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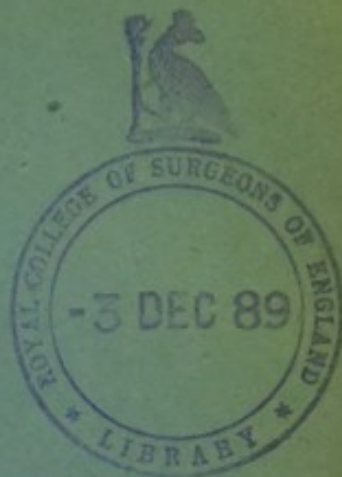
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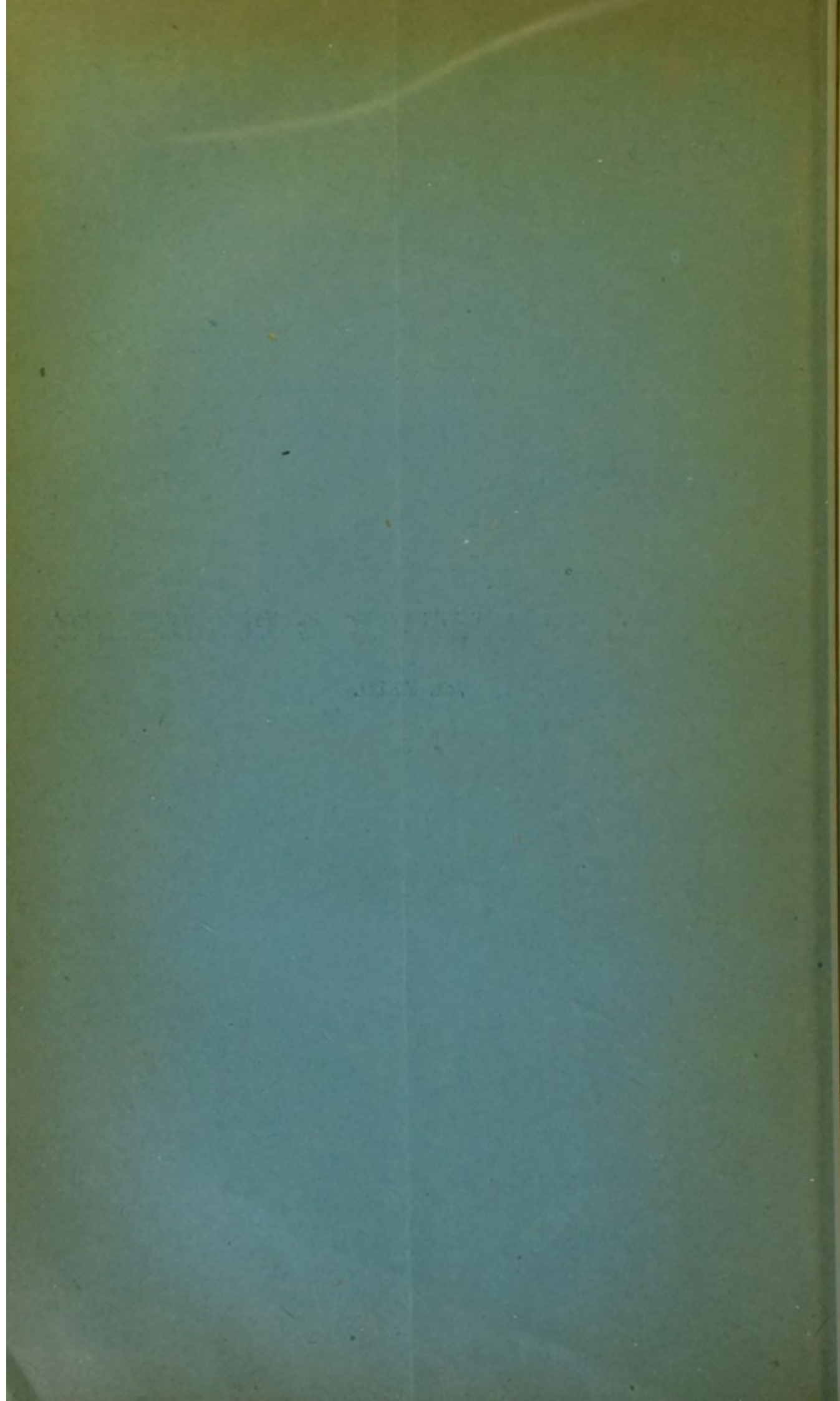
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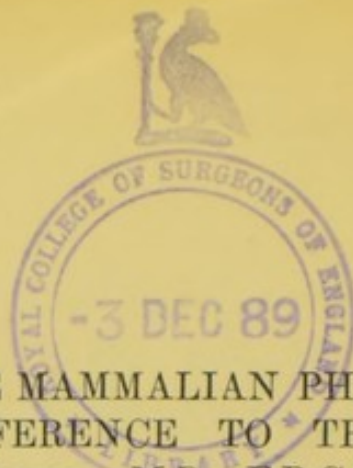
THE UNIVERSITY OF CHICAGO  
DIVISION OF THE PHYSICAL SCIENCES  
DEPARTMENT OF CHEMISTRY  
CHICAGO, ILLINOIS

