

During the preparation of this paper, I have been examining many more specimens of Golden eyes, especially females, which I now can immediately separate from young males by their different wind-pipes. I find that females vary in having, or not having a narrow black bar across the white on the wings. This narrow black bar is formed by the white greater coverts having black tips, where they cover the white secondaries or speculum. In all the specimens studied, I have found this bar only in those I had already considered Barrow's females, whilst the common female had none. But as this bar differs in specimens, and also in the wings of the same bird, as respect to size and interruption, and as I never have had the opportunity to study it in the young males, I think it requires more observation before it is pronounced a typical mark. The pansy purple of the head dress of the male Barrow, in distinction to the duck-green of the common species, noted as typical by Richardson, does not hold, as I had before me this winter, a common Golden Eye drake with head dress of the finest pansy purple. It is now in the collection of Mr. A. Downs, Halifax, N. S.

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ART. VI.—OF THE STRUCTURE OF THE BONES IN BIRDS, AND OF THEIR DIFFERENCES IN THE VARIOUS SPECIES. BY PIERRE CAMPER, 1771. TRANSLATED BY R. MORROW, FROM VOL. 3, PAGE 449, ET SEQ, PARIS EDITION OF CAMPER'S WORKS PUBLISHED IN 1803.

(*Read April 8th, 1878.*)

WHENEVER I have examined the internal structure of animals, I have admired the observation of the great Galileo, that one there always meets with new wonders! I have already given many proofs of it in the exhibition of the generation of the toads of Surinam; in that of the organ of hearing in ordinary and cartilaginous fishes and of the cachalot, which I have pre-

sented in part to the Royal Academy of Sciences, in part to the Society of Haarlem. Among the descriptions which I have not yet had time to complete, none appears to me more worthy of attention than that of the cavities, which are present in the bones of birds, chiefly in those which surround the trunk.

The bones of the wings, the clavicles, the bones of the chest, the vertebræ of the back, the bones of the haunches, and in many, the bones of the thighs, are quite hollow, without marrow, and receive into their cavities, by respiration, the air, by means of which the birds are made lighter and more capable of rising in the air.

This is quite a new discovery, which will be so much the more agreeable to the Academy, that it is purely physical. I made it in the month of February last year, when I was occupied in making investigations upon birds, in order to develop the mechanism of respiration, which in them is very peculiar.

I knew from the studies of Galileo<sup>1</sup> and of Borelli,<sup>2</sup> that the bones of birds were hollow and slight, in order that they may fly more easily: these two great men have been alone studious of the substance of the bones. Galileo especially, who has very evidently proved, in comparing them with tubes of wood or of metal, that a bone of the same length and weight being hollow has more strength than a bone of the same weight and length, but solid;<sup>3</sup> he has even added this remarkable rule: That the strength of hollow bones is to that of solid bones, in this case, as their diameters.<sup>4</sup> This reflection can not only be applied to the structure of bones in general, but also to that of plants, in which we see similar cavities without pith, but full of air.

Borelli<sup>5</sup> has displayed, in the explanation of the flight of birds and of the mechanism of their wings, the perfect knowledge which he had of the composition of their bones,<sup>6</sup> of the cavity of their chest and of their abdomen, as well as of the air which fills these two cavities.

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1. "De Mechan." Dial. II, page 132.

2. "De Motu anim." Proposit 194, page 156.

3. Ibid.

4. "De Mechan." Dial. II, page 132.

5. Proposit 182, page 146.

6. Proposit 194.

The respiration of birds is at the present time too well known to need particular explanation; but the respiration into the bones of the trunk, of the wings and of the thighs, deserves a particular account. It is to this consideration only that I will limit myself in this paper.

I have called it a discovery, because I know of no author who has pointed out the least thing about it. It is very true that M. le Comte de Marsigli<sup>1</sup> knew that the bones of the wings in the pelican were hollow and without marrow, and very light; but he had no idea of the air, nor of the manner in which the air might enter into this cavity.

M. leComte de Buffon, the greatest naturalist which we have had since Aristotle, was not ignorant of that which Galileo and Borelli have communicated on this subject: he makes use of it in his excellent discourse upon the nature of birds;<sup>2</sup> but he did not know that the cavities of these bones received air instead of marrow, and that this fluid entered there by respiration.

They brought to me on the 10th Feb., 1771, a great sea eagle<sup>3</sup> like those of which they annually shoot a large number in the neighbourhood of this city during the frost. I dissected the ribs, above all the claws and their muscles, &c. I prepared a bone of the thigh principally to show its cavity and the fibres which support it within the bony laminae in the animal. I expected to find marrow there, but only found periosteum, a large vein i. k. l., which covered it, and traces of the air vent as I have represented pl. xxxiv., fig. 6.

