deposition[6] like those of fishes.

[1] Properly the spiny lobsters, but A. uses the term also in a general way for all the macrurous crustacea.

[2] 'Wonderful,' because fish are higher in the scale of animals, and copulation is a characteristic of higher animals. But the great majority of fish are against A. for all that.

[3] i. e. of the copulation of cephalopoda and crustacea.

[4] See i. 3 and note. A. seems to have confused his notes on this point.

[5] I do not know what A. means by this.

[6] i. e. they swell up in the water.

The sepia while developing is attached to the egg by its front part, for here alone is it possible, because this animal alone has its front and back part pointing in the same direction. For the position and attitude of the young while developing you must look at the *Enquiries*.[1]

We have now spoken of the generation of other animals, 9
those that walk, fly, and swim; it remains to speak of insects and testacea according to the plan laid down.[2] Let us begin with the insects. It was observed previously that some of these are generated by copulation, others spontaneously, and besides this that they produce a scolex, and why this is so. For pretty much all creatures seem in a certain way to produce a scolex[3] first, since the most imperfect embryo is of such a nature: and in all animals, even the viviparous and those that lay a perfect egg, the first embryo grows in size while still undifferentiated into parts; now such is the nature of the scolex. After this stage some of the ovipara produce the egg in a perfect
758b condition, others in an imperfect, but it is perfected outside as has been often stated of fish. With animals internally viviparous the embryo becomes egg-like in a certain sense after its original formation, for the liquid is contained in a fine membrane, just as if we should take away the shell of the egg, wherefore they call the abortion of an embryo at that stage an 'efflux'.[4]

Those insects which generate at all generate a scolex,

[1] *H. A.* v. 550a 17–26, which was illustrated. A.'s description is correct; the young cephalopod seems to swallow the yolk. The body of these creatures is twisted round upon itself so that the head and the 'funnel' both point forward.

[2] Or 'the order of inquiry which has guided us'.

[3] The scolex is of two kinds, either an egg (though A. does not call it so) or a grub, which A. supposes to be produced from the mother without an egg. This grows for some time and then 'becomes an egg' by spinning its cocoon. Its escape from the cocoon corresponds to that of the chick from the egg or the mammalian embryo from its foetal membranes. A curious fancy! See Ogle, p. xxvii.

[4] The liquid is that within the chorion, not the *liquor amnii*, for A. thought the amnion kept the embryo apart from all liquid. If the egg-shell were removed, the white, corresponding to the liquid, would be contained in a membrane only, and so the egg would be parallel to the chorion and its contents.

and those which come into being spontaneously and not from copulation do so at first from a formation of this nature. I say that the former generate a scolex, for we must put down caterpillars [1] also and the product of spiders as a sort of scolex. And yet some even of these and many of the others may be thought to resemble eggs because of their round shape, but we must not judge by shapes nor yet by softness and hardness (for what is produced by some is hard [2]), but by the fact that the whole of them is changed into the body of the creature and the animal is not developed from a part of them.[3] All these products that are of the nature of a scolex, after progressing and acquiring their full size, become a sort of egg,[4] for the husk about them hardens and they are motionless during this period. This is plain in the scolex of bees and wasps and in caterpillars. The reason of this is that their nature, because of its imperfection, oviposits as it were before the right time, as if the scolex, while still growing in size, were a soft egg.[5] Similar to this is also what happens with all other insects which come into being without copulation in wool [6] and other such materials and in water. For all of them after the scolex-stage become immovable and their integument dries round them, and after this the latter bursts and there comes forth as from an egg an animal

[1] I think that A. really means the eggs from which caterpillars come; it is certain from the next sentence that he was acquainted with the eggs of insects. A. of course includes spiders among insects.

[2] e. g. the eggs of lobsters.

[3] This passage is very important for understanding the difference of scolex and egg. There is no essential distinction between them, but the former has no supply of nutriment with it while the latter has. So nowadays we speak of holoblastic and meroblastic yolks; the *whole* of the former develops into the body of the animal, in the latter only a fraction does so, the rest serving for nutriment.

[4] The pupa is like an egg because it is from it that the real insect is developed, the differentiation into its final parts taking place within it. Also its outside covering is like an egg-shell, and the insect is quiet within it as a bird within the shell.

It is worth observing that what are known in the trade as 'ants' eggs' are really the pupas of ants.

[5] i. e. the metamorphoses of the larva correspond to the development of the hen's egg in its very early stage before it is surrounded by the shell.

[6] Clothes-moths; see *H. A.* v. 32.

perfected in its second metamorphosis,[1] most of those which are not aquatic being winged.[2]

Another point is quite natural, which may be wondered at by many. Caterpillars at first take nourishment, but after this stage do so no longer, but what is called by some the chrysalis is motionless. The same applies to the scolex of wasps and bees, but after this comes into being the so-called nymph[3] . . . .

and have nothing of the kind. For an egg[4] is also of such a nature that when it has reached perfection it grows no more in size, but at first it grows and receives nourishment until it is differentiated and becomes a perfect egg.[5] Sometimes the scolex contains in itself the material from which 759a it is nourished and obtains such an addition to its size, e.g. in bees and wasps;[6] sometimes it gets its nourishment from outside itself, as caterpillars and some others.

It has thus been stated why such animals go through a double development and for what reason they become immovable again after moving. And some of them come into being by copulation, like birds and vivipara and most fishes, others spontaneously, like some plants.[7]

[1] Lit. the third generation, second by our way of counting.

[2] The aquatic are winged also as a rule, e. g. dragon-flies.

[3] i. e. the pupa of wasps and bees. The text is in some confusion, and there must be a considerable lacuna which may be filled up as follows: 'This nymph or pupa takes no nourishment. The difficulty then is that we have here three stages, in the first and third of which the animal is nourished, but not in the second. But this really corresponds to the development of other animals, for the egg also first grows to full size, then ceases growing and is motionless, and thirdly gives rise to a creature which again takes nourishment. Now in birds the mother supplies nourishment which makes the chick grow, and the egg of fish is able to grow after oviposition, but the product of an insect cannot get enough from the mother to develop in the same way because insects are so imperfect and have nothing of the kind. For, &c.'

[4] i. e. of birds or fish.

[5] So also a scolex grows until it gets to the egg stage, i. e. the pupa, but then grows no more in size.

[6] A. does not know then that these insects feed their larvae. I do not see how he supposed the larva to have anything in itself that could make it grow; it could not be anything like the yolk of an egg, for his criterion of the distinction between egg and scolex is just this, that only part of the egg becomes the animal, whereas the whole of the scolex does so. In chap. 11 he says the upper (i. e. front) part of a scolex grows by taking into itself material from the lower part. But this would only involve a rearrangement of the material, not an addition in size.

[7] e. g. mistletoe (i. 1, *ad fin.*).

10 There is much difficulty about the generation of bees.[1] If it is really true that in the case of some fishes there is such a method of generation that they produce eggs without copulation,[2] this may well happen also with bees, to judge from appearances. For they must (1) either bring the young brood[3] from elsewhere, as some say, and if so the young must either be spontaneously generated or produced by some other animal, or (2) they must generate them themselves, or (3) they must bring some and generate others, for this also is maintained by some, who say that they bring the young of the drones only. Again, if they generate them it must be either with or without copulation; if the former, then either (1) each kind[4] must generate its own kind, or (2) some one kind must generate the others, or (3) one kind must unite with another for the purpose (I mean for instance (1) that bees may be generated from the union of bees, drones from that of drones, and kings from that of kings, or (2) that all the others may be generated from one, as from what are called kings and

[1] The facts are briefly as follows. There are three kinds, (1) perfect males or drones, (2) perfect females or queens, (3) undeveloped females or workers. The queen lays eggs before she has been fertilized by a drone; this is known as parthenogenesis; these eggs produce drones. The fertilized eggs of the queen produce workers or queens, according to the way the grub is fed by the workers (some think that drones also may be sometimes produced from fertilized eggs). The workers also, in spite of being sexually undeveloped, do occasionally lay parthenogenetic eggs, which always produce drones.

It will be evident to any reader of this chapter that A. knew next to nothing about the truth. He does indeed hit upon the fact that workers may (but he says *always do*) parthenogenetically produce drones; he gets at this by hard thinking, and the whole chapter is greatly to his credit. But it is not to the credit of any modern writer that he should assert that the Greeks were well acquainted with the internal economy of the hive.

It seems clear that A. had never heard of the alleged generation of bees from the rotting carcases of oxen. He does indeed mention the theory of their spontaneous generation, but it is in connexion not with oxen but with flowers. On the so-called 'bugonia' or ox-birth of bees see C. R. Osten Sacken, *On the Oxen-born Bees of the Ancients*, Heidelberg, 1894, who shows that the legend arose from confusion of the bee with a dipterous insect resembling it, *Eristalis tenax*.

[2] The reference is here, again, to the sea-perch. The right reading of the first word in this sentence is, I think, εἴπερ, not ἐπεί.

[3] τὸν γόνον, i. e. the scoleces.

[4] The three kinds are queens, drones, and workers. When A. says *bees* he generally means the workers, and the queen he calls *king* or *leader*.

leaders, or (3) from the union of drones and bees, for some say that the former are male, the latter female, while others[1] say that the bees are male and the drones female). But all these views are impossible if we reason first upon the facts peculiar to bees and secondly upon those which apply more generally to other animals also.

For if they do not generate the young but bring them from elsewhere, then bees ought to come into being also, if the bees did not carry them off, in the places from which[2] the old bees carry the germs. For why, if new bees come into existence when the germs are transported, should they not do so if the germs are left there? They ought to do so just as much, whether the germs are spontaneously generated in the flowers or whether some animal generates them. And if the germs were of some other animal, then that animal ought to be produced from them instead of bees. Again, that they should collect honey[3] is reasonable, for it is their food, but it is strange that they should collect the young if they are neither their own offspring nor food. With what object should they do so? for all animals that trouble themselves about the young labour for what ap-
759b pears[4] to be their own offspring.

But, again, it is also unreasonable to suppose that the bees are female and the drones male, for Nature does not give weapons for fighting to any female, and while the drones are stingless all the bees have a sting. Nor is the opposite view reasonable, that the bees are male and the drones female, for no males are in the habit of working for their offspring, but as it is the bees do this.[5] And generally, since the brood of the drones is found coming into being among them even if there is no mature drone present, but that of the bees is not so found without the presence of the kings[6] (which is why some say that the

[1] Reading οἱ δέ.

[2] Reading ἐν τοῖς τόποις ἐξ ὧν.

[3] Strictly speaking they collect nectar and turn it into honey.

[4] Perhaps A. is thinking of the foster mother of the cuckoo. (Some ants, however, do carry off the pupas of other ants and bring them up.)

[5] This is an unlucky paragraph, for many female insects have offensive weapons, and many males work for their offspring.

[6] Since the workers occasionally produce a drone by parthenogenesis, but cannot produce another worker, this is true.

young of the drones alone is brought in from outside), it is plain that they are not[1] produced from copulation, either (1) of bee with bee or drone with drone or (2) of bees with drones. (That they should import the brood of the drones alone is impossible for the reasons already given, and besides it is unreasonable that a similar state of things should not prevail with all the three kinds if it prevails with one.) Then, again, it is also impossible that the bees themselves should be some of them male and some female, for in all kinds of animals the two sexes differ. Besides they would in that case generate their own kind, but as it is their brood is not found to come into being if the leaders are not among them, as men[2] say. And an argument against both theories, that the young are generated by union of the bees with one another or with the drones, separately or with one another,[3] is this: none of them has ever yet been seen copulating, whereas this would have often happened if the sexes had existed in them.[4] It remains then, if they are generated by copulation at all, that the kings shall unite to generate them.[5] But the drones are found to come into being even if no leaders are present, and it is not possible that the bees should either import their brood or themselves generate them by copulation. It remains then, as appears to be the case in certain fishes, that the bees should generate the drones without copulation, being indeed female in respect of generative power, but containing in themselves both sexes as plants do. Hence also they have the instrument of offence, for[6] we ought not to call that female in which the male sex is not separated. But if this is found to be the case with drones, if they come into being without copulation, then

[1] Reading *οὐκ*.

[2] Presumably bee-keepers.

[3] i. e. bee with bee apart from drones, or bee with drone.

[4] Union occurs only once in the life of the queen, in the so-called 'marriage flight'. And as this is high in air, it was naturally not observed.

[5] A. seems at first sight to overlook the possibility of (1) union of queen and drone, (2) union of queen and worker. But the first seemed to him to be barred by the fact that young are produced without the presence of drones, the second by the fact stated in the next sentence.

[6] The connexion is: 'And this does not violate the rule that females have none, for, &c.'

it is necessary that the same account should be given of the bees and the kings and that they also should be generated without copulation. Now if the brood of the bees had been found to come into being among them without the presence
760a of the kings, it would necessarily follow that the bees also are produced from bees themselves without copulation, but as it is, since those occupied with the tendance of these creatures deny this, it remains that the kings must generate both their own kind and the bees.

As bees are a peculiar and extraordinary kind of animal so also their generation appears to be peculiar. That bees should generate without copulation is a thing which may be paralleled in other animals, but that what they generate should not be of the same kind is peculiar to them, for the erythrinus generates an erythrinus and the channa a channa.[1] The reason is that bees themselves are not generated like flies and similar creatures, but from a kind different indeed but akin to them, for they are produced from the leaders. Hence in a sort of way their generation is analogous.[2] For the leaders resemble the drones in size and the bees in possessing a sting; so the bees are like them in this respect, and the drones are like them in size. For there must needs be some overlapping unless the same kind is always to be produced from each; but this is impossible, for at that rate the whole class would consist of leaders.[3] The bees, then, are assimilated to them in their power of generation,[4] the drones in size; if the latter had had a sting also they would have been leaders, but as it is this much of the difficulty has been solved,[5] for the leaders are like both kinds at once, like the bees in possessing a sting, like the drones in size.

[1] See on ii. 740a 36, iii. 755b 21.

[2] i.e. the different kinds of generation are analogous to the different kinds of bees.

[3] Since bees only exist because queens produce them, it follows that if all creatures always produced their own kind only there would be no bees, and consequently no drones either.

[4] Reading *καὶ τὸ τίκτειν*.

[5] I read λέλυται for λείπεται. One MS. adds a note on the words *τοῦτο λείπεται τῆς ἀπορίας* running thus: *καὶ ἤδη λέλυται· τὰ προειρημένα γὰρ ἡ λύσις τῆς ἀπορίας.* Perhaps we should assume a lacuna after 'as it is'.

But the leaders also must be generated from something. Since it is neither from the bees nor from the drones, it must be from their own kind. The grubs of the kings are produced last and are not many in number.[1]

Thus what happens is this: the leaders generate their own kind but also another kind, that of the bees; the bees again generate another kind, the drones, but do not also generate their own kind, but this has been denied them. And since what is according to Nature is always in due order, therefore it is necessary that it should be denied to the drones even to generate another kind than themselves. This is just what we find happening, for though the drones are themselves generated, they generate nothing else, but the process reaches its limit in the third stage. And so beautifully is this arranged by Nature that the three kinds always continue in existence and none of them 760b fails, though they do not all generate.

Another fact is also natural, that in fine seasons much honey is collected and many drones are produced, but in rainy seasons a large brood of ordinary bees.[2] For the wet causes more residual matter to be formed in the bodies of the leaders, the fine weather in that of the bees, for being smaller[3] in size they need the fine weather more than the kings do. It is right also that the kings, being as it were made with a view to producing young,[4] should remain within, freed from the labour of procuring necessaries, and also that they should be of a considerable size, their bodies being, as it were, constituted with a view to bearing young, and that the drones should be idle as having no weapon to fight for the food

[1] This sentence is correct. After a great number of drones and workers have been brought up, the workers build one or several larger cells in each of which an egg, not differing from the usual egg in any way so far as can be discerned, is laid by the queen. The grub is fed upon 'royal jelly', and it seems that this special food causes it to develop into a queen.

[2] The reason why there are more drones in fine seasons is that in wet seasons there is less honey to be had and the drones are killed off early as 'useless mouths'.

[3] Reading *ἐλάττω γὰρ ὄντα.*

[4] I translate the vulgate, but suspect strongly that we should omit *ὥσπερ πεποιημένους*, and with one good MS. read *ἐπὶ τῇ τεκνώσει ἔσω μένειν.*

and because of the slowness of their bodies. But the bees are intermediate in size between the two other kinds, for this is useful for their work,[1] and they are workers as having to support not only their young but also their fathers.[2] And it agrees with our views that the bees attend upon their kings because they are their offspring (for if nothing of the sort had been the case the facts about their leadership would be unreasonable), and that, while they suffer the kings to do no work as being their parents, they punish the drones as their children, for it is nobler to punish one's children and those who have no work to perform.[3] The fact that the leaders being few generate the bees in large numbers seems to be similar to what obtains in the generation of lions, which at first produce five, afterwards a smaller number each time, at last one and thereafter none.[4] So the leaders at first produce a number of workers, afterwards a few of their own kind; thus the brood of the latter is smaller in number than that of the former, but where Nature has taken away from them in number she has made it up again in size.

Such appears to be the truth about the generation of bees, judging from theory and from what are believed to be the facts about them; the facts, however, have not yet been sufficiently grasped; if ever they are, then credit must be given rather to observation[5] than to theories, and to theories only if what they affirm agrees with the observed facts.[6]

[1] Because, I suppose, among men the most active and best workers are neither unwieldy nor undersized. But A. has just said correctly that bees are smaller than both kings and drones; either there is something very wrong with the text or else this passage is the remains of earlier notes on the subject, before A. had corrected his views.

[2] As the queens give birth to the bees 'parthenogenetically' it follows that they are 'like plants, containing both sexes within themselves'. Hence they might be called either 'fathers' or 'mothers'.

[3] As the bees punish the drones by massacring them all at the end of the summer, their *patria potestas* seems to carry nobility to extreme lengths.

[4] See above on 750a 32.

[5] *αἰσθήσει*, lit. *sense-perception*, or the evidence of the senses. Plato had maintained that *λόγος* was more trustworthy than *αἴσθησις*.

[6] The translation of this sentence is deservedly printed by AW. in conspicuous type. It should have been kept in mind by those bastard Aristotelians who at the revival of learning refused to accept observed

A further indication that bees are produced without copulation is the fact that the brood appears small in the cells of the comb, whereas, whenever insects are generated by copulation, the parents remain united for a long time 761a
but produce quickly something of the nature of a scolex and of a considerable size.[1]

Concerning the generation of animals akin to them, as hornets and wasps,[2] the facts in all cases are similar to a certain extent, but are devoid of the extraordinary features which characterize bees; this we should expect, for they have nothing divine about them as the bees have. For the so-called 'mothers' generate the young[3] and mould the first part of the combs, but they generate by copulation with one another, for their union has often been observed. As for all the differences of each of these kinds from one another and from bees, they must be investigated with the aid of the illustrations to the *Enquiries*.[4]

11 Having spoken of the generation of all insects, we must now speak of the testacea. Here also the facts of generation are partly like and partly unlike those in the other classes. And this is what might be expected. For compared with animals they resemble plants, compared with plants they resemble animals, so that in a sense they appear to come into being from semen, but in another sense not so, and in one way they are spontaneously generated but in another from their own kind, or some of them in the latter way, others in the former. Because their

facts because they were supposed to contradict Aristotle's statements (which they often did not).

[1] This means in modern language, I think, that bees lay eggs whereas other insects which copulate produce a grub viviparously, e.g. flesh-flies. But A. is quite mistaken in supposing this last to be true of all insects that copulate. It seems evident that he was not altogether happy in his own mind about the bees.

[2] ἀνθρηνῶν τε καὶ σφηκῶν. It is not quite certain exactly what is meant by each of these words.

[3] So far resembling the kings of the bees; where they are less 'extraordinary' is in the absence of parthenogenesis. But in reality it is common in wasps also, and in very many other animals.

[4] *H. A.* ix. 41.

nature answers to that of plants, therefore few or no kinds of testacea come into being on land, e.g. the snails and any others, few as they are, that resemble them; but in the sea and similar waters there are many of all kinds of forms. But the class of plants has but few and one may say practically no representatives in the sea and such places, all such growing on the land. For plants and testacea are analogous; and in proportion as liquid has more quickening power than solid, water than earth, so much does the nature of testacea differ from that of plants, since the object of testacea is to be in such a relation to water as plants are to earth, as if plants were, so to say, land-oysters, oysters water-plants.

For such a reason also the testacea in the water vary more in form than those on the land. For the nature of liquid is more plastic than that of earth and yet not much less material, and this is especially true of the
761b inhabitants of the sea, for fresh water, though sweet and nutritious, is cold and less material. Wherefore animals having no blood and not of a hot nature are not produced in lakes nor in the fresher among brackish waters, but only exceptionally, but it is in estuaries and at the mouths of rivers that they come into being, as testacea and cephalopoda and crustacea, all these being bloodless and of a cold nature. For they seek at the same time the warmth of the sun and food; now the sea is not only water but much more material than fresh water and hot in its nature; it has a share in all the parts of the universe, water and air and earth,[1] so that it also has a share in all living things which are produced in connexion with each of these elements.[2] Plants may be assigned to land, the aquatic

[1] In air because it is warmer than fresh water, and air carries warmth with it according to A.; in earth because it is 'more material', having more earthy matter dissolved in it. Cf. Simroth *apud* Gomperz, *Greek Thinkers* (Eng. ed.), vol i, p. 534.

[2] I omit the unintelligible words *ἐν τοῖς τόποις ζῴων*. That *ζῴων* is wrong is plain from the mention of plants directly after.

The sea has a population belonging to all three elements, sea-weed to earth, fish to water, cetacea to air, as being air-breathers. Land and fresh water have each only two of these classes (but this is not exactly correct, for there are fresh-water cetacea).

animals to water, the land animals to air, but variations of quantity and distance[1] make a great and wonderful difference. The fourth class[2] must not be sought in these regions, though there certainly ought to be some animal corresponding to the element of fire,[3] for this is counted in as the fourth of the elementary bodies. But the form which fire assumes never appears to be peculiar to it,[4] but it always exists in some other of the elements, for that which is ignited appears to be either air or smoke or earth.[5] Such a kind of animal must be sought in the moon, for this appears to participate in the element removed in the third degree from earth.[6] The discussion of these things however belongs to another subject.

To return to testacea, some of them are formed spontaneously, some emit a sort of generative substance[7] from themselves, but these also often come into being from a spontaneous formation. To understand this we must grasp the different methods of generation in plants; some of these are produced from seed, some from slips, planted out, some by budding off alongside, as the class of onions.[8] In the last way are produced mussels,[9] for smaller ones are always growing off alongside the original, but the whelks, the purple-fish, and those which are said to 'spawn'[10]

[1] Lit. 'the more and less, the nearer and further'. I confess I cannot attach any definite meaning to the words.

[2] i. e. a class of animals living in fire.

[3] Lit. 'the post of fire,' its position in the line of the elements, a military metaphor.

[4] At least in our world.

[5] 'A. arrives thus at the right standpoint, that fire is not a body but only a condition of bodies.' AW.

[6] The moon is mentioned as the nearest of the heavenly bodies, which are supposed to move in the region of fire, forming the envelope of the universe between ether and air. A. plainly disbelieves in the stories of the salamander and other strange inhabitants of fire, though they are mentioned in *H. A.* v. 19. We must never conclude too hastily that any of the facts in that miscellaneous storehouse are guaranteed by A. himself.

[7] Lit. 'a sort of power'.

[8] Bulbs often send off a little bulb from themselves, which being freed from the parent grows into a new plant.

[9] *μύες*, probably the common edible mussel.

[10] *κηριάζειν*, 'make combs,' because a mass of whelks' eggs, such as are known to every one on our seashores, looks like a wasp-comb. A. 'failed to see that these masses consist of a multitude of distinct ova,

emit masses of a liquid slime as if originated by something of a seminal nature. We must not, however, consider that anything of the sort is real semen, but that these creatures participate in the resemblance to plants in the manner stated above.[1] Hence when once one such creature has
762a been produced, then is produced a number of them. For all these creatures are liable to be even spontaneously generated, and so to be formed still more plentifully in proportion if some are already existing. For it is natural that each should have some superfluous residue attached to it from the original, and from this[2] buds off each of the creatures growing alongside of it. Again, since the nutriment and its residue possess a like power,[3] it is likely that the product of those testacea which 'spawn' should resemble the original formation,[4] and so it is natural that a new animal of the same kind should come into being from this also.

All those which do not bud off or 'spawn' are spontaneously generated. Now all things formed in this way, whether in earth or water, manifestly come into being in connexion with putrefaction and an admixture of rainwater. For as the sweet is separated off into the matter which is forming, the residue of the mixture takes such a form.[5] Nothing comes into being by putrefying, but by concocting;[6] putrefaction and the thing putrefied is only a residue of that which is concocted. For nothing comes into being out of the whole of anything,[7] any more

yet in recognizing them as the generative products of testacea, he was in advance of the naturalists of the eighteenth century, who described these egg-masses as distinct species of animals and gave them separate names.' Ogle, p. xxviii.

