Contributions to the anatomy of the Indian elephant. Pt. I. The thoracic viscera / by Morrison Watson.

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with Author's Compts

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Thoracic Viscera of the Indian Elephant.

by

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CONTRIBUTIONS TO THE ANATOMY OF THE INDIAN ELEPHANT[1]. Part I., THE THORACIC VISCERA.

By Morrison Watson, M.D., *Demonstrator of Anatomy, University of Edinburgh*[2]. Plate VI.

Owing to the kindness of Professor Turner, I have recently had an opportunity of dissecting the thoracic viscera of an Indian Elephant (*Elephas Indicus*), and the results of this examination I now venture to make public, not so much with the idea that I shall be able to communicate much that is altogether new, but rather, by adding to the descriptions already published, which differ in many points from one another, that of the individual which I have examined, and so clear up some points in the anatomy of an animal which we too seldom have an opportunity of dissecting. At the same time I hope to be able to call attention to certain arrangements, which, so far as I am aware, have, up to the present time escaped observation, and which may therefore prove not altogether uninteresting.

The thoracic portion of the digestive, circulatory, and respiratory organs will be considered consecutively.

Digestive.

It has long been known that both species of elephant have the power of withdrawing water, stored within the cavities of the stomach, by means of the trunk inserted into the mouth. Sir Emerson Tennent says[3]: "I have elsewhere described the occurrence to which I was myself a witness, of elephants inserting their proboscis in their mouths, and withdrawing gallons of water, which could only have been contained in the receptacle figured by Camper and Home, and of which the true uses were discerned by the clear intellect of Professor Owen." I was not, till very recently, aware that a

[1] The viscera of this elephant formed part of the collection of the late Professor Goodsir, purchased after his decease by the University. The animal was bought from a travelling menagerie by Mr Goodsir in 1856.—W. T.

[2] An abstract of this Paper was read before Section D at the Edinburgh Meeting of the British Association for the Advancement of Science, August, 1871.

[3] *Ceylon*, II. 316.

similar observation as to the remarkable habit of the elephant, had been made by the author of the *Ayeen Akberry*, in his account of the *Feel Kaneh*, or elephant stables of the Emperor Akbar, in which he says: "An elephant frequently with his trunk takes water out of his stomach and sprinkles himself with it, and it is not in the least offensive." The means by which this is effected Tennent believed to lie in the presence of a muscle described by the late Prof. Harrison of Dublin, which is referred to as follows in the work already quoted[1]. Dr Harrison in the course of his examination of the thoracic viscera, observed that an unusually close connection existed between the trachea and œsophagus, which he found to depend on a muscle unnoticed by any previous anatomist, connecting the back of the former with the fore part of the latter, along which the fibres descend, and can be distinctly traced to the cardiac orifice of the stomach. Imperfectly acquainted with the habits and functions of the elephant in a state of nature, Dr Harrison found it difficult to pronounce as to the use of this very peculiar structure; but looking to the intimate connection between the mechanism concerned in the functions of respiration and deglutition, and seeing that the proboscis served in a double capacity as an instrument of voice and an organ for the prehension of food, he ventured to express the opinion that this muscle, viewing its attachment to the trachea, might either have some influence in raising the diaphragm, and thereby assisting in expiration, "*or that it might raise the cardiac orifice of the stomach, and so aid this organ to regurgitate a portion of its contents into the œsophagus*[2]." Unfortunately, however, for this theory, no trace whatever of the trachea-œsophageal muscle was to be found in the specimen I examined; and, as no mention is made of it by any other anatomist, we must, I think, conclude that the muscle was only *exceptionally* present in Harrison's elephant (which is also the case with a corresponding muscle in the human subject[3]), as it is hardly probable, supposing the function alluded to to depend exclusively on the existence of such an arrangement, that the muscle should be present in one specimen and absent in another.

[1] *Ib.* II. 314. [2] *Proc. Roy. Irish Acad.* IV. 133.
[3] Vide Henle, *Anatomie des Menschen*, Band II. p. 151.