Astonished with this singularity I went immediately to examine the skeletons of an eagle, a toucan and an owl. I found a very large orifice under the great trochanter from the skeleton of the eagle; I did not perceive any trace of it in the others; but I noticed very large holes under the heads of the bones of the wings in all my skeletons of birds. I then examined the wings of the eagle with much attention; I opened this bone lengthwise and did not find marrow in it, but periosteum as in the bone of the thigh, and a very large opening in the inside

1. Danub. Fran. Mysic. tom, vi, tab 8, page 10 et seq.

2. Pages 16, 33, 34.

3. The sea-eagle of Buffon "Hist. Nat. des oiseaux," tom. I, page 112.

part of the head of the humerus, pl. xxxiv, fig. 1, a. b. c. Here is an analogy. The air can enter by these holes into the cavities of the bones; but I do not yet know how it could penetrate as far as these openings. I had by accident a dead owl. I made a small hole at the extremity of the bone of the wing, fig. 3, idem; I applied a copper tube, and blowing I saw with much pleasure that all the chest and abdomen swelled out; the air went out by the wind-pipe in proportion as I blew. I then tied, in order to have an opposite proof, the wind-pipe around my tube; and blowing I had the satisfaction to see the air go out by the small hole made in the bone of the wing, when I there applied the flame of a candle, or some light body, or a small feather.

The bone of the thigh of the owl, although perforated, did not convey the air; therefore it had no opening under the trochanter.

The chest and the abdomen of the eagle, were too offensive to repeat these experiments; I then removed the intestines, I blew through the bone of the thigh, and I saw that the pleura which goes as far as into the abdomen, forms a membranous conduit, which, going along the crural vessels, comes out at the opening of the thigh, d. e. f., fig. 6, and which gave passage to the air to enter freely into the cavity of this bone. This redoubled my ardour to push my discoveries further.

I took from my larder, a turkey, some pullets; I perforated in the same way the extremities of the bones of the wings; I applied to them my tube, and blowing, I saw, with surprise, the chest and the abdomen swell out as in the owl; the femurs did not admit the air, not being empty, but full of marrow as in the owls. In the grouse the experiment succeeded as in the eagle, for they have the holes under the trochanter, fig. 8, d. e. f.

The stork, of which they showed me the skeleton, has the bones of the wings void of marrow and filled with air, and a considerable hole, a. b. c., fig. 2. It has also the thigh bones empty, and a manifest hole under the trochanter, fig. 7, d. e. f.

I consequently imagined that I would find the bones of the wings in the greater number of birds empty; but that I would find the thigh bones perforated and permeable to the air only in those which fly very high, as the eagles, the storks, and all those which have the body heavy and a great many muscles, &c.

This conjecture was verified by the dissection of a sparrow: its thigh bones as well as its wings were full of marrow, as its flight is not high, nor of long continuance. The lark, for example, which fills the air with its melodious song, sustains itself a long time upon the wing; its wings are hollow, filled with air, and they have a very considerable opening.

I then earnestly desired to have the skeletons of the ostrich, the cassowary and the penguin, in order to know if the bones of their wings were full of air. I had already formed a negative conclusion; I requested M. Professor Allamand, of Leyden, to examine the skeleton of the ostrich; he had the kindness to answer me that he could find no opening under the head of the humerus of this bird. I could find no part of the skeleton of a cassowary nor of a penguin; I have since secured two penguins from the Cape of Good Hope, in spirits of wine; I have not yet had time to dissect the parts which are in question.

Borelli<sup>1</sup> has already made a very beautiful remark, that the wings are greater in proportion as birds fly higher; but ours pronounces their mechanism more curious and more interesting.

I return from this digression to the eagle, of which I examined very attentively the clavicles and the supports of the scapulæ, the scapulæ themselves, the sternum, the ribs and the vertebræ of the back: I have found all these bones hollow, vacant, full of air; also the sacrum and the coccyx.

On the 24th February, 1771, I made the following experiments upon a strangled owl.

1st. Having removed the great pectoral muscle, and perforated the bone of the wing near its extremity, I blew into this hole and I immediately perceived a large membranous pouch between the two pectorals, which goes along the vessels and the brachial nerves, giving a membranous duct towards the opening which lies near the head of this bone; this pouch also swelled when I blew through the trachea.

2nd. I removed the bony support of the scapula which was articulated with the sternum; I then made a very small hole, and blowing into it the same pouch swelled several times.

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1 Proposit. 182.

3rd. I perforated the exterior plate of the sternum, near its union with the supports before described ; the air also passed immediately into the chest and into the abdomen ; almost all birds have orifices in the interior of this bone, and the pleura is the continuation of the internal periosteum of the cells of this bone.

4th. I made the same experiments upon the clavicles, and noticed in the same manner their communication with the cavity of the chest.

5th. I removed the posterior part of the coxa ; perforated the exterior bony plate, and the air passed by its cells into the chest as if I had blown through the trachea.

