

350 BC

ON YOUTH AND OLD AGE, ON LIFE AND DEATH,

ON BREATHING

by Aristotle

translated by G. R. T. Ross

1

WE must now treat of youth and old age and life and death. We must probably also at the same time state the causes of respiration as well, since in some cases living and the reverse depend on this.

We have elsewhere given a precise account of the soul, and while it is clear that its essential reality cannot be corporeal, yet manifestly it must exist in some bodily part which must be one of those possessing control over the members. Let us for the present set aside the other divisions or faculties of the soul (whichever of the two be the correct name). But as to being what is called an animal and a living thing, we find that in all beings endowed with both characteristics (viz. being an animal and being alive) there must be a single identical part in virtue of which they live and are called animals; for an animal qua animal cannot avoid being alive. But a thing need not, though alive, be animal, for plants live without having sensation, and it is by sensation that we distinguish animal from what is not animal.

This organ, then, must be numerically one and the same and yet possess multiple and disparate aspects, for being animal and living are not identical. Since then the organs of special sensation have one common organ in which the senses when functioning must meet, and this must be situated midway between what is called before and behind (we call 'before' the direction from which sensation comes, 'behind' the opposite), further, since in all living things the body is divided into upper and lower (they all have upper and lower parts, so that this is true of plants as well), clearly the nutritive principle must be situated midway between these regions. That part where food enters we call upper, considering it by itself and not relatively to the surrounding universe, while downward is that part by which the primary excrement is discharged.

Plants are the reverse of animals in this respect. To man in particular

among the animals, on account of his erect stature, belongs the characteristic of having his upper parts pointing upwards in the sense in which that applies to the universe, while in the others these are in an intermediate position. But in plants, owing to their being stationary and drawing their sustenance from the ground, the upper part must always be down; for there is a correspondence between the roots in a plant and what is called the mouth in animals, by means of which they take in their food, whether the source of supply be the earth or each other's bodies.

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All perfectly formed animals are to be divided into three parts, one that by which food is taken in, one that by which excrement is discharged, and the third the region intermediate between them. In the largest animals this latter is called the chest and in the others something corresponding; in some also it is more distinctly marked off than in others. All those also that are capable of progression have additional members subservient to this purpose, by means of which they bear the whole trunk, to wit legs and feet and whatever parts are possessed of the same powers. Now it is evident both by observation and by inference that the source of the nutritive soul is in the midst of the three parts. For many animals, when either part—the head or the receptacle of the food—is cut off, retain life in that member to which the middle remains attached. This can be seen to occur in many insects, e.g. wasps and bees, and many animals also besides insects can, though divided, continue to live by means of the part connected with nutrition.

While this member is indeed in actuality single, yet potentially it is multiple, for these animals have a constitution similar to that of Plants; plants when cut into sections continue to live, and a number of trees can be derived from one single source. A separate account will be given of the reason why some plants cannot live when divided, while others can be propagated by the taking of slips. In this respect, however, plants and insects are alike.

It is true that the nutritive soul, in beings possessing it, while actually single must be potentially plural. And it is too with the principle of sensation, for evidently the divided segments of these animals have sensation. They are unable, however, to preserve their constitution, as plants can, not possessing the organs on which the continuance of life depends, for some lack the means for seizing, others for receiving their food; or again they may be destitute of other organs as well.

Divisible animals are like a number of animals grown together, but animals of superior construction behave differently because their constitution is a

unity of the highest possible kind. Hence some of the organs on division display slight sensitiveness because they retain some psychical susceptibility; the animals continue to move after the vitals have been abstracted: tortoises, for example, do so even after the heart has been removed.