The muscular fibres of the œsophagus are distinctly striated even down to the œsophageal opening in the diaphragm, and are arranged in two layers, an external, the fibres of which are distinctly longitudinal in direction, and an internal, which consists of two sets of spiral fibres, one of which passes from right to left, whilst the other passes in the opposite direction, and thus gives rise to a decussation of the fibres at all points. It is thus to be observed that the arrangement of the fibres differs materially from that described by Prof. Rutherford in the gullet of the ruminant[1].

With reference, therefore, to the regurgitation of water, we must, I think, conclude that, in the absence of any peculiarity in the stomach to account for it, in all probability it depends, as Flourens has shown to be the case, in the physiological regurgitation of the ruminant, and Magendie in the pathological regurgitation of other animals, on the action of the diaphragm and abdominal muscles.

Thoracic duct. This vessel presents the usual arrangement as far as its relations are concerned. At the posterior extremity of the thorax it has a diameter equal to that of a goose-quill, whilst towards its termination it has reached the size of the axillary artery of the human subject. No appearance of the reservoir of Pecquet, which is described in the *Encyclopédie Méthodique*[2], as being placed opposite the third dorsal vertebra, and extending for a distance of several inches was to be seen, the canal being of uniform diameter throughout. A single pair of valves was placed about two inches behind the spot where the vena azygos turns downwards to open into the right anterior cava, the presence of such being altogether denied in the article just quoted.

Organs of Circulation.

Pericardium. Fig. 1. The description of this viscus will be better understood after a few words concerning the diaphragm. As this muscle had been removed along with the viscera from the cavity of the thorax, and consequently con-

[1] *Journal of Linnean Society*, VIII.
[2] *Encyclopédie Méthodique*, Article Pachydermes.

siderably injured before I commenced the dissection, the description is not so perfect as might otherwise have been the case.

The greater portion of the diaphragm was occupied by the central tendon, from the margin of which the muscular fibres passed off to their attachment to the circumference of the thorax. These two parts differed materially from one another, for whilst the central tendon was very thick and strong, the muscular portion of the septum, on the other hand, was thin, and the bundles easily separated. An arrangement, however, to strengthen this deficiency was present, consisting of two plates of yellow elastic tissue, one covering each of the surfaces of the muscular portion of the diaphragm. Both of these plates of elastic tissue passed imperceptibly into the substance of the central tendon and there lost themselves. The anterior plate differed from the posterior in this,—that, whilst the posterior plate covered every part of the muscular portion of the diaphragm, the anterior was confined to that part of it which came into relation with the base of the pericardium, and shaded off beyond this region to the left side into a muscular fascia of considerable strength, and composed of fibrous tissue, whilst to the right, owing to the diaphragm having been cut, I could not follow it to its termination. This much however is to be said, that a considerable admixture of fibrous with the yellow elastic tissue having already taken place, seemed to imply that on the right, as on the left side, this elastic plate gradually shaded off into a fibrous tissue. If this supposition be correct, then we must regard the anterior elastic plate as being connected physiologically with the pericardium, and not with the diaphragm. The probability of this view will be increased when the attachment of the pericardium to the diaphragm is considered.

John Hunter[1] states that "The pericardium adheres to the diaphragm nearly as in the human, but not so closely and firmly;" but a more correct description would be that it forms an intermediate stage between the completely free pericardium as described by Prof. Turner in the walrus[2], and the closely adherent human pericardium. Its posterior surface is smooth,

[1] *Essays and Observations* by Owen, II. 172.
[2] *Journal of Anatomy and Physiology*, November, 1870.