THE following report was prepared by  
the members of the Division of the Physical  
Sciences, Department of Chemistry, in  
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OBSERVATIONS UPON THE MAMMALIAN PHARYNX,  
WITH ESPECIAL REFERENCE TO THE EPI-  
GLOTTIS.<sup>1</sup> By R. L. BOWLES, M.D., F.R.C.P. Lond.,  
*Consulting Physician, Folkestone Hospital.*

THE following communication embodies some notes and experi-  
mental observations incident upon my investigations upon stertor  
in animals. The figures which I give will be found to illustrate,  
in part, facts long recorded; but, as no good drawings of so  
familiar an object as the Pig's epiglottis have hitherto been  
published, I supply the want, in the hope that the figures  
proffered may be of service to workers in general.

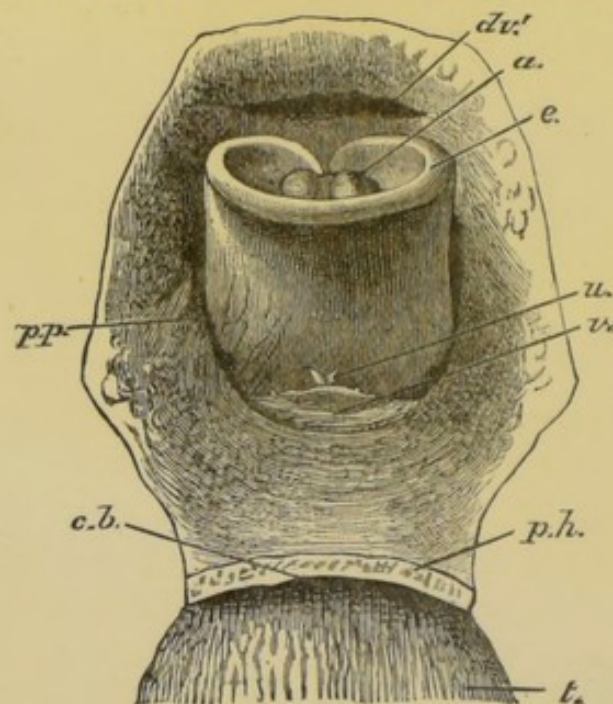


FIG. 1.—Narial pharynx of eighteen-months' Pig, with epiglottis *in situ*; front view, nat. size. *a*, arytæmoid; *c.b.*, buccal cavity; *d.v.*, orifice of diverticulum retro-pharyngeum; *e.*, epiglottis; *p.h.*, cut edge of junction between hard and soft palates; *p.p.*, posterior pillar of soft palate; *t.*, tongue; *u.*, uvula; *v.*, velum.

Comparative anatomists have long ago shown<sup>2</sup> that the characters and relationships of the velum palatinum and epi-

<sup>1</sup> Read before the Anatomical Society of Great Britain and Ireland, March 1889.

