

no inferior larynx. It is true that in the *Vultur cinereus* and *fulvus* as also in *Gypaetos*, there can not be found, as in many other Birds, any coalescence of the lower tracheal rings, or an external tympaniform membrane, but between the demi-rings of the bronchi (which appear, however, in the American Vulture or Gallinazo to be almost complete) there is situated the internal tympaniform membrane, while a single pair of muscles placed externally at the extremity of the trachea, serves to elevate slightly the bronchi upon either side, shorten the trachea, and thus expand the two bronchio-glottidean fissures. This pair of muscles acts moreover as an antagonist to the sterno-tracheales.

In the majority of those Birds which are capable of uttering sounds membranes are found situated both exteriorly and internally to the inferior larynx. There arises from the cross-bone a thin membranous slightly elastic and easily lacerable membrane, which completes the bronchi upon their internal aspect. The extent of this membrane is greater or less in proportion to that of the segment formed by the imperfect bronchial rings; the first two or three of these are usually very slightly curved, and in the form only of a small semicircle; the membrane completing the rings is therefore largest in this situation, and fully merits its appellation of *membrana tympaniformis interna*. In some Birds, as in several Ducks, especially the Mergansers, large flat cartilaginous discs are situated in this tympanic membrane, or, as in *Fulica*, thick cordiform cushions of cellular tissue, either of which structures must exert an indubitable influence upon the formation of the voice. There is generally found a *membrana tympaniformis externa* presenting the form of a fenestroid oval membrane placed between the cross-bone or the lowermost tracheal ring and the most superior of the bronchial semicircular cartilages.

This external fenestra or membrane may be wanting and still the inner one present and the trachea form an osseous drum, as in the Ducks and Mergansers. Or else the hard rings of the trachea may lie closely approximated and invested by fibro-cartilage, beneath which is situated the external ovale membrane, as in the Flamingo. No important change however can be effected in the relative degree of tension of the two membranes in cases where a single pair of muscles is present, and attached high up to the border of a drum formed of immoveable rings, whereas when inserted in the uppermost bronchial rings, a far greater share of mobility is attainable by the membranes.

Such a single pair of muscles (*m. m. broncho-tracheales*) occur in the Rapaces, some Scansores and Picariæ, *e. g.* *Picus*, *Cypselus*, *Caprimulgus*, and, though but feebly developed, in the Cuckoo; also in the Pigeons (which have a large external membranous fenestra), and many Grallæ and Natatores, while it is absent in other Scansores and Picariæ, *e. g.* *Alcedo*, *Upupa*, other Grallæ, and Natatores, as *Hæmatopus*, *Anser*, *Anas*, *Mergus*, and in the Brevipennes and Gallinæ. This single pair of muscles often ascends high up close to the sterno-tracheal muscles, draws the bronchi in the direction outward and thus expands their glottidean fissures.

Two special muscles of the larynx do not appear to occur in these cases, to which succeeds the peculiar structure of that organ in the Parrots, where it has three strong pairs of muscles, but the sterno-tracheales are absent. The inferior glottis is single and narrow in the Parrots, from the inferior partition or cross-bone being wanting. The structure of their larynx is as follows: the trachea passes into a short tympanum, and beneath this there is constantly situated a semilunar ossified cartilage (*cart. semilunaris*), having its concavity directed downward, and between its border which excavated in a crescentic form is curved upward, and the first bronchial demi-ring, is situated the external tympaniform membrane. The superior semilunar pieces can be moved inward and outward upon the tympanum, or raised and depressed like a pair of valves, and the membrane follows these movements. Of the three muscles, that which is situated most deeply is the shortest; it arises from the upper part of the tympanum, and is inserted by its whole breadth to the upper semilunar cartilage which is moveable like a valve. This is the *m. abductor cart. semilunaris*, and while this muscle elevates the corresponding semilunar bone, it draws also the membrane outward, and thus widens the opening of the glottis. Above this is situated another longer muscle, which arises close to it, and passing in a bridge-like manner over the tympaniform membrane, is inserted into the uppermost bronchial ring; it elevates the bronchus of the corresponding side, by which movement the two membranes approximate, come nearly in contact in the middle line, and thus narrow the fissure of the glottis. Above this short *levator bronchi*, is situated another, the *levator longus*, which has the same function, though at the same time its muscular belly arises higher up and is continued into a long tendon which, running over that of the former muscle, is occasionally inserted into the anterior side of the fifth to the seventh, or often the third to the

fifth bronchial ring. Upon the internal side of the tympaniform membrane, which is thrown into vibrations during the passage of the air from the lungs, there is placed a strip of membrane, which also vibrates and may be regarded as corresponding to the *ligamentum vocale externum* of the Singing-birds.