and rests against the anterior surface of the tendinous portion of the diaphragm. It is not, however, attached to this as in man; but the corresponding surfaces of the diaphragm and pericardium being smooth, evidently permit a considerable amount of motion between the opposed surfaces. This motion, however, must be limited by the presence of two stout bands of yellow elastic tissue, which become continuous with the fibrous substance of the pericardium at its posterior extremity. These two bands are flattened from above downwards, and measure each about an inch in breadth. They are separated from one another at their attachment to the pericardium by an interval of about three inches. From this attachment they diverge from one another, passing backwards and downwards and finally become continuous with, and lost in the elastic plate already described as covering a portion of the anterior surface of the diaphragm. It is a fact worthy of notice that the pericardiac band of the right side was entirely composed of that peculiar striated form of yellow elastic tissue which, so far as I am aware, has only once before been described, and that in the ligamentum nuchæ of the giraffe by Mr Quekett[1]. In the left band, as well as in the plate into which the bands expanded, the elastic tissue presented the usual appearance. This mode of attachment of the pericardium to the diaphragm in the elephant seems up to this time to have been overlooked, the nearest approach to an accurate description of it having been made by MM. Vulpian and Philipeaux[2], who say: "Au sommet du cœur le péricarde se termine en pointe obtuse, et se continue directement en ce point avec un fort cordon fibreux qui par son autre extrémité va s'insérer au centre phrénique du diaphragme." This description, however, is incomplete, though nearer the truth than those given by other anatomists. As regards the anterior attachment of the pericardium nothing need be said, farther than that it becomes continuous with the outer coat of the ascending and transverse parts of the arch of the aorta.

Heart. With regard to the external configuration of this organ the reader may be referred to the very excellent descrip-

[1] *Histological Catalogue*, I. 89.
[2] *Ann. des Sc. Nat. Zoologie*, 1856, Vol. v.

tion of MM. Vulpian and Philipeaux already noticed. The only point to which they have omitted to give prominence, being the distinct bifidity of the apex of the organ, a fact which corroborated the statement of Ælian, Stukeley[1], and Mayer[2]. This bifidity of the heart is interesting when taken in connection with the singular and much more pronounced separation of the ventricles in the dugong and manatee, and its occasional occurrence in the porpoise. No trace of an os cordis was to be found in the wall of the heart. The walls of the cavities in general are much thinner than one would expect in so large an animal; they are however, especially on the right side of the heart, extremely elastic.

On opening into the cavity of the right auricle (fig. 2), five distinct openings were seen, viz. those of three venæ cavæ, two anterior—right and left—and one posterior; that of a single coronary vein; and that of the ventricle. At the mouth of each of these openings was placed a valve, with the exception of that of the coronary vein, which lay under cover of a pectinate muscle. The valve at the mouth of the posterior cava—the Eustachian—was of large size, and arranged in the usual manner. That at the mouth of the right anterior cava was peculiar. Taking its rise from the inner aspect of the opening it wound round the *upper* margin, and finally passing backward became attached to the outer wall of the auricle close to the point of entrance of the posterior cava. This description precisely corresponds with that given by Vulpian and Philipeaux, with this exception, that in their specimen the valve passed round the *lower* margin of the caval opening instead of the upper. It is remarkable that their description of the valve corresponds exactly with that given by Prof. Turner[3] of one which he met with as a very rare variation in the human subject—a fact not without interest to those who believe "that man still bears in his bodily frame the indelible stamp of his lowly origin." At the mouth of the left anterior cava was situated a small fenestrated valve formed by a duplication of the endocardium, which is not generally present in those animals possessed of two ante-

[1] *Essay towards the Anatomy of the Elephant*, Lond. 1723.
[2] *Nova acta Acad. Cæs. Leo-Car.* Vol. xxii.
[3] *Proc. Roy. Soc. Edinburgh*, and *Journal of Anatomy*, May, 1869.

rior venæ cavæ, and which I think we must regard as a rudimentary appearance of the Thebesian valve of the higher mammals. Mr Marshall, in his paper on the development of the great veins[1], says: "As to the Thebesian valve it is present in every instance in which the left venous trunk forms a coronary sinus, receiving veins from the heart alone as in man, the monkey, &c.; but amongst those animals which have a left azygos or left superior cava, *it is certainly absent*, as in the calf, hog, &c." The presence of this rudimentary valve in the elephant, therefore, is of interest, not only as establishing a fact not previously known, but also as showing the accuracy of Mr Marshall's observation, that the coronary sinus is the homologue of the lower part of the left anterior cava, since, in the case before us, we not only have the great coronary vein opening into the left anterior vena cava, and defended by the usual pair of valves, but we also have a rudimentary Thebesian valve, which is not usually present in those animals in which the entire left duct of Cuvier is persistent. The fourth opening was that of the anterior coronary vein, which opened on the right wall of the auricle, and, as already stated, was not defended by valves. Vulpian and Philipeaux describe a third coronary vein as opening by a distinct orifice into the auricle, but this was not the case in the present specimen. The right auriculo-ventricular opening was guarded by the tricuspid valve, which however was provided with a small additional cusp placed between the cusps which correspond with the anterior and internal cusps of human anatomy.