[1] i. e. this generative slime is not a distinct organic product like semen but merely so much stuff homogeneous with the body of the animal, like the cutting of a plant.

[2] Read *ἀφ' οὗ* for *ἀφ' ἧς*.

[3] The nutriment is that in the parent's body; the spawn is a residue of this; if then the nutriment builds up, say, a whelk, so the spawn will give rise to another whelk.

[4] The text is corrupt. Qu. *⟨τὴν παρὰ⟩φυσιν* for *οὐσίαν*?

[5] i. e. putrefies.

[6] Early philosophers had thought that living things arose out of putrefaction.

[7] An animal is made out of a selection of material; thus only part

than in the products of art ; if it did art would have nothing to do, but as it is in the one case art removes the useless material, in the other Nature does so. Animals and plants come into being in earth and in liquid because there is water in earth, and air in water, and in all air is vital heat, so that in a sense all things are full of soul. Therefore living things form quickly whenever this air and vital heat are enclosed in anything. When they are so enclosed, the corporeal liquids[1] being heated, there arises as it were a frothy bubble. Whether what is forming is to be more or less honourable in kind depends on the embracing[2] of the psychical principle; this again depends on the medium in which the generation takes place and the material which is included. Now in the sea the earthy matter is present in large quantities, and consequently the testaceous animals are formed from a concretion of this kind, the earthy matter hardening round them and solidifying in the same manner as bones and horns (for these cannot be melted by fire), and the matter (or body) which contains the life being included within it.

The class of snails is the only class of such creatures that has been seen uniting, but it has never yet been sufficiently observed whether their generation is the result of the union or not.

It may be asked, if we wish to follow the right line of investigation, what it is in such animals the formation 762b
of which corresponds to the material principle.[3] For in the females this is a residual secretion of the animal, potentially such as that from which it came,[4] by imparting motion to which the principle derived from the male perfects the animal. But here[5] what must be said to

of an egg turns into the animal, not the whole of it ; in the same way a statue is not the whole of a block of marble ; therefore when spontaneous generation takes place in anything it means that the best part of the stuff has been drawn off, and consequently the rest goes bad. This accounts for the mistake of the early philosophers.

[1] σωματικῶν ὑγρῶν, liquids containing much earthy matter in solution.

[2] This seems to mean 'depends on the question what sort of matter catches the air and soul in its meshes'. But this whole sentence seems corrupt and gives no good sense.

[3] i.e. the material principle in the higher animals.

[4] The mother.

[5] In animals generated spontaneously.

correspond to this, and whence comes or what is the moving principle which corresponds to the male? We must understand that even in animals which generate it is from the incoming nourishment that the heat in the animal makes the residue, the beginning of the conception, by secretion and concoction. The like is the case also in plants, except that in these (and also in some animals) there is no further need of the male principle, because they have it mingled with the female principle within themselves, whereas the residual secretion in most animals does need it. The nourishment again of some[1] is earth and water, of others the more complicated combinations of these, so that what the heat in animals produces from their nutriment,[2] this does the heat of the warm season in the environment put together and combine by concoction out of the sea-water on the earth.[3] And the portion of the psychical principle which is either included along with it or separated off in the air makes an embryo[4] and puts motion into it.[5] Now in plants which are spontaneously generated the method of formation is uniform; they arise from a part of something,[6] and while some of it is the starting-point of the plant, some is the first nourishment of the young shoots.[7] . . . Other animals are produced in the form of a scolex, not only those bloodless animals which are not generated from parents but even some sanguinea, as a kind of mullet and some other river fishes and also the eel kind.[8] For all of these, though they have

[1] i. e. of plants.

[2] i. e. the residual secretions.

[3] This compound corresponds to the female's contribution to the embryo.

[4] Where sexes exist the embryo or conception has been defined as 'the first mixture of male and female'. So in cases of spontaneous generation the embryo is the first mixture of the compound corresponding to the female element and the psychical principle in the air corresponding to the male element.

[5] i. e. sets up the motions which develop it.

[6] e. g. mistletoe arises from part of an oak (according to A.) and draws its nourishment from the oak.

[7] Plainly we expect after this to hear something about animals also which are spontaneously generated. Moreover, the next sentence in the Greek begins with a 'τὰ δέ' which is unconstruable as it stands. I assume therefore a considerable lacuna.

[8] See notes on ii. 5.

but little blood by nature, are nevertheless sanguinea, and have a heart with blood in it as the origin of the parts; and the so-called 'entrails of earth', in which comes into being the body of the eel, have the nature of a scolex.[1]

Hence one might suppose, in connexion with the origin of men and quadrupeds,[2] that, if ever they were really 'earth-born' as some[3] say, they came into being in one of two ways; that either it was by the formation of a scolex at first or else it was out of eggs. For either they must have had in themselves the nutriment for growth (and such a conception is a scolex) or they must have got it from elsewhere, and that either from the mother[4] or from part of the conception.[5] If then the former is impossible (I mean that nourishment should flow to them from the earth as it does in animals[6] from the mother), 763a then they must have got it from some part of the conception, and such generation we say is from an egg.[7]

It is plain then that, if there really was any such beginning of the generation of all animals, it is reasonable to suppose it to have been one of these two, scolex or egg. But it is less reasonable to suppose that it was from eggs,

[1] These 'entrails of earth' are earthworms almost certainly. A. thinks they are spontaneously generated, and develop into eels.

[2] This is, I believe, the only passage from which we can gather anything about Aristotle's views on evolution; it appears to have strangely escaped the notice of modern writers on the subject, at least I have found no reference to it in any whom I have consulted. It is clear that, though he refused to consider seriously the crude and absurd suggestions of Empedocles, he had no objection to the gradual development of man from some lowly organism, but also that he wisely maintained an attitude of absolute agnosticism on the question. Unluckily he gives no hint of any manner in which a scolex might be supposed to develop into a mammal, but I think it certain that the notion of transmutation of species in any modern sense no more occurred to him than to Empedocles. He contemplates the possibility that man's ancestor was a scolex; he never thought that he might have been a monkey. Each species would have a separate beginning by spontaneous generation; they would not be related by descent from a common ancestor.

[3] Anaximander, who said the first animals sprang from the slime of the sea, and a host of philosophers and poets after him.

[4] As in vivipara.

[5] As in ovipara.

[6] Omitting ἄλλοις.

[7] Therefore if they got it from elsewhere at all they must have begun in the form of an egg, not of a complete organism, but we shall see directly that this view also is unlikely.

for we do not see such generation occurring with any animal,[1] but we do see the other both in the sanguinea above mentioned[2] and in the bloodless animals. Such are some of the insects and such are the testacea which we are discussing; for they do not develop out of a part of something (as do animals from eggs), and they grow like a scolex. For the scolex grows towards the upper part[3] and the first principle, since in the lower part is the nourishment for the upper. And this resembles the development of animals from eggs, except that these latter consume the whole egg, whereas in the scolex, when the upper part has grown by taking up into itself part of the substance in the lower part, the lower part is then differentiated out of the rest. The reason is that in later life also the nourishment is absorbed by all animals in the part below the hypozoma.

That the scolex grows in this way is plain in the case of bees and the like, for at first the lower part is large in them and the upper is smaller. The details of growth in the testacea are similar. This is plain in[4] the whorls of the turbinata, for always as the animal grows the whorls become larger[5] towards the front and what is called the head of the creature.

We have now pretty well described the manner of the development of these and the other spontaneously generated animals. That all the testacea are formed spontaneously is clear from such facts as these. They come into being on the side of boats when the frothy mud putrefies.[6] In many places where previously nothing of

[1] We do not see eggs spontaneously produced.

[2] Mullets and eels. Eels are actually developed from a scolex, according to A., the earth-worm.

[3] i.e. towards the head.

[4] Reading ἐν ταῖς ἑλίκαις (AW.)

[5] Read μείζους for πλείους, which is nonsense. The context and sense point plainly to μείζους. As a snail or any turbinate mollusc grows, he keeps on adding new and larger chambers to his shell, leaving the smaller and older empty; thus the whole shell becomes more or less conical in shape. As he moves along with the shell on his back the apex of the cone points backwards away from his head, which accounts for the odd statement in the text.

[6] These are evidently barnacles (which are really crustacea).

the kind existed, the so-called limnostrea, a kind of oyster, have come into being when the spot turned muddy through want of water; thus when a naval armament cast anchor at Rhodes a number of clay vessels were thrown out into the sea, and after some time, when mud had collected round them, oysters used to be found in them. Here is another proof that such animals do not emit any generative substance from themselves; when certain Chians carried 763b
some live oysters over from Pyrrha in Lesbos and placed them in narrow straits of the sea where tides clash,[1] they became no more numerous as time passed, but increased greatly in size. The so-called eggs[2] contribute nothing to generation but are only a sign of good condition, like fat in the sanguinea, and therefore the oysters are savoury eating at these periods.[3] A proof that this substance is not really eggs is the fact that such 'eggs' are always found in some testacea, as in pinnae, whelks, and purple-fish; only they are sometimes larger and sometimes smaller; in others, as pectens, mussels, and the so-called limnostrea, they are not always present but only in the spring; as the season advances they dwindle and at last disappear altogether; the reason being that the spring is favourable to their being in good condition. In others again, as the ascidians,[4] nothing of the sort is visible. (The details concerning these last, and the places in which they come into being, must be learnt from the *Enquiry*.)

[1] Read *ὁμόρρους* for *ὁμοίους* or *ὁμόρους*.

[2] These are the ovaries and their contents, which A. wrongly denies to be eggs; no invertebrate has fat, and so he held these to be the analogue of fat.

[3] 'Namely spring and autumn' (*de Partibus*, iv. 680a 28).

[4] The ascidians or sea-squirts are no longer included in the mollusca. They have no shell but a leathery integument.

BOOK IV

I

WE have thus spoken of the generation of animals both generally and separately in all the different classes. But, since male and female are distinct in the most perfect of them, and since we say that the sexes are first principles of all living things whether animals or plants, only in some of them the sexes are separated and in others not, therefore we must speak first of the origin of the sexes in the latter. For [1] while the animal is still imperfect in its kind the distinction is already made between male and female.[2]

It is disputed, however, whether the embryo is male or female, as the case may be, even before the distinction is plain to our senses, and further whether it is thus differentiated within the mother or even earlier. It is said by some, as by Anaxagoras and other of the physicists, that this antithesis exists from the beginning in the germs or seeds; for the germ, they say, comes from the male while the female only provides the place in which it is to be developed,[3] and the male is from the right, the female from the left testis, and so also that the male embryo is in the
764a right of the uterus, the female in the left. Others, as Empedocles, say that the differentiation takes place in the uterus; for he says that if the uterus is hot or cold what enters it becomes male or female, the cause of the heat or cold being the flow of the catamenia, according as it is

[1] The connexion is: 'That they are first principles, i. e. that they are deeply rooted in the nature of the animal, is plain, for, &c.'

[2] The difference between male and female begins to appear (to the microscope) in the chick on about the sixth day. At that time it is hardly possible to tell whether the embryo will develop into a bird at all, much less is the animal 'perfect in its kind'. A. is therefore justified in his statement.

[3] This theory seems to have been widely accepted; it appears even in the *Eumenides* of Aeschylus. A. occupies a position between these physicists and the medicals.

colder or hotter, more 'antique' or more 'recent'.[1] Democritus of Abdera also says that the differentiation of sex takes place within the mother; that however it is not because of heat and cold that one embryo becomes female and another male, but that it depends on the question which parent it is whose semen prevails,—not the whole of the semen, but that which has come from the part by which male and female differ from one another.[2] This is a better theory, for certainly Empedocles has made a rather light-hearted assumption in thinking that the difference between them is due only to cold and heat, when he saw that there was a great difference in the whole of the sexual parts, the difference in fact between the male pudenda and the uterus. For suppose two animals already moulded in embryo, the one having all the parts of the female, the other those of the male; suppose them then to be put into the uterus as into an oven, the former when the oven is hot, the latter when it is cold; then on the view of Empedocles that which has no uterus will be female and that which has will be male. But this is impossible. Thus the theory of Democritus would be the better of the two, at least as far as this goes,[3] for he seeks for the origin of this difference[4] and tries to set it forth; whether he does so well or not is another question.

Again, if heat and cold were[5] the cause of the difference of the parts, this ought to have been stated by those who maintain the view of Empedocles; for to explain the origin

[1] The words in inverted commas look like quotations from Empedocles. As usual E. does not say clearly what he means, but presumably it is or should be this: if the conception takes place directly after the catamenia, the result is male, if later, female.

[2] Democritus held, somewhat like Hippocrates, that semen contains 'atoms' coming from all parts of both parents; these atoms correspond very closely to the gemmules in Darwin's theory of pangenesis. Hence he could account easily for a child resembling one parent in one feature and the other in another, according as the atoms drawn from e.g. the hand of father or mother were 'pre-potent'. And so also this accounts for the difference of sex. The most modern views on the subject involve a very similar conflict between the constituents of the 'chromosomes', which are drawn equally from both parents.

[3] i.e. in that it accounts better for the difference of the whole of the sexual parts. But the criticism of Empedocles is a gross caricature.

[4] Read τῆς διαφορᾶς τὴν γένεσιν for τῆς γενέσεως τὴν διαφοράν.

[5] Reading κἂν εἰ.

of male and female is practically the same thing as to explain this, which is the manifest difference between them.[1] And[2] it is no small matter, starting from temperature as a principle, to collect the cause of the origin of these parts, as if it were[3] a necessary consequence for this part which they call the uterus to be formed in the embryo under the influence of cold but not under that of heat. The same applies also to the parts which serve for intercourse, since these also differ in the way stated previously.

Moreover male and female twins are often found together in the same part of the uterus; this we have observed sufficiently by dissection in all the vivipara, both land animals and fish.[4] Now if Empedocles had not seen this it was only natural for him to fall into error in assigning this cause of
764^b his; but if he had seen it it is strange that he should still think the heat or cold of the uterus to be the cause, since on his theory both these twins would have become either male or female, but as it is we do not see this to be the fact.

Again he says that the parts of the embryo are 'sundered', some being in the male and some in the female parent, which is why they desire intercourse with one another.[5] If so it is necessary that the sexual parts like the rest should be separated from one another, already existing

[1] This captious criticism of Empedocles amounts simply to this. E. says heat and cold are the cause of male and female, but he does *not* say they are the cause of the difference of the sexual parts, which is what marks off male from female. As if he could have meant anything else!

[2] Qu. δέ for τε?

[3] Qu. ἀναγκαῖον ⟨ὄν⟩?

[4] '*All* the vivipara' means no more than 'both classes', mammalia and cartilaginous fishes. A. probably made these dissections on at any rate the pig (see note on ii. 746^a 18), and *Mustelus laevis* (see on iii. 754^b 33). I take it that the word 'twins' in this passage is to be understood vaguely; e.g. in a sow A. might find half a dozen embryos, some male and some female, but two are enough for the purpose of his argument.

[5] In order to account for the resemblance of the child to both parents, Empedocles assumed that some parts came from the father, others from the mother. Hence it follows that, before the two sets of parts are united in the embryo, they are 'sundered' from each other, living a widowed life in the respective parents. Grotesque as this theory appears, it does not need much alteration to be brought into the form given it by modern science, that the conjugating cells exist apart in the two parents and that it is the need for their conjugation that brings about sexual union.

as masses of a certain size,[1] and that they should come into being in the embryo on account of uniting with one another,[2] not on account of cooling or heating of the semen.[3] But perhaps it would take too long to discuss thoroughly such a cause as this which is stated by Empedocles, for its whole character seems to be fanciful.[4] If, however, the facts about semen are such as we have actually stated, if it does not come from the whole of the body of the male parent and if the secretion of the male does not give any material at all to the embryo, then we must make a stand against both Empedocles and Democritus and any one else who argues on the same lines.[5] For then it is not possible that the body of the embryo[6] should exist 'sundered', part in the female parent and part in the male, as Empedocles says in the words: 'But the nature of the limbs hath been sundered, part in the man's . . .';[7] nor yet[8] that a whole embryo is drawn off from each parent and the combination of the two becomes male or female according as one part prevails over another.[9]

And, to take a more general view, though it is better to say that the one part makes the embryo female by prevailing through some superiority[10] than to assign nothing but

[1] Lit. 'that the size of such parts also should be separated', i. e. that the sexual parts exist separately somehow in each parent (male in male, female in female?), and this not merely in potentiality but already as actually formed parts. For Empedocles supposes that these parts are already formed, though microscopically small, in the semen of each parent before they unite in the embryo.

[2] Read ⟨διὰ⟩ *σύνοδον*.

[3] I transpose *τοῦ σπέρματος* here from the next sentence. Perhaps it should be omitted altogether.

[4] Because it is not based on a knowledge of what semen is.

[5] Empedocles, Democritus, Hippocrates, and their followers all assume both some sort of pangenesis (wrongly) and that the male does contribute matter to the embryo (rightly).

[6] Qu. omit *τοῦ σπέρματος*?

[7] The quotation is incomplete; Empedocles meant 'part in the man's semen, part in the woman's.'

[8] As Democritus says.

[9] Practically Democritus assumes a complete embryo *in posse* from each parent. The two are mixed to form one compound, some parts from each being dominant in the result and other parts receding and disappearing. Substitute in his theory 'characters borne by the germ-cells' for 'parts derived from all parts of the parents' and you have one of the favourite modern theories.

[10] i. e. the uterus derived from the mother prevails over the part derived from the father.

heat as the cause without any reflection, yet, as the form of the pudendum also varies along with the uterus from that of the father, we need an explanation of the fact that both these parts go along with each other.[1] If it is because they are near each other, then each of the other parts also ought to go with them, for one of the prevailing parts is always near another part where the struggle is not yet decided; thus the offspring would be not only female or male but also like its mother or father respectively in all other details.

Besides, it is absurd to suppose that these parts should come into being as something isolated, without the body as a whole having changed along with them. Take first and foremost the blood-vessels, round which the whole mass of the flesh lies as round a frame-work. It is not reasonable that these should become of a certain quality because of the uterus,[2] but rather that the uterus should do so on account of them. For though it is true that each is a receptacle of blood of some kind,[3] still the system of the vessels is prior to the other[4]; the moving principle must needs always be prior to that which it moves, and it is because it is itself of a certain quality that it is the cause of the development.[5] The

[1] The objection to Democritus is this. According to him each of the parts of the child is derived from one or other parent, and each part is independent of all other parts in this respect, e.g. a boy may resemble his father in his nose, his mother in his eyes. So a child may take after either parent in the sexual parts. But, says A., all possible combinations of different parts ought to be expected on this theory; now the sexual part is not one but a number of correlated parts; why then do all these correlated parts always go together instead of varying in all sorts of combinations?

[2] Those parts of the vascular system which are connected with the sexual organs vary with them in the two sexes. How can Democritus account for this correlation?

[3] The uterus is a receptacle of the catamenia, the vascular system of ordinary blood.

[4] Prior in time, because the vessels are developed in the embryo before the uterus; I do not think there is any reference here to priority in any other sense.

[5] The argument is this. The heart is the first principle, and next after it are developed the blood-vessels, which in their turn become moving principles in forming the rest of the embryo, including the uterus. Therefore the vessels must exist before the uterus. And if they, as active causes, make the uterus, it must be because they are themselves of such and such a quality. Therefore the quality of the uterus depends upon that of the blood-vessels, not vice versa.

difference, then, of these parts as compared with each other in the two sexes is only a concomitant result; not this but something else must be held to be the first principle and the cause of the development of an embryo as male or female;[1] 765a
this is so even if no semen is secreted by either male or female, but the embryo[2] is formed in any way you please.[3]

The same argument as that with which we meet Empedocles and Democritus will serve against those who say that the male comes from the right and the female from the left. If the male contributes no material to the embryo, there can be nothing in this view. If, as they say, he does contribute something of the sort, we must confront them in the same way as we did the theory of Empedocles, which accounts for the difference between male and female by the heat and cold of the uterus. They make the same mistake as he does, when they account for the difference by their 'right and left', though they see that the sexes differ actually by the whole of the sexual parts; for what reason then is the body of the uterus to exist in those embryos which come from the left and not in those from the right? For if an embryo have come from the left but has not acquired this part, it will be a female without a uterus, and so too there is nothing to stop another from being a male with a uterus! Besides, as has been said before, a female embryo has been observed in the right part of the uterus, a male in the left, or again both at once in the same part, and this not only once but several times.[4]

[1] Democritus thinks that the sexual parts are the cause of sex; presumably he did not exactly say so, but his theory may be put in that way. However plausible at first sight, this will not bear inspection. The cause of a zebra is not his stripes. The sexual parts, like the stripes of the zebra, are the concomitant results of a development which starts from the very beginning of the life of the organism. In modern language both stripes and sex are characters carried by the germ-cells.

[2] Omit *τὸ σπέρμα* (for which AW. read *τὸ κύημα*).

[3] i.e. even if A. has to give up his own theories and profess total ignorance of the cause, still that cause must be something at the very base of the development.

[4] I omit here the words *ἢ τὸ ἄρρεν μὲν ἐν τοῖς δεξιοῖς, τὸ θῆλυ δ' ἐν τοῖς ἀριστεροῖς*, as added by some one who did not see that *πλεονάκις* only means 'more than once'. Also the next phrase: *οὐχ ἧττον δὲ ἀμφότερα γίνεται ἐν τοῖς δεξιοῖς*, which make no sense here at any rate.

The argument just brought forward is valid against Empedocles and Parmenides, who said that sex depended on the side of the uterus in

Some again, persuaded of the truth of a view resembling that of these philosophers, say that if a man copulates with the right or left testis tied up the result is male or female offspring respectively; so at least Leophanes[1] asserted. And some say that the same happens in the case of those who have one or other testis excised, not speaking truth but vaticinating what will happen from probabilities and jumping at the conclusion that it is so before seeing that it proves to be so. Moreover, they know not that these parts of animals contribute nothing to the production of one sex rather than the other; a proof of this is that many animals in which the distinction of sex exists, and which produce both male and female offspring, nevertheless have no testes, as the footless animals; I mean the classes of fish and of serpents.[2]

To suppose, then, either that heat and cold are the causes of male and female, or that the different sexes come from
765b the right and left,[3] is not altogether unreasonable in itself; for the right of the body is hotter than the left,[4] and the concocted semen is hotter than the unconcocted; again, the thickened is concocted, and the more thickened is more fertile.[5] Yet to put it in this way is to seek for the cause from

which the embryo developed. But it does not touch the theory which ascribes the difference of sex to the different testes.

(Galen (vol. iv, p. 633) asserts that males are found in the right side of the uterus (though he admits that a female embryo *σπανίως ὤφθη* on that side) and females on the left. Hippocrates says in the *Aphorisms* *ἔμβρυα τὰ μὲν ἄρσενα ἐν τοῖσι δεξιοῖσι, τὰ δὲ θήλεα ἐν τοῖσιν ἀριστεροῖσι μᾶλλον*. Some modern authors hold a similar theory, that ova from the right and left ovaries produce boys and girls respectively.

[1] Or Cleophanes; his very name has been disputed. But Κλεωφάνης is not a Greek name at all.

[2] See note on i. 716b 17. Galen *ut supra* reverts to the theory in spite of this passage.

[3] Of either or both parents.

[4] This was A.'s constant opinion.

[5] To put this more plainly:

The thicker semen is more fertile, and the more concocted is thicker;

∴ The more concocted is more fertile.

But the more concocted is also hotter;

∴ The hotter is more fertile.

And the right is hotter than the left;

∴ It is reasonable to expect that semen from the right will be more fertile than semen from the left.

And for A. it then follows that the right will produce males.

too remote a starting-point; we must draw near the immediate causes in so far as it is possible for us.

We have, then, previously spoken elsewhere of both the body as a whole and its parts,[1] explaining what each part is and for what reason it exists. But (1) the male and female are distinguished by a certain capacity and incapacity.[2] (For the male is that which can concoct the blood into semen and which can form and secrete and discharge a semen carrying with it the principle of form—by 'principle' I do not mean a material principle out of which comes into being an offspring resembling the parent, but I mean the first moving cause, whether it have power to act as such in the thing itself or in something else[3]—but the female is that which receives semen, indeed, but cannot form it for itself or secrete or discharge it.) And (2)[4] all concoction works by means of heat. Therefore the males of animals[5] must needs be hotter than the females. For it is by reason of cold and incapacity that the female is more abundant in blood in certain parts of her anatomy, and this abundance is an evidence of the exact opposite of what some suppose, thinking that the female is hotter than the male for this reason, i. e. the discharge of the catamenia. It is true that blood is hot, and that which has more of it is hotter than that which has less. But they assume that this discharge occurs through excess of blood and of heat, as if it could be taken for granted that all blood is equally blood if only it be liquid and sanguineous in colour, and as if it might not become less in quantity but purer in quality in those who assimilate nourishment properly.[6] In fact they look upon this residual discharge in the same light as that of the intestines, when they think that a greater amount of it is a sign

[1] In the *de Partibus* and in the first book of this treatise.