The structure of the inferior larynx is still more complicated in the Singing-birds, and those birds generally which are provided with what is called a true *muscular vocal apparatus*, among these the Ravens being included, from the power they possess, like the Parrots, of imitating the human voice. Although a number of slight varieties occur in the different genera and species, which stand in direct relation with the degree of complexity of their song, still, however, a great general conformity may be perceived in the structure of the singing apparatus, it, as a rule, being formed of five well-developed pairs of muscles. In the Nightingale and other small Singing-birds, this muscular apparatus is indeed very powerfully developed, but on account of its small size, the student will do best to select a larger bird, as the Raven or Rook, for the purposes of examination.

The trachea here consists of a short bony tympanum or drum, constituting its inferior extremity, and usually formed by the early coalescence of three rings. The tympanum is divided as usual inferiorly by a transverse or cross bone. From the superior border of this, a membranous semilunar fold (*membrana semilunaris Savart*) rises to about a line in height, as in the Rook; its dimensions, however, are very various, and in birds of accomplished song, or such as can learn to speak, it is more largely developed. In other Passeres, as in the Sparrow, Haw-grosbeak, &c., these membranes are of course wanting. From these observations it may be inferred that this membrane is of essential importance to the production of song or the power of uttering articulate sounds, since when it is absent or slightly developed, the voice is feeble or has but little variety of tone. The first three bronchial demi-rings exhibit also remarkable peculiarities. The first or uppermost ring is thicker in the middle than at the extremities; at the posterior end inferiorly it becomes broader, and curves in such a manner backward and inward, as to form the posterior and internal wall of the bronchial portion of the inferior larynx; below it passes into an acute angle, which forms the point of support of the internal lip of the glottis. The second bronchial demi-ring is more moveable than the first, especially in the direction outward and upward. The third demi-

ring is nearly straight, and between it and the second demi-ring there is a triangular membranous fenestra, and between the first and second bronchial demi-ring an oval *membrana tympaniformis externa*. Upon its inner surface there is found a remarkable fold of the mucous membrane, consisting of tolerably thick and elastic tissue; it forms a true vocal chord, *ligamentum vocale externum*, which always forms the external lip or wall of the glottidean fissure. This membrane or fold is thrown into vibrations during the passage of the air from the lungs. Besides this the *membrana tympaniformis interna* is found as usual completing the inner side of the bronchi, and is in continuous connexion with the *membrana semilunaris* of the cross-bone. A small pliant cartilage (*cartilago arytenoidea Savart*) is situated in the upper part of this membrane, is in connexion with the second arch of bone, and exhibits manifold diversities.

Two anterior and three posterior pairs of muscles may be distinguished as belonging to the inferior larynx. In front, a long elevator muscle (*m. levator anterior longus*) arises tolerably high up from the trachea, and is firmly attached to the second bronchial demi-ring, the anterior extremity of which it draws upward and outward, and so widens the larynx. In like manner the transverse elevator (*m. levator anterior transversus*) arises in front, but obliquely, from the external part of the superior border of the tympanum; it proceeds in the direction forward, and is attached by its inferior extremity to the anterior part of the second and third bronchial demi-rings, and to their interjacent membrane; elevating and drawing these parts also in the direction outward. By both of these muscles, as well as by the *m. depressor tracheæ s. sterno-trachealis*, which arises externally from the tympanum and passes forward to the border of the sternum, the cavity of the inferior larynx is shortened and dilated. The *membrana semilunaris* and the *ligamentum vocale externum* will be also synchronously stretched in a variety of ways by the action of these muscles, joined to that of the three posterior pairs, the description of which will now occupy our attention. The posterior long elevator (*m. levator posterior longus*) arises high up behind the corresponding anterior elevator muscle, and is inserted posteriorly into the extremities of the second bronchial demi-ring which it draws upward, and at the same time rotates the third. The posterior short elevator (*m. levator posterior*) is partly covered by the former muscle, but is situated more in the direction backward and inward, and at its origin from the upper part of the tympanum abuts closely

against its fellow of the opposite side, and is attached higher up to the posterior extremity of the first bronchial arch, which it serves to elevate. The fifth pair of muscles is situated between the posterior long, and the anterior transverse, elevator, and is called the oblique elevator (*m. obliquus posterior s. rotator posterior*); it arises externally from the superior border of the tympanum by a short and thick muscular belly, passes obliquely backward, and is inserted into the posterior extremities and lower border of the second bony arch, which it rotates and draws in the direction outward.