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The same phenomenon is evident both in plants and in animals, and in plants we note it both in their propagation by seed and in grafts and cuttings. Genesis from seeds always starts from the middle. All seeds are bivalvular, and the place of junction is situated at the point of attachment (to the plant), an intermediate part belonging to both halves. It is from this part that both root and stem of growing things emerge; the starting-point is in a central position between them. In the case of grafts and cuttings this is particularly true of the buds; for the bud is in a way the starting-point of the branch, but at the same time it is in a central position. Hence it is either this that is cut off, or into this that the new shoot is inserted, when we wish either a new branch or a new root to spring from it; which proves that the point of origin in growth is intermediate between stem and root.

Likewise in sanguineous animals the heart is the first organ developed; this is evident from what has been observed in those cases where observation of their growth is possible. Hence in bloodless animals also what corresponds to the heart must develop first. We have already asserted in our treatise on The Parts of Animals that it is from the heart that the veins issue, and that in sanguineous animals the blood is the final nutriment from which the members are formed. Hence it is clear that there is one function in nutrition which the mouth has the faculty of performing, and a different one appertaining to the stomach. But it is the heart that has supreme control, exercising an additional and completing function. Hence in sanguineous animals the source both of the sensitive and of the nutritive soul must be in the heart, for the functions relative to nutrition exercised by the other parts are ancillary to the activity of the heart. It is the part of the dominating organ to achieve the final result, as of the physician's efforts to be directed towards health, and not to be occupied with subordinate offices.

Certainly, however, all sanguineous animals have the supreme organ of the sensefaculties in the heart, for it is here that we must look for the common sensorium belonging to all the sense-organs. These in two cases, taste and touch, can be clearly seen to extend to the heart, and hence the others also must lead to it, for in it the other organs may possibly initiate changes, whereas with the upper region of the body taste and touch have no

connexion. Apart from these considerations, if the life is always located in this part, evidently the principle of sensation must be situated there too, for it is qua animal that an animal is said to be a living thing, and it is called animal because endowed with sensation. Elsewhere in other works we have stated the reasons why some of the sense-organs are, as is evident, connected with the heart, while others are situated in the head. (It is this fact that causes some people to think that it is in virtue of the brain that the function of perception belongs to animals.)

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Thus if, on the one hand, we look to the observed facts, what we have said makes it clear that the source of the sensitive soul, together with that connected with growth and nutrition, is situated in this organ and in the central one of the three divisions of the body. But it follows by deduction also; for we see that in every case, when several results are open to her, Nature always brings to pass the best. Now if both principles are located in the midst of the substance, the two parts of the body, viz. that which elaborates and that which receives the nutriment in its final form will best perform their appropriate function; for the soul will then be close to each, and the central situation which it will, as such, occupy is the position of a dominating power.

Further, that which employs an instrument and the instrument it employs must be distinct (and must be spatially diverse too, if possible, as in capacity), just as the flute and that which plays it-the hand-are diverse. Thus if animal is defined by the possession of sensitive soul, this soul must in the sanguineous animals be in the heart, and, in the bloodless ones, in the corresponding part of their body. But in animals all the members and the whole body possess some connate warmth of constitution, and hence when alive they are observed to be warm, but when dead and deprived of life they are the opposite. Indeed, the source of this warmth must be in the heart in sanguineous animals, and in the case of bloodless animals in the corresponding organ, for, though all parts of the body by means of their natural heat elaborate and concoct the nutriment, the governing organ takes the chief share in this process. Hence, though the other members become cold, life remains; but when the warmth here is quenched, death always ensues, because the source of heat in all the other members depends on this, and the soul is, as it were, set aglow with fire in this part, which in sanguineous animals is the heart and in the bloodless order the analogous member. Hence, of necessity, life must be coincident with the maintenance of heat, and what we call death is its destruction.

