PLATE I

Muscular Structure of the Tongue

ANNALS

OF

ANATOMY AND PHYSIOLOGY.

I.—*On the Muscular Structure of the Tongue of Man, and certain of the Mammalia.* By Mr. JOHN ZAGLAS, Private Anatomical Assistant in the University of Edinburgh.—(Communicated by the Author.)

(PLATE I.)

To facilitate my description of the muscular elements of the Tongue, I shall make a few preliminary remarks on some of its other parts, its general configuration, and division into regions.

In the tongue of the ruminant there are three portions most distinctly indicated principally on the dorsal aspect, the consideration of which affords consistent definitions of the regions usually termed root, body, and tip. I select the tongue of the sheep as a type, and shall merely allude to specific variations in the other ruminants, including the camel.

The first and most anterior of those portions constitutes the tip, and its upper surface may be called dorsum planum. It is limited in a somewhat abrupt manner posteriorly, and thus passes into the second portion by an elevation which is the promontory of a hump, which forms the second portion of the tongue, and whose upper surface may be denominated dorsum gibbosum. The dorsum radicis is the upper surface of the third or posterior part of the organ, and gradually declines backwards in a plane which terminates at the base of the epiglottis.

I shall in the sequel show, that this peculiar configuration is produced by a certain arrangement of the muscular elements of the organ; but at present I shall so far anticipate my description of this arrangement in relation to the so-called lingualis, as to state that this muscle connected posteriorly to the dorsum radicis encompasses the dorsum gibbosum, and extends to the dorsum planum. In the human tongue the lingualis reaches the very tip, so that the whole ante-gibbous portion is deficient: the human tongue is therefore truncated, from which result certain advantages in the performance of its functions, as I shall afterwards endeavour to show in treating of the motions of the organ. There is an additional difference in the structure of the two types of tongue represented by the human and the ruminant, in the complex arrangement of the muscular fasciculi throughout the whole extent of the dorsal cortex in the human tongue, similar to that in the dorsum gibbosum, but unlike that in the dorsum planum of the ruminant.

Those three distinct portions of the organ seem to be well adapted for co-operating with other parts in the primary acts of the process of digestion. The tip assisting in the prehension and mastication of the food; the gibba like a piston pushing the bolus towards the pharyngeal cavity; while the root, by means of the exterior parts of its muscles, enables the organ to move, as if connected by a joint to the hyoid bone.

There is another and perhaps a more essential difference between the human and ruminant types. In the one I find what may be called septum medullæ lingualis, which I will afterwards describe in the human tongue, in which it is known as cartilago lingualis. In the other type there is no trace of this septum. I have found it in man, the monkey, pig, dog, and lion; but not in the sheep, deer, calf, or camel:[1] from which it appears that

[1] This difference between the two types was well known to Vesalius, who says:—"Reliquarum tamen omnium obliquæ transversæque in corporum medio plurimæ reperiuntur, quæ mihi utrinque in proprium linguæ ligamentum longe tenuissimum, et membranæ non absimile, tanquam in ipsorum firmamentum, hominibus, canibus et simiis secus quam bobus et ovibus propemodum desinere videntur . . . . in externa illorum corporum superficie excurrentes."—A Vesalii, De Corp. Hum. Fabrica, lib. vii. cap. xix. Lug. Bat., 1725.

the difference may pervade whole families and orders. In treatises of comparative anatomy, a tendinous cord is described as appearing on the lower surface of the tongues of feræ, which I find to be merely the lower border of the septum medullæ lingualis, which in these animals projects between the two genio-glossi, while some of the fasciculi of these muscles, crossing one another to opposite sides, conceal that border in man. The difference in the disposition of certain muscles in man and the ruminant, to which I have already alluded, does not exist between man and the monkey, and in a very slight degree between the former and the feræ; while the pig approaches in this respect the sheep; it also possesses a gibba, but much less prominent, proceeding far forward towards the tip, and disappearing with a pointed elevation.

Cortex and medulla of the tongue.—To define the situation and limits of the septum in the interior of the tongue, it is necessary to indicate a natural division of the muscles of the tongue into two sets, differing in situation and in complexity of arrangement. This division is important, not only in the description of the organ and of the arrangement of its muscular fasciculi, but also in the explanation of the mechanism of the motions of the tongue.

The muscles of the first set surround the tongue on all sides except below, where the genio-glossi enter it, and form a cortex of the shape of a slipper turned upside down. I borrow the term cortex from Bauer.[1] (*Fig.* 1, *e; figs.* 6, 7, *c c c.*)

In the cavity thus walled in are lodged the muscles of the second set; for which I prefer the term medulla to Bauer's nucleus, in which he has confounded almost all the muscles of the tongue. (*Figs.* 6, 7, *e e.*)

Septum medullæ lingualis or cartilago lingualis of authors.—The septum is a thin fibro-cartilaginous lamina, situated perpendicularly in the mesial plane of the tongue; the cavity, or rather the medulla of which, it divides into equal halves, from the tip to the hyoid bone. When the tongue is boiled the

[1] C. T. Bauer, über den Bau der Zunge. J. F. Meckel's Deutsches Archiv für die Physiologie, Bd. 7.

septum becomes thicker, somewhat stiff, and assumes a gelatinous appearance. It is connected by its posterior extremity to the periosteum of the hyoid bone. Its anterior extends into the sinus or fore-part of the cortex cavity, where it terminates in an obtuse point, formed by its inferior converging towards its superior border. The former sloping backwards and downwards for about two-thirds of the length of the organ passes into the third border, which is directed upwards and backwards to the hyoid bone. This last border is not free, but connected to a fascia which extends from the hyoid bone to the genio-glossi muscles. The upper border is straight, and in contact with the dorsal cortex, by which it is covered, except posteriorly where it is attached to the dorsal fascia of the organ.—(*Fig.* 1, *f.*)

Lingual Fascia.—The lingual mucous membrane is not applied immediately upon the muscular substance of the organ. Interposed between them is a laminar condensation of areolar texture, which, after covering the tongue, is continued on each side into the areolar envelopes of the muscles which enter into and issue from it; and into the periosteum of the hyoid bone. This fascia is of considerable strength on the dorsum of the organ, but strongest towards the root from the papillæ vallatæ backwards. It contains numerous aponeurotic fibres; and in its posterior portion often exhibits many cartilaginous nodules, more or less confluent. From this posterior part it extends laterally, ascending in the triangular space between the anterior and posterior pillars of the fauces, connecting itself to the circumference of the tonsils, and by laminæ which pass between the fasciculi of the glosso-pharyngeus with the fascia bucco-pharyngea. In front of the anterior pillars of the fauces, it passes over the margins of the tongue, to cover anteriorly its lower surface; but posteriorly while gradually becoming looser in its connexion with the mucous membrane which forms the floor of the buccal cavity, it is lost in the areolar envelopes of the muscles which enter the organ. By means of these envelopes, but chiefly by that of the genio-glossi, it becomes connected to another fascia, which is deserving of notice, as forming a more or less strong ligament between the tongue and the hyoid bone.

From the body of the latter, it proceeds forward on each side towards the genio-glossus to form a quadrangular lamina, becoming weaker by degrees, and losing itself in the envelope of that muscle and in its inter-fascicular areolar texture. As already stated, it supports the inferior border of the septum medullæ.—(*Fig.* 1, *d; figs.* 6, 7, *a.*)

Muscles of the Cortex.—M. hyo-glossus; or hyo-glossal system; *basio-cerato-glossus,* with the *stylo-glossus minor* of the lower animals.—The two muscular masses which in man constitute the hyo-glossus, in addition to a portion which in the lower animals arises from the inferior extremity of the uppermost piece of the great anterior horn of the hyoid bone, constitute a muscle, which has no relation to the chondro-glossus or the so-called stylo-glossus minor of man. The term hyo-glossus I employ in a collective sense, and I shall only distinguish its portions by the names already alluded to, when greater precision is necessary.

This muscle presents no important difference, requiring a separate description, in man and the lower animals. My account of it refers to both, only premising, that the stylo-glossus minor of the lower animals has its equivalent in the human tongue in those fasciculi which arise from the highest part of the cornu majus; so that, the part which corresponds to the cerato-glossus in man, is concentrated upon the lower end of the highest piece of the hyoid of the lower animals; at least, I have found it to be so in the ruminants and camel.—(*Fig.* 2, *e e; fig.* 11, *c; fig.* 13, *g g'.*)

To facilitate the conception of the course of the fibres of this system, and the manner in which they are applied upon the side of the tongue, the hyoid bone must be conceived to be reduced to its simplest form as it exists in man. From the external surface of each half of this semicircular bone, the muscle proceeds in the form of a broad ribbon, having an internal concave, and an external convex surface; an upper and a lower border. The fasciculi of the upper border descend to the side of the root in a direction somewhat inward, then beginning to be connected to the tongue they pass inwards and forwards to reach the mesial line of the dorsal surface. The fasciculi of the lower or anterior border, proceeding from the middle of the body of the hyoid bone, and at first stretched below the root of the tongue towards the margin, which they reach in a direction forwards and outwards, then bend round the margin, and assuming a direction forwards and upwards, turn again inwards and forwards to reach the mesial line of the dorsal surface. The intermediate fasciculi have a disposition in accordance with their proximity to one or the other border. The entire arrangement somewhat resembles the reverse made in the application of a surgical bandage.

M. stylo-glossus, portio major stylo-glossi, arises as is well known from the extremity of the styloid process, and from the stylomaxillary ligament, which I find affords the greater part of the origin of this muscle. In a monkey I found that partly the ligament, but chiefly the angle of the lower jaw supplied the surfaces of origin. In other animals it arises from the external surface of the lower end of the bone, which is considered to be the equivalent of the styloid process, that is, the highest piece, of the anterior horn. The variation in the course of the fibres, and in their mode of distribution in the different animals, is too slight to require separate description. In volume it is not as might be expected in proportion to that of the tongue, for like the other muscles of the organ in the camel it is comparatively small.—(*Fig.* 13, *f.*)

Assuming the sheep's tongue as the type, this muscle proceeds from its origin along the external surface of the hyoglossus to the side of the gibba, from which it begins to apply itself to the margin of the tongue, its connexion with it becoming gradually closer. Previous to the point of connexion it presents two borders—an upper and a lower. The latter while proceeding forwards, gradually curves to the lower surface of the organ, converging to the mesial line, to meet the muscle of the opposite side, in front of the point of emergence of the genio-glossus. (*Fig.* 12, *e′ e′*.) The former soon disappears as a plane of radiating fasciculi tending towards the dorsal mesial line. These radiating fibres extend to the tip. At first they extend from the marginal fasciculi in a nearly transverse direction. They are not however directly continuous with the marginal fasciculi ; for each of the latter insinuates itself at first to a certain depth in the marginal cortex, where it splits and exchanges fibres with the neighbouring fasciculi, to afford as it were an attachment for the radiating fasciculi, which consist of a recombination of the already separated fibres into coarser bundles proceeding from the internal surface of the stylo-glossus. When, therefore, a thin section is removed from the marginal cortex, the surface exhibits a longitudinal arrangement of fibres, but a deeper section displays coarser fasciculi, diverging more or less transversely from the margin to reach the mesial line of the upper surface. The inferior fasciculi are parallel to the lower margin of the muscle, some of them even proceeding from it. Those on the margin near the tip, curve so as to surround it, and interlace with the corresponding fasciculi of the opposite side.

In the human tongue the lower border meets that of the opposite side below the tip, the other fasciculi converging towards the mesial line of the lower surface. The radiation of the fasciculi proceeds more directly from the margin than in the lower animals.

M. Chondro-glossus.—This muscle is usually described as a portion of the hyo-glossus, from which it differs as much as the latter does from the stylo-glossus, at least if viewed in reference to its topographical disposition. It is seen on the upper and lower surface of the root, both in man and in the lower animals ; in the latter covered by some fat only. In the sheep's tongue it is best developed. In the camel it is exceedingly thin. I shall describe it in the sheep and in man ; some peculiarities rendering this necessary.

The small horn of the hyoid bone in the sheep tends backwards, and is attached to the posterior surface and inferior margin of the body of the bone. From the anterior surface of the same part, and opposite to the attachment of the small horn, the chondro-glossus arises as a cylindrical bundle, about as thick as a goose-quill, (*Fig.* 12, *c,*) lying upon the commencement of the hyo-epiglottideus, which, arising on its external side, embraces it from below, in order to pass between it and the chondro-glossus of the opposite side, and ascend to the anterior surface of the cartilage of the epiglottis. (*Fig.* 12, *d d.*) From thence the muscle proceeds forwards and upwards to meet at first the most posterior fasciculi of the genio-glossus, (*Fig.* 12, *i'*,) and crossing them and the medulla to appear on the back of the root of the tongue. While crossing the medulla, its fasciculi exchange fibres with one another, and convert the mass into a muscular meshwork, which now appears as such on the dorsum radicis, meeting from opposite sides at the mesial line, as far forward as the gibba. The meshes are wide, occupied by fasciculi of medullary muscles, fat, nerves, and vessels transmitted through them. This arrangement is not represented in any figure, but it may be seen by paring off the mucous membrane in a recent sheep's tongue; or still better by shaving it off in a boiled one. Immediately behind the gibba, the muscles of each side again separate from one another, and proceeding forwards concentrate themselves by degrees into denser fasciculi, particularly towards the margins of the gibba, the mesial line being left free. (*Fig.* 11, *i*, *g.*) Towards the anterior extremity of the gibba, the muscle begins to join with, and to creep beneath and between the fasciculi of the hyo-glossus, with which it is intermixed anteriorly.

In the human tongue the chondro-glossus arises from the articular extremity of the lesser horn, the articulation itself, and by a small portion from the body of the hyoid bone. The analogy between this origin and that of the foregoing is evident; and if the following description be sufficient to establish an identity between the two muscles, their course and connexions will support the analogy between the lesser horn in man and the posterior horn of the lower animals. What has already been stated in reference to the origin and connexion of the hyo-glossus system with the great horn in man and the anterior horns in the lower animals supports this conclusion.

From its origin the muscle proceeds forwards, with its upper surface in contact with the noto-glossus, a muscle to be immediately described. (*Fig.* 3, *d.*) The noto-glossus having been removed, the muscle is observed to flatten by degrees, to extend forwards, and to proceed towards the margin and mesial line of the tongue. It thus forms a horizontal sheet, immediately supported by the medulla; the fasciculi of which penetrate through it to reach the dorsal fascia. The internal margin of the sheet proceeds along the septum medullæ, which, as will be remembered, supports immediately the fascia of the root. More in front this margin enters the mesial line of the dorsal cortex. The outer margin and the intermediate portion gradually run into the hyo-glossus. The lower surface of the muscle soon disappears, (*Fig.* 5, *h,*) being crossed by the most posterior fasciculi of the genio-glossus; and from without by the glosso-pharyngeus.

M. Noto-glossus.—This muscle is a collection of the different fibres on the surface of the tongue mentioned by authors—other fasciculi not belonging to it having been described along with it, and thus much confusion induced. The name I have selected is a translation of the German Rücken-zungen-muskel, (der Rücken, the back, *ὁ νῶτος, τὰ νῶτα*—die Zunge, the tongue, *ἡ γλῶσσα.*) Bauer made use of the term in describing the muscle in the lower animals; but he denied its existence in man, in whom it is, nevertheless, well developed.

In the human tongue this muscle arises from the dorsal fascia, from the root nearly to the tip; the mesial line yielding the greatest number of fasciculi, the margin none. Its most posterior fasciculi begin to arise from the process of the dorsal fascia, by means of which the cartilage of the epiglottis is connected to the latter, and which enters the frenum glosso-epiglotticum. The fasciculi proceed outwards and somewhat forward to the margin of the root. The succeeding fibres become more and more oblique, so as at last to run parallel to the axis of the tongue. (*Fig.* 3, *f f f.*) On the margins of the organ the fasciculi penetrate amongst the other cortical muscles and unite with them. These muscles, therefore, form a continuous superficial layer over the whole dorsal aspect of the tongue, on each side of which the fibres are symmetrically disposed.

This muscle is more or less strong, but disposed in a similar manner in all short or flat tongues of the lower animals. In the gibbous tongues it is somewhat different. Thus in the sheep it arises from the lateral and anterior circumference of the gibba; the mesial line being left more or less free from muscular attachments. Those from the side precipitate themselves on the margin of the tongue, running downwards and forwards with greater obliquity the more anteriorly they are situated. The fibres which originate on the anterior circumference of the gibba are in immediate continuation of the others, and run over the dorsum planum with a greater tendency to become parallel to the mesial line, the nearer their origin is to it; at the margin of the tongue the muscle penetrates into the stylo-glossus, as represented in the tongue of the camel, in which it is less developed than in the sheep. (*Fig.* 13, *i.*)

M. Lingualis.—The anterior portion of this muscle is cortical, the posterior medullary; and if its analogies to the other muscles be examined, it would appear rather to belong to the medullary system. The description of this muscle must now, however, be given, in order to obtain all the elements necessary for a complete view of the constitution of the cortex.

The lingualis arises from the dorsum radicis in transverse series of fasciculi, extending from the margin to the mesial line, or passing a little over it. This latter peculiarity occurs in the tongues which do not possess a septum.

From those transverse series of origins the fasciculi run downwards to the lower surface of the tongue, converging from both sides towards the space between the genio and hyo-glossus. In this manner the fasciculi of each series arrange themselves in perpendicular laminæ, consisting of perpendicular fibres.

In the space just alluded to, the fasciculi are collected into a muscular bundle, laterally compressed, and extending forwards in the groove formed posteriorly between the genio and hyo-glossus, and anteriorly between the latter and the stylo-glossus.

Its anterior extremity presents remarkable differences, not so much in regard to its mode of termination, as in regard to the distance of this termination from the tip, as has already been stated.

In the human tongue which is typical of all the short tongues, it reaches the very tip. (*Fig.* 4, *d d.*) A little beyond its anterior third, its central bundle becomes transversely flattened ; sending off radiations from its upper border ; the lower following the course of the corresponding border of the stylo-glossus. In this manner they creep upwards in order to reach the dorsal mesial line, at the same time tending forwards. A small and apparently constant fasciculus of the muscle separates from its lower margin, and passes between the genio-glossi. (*Fig.* 4, *d'.*)

In the gibbous tongues the lingualis early begins to flatten, and to ascend between the other muscles, as in the short tongues, and on the dorsum the fasciculi curve around the anterior part of the gibba, which is thus embraced by the muscles of opposite sides as in a sling. The obliquity of the fibres increases from behind forwards. (*Fig.* 11, *f.*)

Constitution of the Cortex.—The anterior extremities of the cortical muscles have an intimate connexion with one another. They commonly terminate in fasciculi, which assume a certain similarity of disposition, and produce over the whole tongue similar topical movements which seem to have the principal share in producing the extreme volubility of the organ ; while the posterior portions of the same muscles and their mode of connexion with the tongue, would appear to be well calculated to produce the changes in position of the whole tongue. I shall therefore consider the cortex as a whole.

On the margin of the tongue a partial superposition or mutual covering of portions of the hyo-glossus is observed. Thus the anterior margin of each of these portions while running upon the dorsum, is covered by the posterior margin of the anterior portion. In the same manner the hyo-glossus is more or less covered by the stylo-glossus, especially in the human tongue, a layer being formed by these two muscles, which covers the lingualis, and which is again covered by the noto-glossus. (*Fig.* 4, *f f' f'' c'.*)

In this arrangement the muscles coalesce with one another, forming over the tongue a layer which is densest on the margins. The radiations mentioned in connexion with the stylo-glossus, only present themselves in this layer as recombinations of more or fewer of the cortical muscles, either fixed at the margin, and running inwards parallel to one another, or inwards and forwards to the dorsal mesial line. (*Fig.* 2, *e′*; *fig.* 3, *h*; *fig.* 11 *e.*) In this course the fasciculi again exchange fibres with one another, and thus form a muscular net-work with meshes of greater or less extent, very wide for example in the deer. (*Fig.* 10, *b*, *c.*)

The fasciculi vary in different tongues. In the sheep the most posterior fibres of the hyo-glossus, viz., those of the stylo-glossus minor, tend very much forward along the mesial line of the gibba, with which they only come in contact at its anterior part. They then, joined by those of the cerato-glossus, become parallel to the mesial line upon which they run ; in this manner beginning to form a muscular cord to be afterwards described. The fasciculi in front, taking at the same time a more internal course, and already reinforced from the other muscles, approach at an angle those of the opposite side at the mesial line. In this manner a series of oblique but parallel fasciculi are arranged in front of the gibba ; the fasciculi do not pass over, but dive into the interior, and pass under the cortex, where they constitute a remarkable arrangement. This arrangement is in the form of a muscular cord or rope attached along the roof of the cavity of the cortex, by means of its own constituent fibres. (*Fig.* 11, *h.*) It is smooth, cylindrical, as thick as a crow-quill, and pointed at both extremities. It sends off no fibres except at its anterior extremity. (*Fig.* 11, *k.*) These fibres proceeding forwards, cross the medulla in order to reach different parts of the cortex around the tip of the tongue. If the tongue be cut across, the cord appears as a small disc beneath the mesial line of the dorsal cortex. In the tongue of the deer it presents itself as a mesial fasciculus, into which the fibres pass to proceed directly forwards. (*Fig.* 10, *d.*)

In the human tongue the internal extremities of the fasciculi of this muscle bend forwards, and proceed close to one another at the mesial line, where they gradually accumulate. The most posterior are met with in the neighbourhood of the foramen cæcum. This mesial accumulation of fibres, when it approaches the tip of the tongue, plunges into the medulla, spreading at the same time in order to reach different parts of the circumference of the tip.

I have described the noto-glossus as the last of the cortical muscles; it must be evident, however, that its internal fibres contribute to the formation of the accumulated superficial longitudinal fibres of the tongue.

If in addition to what has already been stated, the cerato-glossus be also taken into consideration, the description of the cortex is completed. It only remains to be observed in reference to gibbous tongues, in which the hump is well developed, that upon it there is an elliptical spot, partly quite bare, partly covered by a very delicate muscular fasciculation, surrounded by the cerato-glossus, hyo-glossus, noto-glossus, and lingualis. (*Fig.* 11, *i.*)

On the lower surface of the tongue the cortex is much denser than on the upper. The fasciculi uniting with one another at the mesial line proceed forwards in it. In the vicinity of the tip the sublingual cortex transmits fibres into the interior, which, crossing the medulla, run upwards and forwards, reaching different points of the cortex of the tip, in an opposite direction to those which proceed from the dorsal cord. The same is the case with the marginal cortex. At no other points does the cortex send fibres into the interior of the tongue, and even the fibres emitted at the apex have no connexion with the medullary fasciculi.