6th. The air passed also through the body of the vertebræ of the back after having removed the flesh, perforated the bony plate and applied a tube.

7th. The ribs are also empty and receive the air by many holes which are visible in the cavity of the chest ; by the same operation can one also blow the air through the ribs into the chest, as by the other bones before named.

I repeated the first, second, third, fourth and sixth experiments upon an eagle, March 13, 1771, before my auditors, in the anatomical theatre, with the same success.

8th. I perforated the bone of the thigh of this sea-eagle ; I applied there my tube, and the air passed easily into the chest of this animal. Having blown by the trachea, the air went out by the same hole with so much violence, that it was easy, by this means, to extinguish a candle very quickly.

I could not say whether the same structure exists in the other birds ; this requires a more particular examination ; it is sufficient that the eagle, of which the velocity and height of flight are the greatest, and of which the strength as much to fly as to seize and tear its prey, ought to be necessarily greatest ; that the eagle, I say, becomes lighter, not only by the air which distends its lungs, its chest and its abdomen, but further with the air which fills the cavities of its bones.

It is very probable from the experiments made upon the owl, that nature makes use of the same mechanism in all birds of prey.

It is likewise very probable that in the ostrich, the cassowary and the penguin, one will not find any hollow bones; that in the swan, the goose and the duck, the bones of the wings only will be empty and full of air; and only in part in the turkey, the fowl and the partridge; for these last have the bones of the wing partly full of marrow and partly full of air, or else, to speak more generally, it is apparent that the bones are void of marrow and full of air, in proportion as the birds carry the flight more or less high.

Galileo and Borelli have proved that the substance of the bones in birds is concave, as in the flute; but they supposed that they were full of an oily marrow much lighter than the bone. M. de Marsigli has observed that the bone of the wing of the pelican was void (of marrow) and full of air. I flatter myself to have discovered that in many birds, and in the birds of prey, all the bones which can have communication with the chest or the abdomen are filled with air, and I have verified the openings by which the air regularly enters, and is thus renewed by respiration.

The air which enters, and which thus fills the cavities of the bones, must necessarily become lighter by the heat of the body, by means of which the animal, becoming specifically lighter than the air itself, flies with more ease.

This discovery makes us see besides that the marrow is not necessary for the nutrition nor for the growth of the bones, nor for the anointing of the articulations, nor for the forming of the callus. I have found very often the bones of the wing, in fowls, broken and perfectly healed. I add, in order that the demonstration should be more complete, the drawing of such a bone, fig. 10, pl. xxxiv. Ossification receives from this much elucidation, and appears to claim to be examined according to this new plan.

It is not, however, without example, even in our bodies, to see the cellular substance of the bones filled with air; the mastoid apophyses receive air by the Eustachian tubes.

The head of the owl furnishes also another curious example—the air enters into the diploe of the whole skull by the auditory

holes, for birds have no Eustachian tubes, like quadrupeds and amphibians.

Having dissected, December 13th, 1773, one of the penguins which I had received from the Cape of Good Hope, of the second species of "diomeda," of Linnæus, edit x., page 214, I found the bones full, as they should be according to the explanation which I have given.

Some time after, one brought me a diver of the species which Linnæus, *ibid.*, page 222, calls "Colymbus immer," of which the wings are too small for it to fly. In this bird the bones of the wings are also filled with marrow and without air holes; therefore the bones of these two species of birds do not admit the air.

The thigh bones of the diver merit the attention of naturalists, in that they have no trochanter, of which the structure with that of its muscles is so admirable. The periosteum is black in this bird, and its colour comes off like that of the uvea of the eyes in the greater part of animals.

The head of the elephant<sup>1</sup> furnishes yet a more striking proof; but it is time to finish this memoir, after having given a short explanation of the figures, without which the description would have been less instructive and clear.

#### EXPLANATION OF THE PLATES.

##### PLATE XXXIV.

Figure 1—Represents the upper part of the bone of left wing of the sea-eagle; a, b, c, the hole by which the air enters.

Figure 2—The upper part of the bone of the left wing of the stork; a, b, c, the air hole.

Figure 3—The bone of the left wing of the owl; a, b, the air hole; p, the hole made at the lower part to apply the tube.

Figure 4—The bone of the right wing of the turkey; a, b, c, the air hole.

1. Camper, vol. 2, page 175, Paris, 1803.—"Account of the dissection of a young Elephant."—In order to confine the brain within proper bounds not to overburden the head with a useless weight of bony matter, and to give, moreover, the greatest spread which the muscles require, the plates of the skull are removed one from the other by a great number of bony partitions prolonged to the distance of many inches. The spaces, filled with an infinite number of cells, more or less spacious, communicate with the gullet by means of the Eustachian tubes, are filled with air in place of blood or of marrow, which is usually found in the diploe of mammalia. Perrault, Blair and Daubenton have noticed this structure in the elephant, in the boar, and in other quadrupeds: but Camper first discovered its analogy with the structure of the skull of birds.