However, it is to be noticed that there are two ways in which fire ceases to exist; it may go out either by exhaustion or by extinction. That which is self-caused we call exhaustion, that due to its opposites extinction. [The former is that due to old age, the latter to violence.] But either of these ways in which fire ceases to be may be brought about by the same cause, for, when there is a deficiency of nutriment and the warmth can obtain no maintenance, the fire fails; and the reason is that the opposite, checking digestion, prevents the fire from being fed. But in other cases the result is exhaustion,-when the heat accumulates excessively owing to lack of respiration and of refrigeration. For in this case what happens is that the heat, accumulating in great quantity, quickly uses up its nutriment and consumes it all before more is sent up by evaporation. Hence not only is a smaller fire readily put out by a large one, but of itself the candle flame is consumed when inserted in a large blaze just as is the case with any other combustible. The reason is that the nutriment in the flame is seized by the larger one before fresh fuel can be added, for fire is ever coming into being and rushing just like a river, but so speedily as to elude observation.

Clearly therefore, if the bodily heat must be conserved (as is necessary if life is to continue), there must be some way of cooling the heat resident in the source of warmth. Take as an illustration what occurs when coals are confined in a brazier. If they are kept covered up continuously by the so-called 'choker', they are quickly extinguished, but, if the lid is in rapid alternation lifted up and put on again they remain glowing for a long time. Banking up a fire also keeps it in, for the ashes, being porous, do not prevent the passage of air, and again they enable it to resist extinction by the surrounding air by means of the supply of heat which it possesses. However, we have stated in *The Problems* the reasons why these operations, namely banking up and covering up a fire, have the opposite effects (in the one case the fire goes out, in the other it continues alive for a considerable time).

Everything living has soul, and it, as we have said, cannot exist without the presence of heat in the constitution. In plants the natural heat is sufficiently well kept alive by the aid which their nutriment and the surrounding air supply. For the food has a cooling effect [as it enters, just as it has in man] when first it is taken in, whereas abstinence from food produces heat and thirst. The air,

if it be motionless, becomes hot, but by the entry of food a motion is set up which lasts until digestion is completed and so cools it. If the surrounding air is excessively cold owing to the time of year, there being severe frost, plants shrivel, or if, in the extreme heats of summer the moisture drawn from the ground cannot produce its cooling effect, the heat comes to an end by exhaustion. Trees suffering at such seasons are said to be blighted or star-stricken. Hence the practice of laying beneath the roots stones of certain species or water in pots, for the purpose of cooling the roots of the plants.

Some animals pass their life in the water, others in the air, and therefore these media furnish the source and means of refrigeration, water in the one case, air in the other. We must proceed-and it will require further application on our part-to give an account of the way and manner in which this refrigeration occurs.

7

A few of the previous physical philosophers have spoken of respiration. The reason, however, why it exists in animals they have either not declared or, when they have, their statements are not correct and show a comparative lack of acquaintance with the facts. Moreover they assert that all animals respire-which is untrue. Hence these points must first claim our attention, in order that we may not be thought to make unsubstantiated charges against authors no longer alive.

First then, it is evident that all animals with lungs breathe, but in some cases breathing animals have a bloodless and spongy lung, and then there is less need for respiration. These animals can remain under water for a time, which relatively to their bodily strength, is considerable. All oviparous animals, e.g. the frog-tribe, have a spongy lung. Also hemydes and tortoises can remain for a long time immersed in water; for their lung, containing little blood, has not much heat. Hence, when once it is inflated, it itself, by means of its motion, produces a cooling effect and enables the animal to remain immersed for a long time. Suffocation, however, always ensues if the animal is forced to hold its breath for too long a time, for none of this class take in water in the way fishes do. On the other hand, animals which have the lung charged with blood have greater need of respiration on account of the amount of their heat, while none at all of the others which do not possess lungs breathe.

Democritus of Abdera and certain others who have treated of respiration, while saying nothing definite about the lungless animals, nevertheless seem to speak as if all breathed. But Anaxagoras and Diogenes both maintain that all breathe, and state the manner in which fishes and oysters respire. Anaxagoras says that when fishes discharge water through their gills, air is formed in the mouth, for there can be no vacuum, and that it is by drawing in this that they respire. Diogenes' statement is that, when they discharge water through their gills, they suck the air out of the water surrounding the mouth by means of the vacuum formed in the mouth, for he believes there is air in the water.