The voice of Birds appears like that of the human subject to be produced by the combined vibrations of the laryngeal membranes and the tongue. The flute-like tones of the Singing-birds are doubtless accomplished by a vibration of the whole column of air while passing through the trachea. Where all the membranes are absent and the bronchial rings complete, the voice is also deficient, as in the Stork.

In addition to the already recorded peculiarities in the anatomy of the inferior larynx, there occur in many Birds expansions of the tympanum or apparatus of resonance which strengthen the tone of their voice. To these belong the large bladder-like dilatations and expansions of the tympanum met with hitherto only in the Natatores, as the Drakes and Ganders. These expansions, which have been called the labyrinth, are peculiar from their occurring only in the male and never in the female sex, and in being asymmetrical or of unequal dimensions upon the two sides, the left being always considerably larger than the right; as a rule, this structure is found upon the left side, it being very rare for the right tympanum to be the largest.

In the Ducks the labyrinth consists for the most part of round bony ampullæ about the size of a pea in the lesser species, as *Anas crecca*, still smaller in *A. clypeata*, but much more developed in the larger species. More rarely there occurs a double irregular labyrinth larger upon the right side than the left, as in *Anas tadorna*. These ampullæ are wanting in the Dipper (*Hydrobates*), and both sexes are alike in this respect. Other Ducks, as *Anas marila*, *fuligula*, *glacialis*, *leucophthalmos*, have a perforate labyrinth: the enlargement is here more angular, and partly provided with membranous fenestræ. This also is generally the case in the male Mergansers, where the labyrinth in *M. merganser* attains its highest grade of development. The larynx here forms a thick-walled and hard bony expansion nearly one and a half inches in length, having an uneven

tubercular surface, and an irregular triangular form. Upon the left the labyrinth has the form of a somewhat irregular tetrahedron, from the basal surface of which the left bronchus arises, its three sides being occupied by oval membranous fenestræ. The membranes are stretched within arched bony frames, so that the whole resembles a lantern. In the female the inferior larynx forms only the usual bony tympanum, but is still somewhat asymmetrical in form. This labyrinth obviously acts in modulating and strengthening the voice, and reminds us of that bony dilatation of the os hyoides constituting an apparatus of resonance in the Howling-apes, as has been already described under the head of the Respiratory Organs in Mammalia. The male Ducks have, as is well known, a stronger voice than the females, and can even produce a considerable variety of tones. Among the more remarkable diversities of the inferior larynx, one in particular deserves to be here indicated. In *Sula-alba* (at least in the male) the trachea is formed as usual, and the bronchi are composed of half-rings, but there invariably projects in the direction outward from between the first and second bronchial demi-ring a yellowish body, tolerably hard and solid, of the size of a pea, and which contains fibres and a great quantity of adipose-cells; with its basis is connected the strong inferior larynx, and by means of this arrangement the bronchi admit of being drawn much apart from each other. This body does not appear to be a gland, for no excretory duct can be detected.

As regards the immediate organs of respiration, the *Lungs*, they are in Birds, as in Mammalia, invariably two in number, but proportionally of very small extent to what they are in the latter class. They are flattened, irregularly triangular, and attached posteriorly to the vertebræ and ribs (from the heads of which last they receive deep permanent impressions) by cellular tissue. They are of a bright florid red color, invested in front only by the pleura, and made up of a loose parenchymatous tissue. They are of largest proportional size in the Singing-birds, but are destitute of lobes throughout the whole class, and exhibit great uniformity of character. The bronchi as soon as they have entered the lungs form always a wide vesicular cavity, perforated by a number of apertures. It is only anteriorly and posteriorly that there are some imperfect cartilaginous arches, and there are here found between the fifth to the sixth most anterior cartilaginous demi-rings, four or five oval apertures, which are kept open by the cartilages already named, and their mutual lateral connexions; they lead into larger superficial membranous tubes,