The cavity of the left auricle (fig. 3) presented the four openings of the pulmonary veins, two of which were derived from each lung. Vulpian and Philipeaux describe only two openings in connection with this auricle, a statement difficult to reconcile with the dissection of the present specimen. In front of these openings was placed a valvular structure, which however (by reason of its small size) could not have been effective in preventing the regurgitation of blood into the veins. It arose from the anterior portion of the auricle, and passing down in front of the openings was inserted posteriorly into the anterior raised margin of the fossa ovalis, which was well defined on this, as on

[1] *Phil. Trans.* Part 1, 1850.

the right side, by several tendinous cords. The relation of this valve to the openings of the pulmonary veins was similar to that of the valve of the right superior cava to its opening. This valve does not seem to have been previously recognised. The mitral valve was composed of three distinct cusps, the third small cusp being situated between the inner extremities of the cusps which correspond with the larger anterior and posterior cusps of human anatomy.

The ventricular cavities presented nothing remarkable, and I may refer those desirous of having a full description of them to the memoir by MM. Vulpian and Philipeaux already quoted.

Pulmonary artery. This vessel entirely concealed the ascending part of the arch of the aorta from below, and presented three well marked dilatations externally, which corresponded to the position of the sinuses of Valsalva. Passing forwards and to the right it divided in the concavity of the aortic arch into its two branches, one of which passed to each lung. The ductus arteriosus was attached not to the left branch of the pulmonary artery, as in the human subject, but to the *trunk* of that vessel, three inches behind its point of bifurcation. In front it was attached to the concavity of the aortic arch, just beyond the place of origin of the left subclavian artery. The small azygos lobe of the right lung did not receive any separate branch from the pulmonary artery before it entered the substance of that lung.

Pulmonary veins. These were two in number on each side; the anterior of which was formed close to the hilum pulmonis by the union of several branches derived from the apical lobes of the corresponding lung; whilst the posterior was derived from the posterior or basal part of the lung of its own side; but the vein of the right side received in addition a branch of considerable size from the azygos lobe of this lung, which opened into it immediately before it entered the auricle. These four veins all opened by distinct orifices into the left auricle close to one another.

Coronary arteries. According to Camper[1] there is but a single coronary artery, which shortly after bifurcates so as to supply the usual branches to the heart. In the present dissec-

[1] *Description anatomique d'un éléphant mâle.*

tion, as in those of Vulpian and Mayer, there were two arteries, which were distributed in all respects in the usual manner to the substance of the heart.

With regard to the number of branches given off from the arch of the aorta there is a difference of statement. For whilst Cuvier[1] and Mayer[2] assert that there are *three* trunks given off, viz. the right subclavian, a trunk common to the two carotids, and the left subclavian: on the other hand, Hunter[3], Tiedemann, and Vulpian[4], only mention *two*, viz. 1st, the innominate, which gives off the right subclavian, and the two carotids; and 2nd, the left subclavian. In the present dissection the arrangement was in accordance with the statement of the authors last mentioned (fig. 1). In addition, however, the trunk of the inferior thyroid artery was given off from the point of separation of the two common carotids, a point which Mayer was the first to notice, although, from the fact of Camper having omitted to mention it, he seems doubtful whether it was not to be set down as a variation in his specimen. None of the other authors quoted make mention of this artery. This point is interesting as showing in one of the lower animals a condition which only occurs exceptionally in the human subject, that is, the presence of an arteria thyroidea ima coming off from the trunk of the innominate.