<sup>2</sup> See papers by Howes, this vol. p. 263, &c.



glottis are, in many quadrupedal mammals, widely different from those of the human subject. Youatt, writing of the Horse, says<sup>1</sup> the velum forms a perfect division between the mouth and nose, so that although it yields and permits the food to pass under it, in order to enter the pharynx, it prevents the return of the food, and the Horse, except in the convulsive spasms of death, breathes and vomits only through the nose. The epiglottis of the adult Pig is well known to lie, like that of the Horse, above the velum (*e*, figs. 1 and 2), and observation upon the living animal shows that normal respiration is carried on exclusively through the nose. On dissection of the pharynxes

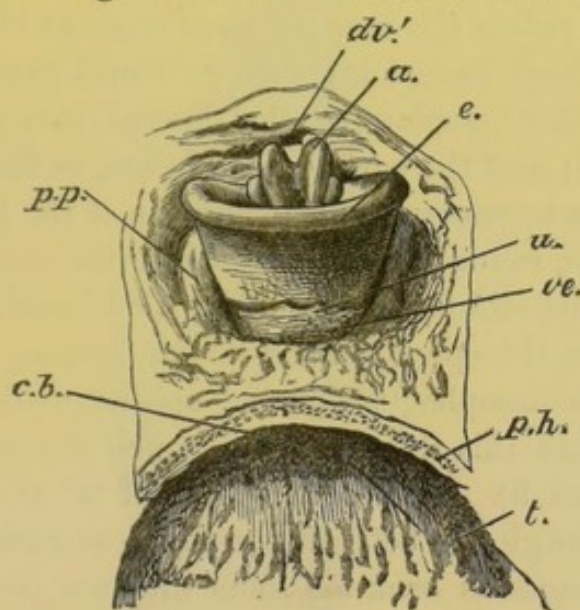


FIG. 2.—Narial pharynx of six-months' Pig, with epiglottis *in situ*; front view, nat. size. References as for fig. 1.

of the adult Horse and Pig a fundamental similarity in disposition of the parts is to be observed.<sup>2</sup> The free border of the velum (which, in the last named animal, bears an insignificant and vestigial uvula, *u*, fig. 1) lies flat upon the tongue, and embraces the upper surface of the same at the root of the epiglottis, in such a manner as to cut off all communication between the mouth and pharynx, except during deglutition. The enormous epiglottis is backwardly extended so as to almost sur-

<sup>1</sup> *The Horse*, London (Gabriel's revision), 1863, p. 213.

<sup>2</sup> Most of the dissections upon which my observations are based were made as follows:—The head was separated from the trunk by cutting through the occipito-atlantal joint, care being taken that the parts about the pharynx were undisturbed, raphé being then divided along the middle line. In Pigs it was found desirable to saw away the occiput before dividing the raphé.



round the aditus laryngis. It stands high up above the level of the arytenoids, and its free border is curled over antero-laterally, whereby its actual apex comes to look downwards and forwards (*cf.* fig.).

An essentially similar condition of the parts is seen in the six-months' Pig (fig. 2), except that the epiglottis is, in it, relatively shorter than in the adult, whereby the arytenoids, *a*, are more fully exposed. The arrangement of the parts is such as would tend to prevent the liquid food, upon which the animal, up to this period, almost entirely lives, from either regurgitating into the nostrils or welling over into the larynx. In front of the palate the mucous membrane at the base of the tongue lies in large loose folds, such as would permit of a great distension of that portion of the buccal cavity during the passage of food; and the parts generally are, in fact, so disposed and modified as to ensure the transmission of the food along the sinus pyriformis, round the epiglottis, into the œsophagus.

The velum palatinum is powerfully developed, and it completely encircles the epiglottis and larynx, forming, at the upper extremity of the œsophagus, a strong sphincter-like band. Immediately behind this there opens a pouch of considerable size (*dv'*, figs. 1 and 9). Chauveau speaks of it<sup>1</sup> as lying "immediately above the glottis, between the thyro- and crico-pharyngeal muscles." It extends back for some distance (*dv''*, fig. 9), and would appear to represent the *diverticulum retropharyngeum* of authors.<sup>2</sup> Concerning its function I have nothing to communicate.

Rückert has recorded the intra-narial condition of the epiglottis in the Sheep (*cf.* Howes, this volume). I find, however, that the same varies in position with animals resting in different positions, and that ordinarily the soft palate does not reach the tongue, while the epiglottis is situated anteriorly to, and (when the animal is prone) at a lower level than, the velum.

Chauveau asserts<sup>3</sup> that in Ruminants there is no aryteno-epiglottidean ligament. I find, however, in an analogous posi-

<sup>1</sup> *Comp. Anat. of Domestic Animals*, Fleming's translation, 1873, p. 376.

<sup>2</sup> Albrecht has suggested that it may be a vestigial homologue of the piscine urine-bladder. *Cf.* Wiedersheim, *Bau des Menschen*, Freiburg, 1887, p. 85.