From this peculiar arrangement of the cortex, a transverse section of the human tongue exhibits the former in the form of a hoop surrounding the medullary mass. This hoop appears thickest at the dorsal mesial line, and on each side of the genio-glossus, an arrangement easily accounted for. (*Figs.* 6, 7, 9, *c c c.*)

Medullary mass.—While the individual arrangement and mutual connexion of the cortical muscles are highly complex, the common character of the medullary muscles is a mere independent apposition of their fasciculi upon one another, by an arrangement which may be described as a sheathing of homogeneous fasciculi by alternating layers of heterogeneous ones, both of which are, generally speaking, very regular.

M. Genio-glossus.—To this muscle belongs a great portion of the perpendicular fibres which are observed in the interior of the tongue. They always occupy the middle of it, and in this respect it is a M. perpendicularis internus, which may justify the term M. perpendicularis externus, which I intend to apply to those perpendicular fibres which occupy the sides of the medulla. A portion only of the genio-glossus muscle is seen on the exterior and below the tongue. (*Fig.* 2, *m* ; *fig.* 5, *i.*) Its hidden portion passes downwards from the dorsum of the organ, and arises by transverse series of fasciculi from the lingual fascia. These series are longer towards the root, and diminish towards the tip, to which circumstance the transverse dimensions of the muscle are conformable. The fasciculi pass into the interior of the tongue through the meshes of the cortex, and then arrange themselves into transverse planes of perpendicular fibres running downwards to the lower surface of the tongue, and converging towards the mesial line. (*Fig.* 6, *d d.*)

In the tongues which are destitute of mesial septa, there is a decussation of the most internal fibres of each side. In tongues with septa the genio-glossi are quite separated down to the inferior border of the septum, immediately below which and concealing it, there exists in some tongues, as in the human, a slight exchange of fibres of the opposite sides. The muscle appears to have no connexion with the septum. The external or sublingual portion is always divided into halves, separated from one another by a mesial interspace. In man, as is well known, the sublingual portion is triangular, with its apex curved forwards, for attachment to the spina mentalis interna by a short strong tendon ; from which, when viewed from the side, the muscular fasciculi appear to radiate towards the tongue in coarse triangular laminæ, in each of which, however, a greater or less number of the internal transverse laminæ are combined.

The dimensions of the sublingual portion of this muscle, which evidently corresponds with the included part, vary, but not in proportion to their bulk, in different tongues. In the ruminants the antero-posterior and transverse dimensions are generally much reduced. (*Fig.* 13, *h*; *fig.* 12, *i*.) In the deer, for instance, the thickness is so much diminished that the sublingual portion resembles a triangular membrane. In man it is comparatively the greatest.

As Blandin has well observed, none of the fibres of this muscle ascend to the pharynx, and none are attached to the hyoid bone; the supposition that they do, being an illusion produced by the penetration of some fasciculi through the chondro-glossus, or by the strong fascia stretched between the bone and the muscle.

M. Perpendicularis Externus.—This muscle appears to be a continuation of the lingualis. It forms the marginal part of the medullary mass; and is so arranged in reference to the genio-glossus, that it extends towards the mesial plane in proportion to the increased distance of the latter muscle from the margin of the tongue. In those tongues, therefore, in which the genio-glossus does not extend to the tip, the space in front is occupied by the perpendicularis.

It also arises by transverse series of fasciculi from the dorsal fascia, and enters the interior of the tongue through the muscles of the cortex.

The fasciculi pass downwards and somewhat outwards through the medulla, arranged in transverse laminæ, the internal fasciculi of which are longest, the external situated in the marginal sinus of the cortex shortest. Before the inferior extremities of these fasciculi reach their destination, they separate into smaller fibres, so as to insinuate themselves, and pass through the comparatively smaller meshes of the marginal and sublingual cortex. (*Fig.* 6, *e e*.) Certain of these fibres seem to intermix with those of the cortex.

Some peculiar fibres deserve to be mentioned here, more, perhaps, for their constancy than their importance. In the sheep these fibres proceed from the medulla, where they occupy its mesial plane, between the genio-glossus and the tip of the tongue. They concentrate themselves into one fasciculus between the anterior extremity of the genio-glossus and the stylo-glossus, and passing backwards curve around the stylo-glossus, so as to enter the cortex from without. In the tongue of the pig the anterior thin extremity of the genio-glossus is in contact laterally with a thin mesial plane of perpendicular fibres. These do not leave the cavity of the tongue, but when near its lower surface collect into two or three fasciculi which curve forwards, and creep along the bottom of the cortical excavation, and on approaching the tip pass into the cortex, running between the two external perpendicular muscles. That small portion of the human lingualis which has been described as passing into the genio-glossus, may be considered as similar to these fibres; and inferences may be drawn from this arrangement regarding the affinity of the perpendicular muscles to each other.

M. Transversus.—The different portions of the system of transverse fibres are characterized by certain peculiarities, and may be considered, in fact, as distinct muscles, which differ from one another in the mechanical effect of their action. By the above denomination I designate those fibres which do not pass beyond the tongue. They are the most numerous.

The origins of the fibres of this muscle are arranged in the same manner as those of the perpendicularis in transverse series, more or less remote from the mesial plane, and extending more or less around the margin of the organ. After passing through the cortical meshes, they are combined in comparatively coarse fasciculi, and arranged in perpendicular laminæ, the constituent fibres of which extend from their origins towards the mesial plane. They are inserted in a very different manner in the two types of tongue.

In the sheep's tongue, the transverse fasciculi running inwards incline somewhat downwards; and before they reach the mesial plane they split into numerous minute fibres, which decussate with those of the opposite side while crossing the plane. Arrived at the other side, they oppose themselves to the fasciculi of the corresponding, or to one of the neighbouring laminæ, and coalesce with them; at least I have not been able to trace them on to the cortex. There is thus in the mesial plane a perpendicular lamina of pale colour and denser consistence, formed by the numerous angular decussations of the central extremities of the fasciculi. The uppermost fasciculi are very short, below they are longer.

In the human tongue the mesial plane being occupied by the septum, the fasciculi are inserted on its sides, and terminate abruptly without splitting into fibres. (*Fig.* 7, *e e*; *fig.* 9, *e e*.)

M. Glosso-palatinus.—If this muscle be followed from the glosso-palatine arch in the fold of which it is situated, some of its fibres will be found to pass directly into the interior of the tongue, and others to run for some distance along the margin of the organ. The latter I have failed in tracing very far, in consequence of their splitting into fibres which pursue a serpentine course. The former I believe I have pursued completely into the medulla. If the transverse fibres of the tongue which are stretched between the anterior palatine arches be examined, the inferior half, more or less, of these laminæ will be found to have their fibres continuous with those in the arch. This is the arrangement in the human tongue.—(*Fig.* 9, *e e*.)

The lower animals appear to be destitute of a glosso-palatine muscle, at least there is none in the ruminants. The other tongues which I have examined were cut too short to admit of a satisfactory examination.

M. Glosso-pharyngeus.—This muscle, a portion of the superior constrictor, descends from the pharynx in front of the great horn of the hyoid bone. Its posterior margin is covered by the chondro-pharyngeus, while its anterior covers, or runs external to the posterior border of the tonsil. It penetrates through the hyo-glossus, and by a few of its fasciculi, the stylo-glossus also, in order to reach the lower surface of the root of the tongue to meet the planes of the genio-glossus. There it separates into fasciculi which penetrate between the laminæ of that muscle, to become continuous with the lower portions of the laminæ of the transverse muscles, or even with all the fibres of these laminæ in the neighbourhood of the hyoid bone. Like the transverse muscles they terminate on the septum.—(*Fig.* 5, *g g′ g″*.)

The portion of this muscle which passes through the stylo-glossus, is the stylo-glossus minor of authors. Its course and insertion I find to be well described by Blandin;[1] but it cannot be separated from the glosso-pharyngeus, and is not a portion of the stylo-glossus.

Another set of fibres arises from the lower border of the tonsil, and from the adjoining parts of the fascia of the root. They are situated between the glosso-pharyngeus and the glosso-palatinus, there being no distinct border between them and the latter. This set of fibres belongs to the transverse system, and is not to be confounded with the perpendicular muscles, which assume a similar disposition in this locality. (*Fig.* 2, *h.*)

In the ruminants there is no trace of the glosso-pharyngeus or of the set of fibres just described. In the camel there exist fibres similar to those of the last set. (*Fig.* 13, *m m.*) These are separated from others which descend from the pharynx and the soft palate by a bare tendinous spot or intersection. (*Fig.* 13, *n p.*)

In the calf, sheep, and deer there is an uncovered or exposed portion of the transverse system visible below the root of the tongue. It consists of a considerable mass proceeding from the knee which is formed by the anterior horn of their hyoid bone suddenly bending backwards and upwards. From its origin this muscle is directed inwards towards the mesial line. It is distinctly divided into more or less horizontal laminae, which interpose themselves between the laminae of the genio-glossus and lingualis. The alternation is very evident; and the lowest laminae of each side decussate and form angles similar to those of the transverse system. (*Fig.* 12, *b.*) The most posterior fibres go directly across from one horn to the other. This muscle is best developed in the sheep, and its dissection requires patience from the quantity of fat in which it is enveloped.

This muscle seems to exist in the greater number of mammalia. In the carnivora it girds the root from below, and is seen to be inserted on the septum. Blandin states that it is very strong in the elephant, and describes it as the stylo-glossus minor. I do not know how it terminates above

[1] T. J. Blandin, sur la Structure de la Langue. Archives gén. de Méd. 1823.

in the carnivora ; but according to the statement of Blandin, it would appear to be a portion of the glosso-pharyngeus, as it is a substitute for the latter in the ruminants. In the camel it does not exist, although the fibres above mentioned as embracing the root, seem to be intermediate between it and the glosso-pharyngeus.

Constitution of the Medulla.—The medullary mass is divided into equal halves, separated either by a septum, or by a dense decussation of the fibres of opposite sides at the mesial plane. This arrangement and the paleness of the fibres in the mesial plane produce the illusory appearance of a septum on the lower surface of ruminant tongues.

Each half consists of successive laminae of fasciculi at right angles to the axis of the tongue, or inclined somewhat backwards in the posterior, and forwards in the anterior part of the organ. The laminae of the transverse, alternate regularly with those of the perpendicular system. Occasional insignificant irregularities occur in the transition of fibres from a lamina of the one system, across an intermediate lamina of the other system, to the next lamina of their own system ; by which their action is in no way modified. From this arrangement it happens that horizontal or perpendicular longitudinal sections of the tongue exhibit the one system as alternate series of more or less uninjured fibres, the other as series of cut extremities of fibres, as in the horizontal section of the human tongue represented in (*Fig.* 8, *c c d d*, &c.)

It is worthy of notice that the cortical cord and the equivalent accumulation of fibres on the mesial line are not interpenetrated by the transverse system ; but are fairly embedded in a sulcus formed by the uppermost transverse fibres, and the upper border of the septum, if one exists.

(*To be continued.*)

Explanation of Plate I.

Fig. 1. *a* hyoid; *b* epiglottis; *c* lower-jaw; *d* fascia dorsalis and mucous membrane; *e* cortex; *f* septum; *g* genio-glossus.

Fig. 2. *a* hyoid bone; *b* styloid process; *c* tonsil; *d* lower-jaw; *e e* hyo-glossus; *f* stylo-glossus; *g* portio minor of stylo-glossus, the anterior portion of the glosso-pharyngeus; *h* perpendicular and transverse fibres proceeding from the circumference of the tonsil; *i* posterior portion of the noto-glossus; *e'* hyo-glossus on the dorsum; *f'* stylo-glossus on the dorsum; *k* lingualis; *l* mesial accumulation of the dorsal fibres; *m* genio-glossus.

Fig. 3. *a* hyoid bone: *b* epiglottis; *c* process of connexion between the dorsal fascia and the septum linguale; *d d* chondro-glossus; *e* glosso-pharyngeal fibres; *f f f* noto-glossus; *g* hyo-glossus; *h* stylo-glossus; *i i* mesial accumulation of the fibres of hyo-, stylo-, and noto-glossus; *k* medullary substance.

Fig. 4. The tongue seen from below, the left side from a preparation. *a* hyoid bone; *b b* hyo-glossus; *c* stylo-glossus; *c'* cut edge of the combined hyo- and stylo-glossus; *d d* lingualis; *d'* a fasciculus of the same muscle passing into the genio-glossus; *e* chondro-glossus; *f f' f''* cut edges of the superimposed lingualis, hyo-, and stylo-glossus; *g* genio-glossus.

Fig. 5. *a* hyoid bone; *b* lower jaw; *c* styloid process; *d* section of the base of the cranium behind the petrous portion of the temporal bone; *e* constrictor pharyngeus medius; *g g* glosso-pharyngeus; *g' g'' g'''* interpenetration of the fasciculi of the glosso-pharyngeus and genio-glossus; *h* chondro-glossus; *i* genio-glossus; *i'* a portion of the same muscle thrown over to exhibit the passage of the fasciculi of the pharyngo-glossus towards the mesial plane; *k* hyo-glossus thrown over; *l* genio-hyoid; *m* cut edge of mylo-hyoid.

Fig. 6. *a* mucous membrane of the tongue with the subjacent fascia; *b* septum linguale; *c c c* cortex; *d d* genio-glossi; *e e* perpendiculares externæ.

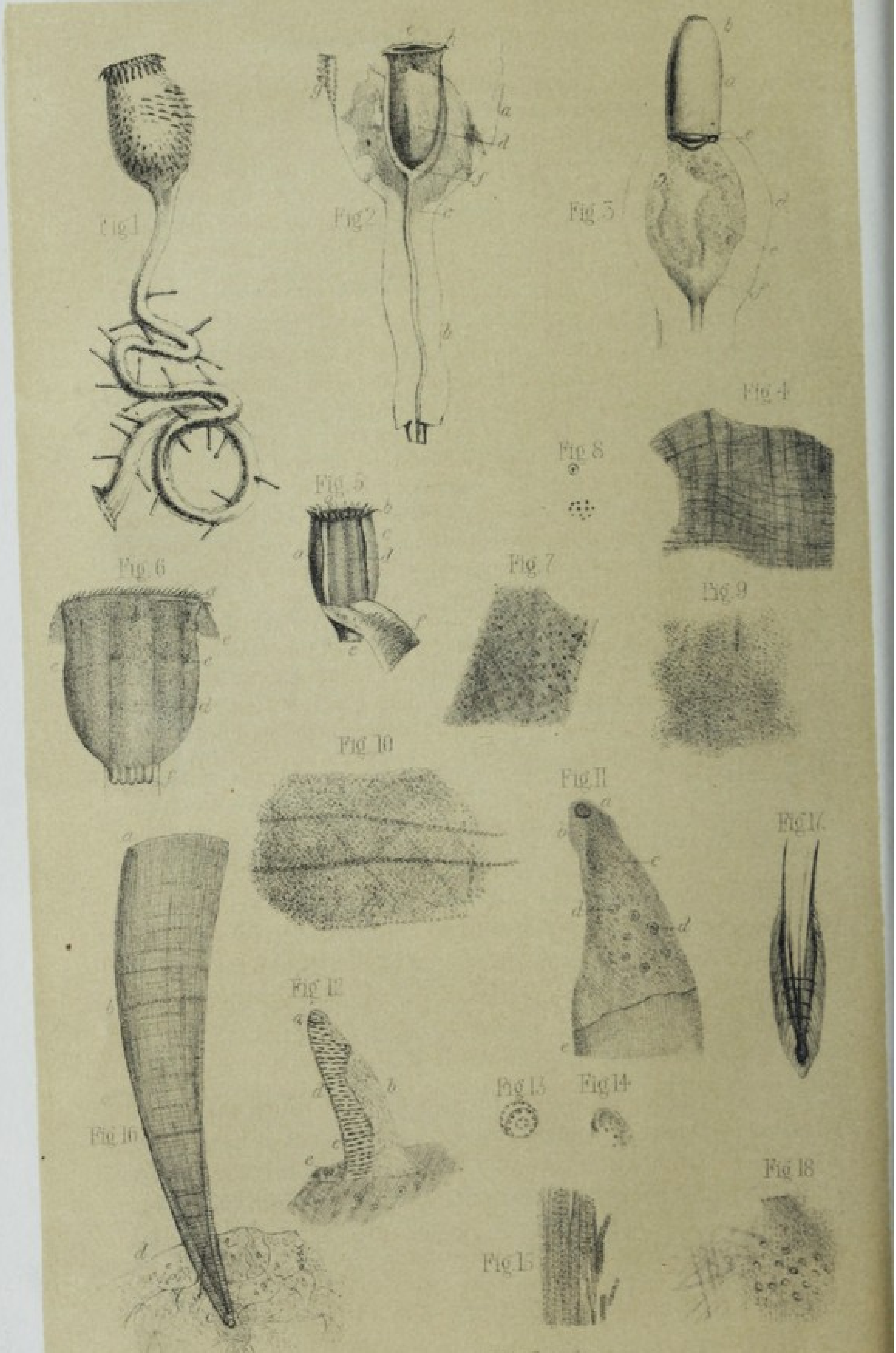
Fig. 7. *a b c d* as in Fig. 6; *e e* lamina of transverse muscular fibres.

Fig. 8. *a a* septum linguale; *b b b b* cortex; *c c c c*, &c., horizontal sections of laminæ of transverse system of fibres; *d d d d* horizontal sections of the transverse laminæ of the perpendicular system of fibres.

Fig. 9. *a b c d* as in Figs. 6 and 7; *e e* laminæ of transverse system of fibres, the lower parts of which pass outwards into the palato-glossus.

Fig. 10. View from above of the tip of a deer's tongue, the mucous membrane and noto-glossus having been removed. *a a* marginal cortex; *b b*, &c., the dorsal muscular net-work of the cortex; *c c* the meshes of the net-work through which the cut extremities of the medullary fasciculi are seen protruding; *d* the mesial muscular cord.

Fig. 11. Tongue of the sheep; the medulla removed, and the cortex inverted and depicted from within. *a* the lower extremity of the upper piece of the anterior horn of the hyoid bone; *b* stylo-glossus; *c c* hyo-glossus; *d* cut



Anatomy of Forbesia.

H. D. S. Goodsir Del.

Fr. Schenck, Lith. Edin.

edge of the combined cortical muscles; *e* dorsal fasciculi of the cortex; *f* lingualis; *g* noto-glossus; *h* muscular cord; *i* the uncovered spot on the mesial line of the gibba; *k* radiating fibres from the muscular cord to the tip.

Fig. 12. Tongue of the sheep seen from below. *a a* the knee of the anterior horn of the hyoid bone; *b b* the exposed portion of the transverse system; *c c* the origins of the noto-glossi; *d* hyo-epiglotticus; *d′* the same muscle turned over; *e* stylo-glossus; *e′ e′* the lower converging border of the same muscle; *i* genio-glossus; *i′* the posterior part of the same muscle; *k* hyo-glossus; *m* lingualis; *n* medullary mass.

Fig. 13. Tongue and pharynx of the camel. *a* hyoid bone; *a′* the upper piece of the anterior horn cut; *b* thyroid cartilage; *c* cricoid cartilage; *d* the buccal orifice of the pharynx; *e* the nasal orifice of the pharynx; *f* stylo-glossus; *g g′* hyo-glossus; *h* genio-glossus; *i* noto-glossus; *k* chondro-glossus; *l* a fibrous ligament below the tip of the tongue; *m m* origin of transverse fibres; *n* a tendinous spot separating the transverse fibres of the tongue from those which descend to it from the pharynx; *o* fibres of the superior constrictor, embracing the nasal opening; *p* fibres of the superior constrictor, tending towards the root of the tongue, but not passing beyond the tendinous spot; *q* fibres of the same constrictor, embracing the pharynx from below, between the horns of the hyoid bone; *r* hyo-pharyngeus; *s* a perpendicular muscular lamina, formed by converging fibres of the superior constrictor of the pharynx meeting in a raphe, from which this muscle arises to suspend the pharynx to the base of the cranium. In the pharynx of the camel the posterior median raphe exists only at this spot; the fasciculi of the middle and inferior constrictor decussating irregularly in the neighbourhood of the mesial line. *t* constrictor inferior; *u* œsophagus; *v* crico-thyroideus; *w* thyro-hyoideus.

II.—*On the Anatomy of* Forbesia. By H. D. S. Goodsir, M.W.S., Acting Assistant-Surgeon of H.M.S. Erebus.—(Transmitted by the Author from Disco Island, Baffins Bay, in June 1845.)

(Plate II.)

The polype-like animal for the reception of which this genus has been proposed[1] is remarkable, both on account of its gigantic size and its peculiar structure. It has the general appearance of a vorticella enormously magnified, with the addition of dis-

[1] H. D. S. Goodsir—Descriptions of some Gigantic Forms of Invertebrate Animals from the Coast of Scotland.—Annals of Natural History, vol. xv. p. 380.

tinctly developed tentacula, in which particular, and in other respects, it has a great resemblance to the pedicellina of Sars. It differs from vorticella and pedicellina, however, in the want of an alimentary tube and anus; having only an oral aperture, like a hydroid polyp, to which it would appear to be nearly allied.

The individuals examined were from five to six inches in length, including the head, which was about an inch. The head was half, the peduncle one-eighth of an inch in diameter.[1] (*Fig.* 1.) The oral surface of the head is truncated, concave towards the centre, where the mouth appears as a linear slit. The lips are thick, rounded, and fleshy, with ridges and intervening furrows at regular intervals. A double row of long fleshy papillae also surrounds the mouth, and the integument, where it covers the lips, presents the aspect of a mucous membrane; but over the rest of its extent it has a very different appearance, being reticulated like the surface of a delicate flustra. Several rows of fleshy papillae surround the head, somewhat nearer its oral than its peduncular extremity. These papillae can be distinctly seen only on one side of the head, being apparently obsolete on the other. Numerous clavate horny spines are attached to the lower half of the peduncle; and a few of them may be seen nearer the head.

Integument.—The integumentary membrane is an extremely beautiful object, consisting of a thin reticular structure of considerable strength, with its external surface of a metallic lustre. Magnified, it much resembles muslin; its fibres crossing one another at right angles in a most regular manner. Numerous lines appear on it at equal distances, the membrane looking as if thrown into folds; or its fibres to be more thickly interwoven, as in a seam. This would appear to be an arrangement for admitting of the extension of the membrane when the head is distended by food or water, for these folds do not exist in the integument of the peduncle. A number of small, clear, circular discs are also visible on the integumentary covering of

[1] A dissected specimen is deposited in the series of Comparative Anatomy in the Museum of the University of Edinburgh.

the head. In the centres of these discs are minute dark coloured spots, which resembled apertures. The papillae which encircle the mouth, and the similar processes which surround the body, have a general resemblance to integumentary appendages; but, as will be shown in the sequel, must probably be referred to other systems, being merely covered by the skin.