But these theories are untenable. Firstly, they state only what is the common element in both operations and so leave out the half of the matter. For what goes by the name of respiration consists, on the one hand, of inhalation, and, on the other, of the exhalation of breath; but, about the latter they say nothing, nor do they describe how such animals emit their breath. Indeed, explanation is for them impossible for, when the creatures respire, they must discharge their breath by the same passage as that by which they draw it in, and this must happen in alternation. Hence, as a result, they must take the water into their mouth at the same time as they breathe out. But the air and the water must meet and obstruct each other. Further, when they discharge the water they must emit their breath by the mouth or the gills, and the result will be that they will breathe in and breathe out at the same time, for it is at that moment that respiration is said to occur. But it is impossible that they should do both at the same time. Hence, if respiring creatures must both exhale and inhale the air, and if none of these animals can breathe out, evidently none can respire at all.

Further, the assertion that they draw in air out of the mouth or out of the water by means of the mouth is an impossibility, for, not having a lung, they have no windpipe; rather the stomach is closely juxtaposed to the mouth, so that they must do the sucking with the stomach. But in that case the other animals would do so also, which is not the truth; and the water-animals also would be seen to do it when out of the water, whereas quite evidently they do not. Further, in all animals that respire and draw breath there is to be observed a certain motion in the part of the body which draws in the air, but in

the fishes this does not occur. Fishes do not appear to move any of the parts in the region of the stomach, except the gills alone, and these move both when they are in the water and when they are thrown on to dry land and gasp. Moreover, always when respiring animals are killed by being suffocated in water, bubbles are formed of the air which is forcibly discharged, as happens, e.g. when one forces a tortoise or a frog or any other animal of a similar class to stay beneath water. But with fishes this result never occurs, in whatsoever way we try to obtain it, since they do not contain air drawn from an external source. Again, the manner of respiration said to exist in them might occur in the case of men also when they are under water. For if fishes draw in air out of the surrounding water by means of their mouth why should not men too and other animals do so also; they should also, in the same way as fishes, draw in air out of the mouth. If in the former case it were possible, so also should it be in the latter. But, since in the one it is not so, neither does it occur in the other. Furthermore, why do fishes, if they respire, die in the air and gasp (as can be seen) as in suffocation? It is not want of food that produces this effect upon them, and the reason given by Diogenes is foolish, for he says that in air they take in too much air and hence die, but in the water they take in a moderate amount. But that should be a possible occurrence with land animals also; as facts are, however, no land animal seems to be suffocated by excessive respiration. Again, if all animals breathe, insects must do so also. many of them seem to live though divided not merely into two, but into several parts, e.g. the class called Scolopendra. But how can they, when thus divided, breathe, and what is the organ they employ? The main reason why these writers have not given a good account of these facts is that they have no acquaintance with the internal organs, and that they did not accept the doctrine that there is a final cause for whatever Nature does. If they had asked for what purpose respiration exists in animals, and had considered this with reference to the organs, e.g. the gills and the lungs, they would have discovered the reason more speedily.

Democritus, however, does teach that in the breathing animals there is a certain result produced by respiration; he asserts that it prevents the soul from being extruded from the body. Nevertheless, he by no means asserts that it is for this purpose that Nature so contrives it, for he, like the other physical philosophers, altogether fails to attain to any such explanation. His statement is that the soul and the hot element are identical, being the primary forms among the spherical particles. Hence, when these are being crushed

together by the surrounding atmosphere thrusting them out, respiration, according to his account, comes in to succour them. For in the air there are many of those particles which he calls mind and soul. Hence, when we breathe and the air enters, these enter along with it, and by their action cancel the pressure, thus preventing the expulsion of the soul which resides in the animal.