<sup>3</sup> *Loc. cit.*, p. 462.



tion, a couple of free folds of mucous membrane (*f*, figs. 3 and 4). These structures are, in life, remarkably loose and elastic; they run from the lateral edges of the epiglottis along the outer sides of the arytaenoids to the bases of the same, and I conceive of them as functional in protecting the larynx during the regurgitation of food in rumination.

Turning now to the human subject we find that, in the adult, the velum does not reach the tongue. In addition to its function in alimentation, the former is here an important accessory

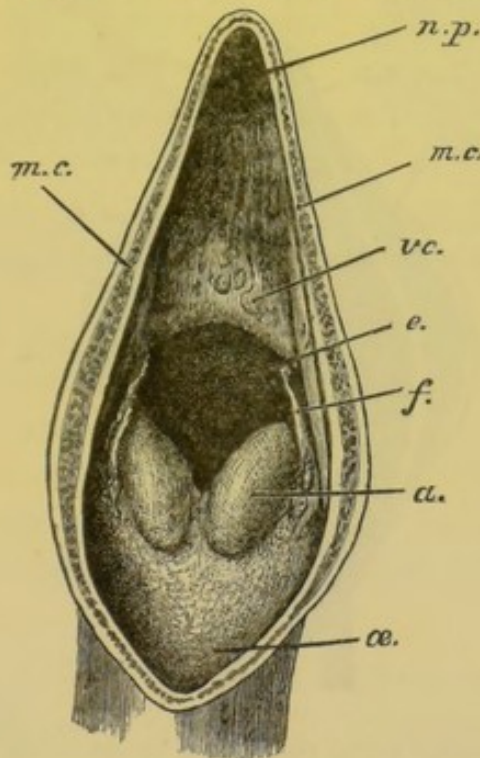


FIG. 3.—The larynx and narial pharynx in the adult Sheep, seen from behind; the constrictors of the pharynx having been divided down the raphé. References as for figs. 1 and 2. *f.*, mucous fold; *m.c.*, constrictor pharyngei muscles, cut edges of; *n.p.*, posterior nares; *œ.*, oesophagus.

to respiration and vocalisation; and it hangs, as it were, in mid-air, ready to respond to the most delicate vibrations and other movements.

I have been struck in the course of my work with the fact that (while much has been done with the comparative anatomy of the adult mammalian larynx) but little attention appears to have been paid to variations and differences due to age in any one case. In the course of my researches into the relative positions of the various parts concerned in the production of stertorous



breathing, I was early struck by the different forms of the epiglottis in many of my subjects, and I ultimately found that this organ differs in shape and position in accordance with the age of the child or quadruped under investigation. In the sucking infant it is curled laterally upon itself, being very convex in front and concave behind; while the rima glottidis is situated relatively higher and closer behind the epiglottis than in later life. The glosso-epiglottidean folds are so disposed as to enclose, on either side, a valley, which lies at a lower level than

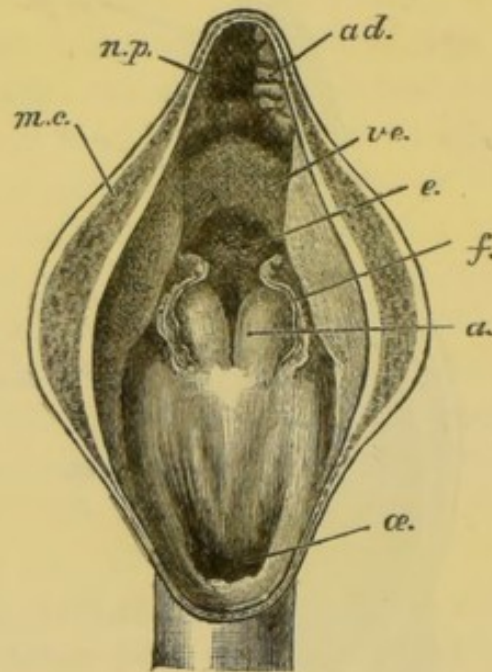


FIG. 4.—The larynx and narial pharynx of an old lamb, seen from behind; nat. size. References as before. *ad.*, adenoid growth.

the glottis; by virtue of the convexity of the front face of the epiglottis, the liquid food of the suckling is directed into the same, being thus prevented from entering the larynx. The uvula, in the few cases which I have examined, fits exactly into the excavated summit of the epiglottis, and the whole condition of the parts suggests an approximation towards that so well known to be realised in the developing marsupial while within the pouch.