The horny spines already alluded to are, however, developments from the integument. They are scattered irregularly over the basal extremity of the peduncle, and appear to be merely organs of defence. Their length somewhat exceeds one-eighth of an inch. They are club-shaped, or conical with their apices attached, and an open conical pit hollowed out in their free extremities; and when magnified, they exhibit an external layer of longitudinally striated texture; then a concentrically laminated structure; and internally, a light-coloured substance, like the pith of a quill, slightly marked across its axis, and bulging considerably about its middle. The external and intermediate layers have a horny consistence and appearance; the former apparently cuticular. The external laminæ of the latter are the largest, and therefore, probably, the first formed from the surface of the enclosed conical pulp. These spines are firmly connected to the skin, and are extracted with difficulty, but do not appear to have any muscular fasciculi attached to their basal extremities.

Internal Membrane.—A very delicate, opaque, flocculent membrane lines the internal surface of the integumentary covering of the head and peduncle, floating loosely within it, and enveloping the deeper structures. It originates from around the oral extremity of the gastric bulb, from between which and the skin it extends downwards into the peduncle. As already stated, this membrane floats free within the integument. This, however, is probably the result of incipient putrefaction or mechanical injury; and subsequent examination will, I think, prove that its external surface is loosely attached, by delicate connecting texture, to the internal surface of the skin. Its internal surface is free, and forms the outer wall of a space which exists between it and the outside of the gastric bulb, with the membrane covering which, the internal membrane now under consideration appears to be continuous. This space or cavity communicates with the exterior by an orifice, to be afterwards described, in the fundus of the stomach, and appears to be of the same nature as the extended cavity which exists around the stomach, and in the axis of the helianthoid and asteroid polyps. The contents of this cavity consist of irregular masses of soft granular matter resembling mucus.

When this cavity is laid open, and the gastric bulb turned out, which is easily effected, as it is only suspended by its oral extremity, a small tubercle is observed at the fold formed by the reflection of the internal membrane upon the outside of the gastric bulb. This tubercle is situated immediately within and beneath the lips. A central depression but no distinct aperture could be detected in it.

Organs of Digestion.—The alimentary apparatus in this animal, as in the polyps, consists of a gastric cavity. When the internal membrane already described is divided, a bulbous mass, which contains the gastric cavity, is seen lying loose within it, suspended freely by its oral extremity. Viewed in its natural position, it has a considerable resemblance to, and is about the size of a date stone. The pyloric orifice is very perceptible at its free extremity, as large as the head of a pin, circular, with numerous radiating folds. One of the blades of a pair of scissors having been introduced through the mouth into the gastric cavity, then through the pylorus, so as to lay the cavity open, it may be observed that the external integument passing into and lining the cavity, leaves it through the pyloric aperture, and proceeding in the direction of the mouth, closely adheres to and covers the external surface of the gastric bulb. It appears to be again reflected, as has already been stated, at the junction of the gastric apparatus with the integument, passing on to be continuous with the internal membrane described above. The gastric cavity has four walls, with an internal membrane, white, thick, and spongy, assuming a coarsely fibrous texture and a metallic lustre, often passing beyond the pyloric orifice upon the outside of the gastric bulb. Two dark brown, hard, horny teeth, of a compressed, conical, recurved form, are situated, one in each of two diagonal corners of the quadrilateral gastric cavity, a little way within the internal edge of the mouth. The papillae which encircle the middle region of the head possess a structure which inclines me to believe that they constitute a hepatic apparatus, although I have failed in detecting any communication between them and the gastric cavity, or the space in which the gastric bulb is suspended. Immediately under the integumentary covering ot these papillae is a delicate membrane, in which are situated numerous elliptical spots, with their extremities produced and pointed. At the free extremity of the papilla, in or within the delicate membrane, is a large clear cell or nucleus; beyond which, in the body of the papilla, are numerous smaller cells, in and around which is an oleaginous fluid resembling bile.

If the cavities of these papillae communicate with the space in which the gastric apparatus is suspended, although differing in form, their morphological position and connexion would indicate a similarity to the glandular fringes on the free margins of the meso-gastric folds of the asteroid polyps.

Organs of Reproduction.—The papillae which surround the mouth appear to contain the ovaries, or to constitute ovarian appendages, as in the tubularian polyps. Each papilla contains a mass of cells in various stages of development, the extremity presenting a clear spot similar to those in the presumed hepatic papillae.

On the external surfaces of the four sides of the gastric cavity, and covered by the membrane reflected upwards from the pyloric orifice, are four elongated masses, each divided longitudinally by a line or impression on its external surface. Each mass consists of a double series of transverse plates, connected in the middle by a longitudinal septum proceeding from the investing membrane, and the edge of which is indicated by the longitudinal line or impression already described on the external surface of the mass. These plates consist of numerous tubes, which contain minute cellules. The tubular masses are white, and do not present the structure or aspect of hepatic organs; and as they may be presumed to open into the cavity around the stomach, into which also it is probable, from their structure, the supposed ovarian papillae empty themselves, I am inclined to consider those four double masses as male organs. This hypothesis is supported by the arrangement of the reproductive organs in the asteroid and helianthoid polyps.

Explanation of Plate II.

Fig. 1. Forbesia formosa of the natural size.

Fig. 2. The external integument laid open, to show the internal membrane, and the parts contained within it. *a* the external integument of the head laid over; *b* the external integument of the peduncle laid over; *c* the internal membrane passing down from off the gastric bulb and (testes ?) into the peduncle; *d* the gastric bulb; *e* the oral aperture; *f* the pyloric orifice; *g* the inferior papillae; *h* the superior papillae.

Fig. 3. The internal membrane laid open, and the gastric bulb turned up to expose the space within the membrane in which it is suspended. *a* the gastric bulb; *b* the pyloric orifice; *c* the tubercle, with a central depression on one side of the oral fold of the internal membrane; *d* the external integument; *e* a mass of mucus contained in the cavity of the internal membrane; *f* the internal membrane.

Fig. 4. The microscopic structure of the membrane which invests the gastric bulb and (testes ?), and is continued through the pyloric orifice from the lining membrane of the gastric cavity.

Fig. 5. The gastric bulb removed, and a portion of the investing membrane turned down to exhibit one of the four double packets of tubular laminæ, (testes ?). *a* the oral aperture; *b* the oral papillae; *c* the investing membrane; *d d* one of the four double packets of tubular laminæ, divided longitudinally by a septum which passes in from the investing membrane; *e* the pyloric orifice; *f* a portion of the investing membrane turned down, showing the line of detachment of the longitudinal septum, and smaller transverse markings on the surface opposed to the (testes ?).

Fig. 6. The gastric bulb laid open, to show the internal surface of its cavity. *a* the oral papillae; *b* the oral aperture laid open; *c* the external integument; *d* the internal surface of the cavity divided longitudinally by four corners into four surfaces, like the walls of a room; *e e* two conical compressed dark brown horny teeth, situated in two of the diagonally opposite corners of the cavity, about a third of its length from the oral aperture; *f* the pyloric orifice, with its radiating folds.

Fig. 7. A portion of the external integument magnified.

Fig. 8. Minute nucleated spots on the surface of the integument.

Fig. 9. The lining membrane of the gastric cavity magnified.

Fig. 10. A portion of the integument of the head magnified to show the folds, which are probably useful in allowing the distention of the head by food or water.

Fig. 11. One of the oral papillae magnified to show its structure. *a* the free extremity of the papilla, within which is seen a clear space or nucleus, surrounded by *b* a cell-wall; *c* the integument of the papilla; *d d* ova (?) in various stages; *e* attached extremity of the papilla.

Fig. 12. One of the papillae which surround the head magnified. *a* its free extremity; *b* cellular structure, probably hepatic; *c* attached extremity; *d* delicate membrane with elliptical spots under the integument which covers the papilla; *e* peculiar bodies in the integument represented in

Fig. 13, and apparently of the same nature as those represented in Fig. 8.

Fig. 14. The extremity of a (hepatic ?) papilla more highly magnified.

Fig. 15. The tubular structure of the (testes ?) magnified.

Fig. 16. One of the clavate, horny spines attached to the external integument magnified. *a* its free extremity, which is hollow; *b* depth to which the cavity proceeds; *c* the attached extremity; *d* the integument.

Fig. 17. The pulp of the spine.

Fig. 18. A portion of the integument and internal membrane magnified; the spots on the former are here very distinct; the fibres of the latter are probably contractile or muscular.

III.—*An Account of some Monstrosities.* By the late Dr. John Reid, Chandos Professor of Medicine and Anatomy in the University of St. Andrews.—(Communicated by the Author in the summer of 1849, shortly before his death.)

I received several years ago from the late Dr. Mackintosh the head of a lamb, from which the skin had been removed, presenting a very rare kind of monstrosity. (*Fig.* 1.) The upper part of the skull was normal, with the exception of being somewhat narrower than usual; the olfactory apparatus was present; the eyes placed close to each other, and apparently upon the base of the skull, not separated by any osseous or membranous partition, but of their usual size, were perfectly well formed, and surrounded by their usual muscles. The greater number of the bones of the face were absent; there was no mouth or tongue, but a small transverse opening, (*Fig.* 1, *o*,) nearly shut up by a membrane, with a curved slip of bone crossing it in the vertical direction, communicated with the pharynx and larynx. This opening passed above the curved bone,

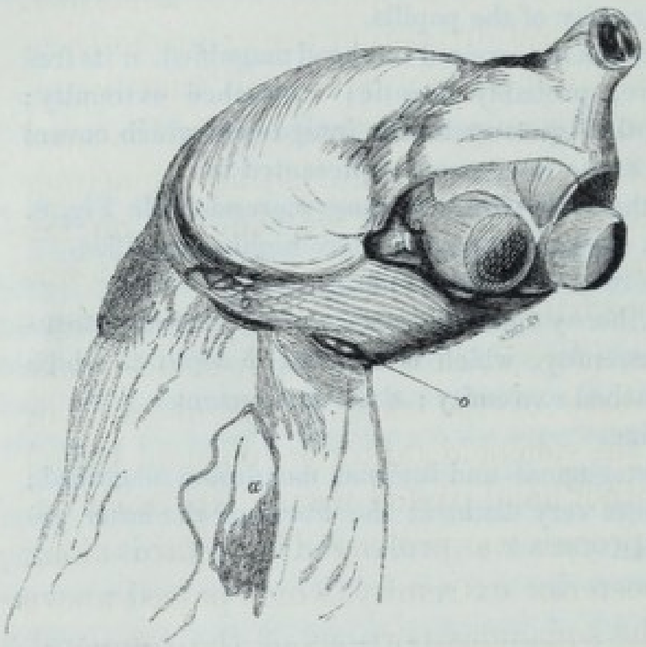


Fig. 1.

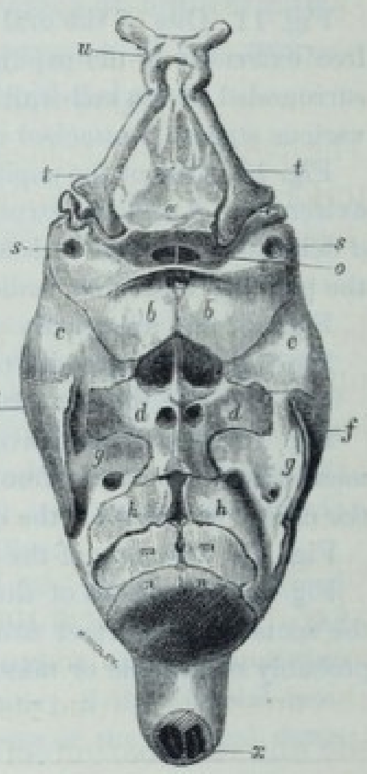


Fig. 2.

and the walls of the pharynx were puckered around it. The pharynx was considerably dilated; and if it had been distended by fluid, this had probably escaped by an incision into the pharynx, (*Fig.* 1, *a*,) made in removing the skin.[1] None of the parts about the isthmus faucium or the openings of the eustachian tubes could be discovered. The brain was normal, and all the encephalic nerves were present. The olfactories, the optic, and the motor nerves of the muscles of the eye-ball, were of their usual size, but the fifth pair and the hypo-glossal

[1] Otto, at page 19 of the introduction to his Monstrorum Sexcentorum Descriptio Anatomica, Vratislavia, 1841, places among the characters of the genus of monstrous organisms, which he terms monstra agenya, or monsters without the maxilla, (from the privative α and γένυς maxilla,) the following "fauces liquore mucoso in magnam strumam sive ingluviem extensae, in qua linguae rudimentum et tubarum eustachianarum aperturae existant." The free communication of the pharynx with the larynx and œsophagus renders it improbable that the dilatation of the pharynx in this case, was dependent upon the effusion of a fluid into it.

were considerably less than usual. The deviation of the bones of the head from the normal structure will be best understood by an examination of a representation of the base of the skull given in *Fig.* 2. All the bones which enter into the formation of the cranium, were present, but two of these, viz., the sphenoid and the temporal, were abnormal. The posterior or spheno-temporal division of the sphenoid (posterior sphenoid bone) was so imperfectly developed that it consisted of a small central portion only, articulated behind as usual with the basilar process of the occipital bone, but having neither larger wings nor pterygoid processes. It was smooth on the upper surface, having no posterior clinoid processes. It was enclosed below by the approximation of the squamous portions of the two temporal bones, (*Fig.* 2, *b b*,) so that it could not be seen by looking at the base of the skull. The anterior or spheno-orbital portion of the sphenoid (anterior sphenoid bone,) (*Fig.* 2, *d d*,) had on the other hand passed through its usual development, and a narrow process was prolonged backwards along the mesial line from its posterior extremity, which passed above the anterior margin of the squamous portions of the temporal, (*Fig.* 2, *b b*,) and united itself through the medium of cartilage to the anterior extremity of the small central portion of the posterior sphenoid. On each side of this slip of bone there was a pretty large opening into the interior of the cranium, bounded anteriorly by the anterior sphenoid, (*Fig.* 2, *d*,) externally by the parietal bone, (*Fig.* 2, *c*,) and posteriorly by the temporal, (*Fig.* 2, *b*.) Through this opening the motor nerves of the muscles of the eye-ball, and the whole of the fifth issued from the interior of the cranium. The optic foramina, (*Fig.* 2, *d*,) placed immediately in front of these larger openings, presented their usual appearance. The external orifices of the ear (*Fig.* 2, *s s*) were not approximated, as is so frequently the case when the jaws are wanting or are imperfectly developed, but the squamous portions of the temporal bones (*Fig.* 2, *b b*) were thrown inwards, passed below the small central portion of the posterior sphenoid, and met each other at the mesial line. The zygomatic arch of each temporal bone was narrow, and fused to the external surface of the squamous portion of the temporal for the greater part of its length, and instead of passing forward, proceeded directly across to meet its fellow of the opposite side at the mesial line, where no suture marked their junction. Placed immediately behind the junction of the true zygomatic arches of the temporal bones, at the mesial line, was the orifice opening into the pharynx seen before the commencement of the dissection. (*Fig.* 1, *o.*) This orifice was bounded on the sides and below by a short and pretty strong curved portion of bone, (*Fig.* 2, *o*,) articulated by a moveable joint with the two temporal bones, immediately behind the roots of the zygomatic processes, and which from its position and connexions appears to be a rudimentary inferior maxilla. A small slip of bone lying in the mesial line, and moveably connected above to the lower surface of the basilar process of the occipital, proceeded across this opening to reach the rudimentary inferior maxilla, to which it was only attached by soft parts. The styloid processes of the temporal (*Fig.* 2, *t t*) which were articulated immediately posterior and external to the articulations of the rudimentary lower jaw, were of their proper size and form, and proceeded downwards to be connected in the usual manner to the hyoid bone. (*Fig.* 2, *u.*) The portion of the walls of the orbital cavities formed by the orbital portion of the frontal (*Fig.* 2, *g*) and orbital plate of the sphenoid was present, but that portion formed by the superior maxilla and malar bones was absent, and there was no septum composed of the pterygoid processes of the sphenoid, and the ascending plates of the palatine bones separating these two cavities from each other. Immediately in front of the anterior sphenoid there was a space (*Fig.* 2, *h*) formed by membrane, and shutting in the cavities of the nostrils from behind; and exactly in front of this were two thin plates of bone on each side, meeting their fellows of the opposite side at the mesial line. (*Fig.* 2, *m*, *n.*) The anterior of those, which was considerably larger than the other, curved upwards in front and on its external edge to reach the cartilages of the nostril, the nasal bones, and anterior extremity of the frontal.

The arrested formation of several of the bones of the face, the arrested development of others of the face, and of one of the skull, and the consequent approximation and fusion of similar parts of the two sides of the body normally separated from each other, furnish, as in similar examples of monstrosity, a sufficient explanation of the appearances presented in this particular case. The atrophied condition of the face caused the eyes to be approximated, and to be placed apparently on the base of the skull. The arrested development of the posterior sphenoid bone led to the approximation of the squamous portions of the temporal bones, and the fusion of the anterior extremities of their zygomatic processes,—affording a good illustration of Geoffroy Saint-Hilaire's well-known law of the "*affinité de soi pour soi.*" In a case of imperfect development of the posterior sphenoid bone (sphenocephalus) described by Isidore G. Saint-Hilaire, the tympanic portions of the temporal bones were fused together at the centre, so that there was only one meatus auditorius externus, and one tympanic cavity. In this case the mouth was present, though smaller than usual, and the eyes were separated from each other by an osseous partition.[1]

As far as I have been able to ascertain, only three cases of this kind of monstrosity have been hitherto recorded, and they have all been observed in lambs. Ruysch has given the representation of the head of a lamb which must have borne a close resemblance to the one here described before the skin was removed;[2] but the following brief notices contain all the information he has left regarding it: "Caput fœtus ovini sine ore nati, uteroque excisi. Oculi extra situm naturalem positi, sine ullo oris vestigio, omnia autem membra bene erant conformata."[3] "Caput fœtus ovini deforme et ore destitutum, vel sine ore formatum."[4] M. Isidore G. Saint-Hilaire has given a representation of the external parts of the dissected head of a lamb exhibiting this kind of monstrosity.[5] It differs from that of

[1] Histoire Générale et Particulière des Anomalies de l'Organisation chez l'Homme et les Animaux, tome ii. p. 423. Paris, 1836.

[2] Thesaurus Anatomicus Quartus, Tab. I. Fig. 4. Amstelodami, 1704.

[3] Opus cit., description of preparation, No. 55.

[4] Opus cit., description of Fig. 4. Tab. I.

[5] Opus supra cit. ([1]), planche vii. d'Atlas, fig. 5.

Ruysch, and from that I have described above, in having the organs of hearing approximated as in the genus of monstrosity which he has named otocephalus. He justly observes, that the remarkable deviations from the normal structure which the head in this kind of monstrosity presents, gives it at first the appearance of being reversed, the eyes and the ears which are normally at its upper being placed at the lower part. The justiçe of this remark appears very obvious in looking at the representation given by Ruysch. It is this singular appearance which led Isidore Saint-Hilaire to bestow upon this kind of monstrosity the name of strophocephalus (from *στροφὴ*, versio, and *κεφαλὴ*, caput.)[1] Otto[2] has given the representation of the external appearance of the head of a lamb very similar to that furnished by Isidore Saint-Hilaire. He has placed it in his genus of monstra agenya. In this specimen the organs of hearing had coalesced, and the optic nerves which were at first united passed through a single opening in the dura mater, and then divided to proceed to the two eyes placed close to each other. The fifth pair of nerves was less by one-half than natural. In none of these cases is the condition of the bones of the head described, so that the above account, as far as I am aware, contains the only description of the state of these parts, in this particular kind of monstrosity, on record.

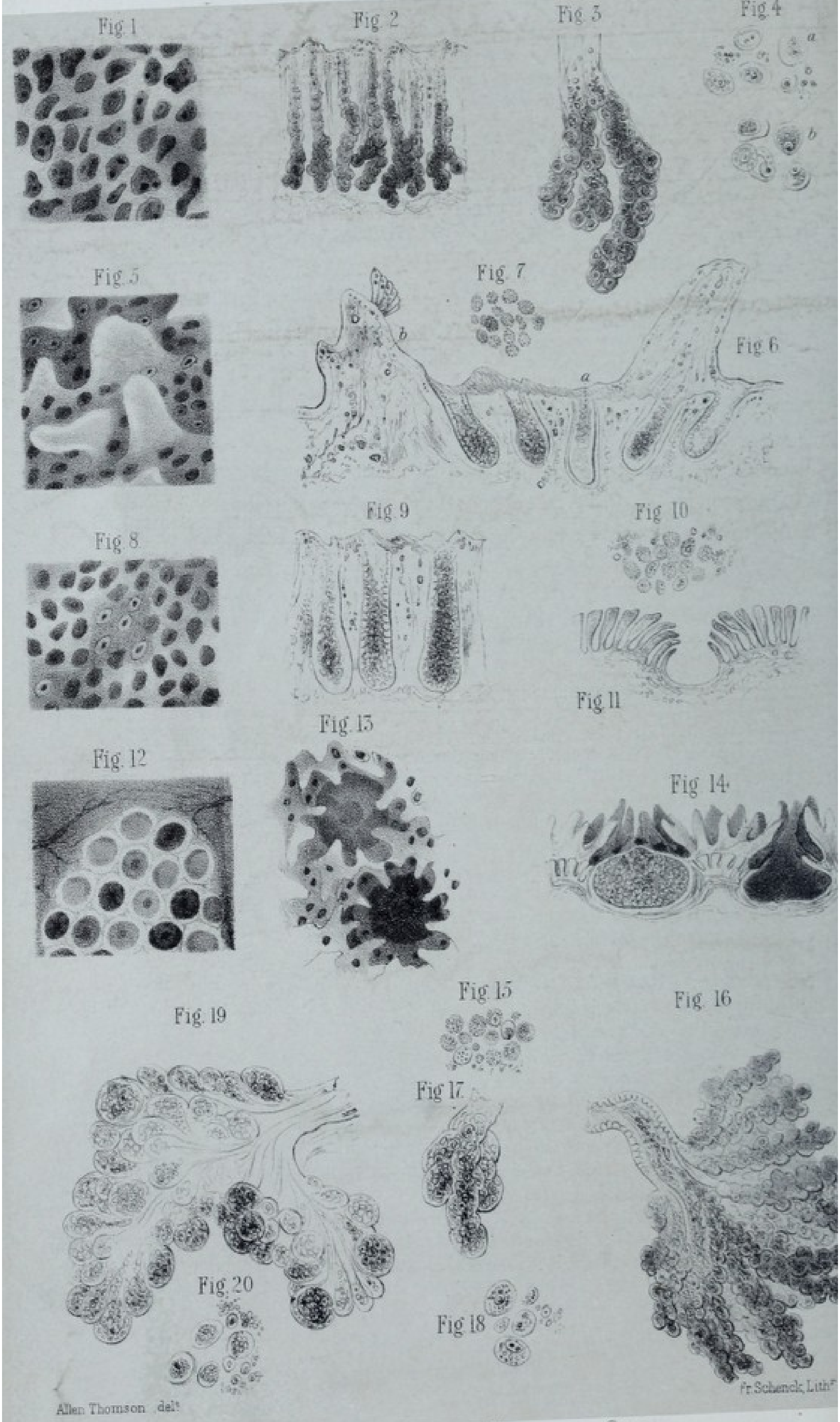
Description of the Figures.