which traverse the internal and inferior side of the lungs; behind these openings are situated others for the superficial tubes, and lesser ones for the deeper. The superficial tubes pass almost completely round the lung upon every side, and their external walls are very thin and transparent. The deeper tubes resemble cylindrical pipes, traverse the lungs in many directions, and are nearly straight and parallel to each other; they are the most numerous, and open in such a manner into the superficial tubes, that they pass from the upper to the under side of the lungs, and communicate laterally with each other. From their walls being thick and remaining constantly patulous, and from those of the superficial tubes into which they open being transparent, the lungs of Birds acquire the perforated tubular appearance which they present. The parietes of the tubes and canals are covered with a most beautiful and delicate network of small cavities and cells, with intervening septa mostly of an hexagonal form, and within the meshes lie other still smaller open cells. The cells of the lungs in Birds are therefore never terminal cells, as in the Mammalia, but open parietal cells from $\frac{1}{4}$ th to $\frac{1}{20}$ th of a line in diameter, upon which the vessels expand and thus come into contact with the air. All the cells and tubes of the lungs communicate naturally with each other, so that the lungs can be perfectly inflated from any one point.

Upon the surface of the lungs near to their posterior margin and upon the inner side, there is observed, upon stripping off the pleura in this situation, openings from five to seven in number, by means of which the bronchi are brought into communication with the peculiar *Air-cells* of the Bird. These highly remarkable receptacles for the atmospheric fluid are membranous, being formed by reflected prolongations of the pleura and peritoneum, and surround all the viscera. These cells may be distinguished in general into the following principal divisions, which are separated by membranous partitions, and for the major part transmit air. 1st, The two empty lateral cells which descend beneath the sternum as far as the pelvis, divide again into an anterior and posterior, or frequently even into three cells, and enclose no viscera. In the Passeres the two anterior lateral cells coalesce into one, and communicate with the bronchial cells. 2d, the two cells which enclose the lobes of the liver, do not communicate with any air-opening, and therefore receive no air, and merely result from the subdivision of the remaining air-cells. 3d, An intestinal cell, also conveying no air, which includes the intestinal canal, and is divided by the mesentery into two

halves. 4th, A cell for the heart. 5th, A cell situated in front of the breast for the bronchi, which it surrounds, together with the inferior larynx. A still greater extension of the air-cells occurs in some Birds. Thus, the Roller (*Coracias*) is provided with a pair of large air-cells beneath the skin of the head and neck, and these communicate with the nasal cavity, but not with the trachea. The distribution of air throughout the body is nowhere more extensive than in the Booby (*Sula*) and the Pelican. In these genera the lateral cells of the trunk are uncommonly large, and separated by two partitions into three large chambers, from the most anterior of which the air gets beneath the axilla under the integument, and fills the space upon the breast and belly from the furcular to the pubic bones. Several larger and various smaller cells are also met with, and the fat, which is generally abundant in such situations, is here wanting. The air-cell above the great pectoral muscle and on the inferior part of the neck is particularly large, and the delicate cellular tissue here forms partitions including cells several lines in diameter, which are continued almost beneath the epidermic layer of the skin as far as the quills of the contour-feathers, but not into their interior. These cellular air spaces are further distributed beneath the short investing feathers of the wing, and between the quills of the great primaries. Upon the middle and upper part of the body tegumentary air-cells do not exist; and upon the head there is found beneath the crisp-feathers covering the occipital region, only a single solitary cell partitioned off into some small spaces. The communication which exists between the pneumatic cells of Birds and the interior of many of their bones, the latter being for this purpose devoid of medullary tissue, and thus rendered permeable to air, has been already mentioned in treating of the skeleton. The Apteryx offers a striking contrast to the Pelican in being entirely devoid of air-cells, and is hitherto the only known exception of this kind among Birds. This extensive distribution of the atmospheric air throughout the body of Birds contributes obviously, by highly oxygenating the blood, to increase the general activity of their arterial system, conditions which are manifested in the greater number of its pulsations within a given time, and its more elevated temperature (107° to 110° Fahr.), as contrasted with that of the Mammalia.

