

## Book V

### 1

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 in colour whether of the skin or of hair and feathers. 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. Further, in connexion with the changes in the time of life, all animals are alike in some points, but are opposed in others 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.

Now we must no longer 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 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. 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. 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 cause, on the view that these things

come into being by Necessity. 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.

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. But when we come to those things which come into being without falling under the heads just mentioned, 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), but it will have an eye of a particular kind 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.

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, they are in the habit of sleeping, because they continue sleeping also within the mother when they first acquire sensation. 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. 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 actually live the life of a plant. But it is impossible that plants should sleep, 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 most of the time because the growth takes place in the upper part of the body, which is consequently heavier (and we have stated elsewhere that such is the cause of sleep). But nevertheless they are found to wake even in the womb (this is clear in dissections and in the ovipara), and then they immediately fall into a sleep again. 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 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, 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, and their growth has taken place more in the upper part of the body.

The eyes of all children are bluish immediately after birth; later on they change to the colour which is to be theirs permanently. But in the case of other animals this is not visible. 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 kinds of animals do not differ from one another in the colour, so neither do they differ from themselves, for they are not of a nature to have more than one colour. Of the other animals the horse has the greatest variety of colour in the eye, for some of them are actually heteroglauous; this phenomenon is not to be seen in any of the other animals, but man is sometimes heteroglauous.

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.

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- this is not well said if indeed we are to assume sight to be connected with water, not fire, in all cases. 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- 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 liquid to be adapted to the movement, 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). 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 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. 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. 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, for the stronger movement drives out the weaker. Hence it is that on changing from strong colours, or on going out of the sun into the dark, men cannot see, for the motion already existing in the eye, being strong, stops that from outside, and in general neither a strong nor a weak sight can see bright things because the liquid is acted upon and moved too much.

The same thing is shown also by the morbid affections of each kind of sight. Cataract attacks the blue-eyed more, but what is called 'nyctalopia' the dark-eyed. Now cataract is a sort of dryness of the eyes 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 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, 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. This ought to be transparent, and it is necessary that the transparent should be thin and white and even, thin that the movement coming from without may pass straight through it, even that it may not cast a shade 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 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 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 heteroglauous 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. 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. Whenever then Nature cannot make the eyes correspond exactly, either by concocting or by not concocting the liquid in both, but concocts the one and not the other, then the result is heteroglauca.

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 shades 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 wells sometimes see the stars. 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, whereas those 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 it makes no difference whether we say, as some do, 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 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. Things at a distance, then, 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 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, 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, ends at the place where the innate spiritus causes in some animals the pulsation of the heart and in others respiration; 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 and moved as the organ moves the breath, for while setting the breath in motion it is moved itself. The same thing happens in wet weather or a damp atmosphere.... And the ears seemed to be filled with air because their starting-point is near the region of breathing.

Accuracy then in judging the differences of sounds and smells 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. 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, the movements from a distance 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.

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. 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.

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.

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, for even when the covering of such animals is spiny it must be considered as a kind of hair, as in the land hedgehog 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, 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 for animals has been previously stated in the work dealing with the causes of the parts of animals; 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. 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 solid and earthy as the moisture evaporates. Now the hairs or their analogue are not formed out of the flesh but out of the skin moisture evaporating and exhaling in them, and therefore thick hairs arise from a thick skin and thin from thin. 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 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. 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 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 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. 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 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 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, for these also are not long but are soft and do not admit of weaving.

The condition of sheep in cold climates is opposite to that of man; the hair of the Scythians is soft but that of the Sauromatic sheep is hard. The reason of this is the same as it is also 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. 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 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, is earthy because the heat fails and the moisture along with it.

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. Similar to this is the condition of baldness in those human beings to whom it is incident. 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. (However we must elsewhere 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. Thus if we reckon up these points, that the brain itself has but little heat, 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 furthest removed from the brain, 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 in man and that he is the only animal to do so; the front part goes bald because the brain is there, 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, 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, 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 his ages do not return, 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.

#### 4

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 uni-coloured or vari-coloured); 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 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.) 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. 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). 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, all earthy vapour being equivalent to thick air. 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 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). 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. The reason is that in sickness the whole body is deficient in natural heat 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. Indeed, we may rightly call disease an acquired old age, old age 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 head is empty of moisture owing to its containing no brain, and the 'bregma' has a great deal of moisture, a large quantity not being liable to decay; 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.

## 5

The reason why this change does not take place visibly 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 to 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.' 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. The reason of this would be, if it should prove true, that their feathers are naturally moister than others and as they grow old the moisture in the feathers is too much to decay easily.

Greyiness 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, 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 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 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, therefore the hairs change according to the skin but the skin does not change at all in consequence of the winds and the sun.

## 6

Of animals some are uni-coloured (I mean by this term 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. 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.

This happens when the course of development is perverted, for what is small is easily spoilt and easily 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 nature the individual is whole-coloured 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. 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. 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. 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. The reason is that assigned before, that the 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; thus bees are more uniformly coloured than hornets and wasps. For if the food is responsible for the change 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.

## 7

As to the voice, it is deep in some animals, high in others, 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 animals when younger, but in cattle that of calves is deeper. 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.

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. But since low-

ness 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. 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 and high. Again, the depth seems to belong to the nobler nature, and in songs the deep note is better than the high-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. And by what else can we define these (I mean loudness and softness of 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. 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, sometimes, having complete command over it, make the movement swift. On the same principle the weak either move too much air for

their strength and so make the movement slow, or if they make it swift move but little because of their weakness.

These, then, are the reasons of these contrarities, 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 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 which is borne along slowly is heavy, and much air is borne along slowly. 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. 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 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.)

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 attaching to it what are called 'laiai'. 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. 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 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 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. 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, cold breath being thin the opposite. This is clear also in pipe-playing, for if the breath of the performer is hotter, that is to say if it is expelled as by a groan, 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 or when it is roughened by any affection, 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 treatise on sensation and in that on the soul.

## 8

With regard to the teeth it has been stated previously 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 grow according to Nature, and suckling is the cause he assigns for their being found too early. Yet the pig also suckles but does not shed its teeth, and, further, all the animals with carnivorous dentition suckle, but some of them do not shed any teeth except the canines, e.g. lions. This mistake, then, was due to his speaking generally without examining what happens in all cases; but this is what

we 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. 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 than the grinders, because the bone of the jaw is flat in that part but narrow towards the mouth. From the greater part, therefore, must flow more nutriment to form the teeth, and from the narrower part less.

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. A proof of this is that even in suckling animals those young which enjoy hotter milk grow their teeth quicker, 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 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 this way; 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 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.

-THE END-