As the child ages, the epiglottis expands laterally, and presents an almost plane surface towards the base of the tongue. At the same time the rima glottidis comes to lie, relatively to the free border of the epiglottis, lower down.

I have, from dissections, long been familiar with the fact that at birth, before the child has breathed, not only is there no air-cavity in the chest, but there are no such cavities in the pharynx, mouth, or nares. The various walls and adjacent surfaces are all in close apposition; the base of the tongue lies against the posterior wall of the pharynx, and its upper surface against the palate; the uvula lies behind and against the epiglottis; and

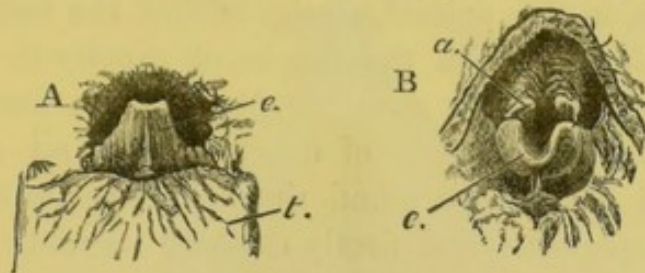
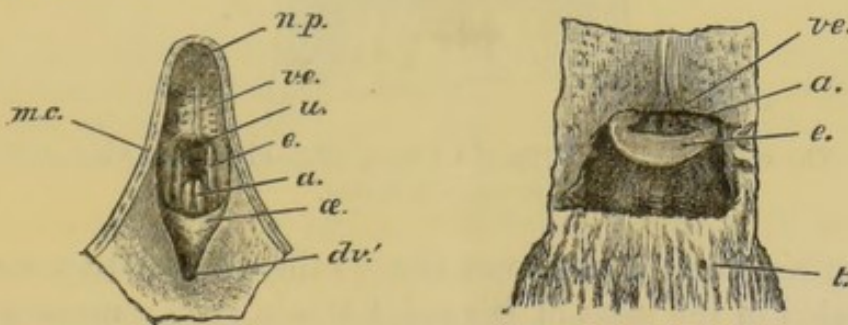


FIG. 5.—The human epiglottis and larynx at twelve months. A, front view; B, top view. References as for previous figures.

the soft walls of the nares, lined with mucus, are all in close contact, and impermeable to air. The first reflex action has for its object the dilatation and opening up of these cavities by forcible separation of their respective walls; but for some months afterwards the palate lies near the upper surface of the tongue, and the uvula is capable of being brought into apposition with the epiglottis.



FIGS. 6 and 7.—6. The narial pharynx of a two-weeks' Pig dissected from behind. 7. The velum and epiglottis of a six-weeks' Pig, front view. Both nat. size. References as for figs. 1-4.

On passing from the human subject to the quadrupedal mammal (Pig), some important and unexpected differences are to be noted, in the correlation of growth and the relationships of the maturing epiglottis and velum palatinum. In the sucking Pig, soon after birth, the epiglottis is to be found in the mouth, below and considerably anterior to the soft palate, while it does



not so far encircle the laryngeal orifice as in later life. The soft palate is less elongated than in the older animal, and the uvula is bifid. The conditions appear to be identical in the fourteen-days' animal (fig. 6), and at this stage the *diverticulum retropharyngeum* (*dv'*) is well developed and proportionately as extensive as in the older Pig.

I have already shown (p. 607, fig. 2) that at six months the epiglottis lies, in this animal, wholly within the narial pharynx, the relationship between the two being exactly in accord with those of the adult. My assistant, Mr Stainer, has introduced his hand into the pharynx of many Pigs of six months and upwards, and has always found the velum to lie anteriorly to (below) the epiglottis and firmly clasping its root. This being so, I was not a little surprised to find that in one animal (said to be five months old) the epiglottis (*e*, fig. 8) lay much more within the buccal cavity than I should have anticipated.