[2] And therefore not by parts only.

[3] e. g. the heart is a moving cause acting in the embryo itself, semen contains a moving cause acting upon something outside itself.

[4] Qu. ἐπεὶ δέ for ἔτι εἰ?

[5] Omitting καί.

[6] Lit. 'the well-nourished'. Man concocts his nourishment more perfectly, turning it in the last stage into semen. Woman, not being able to concoct it so well, has a residue left over which is not properly concocted at all, or which at least remains in the penultimate stage. This is a sign of want of heat and incapacity.

of a hotter nature, whereas the truth is just the opposite. For consider the production of fruit; the nutriment in its first stage is abundant, but the useful product derived from it is small, indeed the final result is nothing at all compared to the quantity in the first stage. So is it with the body; the various parts receive and work up the nutriment, from the whole of which the final result is quite small. This is blood in some animals, in some its analogue.[1] Now since (1) the one sex is able and the other is unable to reduce the residual secretion to a pure form, and (2) every capacity or power in an organism has a certain corresponding organ,
766a whether the faculty produces the desired results in a lower degree or in a higher degree,[2] and (3) the two sexes correspond in this manner (the terms 'able' and 'unable' being used in more senses than one[3])—therefore[4] it is necessary that both female and male should have organs. Accordingly the one has the uterus, the other the male organs.

Again, Nature gives both the faculty and the organ to each individual at the same time,[5] for it is better so. Hence each region comes into being along with the secretions and the faculties, as e.g. the faculty of sight is not perfected without the eye, nor the eye without the faculty of sight; and so too the intestine and bladder come into being along with the faculty of forming the excreta. And since that from which an organ comes into being and that by which it is increased are the same (i.e. the nutri-

[1] And blood in a still more advanced stage becomes semen. The analogy with plants is not developed, but I conceive that we may fairly put it thus. The plant turns its nutriment into leaves and fruit; animals turn theirs into blood and (in males) semen. As luxuriance of leafage without fruit is no sign of capacity in the plant, so abundance of blood without semen is no sign of greater heat in the female.

[2] As do the female and male respectively.

[3] The senses in which they are here used are 'able and unable to do a thing *well*'.

[4] I omit γάρ. AW. with some early editions read οὖν.

The argument may be otherwise stated thus. Male and female differ in that the former concoct the nutriment into a purer form and in a higher degree than the latter. But every function has a distinct organ allotted to it, varying according to the amount of work to be done. Therefore male and female must have organs varying according to their powers.

[5] A. is not always consistent on this point.

ment), each of the parts will be made out of such a material and such residual matter as it is able to receive.[1] In the second place, again, it is formed, as we say, in a certain sense, out of its opposite. Thirdly, we must understand besides this that, if it is true that when a thing perishes it becomes the opposite of what it was, it is necessary also that what is not under the sway of that which made it must change into its opposite. After these premisses it will perhaps be now clearer for what reason one embryo becomes female and another male. For when the first principle[2] does not bear sway and cannot concoct the nourishment through lack of heat nor bring it into its proper form, but is defeated in this respect, then must needs the material which it works on change into its opposite. Now the female is opposite to the male, and that in so far as the one is female and the other male. And since it differs in its faculty, its organ also is different, so that the embryo changes into this state.[3] And as one part of first-rate importance changes, the whole system of the animal differs greatly in form along with it. This may be seen in the case of eunuchs, who, though mutilated in one part alone, depart so much from their original appearance and approximate closely[4] to the female form. The reason of this is that some of the parts are principles, and when a principle is moved or affected needs must many of the parts that go along with it change with it.

If then (1) the male quality or essence is a principle and a cause, and (2) the male is such in virtue of a certain capacity and the female is such in virtue of an incapacity, and (3) the essence or definition of the capacity and of the incapacity is ability or inability to concoct the nourishment in its ultimate stage, this being called blood in the san-

[1] Any part of the body extracts from the residue of the nourishment such material as it is its nature to receive, e.g. bone extracts bone. And the bone was also formed out of that residue in the beginning.

[2] The heart.

[3] Lit. 'change into such', i.e. the embryo becomes a creature of such a kind, possessing the organ (the uterus) which corresponds to its female character.

[4] Reading ἐλλείπουσι.

guinea and the analogue of blood in the other animals, and (4) the cause of this capacity is in the first principle and in the part which contains the principle of natural heat—therefore a heart must be formed in the sanguinea (and
766b the resulting animal will be either male or female), and in the other kinds which possess the sexes must be formed that which is analogous to the heart.[1]

This, then, is the first principle and cause of male and female, and this is the part of the body in which it resides. But the animal becomes definitely female or male by the time when it possesses also the parts by which the female differs from the male, for it is not in virtue of any part you please that it is male or female, any more than it is able to see or hear by possessing any part you please.

To recapitulate, we say that the semen, which is the foundation of the embryo, is the ultimate secretion of the nutriment.[2] By ultimate I mean that which is carried to every part of the body, and this is also the reason why the offspring is like the parent.[3] For it makes no dif-

[1] I read γένεσιν ⟨οἷς⟩ ὑπάρχει.

The argument is this. The sexes depend upon the heart (or its analogue in invertebrata) which is formed first. For this gives the vital heat which concocts the nutriment, and according to the amount of this heat the creature is either male or female, since the difference between them is that the male can concoct the blood into semen and the female cannot.

Absurd as some parts of it now appear, this passage is a truly magnificent piece of analysis. By it A. has pushed back the determination of sex to the very beginning of embryonic development, and is actually in advance of modern science up to the end of the nineteenth century. It is only within the last few years that the determination has been pushed back a little further still, and that upon his own lines, that sex is an ἀρχή residing in the very germ. Any one who will read books on the subject published even so lately as twenty years ago will be astounded to see how firmly A. has grasped this in comparison with those recent writers.

[2] Lit. 'the semen underlies being the last secretion of nourishment'.

[3] The blood is secreted from the nourishment, and the semen from the blood. But the blood runs to every part of the body from the heart, and as the blood forms the parts we may say that the heart forms them by means of the blood.

Thus the hand, e. g. of the parent, is of a certain shape because it was formed by his heart by means of the blood. But from his blood was also secreted his semen, and from that again is formed the offspring. If the heart and blood of the parent were of such a quality as to form the hand of the parent in a certain way, then the secretion of the blood, which forms and sets in motion the heart and blood of ference whether we say that the semen comes from all the parts or goes to all of them, but the latter is the better.[1] But the semen of the male differs from the corresponding secretion of the female in that it contains a principle within itself of such a kind as to set up movements also in the embryo and to concoct thoroughly the ultimate nourishment, whereas the secretion of the female contains material alone.[2] If, then, the male element prevails it draws the female element into itself, but if it is prevailed over it changes into the opposite or is destroyed.[3] But the female is opposite to the male, and is female because of its inability to concoct and of the coldness of the sanguineous nutriment.[4] And Nature assigns to each of the secretions the part fitted to receive it. But the semen is a secretion, and this in the hotter animals with blood, i. e. the males, is moderate in quantity, where-

the offspring, will also be of such a quality. Accordingly the hand of the offspring will resemble that of the parent.

When A. says, 'By ultimate I mean,' &c., he appears to mean: 'what I call the ultimate secretion is carried.'

[1] A reference to the Hippocratic theory that resemblance was due to the semen coming from all parts of the parent. A. has previously shown this to be impossible. By the present sentence he means to say that so far as accounting for the resemblance goes either his own or the Hippocratic theory would sound equally well, but that as a matter of fact his own is the right one.

[2] This sentence looks badly corrupted. The general sense is that the male semen differs from the catamenia in that the former contains the soul and principle of motion, because (?) the male is able to concoct thoroughly, while the latter only contains the material mass of the embryo.

[3] i.e. in the mixture of the germ-cells of both parents, one or other gets the better in a sort of conflict. If the male prevails in this, then it causes the whole mixture to turn out a male, 'drawing into itself' the female, or in other words so influencing the material contributed by the female that the resulting embryo is male. In the other case, the male element is itself so influenced by the female, and therefore either 'changes into its opposite', the total mixture becoming all female, or else 'is destroyed', i. e. the principle carried by the male element disappears from the embryo.

A. appears to assume, consciously or unconsciously, that the element contributed by each parent would naturally produce an embryo of its own sex, were it not overridden by the other. This is quite wrong. In parthenogenesis the unimpregnated female often produces a male (as bees) though in other cases she may produce a female (as rotifers, aphides, &c.).

[4] This seems to mean no more than that the blood of the female is not so hot as that of the male.

fore the recipient parts of this secretion in males are only passages. But the females, owing to inability to concoct, have a great quantity of blood, for it cannot be worked up into semen. Therefore they must also have a part to receive this, and this part must be unlike the passages of the male and of a considerable size. This is why the uterus is of such a nature, this being the part by which the female differs from the male.

2

We have thus stated for what reason the one becomes female and the other male. Observed facts confirm what we have said.[1] For more females are produced by the young[2] and by those verging on old age than by those in the prime of life; in the former the vital heat is not yet perfect, in the latter it is failing. And those of a moister and more feminine state of body are more wont to beget females, and a liquid semen causes this more than a thicker; now all these characteristics come of deficiency in natural heat.

Again, more males are born if copulation takes place when north than when south winds are blowing.[3] For in the latter case the animals produce more secretion, and too much secretion is harder to concoct; hence the semen 767a of the males is more liquid, and so is the discharge of the catamenia.

Also the fact that the catamenia occur in the course of nature[4] rather when the month is waning is due to the same causes. For this time of the month is colder and moister because of the waning and failure of the moon; as the sun makes winter and summer in the year as a whole, so does the moon in the month. This is not due to the turning of the moon, but it grows warmer as the light increases and colder as it wanes.

The shepherds also say that it not only makes a difference in the production of males and females if copulation

[1] The facts given in this chapter are unluckily all a mere string of popular fables.

[2] The word *young* is in the neuter; the male parent appears to be meant.

[3] For the air is moister when the wind is in the south.

[4] Omitting τά before κατὰ φύσιν. The fact is imaginary.

takes place during northern or southerly winds, but even if the animals while copulating look towards the south or north; so small a thing will sometimes turn the scale and cause cold or heat, and these again influence generation.

The male and female, then, are distinguished generally, as compared with one another in connexion with the production of male and female offspring, for the causes stated. However, they also need a certain correspondence with one another to produce at all, for all things that come into being as products of art or of Nature exist in virtue of a certain ratio. Now if the hot preponderates too much it dries up the liquid; if it is very deficient it does not solidify it; for the artistic or natural product we need the due mean between the extremes. Otherwise it will be as in cooking; too much fire burns the meat, too little does not cook it, and in either case the process is a failure. So also there is need of due proportion in the mixture of the male and female elements. And for this cause it often happens to many of both sexes that they do not generate with one another, but if divorced and remarried to others do generate; and these oppositions show themselves sometimes in youth, sometimes in advanced age, alike as concerns fertility or infertility, and as concerns generation of male or female offspring.

One country also differs from another in these respects, and one water from another, for the same reasons. For the nourishment and the medical condition of the body are of such or such a kind because of the tempering of the surrounding air and of the food entering the body, especially the water; for men consume more of this than of anything else, and this enters as nourishment into all food, even solids. Hence hard waters cause infertility,[1] and cold waters the birth of females.

3 The same causes must be held responsible for the following groups of facts. (1) Some children resemble their parents, while others do not; some being like the father

[1] Cf. Hippocrates, vol. i, p. 529.

and others like the mother, both in the body as a whole and in each part, male and female offspring resembling father and mother respectively rather than the other way about. (2) They resemble their parents more than remoter ancestors, and resemble those ancestors more than any chance individual. (3) Some, though resembling none of their relations, yet do at any rate resemble a human being, but others are not even like a human being but a monstrosity.[1] For even he who does not resemble his parents is already in a certain sense a monstrosity; for in these cases Nature has in a way departed from the type. The first departure indeed is that the offspring should become female instead of male; this, however, is a natural necessity. (For the class of animals divided into sexes must be preserved, and as it is possible for the male sometimes not to prevail over the female in the mixture of the two elements, either through youth or age or some other such cause, it is necessary that animals should produce female young). And the monstrosity, though not necessary in regard of a final cause and an end, yet is necessary accidentally. As for the origin of it, we must look at it in this way. If the generative secretion in the catamenia is properly concocted, the movement imparted by the male will make the form of the embryo in the likeness of itself. (Whether we say that it is the semen or this movement that makes each of the parts grow, makes no difference; nor again whether we say that it 'makes them grow' or 'forms them from the beginning', for the formula of the movement is the same in either case.) Thus if this movement prevail, it will make the embryo male and not female, like the father and not like the mother; if it prevail not, the embryo is deficient in that faculty in which it has not prevailed. By 'each faculty' I mean this. That which generates is not

[1] I have found it advisable to rearrange this sentence, which is a confused heap in the original. The important point is that however much offspring may vary from parents, even in monstrosities, we are not to invoke any fresh cause to account for the fact. Presumably Nature seeks to reproduce the parent exactly in the offspring, but fails in different degrees. The ideal would be for male to produce male only; the first fall from this is the production of females, and thence we can proceed by gentle gradations to 'freaks'.

only male but also a particular male, e.g. Coriscus or Socrates, and it is not only Coriscus but also a man. In this way some of the characteristics of the father are more near to him, others more remote from him considered simply as a parent and not in reference to his accidental qualities (as for instance if the parent is a scholar or the neighbour of some particular person).[1] Now the peculiar and individual has always more force in generation than the more general and wider characteristics. Coriscus is both a man and an animal, but his manhood[2] is nearer to his individual existence than is his animal-hood. In generation both the individual and the class are operative, but the individual is the more so of the two, for this is the only true existence.[3] And the offspring[4] is produced indeed of a certain quality,[5] but also as an individual, and this latter is the true existence. Therefore it is from the forces of all such existences[6] that the efficient movements come which exist in the semen; potentially from remoter ancestors but in a higher degree and more nearly from the individual (and by the individual I mean e.g. Coriscus 768a
or Socrates).[7] Now since everything changes not into anything haphazard but into its opposite, therefore also that which is not prevailed over in generation[8] must change

[1] Every parent, as a parent, has more peculiar and intimate characteristics, those of the individual, such as brown or blue eyes; he has also more remote and general characteristics, those common to the human species. Accidental characteristics, as e.g. being a scholar, do not concern us here, where we are considering him only as a parent.

[2] Reading τὸ ἄνθρωπος.

[3] Plato held, on the contrary, that the class or 'idea' of 'man', &c., was the only true existence, the individual only participating in existence by participating in the class. A. says the individual is the truest reality, the class only existing because the individuals exist of which it is composed. Hence, though it is true that a species generates itself as a species, yet in the truest sense it is the individual that generates another individual. So the parent is more a parent considered as an individual than considered as man, and more so when considered as man than as animal.

[4] Reading καὶ τὸ γιγνόμενον.

[5] ποιόν τι, i.e. belonging to a species, a genus, a class, &c.

[6] (1) the individual, (2) the species, (3) the wider class, and so on.

[7] This sentence seems corrupt; I read provisionally δυνάμει μὲν καὶ τῶν προγόνων μᾶλλον δὲ καὶ ἐγγύτερον ἀεὶ τῶν καθ' ἕκαστον.

[8] i.e. the material which the paternal force ought to work upon and turn into male; if this material is not so mastered it will become the opposite, female.

and become the opposite, in respect of that particular force in which the paternal and efficient or moving element has not prevailed. If then it has not prevailed in so far as it is male, the offspring becomes female; if in so far as it is Coriscus or Socrates, the offspring does not resemble the father but the mother. For as 'father' and 'mother' are opposed as general terms,[1] so also the individual father is opposed to the individual mother. The like applies also to the forces that come next in order, for the offspring always changes rather into the likeness of the nearer ancestor than the more remote, both in the paternal and in the maternal line.

Some of the movements exist in the semen actually, others potentially; actually, those of the father and the general type, as man and animal; potentially those of the female and the remoter ancestors.[2] Thus the male and efficient principle, if it lose its own nature, changes to its opposites, but the movements which form the embryo change into those nearly connected with them; for instance, if the movement of the male parent be resolved, it changes by a very slight difference into that of his father, and in the next instance into that of his grandfather; and in this way not only in the male but also in the female line the movement of the female parent changes into that of her mother, and, if not into this, then into that of her grandmother; and similarly also with the more remote ancestors.[3]

[1] Reading τῷ ὅλως πατρί.

[2] The 'movements' are the movements which impart characteristics to the embryo. Practically then they may be identified with them. The characters, then, of the father exist *actually* in the semen, for the semen is in itself male and comes from the father alone. Moreover the father belongs to classes, being a man and an animal; therefore the characters of the classes man and animal also exist already *actually* in the semen. But if the semen cannot impress its male character upon the embryo, it forms the embryo defectively into a female, and hence the female character may be said to exist *potentially* in the semen. The semen also may give characters which do not belong to the father but to a remoter ancestor; these are latent, as we say now, and may crop up any day by reversion; these also then exist *potentially* in the semen.

[3] This is equivalent to saying that if the combination of characters which mark the father be lost in transmission to the offspring, then it is most likely that they will be replaced by the characters of the grand-

Naturally then it is most likely that the characteristics of 'male' and of the individual father will go together, whether they prevail or are prevailed over. For the difference between them is small so that there is no difficulty in both concurring, for Socrates is an individual man[1] with certain characters. Hence for the most part the male offspring resemble the father,[2] and the female the mother.[3] For in the latter case the loss of both characters[4] takes place at once, and the change is into the two opposites; now female is opposed to male, and the individual mother to the individual father.

But if the movement coming from the male principle prevails while that coming from the individual Socrates does not, or vice versa, then the result is that male children are produced resembling the mother and female children resembling the father.

If again the movements be resolved, if the male character remain but the movement coming from the individual Socrates be resolved into that of the father of Socrates, the result will be a male child resembling its grandfather or some other of its more remote ancestors in the male line on the same principle. If the male principle be prevailed over, the child will be female and resembling most probably its mother, but, if the movement coming from the mother also be resolved, it will resemble its mother's mother or the resemblance will be to some other of its more remote 768b
ancestors in the female line on the same principle.

The same applies also to the separate parts, for often some of these take after the father, and others after the mother, and yet others after some of the remoter ancestors.

father reappearing; the next most likely will be those of the great-grandfather, and so on.

[1] The individual father, e. g. Socrates, is a *male* and also a particular individual with e. g. a snub-nose. Therefore if the characters imparted by Socrates prevail over those imparted by the mother, the child will be both male and snub-nosed. We naturally expect the two to go together.

[2] i.e. in other characters as well as sex.

[3] This appears to be true of many peculiarities besides those obviously connected with sex; see Darwin, *Variation*[1], vol. ii, p. 72.

[4] i. e. of 'male' and of special points of resemblance to the individual father.

For, as has been often said already, some of the movements which form the parts exist in the semen actually and others potentially. We must grasp certain fundamental general principles, not only that just mentioned (that some of the movements exist potentially and others actually), but also two others, that if a character be prevailed over it changes into its opposite, and, if it be resolved, is resolved into the movement next allied to it—if less, into that which is near, if more, into that which is further removed. Finally, the movements are so confused together that there is no resemblance to any of the family or kindred, but the only character that remains is that common to the race, i. e. it is a human being. The reason of this is that this is closely knit up with the individual characteristics; 'human being' is the general term, while Socrates, the father, and the mother, whoever she may be, are individuals.

The reason why the movements are resolved is this. The agent is itself acted upon by that on which it acts; thus that which cuts is blunted by that which is cut by it, that which heats is cooled by that which is heated by it, and in general the moving or efficient cause (except in the case of the first cause of all) does itself receive some motion in return; e. g. what pushes is itself in a way pushed again and what crushes is itself crushed again. Sometimes it is altogether more acted upon than is the thing on which it acts, so that what is heating or cooling something else is itself cooled or heated; sometimes having produced no effect, sometimes less than it has itself received.[1] (This question has been treated in the special discussion of action and reaction, where it is laid down in what classes of things action and reaction exist.[2]) Now that which is acted on escapes and is not mastered by the semen, either through deficiency of power in the concocting and moving agent or because what should be concocted and formed into distinct parts is too cold and in too great quantity. Thus the moving agent, mastering it in one part but not in

[1] As AW. remark it is not clear what A. is thinking of, nor can the statement be true. Action and reaction must be equal.

[2] In the lost treatise περὶ τοῦ ποιεῖν καὶ πάσχειν.

another, makes the embryo in formation to be multiform,[1] as happens with athletes because they eat so much. For owing to the quantity of their food their nature is not able to master it all, so as to increase and arrange[2] their form symmetrically; therefore their limbs develop irregularly, sometimes indeed almost so much that no one of them resembles what it was before.[3] Similar to this is also the disease known as satyrism, in which the face appears like that of a satyr[4] owing to a quantity of unconcocted humour or wind being diverted into parts of the face.[5]

We have thus discussed the cause of all these phenomena, 769a
(1) why female and male offspring are produced, (2) why some are similar to their parents, female to female and male to male, and others the other way about, females being similar to the father and males to the mother, and in general why some are like their ancestors while others are like none of them, and all this as concerns both the body as a whole and each of the parts separately. Different accounts,[6] however, have been given of these phenomena by some of the nature-philosophers; I mean why children are like or unlike their parents. They give two versions of the reason. Some say that the child is more like that parent of the two from whom comes more semen, this applying equally both to the body as a whole and to the separate parts, on the assumption that semen comes from each part of both parents; if an equal part comes from each, then, they say, the child is like neither. But if this is false, if semen does not come off from the whole body of the parents, it is clear

[1] Hence one part will resemble the father, being properly controlled by the action of the semen, another will escape control and turn out like some other relation or even no relation at all. A. does not account in all this for any resemblance on the mother's side, so far as I can see.

[2] Reading *διανέμειν*.

[3] This sentence is probably corrupt, but cf. Galen, vol. i, p. 32. For the exaggerated development of parts of the body in athletes see also Xen. *Conv.* ii. 17. Japanese wrestlers are, or used to be, truly 'monstrous' objects.

[4] I omit *τοῦ ζῴου καί* as unintelligible; to read *ἄλλου ζῴου* (AW. with some authority) does not seem to mend matters.

[5] From Galen, vol. vii, p. 728, it appears that this disease is the early stage of elephantiasis.

[6] Read *ἕτερα* for *ἕτεροι*. (*ἕτερόν τι*, which AW. read with one MS., can hardly be right, as A. goes on to give *two* theories.)

that the reason assigned cannot be the cause of likeness and unlikeness. Moreover, they are hard put to it to explain how it is that a female child can be like the father and a male like the mother. For (1) those who assign the same cause of sex as Empedocles or Democritus say what is on other grounds impossible, and (2) those who say that it is determined by the greater or smaller amount of semen coming from the male or female parent, and that this is why one child is male and another female, cannot show how the female is to resemble the father and the male the mother, for it is impossible that more should come from both at once.[1] Again, for what reason is a child generally like its ancestors, even the more remote? None of the semen has come from *them* at any rate.[2]

But those who account for the similarity in the manner which remains to be discussed, explain this point better, as well as the others. For there are some who say that the semen, though one, is as it were a common mixture (panspermia) of many elements; just as, if one should mix many juices in one liquid and then take some from it, it would be possible[3] to take, not an equal quantity always from each juice, but sometimes more of one and sometimes more of another, sometimes some of one and none at all of another, so they say it is with the generative fluid, which is a mixture of many elements, for the offspring resembles that parent from which it has derived most. Though this theory is obscure and in many ways fictitious, it aims
769b at what is better expressed by saying that what is called 'panspermia' exists potentially, not actually; it cannot exist actually, but it can do so potentially.[4] Also,

[1] A boy is male because the father contributed more semen, and is like his mother because the mother contributed more. ∴ they both contributed more, which is absurd.

[2] An answer might obviously be given to this question. And A. must mean 'like its ancestors in some point or other', not generally speaking, or else his ὡς ἐπὶ τὸ πολύ is an expression due to the heat of argument.

[3] Omitting καί before δύναιτ' ἄν (AW.).

[4] These panspermatists seem to have held that the seeds of each of the parts existed separately in the generative fluids. A. has already shown this to be impossible (i. 18). In modern language, the germ-cells do not contain gemmules from the somatic cells. But the germ-

if we assign only one sort of cause, it is not easy to explain all the phenomena, (1) the distinction of sex, (2) why the female is often like the father and the male like the mother, and again (3) the resemblance to remoter ancestors, and further (4) the reason why the offspring is sometimes unlike any of these but still a human being, but sometimes, (5) proceeding further on these lines, appears finally to be not even a human being but only some kind of animal, what is called a monstrosity.