The mechanism of the function of respiration, according to the recent special researches of Dr. Edward Weber, is performed in the following manner. The ramifications of the bronchi with the network of tubes they form within the lung are during inspiration

drawn apart by means of the expansions of the ribs, to which the lung is firmly fixed, and the contraction of those fasciculi of the diaphragm that are inserted upon the free surface of the lung. By this action not only are the tubes expanded and lengthened out, but in like manner also the interspaces included between them. The air must of necessity therefore penetrate and distend the terminal bronchial ramifications situated between these interspaces. The lungs derive their supply of air, which they receive by the process just mentioned, partly from the trachea and partly from the air-sacs, the latter forming pneumatic reservoirs, from and into which the lungs both inspire and expire. Now as each of these reservoirs is in communication with the bronchus through a wide tube, the air they contain is always in a respirable condition, for while the thorax is being expanded that portion also of the pneumatic sac which lies concealed beneath it is expanded also, and sucks in the air upon the one hand through the trunk of the trachea, upon the other, from that part of the air-sac that projects out of the cavity of the thorax, and which may accordingly be seen to collapse during the act of inspiration. When, however, the capacity of the thorax becomes narrowed during expiration, that portion of the air-sac covered by it is compressed and drives out its contained air upon the one hand into the tracheal trunk, upon the other into the projecting part of the air-sac which is then observed to dilate. There appears, moreover, to exist a special provision whereby, when the wings are elevated during flight, and their pressure is consequently removed from the great pneumatic sacs situated in the axilla and between the pectoral muscles, that the sacs become distended with air, which, when the wings are depressed, is driven out of them into the lungs, so that a bird, such as the Lark, while mounting perpendicularly upward to a great altitude in the air, is still enabled to sing without at the same time getting out of breath.

A pair of small glandular bodies devoid of excretory ducts occur in Birds, and from the situation they occupy may be regarded as *Thyroid glands*. They are very generally of a rounded form and of a reddish color, richly supplied with vessels, and lie upon either side of the lower part of the trachea, where they are more or less attached by cellular tissue and an arterial ramuscle to the carotid, or else to the jugular vein. Immediately beneath and united to them, there are found in many Birds small corpuscles of a denser texture, and whitish or yellowish color. Both thyroid glands are separated from each other in the middle line by a wide interval.

THE *Kidneys* in the Bird are very large and impacted within deep depressions in the pelvis, which they completely fill up; they commence immediately beneath the lungs, and like those organs, they retain the impressions of the lowermost ribs, but particularly of the transverse processes of the sacral bone. They almost invariably consist of three principal lobes, of which the middle one is generally the smallest, the anterior frequently the largest, as in the Rapaces, but in other cases, as the Pelican, the posterior lobe. In the Rapaces, Gallinæ, and Columbidae, they are separated from each other by a wide interval, in which the aorta passes, and do not occupy the whole extent of the cavity of the sacrum, part of it being occupied by air-cells. In other Birds, as the Passeres, they come in contact in the median line, and even coalesce in several species, *e. g.* Lanius Excubitor, and more rarely in Ardea cinerea. The kidneys form, however, as a rule one blended mass in the Loons (*Colymbus s. Podiceps*). In the Coot (*Fulica atra*) the kidneys are divided on their postero-superior surface into a great number (about 60) small lobules, which are only loosely connected together by cellular tissue. The kidneys are of a brown color, and friable texture; the delicate urinary canals give off short lateral branches, presenting thus a pinnatifid appearance, and do not terminate upon conical papillæ. The urine of Birds is very rich in earthy constituents, and contains but little water, so that the kidneys frequently appear, after death, as if injected from a deposit of urate of ammonia having taken place and filled their tubes. In the Struthious birds papillæ and calyces are met with in the kidneys, and in the Ostrich a true renal pelvis. Several excretory ducts generally proceed from the kidneys to form the ureters, which descend along the anterior surface of the kidneys, and terminate by perforating the cloaca posteriorly and superiorly. A proper urinary bladder is absent, though the ureters in many Birds open into a distinct pouch-shaped dilatation of the cloaca, bounded above and below by a valvular fold, separating it on the one hand from the urethro-sexual cavity, on the other from the orifice of the rectum, and which is by many writers viewed as a rudimentary urinary bladder; this structure is most strongly developed in the Ostrich.