Figure 5—The bone of the right wing of a hen ; a, b, c, the air hole.

Figure 6—The bone of the left thigh of the sea-eagle ; d, e, f, the air hole under the trochanter, h ; g, the head of this bone ; i, k, l, m, the supports which give strength to the bone, without which it would be too slight ; i, l, m, n, the vein which covers the internal periosteum.

Figure 7—The bone of the left thigh of the stork ; d, e, f, the air hole ; h, the trochanter ; g, the head of the bone.

Figure 8—The bone of the left thigh of the grouse ; d, e, f, the air hole.

Figure 9—The bone of the right thigh of the hen, without air hole.

Figure 10—The bone of the right wing of a pullet ; a, b, the air hole ; g, r, the fracture perfectly united by callus.

[The translator regrets that he is unable to present copies of the plates referred to above, and in the supplement.]

#### STRUCTURE OF THE BONES IN BIRDS.

Letter upon the same subject addressed to the Editors of a Literary Journal entitled “Hedendaagsche Vaderlandsche Letteroeffeningen.”

GENTLEMEN,—It is with pleasure that I have seen in the third volume of your weekly Journal, <sup>1</sup> the Dissertation of Mr. John Hunter, “upon the interstices between the muscles and the cavities in the bones of birds, by which the air communicates with their lungs, which you have translated from the LXIVth volume of the Philosophical Transactions of London ; a volume which only reached Holland in the autumn of 1774 ; whereas this dissertation had been read to the Royal Society, the 27th February, 1774. I have been at the same time pleased that you have done me the justice to remark : “That I had already, March 2nd, 1771, communicated to the Batavian Society of Rotterdam, this discovery, and consequently *three* years before M. Hunter had spoken of it.”

This concurrence of ideas ought in the meanwhile to fix the

1. No. 10, 1774, page 421.

attention of the learned of our country and incite them to compare my dissertation with that of M. Hunter ; and that so much the more as the first volume of the Batavian Society of Rotterdam appeared later than volume LXIV of the "Philosophical Transactions." One might then easily pass over the date of my dissertation, or even as it often happens, neglect it voluntarily ; which might be prejudicial to the priority of my discovery.

In order to remove all doubt upon this subject, I proceed to furnish the most peremptory proof to show that I have in effect discovered and communicated, three years before M. Hunter, this singular property of birds ; and I will produce at the same time, the new observations which I have made since that time, by the dissection of the cassowary, the ostrich, the hooded-crow, the owl and other birds.

Delighted, and not without reason, I think, to have made this beautiful discovery in birds, February 11, 1771, I communicated it at once to many of my friends, and, among others, to M. Allamand, of Leyden. I have preserved for particular reasons, the answer which this *savant* made to me upon this subject. I had promised to him my observations upon the reindeer (which appeared in 1771, in the form of a supplement to the Amsterdam edition of Buffon's Natural History) ; and I communicated to him, in the same letter my discovery of the cavity in the bones of birds. This is the reply which he made me : "I thank you before hand for your observations on the reindeer which you have the kindness to cause me to expect, &c.—I have not yet had the opportunity of making the experiments which prove the communication between the abdomen and the large bones of birds ; but after what you have said of it, I believe the fact as if I had seen it.—I am going to Guelders, where I shall have birds of divers kinds in abundance, in order to verify your beautiful discovery." This letter is without date, but has however been written at the beginning of the year 1771, as appears by the publication of my observations upon the reindeer.

I, at the same time, requested M. Allamand to examine the skeleton of the ostrich ; upon which he answered me in another letter of June 23, 1771 : "Your discovery of the passage of the

“air in the bones of birds, appears to me more and more interesting, and you will not be sorry to learn that your conjecture as to the bones of the ostrich is true, at least in a skeleton which I have of this bird; and I have not been able to discover any vestige of the least opening either in the humerus or in the bone of the thigh. It will be without doubt the same with the cassowary; which seems to show that you have found out the real use of this air passage in the bones; since neither of these two birds nor the penguin can fly.”<sup>1</sup>

However eighteen months passed without my having any hope that they would soon grant the insertion of my discovery in the Transactions of the Batavian Society of Rotterdam to which I had sent it.

This determined me to send my memoir to M. Portal, at Paris, which I did the 21st November, 1772, with some additions in French requesting him to insert it in the Memoirs of the Royal Academy of Sciences, with some observations upon the ant-eater of the Cape of Good Hope, upon the peccary (*Sus*. sp., 3 dorso cystifero, cauda nulla. Linn., gen. 35), and upon the organ of hearing and the blow holes of the cachalot, etc. M. Portal did me the honor to reply to me the 16th March, 1773, that the observations which I had sent to him had been deemed of so great importance by the members of the Academy, that they had commissioned M. M. Daubenton, Tenon and Portal to make observations on the birds which I had named; and M. Portal afterwards informed me, under date of the 26th April, 1774, that they had made these observations with which they had been much satisfied, and which were found perfectly conformable with that which I had said; so that the Royal Academy of Sciences, to which they had reported the 23rd April, in the same year, had judged them worthy to be inserted in its Transactions; certain proof that at this time no person had yet had the least knowledge of this peculiar structure of birds.