Fig. 1. Representation of the lower surface of the head as it came into my possession. *a* artificial opening made into the pharynx; *o* opening which passed above a rudimentary lower jaw into the pharynx.

Fig. 2. Representation of the lower surface of the skull. *a* occipital bone; *b b* temporal bones; *c c* parietal; *d d* anterior sphenoid bone; *ff* frontal bone; *g g* orbital plates of the frontal bones; *h h* membrane closing in the nostrils from behind; *m m n n* two thin plates of bone forming the floor of nostrils; *o* rudimentary inferior maxilla; *s s* external orifices of the organs of hearing; *t t* styloid processes of the temporal bones; *u* hyoid bone; *x* nostrils.

[1] Opus supra cit., tome ii., footnote, pp. 424, 425.

[2] Monstrorum Sexcentorum Descriptio Anatomica, Tab. III, fig. 2. 1841.



Glands of the Alimentary Canal

IV.—*On the Structure of the Glands of the Alimentary Canal.* By Allen Thomson, M.D., F.R.C.S.E., F.R.SS. Lond. and Edin., and Professor of Anatomy in the University of Glasgow.—(Communicated by the Author.)

(Plate III.)

The minute and extended secretory apparatus contained in the mucous membrane of the alimentary canal presents considerable variety of structure, and is of great interest in relation both to the natural process of digestion and to the pathological changes to which that function is liable. The different parts of this apparatus have in recent years been subjected to careful examination by most able observers,[1] but as yet without leading to a complete knowledge of their structure and uses. There

[1] The following references to works on the intestinal glands and mucous membrane will serve to indicate in some measure the sources of information and progress of investigation on this subject :—

J. C. Peyer, Exercit. Anat. de Gland. Intestin. Shafhausen, 1677.
J. C. Brunner, de Gland. in Intestino Duodeno Detect. Heidelberg, 1687.
J. N. Lieberkühn, de Fab. et Act. Villorum Intestin. Leyden, 1745, and Lond. 1782.
R. A. Hedwig, Disquis. Ampull. Lieberkühn. &c. Leipzig, 1797.
Rudolphi, Anat. Physiol. Abhandl. Berlin, 1802.
E. H. Weber, in Meckel's Archiv., 1827 ; and Entfaltung der Drüsengebilde, 1828.
J. Müller, Comment. de Gland. Secern. Struct. Penit. Berol. 1830.
Boehm, de Gland. Intestin. Struct. Penit. Berol, 1835, and also of the same author, Die Kranke Darmschleimhaut in Asiat. Cholera. Berlin, 1838.
Sprott Boyd, in Edin. Med. and Surg. Journ. 1836.
Henle, Symb. ad Villor. Intestin. Hist. 1837.
Bischoff, in Müller's Archiv. 1838, p. 513.
Purkinje, Bericht d. Naturf. in Prag. Isis, 1838.
A. Anderson, in Medical Gazette. 1838.
Krause, in Müller's Archiv. 1837 and 1839.
Wasmann, Dissert. nonnulla de Digestione, &c. 1839.
Pappenheim, Zur Kenntniss der Verdauung, &c. Berlin, 1839.
Todd, in Medical Gazette. 1839.
Müller's Physiology by Baly, and Notes by the latter, vol. i. p. 583, &c. 1840.
Allen Thomson, in Report of Brit. Assoc., 1840, p. 149.
Henle, Allgemeine Anatomie. 1841.
Bowman, in Article "Mucous Membrane" in Todd's Cyclopædia. 1842.
Huschke, Splanchnologie. 1845.
John Goodsir, Anat. and Path. Observations. Edinburgh, 1845.
Sharpey, in Quain's Anat. p. ccxcvii. and p. 1025, &c. 1848.
Frerichs, Article Verdauung in Wagner's Handworterbuch der Physiol. 1849.

are several difficulties opposed to the accurate investigation of the mucous glands of the alimentary canal. In addition to their small size and the softness of their texture, their great tendency to have their appearance rapidly altered after death, and their liability during life to change from age and long continued disease are among the most important. A satisfactory examination of these glands can in general, therefore, be made only in specimens which are quite recent, and which have been procured from the bodies of young persons, and from those who have died suddenly either from accident or from some disease proving rapidly or immediately fatal.

Since the year 1839, when the completion of the discovery of the cellular nature of many of the textures gave to the study of histology the greatest impulse it has received in recent times, I have been repeatedly occupied with the examination of the minute glands of the alimentary canal. In the year 1840, I laid before the meeting of the British Association, held at Glasgow, an account of some researches I had then made on this subject, and a brief notice of my paper was inserted in the Report of the Transactions of the Association for that year. I abstained from publishing a more detailed account of the observations, because of their being at that time incomplete. The learned Editor of these Annals having expressed a wish that I should now communicate my observations on the subject in this Journal, I have revised them in so far as my present limited time and opportunities permit, and I now offer some of them with great diffidence, as a contribution to the history of this extended secretory apparatus; the full and accurate investigation of which, from the circumstances already alluded to, requires the most entire leisure, together with the most favourable specimens and methods of observation.

In the paper laid before the meeting of the British Association in 1840, besides a general description of the structure of the mucous membrane of the alimentary canal and of its various glandular bodies, the following facts were more particularly dwelt upon as resulting from my observations.

1. That the vesicles which constitute the aggregated form of

Peyer's glands not unfrequently exhibit openings, so distinct, and occurring under such determinate circumstances, as to warrant the belief that they are the natural way by which the secreted contents of these vesicles are discharged. These apertures I observed frequently in the pig, sheep, horse, and some other animals, and occasionally in the adult human subject—but not in the young. The openings, which on the small scale might be compared to the pupil in the iris, are visible with the unassisted eye, and more easily with a hand-lens; and the vesicles in which they are seen, are either completely or partially empty of the granular matter with which the closed ones are filled. In the pig, in which the greatest number of observations were made, it was found that in some patches no open vesicles were to be detected; while in others, almost all were open and empty; and in a third set, open and closed vesicles were irregularly placed together in the same patch.

The open vesicles were observed more frequently in the ileum than in the upper part of the intestine, and it appeared to be in those parts of the intestine which contained the more fluid, dark-coloured and bilious matter, that the open vesicles were almost invariably found; while in those parts of the gut which contained a light-coloured chymous or chylous mass, which were more contracted, and in which the coats appeared thickened by the imbibition of the chyle, the vesicles were all closed and full of their usual contents.

I considered these observations, which confirmed those made by Krause and others, as not only of interest in regard to the explanation of the secretory function of these vesicular glands, but as also bearing in an important manner on the then recently produced views of the nature of the process of secretion in general; as they tended to shew, that in some forms of glands, the closed condition of the secretory vesicles most commonly prevailed, and that the open state was of rarer occurrence.

2. I had farther observed that the solitary glands, or larger follicles, of the colon, which are almost always open in the adult, are, at the period of birth, all closed by a thin bulging film of membrane, which gives them the form of true vesicles:

and that as the early age of the infant advances, more and more of these follicles assume the permanently open condition: but even after the age of two years, I occasionally found some of the follicles still closed, or presenting the vesicular form.

3. My observations also led me to believe that the gastric follicular glands have at an early period of life the same closed condition. By these I do not mean the thick set and more numerous tubular glands of which the whole thickness of the gastric mucous membrane may be said to be composed, but the more sparsely distributed shallow pits or follicles, about 1-20th of an inch in diameter, which are sometimes seen studding the greater part of the gastric mucous membrane.

Considerable difference of opinion has existed among anatomists and pathologists, as to whether this appearance of scattered follicles over the gastric mucous membrane is natural or not. I conceived that I had shewn by the examination of persons of different ages, who died suddenly or from acute diseases, not involving any morbid state of the alimentary canal, that the existence of these follicles over nearly the whole surface of the stomach, is most probably the natural condition; and I had reason to believe that the representations given by several authors of enlarged and ulcerated gastric follicles were not fallacious, but were those of true examples of morbid alterations of these scattered, or so called solitary glands of the stomach.[1]

I also observed that these scattered follicular glands of the stomach were closed in the form of vesicles in early life. This I found to be the case in the stomach of a child of eight months old; and still more remarkably in the pig, two or three weeks after birth. In this animal, the gastric follicular glands, which are chiefly to be found in the cardiac portion of the stomach, numerously spread over the mucous membrane near the border of the thick laminated epithelium, which extends for some way into the stomach from the œsophagus, are formed of compound or sacculated follicles; and it was therefore peculiarly interesting to find that in their early and simpler condition they had, like those of the large intestine, the form of closed vesicles. In

[1] As by Roederer and Wagler, Cruveilhier and others.

the stomach of the pig of between two and three weeks old, only two of the gastric follicles had become open, all the others, which were numerous, still retained the closed or vesicular condition. In the stomach of the human infant of sixteen months old, a few of the gastric follicles were observed still to be closed, but the greater number were then open.

I had also noticed repeatedly the occurrence in adult life in the human stomach, and more rarely in the large intestine, of small clear vesicles, on various parts of the surface of the mucous membrane, an appearance previously observed by Boehm, Bischoff, and Henle. I was doubtful whether these vesicles were identical with the closed follicles, to which they have by some been compared; but I thought that I had occasionally perceived a few of the solitary follicles, both of the stomach and colon, exhibiting the closed condition even in the adult human subject. More recent observations have not enabled me to determine this point; but I am inclined to doubt the propriety of comparing these vesicles to the lenticular or vesicular glands, such as those of Peyer, as has recently been done by Frerichs in the article Verdauung of Wagner's Handworterbuch der Physiologie. To this article I would refer, however, as containing a short but most accurate account of the structure of the glandular apparatus of the alimentary canal, with which the greater part of my observations very closely coincide. I have not had an opportunity of seeing a more extended account of researches on this subject by Drs. Frerichs and Frey, to which the former refers in a note at p. 742 of his article on Digestion.

More recent observations by others and by myself, enable me now to correct and to modify in some particulars, the description I previously gave of these glands, and to render our knowledge of them somewhat more precise.

Some ambiguity prevails as to the nomenclature of the minute glands and their parts, in consequence of the various use that has been made by different authors of the terms follicle, crypt, saccule, lacuna, vesicle, cell and others. The words vesicle, follicle, tube or tubule, and raceme or cluster, appear sufficiently descriptive and precise, when taken in their ordinary signification, to warrant their employment for the purpose of distinguishing the principal forms of glands occurring in the alimentary canal, under the four heads of Vesicular, Follicular, Tubular, and Racemose Glands. The following is an enumeration of the various glandular structures, to the number of ten, which may be brought under this fourfold classification :—

I. Vesicular; composed of entire vesicles (or small bladders); usually closed.

1. Aggregated glands of Peyer in the small intestine.
2. Solitary ditto.
3. An occasional state of the next mentioned glands.

II. Follicular; forming small bags or cavities; usually open pits.

1. Of the large intestine ; constant.
2. Of the stomach ; frequent but not constant.

III. Tubular ; composed of membranous tubes, closed at the remote ends, and usually simple.

1. Of the small intestine : Follicles of Lieberkühn.
2. Of the large intestine.
3. Of the stomach.

IV. Racemose ; tubes, simple or sacculated, (and vesicles,) arranged in clusters round a central stalk or duct.

1. Cardiac-œsophageal.
2. Duodenal of Brunner.

In this enumeration of the stomachal and intestinal glands, there is in some measure a progression from the simpler to the more complex ; for the single and distinct vesicles of which the solitary and aggregated kinds of Peyer's glands consist (*Figs.* 12, 13, and 14) may be regarded as the most elementary form of enclosing cavity for a glandular secreting organ. The follicles, mentioned in the second place, consisting in their simplest form of mere depressions of the surface of the mucous texture, (*Fig.* 11,) have originally been, according to what I have previously stated, in the condition of closed vesicles,—a condition which some of them continue occasionally to exhibit in adult life. The tubes, which are placed in the third order, consist in deeper and more cylindrical inflections of the proper or basement membrane of the mucous texture, of great delicacy, and of variable form and extent. This is the form of minute glands now so well known to occupy the whole of the mucous membrane from the cardia to the anus, and which are so thickly set as to appear on a superficial examination to constitute the whole of its substance. The tubules of the large intestine, (*Figs.* 8 and 9,) are longer than those of the small intestine, (*Figs.* 5 and 6,) and those of the stomach, besides being considerably larger than either, are also more complicated, exhibiting frequently a sacculated, and occasionally, though rarely, a subdivision or simple ramification at their remote extremities. (*Figs.* 1, 2, and 3, in which, however, this appearance is more marked than usual.) The gastric tubular glands thus form in some sort a transition to the fourth set, in which the clustering or collecting together of ramified and sacculated tubes, (*Figs.* 16 and 17,) or of pediculated vesicles, (*Fig.* 19,) constitutes the essential character. The last mentioned form, which occurs in Brunner's glands, bears a close resemblance to the structure of the pancreas, salivary, and other compound racemose glands; but the amount of dilatation of the ends of the tubes varies to a great extent in different glands.

In the minute tubular glands of the small and large intestine, in those of the stomach, and in the racemose glands of the cardia and duodenum, the basement membrane, which constitutes the delicate walls of the tubular and sacculated cavities within the glands, is nearly homogeneous, slightly studded with nuclei or small dark particles of variable size, and presenting altogether an appearance not very dissimilar from the continuous parts of the mucous membrane itself. The membrane composing the wall of the vesicles of Peyer's glands, on the other hand, and also that of the bottom of the follicles of the large intestine, is considerably thicker than that of the tubular and racemose glands, and differs from it likewise in its more granular aspect and in its close incorporation at the lower part with the subjacent filamentous tissue. The follicular glands of the stomach appear to consist merely of depressions among the tubes in the otherwise unchanged mucous membrane. In that state of the gastric and large-intestinal follicles in which they present the so-called *lenticular* or closed vesicular form, the closing film, which is of extreme delicacy and great clearness, seems to be a completely homogeneous or structureless membrane.

The columnar epithelium, which everywhere invests the surface of the mucous membrane, extends for some way into the interior of the follicular, tubular, and racemose glands; but no true lining of this kind, different from their secreted contents, exists in the vesicular glands: indeed, these last are probably to be looked upon rather as a modification of parent secreting cells, than as true glandular cavities.

The secreted product of all these glands, presenting to the naked eye the appearance of a greyish, grumous, semifluid mass, exhibits, when viewed with the microscope, a variety of cells mixed with globules, granules, and molecules of various size. The cells contained in the vesicles of Peyer's glands, and in the mucous tubules of the small and large intestine, appear in general to be considerably smaller and more granular in their aspect than those of the tubular gastric, or of the racemose cardiac and duodenal glands. (Compare *figs*, 7, 10, and 15, with *figs.* 4, 18, and 20.) The following are the average results in parts of an inch of a few measurements I have made of the size of the cellular contents of these glands in the human subject:—

Gastric tubular glands, 1-1500th to 1-1200th.
Cardiac-œsophageal racemose glands, 1-1600th.
Brunner's duodenal glands, 1-2000th to 1-1700th.
Aggregate Peyer's glands, 1-2500th to 1-2000th.
Tubular glands of the colon, 1-2500th.
Tubular glands of the jejunum, 1-3000th to 1-2800th.

In the vesicles of Peyer's glands, there is great uniformity in the appearance of the cellular contents; in these and in the tubular glands of the small and large intestines, the cells present very generally a granular aspect; but in the latter they are sometimes mixed with larger and more distinct cells and a quantity of smaller molecules.

In the tubular gastric glands, and in the racemose cardiac and duodenal glands, the larger cells which prevail, exhibit for the most part a distinct external wall, with one or more internal cells, sometimes clear, at other times granular, with nuclei and nucleoli of various appearance.

In the healthy gastric glands, these cells are, during the intervals of digestion, accumulated in considerable quantity in the tubes, so as to cause the membrane of the tubes to bulge out at somewhat regular intervals, and thus to give them the sacculated appearance represented in *Figs.* 2 and 3. In the human stomach, but more especially in that of the dog, cat, and pig, I have frequently seen these cells placed more closely in contact with the basement membrane of the tubes, while the central part was occupied by a mass of smaller cells and granules. These gastric cells are poured out in large quantity on the surface of the mucous membrane during digestion, and may also be frequently seen to exude anew after death, being united by imbibed water so as to form a layer of substance, indefinitely termed mucus, which has often been noticed covering the inner surface of the stomach. The microscopic examination of this layer sometimes affords a most interesting view of the gastric cells in all stages of development or decadence; smaller cells existing within the larger ones to the second and third progeny; and thus very probably furnishing, as Frerichs suggests, the source of that ferment, or analogous matter, which, along with the acid ingredient of the gastric fluid, is essential to the solvent action of stomachal digestion.

In the racemose kinds of glands previously adverted to, a somewhat similar arrangement of the secreted cells is observed. In the duodenal glands, I thought I could perceive in some terminal ducts, the gland-cells enclosed within a vesicular membrane or large cell, of the same size with the dilated ends of the ducts; but this would require farther confirmation.

The limited form of this communication makes it necessary for me to conclude. I beg leave for the present to refer the reader to the description of the Plate for some farther details as to the structure of these glands, and should it appear desirable, I may hereafter continue the account of my observations in regard to them. With the general knowledge that has now been obtained of the distribution and structure of these glands, it seems desirable that hereafter more exact and extended researches should be made with reference to their variations in different circumstances, according to the state of general health of the individual, the age, the period of digestion or fasting, the contents of the alimentary canal, and the food or habits of various animals in which they may be examined, with a view to the more just physiological and pathological application of the information derived from the study of their structure.

Description of Plate III.

Fig. 1. Small portion of the mucous membrane of the human stomach from the middle part, showing the shallow alveolar pits, and in some of these the apertures of the tubular glands: from an epileptic who died suddenly when in good bodily health;—magnified 30 diameters.

Fig. 2. Vertical section of a similar piece, showing a few of the tubular glands filled with cells and granular matter;—magnified 30 diameters. The appearance of ramification is somewhat deceptive or exaggerated.

Fig. 3. Deeper portion of two of these tubular glands;—magnified 65 diameters; showing in some parts the membrane of the tubes, and the manner in which it is bulged out, or sacculated, at various places by the cellular contents.

Fig. 4. Cellular contents of the gastric tubular glands;—magnified 250 diameters. *a* from the human stomach; *b* from that of the pig.

Fig. 5. Small portion of the inner surface of the human jejunum from an adult;—magnified 30 diameters. Several villi are seen lying flat on the surface, and between them the apertures of a number of Lieberkühn's follicles, or the tubular glands: the villi are denuded of their epithelial covering; and most of the tubuli have also lost their epithelial lining; a few, however, are seen in which it remains at the mouths, thus contracting greatly their aperture.

Fig. 6. Vertical section of a portion of the same;—magnified 65 diameters. Two villi and five tubuli are seen: *a* the opening of the middle one of the five tubuli, nearly empty, showing the basement membrane; the other tubes are more or less filled with cellular and granular contents; *b* a few columnar particles of epithelium adhering to one of the villi.

Fig. 7. Granular cells contained in the tubuli of the small intestine of a man who died suddenly;—magnified 250 diameters.

Fig. 8. Small portion of the inner surface of the human colon, showing the

apertures of the tubular glands, most of which are divested of their epithelial lining, but in a few it is seen remaining;—magnified 30 diameters.

Fig. 9. Vertical section of three of these simple tubes; magnified 65 diameters: one of the tubes is full of epithelium and granular cells; the other two are partly emptied, and exhibit in some places the simple basement membrane.

Fig. 10. Granular cells contained in the tubuli of the large intestine;—magnified 250 diameters.

Fig. 11. Vertical section (diagram) of one of the follicular glands, and the adjacent tubules of the human colon, magnified about 6 diameters.

Fig. 12. Portion of a patch of Peyer's vesicular glands from the ileum of the pig, seen from the deep surface; the serous, muscular, and areolar coats being dissected off;—magnified about 3 diameters. The darker vesicles are open and empty, the paler are closed and full.

Fig. 13. Two of these vesicles, viewed from the inner surface of the intestine;—magnified about 15 diameters. One vesicle is closed and full, the other open and empty: in their vicinity are seen villi and the apertures of numerous mucous tubules.

Fig. 14. Vertical section of the same.

Fig. 15. Cellular contents of the vesicles of Peyer's glands;—magnified 250 diameters.

Fig. 16. One of the smallest of the cardiac-œsophageal glands from a man who died of apoplexy, magnified 30 diameters. The branched and sacculated tubes are seen filled with their cellular contents, and their communication with the main excretory duct may be traced: the latter is partially lined with short columnar epithelium.

Fig. 17. Portion of the closed extremity of one of the tubes of the same gland, magnified 65 diameters, showing the basement membrane of the tube and its contained cells.

Fig. 18. The cells of the same;—magnified 250 diameters.

Fig. 19. A small portion of one of Brunner's duodenal glands, from the human subject;—magnified 65 diameters. This specimen shows the more vesicular form of the remote extremities of the glandular tubes, and their communications with one of the branches of the main excretory duct. In some of the vesicular ends of the tubes the contained cells have the appearance of being enclosed within an external delicate cell.

Fig. 20. Cells of Brunner's glands isolated;—magnified 250 diameters.

V.—*Note respecting the Dimensions and Refracting Power of the Eye.* By J. D. Forbes, F.R.S., Sec. R.S.E., Professor of Natural Philosophy in the University of Edinburgh.[1]—(Communicated by the Author.)