This explains why life and death are bound up with the taking in and letting out of the breath; for death occurs when the compression by the surrounding air gains the upper hand, and, the animal being unable to respire, the air from outside can no longer enter and counteract the compression. Death is the departure of those forms owing to the expulsive pressure exerted by the surrounding air. Death, however, occurs not by haphazard but, when natural, owing to old age, and, when unnatural, to violence.

But the reason for this and why all must die Democritus has by no means made clear. And yet, since evidently death occurs at one time of life and not at another, he should have said whether the cause is external or internal. Neither does he assign the cause of the beginning of respiration, nor say whether it is internal or external. Indeed, it is not the case that the external mind superintends the reinforcement; rather the origin of breathing and of the respiratory motion must be within: it is not due to pressure from around. It is absurd also that what surrounds should compress and at the same time by entering dilate. This then is practically his theory, and how he puts it.

But if we must consider that our previous account is true, and that respiration does not occur in every animal, we must deem that this explains death not universally, but only in respiring animals. Yet neither is it a good account of these even, as may clearly be seen from the facts and phenomena of which we all have experience. For in hot weather we grow warmer, and, having more need of respiration, we always breathe faster. But, when the air around is cold and contracts and solidifies the body, retardation of the breathing results. Yet this was just the time when the external air should enter and annul the expulsive movement, whereas it is the opposite that occurs. For when the breath is not let out and the heat accumulates too much then we need to respire, and to respire we must draw in the breath. When hot, people breathe rapidly, because they must do so in order to cool themselves, just when the theory of Democritus would make them add fire to fire.

pushing, by no means determines how, in the case of the animals other than land-animals, their heat is preserved, and whether it is due to the same or a different cause. For if respiration occurs only in land-animals we should be told what is the reason of that. Likewise, if it is found in others also, but in a different form, this form of respiration, if they all can breathe, must also be described.

Further, the method of explaining involves a fiction. It is said that when the hot air issues from the mouth it pushes the surrounding air, which being carried on enters the very place whence the internal warmth issued, through the interstices of the porous flesh; and this reciprocal replacement is due to the fact that a vacuum cannot exist. But when it has become hot the air passes out again by the same route, and pushes back inwards through the mouth the air that had been discharged in a warm condition. It is said that it is this action which goes on continuously when the breath is taken in and let out.

But according to this way of thinking it will follow that we breathe out before we breathe in. But the opposite is the case, as evidence shows, for though these two functions go on in alternation, yet the last act when life comes to a close is the letting out of the breath, and hence its admission must have been the beginning of the process.

Once more, those who give this kind of explanation by no means state the final cause of the presence in animals of this function (to wit the admission and emission of the breath), but treat it as though it were a contingent accompaniment of life. Yet it evidently has control over life and death, for it results synchronously that when respiring animals are unable to breathe they perish. Again, it is absurd that the passage of the hot air out through the mouth and back again should be quite perceptible, while we were not able to detect the thoracic influx and the return outwards once more of the heated breath. It is also nonsense that respiration should consist in the entrance of heat, for the evidence is to the contrary effect; what is breathed out is hot, and what is breathed in is cold. When it is hot we pant in breathing, for, because what enters does not adequately perform its cooling function, we have as a consequence to draw the breath frequently.

It is certain, however, that we must not entertain the notion that it is for purposes of nutrition that respiration is designed, and believe that the internal fire is fed by the breath; respiration, as it were, adding fuel to the fire, while the feeding of the flame results in the outward passage of the breath. To

combat this doctrine I shall repeat what I said in opposition to the previous theories. This, or something analogous to it, should occur in the other animals also (on this theory), for all possess vital heat. Further, how are we to describe this fictitious process of the generation of heat from the breath? Observation shows rather that it is a product of the food. A consequence also of this theory is that the nutriment would enter and the refuse be discharged by the same channel, but this does not appear to occur in the other instances.