As a new proof, useless without doubt, that I had made much sooner than M. Hunter this discovery, I send you from this place

<sup>1</sup> One sees by these two letters that already in 1771, M. Allamand knew not only my discovery, but that he had even verified it by his own experiments.

a latin dissertation which M. Ladislaus Charnack, a Hungarian, read the 25th August, 1773, at a public meeting of the University of Groningen, upon the respiration of birds. <sup>1</sup> M. Charnack, admits that I was the first who made the discovery of this singular property, since he says: "It was the celebrated Camper who first discovered that birds breathe also through the cavities of the bones of the wings, the thighs and even of the trunk, &c." <sup>2</sup> If we compare this dissertation with that which I have sent to the Society of Rotterdam, we shall see that it agrees with it exactly. This is not astonishing: M. Charnack has been one of my most assiduous hearers, to whom I have often repeated my observations upon this subject; even as he also expressly mentions it: "The celebrated Camper, has often made in presence of his hearers, experiments of this kind upon the owl, the eagle, etc." <sup>3</sup>

These convincing proofs show incontestibly that I had already, at this time, a perfect knowledge of the intromission of air into the cavities of the bones of birds, which M. John Hunter spoke of to the Royal Society of London only upon the 27th February, 1774. I pass now to the corrections which I have made since that time to my dissertation.

In the dissertation which I sent the 2nd March, 1771, to the Batavian Society, I say expressly: "Nevertheless, birds have not as the quadrupeds, ducts, which terminate in the mouth or in the gullet; but there is probably an opening in the length of the auditory conduit to introduce and refresh the air between the bony plates of the head." I am so much the more certain in this respect as already in 1745, when I was still studying, I knew, and exactly drew, the organ of hearing of birds; but it was only the 12th November, 1774, that I discovered, for the first time, the outlet of the auditory conduits in the mouth of an ostrich, which was used in my investigations on this subject; and when I found myself once upon the track, it was not difficult to make the same discovery in the cock, the sparrow, the owl, the

1 Dissert. medica de insipitatione volucrum.

2 Respirationem, avium etiam, per ossa cava humeri, femorum et ipsius, trunci exerceri, mortalium primus cel. Camperus detexit, &c.

3 Varia hujus generis, experimenta in noctua et aquila coram auditeribus suis instituit cel. Camperus, etc.

hooded-crow, and in other birds. I then perceived the cause of my error. They have only one common opening for the two Eustachian tubes; and the opening lies placed very much hidden between the two digitiform apophyses above the œsophagus.

DuVerney, Casserius, Blasius, Valentin and Collins even, though the last was well aware of these apophyses, which he called "processus cristati," make no mention of this opening.

The multiplied duties of the place of professor which I then occupied, left me little leisure to read, or even look over all the dissertations which came to us from England. Now as I am disengaged, I find that Dr. Allen Monten had already described in 1681 these conduits, as well as their union with the cavities between the bony walls of the head in birds. One has only to consult Badham or Lowthorp, who say: "There is but one aqueductus (hollow conduit) in the head of all the fowls, exactly in the middle of the palate, below the insertion of the nostrils into it,—It is a membranous tube, which reaches backward as far as the communication from ear to ear." As it was in 1771 that I fell into this error, it appears that it was the following trial which led me into it. Having made a hole in the lamina of the head of a common brown owl, I found that the air went out with such violence by the openings of the ears, that I extinguished the flame of a candle with it; as has been confirmed by M. Charnack.<sup>1</sup> The violence with which I blew had broken the tympanum, because the Eustachian tubes were too small? to permit all this air to pass with sufficient rapidity.

In the sparrow owl (*strix passerina*, Linn.) which I dissected the 25th December, 1774, I made a small opening over above the orbits of the eyes in the exterior bony plate. I blew then by the Eustachian tube, and the flame of a candle held opposite the opening which I had made, confirmed the communication and the statement of M. Hunter,<sup>2</sup> as well as the discovery which Dr. Monten had made nearly a century before. I have renewed since these same experiments upon the hooded-crow, the cock and other birds, always with the same success. In the cock we must make the opening behind the ear.

1. Ibid, page 13.

2. Ibid, page 210.

Respecting the very conspicuous apophyses of which I have spoken in the supplement of my dissertation, I ought to remark here in passing, that Willoughby has indeed published a very rude drawing of these apophyses in his ornithology<sup>1</sup> but without giving a description of it, although he has elsewhere pointed out the situation of the bone of the thigh. Meyer<sup>2</sup> has them also perfectly well drawn in the diver, without speaking of them in his text.