Whilst lecturing lately on the subject of vision, I consulted some recent authorities on the dimensions and curvatures of the refracting apparatus of the eye; and having calculated from them the convergence of rays within the eye, it may save trouble to others to put them on record.

The measures of the eye given in almost every English work on the subject are those given by Young on his own authority, or that of Petit. In the 5th volume of Dove's *Repertorium*, I find a series of measures collected by Treviranus from his own and preceding observations, which I have converted below from French lines into decimals of an English inch. In these the curvatures are supposed spherical. In the same work of Dove I find a series of measures, by Dr. Krause of Hanover, on eight recent human eyes, which seem to have been made with uncommon care, and in which the deviation of the surfaces from sphericity is noticed. I have preferred these last for the purpose of calculation, because *all* the measures are taken from the same eyes, which is not the case with the numbers collected by Treviranus. I have consulted the original papers of Krause in Poggendorff's *Annalen*, vols. 31 and 39, where it appears (1.) that the cornea is thicker at the sides than in the centre; (2.) the anterior curve of the cornea is nearly spherical, the posterior parabolic; (3.) the anterior surface of the lens is elliptical, the lesser diameter being in the axis of vision, the posterior surface is parabolic; (4.) the figure of the retina, or the posterior surface of the vitreous humour is an ellipsoid.

	Mean of several Authors, by Treviranus.	Mean of 8 measures, by Krause.
	Inches.	*Inches.*
Thickness of cornea (central part.)	0.032	0.040
Distance of first surface of lens from back surface of cornea, ...	0.104	0.107

[1] Read to the Royal Society of Edinburgh, 17th December 1849.

	Mean of several Authors, by Treviranus.	Mean of 8 measures, by Krause.
	Inches.	*Inches.*
Pupil behind cornea,	0.096	0.083
Thickness of lens,	0.181	0.181
Axis of vitreous humour,	0.548	0.567
Axis of the eye from interior of the cornea to the retina,	0.833	0.855
Radius of first surface of cornea,	0.301	0.348
Radius of first surface of lens,	0.280	0.369
Radius of second surface of lens,	0.196	0.201
Curvature of retina near the axis,	0.534	0.524

These numbers agree tolerably well, only that the radius of curvature of the first surface of the lens is disproportionately great in the last column. This arises from the circumstance that it is derived by calculation from the curvature of an ellipse at the lesser axis, the two axes of which are alone given by Krause. Now, it is evident that, if we regard the lens *as a whole*, or even any considerable breadth of it, its mean radius of curvature will be sensibly smaller. In fact, Krause finds that it may be tolerably represented by a circular curvature having a radius of .329 inches. It occurred to me, however, that by taking the *greatest* density of the lens, as given by Brewster, and the curvature of the middle part, both anterior and posterior, as given by Krause, I ought to arrive at a close approximation to the course of the axial pencil.

I have adopted for the refractive indices of the parts of the eye those given by Sir D. Brewster in his Original Paper in the Edinburgh Philosophical Journal, vol. i. p. 44, with the exception of that of the densest part of the lens, which is almost certainly misprinted.

They are as follow :—

Aqueous humour,	1.3366 $= \mu_1$.
Crystalline, outer coats,	1.3767
Crystalline, middle,	1.3786
Crystalline, central,	1.3990[1] $= \mu_2$.
Crystalline, the whole,	1.3839
Vitreous humour,	1.3394 $= \mu_3$.

Calculating from the preceding data, I find the positions of

[1] In the Ed. Phil. Journ. we find 1.3999. But I take this to be a misprint, as in Sir D. Brewster's own subsequent writings we always find 1.3990.

the foci towards which the rays converge after refraction at the successive surfaces, to be the following, (reckoning from the internal surface of the cornea, the thickness of which has been neglected,)—

	For rays falling parallel on the cornea.	For rays diverging from a point ten inches distant.
	Inches.	*Inches.*
After first refraction at the aqueous humour, .	1.382	1.541
After second refraction at first surface of the lens,	1.260	1.377
After third refraction into vitreous humour, .	1.060	1.135

Now the emasure of the axis of the eye we have seen to be only .833 inches, according to Treviranus, and .855 according to Krause; consequently rays of mean refrangibility, (to which Brewster's measures refer,) converge to a point no less than .227 inches behind the retina, when the rays fall parallel on the cornea, and .302 when the object viewed is at ten inches distance. The axis of the eye, even as measured by Dr. Young, though somewhat greater than we have reckoned it above, (Dr. Young makes it .91,) does not come up to the requisite dimension; and Dr. Young, with his usual acuteness, ascribes the difference to the gradually varying density of the strata or coats of the lens,[1] the dense small nucleus evidently acting as a lens of comparatively short focus; and this explanation is, I have no doubt, the correct one, to which we may add that the configuration of the coats of equal density, which, near the surface of the lens, are very elliptical, become near its centre gradually nearly spherical. On this account it is all but impossible to predict the exact course of the rays through a structure of so much complication.

Dr. Young had considered the case with his usual attention and penetration. He investigates the focus of a spherical lens, or a lens with surfaces which are segments of spheres, and whose density is variable,[2] and the result may be recalled here as one which perhaps has not been sufficiently remarked. "On the whole," he says, "it is probable that the refractive power of the centre of the human crystalline in its living state is to that of water nearly as 18 to 17 [gives index refr. = 1.415];

[1] Lectures on Nat. Phil. vol. ii. p. 580. [2] Nat. Phil. vol. ii. p. 82.

that the water imbibed after death from the humour of the capsule, reduces it to the ratio of 21 to 20 [1.403]; but that on account of the unequable density of the lens, its effect on the eye is equivalent to a refraction of 14 to 13 [1.439] for its whole size."

The radius of curvature of the retina near the axis (where it is greatest) corresponds to a centre wholly within the vitreous humour. But the optical centre of the eye lies within the lens, consequently the curvature of the sensitive surface is greater than that of a sphere whose centre coincides with the optical centre. This corresponds so far with the theory of the curvature of the screen in the camera obscura.

On the whole, these calculations, as well as the considerations into which I entered in a former paper, read to the Royal Society in 1844, on the mechanism of the focal adjustment,[1] have left on my mind the conviction that the optical and mechanical structure of the organ of sight, is even less understood than it is commonly believed to be. Simple as are its general arrangements, and comparable in some respects to those of artificial combinations, we perceive surfaces figured in a complex manner, and structures of varying refractive density combined in a very complicated manner. Krause's measure of the curvature of the surfaces of the lens confirm the inadmissibility of the all but universal opinion of the variation of density of the crystalline, being intended to correct the aberration of spherical surfaces, when in reality no such surfaces exist. We are quite unable to trace the exact course by which the rays of light are focalized on the retina, since it depends entirely on the internal constitution of the lens that they do not meet very far behind it; and it still remains at least doubtful how the adjustment to distinct vision of objects at different distances is effected.

Finally, the question of the achromatism of the eye has its own difficulties. It is not now contended that the eye has the power of converging equally rays of different refrangibilities; but it is not unreasonable to suppose that the chromatic aberration is at least partially corrected. One result of the calculations into

[1] Transactions of the Royal Society of Edinburgh, vol. xvi. p. 1.

which I have entered (which were first in part undertaken at my request by Mr. James Clerk Maxwell, and since entirely repeated and extended by myself) is a clear exhibition of the physical conditions of perfect achromatism in the eye. The form is simpler than I have elsewhere seen, and may at once satisfy any reasonable person of the *possibility* that the eye might be rendered achromatic, at least for objects at a certain distance; to prove which so much has been written, and at so great length. The result may be stated in two lines. If we calculate the effect upon the *final* focal distance of the whole refracting system of the eye (q''), of a variation in the refractive index of each of its three humours, (denoted by μ_2, μ_3, μ_4,) we find this equation, where the incident rays are parallel, or reach the eye from a very distant object:

$$\delta q'' = 1\cdot579\delta\mu_2 + 1\cdot150\delta\mu_3 - 2\cdot788\delta\mu_4.$$

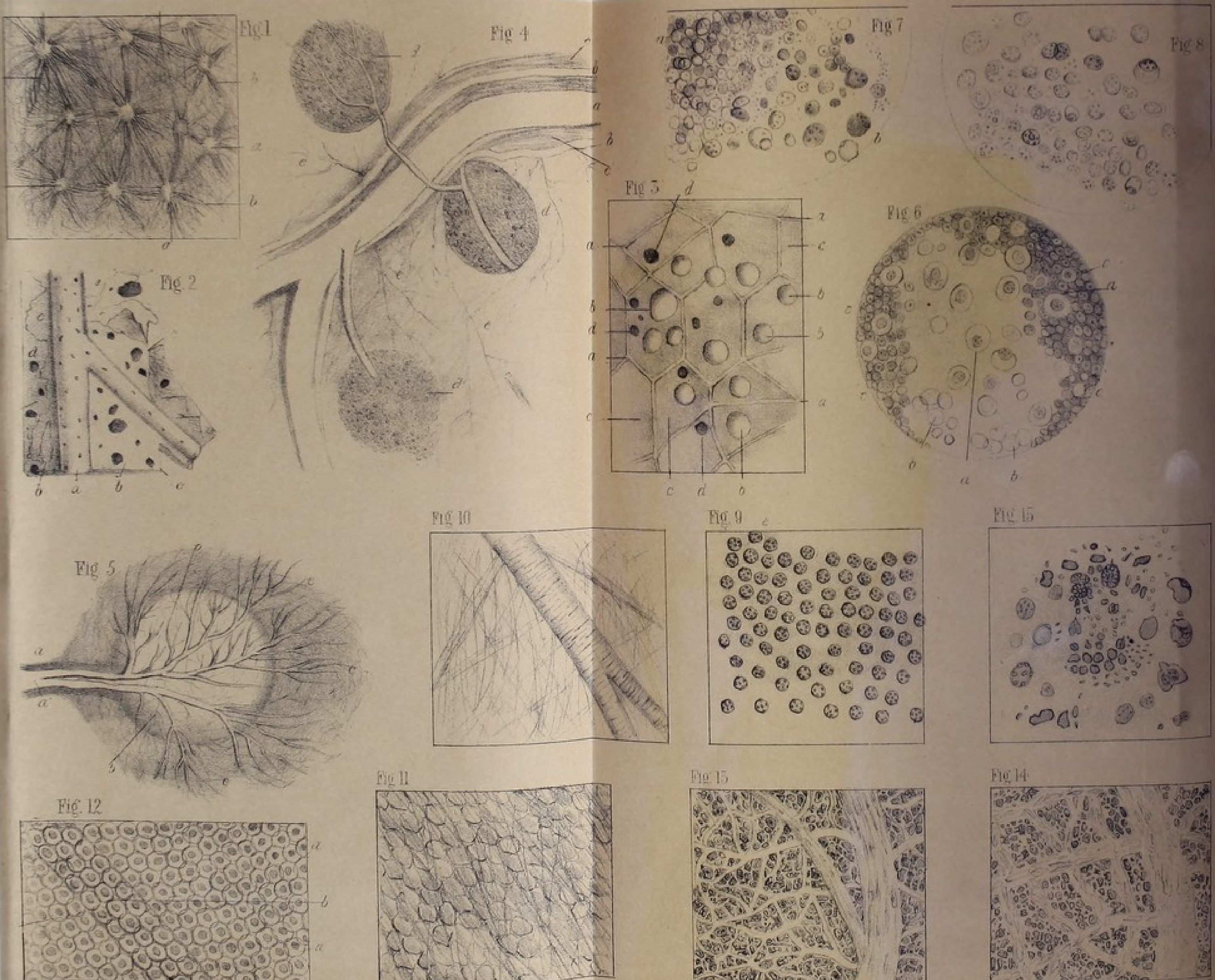
Let the co-efficients, $\delta\mu_2$, $\delta\mu_3$, $\delta\mu_4$, denote the dispersion or differences of the indices of refraction for extreme rays, corresponding to the three media, then it is evident, from the negative sign of the third term on the right hand, that they may be so chosen as to annihilate the second side of the equation, or make the variation of focal distance *nothing*, for the differently refrangible rays.

If the rays proceed from a point ten inches distant from the eye, the equation for the variation of the focus will be—

$$\delta q'' = 1\cdot873\delta\mu_2 + 1\cdot402\delta\mu_3 - 3\cdot298\delta\mu_4;$$

and the condition which makes this equal to zero, or the focus, independent of small variations of the refrangibility of the ray, may be satisfied at the same time that the former equation is satisfied also. Consequently, with three media as in the eye, we may have perfect achromatism for any two distances; which would be sensibly perfect for the intervening ones. Of course, by perfect achromatism, we here mean a union of the extreme red and violet rays; the *irrationality* of dispersion does not concern this question.

PLATE. IV.



W. Sanders delᵗ

Structure of the Spleen.

Fr. Schenck, Lithʳ Edinʳ

Explanation of Plate IV.

Fig. 1. External surface of the internal layer of the proper fibrous tunic of the spleen, seen in situ by the naked eye, or with a magnifying power of 5 diameters.—*a a*, the white round prominences from thickening of the membrane at the insertion of the trabeculae on the inner surface; *b b*, fibres radiating from these prominences, and passing in stronger bands between adjacent prominences.

Fig. 2. The large vein and artery of the bullock's spleen laid open.—*a*, internal surface of the splenic artery, the black points indicate the orifices of the small trabecular branches, given off nearly at right angles to the axis of the vessel; *b*, internal surface of the splenic vein, shewing the foramina or orifices of the small veins, given off nearly at right angles, and piercing through the fibrous capsula, *c*, and through the pulp,*d*.

Fig. 3. Substance of the sheep's spleen seen in section, by the naked eye or magnified 5 diameters.—*a*, the trabeculae, arterial and fibrous, form a framework, whose meshes divide the pulp into compartments, *c c;* filled up by the pulp, in which are situated Malpighian sacculi, *b b;* and venous foramina, *d d.*

These compartments, *c c*, though incompletely bounded, and not inclosed, but continuous with one another, may nevertheless be considered as lobules of the spleen, because they exhibit all the essential elements of the gland, and represent the organ on a small scale.

Fig. 4. A trabecula torn out from the sheep's spleen, with the pulp and Malpighian sacculi adhering to it.—*a*, the trabecular artery; *b b*, nerves; *c*, fibrous tissue, or capsula; these parts compose the larger trabeculae, as seen in Fig. 3, *a; d d*, Malpighian sacculi, attached by arterial and fibrous pedicles to the large trabecula, their contained grey particles are represented, one at *d′* has partially burst; they are imbedded in the pulp, *e;* magnified about 40 diameters.

Fig. 5. An entire Malpighian sacculus from the bullock's spleen, magnified 60 diameters, the grey corpuscles are not represented.—*a*, the fibrous pedicle containing an arterial twig, the branches of which pass over the external surface of the sacculus, supply it with vessels, and then terminate as a tuft or pencil in the pulp, *c*.

Fig. 6. Saccular cells and corpuscles unaltered by the action of water, as they appear when an opening is made by bursting or tearing the membrane of the sacculus.—*a*, the clear bright cells, containing nuclei; *b*, free clear nuclei, not altered by water; these have a yellow tinge; *c*, the ordinary grey saccular corpuscles, adhering by plasma, with clear cells resting upon them;—magnified 250 diameters.

Fig. 7. Corpuscles, cells, and granules effused from the Malpighian sacculus, adhering to the plasma at *a*. At *b*, the cells are becoming dark, and some are dissolving by the action of water;—magnified 250 diameters.

Fig. 8. Saccular corpuscles and cells diffused in, and freely acted on by water, which renders the corpuscles clear and spherical, and displays the nucleoli; the cells are either rendered granular, or become faint, and are then dissolved;—magnified 250 diameters.

Fig. 9. Saccular corpuscles acted on by acetic acid, which renders their edges and nucleoli very dark, and well defined;—magnified 400 diameters.

Fig. 10. Portion of the fibrous tunic or membrane of the Malpighian sacculus; an arterial branch and capillaries are seen enveloped in the loose fibrous membrane;—magnified 400 diameters.

Fig. 11. Inner granular membrane of the Malpighian sacculus, divided imperfectly into scales; the ramifying fibres of the fibrous tunic are seen through it;—magnified 400 diameters.

12. The saccular cells, (represented free in fig. 6,) forming a layer on the inner surface of the saccular membrane *a*; at *b*, they are seen covering an arterial branch;—magnified 400 diameters.

Fig. 13. Capillaries of the pulp entering a small venous branch of 1-600th of an inch diameter. The irregular splenic corpuscles of the pulp are seen filling the interstices of the capillary plexus;—magnified 400 diameters.

Fig. 14. Similar view, after treatment by acetic acid.

Fig. 15. Different forms of coloured particles of the splenic pulp, varying from dark-red to brownish or yellow. Granules, globular particles, and large aggregated particles; some containing bodies resembling nuclei. These are the coloured corpuscles referred to by Dr. Handfield Jones, Ecker, Kölliker, &c.;—magnified 250 diameters.

VI.—*On the Structure of the Spleen.* By William R. Sanders, M.D., Edinburgh.[1]—(Communicated by the Author.)

(Plate IV.)

In this paper I shall first give an analysis of recorded opinions regarding the structure of the spleen, and then state the result of my own observations, in the course of which I have detected some particulars hitherto apparently unnoticed ; but which seem to throw light on this obscure subject.

Enumeration and Nomenclature of the more obvious constituent parts of the Spleen.—Before entering on the history of splenic anatomy, I shall, for the sake of precision, enumerate the terms applied to those parts which may be seen with the naked eye in a section of the bullock's spleen, in which they are most distinct and obvious.

At the margin of the section are the serous, and the internal, proper, fibrous, or albugineous tunics. Where the vessels enter the organ the fibrous tunic sends sheaths around them which are called capsulae or involucra.

On the surface of the section is exposed a reticulum or network of fibrous-looking bands, named trabeculae, or ligaments, which, springing at the periphery from the fibrous tunic, pass inwards, anastomosing, and becoming connected to the capsulae of the vessels form the frame-work of the organ (*compages.*) Occupying the areolae of this frame-work, is a reddish brown, or black, soft pulp or parenchyma. In this pulp are imbedded spheroidal white gelatinous bodies, about the size of a large pin-head, or larger. These are the glandulae or acini of Malpighi, also termed Malpighian bodies, corpuscles, vesicles, folliculi, or sacculi lienis. The last term is preferable as the

[1] This paper contains the substance of the Inaugural Dissertation given in by Dr. Sanders, on the 31st March 1849, previous to his Medical Graduation in the University of Edinburgh. It obtained for the author one of the annual Medals adjudged by the Medical Faculty.

least ambiguous. The red pulp presents many round holes in its substance, which are venous canals or foramina. Both externally and internally are blood-vessels, nerves, and lymphatics. Internally the larger arterial branches with their investing capsulae form the thickest bands of the trabeculae.

Those anatomical constituents, though the existence of some of them is questioned in recent works, will not, I presume, be any longer denied: since they can be seen at a single observation in a bullock's or sheep's spleen, if examined soon after removal from the animal.

In the following history, I shall endeavour to ascertain what structures are described by anatomists under the terms above enumerated.

Analysis of Works on the Spleen.—Anatomists, down to the time of Malpighi (1665) appear to have had no more accurate idea of the structure of the Spleen, than that it consisted of a membranous bag, containing a soft spongy flesh or pulp, of a dark colour, generally supposed to be concrete blood, or some analogous substance, and that this parenchyma was supported by ramifying fibres, with blood-vessels imbedded in it. Even from this rude anatomy, however, they concluded that the spleen was a secreting organ, believing,—

1*st*, That it secreted dark bile, (probably the dark pulp,) and purified the blood; being thus the organ of all joyful and exciting emotions.[1] 2*d*, That it generated some acrid juice or spirituous ferment, which, conveyed to the stomach by the vasa brevia, assisted in concoction, or, conveyed to the heart, excited its movements;[2] or that a juice secreted from the splenic nerves, was mixed with the blood;[3] and it is not unlikely, that from some opinion similar to that last mentioned, Van Helmont considered the spleen to be the seat of the sensitive soul. 3*d*, At the time when the liver was thought to receive the lacteals, and to form blood from the chyle, the spleen was supposed to

[1] Aretæus, Galen, Avicenna.

[2] Perrault. At a much later period Clopton Havers thought it secreted synovial juice.

[3] Sylvius, Glisson.

share this function, and believed to prepare from the chyle, the blood destined for the viscera of the lower belly. Besides those secreting functions, other uses were also ascribed to the spleen, as, that it afforded heat to the stomach, was a counterpoise to the liver, &c. Lastly, the opinion has often been maintained that the spleen has no use whatever.

Those obscure and varying notions, proceeding from an imperfect anatomy, are interesting historically, and shew the immense progress made in a knowledge of the organ, by the labours of one single careful and diligent observer, Malpighi. To this profound investigator of glandular anatomy, belongs the extraordinary merit of having described so perfectly the structure and uses of the Spleen, that, for nearly 200 years, his work has remained, among the many treatises which have been written, the only standard authority, unrivalled for extent and accuracy of observation, for close philosophical reasoning, and for the singular purity and beauty of a style which leaves not one doubtful or obscure impression on the mind of the reader.

Of such a work it is unnecessary to give more than an outline, and to point out those opinions which are liable to objection, and have been questioned by succeeding authors.

The discovery by Malpighi of the spheroidal white glandules[1] or acini in the substance of the spleen, constituted an era in the history of the organ. Malpighi fixed upon them as true secreting elements, and proved that the spleen was not a mere mass of concrete blood, but possessed a structure like that of a true gland; and, although no special duct to carry off its secretion could be detected, he believed that its other textures, and in particular the veins, were modified so as to perform the function of a duct. Those facts he demonstrated in the following manner :—

1*st*, The glandules, spheroidal and turgid in the natural state, collapse on being punctured, and effuse fluid contents. They are therefore composed of a membranous sac containing some

[1] Malpighi,—De Viscerum Structura Exercitatio Anatomica, 1665; also, Opera Posthuma, 1696, pp. 42, 43, 44. Also Malpighi's Letter of date 1671, in Phil. Transactions, vol, vi. No. 71, p. 2150.

juice, and their obvious analogy to the acini of known secreting glands, as Malpighi had described, indicated their secreting function.