Anterior venæ cavæ.—Each was formed by the junction of *three* large trunks a short distance in front of the arch of the subclavian artery. Of these, one came from the outside, a second came from the direction of the middle line, whilst an intermediate one passed directly backwards. The vena cava of each side, thus formed, passed directly backwards, receiving in its course several smaller veins, one of which was the trunk formed by the union of the companion veins of the mammary artery, and finally opened into the right auricle. In addition to these the right anterior cava received the azygos vein immediately before piercing the pericardium. There was no trace of a small or left azygos vein: the posterior cava immediately after piercing the diaphragm opened into the auricle.

[1] *Leçons d'anatomie comparée*, Paris, 1802.
[2] *Nov. Act. Acad. Cæs. Leo-Car.* Vol. XXII.
[3] *Essays and Observations* by Owen.
[4] *Ann. Sc. Nat.* Vol. V.

Coronary veins.—These are two in number, a great, and small. The great coronary vein commenced toward the apex of the heart by the union of several branches, the trunk formed by which lay in the anterior ventricular groove. It then turned to the left along the left auriculo-ventricular groove, received in this course a large vein from the posterior-ventricular groove, and opened finally into the left anterior vena cava, a short distance from its termination in the auricle. A pair of valves guarded the entrance into the cava.

The small coronary vein, corresponding to the small anterior vein of Galen of human anatomy, commenced by the union of a number of small twigs toward the left side of the base of the right ventricle. It then passed from left to right along the right auriculo-ventricular groove, and opened into the right auricle by a distinct opening which was not guarded by any valve. Vulpian and Philipeaux described a third coronary vein as opening by a distinct orifice into the auricle, but such was not to be found in the present dissection.

Respiratory System.

Trachea. This tube, so far as it lay in the cavity of the thorax, consisted of twelve rings, which were all incomplete behind. These rings presented a peculiarity which, so far as I am aware, has not been observed in the trachea of any other animal; that is, the subdivision of the different rings into distinct segments by means of distinct synovial joints. These joints were each enclosed in a distinct capsule, and presented all the characters of perfect articulations (fig. 4). The number of these articulations in any given ring varied, as many as three being found in a single ring; in others, only two or one, and in others none at all. The same peculiarity manifested itself in the bronchial cartilages. Mr Bishop[1], in his reference to the trachea of the elephant, says, "Trachea thirty rings, which are often partially subdivided." Whether this applies to the peculiarity mentioned, or whether it refers only to that incomplete formation of the separate rings, so common in many animals, I am at a loss to determine, as beyond the statement quoted he makes no further reference to the subject.

[1] *Cyclopædia of Anatomy*, article Voice.

In addition to and internal to the rings, the trachea presented a strong lining of yellow elastic tissue, the fibres of which were longitudinal in direction. This lining passed uninterruptedly from the trachea into the bronchial tubes. Resting directly against this elastic plate was the tracheal mucous membrane, which was thrown into distinct longitudinal folds or rugæ (fig. 5).

The interval posteriorly between the ends of the rings, in addition to the structures just mentioned, was completed by two distinct layers of involuntary muscle. One of these, the more superficial, passed directly across the interval so as to be attached to the extremities of the rings of the trachea. The deeper set arose from the V-shaped projection of the last tracheal ring, the central fibres passing vertically upwards beneath the transverse fibres of the superficial layer, the lateral bundles assuming a more and more transverse direction, so that the most external of these formed the commencement of the series which filled up the interval between the extremities of the bronchial cartilages.

Bronchi. The right bronchus consisted of eight, the left of six rings. In addition to these, however, there were several small cartilaginous nodules of small size representing rudimentary rings. No accessory bronchus such as is so common among the ruminants was met with; the azygos lobe of the right lung receiving its air-tube from the right bronchus after it had entered the substance of the lung.

