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XXIX. *An Account of certain Receptacles of Air, in Birds, which communicate with the Lungs, and are lodged both among the fleshy Parts and in the hollow Bones of those Animals.* By John Hunter, F. R. S.

Redde, Feb. 27, 1774. **T**HE singular communications which are found to subsist, in birds, between the cavities of the lungs, and certain other cavities in the fleshy parts and in the bones, being peculiar to that tribe of animals, and having never yet been sufficiently explained, nor perhaps attended to, either by anatomists or natural historians; I imagine, that an account of them will not be unacceptable to this society. It is not my present design, to enter into minute descriptions of all the particular communications of this sort, to be found in the dissection of these animals; but only to mention such general facts, as will be sufficient to introduce the subject into natural history, and serve to open the enquiry into the final cause.

To make this matter more intelligible, I must previously give an idea of the difference, between the particular cells in question, and those other cells of the cellular membrane, common to all animals; and

and also shew wherein those bones which receive air, differ from such as do not.

The air-cells, which are found in the soft parts of birds, have no communication with the cavity of the common cellular membrane of the body: some of them communicate immediately with one another; and all of them may be said to have a communication together, by means of the lungs, as a common centre. Some of these are bags placed in larger cavities, such as the *abdomen*; others are lodged in the interstices of parts, that they would, at first, appear to be the common connecting membrane, as about the breast, *axilla*, &c.

They are of very different sizes, just as best suits the circumstances of the particular parts, where they are placed.

The bones which receive air are of two kinds; some, as the *sternum*, ribs, and *vertebra*, have their internal substance divided into innumerable cells; whilst others, as the *os humeri* and the *os femoris*, are hollowed out into one large canal, sometimes with a few bony columns running across, at the extremities. Bones of this kind may be distinguished from those that do not receive air, by several marks; 1st, by their less specific gravity; 2dly, by being less vascular than the others, and therefore whiter; 3dly, by their containing little or no oil, and consequently being more easily cleaned; and appearing much whiter, when cleaned, than common bones; 4thly, by having no marrow, nor a bloody, pulpy substance, even in their cells; 5thly, by their not being, in general, so hard and firm as other bones; those of some birds are so soft, that they can be squeezed

squeezed together with the finger and thumb: however, the bones of the extremities have very solid sides. 6thly, the passage by which the air gets into the bones can be easily perceived, even in cleaned bones. Generally there are several holes, placed together, near the end of the bone which is next the trunk of the bird; and distinguishable, by having their external edges rounded off; which is not the case with those holes, through which either nerves or blood vessels pass, into the substance of the bone.

I must next give an idea of the mechanism of the lungs in birds, which renders them fit for communicating air to the above described parts. This consists principally in certain connexions.

It has been asserted, that birds have no diaphragm; but this opinion must have arisen either from a want of observation, or from too confined an idea of a diaphragm; for there is a pretty strong, but thin and transparent, membrane, which covers the lower surface of the lungs, and adheres to them; this membrane gives insertion to several thin muscles, which arise from the inner surfaces of the ribs.

The use of this part is to lessen the concavity of the lungs towards the *abdomen*, at the time of inspiration; and thereby to assist in dilating the air-cells; for which reason, it is to be considered as answering one main purpose of a diaphragm.

Besides this attachment of the lungs to the diaphragm, they are also connected to the ribs and sides of the *vertebræ*.

These adhesions are peculiar to this tribe of animals; and are of singular use, or rather of absolute

lute necessity, in such lungs as those of birds, out of which the air can find a passage into other cavities; for if the lungs were loose in the cavity of the *thorax*, as is the case in all other animals, their cells could not be expanded, either by the depression of the diaphragm, or the elevation of the ribs; since the air rushing in, to fill up the *vacuum* in the cavity of the chest, occasioned by these actions, would take the straight road from the *trachea* through those passages; and, of consequence, expand no part of the lungs which lay out of that line, whereby respiration would be totally prevented; it would be exactly the same case, as when the lungs are so much wounded, in other animals, as to allow of a free passage for the air into the cavity of the *thorax*, &c.

*Of the internal openings of the lungs.*

The openings in the lungs, by which they communicate air to the other parts, are as follow:

The membrane, or diaphragm above mentioned, is perforated in several places, with pretty large holes, which admit of a free passage, between the cells of the lungs and the *abdomen*. A communication which has frequently been noticed.

To each of these perforations is joined a distinct membranous bag, which is extremely thin and transparent; it receives the air, and being afterwards continued through the *abdomen*, gets attachments to many of those parts with which it comes in contact.

There is no occasion to describe here all these bags, or their attachments; it being sufficient to say, that they extend over the whole *abdomen*.

The lungs open at their anterior part, that is, towards the *sternum*, into certain membranous cells which lie upon the sides of the *pericardium*, and communicate with the cells of the *sternum*.

The superior part of the lungs opens into the large cells of a loose net-work, through which the *trachea*, *oesophagus*, and large vessels, going from, and coming to the heart, pass.

When these cells are distended with air, it increases the size of that part, where they lie, very considerably; which, in general, is a mark of passion; as appears evidently in the turkey-cock, the pouting-pidgeon, &c. and is extremely visible, in the breast of a goose, when she cackles.

These cells communicate with others in the *axilla*, under the large pectoral muscle, &c.: and those again with the cavity of the *os humeri*, by means of small openings, in the hollow surface, near the head of that bone.