2*d*, Malpighi had noticed that the veins of the spleen were particularly large, and that on entering the organ, more especially in the bullock's spleen, they were divested of their external tunics, and appeared as holes perforated in the parenchyma of the spleen. Accordingly, in his investigations of the parenchyma, finding other means unsuccessful, he resorted to the method of inflating the veins, and then drying the organ. On examining sections so prepared, he found that the pulp had greatly diminished in volume, and had dried into membranous septa between the dilated venous cavities, so that the spleen appeared to be made up of large cells (cellular spaces) communicating with the veins, the parietes of these cells being formed by the dried membranous pulp, supported by the trabeculae, and presenting the glandulae either situated in their substance or suspended from them within the cells. This structure, consisting of "a congeries of membranes formed into cavities," he compares to the honeycomb.

From the arrangement of parts thus demonstrated, he concluded, that the glandulae suspended from the extremities of the arteries, poured their secretion into the cells, by which it was conveyed to the veins, where it mixed with the venous blood, and was carried along with it into the liver.

Had Malpighi no other notion of the structure of the parenchyma than that it consisted of the collapsed walls of venous cells? He has in one place expressed a doubt whether there might not also be some peculiar red substance surrounding the glandulae; but on investigating the properties of this "subrubra substantia" by coction, and comparing it with blood similarly treated, he found that they presented the same appearance; he therefore settled in the belief that this red substance was only the remains of the blood in the venous cells.

The description of the proper tunic, vascular capsulae, and the trabeculae ramifying between them, originally made out by Malpighi, is so generally given nearly in the words of that anatomist, and is besides so free from doubt, that nothing need here be said of their arrangement. Regarding their nature,[1] Malpighi changed remarkably in opinion. In his first account, he considered them to be fibrous, and destined to support the venous cells. Afterwards he regarded them as muscular, forming a contractile texture similar to that in the auricles of the heart, and having for their function to compress and empty the venous cells of their blood and secretion, to prevent that stagnation of the circulation which he supposed would be caused by the venous sinuses.

Malpighi's account of the anatomy of the spleen, apart from details, amounts to this : The organ is composed, 1*st*, of venous cells, (spaces ;) 2*d*, of secreting glandules projecting into these cells, and pouring their secretion into them ;[2] and 3*d*, of a muscular structure in the walls of these cells, compressing their contents into the splenic veins. The juice poured from the glandules into the venous blood, by inducing chemical changes, so loosened and dissociated its elements, and exalted its nature, as to render it of great service in the secretion of bile, when it had been carried to the liver. This theory, suggested by anatomy, he supported by physiological considerations, experiments, and chemical researches.

Every opinion put forth by Malpighi has remained to the present time ; but various authors have assailed some part of his description. Leaving therefore the examination of his views to the anatomists who opposed him, and whose opinions will presently be given, I only remark, 1*st*, That the method of preparation by inflation is liable to objection, and that the whole doctrine of splenic venous cells (spaces) rests on insufficient proof ; 2*d*, The muscularity of the proper tunic and trabeculae is not demonstrated ; and the support for both of these opinions, from analogy with the lungs, is entirely deficient, because the

[1] See Malpighi's Letter, (1671,) where the muscularity of the trabeculae is first mentioned, and is compared to similar structures in the lungs, testicles, &c.—Phil. Trans. vol. vi. No. 71, p. 2150. In his Posthumous Works the same opinion is maintained.

[2] Malpighi also admitted it as probable, that the nerves poured out some juice or secretion into the glandulae.

cells of the lung, containing air and not blood, may be legitimately demonstrated by inflation, while the enveloping membrane and trabecular tissue of the lungs are not admitted to be muscular.[1]

Blasius, Steno, and Bartholin were convinced by Malpighi of the accuracy of his description, which was indeed generally received by the ablest anatomists. Bidloo in his plates follows exactly Malpighi's account, and valuable illustrations were thus added in its confirmation. Malpighi's philosophical views, however, were destined to be soon overthrown, by the arguments of Ruysch, who investigated the structure of the organ by means of injections to the neglect or even the exclusion of other methods.

According to Ruysch,[2] the human spleen is composed of a congeries of arteries, veins, lymphatics, and nerves, held together by enveloping membranes; and contains no peculiar glandular or trabecular texture. The trabeculae he describes to be only vessels and nerves surrounded by membrane; the soft pulp to be the capillaries, having a peculiarly soft and succulent texture; and the glandulae of Malpighi, nothing but minute blood-vessels in convoluted fasciculi, and formed into round succulent bodies; while the cells (venous cavities) do not exist naturally but are produced by the force used in inflation. In the spleen of the bullock, however, he admitted the existence of trabeculae, *i.e.*, fibrous bands, which he supposed gave firmness to the venous canals, which in that animal have no fibrous coat. These trabeculae might also, he adds, be considered as forming cells, or areolae.

From this structure, which consists of nothing but vascular plexuses, Ruysch inferred that the spleen secreted from the ar-

[1] In his work on the Spleen, and more particularly in his letter in the Phil. Trans. No. 71, this analogy of the spleen to the lungs and other glands with fibrous envelopes, is pointed out, and appears important because it would otherwise be impossible to understand from what facts this celebrated doctrine of the muscularity of the spleen originated.

[2] Ruysch.—Ruyschii Opera.—Responsio ad Joh. Jac. Campdomercum de glandulis, fibris, cellulisque lienalibus. Amstelodami, 1696. Also Ruysch's Observationes Anatomicæ, Nos. li., c., &c., his Thesauri Anatomici; Responsio ad Bidloi libellum —*passim*.

teries, a fluid which, carried off by the lymphatics,[1] was mixed with and perfected the lymph, and contributed to the formation of the blood. The spleen was therefore a sanguineous gland.[2]

It was objected to Ruysch's demonstrations, that in washing his preparations, in water, in order to unfold the injected vessels, he removed the glandular substance which connected them. In fact, accurate as his description of the vascular elements of the spleen doubtless is, beyond this one particular his account cannot be relied on. He nowhere gives a satisfactory explanation of what that substance is, which he washed away from around the vessels, and which caused that peculiar succulence he so often mentions. And it is evident that the observations of Malpighi were not at all refuted by injections, which could not account for the appearances, glandulae, &c., presented to the naked eye, as described by the Italian anatomist.

In the year 1706, Leeuwenhoek gave in the Phil. Transactions of London, an account of his microscopical observations on the spleen.[3] He investigated directly the parenchyma, which Malpighi and Ruysch had sought to display by artificial preparations. Rejecting the vulgar opinion that the spleen is composed of spongy flesh, he showed that its substance was not muscular, but consisted of very small globules or particles, so small he says that he could give no figure of them, and that these globules were "depending on" and proceeded out of the small fibrous branches (minute trabeculae,) and also occupied the meshes of the fibrous branches. The larger fibrous trunks (trabeculae) he describes as arising by roots from the inner surface of the fibrous tunic of the spleen, ramifying and anastomos-

[1] The lymphatics were considered continuous with the "minute secreting arteries," as all gland-ducts were thought to be by Ruysch in his theory of secretion. Ruysch first carefully investigated the lymphatics of the spleen.

[2] Ruysch classified the spleen with the thyroid and lymphatic glands, the supra-renal capsules (and the liver?) as sanguineous glands, (glandulae sanguineae,) serving one common function of perfecting the lymph.—Obs. An. 51.

[3] Microscopical Observations on the Structure of the Spleen and the Proboscis of Fleas. By Anthony Van Leeuwenhoek, F.R.S. Delft, June 1, 1706. Phil. Trans. vol. xxv. p. 2305, with plates representing the fibrous parts or trabeculae arising from the inner tunic, their ramifications, &c.

ing till they joined those arising similarly from the membrane on the opposite side. He notices the distinct fibrous nature of these bands, and considers it doubtful whether the fine fibrils of which they are made up might not be hollow tubes or vessels conveying juices out of the membrane. Supposing, further, that the blood would be apt to stagnate, from the opposition to the circulation in the liver, he attributed to the spleen a power of propelling the blood, both by the pressure of the diaphragm in expiration, and by the fibrous parts (trabeculae) being specially endowed with contractility.

He makes no mention of the Malpighian glandulae, and offers no conjecture on the function of the organ whose anatomy he describes. He does not even allude to the labours of his predecessors.

In the Phil. Transactions for 1716, Douglas has related a case of atrophy or consumption[1] of all the muscular fleshy parts of the body occasioned from numerous glandular swellings in the mesentery (*tabes mesenterica,*) in a boy aged five years, where after death the spleen contained " round whitish bodies of pretty hard consistence, and abundance of small, white, and softer specks, both of which were of the same nature." This aspect of the glandulae corresponds with what Malpighi had observed in a similar case in the human subject.

The next original treatise on the spleen, after that of Leeuwenhoek, is the inaugural dissertation of Eller,[2] who describes the spleen differently from preceding authors, but whose opinions may in greater part be resolved into those of Malpighi and Ruysch. His most important observation is, that the arteries of the spleen, after breaking up into small branches, terminate in pencils or tufts, which soon become invisible, being confounded under the appearance of a homogeneous mucus, (doubtless the pulp,) from which the venous radicles take their origin. His account of the vascular capsule and trabeculae differs more

[1] Douglas in Phil. Trans. vol. xxix. p. 499, No. 349. There are other notices of the spleen in old volumes of the Transactions, in particular by Behm, Grandi, Grew, Cowper, &c., vols. xvii. xxiii. &c.

[2] Dissertatio Inauguralis de Liene, pro gradu Doctoris, &c., a Johanne Theodoro Eller, Anhaltin. Lugd. Bat. 1716; in Haller's Collect. Disput. Anat., vol. iii.

in words than in facts from that of Malpighi. The trabeculae, according to him, are of two kinds, containing respectively arteries and nerves. It is curious that he saw the glandulae of Malpighi, described accurately their appearance, and the arterial capillaries spread over them, and yet mistook them for cut fibres, (abscissae fibrae). He denies the normal existence of cells in the spleen, ascribing their formation to distention of the veins or their rupture by inflation: nevertheless, he agrees with Malpighi that the spleen produces chemical changes in the blood circulating through it, which promote the secretion of bile: his theory being that certain saline (microscopic) particles exist in greater numbers in splenic than in other arterial blood; and that in the glandular part of the spleen, (the homogeneous mucus and capillaries,) the more subtle and serous particles of this blood, having perhaps received some juices from the nerves, are carried off by the serous or lymphatic vessels, which are continuous with the minutest arteries, and are conveyed by them to the surface of the spleen, and poured into the splenic blood by the junction of these lymphatics with the splenic vein.[1]

The work of Stukeley,[2] in 1722, contains no new facts, and his description is very faulty; yet the importance of his views of the venous cavities, and their influence on the circulation, have remained as standard doctrines in regard to the spleen, and have been frequently revived in modern times. Following Malpighi in his account of the fibrous tunic, the trabeculae and the venous cells, he rests his views of the anatomy and uses of the spleen wholly on those textures. He denies the existence of the

[1] Eller describes on the sides of the trabeculae containing nerves, serous or lymphatic vessels arising within the spleen, from the follicles of Malpighi and from the extremities of the minute arteries. These serous vessels terminated in the proper membrane of the spleen, and were inserted into the splenic vein.

In Haller's Collect. Dissert. Anat. There are many other theses on the spleen, (its excision by Deisch, &c.) particularly in vols. i. iii. iv. vii.

[2] Of the spleen, its description and history, uses, and diseases, particularly the vapours and their remedy, (being the Gulstonian Lecture for 1722,) by William Stukeley, M.D., C.M.L. and S.R.S., London 1723, in folio. Stukeley's work contains some details on the comparative Anatomy of the spleen; it is, in its general character, a work of erudition and argument.

glandulae Malpighii, supposing that the "tendons of the trabecular muscles," or "glands serving to lubricate those tendons," or perhaps "plexuses of nerves," had been mistaken for glandulae by Malpighi; and of the red pulp he had no other notion than that it was coagulated blood in the cells of the spleen. Carrying out, however, Malpighi's view of the muscularity of the investing membrane and trabeculae, and attributing in consequence to the spleen a slow and periodic contraction, he discusses all the uses and advantages which would result from the emptying and filling of the large venous cells by the alternate shrinking and expansion of the organ.[1] In short, Stukeley ascribes to the spleen an intelligent control over the circulation. When there is too much blood in the abdominal vessels, the spleen opens its cells and relieves the plethora. When, on the contrary, a supply of blood is required, the spleen pours forth its contents to meet the demand. In every altered state of the circulation, therefore, in digestion, plethora, menstruation, as in most diseases, fevers, colic, vomiting, the spleen, according to Stukeley, is of the greatest service; and besides its almost innumerable uses in these affections, it maintains the equilibrium between the solids and fluids. Taking a part, therefore, in every function of the body, it is so necessary to health, that its slightest disorders induce the vapours—hypochondriasis, dyspepsia, and hysteria,—with the symptoms and treatment of which disease the author concludes his treatise.[2]

Lieutaud,[3] in the Mémoires de l'Académie de Paris for 1738, mentions the variations in size of the spleen at different periods; it is, he says, large when the stomach is empty, and small when

[1] Stukeley's opinions are expressed by three comparisons,—*1st*, The spleen is a vascular sponge. *2d*, It is a secondary heart. *3d*, It is the great regulator or "water-guage" (or blood-guage) to the heart.

[2] In the Phil. Trans. for 1734, is the celebrated case by Ferguson, where the spleen having protruded through a wound in the left hypochondrium, and being cold, black, and mortified from exposure to the air, was cut off to the extent of three and a-half ounces. A pretty large artery sprung, and was tied. The patient recovered perfectly, and felt no inconvenience from the loss of part of his spleen. Other recorded cases of excision are quoted by authors, Stukeley, Haller, &c.

[3] Lieutaud, sur la grosseur naturelle de la Rate, Mém. de l'Acad. des Sciences de Paris, 1738.

it is full: and he ascribes these changes of bulk to the pressure of the distended stomach emptying the spleen of its blood, which flows into and fills the organ when the pressure is removed.

The anatomical description of Winslow, given in his Exposition Anatomique,[1] published in 1732, is confused and obscure: most probably, because he describes the spleen under different modes of preparation, without mentioning what these were, and because he did not sufficiently compare the results of his different investigations with one another, or with those of previous observers. The individual details, therefore, given by so accurate an anatomist are probably correct, while his description as a whole is nearly unintelligible. The splenic substance, he says, is in man almost all vascular; in the ox, it is composed chiefly of reticular texture (trabeculae;) in the sheep, its structure is made up of cells, (venous spaces.) He next describes a peculiar texture which he names cottony tissue[2] (tissu cotonneux,) and which does not precisely correspond with anything previously noticed by authors. "Between the very numerous venous ramifications is seen, as it were, a universal effusion of extravasated blood, which is imbibed or retained in a kind of cottony texture, transparent and of extreme fineness, which is spread throughout the whole mass of the spleen." The cottony texture, with the extravasated blood, evidently corresponds to the parenchyma. This texture, after surrounding the venous ramifications, terminates finally in cells almost imperceptible, which communicate with each other, so that in inflating the spleen by a hole made in the enveloping membrane, the whole bulk of the organ is at once distended. These cells he thought, were what Malpighi had described as glandules, or follicles containing glandular particles.[3] In these cottony

[1] Winslow, Exposition Anatomique de la Structure du Corps Humain, Paris 1732, p. 540; or Nouvelle Edition, tom. iii., p. 175, and § 337, 338, 339, 346, 348, 349.

[2] This cottony texture was probably demonstrated by maceration of the splenic parenchyma in water—at least an appearance similar to that described may be so produced; the cells were evidently demonstrated by inflation.

[3] Malpighi a regardé ces petites cellules cotonneuses "comme des capsules particulières ou des follicules, qui renferment autant de petits corps glanduleux."—§ 546.

cells, the venous and arterial capillaries terminated; their vascular extremities floating in them and filling them with blood.

Besides these textures, he mentions glandular grains as seen in the spleen both of man and animals. He elsewhere adds, that he had seen little grains (most likely the same glandular grains) attached to the end of the "extreme arterial branches," much in the same way as a bunch of grapes is arranged. From each of these grains issued two small tubes or canals, of which the one was short and opened into the cells; the other long and more slender, proceeded to the walls of the spleen, (" parois de la rate," *i.e.*, the enveloping membrane,) and became lost there. The latter he supposes to be the origin of a lymphatic. These grains, he adds, are easily seen and demonstrated in an ox's spleen cooked and prepared by a peculiar manipulation. In the fresh spleen they are much larger, but have less firmness, and collapse when injured. Similar grains are seen in the human spleen, but are extremely small, and " visible only by the microscope."

The spleen he considers to be serviceable as an auxiliary organ to the formation of bile, producing in common with the epiploon, pancreas, intestinal glands, &c.,[1] changes on the venous blood, which was more particularly altered in the spleen by the mechanical retardation of the flow, and acquired some peculiar development by the action of the splenic nerves.

The Memoir of De la Sône,[2] in the Histoire de l'Académie de Paris, for 1754, is much more satisfactory, and is peculiarly valuable in comparing, illustrating, and sometimes correcting by original researches and experiments the opinions of his predecessors, Malpighi, Ruysch, and Winslow.

Agreeing with Malpighi in his description of the proper tunic and trabeculae, he differs from him in denying altogether their muscularity, maintaining that they are fibrous in texture and distinctly ligamentous. Farther, the net-work of the trabeculae

[1] Op. cit., ed. 1766, tom. iii. p. 196. § 387, 388, *et seq.*

[2] De la Sône, Sur la Rate, ou Histoire Anatomique de la Rate, Premier Mémoire, at p. 288 of Part 1st of the Histoire de l'Académie Royale des Sciences de Paris, for 1754.

is pierced (pénetré) in every direction by the vascular ramifications, which form another net-work within the meshes of the former. De la Sône also thought that the vascular capsula, coveringthe arter y,[1] together with the thinning of the venous coats, existed only in spleens where the vessels entered by single trunks, (spleens of bullocks, sheep, &c. ;) and that these peculiarities of texture did not exist where (as in man, the horse, &c.) the vessels were subdivided at their entrance into the spleen. With regard to the splenic substance, (parenchyma,) he is very explicit. The arteries at their ultimate ramifications degenerate into a substance of consistence as delicate as that of brain. This soft matter is not blood, for it remains after the blood has been washed out by injections of warm water, after which preparation it appears as a pulpy cotton, and sometimes red globules are distinguished in it. In further speaking of this soft substance, he quotes Malpighi's account of the glandules (sacculi) which he calls grains, and asserts that they could only be seen certainly by maceration. But there is no evidence from his statement that he had clearly made out the Malpighian glandules, as distinguished from the pulp.[2] On the contrary, he confounds them, and concludes that follicular and glandular grains compose the pulpy part of the spleen.

Finally, De la Sône doubts the great vascularity of the spleen, as shown by Ruysch's injections, and raises several objections to the mode of preparation of that anatomist. Further, contrary to Ruysch's opinion, he believes in the existence of the venous cells (cavities) of Malpighi, which he demonstrated by inflation and desiccation, but he denies that these cells have membranous walls, because in that case they would not disappear by maceration. He considers that the pulp forms the walls of the cells, and that this pulp appears membranous only in consequence of

[1] He denies the venous capsula: describing only a demi-capsula round the artery, p. 69.

[2] The word grains used by Winslow and De la Sône evidently denotes objects different from and smaller than the glandules of Malpighi. It is applicable to the granular aggregations of its particles, which the substance of the spleen exhibits on maceration, after the glandulae and the pulp have been confounded together by softening of their textures.

the distention and drying used in inflation. This last observation is an important commentary on Malpighi's description. De la Sône promised further details in another memoir, which, however, was never published.

Haller's description of the spleen[1] is chiefly a compilation of the opinions of preceding authors; and the hesitation and want of precision in his statements show the perplexity in which the conflicting accounts of observers had involved the subject. Agreeing with Ruysch in most particulars, he considers the substance of the spleen to be formed by vessels and membrane, and denies the venous cells. In the bullock's spleen, however, he admits the trabeculae and the cottony pulp, as described by De la Sône. He rejects the glandulae Malpighii, and refutes the supposed muscularity of the proper tunic and trabeculae, an important statement from such an authority. He supports the common opinion, that the spleen prepares the blood for the liver.[2]

Opinions with regard to the spleen were remarkably changed and took a new direction from the researches of Hewson[3] (1777,) with whom the modern notions of its anatomy and physiology originated. He was the first to put the spleen into direct re-

[1] Haller, Elementa Physiologiae, vol. vi. pp. 385-426. Liber xxi. De Liene.

[2] B. S. Albinus (in Annot. Academ., lib. vii. cap. xiv. p. 84, 1764) relates the dissection of a male adult in which no spleen was found in the usual situation, but on examining the viscera of the pelvis, the missing organ was found enlarged but quite free, being attached only by the usual membranes (peritoneum) and vessels, which had become elongated. He quotes other anomalies of the same kind recorded in authors. It is not improbable that the supposed cases of absence of the spleen may have been merely such malpositions not fully investigated. He mentions also another case in which a supernumerary spleen (splenculus) was present—instances of which had often previously been mentioned, and are not uncommon.

[3] Hewson—On the Red Particles of the Blood. Chap. IV. on the Spleen, and V. on the manner in which the red particles of the blood are formed.—Experimental Inquiries, Part III., published by Falconer in 1777. Ed. Sydenham Society of 1846, pp. 264-286.

The method of demonstrating Malpighian venous cells or sinuses by injection, described by Hewson as practised by anatomists, is curious. They injected warm water into the spleen through the blood-vessels, and then kneading the substance of the organ till it was broken down and washed out by the water, they then inflated the spleen and dried it. The cellular appearance presented on section, being in fact only the trabecular framework, or skeleton of the spleen, as Hewson calls it, which they mistook for Malpighi's venous cells.

lation with the lymphatic system and the vascular glands, (thyroid and thymus ;) and inferring the glandular nature of the spleen from its large vascular supplies, he attributed to it the function of secreting the red blood particles, which he believed were carried off by the lymphatics, the excretory ducts of the organ. "The pulp or tender substance, which at first looks like effused blood, is proved by many experiments to be no other than very small vessels broken down by putrefaction ;" but besides these, the microscope shows that it contains "an almost infinite number of cells (corpuscles) of a round figure, and of a size and shape very nearly resembling those in the lymphatic glands," and the ultimate branches of the arteries and veins "form a most beautiful net-work of blood-vessels upon each particular cell !" In these cells the secretion takes place. The lymph-particles, formed by the thymus and lymphatic glands, are carried with the blood into the spleen, by which they are separated and deposited in the cells. The arteries in the cell-walls then secrete the red vesicular portion around these central or lymph particles, which being thus changed into perfect red blood particles, are absorbed from the cells by the lymphatics, and pass through the thoracic duct into the blood-vessels. That such is the function of the spleen, he considers proved by the large number of lymphatics, and the analogy of the spleen to the lymphatic and vascular glands, by experiments showing that the lymph in the splenic lymphatics is peculiarly coagulable and reddish-coloured from the presence of large numbers of red blood particles, by observation of the absence of central particles or lymph globules in the splenic vein, and by the incoagulability of the splenic venous blood, arising from the coagulable lymph being employed by nature in the formation of the red blood vesicle.