For, following what has been said, it remains to give the reason for such monsters. If the movements imparted by the semen are resolved and the material contributed by the mother is not controlled by them, at last there remains the most general substratum, that is to say the animal.[1] Then people say that the child has the head of a ram or a bull, and so on with other animals, as that a calf has the head of a child or a sheep that of an ox. All these monsters result from the causes stated above, but they are none of the things they are said to be ; there is only some similarity, such as may arise even where there is no defect of growth. Hence often jesters compare some one who is not beautiful to a 'goat breathing fire', or again to a 'ram butting', and a certain physiognomist reduced all faces to those of two or three animals, and his arguments often prevailed on people.

That, however, it is impossible for such a monstrosity to come into existence—I mean one animal in another—is shown by the great difference in the period of gestation between man, sheep, dog, and ox, it being impossible for each to be developed except in its proper time.

This is the description of some of the monsters talked

cells have the power of developing in all sorts of ways, so that the body which they build up may become of any kind—within limits. Therefore we may say with A. that the panspermia exists potentially but not actually, i.e. the fertilized germ-cell *may develop into* a body with any one combination of many parts resembling various ancestors, but does not contain within itself gemmules separately existing drawn from the different parts of the two parents.

[1] i.e. if the embryo is not properly formed by the influence which makes it develop into a human being, it will resemble a sort of generalized type of animal, such as the foetus appears to be at an early stage.

about; others are such because certain parts of their form are multiplied so that they are born with many feet or many heads.

The account of the cause of monstrosities is very close and similar in a way to that of the cause of animals being born defective in any part, for monstrosity is also a kind of deficiency.[1]

Democritus said that monstrosities arose because two 4
emissions of seminal fluid met together, the one succeeding the other at an interval of time; that the later entering into the uterus reinforced the earlier so that the parts of the embryo grow together and get confused with one another.[2] But in birds, he says, since copulation takes place quickly, both the eggs and their colour always cross one another.[3] But if it is the fact, as it manifestly is, that
770a several young are produced from one emission of semen and a single act of intercourse, it is better not to desert the short road to go a long way about, for in such cases it is absolutely necessary that this should occur when the semen is not separated but all enters the female at once.[4]

If, then, we must attribute the cause to the semen of the male, this will be the way we shall have to state it, but we must rather by all means suppose that the cause lies in the material contributed by the female and in the embryo as it is forming. Hence also such monstrosities appear very rarely in animals producing only one young one, more

[1] Both are produced by failure of the movements imparted by the semen, and such failure resulting in monstrosity is therefore similar to failure resulting in blindness or absence of a limb.

[2] This sentence is corrupt. As a partial remedy I read *συμπίπτειν* for *πίπτειν* and *ἐπελθοῦσαν* for *ἐξελθοῦσαν*. Democritus seems to be accounting for cases of 'monstra per excessum', children with two heads and the like.

[3] This sentence as it stands is obviously nonsense. I should expect something like this: 'As in birds copulation is brief and frequently repeated, two eggs often grow together and produce double monsters and the white and yolk in a single egg are often not properly separated from each other.'

[4] i. e. when a single copulation produces many young, as in the pig, it is obvious that all the semen enters at once. Therefore on the theory of Democritus such pigs should never produce a monstrosity. But they do, and the 'short road' or obvious conclusion is that the cause is something else than that assigned by Democritus.

frequently in those producing many, most of all in birds and among birds in the common fowl.[1] For this bird produces many young, not only because it lays often like the pigeon family, but also because it has many embryos at once and copulates all the year round. Therefore it produces many double eggs, for the embryos grow together because they are near one another,[2] as often happens with many fruits.[3] In such double eggs, when the yolks are separated by the membrane,[4] two separate chickens are produced with nothing abnormal about them; when the yolks are continuous, with no division between them, the chickens produced are monstrous, having one body and head but four legs and four wings; this is because the upper parts are formed earlier from the white,[5] their nourishment being drawn from the yolk, whereas the lower part comes into being later and its nourishment is one and indivisible.[6]

[1] According to Vrolik monsters generally are commoner in the higher than in the lower animals, much commoner in mammals than in birds; double monsters in particular are commonest in man (Todd, vol. iv, p. 946). But a double pair of legs is a monstrosity 'rare chez l'homme et les mammifères, mais commune chez les oiseaux, *surtout chez la poule*' (Isidore Geoffroy St. Hilaire, *Traité de Tératologie*, tom. iii. p. 264). St. Hilaire has also observed it in the goose, pigeon, and duck. And this is the particular monstrosity which A. has in mind. He mentions, however, also double wings; for this see Newton's *Dictionary of Birds*, p. 588: 'supernumerary wings . . . occur, but very rarely except the legs be also doubled, so that the monster possesses eight limbs.'

[2] This explanation is now exploded. 'Double monsters were formerly thought to be formed by the union of two originally distinct embryos developed upon distinct vitelli; but now it is admitted that "their production is due to the spontaneous divarication of the embryonic mass into two halves"' (Darwin, *Variation*[1], vol. ii, p. 340, quoting Carpenter.) Other monsters are due to the doubling of the parts 'independently of the existence of two embryos' (ibid.). The doubled legs of chickens would come under the latter class.

[3] *περικαρπίων.* Instances of *περικάρπια* in *Problems*, xx. 25, are cucumbers and acorns.

[4] i. e. the vitelline membrane.

[5] As we have seen (iii. 751^{b}7) A. incorrectly supposes the chick to be formed in the white of the egg, the yolk serving only for nutrition.

[6] An egg with double yolk is formed when two separate yolks become accidentally enclosed in one layer of white; as the two yolks have two separate blastoderms, they hatch out into two chickens. The other case (of two yolks without dividing membrane) is a mere guess to account for the doubling of the legs and wings, which is a phenomenon parallel to polydactylism; such a chicken would be developed from a

A snake has also been observed with two heads[1] for the same reason, this class also being oviparous and producing many young. Monstrosities, however, are rarer among them owing to the shape of the uterus, for by reason of its length the numerous eggs are set in a line.[2]

Nothing of the kind occurs with bees and wasps, because their brood is in separate cells.[3]

But in the fowl the opposite is the case,[4] whereby it is plain that we must hold the cause of such phenomena to lie in the material. So, too, monstrosities are commoner in other animals if they produce many young.[5] Hence they are less common in man, for he produces for the most part only one young one and that perfect; even in man monstrosities occur more often in regions where the women give birth to more than one at a time, as in Egypt.[6] And they are commoner in sheep and goats, since they produce more young. Still more does this apply to the fissipeds, for
770b such animals produce many young and imperfect, as the dog, the young of these creatures being generally blind.[7]

single blastoderm. (A single yolk however, according to Dareste, may have two blastoderms, but A. anyhow does not contemplate this possibility.) The last words are obscurely expressed but the argument runs thus: 'The head and body are formed from one spot in the white, the yolk only serving as further nourishment to them; hence the double yolk does not cause the head and body to be doubled. But the limbs are formed later, drawing their nourishment and material from the yolk *alone*; hence, as there are two yolks, the limbs are doubled.'

[1] Two-headed monsters are particularly common among serpents (St. Hilaire, tom. iii, pp. 185, 192; cf. Bateson, *Materials for the Study of Variation*, p. 561: 'Of snakes having complete or partial duplicity, nearly always of the head, some twenty cases are recorded. Some of these were animals of good size, and must have had an independent existence for some considerable time').

[2] Whereas in birds, means A., they are placed anyhow all over the surface of the ovary, and so become more easily joined to one another.

[3] As a pupa, according to A., corresponds to the egg, it follows that, if monstrosities are formed by combination of two eggs, a monstrous bee would be formed by combination of two pupae. But the pupae cannot be so combined because they are separated from one another by the walls of the cells. But of course monsters *are* found among insects.

[4] i.e. the germs are so placed that they can grow together.

[5] And this shows the same thing, for if the female produce many germs at once they are liable to confusion with each other.

[6] Hippocrates (vol. i, p. 548), apparently referring to Egypt and Libya, speaks of domestic animals there being most fertile, *τίκτειν πυκνότατα*.

[7] And the animal is not perfect till its eyes are opened.

Why this happens and why they produce many young must be stated later,[1] but in them Nature has made an advance towards the production of monstrosities in that what they generate,[2] being imperfect, is so far unlike the parent; now monstrosities also belong to the class of things unlike the parent. Therefore this accident also often invades animals of such a nature.[3] So, too, it is in these that the so-called 'metachoera'[4] are most frequent, and the condition of these also is in a way monstrous, since both deficiency and excess are monstrous. For the monstrosity belongs to the class of things contrary to Nature, not any and every kind of Nature, but Nature in her usual operations; nothing can happen contrary to Nature considered as eternal and necessary, but we speak of things being contrary to her in those cases where things generally happen in a certain way but may also happen in another way. In fact, even in the case of monstrosities, whenever things occur contrary indeed to the established order but still always in a certain way and not at random, the result seems to be less of a monstrosity because even that which is contrary to Nature is in a certain sense according to Nature, whenever, that is, the formal nature has not mastered the material nature.[5] Therefore they do not call such things monstrosities any more than in the other cases where a phenomenon occurs habitually, as in fruits; for instance, there is a vine which some call 'capneos'; if this bear black grapes they do not judge it a monstrosity because it is in the habit of doing this very often.[6] The reason is that it is in its nature intermediate between white and black;

[1] In this chapter.

[2] Reading τῷ γεννᾶν.

[3] i.e. it is in animals that produce imperfect young that we find most instances of monstrosity.

[4] This term properly applies to dwarfed pigs, but is here evidently used in a general way for any dwarfed animal in a litter. Certain monstrosities are however particularly common in pigs.

[5] The meaning of this terrible sentence seems to be this. If in the development of the embryo the form masters the material, the result is the normal animal. Anything falling away from this is in a sense a monstrosity. But such falling away may be either absolutely haphazard, or may itself be in a certain sense normal, as e.g. when a child is born with a hare-lip, for such cases occur 'always in a certain way and not at random'.

[6] See similar cases in Darwin, *Variation*[1], vol. i, p. 375. Cf. also

thus the change is not a violent one nor, so to say, contrary to Nature; at least, it is not a change into another nature. But in animals producing many young not only do the same phenomena occur, but also the numerous embryos hinder one another from becoming perfect and interfere with the generative motions imparted by the semen.[1]

A difficulty may be raised concerning (1) the production of many young and the multiplication of the parts in a single young one, and (2) the production of few young or only one and the deficiency of the parts. Sometimes animals are born with too many toes,[2] sometimes with one alone,[3] and so on with the other parts, for they may be multiplied or they may be absent. Again, they may have the generative parts doubled, the one being male, the other female; this is known in men and especially in goats.[4] For what are called 'tragaenae' are such because they have both male and female generative parts; there is a case also of a goat being born with a horn upon its leg.[5] Changes and
771a deficiencies are found also in the internal parts, animals either not possessing some at all, or possessing them in a rudimentary condition, or too numerous or in the wrong place.[6] No animal, indeed, has ever been born without a heart, but they are born without a spleen or with two spleens or with one kidney; there is no case again of total absence of the liver, but there are cases of its being incom-

the statement in Mandeville's *Travels*, chap. iv, about the vines of Cyprus 'that first ben rede and aftre o yeer thei becomen white.'

[1] Reading ἐμποδίζει.

[2] Polydactylism; see Darwin, *Variation*[1], vol. ii, p. 12.

[3] Syndactylism, or 'lobster-claw', when the fingers or toes are never properly separated, or such cases as that of solid-hoofed swine, or again some of the fingers or toes may be absent altogether.

[4] St. Hilaire (tom. ii, p. 166) says of the horned ruminants: 'famille dans laquelle l'hermaphrodisme se montre plus fréquemment et sous des formes plus variées que dans aucun autre groupe zoologique. Aristote avait déjà remarqué que l'hermaphrodisme s'observe fréquemment chez les chèvres'.

[5] If this is true it is not perhaps stranger than the apparently well-authenticated instance of a small leg with three toes, interdigital membrane, &c., growing on the head of a duck (St. Hilaire, tom. iii, p. 272). More likely it was not a true horn but a horny growth such as is occasionally met with on the human body; but indeed Erasmus Wilson (*On Healthy Skin*[2], p. 346) describes such a growth as 'actually horn both in intimate and in coarser structure'.

[6] All these phenomena are common enough.

plete. And all these phenomena have been seen in animals perfect and alive.[1] Animals also which naturally have a gall-bladder are found without one; others are found to have more than one. Cases are known, too, of the organs changing places, the liver being on the left, the spleen on the right. These phenomena have been observed, as stated above, in animals whose growth is perfected; at the time of birth great confusion of every kind has been found. Those which only depart a little from Nature commonly live; not so those which depart further, when the unnatural condition is in the parts which are sovereign over life.

The question then about all these cases is this. Are we to suppose that a single cause is responsible for the production of a single young one and for the deficiency of the parts, and another but still a single cause for the production of many young and the multiplication of parts, or not?

In the first place it seems only reasonable to wonder why some animals produce many young, others only one. For it is the largest animals that produce one, e.g. the elephant, camel, horse, and the other solid-hoofed ungulates; of these some are larger than all other animals, while the others are of a remarkable size. But the dog, the wolf, and practically all[2] the fissipeds produce many, even the small members of the class, as the mouse family. The cloven-footed animals again produce few, except the pig, which belongs to those that produce many. This certainly seems surprising, for we should expect the large animals to be able to generate more young and to secrete more semen.[3] But precisely what we wonder at is the reason for not wondering; it is just because of their size that they do not produce many young, for the nutriment is expended in such animals upon increasing the body. But in the smaller animals Nature takes away from the size and adds the excess so gained to the seminal secretion. Moreover, more semen must needs be used in generation by the larger

[1] i.e. they are found on inspection of animals which *were* living in this condition, not merely in embryos.

[2] Reading *πάντα σχεδὸν πολυτόκα*. Fissipeds = carnivora, rodents, and insectivora, roughly.

[3] Reading *σπέρμα τ' ἐκκρίνειν πλεῖον*.

animal, and little by the smaller. Therefore many small ones may be produced together, but it is hard for many large ones to be so, and to those intermediate in size Nature has assigned the intermediate number. We have formerly given the reason why some animals are large, some smaller,
771b and some between the two, and speaking generally, with regard to the number of young produced, the solid-hoofed produce one, the cloven-footed few, the many-toed many. (The reason of this is that, generally speaking, their sizes correspond to this difference.) It is not so, however, in all cases; for it is the largeness and smallness of the body that is cause of few or many young being born, not the fact that the kind of animal has one, two, or many toes. A proof of this is that the elephant is the largest of animals and yet is many-toed, and the camel, the next largest, is cloven-footed. And not only in animals that walk but also in those that fly or swim the large ones produce few, the small many, for the same reason. In like manner also it is not the largest plants that bear most fruit.

We have explained then why some animals naturally produce many young, some but few, and some only one;[1] in the difficulty now stated we may rather be surprised with reason[2] at those which produce many, since such animals are often seen to conceive from a single copulation. Whether the semen of the male contributes to the material of the embryo by itself becoming a part of it and mixing with the semen of the female, or whether, as *we* say, it does not act in this way but brings together and fashions the material within the female and the generative secretion as the fig-juice does the liquid substance of milk, what is the reason why it does not form a single animal of considerable size? For certainly in the parallel case the fig-juice is not separated if it has to curdle a large quantity of milk, but the more the milk and the more the fig-juice put into it, so much the greater is the curdled mass.[3] Now it is no use to say that the several regions of the uterus attract the semen and

[1] Reading τὰ δὲ μονοτόκα after ὀλιγοτόκα.
[2] Reading εὐλόγως after ἄν τις.
[3] The text of this sentence is somewhat uncertain. We should expect the argument to run thus: As fig-juice does not curdle several

therefore more young than one are formed, because the regions are many and the cotyledons are more than one. For two embryos are often formed in the same region of the uterus, and they may be seen lying in a row in animals that produce many, when the uterus is filled with the embryos.[1] (This is plain from the dissections.) Rather the truth is this. As animals complete their growth there are certain limits to their size, both upwards and downwards, beyond which they cannot go, but it is in the space between these limits that they exceed or fall short of one another in size, and it is within these limits that one man (or any other animal) 772a
is larger or smaller than another. So also the generative material from which each animal is formed is not without a quantitative limit in both directions, nor can it be formed from any quantity you please. Whenever then an animal, for the cause assigned, discharges more of the female secretion than is needed for beginning the existence of a single animal, it is not possible that only one should be formed out of all this, but a number limited by the appropriate size in each case; nor will[2] the semen of the male, or the power residing in the semen, form anything either more or less than what is according to Nature. In like manner, if the male emits more semen than is necessary, or more powers in different parts of the semen as it is divided, however much it is it will not make anything greater;[3] on the contrary it will dry up the material of the female and destroy it.[4] So fire also does not continue to make water hotter in proportion as it is itself increased, but there is a fixed limit to the heat of which water is capable; if that is once reached and the fire is then increased, the water no longer gets hotter but rather evaporates and at last disappears and is dried up. Now since it appears that the secretion of the female and

separate masses of milk, so semen would not be expected to form several embryos out of the material in the female.

[1] Probably A. is thinking of the pig.

[2] Reading *συστήσει*.

[3] i.e. exceeding the limits fixed by the nature of the particular animal.

[4] The material contributed by the female is fluid and shapeless; the male influence solidifies and forms it, making it less fluid. If then there is too much semen, it will carry this process too far and may dry it up altogether.

that from the male need to stand in some proportionate relation to one another (I mean in animals of which the male emits semen), what happens in those that produce many young is this: from the very first [1] the semen emitted by the male has power, being divided, to form several embryos, and the material contributed by the female is so much that several can be formed out of it. (The parallel of curdling milk, which we spoke of before, is no longer in point here, for what is formed by the heat of the semen is not only of a certain quantity but also of a certain quality, whereas with fig-juice and rennet quantity alone is concerned.) This then is just the reason why in such animals the embryos formed are numerous and do not all unite into one whole; it is because an embryo is not formed out of any quantity you please, but whether there is too much or too little, in either case there will be no result, for there is a limit set alike to the power of the heat which acts on the material and to the material so acted upon.

On the same principle many embryos are not formed, though the secretion is much, in the large animals which produce only one young one, for in them also both the material and that which works upon it are of a certain quantity. So then they do not secrete such material in too great quantity for the reason previously stated, and what they do secrete is naturally just enough for one embryo alone to be formed from it. If ever too much is secreted, then twins are born. Hence such cases seem to be more portentous, because they are contrary to the general and customary rule.

772b Man belongs to all three classes, for he produces one only and sometimes many or few [2], though naturally he almost always produces one. Because of the moisture and heat of his body he may produce many [for semen is naturally

[1] These words are inserted by A. because he has to account for several embryos forming in consequence of a single copulation.

[2] It is quite plain that we have hitherto been discussing the number of young produced at one birth. A. then cannot be here talking of large familes; apparently he is thinking of triplets (*many*) or still more being born together; *few* may mean twins. (The author of the spurious seventh book of the *H. A.* says that 'five at a birth are the most that have been produced' and this seems to be true.) Read ποτε after πολυτοκεῖ.

fluid and hot],[1] but because of his size he produces few or one. On account of this it results that in man alone among animals the period of gestation is irregular; whereas the period is fixed in the rest, there are several periods in man, for children are born at seven months and at ten months and at the times between, for even those of eight months do live though less often than the rest. The reason may be gathered from what has just been said, and the question has been discussed in the *Problems*.[2] Let this explanation suffice for these points.

The cause why the parts may be multiplied contrary to Nature is the same as the cause of the birth of twins. For the reason exists already in the embryo, whenever it aggregates[3] more material at any point of itself than is required by the nature of the part. The result is then that either one of its parts is larger than the others, as a finger or hand or foot or any of the other extremities or limbs; or again if the embryo is cleft there may come into being more than one such part, as eddies do in rivers; as the water in these is carried along with a certain motion, if it dash against anything two systems or eddies come into being out of one, each retaining the same motion; the same thing happens also with the embryos.[4] The abnormal parts generally are attached near those they resemble,[5] but sometimes at a distance because of the movement taking place in the embryo, and especially because of the excess of

[1] The bracketed words seem to be a foolish interpolation, nor will it mend matters if we translate τοῦ σπέρματος as '*his* semen'. If we were to read τοῦ σώματος we might keep the words.

[2] Not in the extant collection.

[3] It seems an extraordinary thing to say that the embryo brings material together. Should we perhaps read πλείων ὕλη συστῇ for πλείω ὕλην συστήσῃ?

[4] Suppose the water in an eddy to be whirling round the same way as the hands of a clock; if this eddy strike a stick standing up in the river it will be split into two new smaller eddies still whirling the same way. The movements which take place in the embryo are like such an eddy, and if e.g. the cells which are to form the little finger in the embryo are 'split', they will form two such fingers, the same movement going on in each set of cells. Cf. *de Somniis*, 461a 8; and for the metaphor J. A. Thomson, *Heredity*, p. 270: 'those particularly constant forms of whirlpool which we call the germ-cells, which repeat themselves and propagate themselves.'

[5] Lit. 'they mostly grow on near one another.'

material returning to that place whence it was taken away while retaining the form of that part whence it arose as a superfluity.[1]

In certain cases we find a double set of generative organs [one male and the other female].[2] When such duplication occurs the one is always functional but not the other,[3] because it is always insufficiently supplied with nourishment as being contrary to Nature; it is attached like a growth [4] (for such growths also receive nourishment though they are a later development than the body proper and contrary to Nature). If the formative power prevails, both are similar; if it is altogether vanquished, both are similar [5]; but if it prevail here and be vanquished there, then the one is female and the other male. (For whether we consider the reason why the whole animal is male or female, or why the parts are so, makes no difference.[6])

When we meet with deficiency in such parts, e. g. an extremity or one of the other members, we must assume

[1] If too much material is drawn to what is going to develop into a finger, we may get two fingers instead of one. But this superfluous material must have been drawn from somewhere else, say from the wrist; then it tends to return to the wrist and so a superfluous finger may be found there, instead of its being attached to the hand at the same point as the normal finger. As it was developed alongside of the normal finger, it will still retain the form of one. 'The movement taking place in the embryo' apparently enables these astonishing migrations to occur. Darwin's 'gemmules' were supposed to wander about the body with the same freedom, and had to account for strange growths in a somewhat similar way.

[2] The bracketed words must be interpolated, as appears from considering this paragraph as a whole.

[3] *τὸ μὲν κύριον τὸ δ᾽ ἄκυρον.*

[4] 'Quelques auteurs rapportent des cas dans lesquels il existait deux pénis, non plus placés l'un à côté de l'autre, ce qui est le cas le plus ordinaire, mais superposés l'un à l'autre' (St. Hilaire, tom. i, p. 731). It seems that A. is thinking of a case of this kind. As for duplication of the female organs, I suppose he is alluding to a double uterus, in which one of the two halves may be smaller than the other.

[5] i. e. if the semen prevails, both are male, if it does not, both are female.

[6] i. e. the theory that the organism as a whole is male if the male formative element prevails, female if that element is overcome by the female element, may be equally well applied to the development of the parts considered by themselves. Hence hermaphroditism is to be explained by saying that the male element prevails in one part of the developing tissue but not in the other.

the same cause as[1] when the embryo is altogether aborted (abortion of embryos happens frequently).

Outgrowths differ from the production of many young in the manner stated before;[2] monsters differ from these in that most[3] of them are due to embryos growing together. Some however are also of the following kind, when the monstrosity affects greater and more sovereign parts, as for instance some monsters have two spleens or more than two kidneys. Further, the parts may migrate, the movements which form the embryo being diverted and the material changing its place. We must decide whether the monstrous animal is one or is composed of several grown together by considering the vital principle; thus, if the heart is a part of such a kind[4] then that which has one heart will be one animal, the multiplied parts being mere outgrowths, but those which have more than one heart will be two animals grown together through their embryos having been confused.[5]

It also often happens even in many animals that do not seem to be defective and whose growth is now complete, that some of their passages may have grown together or others may have been diverted from the normal course. Thus in some women before now the os uteri has remained closed, so that when the time for the catamenia has arrived pain has attacked them,[6] till either the passage has burst

[1] Reading *αἰτίαν ἥνπερ καὶ ἐὰν ὅλον.*

[2] i.e. the cause of multiplication of parts differs from the cause of birth of many young in that the multiplication of parts is due to an excess of material in some part of a single embryo, whereas many young are produced if the laws of growth enable the female material to be divided up into many embryos.

[3] Reading *τῷ τὰ πολλά.* The meaning is that 'Siamese' monsters differ from *monstra per excessum* in that the former are due to confusion of distinct embryos. By 'monsters' in this sentence A. only means the class of 'Siamese' monsters, but he has previously been using the term to include all classes, and in the next sentence again uses it of *monstra per excessum.* The whole of this discussion is however in dreadful confusion.