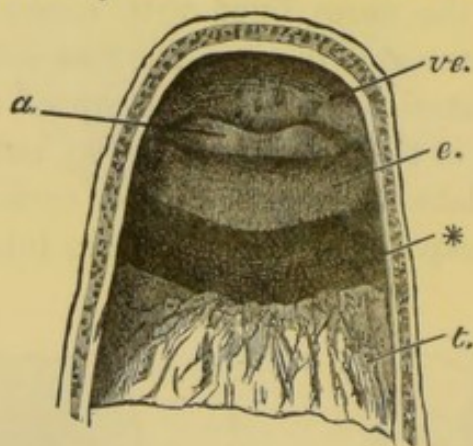


FIG. 8.—The velum and epiglottis of a five-months' Pig; front view, nat. size.  
References as before.

In the six-months' specimen (fig. 7) the soft palate is seen to have curled in the sides of the epiglottis in such a manner that half of that organ lay in the mouth and half in the narial passage. In the fourteen-weeks' specimen (fig. 9) (the relationships of the parts of which have become somewhat disturbed by repeated manipulation) the relations were much the same, except that a considerably greater portion of the epiglottis was seen to lie in the narial passage. It will be observed that the two last-named animals would appear to be, with respect to general relationships of the parts concerned (as in age), transitional between the earlier and later stages here dealt with, and the facts suggest



the probability that it is within the 5-6 month of extra-uterine life that the Pig's epiglottis finally becomes intra-narial. Further inquiry is requisite for the settlement of the question; but it is clear, from the facts delineated in figs. 1 and 2, that after the sixth month the epiglottis continues to elongate, whereby it ascends the more completely into the narial pharynx.

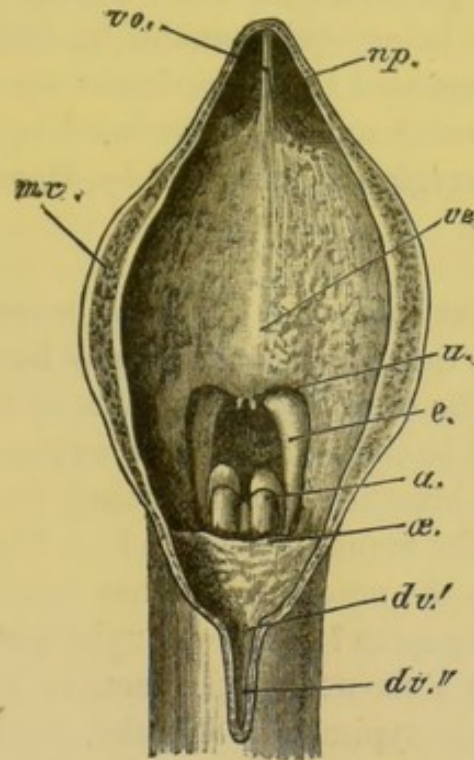


FIG. 9.—The narial pharynx, larynx, and posterior nares of a fourteen-weeks' Pig, seen from behind. The diverticulum retropharyngeum (*dv'*) has been opened up for its whole length. Nat. size. References as for other figs. *vo.*, vomer (posterior edge of nasal septum).

I have examined a series of different forms, with a view of ascertaining how far the facts above recorded for the Pig might be typical of the leading mammalian orders. I am unable to detect between either the Lamb and full-grown Sheep or the Calf and Ox any such remarkable differences as those noted for the Pigs. It might reasonably be expected that in each order a definite type of structure and relationship of the parts under consideration would be discernible. So far as my investigation carries me, this is not the case; for while the arrangement and relations of the palate are, in a series (Horse, Pig, Rabbit, Guinea-pig, and others), similar, the shapes of the epiglottides vary considerably in each member of the same at corresponding ages.



I am able to confirm Howes' observation<sup>1</sup> concerning the intra-narial condition of the Rabbit's epiglottis. When the head is dissected from behind, in the manner which I have adopted, this becomes very striking. It has occurred to me to put the matter to the test of experiment in its bearing upon respiration, and I accordingly stopped up the nostrils of this animal for a short period during life. I found that the creature was, for the time being, quite unable to breathe through its mouth. I have repeated this experiment upon full-grown Pigs with a similar result,<sup>2</sup> and I am inclined to believe that the condition of the epiglottis described by Howes is the normal one for the Rabbit.

In addition to the foregoing, I append some notes of a more general nature, in the hope that they may be of service in the further study of the co-ordinate functions of the great cavities and organs related to the mammalian pharynx.