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Empedocles also gives an account of respiration without, however, making clear what its purpose is, or whether or not it is universal in animals. Also when dealing with respiration by means of the nostrils he imagines he is dealing with what is the primary kind of respiration. Even the breath which passes through the nostrils passes through the windpipe out of the chest as well, and without the latter the nostrils cannot act. Again, when animals are bereft of respiration through the nostrils, no detrimental result ensues, but, when prevented from breathing through the windpipe, they die. Nature employs respiration through the nostrils as a secondary function in certain animals in order to enable them to smell. But the reason why it exists in some only is that though almost all animals are endowed with the sense of smell, the sense-organ is not the same in all.

A more precise account has been given about this elsewhere. Empedocles, however, explains the passage inwards and outwards of the breath, by the theory that there are certain blood-vessels, which, while containing blood, are not filled by it, but have passages leading to the outer air, the calibre of which is fine in contrast to the size of the solid particles, but large relatively to those in the air. Hence, since it is the nature of the blood to move upwards and downwards, when it moves down the air rushes in and inspiration occurs; when the blood rises, the air is forced out and the outward motion of the breath results. He compares this process to what occurs in a clepsydra.

Thus all things outwards breathe and in;- their flesh has tubes
Bloodless, that stretch towards the body's outmost edge,
Which, at their mouths, full many frequent channels pierce,
Cleaving the extreme nostrils through; thus, while the gore
Lies hid, for air is cut a thoroughfare most plain.
And thence, whenever shrinks away the tender blood,
Enters the blustering wind with swelling billow wild.

heat. Not even the digesting process to which is due the nutrition of animals occurs apart from soul and warmth, for it is to fire that in all cases elaboration is due. It is for this reason, precisely, that the primary nutritive soul also must be located in that part of the body and in that division of this region which is the immediate vehicle of this principle. The region in question is intermediate between that where food enters and that where excrement is discharged. In bloodless animals it has no name, but in the sanguineous class this organ is called the heart. The blood constitutes the nutriment from which the organs of the animal are directly formed. Likewise the bloodvessels must have the same originating source, since the one exists for the other's behoof-as a vessel or receptacle for it. In sanguineous animals the heart is the starting-point of the veins; they do not traverse it, but are found to stretch out from it, as dissections enable us to see.

Now the other psychical faculties cannot exist apart from the power of nutrition (the reason has already been stated in the treatise *On the Soul*), and this depends on the natural fire, by the union with which Nature has set it aglow. But fire, as we have already stated, is destroyed in two ways, either by extinction or by exhaustion. It suffers extinction from its opposites. Hence it can be extinguished by the surrounding cold both when in mass and (though more speedily) when scattered. Now this way of perishing is due to violence equally in living and in lifeless objects, for the division of an animal by instruments and consequent congelation by excess of cold cause death. But exhaustion is due to excess of heat; if there is too much heat close at hand and the thing burning does not have a fresh supply of fuel added to it, it goes out by exhaustion, not by the action of cold. Hence, if it is going to continue it must be cooled, for cold is a preventive against this form of extinction.

Some animals occupy the water, others live on land, and, that being so, in the case of those which are very small and bloodless the refrigeration due to the surrounding water or air is sufficient to prevent destruction from this cause. Having little heat, they require little cold to combat it. Hence too such animals are almost all short-lived, for, being small, they have less scope for deflection towards either extreme. But some insects are longer-lived though bloodless, like all the others), and these have a deep indentation beneath the waist, in order to secure cooling through the membrane, which there is thinner. They are warmer animals and hence require more refrigeration, and such are bees (some of which live as long as seven years) and all that make a humming noise, like wasps, cockchafers, and crickets. They make a sound

as if of panting by means of air, for, in the middle section itself, the air which exists internally and is involved in their construction, causing a rising and falling movement, produces friction against the membrane. The way in which they move this region is like the motion due to the lungs in animals that breathe the outer air, or to the gills in fishes. What occurs is comparable to the suffocation of a respiring animal by holding its mouth, for then the lung causes a heaving motion of this kind. In the case of these animals this internal motion is not sufficient for refrigeration, but in insects it is. It is by friction against the membrane that they produce the humming sound, as we said, in the way that children do by blowing through the holes of a reed covered by a fine membrane. It is thus that the singing crickets too produce their song; they possess greater warmth and are indented at the waist, but the songless variety have no fissure there.