In these observations Hewson does not appear to mention the Malpighian glandulae: his cells (corpuscles) evidently do not correspond with them : and in regard to the size of these cells, he makes most contradictory statements.[1]

[1] The cells are first mentioned as being of the size of lymph particles, which are afterwards described as being deposited within these cells (of their own size?) to be

Hewson, in conclusion, offers many arguments in support of his views: and in answer to the objection, that the excision of the spleen causes little or no injury to animals, he contends that the spleen being an organ accessory only to the lymphatic system, (which of itself forms the red blood particles,) its removal can impair only, and not arrest any function essential to life.

The Dissertation of Assolant (Paris, 1801), remarkable for originality and research, has probably exerted a discouraging influence on investigations of the subject by the disappointment which the author expresses at his utter failure to discover the uses of the spleen. His account[1] of the glandulae Malpighii singularly contradicts almost all previous observations. "They are from one-fifth of a line to one line in size, mostly round, sometimes angular, attached to the surrounding tissue, and provided with a small number of vessels, occurring sometimes close together, sometimes scattered: they have no cavity in their interior, and do not effuse any liquid when punctured or cut." A description accurate as to their general appearance, but novel, singular, and perplexing, in making the glandulae to be solid. He believes the venous cells to be an artificial structure, and he adds some original and important observations on the circulation in the spleen. He finds that liquid or air injected into an artery passes out most generally by the corresponding vein, and not by any other artery or vein; and that in tying the vessel,[2] going to one part of the spleen, that part alone becomes gangrenous among surrounding healthy texture. By these experiments he demonstrates that the circulation in the spleen is divided into compartments which have little or no communication with each other by anastomosis.

there enlarged by the addition of a vesicular covering: further, these microscopic cells are said to have plexuses of blood-vessels and lymphatics distributed upon them. It is difficult to reconcile or understand these statements.

[1] I have been disappointed in my endeavours to procure Assolant's work. The account here given is from notices of his work by different authors in their description of the spleen, more particularly, Burdach, the Encyc. Anat., vol. v., and Bourgery.

[2] Heusinger tied all the arteries except one, and obtained a similar result to that mentioned by Assolant.—Encyc. Anat., vol. v. p. 168.

Along with Dupuytren, Assolant performed excision of the spleen on a large number of dogs, but appears to have met with such contradictory results that no conclusions could be drawn from his experiments.

Moreschi[1] (1803 and 1817) studied chiefly the blood-vessels of the spleen, and arrived at conclusions very similar to the opinions of Stukeley : believing that the splenic vascular system acts as a sort of reservoir and regulator of the circulation in the stomach ; the arterial blood supplying the stomach during the process of digestion, while the venous blood is useful in augmenting the fluidity of the portal blood conveyed to the liver.

Heusinger,[2] in 1817, seems to have investigated with much care the glandulae Malpighii. He describes them as whitish bodies, generally small, occasionally larger : disappearing when the splenic veins are inflated, but reappearing on an incision into the part, and proved by injection to be abundantly supplied with blood-vessels. He infers from his researches, "that they are vesicles or minute glands liable to occasional dilatation in various degrees ; and which, when filled, would by mutual compression assume the hexagonal figure."

This return to the description of Malpighi was checked by the researches of Hopfengaertner,[3] who maintains that these glandules are globular and separate only on the surface of the spleen, while in the interior they appear as convolutions, or cylindrical turnings, (gyri.) Dr. Hopfengaertner attributes more

[1] A. Moreschi, Del vero è primario usu della Milza, Milan 1803, and Comm. de Urethræ Struct. ; accedit de Vasor. splenicor. in animal. constitut. Milan 1817. Also review of the latter in Ed. Med. and Surg. Journal, vol. xxi.

[2] Heusinger (C. H.) Ueber d. Bau und die Verrichtung der Milz. Thionville, 1817. (The notice here given of the Treatises of Heusinger and Hopfengaertner is chiefly extracted from the Ed. Med. and Surg. Journal, vol. xviii. pp. 279-295. 1822.)

In Burdach Phys. tom. vii. p. 142, it is stated as the opinion of Heusinger, that air forced into the veins penetrates into these vesicles (glandulae.) Heusinger also states that they swell up after drink has been taken, as had been remarked by Sir E. Home and others. Henlé Anat. Génér. Trad. de Jourdan, tom. ii. p. 581.

[3] C. F. Hopfengaertner—Diss. Hist. Annot. ad Structuram Lienis, in 4to. Tübingen, 1821.

importance to the proper substance, (pulp,) which is soft and fluid, but its minute nature is not distinctly described. He denies that the direct passage of arterial into venous radicles can anywhere be demonstrated in the spleen.

In 1808, 1811, and 1821, Sir Everard Home[1] published the results of his inquiries into the anatomy and uses of the spleen. In his first papers, he describes the glandulae Malpighii as distinct cells with membranous walls, "containing a fluid which escapes when the cells are punctured." These cells have numerous arterial but no venous branches ramifying on their walls. They become distended only occasionally in connexion with the state of the stomach; and when the cells are empty and contracted, and the blood-vessels very minutely injected, the appearance of cells is entirely lost. The veins appear to arise like radii from the exterior of the cells, but in minute injections, they form plexuses round the cells. He notices also the very large size of the splenic vein, and considers the trabecular net-work to be composed of elastic texture. But the fact to which most importance is attached, is the swelling or enlargement of the spleen, and particularly of the cells (glandulae) as shewn by experiments, during the absorption of fluids from the stomach; so that when distended, the spleen is twice as large as when contracted, and the cells could only be seen in distended spleens, from which Home concluded, that liquids were carried through this organ into the circulation. He afterwards renounced this opinion on finding that after the removal of the spleen, the absorption of fluid took place with equal rapidity, (1811,) but he still maintained that fluids were secreted in these cells, during the process of digestion; and from the large size and number of its lymphatic vessels, he believed with Hewson that they were the excretory ducts. His paper of 1821 contained his latest and most complete account of the spleen. By cutting human spleens into thin slices, and putting them in water, which was changed every day till they putrified, he found,

[1] Everard Home — On the Structure and Uses of the Spleen. Phil. Trans. 1808, 1811, 1821.

1*st*, That the contents of the cells (glandulae) are liquid and colourless; and he describes the former as mucus soaked in water, together with lymph globules; 2*d*, That fluid colouring matter is discharged from a slice of spleen kept in water, and this colouring matter he judged from its appearance to be red serum. *Lastly*, He demonstrated by injection, that the trabeculae were vascular, and that their minute branches terminated in the cells (glandulae Malpighii) which, he believed, were originally formed by blood from these vessels poured into empty cells, and moulded to their form.[1]

From those observations he sums up his description,—"The spleen consists of blood-vessels [vascular trabeculae] between which there is no cellular membrane, and the interstices are filled with serum, and the colouring matter of the blood, from the lateral orifices in the veins, when these are in a distended state, which serum is afterwards removed by the numberless absorbents belonging to the organ, and carried into the thoracic duct, by a very large absorbent trunk."

The formation of the glandulae Malpighii or cells is next accounted for,—"The lymph-globules [in the serum, or the arterial blood ?] carry along with them into the intestines carbonic acid gas and mucus, soluble in water in great abundance; but no blood-globules, since none are found in the cells. As soon as the lymph is at rest, the carbonic acid being let loose, forms the cells (glandulae) that surround the lymph-globules, the sides of which are held together by the mucus; putting on the appearance of corpuscles without colour, and are thus mistaken for glands. The gas is absorbed by the blood in the arteries and veins. From this mechanism the spleen appears to be a reservoir for the superabundant serum, lymph-globules, soluble mucus, and colouring matter, carried into the

[1] In this last description of the cells or glandulae by Home, the difference is very remarkable from his first account of them, (1808,) as distinct cells with membranous walls, &c. See his Plate III. fig. 1. In this last paper, "cells" evidently stands for two things,—1*st*, Spaces into which the arteries opened, or empty cells. 2*d*, Bodies composed of mucus and lymph-globules, distended by carbonic acid gas, into the appearance of corpuscles, mistaken for glands. See Plate III. fig. 1, and Plate VII. figs. 3 and 4, with the explanation in the Phil. Trans.

circulation, immediately after the process of digestion is completed."

About the same period, (1821,) Hewson's opinions were further corroborated by the inquiries and experiments of Tiedemann and Gmelin, who, from the coexistence of the spleen and the lymphatic system in the vertebrate animals,[1] as well as from the number of splenic lymphatics, and the reddish colour of their lymph, inferred that the spleen formed from the arteries a secretion, which, conveyed into the lymphatics and thoracic duct, made the chyle resemble the mass of the blood. They endeavoured to prove this opinion by examining the lymph in the thoracic duct of a dog from which they had a short time previously excised the spleen, when they found a smaller quantity of crassamentum, and more serum, of a paler red colour, than they had found in prior experiments on healthy dogs. Not entering into the anatomy of the spleen,[2] their experiments and observations, which are not free from objection nor conclusive, have not added much to our positive knowledge of the subject.

In 1822, Mr. Hodgkin[3] revived Stukeley's opinion that the spleen maintains the balance of the circulation, and endeavoured to explain the facts known in regard to the natural and morbid condition of the organ in accordance with this view.

In 1827, M. Julio Arthaud[4] concluded, from some microscopical observations made by M. Strauz, that the trabecular texture of the spleen contained nervous pulp, and that the spleen, therefore, was only "a plexus of nerves connected with the visceral ganglia." In support of this view, he adduces several

[1] Tiedemann et Gmelin, sur l'Absorption, 1821. See also Rech. Exp. sur la Digestion. They cite the example of the turtle, in which the connexion of the lymphatics or the absorbents with the spleen is stated to be particularly evident.

[2] They are of opinion that the cells of Home (glandulae Malpighii) are distended lymphatics. They also mention the curious fact, previously noticed by many others, that injections pass from the arteries into the lymphatics of the spleen without any detectible rupture.

[3] Thos. Hodgkin—On the Uses of the Spleen, Ed. Med. and Surg. Journal, vol. xviii. p. 83. 1822.

[4] Note sur l'Organisation de la Rate, par M. J. Arthaud, in Journal des Progrès des Sciences Médicales, 1827, p. 216.

observations, most of which are incorrect, and believes that he can demonstrate, by facts from comparative anatomy, that the spleen is an electrical apparatus.

The experiments of Dr. Dobson (1830)[1] on the relation between the size of the spleen and the process of digestion, are an interesting continuation of Home's researches. In dogs killed during digestion, the spleen was found progressively increased in size up till five hours after the time of eating, and after that period its size gradually diminished. On injecting blood into the jugular vein, the spleen was also observed to increase in size ; and, on the contrary, its volume was diminished, when blood was withdrawn from the jugular vein. Finally, in dogs whose spleen had been excised, symptoms of plethora came on after full meals. From those data, Dr. Dobson infers that the function of the spleen is to act "as a reservoir for the additional quantity of blood, which the vascular system has received by means of the nutritive process." Soon after, Dr. Holland[2] (1831) put forward the view, that the spleen and the liver were diverticula of the circulation. His arguments are similar to those of Stukeley.

Numerous dissertations on the spleen have been published on the Continent[3] between 1830 and 1840, but of these I have been unable to procure any account.

Müller[4] has investigated the white corpuscles, (glandulae Malpighii), and is remarkable for distinguishing them into two kinds :—1. Soft and gelatinous, but *solid,* found in the human subject very rarely, and sometimes in the dog and cat. 2. Round white bodies, somewhat firmer, seen in the spleen of herbivorous animals. The latter he considers to be the true Malpighian corpuscles (glandulae.) They are described as being hollow, attached to the splenic artery and its fibrous sheath, and as con-

[1] An Experimental Inquiry into the Structure and Functions of the Spleen, by William Dobson, 1830. Noticed in Lond. Med. and Phys. Journal, Oct. 30, 1830.

[2] Holland—On the Physiology of the Fœtus, Liver, and Spleen. Lond. 1831.

[3] See Bibliographic List of the Encyc. Anat. of Soëmmering, Trad. de Jourdan, vol. v.—Art. *La Rate.*

[4] Physiology, translated by Baly, 2d ed., vol. ii. p. 616.

taining a white pulpy fluid matter, which consists of irregularly globular "particles, all nearly of same size as the red blood corpuscles," but not flattened like them. The globular particles have, further, the same appearance with the particles found in the pulp, which is described as consisting of a mass of "red brown granules," among which capillary blood-vessels form plexuses. Müller describes the arrangement of the blood-vessels as shown by injection; the apparent want of distinct coats in the venous radicles; the appearance of the veins as foramina, and their enlargement by injections of wax, or inflation of air. He denies the existence of true cells (venous cells or sinuses of Malpighi) in the spleen; and states that "the white corpuscles are imbedded in the pulpy substance, and not contained in cells, as Malpighi supposed." He admits also the fibrous trabecular texture. The function of the spleen consists, in his opinion, either in the production of changes in the blood circulating through it, or in the secretion of a lymph of a peculiar nature.

This description by Müller, except in the distinction of the two kinds of glandulae, whose characters are not sufficiently defined, is singularly clear, and shows a great advance in positive information, when compared with previous accounts and observations.

In 1838 and 1839, Dr. Thos. G. Hake[1] published the results of his researches on the structure and functions of the spleen. He describes splenic venous cells and cellules, and glandular grains, and refers to some peculiarities in the distribution of vessels in the spleen. His account does not appear to differ much from that of some of the older observers, as Winslow and De la Sône. I cannot find that he makes any mention of the Malpighian glandulae. He describes cellular texture as forming a considerable part of the pulp of the spleen, (the terminations of the veins and arteries, the cellules, &c.,) and he believes the spleen to be a diverticulum of venous blood.

[1] Hake's original paper is in the Proceedings of the Royal Society, No. 39, for June 30, 1839. Notices and abstracts of it are found in Brit. and For. Med. Review, vol. viii. p. 593, 1839; and in l'Institut, vol. vi. p. 397, 1838, No. 258.

In 1842, M. J. M. Bourgery[1] presented to the Academy of Sciences of Paris a memoir "On the Microscopical Anatomy of the Spleen of Man and Mammalia," which he afterwards published. It was not the spleen in its natural condition, however, that he studied, but spleens prepared by injection and inflation, which he then cut into thin slices, and subjected to magnifying powers of 4, 12, 20, or 30 diameters. Sometimes smaller portions were examined under powers of 125 diameters, or even higher powers. From these preparations, which he has described with the greatest minuteness, M. Bourgery has constructed a most complicated anatomy of the organ, which he has still further perplexed by the addition of an entirely new nomenclature.

In the following account, the chief object will be to show what structures the descriptions of M. Bourgery really correspond to; for his paper contains few additional facts, and its novelty consists in the manner of describing them.

M. Bourgery, in his preparations, injects the smaller vessels, and inflates the large venous trunks. By this process, he analyzes the spleen, as Malpighi had done, into—1. The hollow communicating venous cavities filled with air, which he names the vesicular apparatus ; and 2. The substance of the spleen, forming the partitions of these cavities or vesicles, which he names intervesicular spaces or glandular apparatus. The vesicular apparatus is so termed from the appearance of being divided into pouches, which the distended veins present by projecting lamelliform bands or processes, which are the smaller vessels and trabeculae. These venous pouches or vesicles he describes as presenting a complex structure. Their internal surfaces or walls are formed (besides the trabeculae or vessels, which, from not yielding to distention, project) by a capillary net-work and a granular basis (*champ granulo-capillaire, i.e.*, the surface of the pulp forming the parietes of the veins.) From these walls the Malpighian glandulae are suspended by a pedicle, and float in the cavity of the vesicles or cells, (cavities,) as

[1] Anatomie Microscopique de la Rate, dans l'Homme et les Mammifères, par J. M. Bourgery, lu à l'Acad. des Sciences, Juin 1842, publié à Paris, 1843.

Malpighi had originally described. M. Bourgery having succeeded in injecting these glandulae, calls them "*Corpuscules Vasculaires flottans.*" This vesicular apparatus, or system of venous cavities, lined by granules, capillaries, projecting corpuscles, (glandulae,) and divided by constrictions of trabeculae, but everywhere continuous, is supposed to be the secreting structure of the spleen; the corpuscles (glandulae) and granules pouring out a splenic liquid, which is mixed with the splenic venous blood, and after undergoing certain changes, is absorbed by the capillary lymphatics on the walls of the vesicles, and carried by them to the intervesicular spaces or structures situated between the vesicles, and separating them from each other. These intervesicular structures, which correspond to the pulp, he asserts to be a series of lymphatic glands, connected together by cylindrical continuations of their substance, ("Cordons de liaison,") and forming thus a connected chain or chaplet throughout the whole organ. Into this immense lymphatic system, the splenic secretion from the vesicles is absorbed, and is carried by the lymphatic vessels out of the organ; contributing in this manner to haematosis, while the impoverished venous blood goes to furnish bile in the liver.

Dr. Julian Evans'[1] Microscopical Observations on the Anatomy of the Spleen, which followed soon after, contain much positive information, and form the latest complete work upon the subject, till the recent observations of Kölliker.[2] Dr. Evans admits the trabeculae as described by Malpighi, but denies their muscularity: he describes also the venous cells (of Malpighi) as prepared by inflation or injection: he could not, however, find in them the vascular floating bodies (injected Malpighian glandulae) mentioned by Bourgery. The venous cavities, with the elastic proper membrane of the spleen and the elastic tuberculae, constitute a "multilocular reservoir," capable by its distention of relieving the abdominal circulation. The splenic pulp, seen under the microscope, consists of capil-

[1] W. J. Evans on the Microscopic Anatomy of the Spleen in Man and Mammalia.—Philos. Magazine, 1843. Lancet, 1844.

[2] Cyclop. of Anat. and Phys.—Art. *Spleen.*

lary vessels and of splenic corpuscles, "which are much smaller than blood particles, pretty uniform in size, spherical in shape, and usually corrugated on the surface :"—and besides these elements, the pulp, on pressure between glasses, gives out a reddish fluid, ("the splenic liquid, or secretion, or liquor lienis,") which contains blood corpuscles, and particles similar to those found in lymphatic glands. The splenic pulp further exhibits a number of very minute transparent vessels, less than 1-7000th of an inch, and smaller therefore than the splenic corpuscles. These vessels arise from each splenic corpuscle, and unite into larger trunks shewing distinct valves. They then enter the Malpighian glandulae, which are composed partly of the ramifications of an arteriole, but chiefly of a plexus of the lymphatics coming from the pulp. In the glandulae, the contents of the lymphatics, which had previously been transparent, exhibit spherical nucleated particles, like those in the milky fluid of lymphatic glands. The lymphatics, on their exit from the Malpighian glandulae, unite in larger trunks, which carry off the globules into the lymphatic system. The spleen in this description is made out to be a lymphatic gland : its parenchyma, secreting a kind of liquor sanguinis, which the lymphatics absorb, elaborate and transform into globules within their plexuses, (Malpighian glandulae,) and convey out of the organ.

Such is the account given in the latest special work on the subject. From detached observations and notices of works recorded in different journals,[1] the following microscopical elements may be collected :—

1*st*, Granular Corpuscles (Gulliver, Henlé, Ecker, Simon, Sharpey.) They are about the size of red blood-corpuscles ;

[1] See Gulliver, Appendix to Gerber's General Anatomy (translation) ; Henlé, Anatomie Générale, Trad. de Jourdan, tom. ii. ; Quain and Sharpey's Anatomy, vol. iii. ed. 1848 ; Brit. and For. Med. Review, vol. xxi. 1846, (where Simon and Oesterlen's views are noticed in Mr. Paget's report) ; Edin. Monthly Journal of Medical Science, Heinrich on the Spleen, reviewed in Nos. for March and June 1848 ; and Ecker in the Retrospect, of Nos. for May, July, and August 1848 ; H. Jones in Med. Gazette, 1847, and Lancet, 1846 ; Ecker on the Suprarenal Capsules, in Med. Gazette, 1847, and in Annales des Sciences Naturelles, Août, 1847, Zoologie, tom. viii. p. 103.

are sometimes of a reddish colour (Sharpey), and more or less irregular, &c.

2*d*, Caudate Corpuscles, (Sharpey, &c.) or fusiform cells.

3*d*, Cells with nuclei, more or less granular (Henlé.) These considered to be rare, and thought by Henlé to be accidental.

4*th*, Yellow-coloured particles, cells or corpuscles, (Handfield Jones,) containing blood globules, (Ecker, Kölliker.)

It is a general opinion that the spleen consists of nuclei or cytoblasts, which never reach the higher development of the nucleated cell, (Simon, Jones, &c.)

5*th*, A homogeneous membrane around the Malpighian glandulae is denied by most observers, (Henlé, Oesterlen, Simon, &c.) It has been stated to exist by Ecker; but as he demonstrated it by the application of potassa, which dissolves animal textures into a homogeneous matter, this observation is very uncertain.

6*th*, Muscular fibres of the involuntary kind, and differing in different animals, are described by Kölliker in the proper membrane and trabeculae of the spleen.[1]

The globules of the spleen, and more particularly those in the Malpighian glandulae, have been generally compared to the corpuscles of the lymphatic glands; and the corpuscles of the pulp are stated by some to be of the same kind; by others to be different.

As the spleen had formerly been supposed to form the blood particles,[2] it has of late had the function assigned to it of breaking up and destroying them (Kölliker). To the immense variety of theories unsupported by anatomical proof I make no reference.

Such is the past history of the subject. For contemporaneous observations, I refer to the monographs of Kölliker and Gerlach, published since this paper was written.[3]

[1] See note to Spleen, in Quain and Sharpey's Anat., edit. 1848.

[2] This opinion is revived by Donné, Comptes Rendus de l'Acad. des Sciences, 1842. The spleen has also been supposed to secrete the colouring matter of the blood (by Heinrich); or to break down and decompose the epithelium of the vascular system, (Tigri, in Gaz. Méd. de Paris, 1848, p. 996.)

[3] Todd's Cyclop. of Anat. and Phys.—Art. *Spleen*.—Kölliker. Gerlach—Handbuch der allgem und Speciel. Gewebelehre.—1849.