[4] i.e. a vital principle.

[5] But there is the possibility of the formation of a double heart in development, which sometimes happens (Panum, *Untersuchung über die Entstehung der Missbildungen*, 1860, p. 81). And all double monsters are in reality developed from the splitting of a single germ.

[6] Reading *ἐπιγιγνομένων.*

open of its own accord or the physicians have removed the impediment; some such cases have ended in death if the rupture has been made too violently or if it has been impossible to make it at all. In some boys on the other hand the end of the penis has not coincided with the end of the passage where the urine is voided, but the passage has ended below, so that they crouch sitting to void it, and if the testes are drawn up they appear from a distance to have both male and female generative organs.[1] The passage of the solid food also has been closed before now in sheep and some other animals; there was a cow in Perinthus which passed fine matter, as if it were sifted, through the bladder, and when the anus was cut open it quickly closed up again nor could they succeed in keeping it open.[2]

We have now spoken of the production of few and many young, and of the outgrowth of superfluous parts or of their deficiency, and also of monstrosities.

Superfoetation[3] does not occur at all in some animals but 5
does in others; of the former some are able to bring the later formed embryo to birth, while others can only do so sometimes. The reason why it does not occur in some is
773b that they produce only one young one, for it is not found in solid-hoofed animals and those larger than these, as owing

[1] 'L'hypospadias est l'ouverture anomale de l'urèthre à la partie inférieure du pénis' (St. Hilaire, tom. i, p. 607). 'La fissure du périnée qui simule quelquefois chez les mâles une vulve' (ibid.).

[2] Such congenital malformation is known as *atresia ani*. In one form of this there is 'no anus, but the rectum has opened into, and its contents escaped either by the urethra in the male, or by the vagina in the female. . . . Life may continue under such an arrangement, particularly in the female' (Todd, vol. i, p. 182). When an operation is performed to rectify this state of things, 'the channel is to be kept carefully dilated, in order to oppose the natural tendency in the parts to close' (ibid.).

[3] There are two kinds of superfoetation; either ova produced at the same period may be fertilized by two different impregnations, or the ova may themselves be produced at two different periods and the earlier and later ova may then be fertilized by earlier and later impregnations. A. speaks only of the latter (the former is now generally called superfecundation). It seems impossible to deny that superfoetation in the Aristotelian sense occurs occasionally in man; see Playfair, *Midwifery*[6], vol. i, p. 189.

to their size the secretion of the female is all used up for the one embryo. For all these have large bodies, and when an animal is large its foetus is large in proportion, e.g. the foetus of the elephant is as big as a calf. But superfoetation occurs in those which produce many young because the production of more than one at a birth is itself a sort of superfoetation, one being added to another. Of these all that are large, as man, bring to birth the later embryo, if the second impregnation takes place soon after the first, for such an event has been observed before now. The reason is that given above, for even in a single act of intercourse the semen discharged is more than enough for one embryo, and this being divided causes more than one child to be born, the one of which is later than the other. But when the embryo has already grown to some size and it so happens that copulation occurs again, superfoetation sometimes takes place, but rarely, since the uterus generally closes in women during the period of gestation. If this ever happens (for this also has occurred) the mother cannot bring the second embryo to perfection, but it is cast out in a state like what are called abortions. For just as, in those animals that bear only one, all the secretion of the female is converted to the first formed embryo because of its size, so it is here also; the only difference is that in the former case this happens at once, in the latter when the foetus has attained to some size, for then they are in the same state as those that bear only one.[1] In like manner—since man naturally would produce many young, and since the size of the uterus and the quantity of the female secretion are both greater than is necessary for one embryo, only not so much so as to bring to birth a second[2]—therefore women

[1] In a horse, e.g., all the female material goes to form one foal, and thus it produces only one. Man would naturally produce many, indeed sometimes does so, but if one foetus of some size already exists, it draws to itself any other material, and thus the woman resembles the mare in being only able to produce one child. This seems to be the meaning, but why should the already existing foetus prevent another being formed if twins do not prevent one another? Besides the fact is that cases of superfoetation of this kind are known in man.

[2] i.e. if the second starts life later than the first. But again what about twins?

and mares are the only animals which admit the male during gestation, the former for the reason stated, and mares both because of the barrenness of their nature [1] and because their uterus is of superfluous size, too large for one but too small to allow a second embryo to be brought to perfection by superfoetation. And the mare is naturally inclined to sexual intercourse because she is in the same case as the barren among women; these latter are barren because they have no monthly discharge (which corresponds to the act of intercourse in males) and mares have exceedingly little. And in all the vivipara the barren females are so inclined, because they resemble the males when the semen has collected in the testes but is not being
774a got rid of. For the discharge of the catamenia is in females a sort of emission of semen, they being unconcocted semen as has been said before. Hence it is that those women also who are incontinent in regard to such intercourse cease from their passion for it when they have borne many children, for, the seminal secretion being then drained off, they no longer desire this intercourse. And among birds the hens are less disposed that way than the cocks, because the uterus of the hen-bird is up near the hypozoma; but with the cock-birds it is the other way, for their testes are drawn up within them so that, if any [2] kind of such birds has much semen naturally, it is always in need of this intercourse. In females then it encourages copulation to have the uterus low down, but in males to have the testes drawn up.[3]

It has been now stated why superfoetation is not found in some animals at all, why it is found in others which sometimes bring the later embryos to birth and sometimes not, and why some such animals are inclined to sexual intercourse while others are not.

Some of those animals in which superfoetation occurs can bring the embryos to birth even if a long time elapses

[1] See ii. 8. The explanation of Philoponus (quoted by AW.) is altogether mistaken.

[2] Reading τι for τό.

[3] Why is this supposed to be so? A. does not give any reason; perhaps he means simply that it is observed to be so.

between the two impregnations, if their kind is spermatic,[1] if their body is not of a large size, and if they bear many young. For because they bear many their uterus is spacious, because they are spermatic the generative discharge is copious, and because the body is not large but the discharge is excessive and in greater measure than is required for the nourishment wanted for the embryo, therefore they can not only form animals but also bring them to birth later on. Further, the uterus in such animals does not close up during gestation because there is a quantity of the residual discharge left over.[2] This has happened before now even in women, for in some of them the discharge continues during all the time of pregnancy. In women, however, this is contrary to Nature, so that the embryo suffers, but in such animals it is according to Nature, for their body is so formed from the beginning, as with hares.[3] For superfoetation occurs in these animals, since they are not large and they bear many young (for they have many toes and the many-toed animals bear many), and they are spermatic. This is shown by their hairiness, for the quantity of their hair is excessive, these animals alone having hair under the feet and within the jaws.[4] Now hairiness is a sign of abundance of residual 774[b] matter, wherefore among men also the hairy are given to sexual intercourse and have much semen rather than

[1] By 'spermatic' A. means that both sexes produce large quantities of residual matter, which is worked up into semen by the male and remains in a sanguineous condition in the female.

[2] i.e. it is still left over after the formation of the first embryos, and as it continues to flow it must find a way out.

[3] The Greeks knew two kinds of hare, a larger and a smaller (Xen. *Cyn.* v. 22-4.) These were not hares and rabbits, for the rabbit had not then spread so far East as even Italy, nor *Lepus timidus* and *L. variabilis*, for the latter does not come so far south, but two varieties of *L. timidus*, (1) the ordinary brown hare of central Europe and England, (2) the smaller variety confined to the Mediterranean sub-region, which does not scale more than five or six pounds.

For superfoetation in the hare cf. Xen. *Cyn.* v. 13. 'Beim Hasen ist die Superfoetation nicht so sehr Regel wie der Verfasser glaubt, soll sich aber doch finden' (Sundevall, *Thierarten des Aristoteles*, p. 56).

[4] This is true of the whole genus *Lepus* (Flower and Lydekker, *Mammals*, p. 492). But A. adds in *H. A.* iii. 519[a] 23 that a certain whale also has hair in its mouth, i.e. the fibres of the whalebone (*Mammals*, p. 235).

the smooth. In the hare it often happens that some of the embryos are imperfect while others of its young are produced perfect.

Some of the vivipara produce their young imperfect, 6
others perfect; the one-hoofed and cloven-footed perfect, most[1] of the many-toed imperfect. The reason of this is that the one-hoofed produce one young one, and the cloven-footed either one or two generally speaking; now it is easy to bring the few to perfection. All the many-toed animals that bear their young imperfect give birth to many. Hence, though they are able to nourish[2] the embryos while newly formed, their bodies are unable to complete the process when the embryos have grown and acquired some size. So they produce them imperfect, like those animals which generate a scolex, for some of them when born are scarcely brought into form at all, as the fox, bear, and lion, and some of the rest in like manner; and nearly all of them are blind, as not only the animals mentioned but also the dog, wolf, and jackal. The pig alone produces both many and perfect young, and thus here alone we find any overlapping; it produces many as do the many-toed animals, but is cloven-footed or solid-hoofed (for there certainly are solid-hoofed swine).[3] They bear, then, many young because the nutriment which would otherwise go to increase their size is diverted to the generative secretion (for considered as a solid-hoofed animal the pig is not a large one), and also it is more often cloven-hoofed, striving as it were with the nature of the solid-hoofed animals. For this reason it produces sometimes only one, sometimes[4] two, but generally many, and brings them to perfection before birth because of the good condition of its body, being like a rich soil which has sufficient and abundant nutriment for plants.

The young of some birds also are hatched imperfect, that is to say blind; this applies to all small birds which lay

[1] Reading τὰ πολλά. [2] Reading τρέφειν.

[3] In *H. A.* ii. 499b 12 such swine are said to exist 'in Illyria, Paeonia, and elsewhere'. This abnormal condition is found in many races of domestic swine (AW.), and see Darwin, *Variation*[1], vol. i, p. 75.

[4] Reading ποτέ after πολυτοκεῖ.

many eggs, as crows and rooks,[1] jays, sparrows, swallows, and to all those which lay few eggs without producing abundant nourishment along with the young,[2] as ring-doves, turtle-doves, and pigeons.[3] Hence if the eyes of swallows while still young be put out they recover their sight again, for the birds are still developing, not yet developed, when the injury is inflicted, so that the eyes grow and sprout afresh.[4] And in general the production of young before they are perfect is owing to inability to continue nourishing them, and they are born imperfect because they are born too soon. This is plain also with seven-months children, for since they are not perfected it often happens 775a that even the passages, e. g. of the ears and nostrils, are not yet opened in some of them at birth, but only open later as they are growing, and many such infants survive.

In man males are more often born defective than females,[5] but in the other animals this is not the case. The reason is that in man the male is much superior to the female in

[1] κορώνη seems to include both these birds; see D'Arcy Thompson's *Glossary*, p. 97. All young birds which remain in the nest some time after hatching are born blind; these would include all or nearly all small birds and also some large ones, e. g. owls; all birds which leave the nest at once are born in possession of sight. Every one of the birds mentioned here by A. as born blind is correctly given. See Newton's *Dictionary of Birds*, svv. *Nidicolae*, *Nidifugae*.

[2] i. e. eggs with but little yolk.

[3] φάττα, τρυγών, περιστερά. I follow D'Arcy Thompson. The περιστερά in a specific sense, as here, is the domestic pigeon, in a general sense it includes the whole family.

[4] AW. say simply that modern experiments confirm this, but we must look a little more deeply into the matter. Redi (*Opuscula*, *pars secunda*, ed. 1729, p. 16) does indeed confirm the statement that the young swallow can recover its sight, 'id quod cuivis manifestum esse poterit, cui placuerit oculos hirundinum, aut alterius cuiuscunque aviculae, acu vel scalpro *solerter terebrare*.' And he says that he made the experiment himself on many birds. But Professor Morgan, of Columbia University, whom I consulted on this point, has kindly written to say 'if the eyes were "put out", i. e. injured, they might heal and regain their function, but if by "put out" one means "removed", then there can be no question of renewal.' Consequently when A. says that the eyes φύονται καὶ βλαστάνουσιν ἐξ ἀρχῆς he greatly exaggerates.

Observe how admirably A. has grasped the principle that regeneration is a phenomenon of embryonic growth, 'while the bird is developing but not developed.' Cf. Darwin, *Variation*[1], vol. ii, p. 15.

[5] Vrolik says just the opposite: 'In impeded development the malformed children are more frequently female' (Todd, vol. iv, p. 495).

natural heat, and so the male foetus moves about more than the female, and on account of moving is more liable to injury, for what is young is easily injured since it is weak. For this same reason also the female foetus is not perfected equally with the male in man[1] (but they are so in the other animals, for in them the female is not later in developing than the male). For while within the mother the female takes longer in developing, but after birth everything is perfected more quickly in females than in males; I mean, for instance, puberty, the prime of life, and old age. For females are weaker and colder in nature, and we must look upon the female character as being a sort of natural deficiency. Accordingly while it is within the mother it develops slowly because of its coldness (for development is concoction, and it is heat that concocts, and what is hotter is easily concocted); but after birth it quickly arrives at maturity and old age on account of its weakness, for all inferior things come sooner to their perfection or end, and as this is true of works of art so it is of what is formed by Nature. For the reason just given also twins are less likely to survive in man if one be male and one female, but this is not at all so in the other animals; for in man it is contrary to Nature that they should run an equal course, as their development does not take place in equal periods, but the male must needs be too late or the female too early;[2] in the other animals, however, it is not contrary to Nature. A difference is also found between man and the other animals in respect of gestation, for animals are in better bodily condition most of the time, whereas in most women gestation is attended with discomfort. Their way of life is partly responsible for this,[3] for being sedentary they are full of more residual matter; among nations where the women live a laborious life gestation is not equally conspicuous and

[1] Read *ἐν τοῖς ἀνθρώποις* for *ἐν ταῖς γυναιξίν*, 'in genere hominum,' Gaza. The sentence following in parenthesis was added by Schneider from the old Latin versions.

[2] If the male took less time to form than the female, this would follow. A. seems to think that the period of gestation differs for the two sexes. Cf. *H. A.* vii. 583ᵇ 23.

[3] Qu. *τούτου* for *τούτων*?

those who are accustomed to work bear children easily both there and elsewhere ; for work consumes the residual matter, but those who are sedentary have a great deal of it in them because not only is there no monthly discharge during pregnancy but also they do no work ; therefore their travail is painful. But work exercises them so that they can hold 775b
their breath, upon which depends the ease or difficulty of child-birth.[1] These circumstances then, as we have said, contribute to cause the difference between women and the other animals in this state, but the most important thing is this: in some animals the discharge corresponding to the catamenia is but small, and in some not visible at all, but in women it is greater than in any other animal, so that when this discharge ceases owing to pregnancy they are troubled (for if they are not pregnant they are afflicted with ailments whenever the catamenia do not occur) ; and they are more troubled as a rule at the beginning of pregnancy,[2] for the embryo is able indeed to stop the catamenia but is too small at first to consume any quantity of the secretion ; later on it takes up some of it and so alleviates the mother. In the other animals, on the contrary, the residual matter is but small and so corresponds with the growth of the foetus, and as the secretions which hinder nourishment are being consumed by the foetus the mother is in better bodily condition than usual.[3] The same holds good also with aquatic animals and birds.[4] If it ever happens that the body of the mother is no longer in good condition when the foetus is now becoming large, the reason is that its growth needs more nourishment than the residual matter supplies. (In some few women it happens that the body is in a better state during pregnancy ; these are women in whose body

[1] 'Holding the breath is of no consequence at all, or at any rate of very little' (AW.). A. thought that 'holding the breath produces strength' (*de Somno*, 456a 16).

[2] Reading συλλαβοῦσαι.

[3] This appears unintelligible. That the discharge should hinder the nourishment of an animal is a reasonable view, for the matter which might go to nourishing it is wasted, but if the same matter is used up to increase the growth of the foetus, how can this help the mother?

[4] A. means that cephalopoda and crustacea (i. 727b 2) and birds (*H. A.* vi. 564a 3) are in better condition when breeding.

the residual matter is small so that it is all used up along with the nourishment that goes to the foetus.)

We must also speak of what is known as *mola uteri*,[1] 7
which occurs rarely in women but still is found sometimes during pregnancy. For they produce what is called a *mola*; it has happened before now to a woman, after she had had intercourse with her husband and supposed she had conceived, that at first the size of her belly increased and everything else happened accordingly, but yet when the time for birth came on, she neither bore a child nor was her size reduced, but she continued thus for three or four years until dysentery came on, endangering her life, and she produced a lump of flesh which is called *mola*.[2] Moreover this condition may continue till old age and death. Such masses when expelled from the body become so hard that they can hardly be cut through even by iron.[3] Concerning the cause of this phenomenon we have spoken in the *Problems*;[4] the same thing happens to the embryo in the
776a womb as to meats half cooked in roasting, and it is not due to heat, as some say, but rather to the weakness of the maternal heat. (For their nature seems to be incapable, and unable to perfect or to put the last touches to the process of generation. Hence it is that the *mola* remains in them till old age or at any rate for a long time, for in its nature it is neither perfect nor altogether a foreign body.[5]) It is want of concoction that is the reason of its hardness, as with half-cooked meat, for this half-dressing of meat is also a sort of want of concoction.

[1] If the foetus die during pregnancy and is not cast forth, part of the placenta or membranes may continue to be nourished, causing the formation of a 'mola' or 'mole'. This is finally 'cast off in the form of a thick fleshy mass' (Playfair, *Midwifery*[6], vol. i, p. 286).

[2] 'The longest authentic case of a true uterine mole is about eighteen months. But an extra-uterine mole may be retained in the body for many years' (G. Blacker).

[3] 'An extra-uterine mole or a body of similar nature may become calcified and be of stony hardness' (Blacker, who also remarks that a calcified 'fibroid' might be confused with a mole).

[4] Not in our present collection.

[5] If it were perfect it would be brought to birth as a child at the right time; if it were a foreign body it would soon be expelled, like a noxious humour.

A difficulty is raised as to why this does not occur in other animals, unless indeed it does occur and has entirely escaped observation. We must suppose the reason to be that woman alone among animals is subject to troubles of the uterus, and alone has a superfluous amount of catamenia and is unable to concoct them; when, then, the embryo has been formed of a liquid hard to concoct, then comes the so-called *mola* into being, and this happens naturally in women alone or at any rate more than in other animals.

8 Milk is formed in the females of all internally viviparous animals, becoming useful for the time of birth. For Nature has made it for the sake of the nourishment of animals after birth, so that it may neither fail at this time at all nor yet be at all superfluous; this is just what we find happening, unless anything chance contrary to Nature. In the other animals the period of gestation does not vary, and so the milk is concocted in time to suit this moment, but in man, since there are several times of birth, it must be ready at the first of these; hence in women the milk is useless before the seventh month and only then becomes useful. That it is only concocted at the last stages is what we should expect to happen also as being due to a necessary cause.[1] For at first such residual matter when secreted is used up for the development of the embryo; now the nutritious part in all things is the sweetest and the most concocted, and thus when all such elements are removed what remains must become of necessity bitter and ill-flavoured.[2] As the embryo is perfecting, the residual matter left over increases in quantity because the part consumed by the embryo is

[1] As well as to the final cause.

[2] Milk is a residual secretion of the blood, and as A. says presently 'of the same nature as the matter of which the embryo is made'. If the embryo consumes most of this matter as nourishment at an early stage, then, since nourishment is the sweetest part of it, it follows that what is left over will be sour, for the embryo will extract all the sweet part. When the embryo ceases doing so the sweet part will be included in the rest of what goes to form the milk. Hence it is a *necessary* result that milk will be sour in the first months of pregnancy and sweet at the end, besides which there is also a final cause subserved. We should now, I suppose, lay more stress on the final cause than A. does.

less; it is also sweeter since the easily concocted part is less drawn away from it. For it is no longer expended on moulding the embryo but only on slightly increasing its growth, it being now fixed because it has reached perfection
776b (for in a sense there is a perfection even of an embryo).[1] Therefore it comes forth from the mother and changes its mode of development, as now possessing what belongs to it; and no longer takes that which does not belong to it; and it is at this season that the milk becomes useful.

The milk collects in the upper part of the body and the breasts because of the original plan of the organism. For the part above the hypozoma is the sovereign part of the animal, while that below is concerned with nourishment and residual matter, in order that all animals which move about may contain within themselves nourishment enough to make them independent when they move from one place to another.[2] From this upper part also is produced the generative secretion for the reason mentioned in the opening of our discussion.[3] But both the secretion of the male and the catamenia of the female are of a sanguineous nature, and the first principle of this blood and of the blood-vessels is the heart, and the heart is in this part of the body. Therefore it is here that the change of such a secretion must first become plain.[4] This is why the voice changes in both sexes when they begin to bear seed[5] (for the first

[1] In the ordinary sense the animal is not perfect until it is adult, but in a certain sense it may be regarded as being perfect when the time comes for it to be born.

[2] Non-locomotive animals, such as sponges, have indeed the distinction of 'upper' and 'lower' but are not definitely differentiated in their parts as the higher animals are, and in particular are not divided into two halves by a diaphragm, as mammalia, or by any corresponding division like the waist of insects. The lower part in locomotive animals is like the commissariat of an army, enabling the upper part to move away from its base of supplies.

[3] This may mean either the beginning of this treatise, or the *Historia Animalium*, but I cannot find any passage to the point.

[4] It is true, says A., that semen and catamenia are discharged low in the body, but yet they both (being residues of the blood) come originally from the centre of life in the upper part. Therefore we should expect any change connected with them to show itself first in the upper part, as we do find in the case of milk, breaking of the voice, &c.

[5] *σπέρμα φέρειν*, a phrase properly used of plants and oddly applied to men. As applied to women, indeed, it is quite incorrect except metaphorically, for A. denies *σπέρμα* to them.

principle of the voice resides there, and is itself changed when its moving cause changes).[1] At the same time the parts about the breasts are raised visibly even in males but still more in females, for the region of the breasts becomes empty and spongy in them because so much material is drained away below. This is so not only in women but also in those animals which have the mammae low down.[2]

This change in the voice and the parts about the mammae is plain even in other creatures to those who have experience of each kind of animal,[3] but is most remarkable in man. The reason is that in man the production of secretion is greatest in both sexes in proportion to their size as compared with other animals; I mean that of the catamenia in women and the emission of semen in men. When, therefore, the embryo[4] no longer takes up the secretion in question but yet prevents its being discharged from the mother, it is necessary that all the residual matter should collect in all those empty parts which are set upon the same passages.[5] And such is the position of the mammae in each kind of animals for both causes; it is so both for the sake of what is best and of necessity.

It is here, then, that the nourishment in animals is now[6] formed and becomes thoroughly concocted. As for the cause of concoction, we may take that already given,[7] or we may take the opposite, for it is a reasonable view also that 777a

[1] The efficient cause is the heart. As the centre of life the heart must be responsible for the changes of puberty. 'The principle of the voice resides' in the thorax near the heart, and is changed along with the other changes. In modern language, this principle is the larynx, which is elongated at puberty and so lowers the voice.

[2] The discharge of matter at puberty may perhaps account with some reason for the breasts becoming spongy, but how does A. suppose that it can cause them to swell? If the region is 'empty' it ought to collapse.

[3] Shepherds, grooms and so on.

[4] At the end of pregnancy.

[5] The 'passages' here mean of course blood-vessels, but it is not clear why A. should say that the vessels of the breasts and of the uterus are 'the same', in any sense which would not apply equally well to the vessels of almost any other two parts of the body. But it was a doctrine of the medicals; see Hippocrates, vol. i, p. 402.

[6] i.e. at the time of giving birth.

[7] i.e. that the embryo takes less nourishment from the mother towards the end of pregnancy.

the embryo being larger takes more nourishment, so that less is left over about this time, and the less is concocted more quickly.

That milk has the same nature as the secretion from which each animal is formed is plain, and has been stated previously. For the material which nourishes is the same as that from which Nature forms the animal in generation. Now this is the sanguineous liquid in the sanguinea, and milk is blood concocted (not corrupted; Empedocles either mistook the fact or made a bad metaphor when he composed the line: 'On the tenth day of the eighth month the milk comes into being, a white pus,' for putrefaction and concoction are opposite things, and pus is a kind of putrefaction but milk is concocted). While women are suckling children the catamenia do not occur according to Nature,[1] nor do they conceive; if they do conceive, the milk dries up. This is because the nature of the milk and of the catamenia is the same, and Nature cannot be so productive as to supply both at once; if the secretion is diverted in the one direction it must needs cease in the other, unless some violence is done contrary to the general rule. But this is as much as to say that it is contrary to Nature, for in all cases where it is not impossible for things to be otherwise than they generally are but where they may so happen, still what is the general rule is what is 'according to Nature'.