Animals also which are sanguineous and possess a lung, though that contains little blood and is spongy, can in some cases, owing to the latter fact, live a long time without breathing; for the lung, containing little blood or fluid, can rise a long way: its own motion can for a long time produce sufficient refrigeration. But at last it ceases to suffice, and the animal dies of suffocation if it does not respire-as we have already said. For of exhaustion that kind which is destruction due to lack of refrigeration is called suffocation, and whatsoever is thus destroyed is said to be suffocated.

We have already stated that among animals insects do not respire, and the fact is open to observation in the case of even small creatures like flies and bees, for they can swim about in a fluid for a long time if it is not too hot or too cold. Yet animals with little strength tend to breathe more frequently. These, however, die of what is called suffocation when the stomach becomes filled and the heat in the central segment is destroyed. This explains also why they revive after being among ashes for a time.

Again among water-animals those that are bloodless remain alive longer in air than those that have blood and admit the sea-water, as, for example, fishes. Since it is a small quantity of heat they possess, the air is for a long time adequate for the purposes of refrigeration in such animals as the crustacea and the polyps. It does not however suffice, owing to their want of heat, to keep them finally in life, for most fishes also live though among earth, yet in a motionless state, and are to be found by digging. For all animals that have no lung at all or have a bloodless one require less refrigeration.

is the surrounding air, in others fluid, that aids the maintenance of life. But in the case of animals possessing blood and heart, all which have a lung admit the air and produce the cooling effect by breathing in and out. All animals have a lung that are viviparous and are so internally, not externally merely (the Selachia are viviparous, but not internally), and of the oviparous class those that have wings, e.g. birds, and those with scales, e.g. tortoises, lizards, and snakes. The former class have a lung charged with blood, but in the most part of the latter it is spongy. Hence they employ respiration more sparingly as already said. The function is found also in all that frequent and pass their life in the water, e.g. the class of water-snakes and frogs and crocodiles and hemydes, both sea- and land-tortoises, and seals.

All these and similar animals both bring forth on land and sleep on shore or, when they do so in the water, keep the head above the surface in order to respire. But all with gills produce refrigeration by taking in water; the Selachia and all other footless animals have gills. Fish are footless, and the limbs they have get their name (pterygion) from their similarity to wings (pteryx). But of those with feet one only, so far as observed, has gills. It is called the tadpole.

No animal yet has been seen to possess both lungs and gills, and the reason for this is that the lung is designed for the purpose of refrigeration by means of the air (it seems to have derived its name (pneumon) from its function as a receptacle of the breath (pneuma)), while gills are relevant to refrigeration by water. Now for one purpose one organ is adapted and one single means of refrigeration is sufficient in every case. Hence, since we see that Nature does nothing in vain, and if there were two organs one would be purposeless, this is the reason why some animals have gills, others lungs, but none possess both.

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Every animal in order to exist requires nutriment, in order to prevent itself from dying, refrigeration; and so Nature employs the same organ for both purposes. For, as in some cases the tongue serves both for discerning tastes and for speech, so in animals with lungs the mouth is employed both in working up the food and in the passage of the breath outwards and inwards. In lungless and non-respiring animals it is employed in working up the food, while in those of them that require refrigeration it is the gills that are created for this purpose.