Lungs. Each of these presented an elongated oval form, the length being about twice the breadth. Only two surfaces are to be distinguished in each, a dorsal and a ventral; or, more properly speaking, an external and internal. There was thus no distinct diaphragmatic surface to be recognised, as in the human subject; the base of the lung, on account of the peculiarly elongated condition of the thorax dorsally, being continuous with the ventral surface, and being wedged in, as it were, between the diaphragm and the upper wall of the thorax. The line of junction of the two surfaces thus gave rise to the margin of the lung, which was marked externally with distinct marginal notches similar to those described by Owen[1]

[1] *Anatomy of the Vertebrates*, Vol. III.

in the lung of the Rhinoceros. The hilum of the lung was situated on its internal surface at the junction of the anterior with the middle third of its length. The substance of each lung was divided into a number of lobes by processes of a lax connective tissue, which could be easily torn so as to separate the lobes. These rudimentary lobes were much more numerous towards the apex than at the opposite extremity of the organ, and they corresponded exactly in number and form in the lung of each side. The only difference in the two lungs consisted in the possession by the right of a small quadrangular azygos lobe which, connected to the organ immediately below the hilum, projected transversely towards the left, lying between the vena cava inferior and the anterior surface of the diaphragm. Vulpian and Philipeaux describe three distinct lobes in the right lung, and none in the left. This, however, was certainly not the case in the present dissection. The arrangement of the pleural sacs could not be determined on account of their lacerated condition. This membrane, however, did not separate the lobes from one another, but passed continuously over the surface of the lung. The pleura were devoid of all trace of yellow elastic tissue; but upon stripping them off their respective lungs, each of these last was found to be be invested as far forward as the hilum with a thick covering of yellow elastic tissue, which gradually thinned off towards the apex, although it could be traced as a separable membrane over the entire surface of the lung. This investment is much thinner on the internal than on the external surface. This covering towards the posterior extremity of the lung was almost entirely composed of yellow elastic tissue, although containing a slight admixture of ordinary fibrous tissue, but on passing forward to the front of the lung, the quantity of the latter increased so that at the apex the membrane now became very thin so as to be almost entirely composed of it.

The bronchi on entering their respective lungs branched into a number of subdivisions, all of which passed to the apical lobes, with a single exception. This, which was the largest of all, passed backwards in order to supply the larger posterior portion of the lung, giving off in its course numerous branches for the supply of the entire organ. The mode of subdivision of the

bronchi, however, was not dichotomous, but quite irregular. As regards the structure of the bronchi themselves, upon entering the lung they at once lost all trace of cartilaginous rings, no trace of this tissue being found in any part of their ramifications. Throughout their entire extent the mucous membrane was thrown into folds as already described in the trachea.

This peculiar non-cartilaginous condition of the intra-pulmonic portion of the bronchi has been recognised before in the howling monkey[1], ichneumon[2], and several other animals, but not, so far as I am aware, has it been previously noticed in the elephant.

Upon transverse section under the microscope the bronchi were found to be composed from without inwards, of, first, a layer of strong elastic tissue; second, a circular layer of involuntary muscular fibres; thirdly, a layer of elastic tissue, but of a finer quality than that composing the external coat; and lastly, of the mucous membrane, the minute structure of which could not be satisfactorily investigated on account of the age of the specimen.

EXPLANATION OF FIGURE ON PLATE VI.

Fig. 1. Heart, pericardium and diaphragm. The pericardium has been cut through and partially turned down to shew the great vessels. *a*, Left auricle. *b*, Right auricle. *c*, Pulmonary artery. *d*, Aorta. *e*, Innominate artery, giving off the right subclavian. *f*, Right and left common carotids; *gg*, and the inferior thyroid artery between the latter. *h*, Left subclavian artery. *ii*, Right and left anterior venæ cavæ thrown down. *k*, Pericardium with the two bands *kk*. *l*, Diaphragm. *m*, Anterior elastic lamina.