The time also at which the young animal is born has been well arranged. For when the nourishment coming through the umbilical cord is no longer sufficient for the foetus because of its size, then at the same time[2] the milk becomes useful for the nourishment of the newly-born animal,[3] and the blood-vessels round which the so-called umbilical cord lies as a coat collapse as the nourishment is no longer passing through it; for these reasons it is at that time also that the young animal enters into the world.

The natural birth of all animals is head-foremost, because 9
the parts above the umbilical cord are larger than those

[1] Though they may do so exceptionally.
[2] Read ἅμα for ἀλλά.
[3] Reading τὴν τοῦ γενομένου τροφήν, as suggested by AW.

below. The body then, being suspended from the cord as in a balance, inclines towards the heavy end, and the larger parts are the heavier.

10 The period of gestation is, as a matter of fact, determined generally in each animal in proportion to the length of its life. This we should expect, for it is reasonable that the development of the long-lived animals should take a longer time. Yet this is not the cause of it, but the periods only correspond accidentally for the most part; for though the larger and more perfect sanguinea do live 777b
a long time, yet the larger are not all longer-lived. Man lives a longer time than any animal of which we have any credible experience except the elephant,[1] and yet the human kind is smaller than that of the bushy-tailed animals[2] and many others. The real cause of long life in any animal is its being tempered in a manner resembling the environing air,[3] along with certain other circumstances of its nature,[4] of which we will speak later; but the cause of the time of gestation is the size of the offspring.[5] For it is not easy for large masses to arrive at their perfection in

[1] Obviously A. is here thinking only of mammalia, as the period of gestation can only apply to them. Hence his statement is correct; we have no credible experience of the cetacea. He is probably thinking of the stag, which was fabled to be very long lived.

[2] The genus *Equus*.

[3] This 'tempering' requires some explanation. The heart and blood are hot; the office of the brain is to cool the blood. Why then, it may be asked, should Nature first make a thing hot and then add an apparatus to cool it again? The answer is that the heat of the heart is necessary to all the higher functions of life; compare the vitality of a mammal with that of a tortoise. Man is the most intellectual and most vigorous of animals because he is the hottest, and therefore he has the largest brain in order to keep him properly 'tempered'. (While *we* should say that man is most intellectual because he has the largest brain, A. says he has the largest brain because he is most intellectual.)

What A. means by the words 'in a manner resembling the air' is not so clear. Probably, I think, his idea is that the surface of the body should be at the same temperature as the air, or at any rate not too far from it.

[4] *συμπτώματα φυσικά*, perhaps 'accidents' or 'coincident characteristics' rather than 'circumstances'. A. means the character of the liver; see *de Partibus*, iv. 677a 36; and other reasons are given in the fifth chapter of the treatise *de Longitudine Vitae*. Perhaps this is what he has in mind when he promises to speak later on the subject.

[5] This is true roughly, but not exactly.

a small time, whether they be animals or, one may say, anything else whatever. That is why horses and animals akin to them, though living a shorter time than man, yet carry their young longer; for the time in the former is a year,[1] but in the latter ten months[2] at the outside. For the same reason also the time is long in elephants; they carry their young two years[3] on account of their excessive size.

We find, as we might expect, that in all animals the time of gestation and development and the length of life aims at being measured by naturally complete periods.[4] By a natural period I mean, e.g., a day and night,[5] a month, a year, and the greater times measured by these, and also the periods of the moon, that is to say, the full moon and her disappearance and the halves of the times between these,[6] for it is by these that the moon's orbit fits in with that of the sun [the month being a period common to both].[7]

The moon is a first principle[8] because of her connexion with the sun and her participation in his light, being as it were a second smaller sun, and therefore she contributes to all generation and development. For heat and cold varying within certain limits make things to come into being and after this to perish, and it is the motions of the sun and moon that fix the limit both of the beginning and of the end of these processes. Just as we see the sea and all bodies of water[9] settling and changing[10] according to the movement or rest of the winds, and the air and winds

[1] See note on ii. 748a 30. [2] i. e. lunar months.

[3] An exaggeration; it should be about twenty-one months.

[4] Reading περιόδοις ὅλαις. It seems necessary to the sense to take κατὰ φύσιν with these words.

[5] It is not clear whether 'day and night' are to be taken together as one period, or whether they are two.

[6] i. e. the whole period of a month is divided into the four quarters, each being a subordinate period.

[7] The bracketed words give no sense. A period common to both sun and moon would be one which contained both the solar and lunar periods exactly. The form μεὶς is also very suspicious, not being found elsewhere in Aristotle.

[8] i. e. the moon is one of the primary causes affecting life on earth. Cf. Darwin, *Descent of Man*, chap. vi, note 32.

[9] Lit. 'all the nature of liquids'. [10] i. e. calm or moving.

again according to the course of the sun and moon, so also the things which grow out of these or are in these[1] must needs follow suit. For it is reasonable that the periods of 778a
the less important should follow those of the more important. For[2] in a sense a wind, too, has a life and birth and death.

As for the revolutions of the sun and moon, they may perhaps depend on other principles.[3]

It is the aim, then, of Nature to measure the coming into being and the end of animals by the measure of these higher periods, but she does not bring this to pass accurately because matter cannot be easily brought under rule and because there are many principles which hinder generation and decay from being according to Nature, and often cause things to fall out contrary to Nature.

We have now spoken of the nourishment of animals within the mother and of their birth into the world, both of each kind separately and of all in common.

[1] What are 'these'? Air and water apparently; all plants and animals are 'in' these, and to some extent 'grow out of' them; at least they all have both air and liquid in their composition.

[2] The connexion is: 'Therefore the life-periods of plants and animals follow those of winds, &c. For . . .'

[3] Which will be higher still.

BOOK V

We must now investigate the qualities by which the parts of animals differ. I mean such qualities of the parts as blueness and blackness in the eyes, height and depth of pitch in the voice, and differences[1] in colour whether of the skin or of hair and feathers.[2] Some such qualities are found to characterize the whole of a kind of animals sometimes, while in other kinds they occur at random, as is especially the case in man.[3] Further, in connexion with the changes in the time of life, all animals are alike in some points, but are opposed in others[4] as in the case of the voice and the colour of the hair, for some do not grow grey visibly in old age, while man is subject to this more than any other animal. And some of these affections appear immediately after birth, while others become plain as age advances or in old age. I

Now[5] we must no longer[6] suppose that the cause of these and all such phenomena is the same. For whenever things are not the product of Nature working upon the

[1] Reading *διαφοράς*.

[2] This passage has some error in the text. I read provisionally *ἢ δέρματος ἢ τριχῶν καὶ πτερῶν*, for what A. deals with later is the colour of skin, &c. The MSS. give *ἢ σώματος καὶ τριχῶν ἢ* (or *ἢ καὶ*) *πτερῶν*.

[3] e.g. the hair of all lions is tawny; this colour characterizes the whole lion kind. But the hair of man may be of almost any colour.

[4] e.g. all animals alike change by becoming dimmer sighted in old age, but the voice does not always become deeper in the adult nor the hair always greyer in old age.

[5] Reading *δή*.

[6] 'No longer', because hitherto we have assumed the causes of development to be the same for each individual in any given 'kind'. The laws of development cause every normal chicken to grow a heart, kidneys, legs, feathers, &c., in the same way; even an abnormal chicken with four legs is only due to some accident, not to any 'cause' in the sense of what we now call a 'law'. But when we come to such differences among individuals as blue and brown eyes, we cannot any longer say that these are due to the law of development common to the species.

animal kingdom as a whole, nor yet characteristic of each separate kind, then none of these things is such as it is or is so developed for any final cause.[1] The eye for instance exists for a final cause, but it is not blue for a final cause unless this condition be characteristic of the kind of animal.[2] In fact in some cases this condition has no connexion with the essence of the animal's being, but we must refer the causes to the material and the motive principle or efficient 778b
cause, on the view that these things come into being by Necessity.[3] For, as was said originally in the outset of our discussion, when we are dealing with definite and ordered products of Nature, we must not say that each *is* of a certain quality because it *becomes* so, but rather that they *become* so and so because they *are* so and so, for the process of Becoming or development attends upon Being and is for the sake of Being, not *vice versa*.[4]

[1] In modern language 'if a character is common to all animals or to all the members of a group or species, then it exists and is developed for some definite purpose, but fluctuating characters are not so developed.' This is precisely the position of Darwin and Wallace. When A. proceeds from these characters to others which differ within the species, as blue and brown eyes, he may be said to be taking the step from the subject-matter of Darwin to that of Mendel. There are few if any passages even in Aristotle which strike one with greater astonishment and admiration than this.

[2] If a character is constant, it is the 'work of Nature', for by 'natural' we mean whatever is regularly of such or such a kind. And as 'Nature makes nothing in vain' such a character must exist for some final cause. Thus the eye of a lion is always brown, and accordingly we say that this is a protective colour, like that of his coat. But when we find that in man some eyes are blue and some brown we can no longer say that this is a work of Nature in exactly the same sense, or that the colours are for a final cause.

[3] A horse is a horse because Nature has so handled the material horse-flesh, &c., that it is put into the proper *form*, which is the essence of horse-nature, and fulfils its purpose or the *final cause* of its existence. The formal and final causes are the same thing in the case of an animal, and with them is concerned the workmanship of Nature. But Nature cannot always control her material, and hence arise variations from the perfect type, which A. puts down to Necessity. Apparently the material and efficient causes are to be reckoned here as practically identical with Necessity. Matter is always recalcitrant and hinders Nature from her purpose because of its inherent deficiency. The efficient cause also (the semen in the case of an animal) may fail to carry out Nature's intention.

[4] These metaphysics may be interpreted into science by saying that the process of development is not an end in itself but has only been evolved for the sake of continuing the race. In particular the foetal membranes, for instance, have been evolved as an afterthought simply

The ancient Nature-philosophers however took the opposite view. The reason of this is that they did not see that the causes were numerous, but only saw the material and efficient and did not distinguish even these, while they made no inquiry at all into the formal and final causes.

Everything then exists for a final cause, and all those things which are included in the definition of each animal, or which either are means to an end or are ends in themselves, come into being both through this cause and the rest.[1] But when we come to those things which come into being without falling under the heads just mentioned,[2] their course must be sought in the movement or process of coming into being, on the view that the differences which mark them arise in the actual formation of the animal. An eye, for instance, the animal must have of necessity (for the fundamental idea of the animal is of such a kind),[3] but it will have an eye of a particular kind[4] of necessity in another sense, not the sense mentioned just above, because it is its nature to act or be acted on in this or that way.[5]

to aid in bringing the foetus to its perfection as a member of the species, which is the important thing. Hence we may still agree with A. that the 'becoming' is for the sake of 'being'.

[1] i.e. through the final and also through the formal, material, and efficient causes. The horse exists for his final cause, simply that he may be a horse; included in his essence are also four solid hoofs, which we may look upon either as means to an end or as ends in themselves; these come into being not only for the final cause, but also through the material cause, since a certain quantity of matter goes to them, through the formal cause, since that matter must be put into the proper shape, and through the efficient cause, which is the movements in the embryo that cause the hoofs to develop.

[2] i.e. without being included in the essence of the animal and without being either means to an end or an end in themselves. Such are, for instance, blue and brown colour in the human eye. When A. goes on to say that such differences arise in the process of development, &c., he seems to be wrapping up the confession that he can only put them down to chance—or Necessity if you prefer to call it so.

[3] Of course A. did not believe *all* animals to have eyes; he is thinking of particular kinds, which alone concern his argument.

[4] i.e. colour.

[5] The meaning seems to be that eyes may be e.g. blue or brown indifferently; some necessity doubtless causes them to be one or other, but it is not a law of Nature like that which compels an eye to exist in man. The eye may thus vary because it is the nature of the eye so to 'act or be acted on' in development that it may turn out either of this colour or of that.

These distinctions being drawn let us speak of what comes next in order. As soon then as the offspring of all animals are born, especially those born imperfect,[1] they are in the habit of sleeping, because they continue sleeping also within the mother when they first acquire sensation.[2] But there is a difficulty about the earliest period of development, whether the state of wakefulness exists in animals first, or that of sleep. Since they plainly wake up more as they grow older, it is reasonable to suppose that the opposite state, that of sleep, exists in the first stages of development. Moreover the change from not being to being must pass through the intermediate condition, and sleep seems to be in its nature such a condition, being as it were a boundary between living and not living, and the sleeper being neither altogether non-existent nor yet existent. For life most of all appertains to wakefulness, on account of sensation.[3] But on the other hand, if it is necessary that the animal should have sensation and if it is then first an animal when it has acquired sensation, we ought to consider the original condition to be not sleep but only something resembling sleep, such a condition as we find also in plants, for indeed at this time animals do 779a
actually live the life of a plant.[4] But it is impossible that plants should sleep,[5] for there is no sleep which cannot be broken, and the condition in plants which is analogous to sleep cannot be broken.

It is necessary then for the embryo animal to sleep[6]

[1] The Greek is corrupt; for the sense cf. 779a 24.

[2] As all sensation has its origin in the heart (ii. 743b 25) we may assume that A. supposes the embryo to possess sensation from the time that the heart is first formed.

[3] By 'life' here A. means animal life. The distinguishing mark of this as compared with plant-life is sensation, but sensation is suspended during sleep, and so animal life in a strict sense implies wakefulness.

[4] That the embryo lives the life of a plant we have heard before (ii. 736b 13). If so, it follows that the embryo does not sleep (for plants do not), at any rate till it has acquired sensation and so become truly an animal.

[5] The botanists now talk of the 'sleep' of plants, but they do not mean the same thing as A. does here. His 'condition analogous to sleep' means nothing but the ordinary state of a plant in which the life of growth and nutrition continues but nothing higher.

[6] A. suddenly concludes that the state of the embryo *is* sleep as a rule, giving a new reason apparently as an afterthought.

most of the time because the growth takes place in the upper part of the body,[1] which is consequently heavier (and we have stated elsewhere that such is the cause of sleep).[2] But nevertheless they are found to wake even in the womb (this is clear in dissections and in the ovipara),[3] and then they immediately fall into a sleep again.[4] This is why after birth also they spend most of their time in sleep.

When awake infants do not laugh, but while asleep they both laugh and cry. For animals have sensations even while asleep, not only what are called dreams but also others besides dreams, as those persons who arise while sleeping and do[5] many things without dreaming. For there are some who get up while sleeping and walk about seeing just like those who are awake; these have perception of what is happening, and though they are not awake, yet this perception is not like a dream. So infants presumably have sense-perception and live in their sleep owing to previous habit, being as it were without knowledge of the waking state. As time goes on and their growth is transferred to the lower part of the body,[6] they now wake up more and spend most of their time in that condition. Children continue asleep at first more than other animals, for they are born in a more imperfect condition than other animals that are produced in anything like a perfect state,[7] and their growth has taken place more in the upper part of the body.

[1] The upper part being far more developed than the lower in the early stages.

[2] *de Somno*, 456^b 26.

[3] A. means that the embryo may be extracted in a wakeful condition from the eggs of ovipara or by being cut out from the mother in mammalia.

[4] *καθεύδουσι καὶ καταφέρονται.* The latter word is extremely common in the medical writers in the sense of 'falling asleep'. Is *καθεύδουσι* a gloss upon it? Or does A. add the medical after the vulgar term as illustrating by its derivation his theory that sleep is caused by heaviness?

[5] Read *πράττουσιν* for *πράττειν.*

[6] The head is at first out of all proportion to the lower part of the body, especially the legs. The growth is diverted more towards the lower part in proportion as children grow up.

[7] 'Lit. 'for they are born most imperfect of the perfected' animals, i.e. they are more removed from the adult state than any other animals which are produced viviparously and not as an egg or a scolex.

The eyes of all children are bluish[1] immediately after birth;[2] later on they change to the colour which is to be theirs permanently. But in the case of other animals this is not visible.[3] The reason of this is that the eyes of other animals are more apt to have only one colour for each kind of animal; e. g. cattle are dark-eyed, the eye of all sheep is pale, of others again the whole kind is blue or grey-eyed, and some are yellow (goat-eyed), as the majority of goats themselves, whereas the eyes of men happen to be of many colours, for they are blue or grey or dark in some cases and yellow in others. Hence, as the individuals in other 779[b]
kinds of animals do not differ from one another in the colour, so neither do they differ from themselves,[4] for they are not of a nature to have more than one colour.[5] Of the other animals the horse has the greatest variety of colour in the eye, for some of them are actually heteroglaucous;[6] this

[1] *γλαυκότερα*. One cannot be sure of the right translation of colour terms in A. I take it that *γλαυκός* means blue or green, *χαροπός* grey, *ὑδαρής* a pale yellow or perhaps greenish, *αἰγωπός* (goat-eyed) yellow or yellow-brown, *μέλας* dark brown. Familiar as black eyes are in poetry, the iris is never actually black, not even in negroes (Lawrence, *Lectures on Physiology, &c.*, 1822, p. 280). In translating, I shall use the words blue, grey, pale, yellow, and dark respectively.

AW. give *αἰγωπός* up as unintelligible. But why did they not look at a goat? The eyes of goats vary from a brownish yellow to very light yellow, almost white. Yellow eyes are common enough in man. Cf. Hudson, *Idle Days in Patagonia*, p. 205, 'the yellowish tint resembling that of the sheep's iris.' I do not understand why Lawrence describes the colour as 'an obscure orange' (*Lectures on Physiology, &c.*, p. 279).

Practically A. only speaks of light and dark eyes in the following discussion. The important question is whether they have or have not pigment in the stroma of the iris. If both uvea and stroma are pigmented, the eye is dark, if only the former it is light. If neither iris nor retina is pigmented the result is the pink eye of the albino (Juler, *Ophthalmic Science and Practice*[3], p. 172).

[2] Reading *γενομένων*. AW. say that children are occasionally born with a brown iris, but even negroes are normally born with blue eyes.

[3] An odd statement.

[4] i. e. the colour of the eye does not vary at different ages in the individual.

[5] Read *πλείους μιᾶς ἴσχειν χρόας*.

[6] i. e. with one eye blue (or some light colour), the other dark. This condition obtains occasionally in man and the horse, and AW. say it is also found in dogs. A. evidently considers the occurrence of two

phenomenon is not to be seen in any of the other animals, but man is sometimes heteroglaucous.

Why then is it that there is no visible change in the other animals if we compare their condition when newly born with their condition at a more advanced age, but that there is such a change in children? We must consider just this to be a sufficient cause, that the part concerned has only one colour in the former but several colours in the latter. And the reason why the eyes of infants are bluish and have no other colour is that the parts are weaker in the newly born and blueness is a sort of weakness.[1]

We must also gain a general notion about the difference in eyes, for what reason some are blue, some grey, some yellow, and some dark. To suppose that the blue are fiery, as Empedocles says, while the dark have more water than fire in them, and that this is why the former, the blue, have not keen sight by day, viz. owing to deficiency of water in their composition, and the latter are in like condition by night, viz. owing to deficiency of fire[2]—this is not well said if indeed we are to assume sight to be connected with water, not fire, in all cases.[3] Moreover it is possible to render another account of the cause of the colours, but if indeed the fact is as was stated before in the treatise on the senses, and still earlier than that in the investigations concerning soul[4]—if this sense organ is composed of water and if we were right in saying for what reason it is composed of water and not of air or fire then we must assume the water to be the cause of the colours mentioned. For some eyes have too much

colours in one individual to be a sign of greater colour-variability than the occurrence of two colours in two distinct individuals.

[1] As blueness is due to deficiency of pigment, this may be considered to be true. The eye of man's arboreal ancestor was no doubt brown, and lightness of colour is a 'fall of man'.

[2] It is always said that the unpigmented eyes of albinos see better than a normal eye in the dark. Dr. Spearman and myself have carried out experiments to test the statements in the text; we found that the light eye certainly had a small advantage over the dark eye in a bad light, but did not find that the dark eye had any advantage in a good light; in fact the light eye was better in both good and bad.

[3] 'If indeed' as usual introduces Aristotle's own theory. He assumes that he has proved all sight to be due to water in the eye, and this if true is fatal to the theory of Empedocles.

[4] *de Sensu*, 2; *de Anima*, iii. 425a 4.

liquid to be adapted to the movement,[1] others have too little, others the due amount. Those eyes therefore in which there is much liquid are dark because much liquid is not transparent, those which have little are blue; (so we find in the sea that the transparent part of it appears light blue, the less transparent watery, and the unfathomable water is dark or deep-blue on account of its depth).[2] When we come to the eyes between these, they differ only in degree.

We must suppose the same cause also to be responsible for the fact that blue eyes are not keen-sighted by day nor dark eyes by night. Blue eyes, because there is little liquid 780a
in them, are too much moved by the light and by visible objects in respect of their liquidity as well as their transparency, but sight is the movement of this part in so far as it is transparent, not in so far as it is liquid. Dark eyes are less moved because of the quantity of liquid in them.[3] And so they see less well in the dusk, for the nocturnal light is weak; at the same time also liquid is in general hard to move in the night.[4] But if the eye is to see, it must neither not be moved at all nor yet more than in so far as it is transparent,[5] for the stronger movement drives out the weaker. Hence it is that on changing from strong colours,[6] or on going out of the sun into the dark, men cannot see, for the motion already existing in the eye, being strong,

[1] i.e. the movement imparted to them by the shock of the light falling upon them.

[2] This description is correct though it sounds strange. On some beaches when the waves are breaking in gentle ripples, one sees the water a bluish or greenish grey on the sand or shingle, just beyond the break it may be more turbid and yellowish, which is what A. must mean by 'watery', and further out again it will be dark blue.

[3] Sight is the movement caused by the rays of light striking a transparent liquid. The eye cannot be too transparent for its purpose, and the movement cannot perturb it in so far as it is transparent, but if the liquid is too little it will be too much shaken by the excess of light. The same impact will produce less effect on a dark eye because the liquid is deeper. Such is A's account.

[4] I do not see what these words mean, but cf. *de Div. per Somnum*, 464a 14.

[5] If there is too much light, it not only passes through the transparent liquid but also throws the liquid itself into confusion.

[6] i.e. bright colours, which set up a strong movement in the eye.

stops that from outside,[1] and in general neither a strong nor a weak sight can see bright things because the liquid is acted upon and moved too much.[2]

The same thing is shown[3] also by the morbid affections of each kind of sight. Cataract[4] attacks the blue-eyed more, but what is called 'nyctalopia'[5] the dark-eyed. Now cataract is a sort of dryness of the eyes[6] and therefore it is found more in the aged, for this part also like the rest of the body gets dry towards old age; but nyctalopia is an excess of liquidity and so is found more in the younger, for their brain is more liquid.

The sight of the eye which is intermediate between too much and too little liquid is the best, for it has neither too little so as to be disturbed and hinder the movement of the colours,[7] nor too much so as to cause difficulty of movement.

Not only the above-mentioned facts are causes of seeing keenly or the reverse, but also the nature of the skin upon what is called the pupil.[8] This ought to be transparent, and it is necessary that the transparent should be thin and white[9] and even, thin that the movement coming from without may pass straight through it, even that it may not cast a shade upon the liquid behind it by wrinkling (for this also is a reason why old men have not keen sight, the skin of the eye like the rest of the skin wrinkling and becoming

[1] i.e. prevents any further movement, caused by rays of light from an external object, from producing any sensible effect. Such further movement *ex hypothesi* will be a weak one.

[2] The meaning seems to be that not only a weak sight cannot stand a bright light, but even a strong one cannot do so if the light be bright enough, as that of the sun.

[3] Namely that the liquid theory is the right one.

[4] *γλαύκωμα*. It is not certain what is meant exactly, but it is clearly not what is now called glaucoma.

[5] Nyctalopia is now (or was recently) used to mean a condition in which the eye sees better in twilight than in daylight. But A., like Galen, means by it exactly the opposite, a condition in which a great deal of light is required.

[6] Omitting *μᾶλλον* (AW.).

[7] i.e. the movement set up in the eye by the colours of visible things, for colour is the true object of sight according to Aristotle and Plato.

[8] The cornea, or rather that part of the cornea which is in front of the pupil.

[9] By 'white' A. sometimes means transparent, but what he means here is very obscure.

thicker in old age), and white because black is not transparent, for that is just what is meant by 'black', what is not shone through, and that is why lanterns cannot give light if they be made of black skin. It is for these reasons then that the sight is not keen in old age nor in the diseases in 780b
question, but it is because of the small amount of liquid that the eyes of children appear blue at first.

And the reason why men especially and horses occasionally are heteroglaucous is the same as the reason why man alone grows grey and the horse is the only other animal whose hairs whiten visibly in old age.[1] For greyness is a weakness of the fluid in the brain and an incapacity to concoct properly, and so is blueness of the eyes; excess of thinness or of thickness produces the same effect, according as this liquidity is too little or too much.[2] Whenever then Nature cannot make the eyes correspond exactly, either by concocting or by not concocting the liquid in both,[3] but concocts the one and not the other, then the result is heteroglaucia.