We shall state further on how it is that these organs have the faculty of producing refrigeration. But to prevent their food from impeding these operations there is a similar contrivance in the respiring animals and in those

that admit water. At the moment of respiration they do not take in food, for otherwise suffocation results owing to the food, whether liquid or dry, slipping in through the windpipe and lying on the lung. The windpipe is situated before the oesophagus, through which food passes into what is called the stomach, but in quadrupeds which are sanguineous there is, as it were, a lid over the windpipe—the epiglottis. In birds and oviparous quadrupeds this covering is absent, but its office is discharged by a contraction of the windpipe. The latter class contract the windpipe when swallowing their food; the former close down the epiglottis. When the food has passed, the epiglottis is in the one case raised, and in the other the windpipe is expanded, and the air enters to effect refrigeration. In animals with gills the water is first discharged through them and then the food passes in through the mouth; they have no windpipe and hence can take no harm from liquid lodging in this organ, only from its entering the stomach. For these reasons the expulsion of water and the seizing of their food is rapid, and their teeth are sharp and in almost all cases arranged in a saw-like fashion, for they are debarred from chewing their food.

18

Among water-animals the cetaceans may give rise to some perplexity, though they too can be rationally explained.

Examples of such animals are dolphins and whales, and all others that have a blowhole. They have no feet, yet possess a lung though admitting the sea-water. The reason for possessing a lung is that which we have now stated [refrigeration]; the admission of water is not for the purpose of refrigeration. That is effected by respiration, for they have a lung. Hence they sleep with their head out of the water, and dolphins, at any rate, snore. Further, if they are entangled in nets they soon die of suffocation owing to lack of respiration, and hence they can be seen to come to the surface owing to the necessity of breathing. But, since they have to feed in the water, they must admit it, and it is in order to discharge this that they all have a blow-hole; after admitting the water they expel it through the blow-hole as the fishes do through the gills. The position of the blow-hole is an indication of this, for it leads to none of the organs which are charged with blood; but it lies before the brain and thence discharges water.

It is for the very same reason that molluscs and crustaceans admit water—I mean such animals as Carabi and Carcini. For none of these is refrigeration a necessity, for in every case they have little heat and are bloodless, and hence are sufficiently cooled by the surrounding water. But in feeding they admit water, and hence must expel it in order to prevent its being swallowed

simultaneously with the food. Thus crustaceans, like the Carcini and Carabi, discharge water through the folds beside their shaggy parts, while cuttlefish and the polyps employ for this purpose the hollow above the head. There is, however, a more precise account of these in the History of Animals.

Thus it has been explained that the cause of the admission of the water is refrigeration, and the fact that animals constituted for a life in water must feed in it.

19

An account must next be given of refrigeration and the manner in which it occurs in respiring animals and those possessed of gills. We have already said that all animals with lungs respire. The reason why some creatures have this organ, and why those having it need respiration, is that the higher animals have a greater proportion of heat, for at the same time they must have been assigned a higher soul and they have a higher nature than plants. Hence too those with most blood and most warmth in the lung are of greater size, and animal in which the blood in the lung is purest and most plentiful is the most erect, namely man; and the reason why he alone has his upper part directed to the upper part of the universe is that he possesses such a lung. Hence this organ as much as any other must be assigned to the essence of the animal both in man and in other cases.

This then is the purpose of refrigeration. As for the constraining and efficient cause, we must believe that it created animals like this, just as it created many others also not of this constitution. For some have a greater proportion of earth in their composition, like plants, and others, e.g. aquatic animals, contain a larger amount of water; while winged and terrestrial animals have an excess of air and fire respectively. It is always in the region proper to the element preponderating in the scheme of their constitution that things exist.

20

Empedocles is then in error when he says that those animals which have the most warmth and fire live in the water to counterbalance the excess of heat in their constitution, in order that, since they are deficient in cold and fluid, they may be kept in life by the contrary character of the region they occupy; for water has less heat than air. But it is wholly absurd that the water-animals should in every case originate on dry land, and afterwards change their place of abode to the water; for they are almost all footless. He,