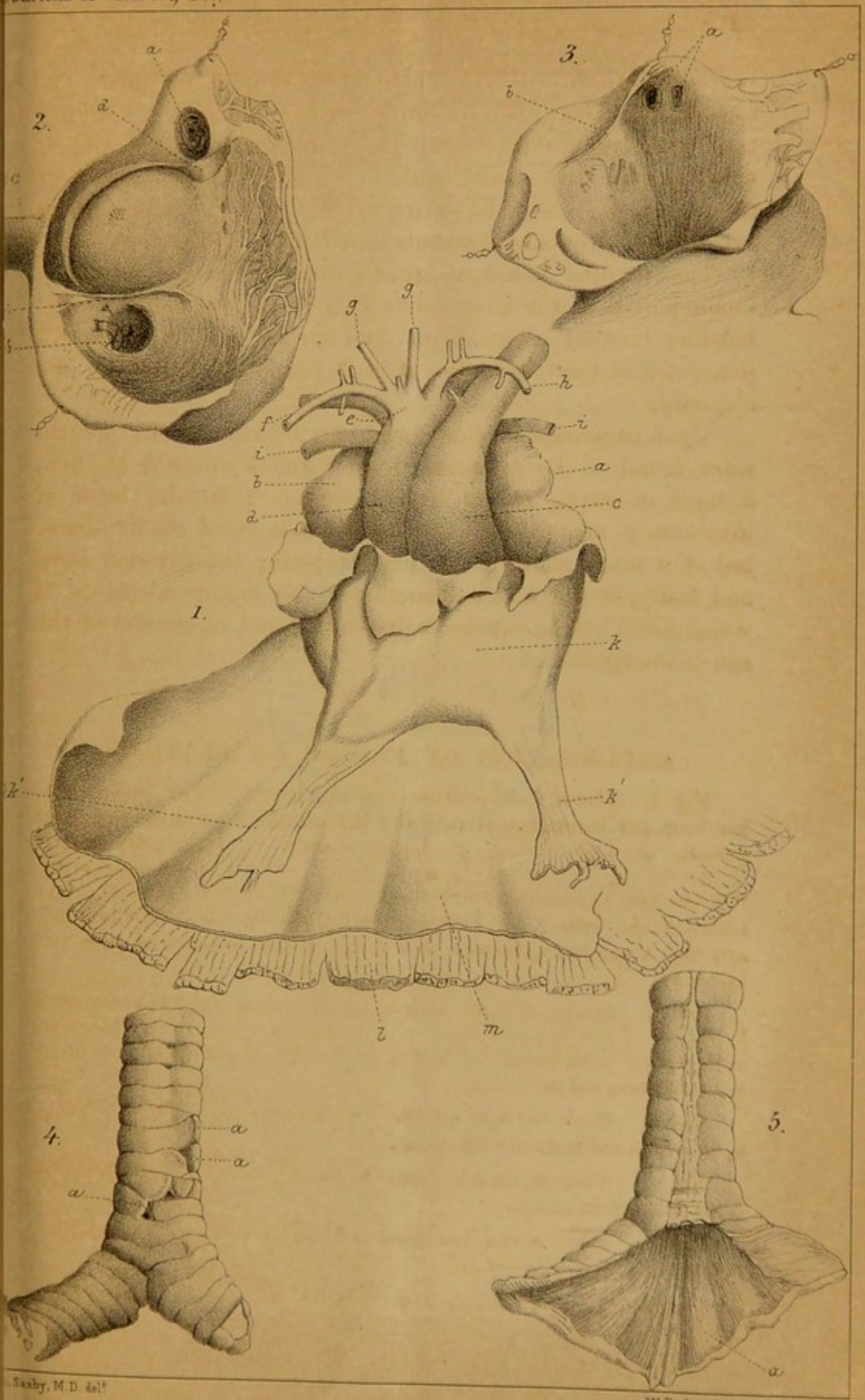
Fig. 2. Cavity of right auricle. *a*, Mouth of right anterior cava. *b*, Mouth of left anterior cava with rudimentary valve of Thebesius. *c*, Posterior vena cava. *d*, Valve at mouth of right anterior cava. *e*, Eustachian valve.

Fig. 3. Cavity of left auricle. *a*, Mouths of pulmonary veins. *b*, Valve in connection with these.

Fig. 4. View of trachea from the front. *aaa*, Synovial articulations of tracheal rings.

Fig. 5. View of trachea from behind, shewing rugose condition of the mucous membrane (*a*).

[1] Cuvier, *Leçons d'anatomie comparée*, Tom. IV. p. 311. [2] *Ibid.* p. 313.



Saxby, M.D. del.

M.t Farlane & Erskine, Lith.rs Edin.r

HEART & WINDPIPE OF ELEPHANT.