The cause of some animals being keen-sighted and others not so is not simple but double. For the word 'keen' has pretty much a double sense (and this is the case in like manner with hearing and smelling). In one sense keen sight means the power of seeing at a distance, in another it means the power of distinguishing as accurately as possible the objects seen. These two faculties are not necessarily combined in the same individual. For the same person, if he shade his eyes with his hand or look through a tube, does not distinguish the differences of colour either more or less in any way, but he will see further; in fact, men in pits or

[1] It is strange that A. should not have known that dogs go grey. Even sea-lions do.

[2] Grey hair, says A., is due to excess of liquid (784b 5), blue eyes to deficiency of it.

[3] If the liquid is properly concocted in both eyes, they are dark; if not, they are light. But this theory does not seem to square with the statement that blueness is due to want of liquid, not to its not being concocted. To bring the two together we must suppose that what causes the deficiency of liquid is want of concoction, in the brain, of the material which is to go to the eyes.

Both the eyes and the hair of the head are formed from the brain, according to A.

wells sometimes see the stars.[1] Therefore if any animal's brows project far over the eye, but if the liquid in the pupil is not pure nor suited to the movement coming from external objects and if the skin over the surface is not thin, this animal will not distinguish accurately the differences of the colours but it will be able to see from a long distance (just as it can from a short one) better than those in which the liquid and the covering membrane are pure but which have no brows projecting over the eyes. For the cause of seeing keenly in the sense of distinguishing the differences is in the eye itself; as on a clean garment even small stains are visible, so also in a pure sight even small movements are plain and cause sensation. But it is the position of the eyes that is the cause of seeing things far off and of the movements in the transparent medium coming to the eyes from distant objects. A proof of this is that animals with prominent eyes do not see well at a distance,[2] whereas those
781a which have their eyes lying deep in the head can see things at a distance because the movement is not dispersed in space but comes straight to the eye. For[3] it makes no difference whether we say, as some do,[4] that seeing is caused by the sight going forth from the eye—on that view, if there is nothing projecting over the eyes, the sight must be scattered and so less of it will fall on the objects of vision[5] and things at a distance will not be seen so well—or whether we say that seeing is due to the movement coming from the objects; for the sight also must see, in a manner resembling the movement.[6] Things at a distance, then,

[1] 'In the daytime' of course is meant.

[2] 'Prominent eyes are not always short sighted.'—AW. But they are apt to be so because a prominent eye is probably too much elongated, so that the light-rays come to a focus before reaching the retina, which causes myopia. 'Prominence of the globes' is one of the signs of myopia given by Juler, *Ophthalmic Science and Practice*[3], p. 492.

[3] The connexion is: 'This theory will hold good even if we give up our theory of vision, for,' &c.

[4] Plato thought that sight was caused by a ray proceeding from the eye and meeting rays from the objects.

[5] *Sight* must here be taken to mean the rays from the eyes. How these rays falling on objects outside the eye could cause sight within the eye was never very satisfactorily explained so far as I know, and A.'s own theory of sight is a vast advance upon it.

[6] If sight is caused by rays from an object striking the eye, it is

would be seen best if there were, so to say, a continuous tube straight from the sight to its object, for the movement from the object would not then be dissipated; but, if that is impossible, still the further the tube extends[1] the more accurately must distant objects be seen.

Let these, then, be given as the causes of the difference in eyes.

2 It is the same also with hearing and smell; to hear and smell accurately mean in one sense to perceive as precisely as possible all the distinctions of the objects of perception, in another sense to hear and smell far off. As with sight, so here the sense-organ is the cause of judging well the distinctions, if both that organ itself and the membrane round it be pure. For the passages of all the sense-organs, as has been said in the treatise on sensation,[2] run to the heart, or to its analogue in creatures that have no heart. The passage of the hearing, then, since this sense-organ is of air,[3] ends at the place where the innate spiritus causes in some animals the pulsation of the heart and in others respiration;[4] wherefore also it is that we are able to understand what is said and repeat what we have heard, for as was the movement which entered through the sense-organ, such again is the movement which is caused by means of the voice, being as it were of one and the same stamp, so that a man can say what he has heard. And we hear less well during a yawn or expiration than during inspiration, because the starting-point of the sense-organ of hearing is set upon the part concerned with breathing and is shaken

evident that it is better they should not be dissipated. If we suppose it caused by rays going forth from the eye, it will still be better that they should not be dissipated before meeting the rays from the object or striking the object itself, for even if we accept that theory we shall be dealing with rays in a medium; those of the sight will act like the 'movement' of those from the object.

[1] Reading ἐπέχῃ for ἀπέχῃ.

[2] Not in the existing *de Sensu*. What these passages were is uncertain; see Ogle on *de Partibus*, ii. 656b 17.

[3] See *de Anima*, ii. 8.

[4] Omitting καὶ εἰσπνοήν. But the passage is unintelligible; no animal, according to A., respires without having a heart; see *de Respiratione*, 21, 22. The words here must have been corrupted.

and moved as the organ moves the breath, for while setting the breath in motion it is moved itself.[1] The same thing happens in wet weather or a damp atmosphere. . . . And
781b the ears seemed to be filled with air because their starting-point is near the region of breathing.[2]

Accuracy then in judging the differences of sounds and smells[3] depends on the purity of the sense-organ and of the membrane lying upon its surface, for then all the movements become clear in such cases, as in the case of sight. Perception and non-perception at a distance also depend on the same things with hearing and smell as with sight.[4] For those animals can perceive at a distance which have channels, so to say, running through the parts concerned and projecting far in front of the sense-organs. Therefore all animals whose nostrils are long, as the Laconian hounds, are keen-scented, for the sense-organ being above them,[5] the movements from a distance[6] are not dissipated but go straight to the mark, just as the movements which cause sight do with those who shadow the eyes with the hand.

[1] The heart or some part about the heart is the starting-point or rather terminus of the ear, because it is connected with it by its passage. As the heart lies next the lungs, the terminus is affected by the movement of the lungs in expiration, and so we hear worse. But why not also in inspiration? And, to make things worse, yawning is an inspiration, yet A. says we hear badly during yawning. Nor is it true that we hear any better during inspiration; he assumes it because it suits his theory that we hear by means of the *συμφυὴς ἀήρ* in the ear, and the ear-passage.

[2] Two things seem clear to me about this passage. First that something has dropped out, for there is no connexion between the damp atmosphere and what follows. Secondly that we must read *τὴν ἀρχὴν* for *τῇ ἀρχῇ*, since it is absurd to say that 'the ears are filled with air because they are near the starting-point of the breathing region'. What *is* this starting-point 'of a region'? And the ears are not near it, whatever it may be. Also it seems that we must read *τῷ πνευματικῷ τόπῳ*. Cf. 781a 31.

[3] Nothing has been said about smells; probably a passage dealing with them has dropped out.

[4] The construction must be explained as being *καὶ τὸ πόρρωθεν δὲ ⟨τὰ μὲν⟩ αἰσθάνεσθαι, τὰ δὲ μή*. One MS. (Z) omits *τὰ δὲ μὴ αἰσθάνεσθαι*, but Z has many omissions due to homoioteleuton.

[5] The sensitive part of the nose being above the nostrils in man, A. uses the term 'above' loosely for the position in any animal; he should rather have said 'behind'. Had he known the modern greyhound, whose nostrils are longer than any other dog's and who yet has quite lost the sense of smell, he might have modified his opinion.

[6] Read *αἱ πόρρωθεν κινήσεις*.

Similar is the case of animals whose ears are long and project far like the eaves of a house, as in some quadrupeds, with the internal spiral passage long; these also catch the movement from afar and pass it on to the sense-organ.

In respect of sense-perception at a distance, man is, one may say, the worst of all animals in proportion to his size, but in respect of judging the differences of quality in the objects he is the best of all.[1] The reason is that the sense-organ in man is pure and least earthy and material, and he is by nature the thinnest-skinned of all animals for his size.[2]

The workmanship of Nature is admirable also in the seal, for though a viviparous quadruped it has no ears but only passages for hearing. This is because its life is passed in the water; now the ear is a part added to the passages to preserve the movement of the air at a distance; therefore an ear is no use to it but would even bring about the contrary result by receiving a mass of water into itself.[3]

We have thus spoken of sight, hearing, and smell.

3 As for hair, men differ in this themselves at different ages, and also from all other kinds of animals that have hair. These are almost all which are internally viviparous,[4] for even when the covering of such animals is spiny it must be considered as a kind of hair,[5] as in the land hedge-

[1] Dr. Spearman tells me that it is impossible to test this statement.

[2] And therefore the membranes on the sense organs are also thinnest. It is impossible to be sure whether this paragraph applies to all the senses or only hearing. In favour of the former view is the plural *αἰσθήσεων*, and we should naturally expect A. not to confine an observation of this kind to a single sense. In favour of the latter view is the singular *αἰσθητήριον*, and the position of the passage. For myself I incline to the former and have translated and punctuated accordingly.

[3] The only seals known to A. have no external ear. It has been lost by cetacea and these seals probably because it would interfere (however slightly) with the passage of the animal through the water. This, however, is not what A. means when he says the ear would 'receive water into itself'; he means that this water would interfere with the hearing when the seal has its head in the air.

[4] See notes on i. 9.

[5] 'Such hairs assume various forms . . . the spines of the Hedge-

hog[1] and any other such animal among the vivipara. Hairs differ in respect of hardness and softness, length and shortness, straightness and curliness, quantity and scantiness, and in addition to these qualities, in their colours, whiteness and blackness and the intermediate shades. They differ also in some of these respects according to age, as they are young or growing old. This is especially plain in man; the hair gets coarser as time goes on,[2] and some go bald on the front of the head; children indeed do not go bald, nor do women, but men do so by the time their age is advancing. Human beings also go grey on the head as they grow old, but this is not visible in practically any other animal, though more so in the horse than others. Men go bald on the front of the head, but turn grey first on the temples; no one goes bald first on these or on the back of the head. Some such affections occur in a corresponding manner also in all animals which have not hair but something analogous to it, as the feathers of birds and scales in the class of fish.

For what purpose Nature has made hair in general[3] for animals has been previously stated in the work dealing with the causes of the parts of animals;[4] it is the business of the present inquiry to show under what circumstances and for what necessary causes each particular kind of hair occurs. The principal cause then of thickness and thinness is the skin, for this is thick in some animals and thin in others, rare in some and dense in others.[5] The different quality of the included moisture is also a helping cause, for in some animals this is greasy and in others watery. For generally speaking the substratum of the skin is of an earthy nature; being on the surface of the body it becomes

hog and Porcupine (are) modifications of the same structure.' Flower and Lydekker, *Mammals*, p. 7.

[1] 'Land' to distinguish it from the sea hedgehog or Echinus.

[2] 'As a general rule the hair of children will be found finer than that of adults.' Erasmus Wilson, *On Healthy Skin*[2], p. 87.

[3] Lit. 'the class of hair.' Hair as a whole exists for a final cause; the varieties are due to necessity.

[4] *de Partibus*, ii. 658^{a} 18 'For the sake of shelter.'

[5] And the hair follows the skin. Cf. Darwin, *Variation*[1], vol. ii, p. 327. Hippocrates (vol. iii, p. 598) refers to the quality of the hair on parts of the body as proving the skin to be thinner.

solid and earthy as the moisture evaporates.[1] Now the hairs or their analogue[2] are not formed out of the flesh but out of the skin, [the moisture evaporating and exhaling in them, and therefore thick hairs arise from a thick skin and thin from a thin].[3] If then the skin is rarer and thicker, the hairs are thick because of the quantity of earthy matter and the size of the pores, but if it is denser 782b
they are thin because of the narrowness of the pores. Further, if the moisture be watery it dries up quickly and the hairs do not gain in size, but if it be greasy the opposite happens, for the greasy is not easily dried up. Therefore the thicker-skinned animals are as a general rule thicker-haired for the causes mentioned; however, the thickest-skinned are not more so than other thick-skinned ones, as is shown by the class of swine compared to that of oxen and to the elephant and many others.[4] And for the same reason also the hairs of the head in man are thickest, for this part of his skin is thickest and lies over[5] most moisture and besides is very porous.

The cause of the hairs being long or short depends on the evaporating moisture not being easily dried. Of this there are two causes, quantity and quality; if the liquid is much it does not dry up easily nor if it is greasy. And for this reason the hairs of the head are longest in man, for the brain, being fluid and cold, supplies great abundance of moisture.

The hairs become straight or curly on account of the vapour arising in them. If it be smoke-like, it is hot and

[1] Compare Erasmus Wilson's account of the growth of the outer skin: 'as by degrees the deep layers are gradually pushed upwards towards the surface, the cells lose by evaporation their fluid contents and are converted into dry, flattened and extremely thin scales.' *On Healthy Skin*[2], p. 6.

[2] Feathers and scales.

[3] The bracketed words are partly unintelligible in themselves, and do not fit on to what follows.

[4] This sentence is barely intelligible. The meaning seems to be that though thick-skinned generally is thicker-haired than thin-skinned, yet in the thick-skinned class itself the ratio is no longer observed. Thus the bristles of swine are thicker (according to A.) than those of elephants, though the elephant is the thicker-skinned of the two.

[5] Reading ἐπί. The 'most moisture' is that of the brain.

dry and so makes the hair curly, for it is twisted as being carried with a double motion, the earthy part tending downwards and the hot upwards.[1] Thus, being easily bent, it is twisted owing to its weakness, and this is what is meant by curliness in hair. It is possible then that this is the cause, but it is also possible that, owing to its having but little moisture and much earthy matter in it, it is dried by the surrounding air and so coiled up together. For what is straight becomes bent, if the moisture in it is evaporated, and runs together as a hair[2] does when burning upon the fire; curliness will then be a contraction owing to deficiency of moisture caused by the heat of the environment. A sign of this is the fact that curly hair is harder than straight, for the dry is hard. And animals with much moisture are straight-haired; for in these hairs the moisture advances as a stream, not in drops. For this reason the Scythians on the Black Sea and the Thracians are straight-haired, for both they themselves and the environing air are moist, whereas the Aethiopians and men in hot countries are
783a curly-haired, for their brains and the surrounding air are dry.

Some, however, of the thick-skinned animals are fine-haired for the cause previously stated, for the finer the pores are the finer must the hairs be. Hence the class of sheep have such hairs (for wool is only a multitude of hairs).

There are some animals whose hair is soft and yet less fine, as is the case with the class of hares compared with that of sheep; in such animals the hair is on the surface of the skin, not deeply rooted in it, and so is not long but in much the same state as the scrapings from linen,[3] for these also are not long but are soft and do not admit of weaving.[4]

The condition of sheep in cold climates is opposite to that of man; the hair of the Scythians is soft but that of

[1] The earthy part is the solid material of the hair, which would naturally hang straight down; but the hot vapour tends upwards and the conflict of the two tendencies curls the hair.

[2] Omitting ᾗ.

[3] Qu. λινῶν for λίνων?

[4] Because they are too short.

the Sauromatic sheep is hard. The reason of this is the same as it is also in all wild animals. The cold hardens and solidifies them by drying them, for as the heat is pressed out the moisture evaporates, and both hair and skin become earthy and hard. In wild animals then the exposure to the cold is the cause of hardness in the hair, in the others the nature of the climate is the cause. A proof of this is also what happens in the sea-urchins which are used as a remedy in stranguries.[1] For these, too, though small themselves, have large and hard spines because the sea in which they live is cold on account of its depth (for they are found in sixty fathoms and even more). The spines are large because the growth of the body is diverted to them, since having little heat in them they do not concoct their nutriment and so have much residual matter and it is from this that spines, hairs, and such things are formed; they are hard and petrified through the congealing effect of the cold. In the same way also plants are found to be harder, more earthy, and stony, if the region in which they grow looks to the north than if it looks to the south, and those in windy places than those in sheltered, for they are all more chilled and their moisture evaporates.

Hardening, then, comes of both heat and cold, for both cause the moisture to evaporate, heat *per se* and cold *per accidens* (since the moisture goes out of things along with the heat, there being no moisture without heat), but whereas
cold not only hardens but also condenses, heat makes 783b
a substance rarer.

For the same reason, as animals grow older, the hairs become harder in those which have hairs, and the feathers and scales in the feathered and scaly kinds. For their skins become harder and thicker as they get older, for they are dried up, and old age, as the word denotes,[2] is earthy because the heat fails and the moisture along with it.

[1] The eggs of sea-urchins were given as diuretics. Hippocrates, vol. i, p. 682; Dioscorides, vol. i, p. 167. To what kind does A. refer? The ordinary edible sea-urchin is as large as an orange, and does not live at so great a depth. Cf. *H. A.* iv. 530b 7–10.

[2] γῆρας γεηρόν!

Men go bald visibly more than any other animal, but still such a state is something general, for among plants also some are evergreens while others are deciduous, and birds which hibernate shed their feathers.[1] Similar to this is the condition of baldness in those human beings to whom it is incident.[2] For leaves are shed by all plants, from one part of the plant at a time, and so are feathers and hairs by those animals that have them ; it is when they are all shed together that the condition is described by the terms mentioned, for it is called 'going bald' and 'the fall of the leaf' and 'moulting'. The cause of the condition is deficiency of hot moisture, such moisture being especially the unctuous, and hence unctuous plants are more evergreen.[3] (However we must elsewhere[4] state the cause of this phenomena in plants, for other causes also contribute to it.) It is in winter that this happens to plants (for the change from summer to winter is more important to them than the time of life), and to those animals which hibernate (for these, too, are by nature less hot and moist than man) ; in the latter it is the seasons of life that correspond to summer and winter. Hence no one goes bald before the time of sexual intercourse, and at that time it is in those naturally inclined to such intercourse that baldness appears, for the brain is naturally the coldest part of the body and sexual intercourse makes men cold, being a loss of pure natural heat. Thus we should expect the brain to feel the effect of it first, for a little cause turns the scale where the thing concerned is weak and in poor condition.[5] Thus if we reckon up these points, that the brain itself has but little heat,

[1] See *H. A.* viii. 26, where swallows are particularly mentioned; Gilbert White was haunted all his life with the notion that some swallows may hibernate. But no bird does so in reality, though some when they moult do slink out of the way. That birds moult in winter was a popular idea, it seems ; see Aristoph. *Birds*, 105.

[2] This qualification is put in to exclude women, children, and eunuchs.

[3] Prof. Oliver assents to this.

[4] Probably in the lost botanical treatise.

[5] Though the brain is a very important organ in the opinion of A., yet its importance is negative rather than positive. Heat is the sovereign quality of life, and the brain exists mainly to cool the blood, and is itself the coldest part. It is because of this cold that it is described as 'weak and in poor condition'.

and further that the skin round it must needs have still less, and again that the hair must have still less than the skin inasmuch as it is the furthest removed from the brain,[1] we should reasonably expect baldness to come about this age upon those who have much semen. And it is for the same reason that the front part of the head alone goes bald[2] in man and that he is the only animal to do so; the 784a front part goes bald because the brain is there,[3] and man is the only animal to go bald because his brain is much the largest and the moistest. Women do not go bald because their nature is like that of children, both alike being incapable of producing seminal secretion. Eunuchs do not become bald,[4] because they change into the female condition. And as to the hair that comes later in life, eunuchs either do not grow it at all, or lose it if they happen to have it,[5] with the exception of the pubic hair; for women also grow that though they have not the other, and this mutilation is a change from the male to the female condition.

The reason why the hair does not grow again in cases of baldness, although both hibernating animals recover their feathers or hair and trees that have shed their leaves grow leaves again, is this. The seasons of the year are the turning-points of their lives, rather than their age, so that when these seasons change they change with them by growing and losing feathers, hairs, or leaves respectively. But the winter and summer, spring and autumn of man are defined by his age, so that, since[6] his ages do not return,[7] neither do the conditions caused by them return, although the cause of the change of condition is similar in man to what it is in the animals and plants in question.

We have now spoken pretty much of all the other conditions of hair.

[1] One would rather expect 'from the heart', but that can hardly be supplied from the context. What little heat there is in the hair has to come from the heart, passing through the cold brain, so that the hair will be even colder than the brain itself.

[2] i. e. at first.

[3] A. held that the brain was in the front part of the skull, the hinder part being empty. See *de Partibus*, ii. 656b 12 and Ogle's note.

[4] This is a medical tradition; Hippocrates, vol. i, p. 400.

[5] i. e. if castration is performed after puberty.

[6] Reading ἐπειδή.

[7] Lit. 'change'.

But as to their colour, it is the nature of the skin that is the cause of this in other animals (and also of their being unicoloured or varicoloured); but in man it is not the cause, except of the hair going grey through disease (not through old age), for in what is called leprosy the hairs become white; on the contrary, if the hairs are white the whiteness does not invade the skin. The reason is that the hairs grow out of skin; if, then, the skin is diseased and white the hair becomes diseased with it, and the disease of hair is greyness. But the greyness of hair which is due to age results from weakness and deficiency of heat. For as the body declines in vigour we tend to cold at every time of life, and especially in old age, this age being cold and dry. We must remember that the nutriment coming to each part of the body is concocted by the heat appropriate 4

784b to the part; if the heat is inadequate the part loses its efficiency, and destruction or disease results. (We shall speak more in detail of causes in the treatise on growth and nutrition.[1]) Whenever, then, the hair in man has naturally little heat and too much moisture enters it, its own proper heat is unable to concoct the moisture and so it is decayed by the heat in the environing air. All decay is caused by heat, not the innate heat but external heat, as has been stated elsewhere.[2] And as there is a decay of water, of earth, and all such material bodies, so there is also of the earthy vapour, for instance what is called mould (for mould is a decay of earthy vapour).[3] Thus also the liquid nutriment in the hair decays because it is not concocted, and what is called greyness results. It is white because mould also, practically alone among decayed things, is white. The reason of this is that it has much air in it,

[1] This is lost.

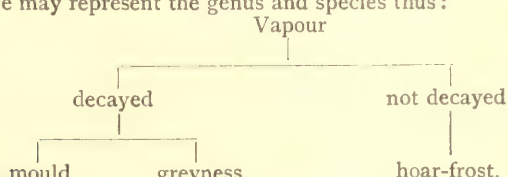
[2] *Meteorologica*, iv. 379a 18. The innate, or more literally connate, heat is the same as the natural heat which plays so large a part in A.'s physiology. Being natural it cannot cause decay in the body or part in which it resides.

[3] The earthy vapour is moisture evaporated from 'earth' in the Aristotelian sense as one of the four elements. In this case it is the vapour from the solid material of the hair. In reality, mould is a fungoid growth, and so is in no way parallel to greyness of the hair (though there is a fungus which causes baldness); greyness is due to bubbles of air or absence of pigment.

all earthy vapour being equivalent to thick air.[1] For mould is, as it were, the antithesis of hoar-frost; if the ascending vapour be frozen it becomes hoar-frost, if it be decayed, mould. Hence both are on the surface of things, for vapour is superficial. And so the comic poets make a good metaphor in jest when they call grey hairs 'mould of old age' and 'hoar-frost'. For the one is generically the same as greyness, the other specifically; hoar-frost generically (for both are a vapour), mould specifically (for both are a form of decay).[2] A proof that this is so is this: grey hairs have often grown on men in consequence of disease, and later on dark hairs instead of them after restoration to health.[3] The reason is that in sickness the whole[4] body is deficient in natural heat[5] and so the parts besides, even the very small ones, participate in this weakness; and again, much residual matter is formed in the body and all its parts in illness, wherefore the incapacity in the flesh to concoct the nutriment causes the grey hairs. But when men have recovered health and strength again they change, becoming as it were young again instead of old; in consequence the states change also.[6] Indeed, we may rightly call disease an acquired old age, old age

[1] It is true that whiteness in vapour, hoar-frost, foam, and the like is caused by the presence of air between the particles.

[2] We may represent the genus and species thus:



Thus greyness and hoar-frost both belong to the genus, but hoar-frost is not in the same species 'decayed'.

[3] See instances of recovery of colour in grey hair in Erasmus Wilson, *On Healthy Skin*[2], p. 122.

[4] Reading ὅλον with the Aldine (AW.).

[5] This is an interesting remark as showing how distinct is 'natural heat' from ordinary heat. A. knew very well that the body is often hotter in illness, but natural heat could not cause this as being 'against Nature'; such unnatural heat must be ascribed to something else. But what right has he to assume a deficiency in natural heat in all cases of illness? Perhaps he argued that death is cold and all disease is an approximation to death.

[6] i. e. the states of the body and of its parts change from age to youth, from grey hair to dark.

a natural disease; at any rate, some diseases produce the same effects as old age.

Men go grey on the temples first, because the back of the
785a head is empty of moisture owing to its containing no brain,[1] and the 'bregma'[2] has a great deal of moisture,[3] a large quantity not being liable to decay;[4] the hair on the temples however has neither so little that it can concoct it nor so much that it cannot decay, for this region of the head being between the two extremes is exempt from both states. The cause of greyness in man has now been stated.