M. Hoffman, a celebrated Doctor of Batavia, formerly one of my most zealous pupils, and to whom I owe many precious morsels in my collection, has sent me from the East a cassowary preserved in arrack, after having removed the intestines. The bones of the wings are proportionately to the size of its body, unusually small, and absolutely receive no air, nor do the bones of the thighs or the ribs; but there is air in the cavities between the haunch bones and the sacrum. This bird does not run quickly; and its wings are even much smaller than those of the penguin from the Cape of Good Hope. In this bird the middle claw of the feet was not the largest, as Linnæus<sup>3</sup> contends; but it was the inside claw, which was as long again as all the others.

A short time after, M. Pennant, arrived at the end of September, 1774, from Holland, at Leeuwarden, with an elephant, an ostrich and other animals; the ostrich died from having swallowed too much copper coin. I bought this dead bird in October, but divers occupations compelled me to put off dissecting it until the 6th November, 1774.

The ostrich is a bird too well known, and has been too well described by Perrault, Valisneri, Brown, Ranby, Warren and Buffon, for it to be necessary that I should stop here to speak of its exterior form. I will merely remark that it is with astonishment I have seen, that Valisneri, Brown, Perrault, Klein, Brisson and Linnæus, have not observed the claw of the little toe, whereas it is visibly half an inch and often even three quarters of an inch in length. It certainly sometimes happens that the scaly skin covers this claw, but one can, however, always per-

1. Figure 62.

2. Kur Vorstell, allerh. thiera. Nar. 1748, B. I., fig. 99; 100.

3. Dixieme edition, page 265.

ceive it. Johnston, Cheseldon and Meyer, have, on the contrary, represented this toe very large; perhaps from want of attention, or because they have imagined that it ought to be so.

I have found (and this is the question here) in the ostrich that which M. John Hunter had remarked in it, namely, that no air enters into the bones of the wings, but certainly in all the other bones as in all other birds; that is to say, in the vertebræ, the sternum, the ribs, &c.; and, that which is here the principal subject in the bones of the thighs. On the 11th December, 1774, whilst preparing the skeleton of this bird, I noticed on the front of the thigh bone quite a large air hole, divided into many small holes between the condyles; so that the bone of the thigh is not only full of air, but it appears even probable that the air goes out again between the membranous interstices of the muscles. However, this requires further investigation.

The air penetrates to the end of the coccyx along the spinous apophyses. It fills the large interstice of the sacrum, and of the bones of the haunches, with the peculiar membranes which communicate with the stomach and with the chest. M. J. Hunter was then right and I am not the only one who has deceived himself. The cause of this error appears to consist in this, that these holes are not found as in the eagle, the stork, the grouse, etc., on the front, but entirely on the posterior side of the thigh; so that it is only with difficulty that one discovers them, particularly when one does not suppose them to be there.

M. Hunter also says that the air penetrates into the "medulla oblongata": I have found this to be true in a hooded-crow; after having made an incision in the middle of the neck, and introduced a blow pipe between the spinal marrow and its membranes, I caused the air to enter quite easily until I had distended the stomach; and the air then went out through a hole which I had made in the bone of the wing. I cut off the head of another hooded-crow between the occiput and the atlas; but it was impossible for me to introduce the air into the spinal marrow. It appears to me by the experiments which I have made as much upon the hooded-crows as upon fowls, that the air can permeate within the vertebræ of the neck.

I had already seen but not so distinctly as I could desire, that the lower jaw of the ostrich, the heron, the bittern and the crow, was filled with air. It appears that M. Hunter has noticed the same thing in the pelican, he says : " The lower jaw of the pelican is also furnished with air ; but by what means I do not know." <sup>1</sup>

I have sought to know this means and have discovered it evidently in the ostrich, the heron and in the bittern. It is easy to perceive it in the hooded-crow. On the upper side of the apophyses placed behind the lower jaw which are curved inside there is a round hole, large enough in the ostrich for one to introduce a quill into it ; in the heron and the other birds this hole was smaller, but however, conspicuous and spacious. From this hole proceeded a membranous conduit which went round it showing behind the tympanum, and is attached to a similar hole a little below the upper edge of the drum. It is by this conduit that the air penetrates from the cavities between the bony laminae of the head into the lower jaw ; so that the lower jaw receives the air through the Eustachian tubes.

It is with the hooded-crow that one can best make this experiment, making a hole in the horny part of the lower jaw, and another hole behind the ear after having raised the skin. Let one then blow through a blow-pipe alternately into the one and the other hole. When we hold the head with one of these holes beneath water we shall see the air go out with force ; and if we raise the muscle behind the lower jaw, we will very distinctly see the membranous conduit.