A Horse cannot breathe or vomit through the mouth, but does it neigh through the mouth or nostrils? A Pig snores or grunts ordinarily through the nose, but who has not heard this animal squeal through its mouth? A Lion ought not (if the anatomy of the pharynx in a six-weeks' specimen in Professor Cleland's series at Glasgow is typical)<sup>3</sup> to breathe, vomit, or emit noises by the mouth; and yet a friend of mine, probably one of the greatest lion-hunters of the age, assures me that Lions open their mouths with their heads low down, and appear to roar through the former. When they attack, however, they throw up their heads and emit sudden yelps like a Dog. Dogs appear

<sup>1</sup> This vol. p. 264.

<sup>2</sup> I saw this experiment performed, for purposes of safety, upon a violent Horse while in Paris during the slippery weather of last year. A large chestnut brougham horse had got his legs entangled between the broken shafts and harness of another horse; in his terror he plunged and kicked most violently, and nothing appeared to be possible to save both animals from destruction, until the coachman got down from his box and grasped the chestnut's nostrils. The animal was at once subdued, and he gradually fell senseless to the ground, remaining there while the harness was cut, and all danger removed. The knowledge of the fact that pressure on the nares will stop the breath in horses is practically utilised in an invention for stopping "bolters" by an arrangement of pads to the nostrils, which can be closed at the will of the rider.

<sup>3</sup> The arch of the palate clipped the root of the epiglottis in front, like that of the Horse or full-grown Pig.



to breathe in ordinary through the nose; they can, however, by volition, breathe as efficiently through the mouth.

Since writing the above, I have elicited the information that Horses, when much excited, neigh through the mouth. I have, moreover, experimented again on the full-grown Pig by stopping up its nostrils for a short time, and have found that although it does not appear to be capable of inspiring by the mouth, it can yell and shriek through it most terribly<sup>1</sup>—shrieking being, of course, the result of an expiratory effort. The same explanation may perhaps apply to the Horse and Lion.

In conclusion, I desire to state that I have been enabled, by dissection, to establish my belief that the cause of death in "cast" or "misland" Sheep and Oxen depends upon suffocation from gravitation of the tongue, epiglottis, and other pharyngeal appendages against the posterior wall of the pharynx when the animal is supine. I believe that physiologists have experienced difficulties in conducting certain investigations upon the Rabbit while supine. I have dissected two Rabbits in this position, and find that they would probably have died from the cause alluded to above had they been fixed in supination. I have elsewhere dealt with the cause of stertor in Man<sup>2</sup> and with the fact of its being so common in Swine.<sup>3</sup> I submit, finally, that the great development of the epiglottis in many of the "dumb" animals is opposed to the view which now tends to prevail, that the epiglottis is not primarily protective of the opening of the larynx.

<sup>1</sup> While this paper was passing through the press, I have experimented upon an old boar by corking up his nostrils. I found, in this instance, that the animal could both shriek and breathe through the mouth.

<sup>2</sup> *Trans. Med. and Chirg. Soc.*, vol. xliii. p. 41, 1860; *Proc. of same*, vol. vi. p. 291, 1871; cf. *Lancet*, 1880, p. 971; and Quain's *Dict. of Medicine*, article "Stertor."

<sup>3</sup> Paper on "Stertor in Animals," read before section "Medicine," Brit. Med. Ass., Glasgow meeting, 1888 (not yet published).



CHAPTER I  
THE DISCOVERY OF AMERICA  
The discovery of America by Christopher Columbus in 1492 is one of the most important events in the history of the world. It opened up a new world of exploration and discovery, and led to the establishment of a new global economy. Columbus's voyage was the first of many that followed, as European powers sought to claim the newly discovered lands. The discovery of America also led to the introduction of new crops and animals to the Old World, which had a profound impact on the development of agriculture and industry. The discovery of America is a testament to the human spirit of exploration and discovery, and it is a reminder of the importance of looking for new opportunities and challenges in the world.

CHAPTER II  
THE AGE OF DISCOVERY  
The Age of Discovery was a period of European exploration and discovery that lasted from the late 15th century to the early 17th century. It was a time when European powers sought to expand their territories and establish trade routes to the newly discovered lands. The Age of Discovery was characterized by the voyages of explorers such as Christopher Columbus, Vasco da Gama, and Ferdinand Magellan. These voyages led to the discovery of new lands and the establishment of a global trade network. The Age of Discovery was a period of great achievement and discovery, and it is a testament to the human spirit of exploration and discovery.