The reason why this change does not take place visibly 5
on account of age in other animals is the same as that already given in the case of baldness; their brain is small and less fluid than in man, so that the heat required for concoction does not altogether fail. Among them it is most clear in horses of all animals that we know, because the bone about the brain is thinner in them than in others in proportion to their size. A sign of this is that a blow on this spot is fatal to them, wherefore Homer also has said: 'where the first hairs grow on the skull of horses, and a wound is most fatal.'[5] As then the moisture easily flows to these hairs because of the thinness of the bone, whilst the heat fails on account of age, they go grey. The reddish hairs go grey sooner than the black, redness also being a sort of weakness of hair and all weak things ageing sooner.

It is said, however, that cranes become darker as they grow old.[6] The reason of this would be, if it should prove

[1] See above on 784a 2.

[2] See on ii. 744a 24. Here the bregma evidently means the whole of the front part of the crown.

[3] This is doubtless owing to its being above the brain, the moisture evaporating upwards. The word *βρέγμα* is actually derived from *βρέχω*, *to wet*, because of the softness of this part in infancy.

[4] A lake remains fresh when a small pool becomes stagnant.

[5] *Iliad* viii. 83, 84. It would be pertinent to the argument if A. had shown that other animals could be knocked on the head with impunity. Besides it was not for any thinness of the bone that Nestor's horse was killed. 'Exactly where the mane begins, the bony shield of the skull comes to an end, and the route to the brain, especially to a dart coming like that of Paris from behind, lies comparatively open.' Agnes Clerke, *Familiar Studies in Homer*, p. 114.

[6] This may refer to the heron, which would easily be confused with the

true, that their feathers are naturally moister[1] than others and as they grow old the moisture in the feathers is too much to decay easily.[2]

Greyness comes about by some sort of decay, and is not, as some think, a withering. (1) A proof of the former statement is the fact that hair protected by hats or other coverings goes grey sooner (for the winds prevent decay and the protection keeps off the winds), and the fact that it is aided by anointing with a mixture of oil and water. For, though water cools things, the oil mingled with it prevents the hair from drying quickly, water being easily dried up. (2) That the process is not a withering, that the hair does not whiten as grass does by withering, is shown by the fact that some hairs grow grey from the first,[3] whereas nothing springs up in a withered state. Many hairs also whiten at the tip, for there is least heat in the extremities and thinnest parts.

When the hairs of other animals are white, this is caused 785b
by nature, not by any affection. The cause of the colours in other animals is the skin; if they are white, the skin is white, if they are dark it is dark, if they are piebald in consequence of a mixture of the hairs, it is found to be white in the one part and dark in the other. But in man the skin is in no way the cause, for even white-skinned men have very dark hair. The reason is that man has the thinnest skin of all animals in proportion to his size[4] and therefore it has not strength to change the hairs; on the contrary the skin itself changes its colour through its weakness and is darkened by sun and wind, while the hairs do not change along with it at all. But in the other animals the skin, owing to its thickness, has the influence belonging to the soil in which a thing grows, wherefore the hairs change

crane. At least 'the fine leaden-grey back' is only found in the adult heron (Newton's *Dict. of Birds*, p. 418). The heron's breast, however, becomes whiter.

[1] Reading ὑγροτέραν for λευκοτέραν (AW.).

[2] Read εὔσηπτον for εὐσηπτότερον.

[3] I suppose this means that, if e.g. one shaves a white hair off, a new white one springs up, whereas, if we cut off a withered blade of grass, the new one is green.

[4] This can hardly be true of man as compared at any rate with birds.

according to the skin but the skin does not change at all in consequence of the winds and the sun.

Of animals some are uni-coloured (I mean by this term 6
those of which the kind as a whole has one colour, as all lions are tawny; and this condition exists also in birds, fish, and the other classes of animals alike); others though many-coloured are yet whole-coloured (I mean those whose body as a whole has the same colour, as a bull is white as a whole or dark as a whole); others are vari-coloured. This last term is used in both ways; sometimes the whole kind is vari-coloured, as leopards and peacocks, and some fish, e. g. the so-called 'thrattai'; sometimes the kind as a whole is not so, but such individuals are found in it, as with cattle and goats and, among birds, pigeons; the same applies also to other kinds of birds. The whole-coloured change much more than the uniformly coloured, both into the simple colour of another individual of the same kind (as dark changing into white and *vice versa*) and into both colours mingled.[1] This is because it is a natural characteristic of the kind as a whole not to have one colour only, the kind being easily moved in both directions so that the colours both change more into one another and are more varied. The opposite holds with the uniformly coloured; they do not change except by an affection of the colour, and that rarely; but still they do so change, for before now white individuals have been observed among partridges, ravens, sparrows, and bears.[2] This happens when the course of development is perverted, for what is small is easily spoilt and easily
786a moved, and what is developing is small, the beginning of all such things being on a small scale.

Change is especially found in those animals of which by

[1] e.g. white cattle may produce a black calf, or a piebald one, black and white.

[2] This observation is true and profound. The white animals mentioned are cases of albinism, which is an 'affection', as A. says, due to absence of pigment. It is true that the whiteness of a calf is also due to this absence, but the point is that while the whiteness of the calf is normal, the whiteness of a normally brown bear (the only sort known to A.) is abnormal and a πάθος.

nature the individual is whole-coloured [1] but the kind many-coloured. This is owing to the water which they drink, for hot waters make the hair white, cold makes it dark, an effect found also in plants. The reason is that the hot have more air than water in them, and the air shining through causes whiteness, as also in froth.[2] As, then, skins which are white by reason of some affection differ from those white by nature, so also in the hair the whiteness due to disease or age differs from that due to nature in that the cause is different ; the latter are whitened by the natural heat, the former by the external heat.[3] Whiteness is caused in all things by the vaporous air imprisoned in them. Hence also in all animals not uniformly coloured all the part under the belly is whiter.[4] For practically all white animals are both hotter and better flavoured for the same reason ; the concoction of their nutriment makes them well-flavoured, and heat causes the concoction. The same cause holds for those animals which are uniformly-coloured, but either dark or white ; heat and cold are the causes of the nature of the skin and hair, each of the parts having its own special heat.

The tongue also varies in colour in the simply coloured as compared with the vari-coloured animals, and again in the simply coloured which differ from one another, as white and dark.[5] The reason is that assigned before, that the

[1] Reading ὁλόχροα with the Aldine and other authorities (AW.).

[2] As the hot waters, whatever they may be, are white owing to imprisoned air, so this effect is somehow passed on to the creatures that drink them.

[3] The natural heat seems to be increased by the 'hot waters', the external heat is that of the environment, which as we have seen above turns hair unnaturally white.

[4] The whiteness of the under part of animals is for the sake of making them harder to see at a distance. See the elegant experiments of Mr. Abbott Thayer on this point in birds, given by Beebe, *The Bird*, p. 299. Exceptions, e.g. the ratel, are nocturnal animals or live in holes, or, like the elephant, have no enemy to fear. A.'s argument may be put thus: the under part of an animal is hotter, because it contains more air. But what contains air is white. Therefore the under part is white.

[5] These seem to be the same as the 'whole-coloured'. The meaning is that the tongue of a dark or white ox is dark or white respectively. 'Every one knows that the colour of the skin and that of the hair usually vary together ; so that Virgil advises the shepherd to look

skins of the vari-coloured are vari-coloured, and the skins of the white-haired and dark-haired are white and dark in each case. Now we must conceive of the tongue as one of the external parts, not taking into account the fact that it is covered by the mouth but looking on it as we do on the hand or foot; thus since the skin of the vari-coloured animals is not uniformly coloured, this is the cause of the skin on the tongue being also vari-coloured.

Some birds and some wild quadrupeds change their colour according to the seasons of the year. The reason is that, as men change according to their age, so the same thing happens to them according to the season; for this makes a greater difference to them than the change of age.

The more omnivorous animals are more vari-coloured to speak generally, and this is what might be expected;[1] thus
786b bees are more uniformly coloured than hornets and wasps. For if the food is responsible for the change,[2] we should expect varied food to increase the variety in the movements which cause the development and so in the residual matter of the food, from which come into being hairs and feathers and skins.

So much for colours and hairs.

As to the voice, it is deep in some animals, high in others, 7
in others again well-pitched and in due proportion between both extremes. Again, in some it is loud, in others small, and it differs in smoothness and roughness, flexibility and inflexibility. We must inquire then into the causes of each of these distinctions.

We must suppose then that the same cause is responsible for high and deep voices as for the change which they undergo in passing from youth to age. The voice is higher in all other

whether the mouth and tongue of the ram are black, lest the lamb shall not be purely white.' Darwin, *Variation*[1], vol. ii, p. 325.

[1] This is of course quite untrue; the case of bees and wasps is in favour of A.'s theory no doubt, but on a general view there is nothing whatever to be said for it.

[2] This is true to a great extent, but it is not *directly* responsible. The coloration of lion, leopard, tiger, polar bear is what it is in order that they may steal upon their prey unobserved, and so in a certain sense is due to their food. A. puts it more correctly when he says that their *way of life* is the cause of an animal being what it is.

animals when younger, but in cattle that of calves is deeper.[1] We find the same thing also in the male and female sexes; in the other kinds of animals the voice of the female is higher than that of the male (this being especially plain in man, for Nature has given this faculty to him in the highest degree because he alone of animals makes use of speech and the voice is the material of speech), but in cattle the opposite obtains, for the voice of cows is deeper than that of bulls.[2]

Now the purpose for which animals have a voice, and what is meant by 'voice' and by 'sound' generally, has been stated partly in the treatise on sensation, partly in that on the soul.[3] But since lowness of voice depends on the movement of the air being slow and its highness on its being quick, there is a difficulty in knowing whether it is that which moves or that which is moved that is the cause of the slowness or quickness.[4] For some say that what is much is moved slowly, what is little quickly, and that the quantity of the air is the cause of some animals having a deep and others a high voice. Up to a certain point this is well said (for it seems to be rightly said in a general way that the depth depends on a certain amount of the air put in motion), but not altogether, for if this were true it would not be easy to speak both soft and deep at once, nor again both loud[5] and high. Again, the depth seems to belong to the nobler nature, and in songs the deep note is better than the high- 787a
pitched ones, the better lying in superiority, and depth of tone being a sort of superiority. But then depth and height in the voice are different from loudness and softness, and some high-voiced animals are loud-voiced, and in like manner some soft-voiced ones are deep-voiced, and the same applies to the tones lying between these extremes.[6] And by what else can we define these (I mean loudness and softness of

[1] Cf. *H.A.* v. 545a 19.

[2] Cf. *H.A.* iv. 538b 14, v. 545a 19. 'Bulls,' says White, *Natural History of Selborne*, letter 74, 'though they mutter and grumble in a deep tremendous tone, yet low in a shrill high key,' whereas cows have 'hoarse voices when they low'.

[3] *de Anima*, ii. 8; cf. *de Sensu*, 440b 27.

[4] Omitting δέ before βραδέως.

[5] Reading μέγα (AW. after the Latin versions).

[6] i.e. intermediate depth does not always go with intermediate loudness, as it should on the theory.

voice) except by the large and small amount of the air put in motion? If then height and depth are to be decided in accordance with the distinction postulated, the result will be that the same animals will be deep- and loud-voiced, and the same will be high- and not loud-voiced; but this is false.

The reason of the difficulty is that the words 'great' and 'small', 'much' and 'little' are used sometimes absolutely, sometimes relatively to one another. Whether an animal has a great (or loud) voice depends on the air which is moved being much *absolutely*, whether it has a small voice depends on its being little *absolutely*; but whether they have a deep or high voice depends on their being thus differentiated in relation to one another.[1] For if that which is moved surpass the strength of that which moves it, the air that is sent forth must go slowly; if the opposite, quickly. The strong, then, on account of their strength, sometimes move much air and make the movement slow,[2] sometimes, having complete command over it, make the movement swift.[3] On the same principle the weak either move too much air for their strength and so make the movement slow,[4] or if they make it swift move but little because of their weakness.[5]

These, then, are the reasons of these contrarieties, that neither are all young animals high-voiced nor all deep-voiced, nor are all the older, nor yet are the two sexes thus opposed, and again that not only the sick speak in a high voice but also those in good bodily condition, and, further, that as men verge on old age they become higher-voiced, though this age is opposite to that of youth.

Most young animals, then, and most females set but little air in motion because of their want of power, and are consequently high-voiced, for a little air is carried along quickly, and in the voice what is quick is high. But in calves and cows, in the one case because of their age, in the other because of their female nature, the part by which they set

[1] A. must really mean: 'depends on the relation of what is moved to that which moves it.'

[2] So that the voice is both loud and deep.

[3] So that the voice is both loud and high.

[4] And the voice is deep and weak.

[5] And the voice is high and weak.

the air in motion is not strong; at the same time they set a great quantity in motion and so are deep-voiced; for that 787b
which is borne along slowly is heavy, and much air is borne along slowly.[1] And these animals set much in movement whereas the others set but little, because the vessel through which the breath is first borne has in them a large opening and necessarily sets much air in motion, whereas in the rest the air is better dispensed.[2] As their age advances this part which moves the air gains more strength in each animal, so that they change into the opposite condition, the high-voiced becoming deeper-voiced than they were, and the deep-voiced higher-voiced, which is why bulls have a higher voice than calves and cows. Now the strength of all animals is in their sinews, and so those in the prime of life are stronger, the young being weaker in the joints and sinews; moreover, in the young they are not yet tense, and in those now growing old the tension relaxes, wherefore both these ages are weak and powerless for movement. And bulls are particularly sinewy, even their hearts, and therefore that part by which they set the air in motion[3] is in a tense state, like a sinewy string stretched tight. (That the heart of bulls is of such a nature is shown by the fact that a bone is actually found in some of them, and bones are naturally connected with sinew.)[4]

All animals when castrated change to the female character, and utter a voice like that of the females because the sinewy strength in the principle of the voice is relaxed. This relaxation is just as if one should stretch a string and make it taut by hanging some weight on to it, as women do who weave at the loom, for they stretch the warp by

[1] We see here plainly that the equivocal meaning of the word βαρύς underlies A.'s theory. It signifies both *heavy* and *deep*. A 'heavy' voice then moves slowly, because heavy things in general move slower than light ones (a statement which may be taken as true in so far as the same force will move a heavier thing more slowly than a lighter one).

[2] 'Better dispensed,' in that it is poured out gradually as from a narrow-necked bottle.

[3] The wind-pipe.

[4] Lit. 'seek the nature of sinew'. This may mean that sinews are regularly attached to bones, or that bones approximate to sinews in nature. On the bone in the heart of bulls see Ogle on *de Partibus*, iii. 666b 19.

attaching to it what are called 'laiai'.[1] For in this way are the testes attached to the seminal passages, and these again to the blood-vessel which takes its origin in the heart near the organ which sets the voice in motion.[2] Hence as the seminal passages change towards the age at which they are now able to secrete the semen, this part also changes along with them. As this changes, the voice again changes, more indeed in males, but the same thing happens in females too, only not so plainly, the result being what some
788a call 'bleating' when the voice is uneven. After this it settles into the deep or high voice of the succeeding time of life. If the testes are removed the tension of the passages relaxes, as when the weight is taken off the string or the warp; as this relaxes, the organ which moves the voice is loosened in the same proportion. This, then, is the reason why the voice and the form generally changes to the female character in castrated animals; it is because the principle is relaxed upon which depends the tension of the body; not that, as some suppose, the testes are themselves a ganglion[3] of many principles, but small changes are the causes of great ones, not *per se* but when it happens that a principle changes with them.[4] For the principles, though small in size, are great in potency; this, indeed, is what is meant by a principle, that it is itself the cause of many things without anything else being higher than it for it to depend upon.

The heat or cold also of their habitat contributes to make some animals of such a character as to be deep-voiced, and others high-voiced. For hot breath being thick causes depth[5], cold breath being thin the opposite. This is clear also in pipe-playing, for if the breath of the performer is

[1] And should then remove this weight.

[2] This amazing theory assumes *inter alia* that the removal of the weight will make the note of the string higher! Possibly A. confused the tension of a string with the length.

[3] *σύναμμα*, a knot of things tied up together.

[4] i. e. the testes are small things comparatively in themselves, but the whole principle of sexuality is so closely connected with them that it all changes on their removal.

[5] Lit. 'heaviness'; A. is again misled by the double meaning of *βαρύς*. He also assumes hot air to be more condensed than cold.

hotter, that is to say if it is expelled as by a groan[1], the note is deeper.

The cause of roughness and smoothness in the voice, and of all similar inequality, is that the part or organ through which the voice is conveyed is rough or smooth or generally even or uneven. This is plain when there is any moisture about the trachea[2] or when it is roughened by any affection[3], for then the voice also becomes uneven.

Flexibility depends on the softness or hardness of the organ, for what is soft can be regulated and assume any form, while what is hard cannot; thus the soft organ can utter a loud or a small note, and accordingly a high or a deep one, since it easily regulates the breath, becoming itself easily great or small. But hardness cannot be regulated.

Let this be enough on all those points concerning the voice which have not been previously discussed in the 788b
treatise on sensation and in that on the soul.

8 With regard to the teeth it has been stated previously[4] that they do not exist for a single purpose nor for the same purpose in all animals, but in some for nutrition only, in others also for fighting and for vocal speech. We must, however, consider it not alien to the discussion of generation and development to inquire into the reason why the front teeth are formed first and the grinders later, and why the latter are not shed but the former are shed and grow again.

Democritus has spoken of these questions but not well, for he assigns the cause too generally without investigating the facts in all cases. He says that the early teeth are shed because they are formed in animals too early, for it is when animals are practically in their prime that they

[1] *αἰάζοντες*. The idea is that if the breath is drawn deep it will be hotter as coming from near the bodily centre of heat. A chest-note in singing is deeper than a head-note; this, according to A., is because the air from the chest is hotter. But then he speaks here not of singing but of playing the pipe; and Mr. H. T. Clarke tells me that no difference of the kind can be thus caused in any wind-instrument.

[2] i. e. if we have a cold in the throat.

[3] e. g. sore throat.

[4] *de Partibus*, iii. 661a 34 et seqq.

grow according to Nature,[1] and suckling is the cause he assigns for their being found too early. Yet the pig also suckles but does not shed its teeth,[2] and, further, all the animals with carnivorous dentition[3] suckle, but some of them do not shed any teeth except the canines, e.g. lions[4]. This mistake, then, was due to his speaking generally without examining what happens in all cases; but this is what we ought to do, for any one who makes any general statement must speak of all the particular cases.

Now we assume, basing our assumption upon what we see, that Nature never fails nor does anything in vain so far as is possible in each case. And it is necessary, if an animal is to obtain food after the time of taking milk is over, that it should have instruments for the treatment of the food. If, then, as Democritus says, this happened about the time of reaching maturity, Nature would fail in something possible for her to do. And, besides, the operation of Nature would be contrary to Nature, for what is done by violence is contrary to Nature, and it is by violence that he says the formation of the first teeth is brought about.[5] That this view then is not true is plain from these and other similar considerations.

Now these teeth are developed before the flat teeth, in the first place because their function is earlier (for dividing comes before crushing, and the flat teeth are for crushing, the others for dividing), in the second place because the smaller is naturally developed quicker than the larger, even if both start together, and these teeth are smaller in size

[1] i. e. the only natural teeth, according to D., are those which grow when the animal is practically mature. There is an untranslatable play on the words φύεσθαι and φύσιν.

[2] The pig sheds its teeth just like any other mammal.

[3] καρχαρόδοντα, explained in *H. A.* ii. 501ᵃ 18 to mean 'with the sharp teeth fitting into one another'.

[4] As usual, A. is wrong about the lion, which of course sheds all its milk teeth. There is no animal which sheds only the canines.

[5] By altering the punctuation I hope I have made sense of this passage. The objections are (1) that if there were no first set of teeth the animal could not get food between the period of suckling and that of maturity, (2) that if these teeth were unnatural, as D. says (or as A. puts it, to make it worse, formed 'by violence'), Nature would produce an unnatural thing, and this not as an occasional monstrosity, such as teeth in a uterine tumour, but as a regular process.

than the grinders, because the bone of the jaw is flat in that part but narrow towards the mouth.[1] From the greater part, therefore, must flow more nutriment to form the teeth, and from the narrower part less.[2]

The act of sucking in itself contributes nothing to the formation of the teeth, but the heat of the milk makes them appear more quickly.[3] A proof of this is that even in suckling animals those young which enjoy hotter milk grow their teeth quicker,[4] heat being conducive to growth.

They are shed, after they have been formed, partly because it is better so (for what is sharp is soon blunted, so that a fresh relay is needed for the work, whereas the flat teeth cannot be blunted but are only smoothed in time by wearing down), partly from necessity because, while the roots of the grinders are fixed where the jaw is flat and the bone strong, those of the front teeth are in a thin part, so that they are weak and easily moved. They grow again because they are shed while the bone is still growing and the animal is still young enough to grow teeth. A proof of this is that even the flat teeth grow for a long time, the last of them cutting the gum at about twenty years of age; indeed in some cases the last teeth have been grown in quite old age. This is because there is much nutriment in the broad part of the bones,
whereas the front part being thin soon reaches perfection 789b
and no residual matter is found in it, the nutriment being consumed in its own growth.

Democritus, however, neglecting the final cause, reduces to necessity all the operations of Nature. Now they are necessary, it is true, but yet they are for a final cause and for the sake of what is best in each case. Thus nothing prevents the teeth from being formed and being shed in

[1] I read ⟨τῷ⟩ (AW.) τὸ ὀστοῦν and omit *καί*.

[2] Read ἐκ δὲ τοῦ στενωτέρου ἔλαττω, or something of the sort, for ἐκ δὲ τοῦ ἐλάττονος στενωτέραν.

[3] The theory is quite different from that of Democritus, though at first sight it may look very like it.

[4] This is unintelligible.

this way;[1] but it is not on account of these causes but on account of the end (or final cause); these are causes only in the sense of being the moving and efficient instruments and the material. So it is reasonable that Nature should perform most of her operations using breath as an instrument, for as some instruments serve many uses in the arts, e.g. the hammer and anvil in the smith's art, so does breath in the living things formed by Nature. But to say that necessity is the only cause[2] is much as if we should think that the water has been drawn off from a dropsical patient on account of the lancet, not on account of health, for the sake of which the lancet made the incision.

We have thus spoken of the teeth, saying why some are shed and grow again, and others not, and generally for what cause they are formed. And we have spoken of the other affections of the parts which are found to occur not for any final end but of necessity and on account of the motive or efficient cause.

[1] i.e. there is no reason why it may not be true that the teeth are formed and shed in consequence of certain mechanical processes.

[2] Lit. 'to speak of the causes from necessity'.

ADDENDA

717^b 31. On the hedgehog compare Buffon: 'Ils ne peuvent s'accoupler à la manière des autres quadrupèdes ; il faut qu'ils soient face à face, debout ou couchés' (ed. 1844, vol. iv, p. 68). Evidently Buffon is only guessing, and probably A. is guessing too.

724^b 27. *σύντηγμα*. The meaning of this word seems to be better expressed by 'waste-product' than by anything else. It is the result of the process called *σύντηξις* or 'colliquescence'. The most useful part of the nutriment (*τροφή*) is turned into blood; from this again are formed the most vital and important organs, such as heart and liver. The superfluous but still useful residues again from the blood (*περιττώματα*, which in this sense I translate 'secretions') are used up to make the less vital and important parts of the body, such as hair and nails. The nutriment has also to maintain the body when fully formed at its proper level. Thus the process of *τροφή* corresponds in modern language to 'anabolism'. But a process of waste, *σύντηξις*, is also continually going on, and its products 'flow wherever they happen to find a passage'; sweat, for example, would be a *σύντηγμα*, I take it. *σύντηξις* then corresponds in modern language to 'katabolism'.

Semen is plainly not 'katabolic', or a 'waste-product', but belongs to the opposite process; it is a *χρηστὸν περίττωμα*, or 'useful residue' of the blood and the nutriment, formed by Nature for a definite and most important purpose. We should have expected A. to argue on these lines, and it is somewhat disappointing to find him raising comparatively trifling objections to the Hippocratic view (which after all he has put himself into the medical mouth), such as that semen has a definite place assigned to it in the organism whereas a *σύντηγμα* flows wherever it can.

In the spurious *Problems* it is actually stated positively that semen is a *σύντηγμα* (v. 31), and again that *ἡ σύντηξις περίττωμά ἐστι* ! (v. 7).

752^a 11. I could not imagine why A. supposed the chick to be developed at the sharper end of the egg until at last this absurdly simple explanation flashed upon me. In whatever position you place a new laid egg the germ from which the chick is to come will float up toward the surface. A. then was a 'little-endian'; he put his eggs in cups with the broad end downwards and opened them at the sharp end; consequently he always found the chick there and supposed it to be the natural place for it.

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