A pair of yellow or orange colored *Suprarenal Capsules*, of the shape of millet-seeds, flat and usually of small size, are constantly

found, situated on the mesial line of the anterior extremity of the kidneys, are in contact externally with the large vascular trunks, and are partly covered by the testes and ovaria.

PARTICULAR ORGANS OF SECRETION.

PARTICULAR glandular organs are found very generally distributed in the region of the tail and cloaca; but really specific secretions, such as occur so frequently in several of the orders and genera of Mammalia, do not appear to occur in Birds.

A peculiar gland, which is called the *Glandula Uropygii*, exists very commonly throughout the class, and secretes an oily fluid of a whitish or yellowish color, having occasionally a musky odor, and which is applied by the bill to anoint the feathers, so as to prevent their getting wet. It is situated above the last caudal vertebra upon the quills of the remigial feathers of the tail, and consists properly of two distinct glands, which are either united in the median line, or frequently only by their posterior extremities. They consist internally of close-set elongated cæcal tubules, not intercommunicating and opening into a mostly linear cavity of greater or less size situated in the centre of the gland. A double orifice, rarely one (or many, as in the Pelican, where twelve apertures are found arranged in two rows), which opens upon a papilla, and, as in the Diurnal birds of Prey, the Parrots, Gallinæ, and Natatores, is surrounded by a tuft of small feathers, indicates the outlet of the excretory duct. The gland itself is usually triangular or cordiform in the Natatores, as the Ducks, where it is of the largest size, and divided by a fissure into two clavate lobes. It is very rarely absent, as in the Brevipennes, e. g. the Bustard, in the Penguin, and some only of the American Parrots, for others possess it.

Another organ that may be conjectured to be one of secretion also, is called the *Bursa Fabricii*. It occurs in nearly all Birds, being wanting in the Ostrich, probably alone among the Brevipennes, and is situated deep within the pelvis between the ureters and behind or above the cloaca, in front of the extremity of the sacrum, and is usually covered by cellular and adipose tissue. It opens below the two ureters into the cloaca by a considerable orifice, which is separated by a fold from the urinary compartment of that cavity. Covered externally by a layer of muscular fibres, it is in some cases of a thin membranous texture, but in others frequently provided with a thick layer of small follicles, as is especially the case in the Grallæ

and Natatores. It appears to be very much developed in young Birds, but dwindles in size so as to be scarcely apparent in adult age; still, however, it exhibits varieties of form and proportions. Its function is not accurately known. At first sight it might be compared to the anal sacs of the Mammalia, while some anatomists on the contrary regard it as the urinary bladder of the Bird, but both its position, and the certain fact that urine gets into it only by accident, militate against this opinion. Furthermore, its equal degree of development in both sexes is opposed to the view of its being destined to receive in the female the seminal fluid of the male, and be thus analogous to the spermatheca in the female insect.

ORGANS OF GENERATION.

THE Generative apparatus in Birds, especially of the female, departs very considerably from its conditions in the Mammalia, and throughout the whole class exhibits a very close conformity of character with the type of organization in the inferior Vertebrata.

The Female organs of generation are, as a rule, asymmetrically disposed, being only fully developed upon the left side. The ovarium consists of a small stroma made up of a bed of compact fibres, in which are situated the very small vitelline vesicles. It is situated in the lumbar region, and is attached to the superior or anterior extremity of the left kidney, and partly also to the renal capsule. The free surface, or that directed toward the abdominal cavity, is disposed in transverse folds, from beneath which the vitelli gradually protrude during their growth, so that the ovarium soon assumes the appearance of a cluster of berries supported upon pedicles or stalks. The oviduct, spirally contorted like an intestine, and attached to a fold of the mesentery, descends parallel with the left kidney, and commences by an open funnel-shaped or truncate abdominal ostium, adapted for receiving the ova after they have been detached from the ovarium. This part is called the *infundibulum*, and after being continued into a narrower portion, the oviduct again expands into a kind of ventricle, within which the vitellus obtains its complete investiture of albumen, and external to that the calcareous shell; the rest of the tube is termed vagina, and short and narrow opens upon the left side of the cloaca. The mucous lining of the oviduct presents well-developed longitudinal folds, and the whole organ augments in length as well as in capacity during the period of oviposition. There are only a few Birds that possess a