The discovery of this part belongs then to me. My account, as if the holes in the bones of birds were peculiar to those which fly a long time and very high, appears certainly, to lose its weight, from what I have just now said with regard to the ostrich, but it is not nevertheless entirely destroyed, since we know that the ostrich runs with extreme velocity and flies even along the earth ; which it could not do, if the Creator had not considerably diminished its weight by giving to it this admirable structure. This will become still more clear, if we call to mind

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1. *Ibid*, page 211.



what the Count de Buffon says, according to M. Martine, <sup>1</sup> that the natural heat of birds is very much greater than that of man, and that it consequently should render the air in all the cavities of the bones sensibly lighter than that of our atmosphere. The cassowary, whose running is not swift, has not the bones of the thighs and of the wings, etc., empty, as I have already noticed.

The snipe, the sea-swallow and sparrows, do not have the bones of the thighs and of the wings empty. The feathers of the tail of these birds appear to make up this defect; besides, these birds do not fly very high nor remain a long time upon the wing.

For these reasons I cannot determine to abandon my conjectures, to adopt those of M. John Hunter, "That all these cavities are only appendages of the lungs, and that we should only regard them as reservoirs of air."

Franeker, January 15, 1775.

### SUPPLEMENT

TO THE MEMOIR UPON THE STRUCTURE OF THE BONES OF BIRDS.

Sec. I. In my letter to the editors of the "Hedendaagsche Vaderlandsche Letteroeffeningen," I have already observed <sup>2</sup> that there is a large air hole in the posterior side of the thigh bone of the ostrich. I think that the reader will be pleased to find here the drawing of a similar bone, taken from a young ostrich and represented with great accuracy, though reduced a little.

Fig. 11 of plate xxxiv, represents the bone of the right leg seen in front: A, is the head; B, the great trochanter; D and C, are the condyles which are united with the tibia by the articulations, to which E also belongs. There is something which is visible only in part, this is the epiphysis of the upper part, a, b.; in the same manner as c, d, e, f, g, is the epiphysis of the lower part of the bone of the leg.

One sees clearly that from this side there is no hole visible; but on the back side where A, B, C, D and E, point out this same part in fig. 12, plate xxxiv., we see very distinctly the large air holes, h, i, k, l, m, on the upper part, and n, p, q, on the lower

1. Suppl. tom I, page 84, note C.

2. See page 417.

part above the cartilage, C and E. These holes were covered with periosteum; in such a manner however, as to leave sufficiently large openings so that the air could pass in requisite quantity into the bones.

I ought here to return many thanks to the learned Dr. Bloch, of Berlin, for the friendly reception which he has given to me during my stay in this city, and for so obligingly sending me a male bustard, (otus, gen. 95, sp. edit. x. Linn.) In the hollow bone of the leg of this bird there is a remarkable air hole, but exactly upon the great trochanter; it appears then that the situation of this hole varies much in many birds, though it is found to be, in truth almost always on the front side of the bone.

In the crowned Indian pheasant (columba, Linn., gen. 104, sp. 17). I have found the same bone of the leg filled with air, and the air hole placed upon the front of the bone, as in the eagle, the stork, the grouse, etc.

In a spoonbill (platalea, gen. 80, sp. 1, Linn.) which had been dissected the preceding winter, the bones of the legs were entirely filled with marrow. It was remarkable that between the muscles of the coccyx (glutei) it had two large air pouches, which resembled those which are between the pectoral muscles, which were also very considerable. The air penetrates even into all the bones of the chest and of the stomach in the same way as into the bones of the thighs and of the sacrum.

Sec. II. Although the holes by means of which the air penetrates into the lower jaw of the terrestrial birds, have been sufficiently described in the before mentioned letter,<sup>1</sup> I think that it is necessary, to make me better understood in this respect, to give drawings of these parts: I have then in fig. 13 of plate xxxiv. represented the lower jaw of an ostrich, and in fig. 14 that of the third species of hornbill (buceros, gen. 74, Linn.) as well as that of the fourth species of hornbill, in fig. 15. Figure 16 represents the entire lower jaw of a hooded-crow (cornix, gen. 50, sp. 5, Linn.) In fig. 17 we see the lower jaw of a heron (ardea, gen. 84, sp. 12.) All these jaws are of natural size and seen from above.

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<sup>1</sup> See page 418.

A and B, in figs. 13 and 17, but A, D, in the figs. 14, 15 and 16, are the inside epiphyses of the extremities of the lower jaw. C, is the point of it; but as in the figs. 14 and 15, the jaws of the hornbill have been mutilated, C, C, show the place where this amputation has been made. R, points out in all these jaws the air hole, to which is attached the tube which goes from the interior of the ear and which receives the air by the Eustachian tubes. The lower jaw of aquatic birds, such as the swan, the duck, the goose, the penguin and others similar, receives positively no air, no more than the other bones of the head. It appears that nature has by this means intended to make their heads better fitted for diving.