The posterior edges of the lungs, which lie on the sides of the spine, and project backwards between the ribs, open into the cells of the bodies of the *vertebræ*, those of the ribs, the canal of the *medulla spinalis*, the cells of the *sacrum*, and other bones of the *pelvis*; from which parts the air finds a passage to the cavity of the thigh-bone.

This account agrees with what we find in most birds; though some have more, and some fewer of these communications.

In the OSTRICH, no air gets into the *os humeri*; but it enters every other part, as described above, in very large quantities. In the common FOWL, no air appears to enter any bone but the *os humeri*. The WOOD-COCK has none either in the first bone of the wing, or in the thigh-bones. On the other hand, in the PELICAN, the air passes on to the *ulna* and *radius*, and into those bones which answer to the *carpus* and *metacarpus* of *quadrupeds*.

Thus then, the *abdomen*, the cells surrounding the *pericardium*, the lower and fore part of the neck, the *axilla*, the cellular membrane under the pectoral muscles, &c. all communicate with the lungs, and are capable of being filled with air; and again, from those cells the *sternum*, ribs, *vertebræ* of the back and loins, bones of the *pelvis*, *ossa humerorum*, and *ossa femorum*, can, in many birds, be furnished with air.

This supply, of the bones with air, is not wholly by means of the lungs; for the cells of the bones of the head, in some birds, are filled with it, of which the OWL is a remarkable instance. In this bird, the *diploe* between the two plates of the skull is cellular, and admits a considerable quantity of air, which is furnished by the Eustachian tube.

Some authors considered the *diploe*, in the *cranium* of a bird, as a continuation of the mamillary process\*; and have looked upon it as a circumstance peculiar to singing birds; but this is not the case.

\* The only thing similar to this communication, in birds, of the cells of bones with the external air, is that of the internal ear of *quadrupeds*, by the Eustachian tube.

The lower jaw of the PELICAN is also furnished with air; but by what means I do not know.

Having formerly observed these facts, I made several experiments in the year 1758, upon the breathing of birds, to prove the free communication between the lungs and the abovementioned parts.

The first was upon a cock. I made an opening into the belly of this animal, and introduced a silver *cannula*; then tied up the *trachea*, and found that he breathed by this opening, and lived; but an inflammation came on, in the bowels, which produced adhesions, and cut off the communication.

I cut the wing through the *os humeri*, in another fowl, and tied up the *trachea* as in the cock; and found that the air passed to and from the lungs by the canal in this bone; the same experiment was made with the *os femoris* of a young HAWK, which was attended with nearly the like success; but the passage of air, through both these parts, especially the last, was attended with more difficulty than in the first experiment; indeed so much, as to render it impossible for the animal to live longer, than to prove evidently, that he did breathe through the cut bone.

The exceeding singularity of these communications, in birds, put me upon thinking, what could be the final cause. At first I suspected, that it might be intended for the benefit of flying, that being the circumstance which appears the most peculiar to birds; and it might be of service in this respect, I thought, by encreasing the volume and strength, with the same quantity of matter, and therefore



without adding to the weight of the whole ; which will rather indeed be diminished by the difference of specific gravity, between the external and internal air. This opinion was strengthened, by observing, that the feathers of birds also contain a considerable quantity of air, and in the very part which requires the greatest strength ; as likewise by the analogy of fish, which have air contained in their bodies, to lessen their specific gravity ; though the use of this, in fish, which are to move in a much heavier element, is more obvious than in birds.

But when I found the OSTRICH, which is not intended to fly, endowed with nearly the same construction ; and that the common FOWL, and many others of that class, which do fly ; and also the WOOD-COCK, which flies, and is supposed to be a bird of passage, are not so well provided with air, as the OSTRICH ; and that the BATT, which flies, differs not, in that way, from animals that do not fly ; so many contradictions to the theory, obliged me to think of some other use, for this singular mechanism.

The next conjecture, that offered itself, was, that these parts were to be considered as an appendage to the lungs. The analogy of *amphibious* animals leads to this ; for, in many of them, the snake, viper, &c. the lungs are continued down through the whole belly, in form of two bags, the upper part only of which can do the office of respiration ; and therefore, the remainder is to be considered as a reservoir of air. Now there is a great similarity between birds and that class of animals,

mals, called *amphibious*; and although a bird and a snake are not the same, in the construction of the respiratory organs, yet the circumstance of the air passing beyond the lungs, into the cavity of the *abdomen*, in both, naturally leads us to suppose, that so similar a structure is designed for the same purpose in both; and this analogy is further confirmed by the texture of the lungs in both, which consist of large cells. Now in amphibious animals, the use of this conformation of the lungs is evident; for it is in consequence of this, that they can breathe less frequently than others. Considering the matter in this light, it may still, in birds, have some connexion with flying; for that motion may easily be imagined, to render frequency of respiration difficult; and may, therefore, make a reservoir of air singularly useful.

It may, perhaps, occur to some, that the whole of these communicating cells are to be considered as extended lungs; but I can hardly think, that any air, which gets beyond the vesiculated lungs themselves, is capable of affecting the blood of the animal; as the other cavities, into which it comes, as well those of the soft parts, as of the bones, are very little vascular.

How far this construction, of the respiratory organs, may assist birds in singing, is worthy of consideration, as the vast continuance of song, between the breathings, in a CANARY-BIRD, would appear to be owing to this cause.

At present, I shall pursue this subject no farther; but leave it to a subsequent paper, as requiring a great many comparative facts, to establish the final cause.