Sec. III. Though nothing may be more easy to demonstrate than the manner by which the air finds its way into all the bones which surround the cavity of the chest, it appeared to me however, difficult to divine how the air could fill all the vertebræ of the neck so far as the head.

In dissecting, November 24th of last year, 1780, the spoonbill, I discovered very evidently an air duct, which from the anterior cavity of the chest passed the whole length of the vertebræ of the neck as far as the head. The bird was too fat, so that it was impossible for me to follow its other air tubes.

The 27th November I killed a heron, in which I discovered three air tubes, which proceeded from the anterior side of the pleura. One of these tubes passed in front along the vertebræ of the neck as in the spoonbill, and two laterally between the intertransversary muscles, that is to say, which are found placed between the tranverse apophyses of the vertebræ. Each vertebra takes a branch from these tubes, and by this means is filled with air. But I have not yet been able to discover how the air can find its way even into the tough membrane which envelopes the spinal marrow (*medulla oblongata*).

It is probable that for this it will be necessary to make injections with mercury, as well upon the sides of the chest as the length of the neck, etc. But it would require the investigations, not of one person only, but of many. Until this is done, I proceed by way of recapitulation to sum up with a species of conviction that which I have said before.

1st.—That the air penetrates, in birds, through the nose, between the bony plates of the skull and the vomer, as in the ostrich, the hooded-crow, the heron, and other similar birds.

2nd.—That the skull and all the lower jaw receive the air by the Eustachian tubes.

3rd.—That the vertebræ of the neck receive the air through the three ducts from the anterior cavity of the chest, of which I have before spoken.

4th.—All the bones around the chest and the body have large holes which come out internally into the pleura, and which easily admit the air inhaled through the trachea.

5th.—The bones of the wings and the air pouches which are found between the pectoral muscles receive the air immediately from the cavity of the chest by the brachial vessels.

6th.—The thigh bones receive the air, by the membranous conduits of the pleura, or from the air holes which are above the intestines as far as the haunch bones: these are also accompanied by the crural vessels. They have sometimes the form of large bladders between the coccygeal muscles, as I have observed in the spoonbill. It may be possible that the same thing occurs in the ostrich and other birds. Perhaps there are behind, air pouches which go downwards beneath the crural muscle. But I had so much to observe in the dissection of this large and rare bird, in regard to the eyes, the feet, the intestines, &c., that it was impossible for me to examine the whole of it with the proper care.

7th.—Aquatic <sup>1</sup> birds do not appear to have air in the bony frame of the head, nor even in their other bones.

8th.—Some birds, such as the woodcock (*rusticula* or *kolopax*, gen. 86, sp. 6) and others of similar character, have positively no air in their bony frame, and fly nevertheless far and a very long time. But in all these birds the pectoral muscles are strong enough for such a flight, and the apophysis of the sternum is very large.

1. The Wild Goose (*B. Canadensis*) and Black Duck (*A. obscura*) have the humerus hollow with large air holes, and other aquatic birds are most probably similarly furnished.—Note by the Translator—see also page 409.

We see also in the bat that nature compensates for the great weight which results from the marrow of the bones, in opposition to air, by the strength of the muscles which move the wings, and by the magnitude of the wings themselves.

Sec. IV. However it may be, I was much gratified when I perceived that the primary feathers of the eagle are hollow up to the end. I have noticed the same thing in the primary feathers of the heron and of the spoonbill; and there is room to believe that this is also the case in many other birds.

An observation which seems to me worthy of naturalists, would be to know how the air finds its way into the feathers and penetrates into the stalks of the feathers of all birds? How then does it come into the quills of the porcupine, etc.? It is certain that there are no air-ducts which go there from the chest. In what way can this then be brought about? It is probable that it is the blood-vessels which take the air there; the same as we see that the plants carry the air into their air-ducts. Let this be as it may, it appears that nature has intended to make a mystery of this admirable peculiarity; and notwithstanding that the celebrated Poupert <sup>1</sup> has made some attempts in order to discover the mechanism of it, and that Perrault speaks <sup>2</sup> of it in his description of the ostrich, all the other naturalists have kept silence upon this important and obscure point.

ART. VII.—NOTES ON NOVA SCOTIAN MINERALOGY. BY HENRY LOUIS, ESQ., ASSOC. R. S. M., LONDONDERRY MINES, N. S.

(Read May 13.)

THE extensive development in Nova Scotia of the palæozoic formations, the metamorphism which they have undergone, their frequent and excessive dislocations and contortions, together with the physical features of the country, all combine to render this Province peculiarly attractive as a field for mineralogical research. For, whilst violent volcanic and metamorphic agencies

1. Hist. de l'Acad. royale des sciences, année 1699, p. 56 in 8vo.

2. Mém. pour servir à l'hist. nat. des anim, part II., page 272.