Original Observations on the Structure of the Spleen.[1] *Malpighian bodies, glandulae or sacculi.*[2] (*Fig.* 3, *b b.*)—These are small spherical bodies, from one-third to two-thirds of a line in diameter, of a semi-opaque white colour and gelatinous consistence. They occur in great numbers, imbedded in the red pulp, and separated from each other by small intervals. They have a swollen or turgid appearance; and on being punctured, they collapse. When cut through with a sharp knife, they exhibit a distinct internal cavity.

On isolating one of these sacculi, it will be found attached by a short fibrous pedicle to a neighbouring trabecula, and in detaching it, some portion of the pulp always adheres. After cleaning it as completely as possible without injury, on a glass slip, with a little pure water, it is covered with thin glass, and examined with a magnifying power of thirty to sixty diameters, when we observe that by direct light it presents a whitish, by transmitted light a dark grey colour. These colours are owing to numerous minute spheroidal dark particles which fill the sacculus, contrasting with the yellowish or brownish particles of the red pulp adhering around. The fibrous pedicle is composed of fibrous tissue enveloping a small artery, which, passing on to the surface of the sacculus, divides into several branches, which supply numerous twigs to it, and then proceed into the surrounding pulp, breaking up into terminal tufts of capillaries. The sacculus has a distinct outline, and possesses a very delicate circumscribing membrane. On gentle pressure it shows considerable elasticity; it is, however, very easily burst, and when it is, the contained grey particles suspended in a clear fluid, are rapidly effused from its interior, and collect around the sacculus, the parietes of which become considerably collapsed. Sometimes through a small opening, the fluid and

[1] These observations were made on the spleens of sheep or bullocks, obtained generally a few hours after death, kept under examination not longer than two days, and they were afterwards verified on the human spleen.

[2] Their size in the bullock's spleen varies from 1-18th to 1-40th of an inch; in that of the sheep, from about 1-25th to 1-40th; in the human spleen they are much smaller, being from 1-60th to 1-90th of an inch.

particles are projected with considerable force in a narrow stream, and it may then be observed that the particles within the sacculus are all affected by the movement, proving that they are quite free and moveable in an internal cavity, and not confined within tubes.

This view, under a low magnifying power, establishes, that the Malpighian sacculi consist, 1*st*, Of a hollow membranous bag or capsule, with a fibrous pedicle containing an arteriole, the surface of the capsule being covered by minute blood-vessels and capillaries: 2*d*, Of fluid contents in the interior of the capsule, composed of a clear fluid, and of minute corpuscular particles, which seen in mass have a distinct grey colour.

Of the fluid and corpuscular contents of the Malpighian Sacculi. (*Fig.* 7, *a*, and *fig.* 6, *c.*)—The effused contents seen under a power of 400 diameters, exhibit a mass of well-defined circular particles, of nearly uniform size, slightly larger than blood corpuscles, and of great regularity in shape and aspect. These particles are held together by a homogeneous or granular plasma, and the whole presents a singularly bright appearance from the great clearness and translucency of the plasma and the particles themselves. The individual particles are observed to have a well-defined, but not strongly marked edge, and a smooth surface, slightly flattened; they are of a greyish colour, but very translucent, generally with one, or several small and rather indistinct granules or nucleoli.

These splenic saccular corpuscles afford very characteristic appearances when treated by reagents.

When a portion of the plasma, (*Fig.* 8,) with its corpuscles, is isolated and freely diluted with water, so as to detach the corpuscles from one another, they swell slightly, become clear and more distinctly spherical, and exhibit in their interior several well-defined rounded nucleoli, generally 5 to 8, sometimes, however, only one nucleolus. The corpuscles may also be seen occasionally to revolve on their axes, when put in motion, and their walls exhibit considerable elasticity, not flattening by their weight when the corpuscles are at rest. Differences in size also become apparent.

Acetic Acid (*Fig.* 9) produces much more rapidly a similar, but more marked change. The corpuscles shrink in size, but preserve their accurate globular form ; their outline becomes dark, and clearly defined, and the contained granules or nucleoli also present distinct dark margins. This reaction, which is more easily obtained than that by dilution with water, is very characteristic.

Alcohol contracts the corpuscles and displays their nucleoli. The plasma is also rendered more distinctly granular by reagent.

Aqua Potassae and Aqua Ammoniae dissolve the corpuscles, leaving only a homogeneous or faintly granular mass.

The reactions above described take place almost instantaneously. By the prolonged action of water, the corpuscles break up into granules, or become so faint that their forms are with difficulty recognised ; in this state, however, they may be made to reappear to some extent on the addition of acetic acid. By the prolonged action of acetic acid, the corpuscles become very much shrivelled and contracted, without however losing their spherical form ; whilst the dark edges and granules give the corpuscle, which still preserves its great translucency, a somewhat crystalline appearance.

As the action of acetic acid displays the structure very distinctly, we may conclude that the corpuscles consist of a smooth spherical membrane, with several nucleoli attached to its interior, and revolve with it, and containing some fluid matter, the quantity of which may probably be influenced by endosmosis.

In size the corpuscles vary a little, and may be distinguished into two sets : 1*st*, the smaller, but more numerous, about the size of blood-corpuscles, from 1-6000th to 1-4000th of an inch ; and, 2*d*, a few of a larger size, and more distinctly granular before the addition of reagents, from 1-3500th to 1-3000th of an inch. Although there are some of intermediate magnitude, yet these two sets are sufficiently distinct to deserve notice.

In addition to these elements, which are constant, and the most important, other corpuscles are generally observed in small quantity. (*Fig.* 7, *b.*)

1*st*, Larger granular corpuscles, from 1-2500th to 1-2000th of an inch in diameter, of a pale grey colour, and containing, some a few, others a greater number of granules.

2*d*, Distinct nucleated cells of 1-2000th of an inch in diameter; the nuclei of 1-4000th of an inch correspond in size and appearance to the saccular corpuscles first described. These cells either contain granules, or merely present a faint outline, rough internally, but without distinct granules.

Contents of Malpighian Sacculus, as seen in their natural situation.—If we examine with a power of 400 diameters the contents of a sacculus that has remained entire, we shall find that its interior is filled and rendered dark by the numerous saccular corpuscles, whose characters can now be recognised; but on further carefully adjusting the focus, so as to bring into view the superficial layer of particles, *i.e.*, those immediately beneath the fibrous membrane of the sacculus, we observe, at first with some difficulty,[1] in that situation a number of large globular bodies, about twice or thrice the diameter of the corpuscles, and further differing from them in their smoother and clearer aspect, most of them containing in their interior dark nuclei of the size and appearance of the saccular corpuscles. If the specimen is favourable, these globules are seen uniformly arranged over the surface, and when the preparation becomes clearer from flattening, they present the appearance of a layer of nucleated cells, having a very light golden yellow colour, and of great brightness, contrasting vividly both with the dark, somewhat granular, corpuscular nuclei within them, and with the dark free corpuscles which lie under them. This layer of cells lies upon or is attached to the inner surface of the saccular membranes, and can be traced lining either the whole or the greater part of their extent. Sometimes this layer is observed to be only partial, for the cells are readily displaced, but with care its continuity may usually be seen over a large portion of the sacculus. (*Fig.* 12.)

[1] This difficulty arises from the darkness of the corpuscles seen in mass. By patience, care, and frequent trials, the observation may be satisfactorily verified. In a ruptured sacculus, which has been slowly emptied, the cells may be seen distinctly, as represented in *fig.* 12.

It is difficult to isolate these globules, which we may call saccular cells, so as to examine them while floating free in a fluid, in consequence of the cell-wall, unlike that of the corpuscles, becoming pale or dissolving by dilution with water. Sometimes, however, by tearing the membrane of the sacculus at a central part, the globules pass out into the free space thus made, where the water being mixed with plasma, does not alter their appearance, and they can then be distinctly observed. (*Fig.* 6, *a* and *b.*)

These cells present the following general characters :—1*st*, a perfectly spherical form. While seen, however, close together under the membrane of the sacculus, some of them exhibit a compressed appearance from pressure ; 2*d*, a very smooth and bright cell-wall, of a pale yellow hue ; 3*d*, the matter between the cell-wall and the nucleus transparent and without granules ; 4*th*, the cells themselves very elastic and mobile, moving freely and quickly in the surrounding fluid, those which possess a nucleus rolling over, whilst the nucleus adheres to the cell-wall ; 5*th*, the greater number are the 1-1200th or 1-1500th of an inch in size, and contain a single nucleus, sometimes smaller, but generally of the same size and identical in appearance with the saccular corpuscles. These nuclei have a greyish aspect, depending probably on their situation within the cell, (which does not admit of their being seen by transmitted light,) and sometimes a slightly granular surface ; but when the part of the cell-wall to which they are attached is uppermost, they are frequently seen translucent and smooth. The nuclei, from adhering to the cell-wall, sometimes appear centric, at other times eccentric. Besides these cells, there are others larger, 1-1000th of an inch or more, which sometimes contain two or three nuclei ; cells much smaller, from 1-2000th to 1-3500th of an inch, in which the nuclei often appear of large size, filling up the cell and leaving only a bright border round it ; and *lastly*, yellow globules, without nuclei, of all sizes, from 1-4000th to 1-12,000th of an inch. With regard to these last, it seems most probable that they are either small cells whose nuclei have escaped, or that they are nuclei of the larger cells, and have escaped in a situation where not being acted on by water, they do not assume the grey appearance to be presently mentioned.

The characters given above are observed when the quantity of water is not so great as to act directly upon the cells, which are in some measure protected by the surrounding plasma. But when the cells are exposed freely to water, they change their aspect. They very generally allow the nucleus to escape, and then both cell and nucleus undergo alteration: they become of a pale grey colour, and show a few granules; or they become perfectly clear, dissolve, and leave only a distinct circular outline; or *lastly*, the cell dissolves, while the nucleus, set free, resists the action of water, acetic acid, &c. By these changes they may be traced as corresponding to the corpuscles and cells previously described, (*Fig.* 7, *b*,) as occurring in the effused contents of the Malpighian sacculus.

It should have been mentioned that there is the greatest difference in different specimens with respect to the amount of granules in the saccular corpuscles; sometimes they contain very few and indistinct nuclei, in other cases they contain numerous and very dark nucleoli. These differences there is reason to believe depend on their stage of development, and it is probable that at first both the corpuscles and the cells contain a homogeneous matter, which subsequently becomes granular, exhibiting the granules or nucleoli on the addition of water or acetic acid.

Acetic acid dissolves the cell-wall of the saccular cells: Aq. Potassæ, Aq. Ammoniæ, &c., also quickly dissolve them.

The saccular cells and corpuscles have been described with some minuteness, because they are of great importance, as shown, 1*st*, By their abundance; 2*d*, By the constancy of their occurrence, and the uniformity of their aspect. Both corpuscles and cells are observed in every instance. The latter are not always uniform in number or distinctness; they are generally, however, very evident, and may always be detected if carefully looked for. The former differ only in the amount and distinctness of their granules and nucleoli.

The plasma does not require detailed description. It is semi-fluid, clear, white, and transparent, sometimes faintly granular; and where the corpuscles contain numerous dark nucleoli, free dark granules are seen abundantly in it.

It is obvious that those bodies have some important function assigned to them. The characteristic appearance of the cells themselves, and the relation of the corpuscles to them as their nuclei, are tolerably conclusive as to their influence in the production of the plasma. And it is in the discharge of this function, and by the processes of growth required for it, that the changes in the corpuscles, in regard to their granular matter, and changes in the sacculus itself, in regard to size, &c., are effected. Both cells and corpuscles in their earliest state probably contain fluid only, and are then capable of being dissolved in water, or at least of becoming so transparent as to be rendered invisible. At a later period the corpuscles always become occupied by granules, and are then insoluble both in water and acetic acid; but the cells appear generally to remain capable of solution, a few of them only showing granular matter in their interior when acted on by water. Nucleated cells containing granules, and resisting for a time the action of acetic acid, are very rare. The probable ulterior change in the corpuscles will appear from the examination of the pulp or parenchyma.

The Parietes and Blood-vessels, &c., of the Malpighian Sacculi.—The pedicle, by which the sacculus is attached to a trabecula, may be observed under a magnifying power of 300 diameters, to consist of an artery from 1-150th to 1-250th of an inch in diameter, the characteristic structure of which is readily manifested on the addition of acetic acid; and of fibrous tissue forming a sheath round the artery: this fibrous tissue being in great part soluble in acetic acid, but containing insoluble or elastic fibres. The artery on reaching the sacculus (*Fig.* 5) divides into several branches which pass over its surface, the fibrous tissue spreads out with them on all sides, completely enveloping the sacculus and forming an areolar net-work, (*Fig.* 10,) in which the vessels ramify. The fibres composing this external fibrous membrane are very distinct over the whole sacculus, and are nearly all soluble in acetic acid. The distribution of the minute arteries is somewhat peculiar: the branches into which the trunk divides radiate in straight lines over the sacculus, with few subdivisions, and give off laterally minute branches, which soon become capillary: but when on the point of passing from the sacculus into the surrounding pulp, they split into tufts of terminal branches of nearly equal size, which proceed into the pulp, and there ramify and anastomose very abundantly. (*Fig.* 5.) It appears, therefore, that the blood-vessels of the sacculus consist of minute arteries and capillaries, which communicate or are continuous with those of the pulp, where the veins are numerous. Veins do not seem to be present in the walls of the sacculus; and although it is not improbable that lymphatics exist there, yet even if they do, it must be admitted that they would be very difficult of detection, as the microscope does not furnish unequivocal characters by which they could be distinguished. Indeed, lymphatics have not been demonstrated in this locality by injection, and as no trace of them can be detected by the microscope, their connexion with the sacculi must be considered very doubtful.

In addition to the fibrous and vascular membrane, do the sacculi possess any other membrane? Have they a true basement membrane? From analogy, there is the strongest reason to presume its existence, and although I have not succeeded in isolating an entirely structureless membrane, the following observations indicate unequivocally the existence of such a limitary membrane:—

The fibrous membrane of the sacculus is composed of such loose and open texture, that the plasma and corpuscles could not be confined by it; yet these are not found effused nor mingled with the pulp, but are retained within the distinct outline of the sacculus. When a portion of the saccular membrane is torn off by means of needles, spread out and washed with water on a glass slip, it presents the aspect of a finely granular surface, which is divided into spaces by the meshes of the fibrous external membrane. (*Fig.* 11.) On close inspection, however, pretty regular and smaller divisions into somewhat hexagonal compartments are noticed, as if the surface were composed of scales, united together at their edges; the scales being about 1-2000th to 1-2500th of an inch in diameter. The same appearance is also frequently seen when diluted Aqua Potassae or Ammoniae is made to act slowly upon the granular membrane. And occasionally portions of the membrane of considerable size may be seen separated from the fibrous membrane of the sacculus, and then exhibit a very pale granular appearance, with a very apparent division into scales.

By the action of acetic acid, elongated dark-edged nuclei are seen on this granular membrane, which may possibly however belong to the fibrous tissue lying on its external surface. The granular appearance of its internal surface also depends greatly on adhering plasma; and if this could be separated, probably a homogeneous structureless membrane would remain. The appearance of the limitary granular membrane, as above described, however, is plainly made out, and may be named the internal tunic of the sacculus.

The Malpighian sacculus consists then of a hollow sphere, formed by—1*st*, externally, a fibrous membrane containing blood-vessels, and attached by a vascular pedicle; 2*d*, internally, a granular membrane, the internal surface of which is lined by a layer of large nucleated cells, while free nuclei or corpuscles with a homogeneous or granular plasma fill its interior. It is a closed sac, containing secreting elements.

The analogy of the closed sacculus to the acini of secreting glands, first adverted to by Malpighi, is very striking. Modern investigation[1] has shewn that the ultimate secreting structure of glands in general, consists of follicles or closed acini, containing cells and nuclei, by the solution of which the secretion is formed; and, as the communication with the excretory duct is frequently not opened up till the secreting cells are mature, it then takes place by rupture of part of the acinus. This fact attaches much interest to the structure of the closed sacculi of the spleen.

[1] Henlé, Anatomie Générale, trad. par Jourdan, 1843; and Goodsir, Trans. Roy. Soc. Edin., 1842, and Secreting Structures, in Anat. and Path. Observations, 1845.

In pursuing, therefore, the analogy between the splenic sacculi and the acini of glands, it appears to be a legitimate and attainable object of investigation to obtain evidence of the growth of these sacculi, of their bursting as acini do, and of their mode of reproduction and decay. The following facts bear upon these questions:—

1*st*, The size of the Malpighian sacculi in the same spleen varies remarkably, from small points up to the size of a large pin's head; sometimes several small sacculi are closely grouped together; at other times the smaller are arranged around or near one or more larger sacculi; and it is generally found, although this must not be stated too confidently, that the contents of the larger are more granular and dark than the corpuscles of the smaller sacculi, and abound more in free dark granules.

2*d*, In different spleens it has often been remarked, that the size of the sacculi varies much. In the numerous instances, however, in which I have had occasion to observe them, their size was in general tolerably uniform. They were seldom found smaller than the average size, when the spleen was quite fresh; but in one example they were seen of very large size, above one line in diameter, of a more opaque white than usual, comparatively firm and fibrous, shewing a very distinct internal cavity, when divided, and not collapsing very much when punctured. They were too large to be seen entire under the higher powers of the microscope, and they resisted the pressure of thin glass slips. They were examined by tearing them with needles. The fibrous tunic was strong; their elements did not differ from the usual forms, but the internal granular membrane, divided into scales, appeared unusually distinct.

3*d*, These evidences of growth in the sacculi, corresponding with the known process of growth in nucleated cells, tend to shew that the sacculi, small at first, enlarge as their contents increase and become mature. Do they then burst and disappear? No direct evidence of this has yet been found, but it is rendered probable by the microscopical appearance of the pulp, which presents corpuscles similar to, but apparently degenerating from, the saccular corpuscles. How do the sacculi arise? On this also there is no positive evidence: they may be formed by the enlargement and development of one or more of their contained cells, as acini are found to be formed by the enlargement and distention of a parent cell; or they may be produced by some part of the sacculus; or lastly, but with least probability, they may arise in the pulp. This must be decided by future investigation.

4th, If these sacculi perform important functions in the spleen, why are they not invariably present? As observers have denied the existence of these sacculi in the spleens of animals in which they most certainly exist, their testimony is not to be relied on in regard to their absence in spleens in which they are more difficult of detection. In the spleens of the bullock and sheep, I have never once found them absent or indistinct, but always so plain that even those unaccustomed to such observations might at once discern them. Their presence appears to me to be invariable.

In regard to the human spleen, of which nothing has yet been said, these sacculi have been almost universally denied. Sir Everard Home's plates, however, afford sufficient evidence of their occasional existence, and in the course of my own observations, (1848-49,) they have in numerous instances appeared with unequivocal distinctness. In these examples, the microscopical character of the sacculi was in every respect identical with that observed in the spleens of animals; they exhibited the same grey appearance contrasting with the yellowish colour of the pulp, under low or high magnifying powers; the same form of the corpuscles, and the same cells seen under the fibrous membrane of the sacculus; finally, the same reactions with acetic acid, &c. It is very remarkable that the sacculi are seldom seen with the naked eye in human spleens, while they are so constantly and readily seen in those of animals; but this difference is not more remarkable than that which occurs in a spleen in which the sacculi are at first quite visible; for by keeping the spleen for a few days, nearly all trace of the sacculi disappears; and, whereas before they could not be overlooked, they are then scarcely visible on the closest inspection. By keeping, the Malpighian sacculi soften and melt away, becoming really confounded with the pulp; and it is highly probable that this fact explains both their supposed absence in the spleens of animals, and their usual indistinctness in the human spleen. But here the microscopic appearances of the saccular elements come to the aid of the observer; and from the presence of saccular corpuscles and cells, I have found evidence of the Malpighian sacculi in the human spleen, when they could not be detected with the naked eye. A light whitish gelatinous appearance generally remains in the situation where the sacculi have been, and where their corpuscular elements may be discovered. When we farther consider the small size of the sacculi in the human spleen, (1-50th to 1-90th of an inch in diameter;) its congestion and alterations in consistence, and the rapidity with which the organs of the human body putrify after death, the existence of Malpighian sacculi as essential elements of the organ cannot easily be denied.

I have already mentioned the influence of time, softening, and putrefaction, in removing all traces of the sacculi. Another circumstance has been much insisted upon by Sir E. Home and others, viz., the taking of liquids into the stomach shortly before death, which is said to increase greatly the size of the spleen, and particularly of the Malpighian sacculi. Several strong objections may be urged against the inference:—1*st*, In animals which have not taken drink for many hours before death, these sacculi are perfectly distinct and large; and, 2*d*, In the bodies of persons who have died of cholera, in, or immediately after the collapse, and in which the spleen is remarkably empty of blood and small in size, the Malpighian sacculi are seen with great distinctness. It is difficult, in the latter case, to admit that the quantity of fluids could be such as to distend the sacculi. On the other hand, it is evident, that as the bodies of such persons are examined comparatively soon after death, the spleen is in a fresher state, and, from the absence of fluids, may perhaps be less apt to soften than usual. During the epidemic of cholera in Edinburgh in the winter of 1848-49, as had formerly been observed in 1832-33, I remarked the presence of the Malpighian sacculi in the spleens of the bodies examined.[1] It may also be added, that, generally, in the spleens of young subjects, being less congested or altered, the sacculi are better seen.[2]

Of the Pulp or Parenchyma of the Spleen.—The soft pulp is distinguished from the sacculi very readily by its red colour. There are two varieties of this colour—a light or flesh red, and a dark-brown or blackish red. When of the former hue, it brightens to scarlet on exposure to air; when of the latter, that change takes place very slowly, or not at all. This colour, as seen by the naked eye, is owing in greater part to the blood remaining in the organ, which, when it remains fluid, brightens on exposure; but when coagulated, does not readily do so. Such is shewn to be the fact, as blood globules are detected abundantly by the microscope, and when the blood is washed out by injecting the spleen with water, the pulp appears of a yellowish white colour; the human spleen, when empty of blood and collapsed, as in bodies of cholera patients, being of a greyish colour. Indeed, the colour of the spleen, as usually seen on a fresh section, is an intermediate tint produced by the mixture of the whitish colour of the pulp with the red colour of the blood.

Under microscopical examination the colour of the pulp is very characteristic; for, even when the blood has been dissolved or washed from the preparation by water, or acetic acid, the pulp still appears in mass slightly yellowish or lightish brown,[3] composed of small particles connected by plasma, and in this way distinguishable from the grey colour of the saccular elements. Proceeding upon these distinctions at first, more de-

[1] The experiments of Dobson show that the bulk of the spleen increases after meals; but he does not state that the Malpighian sacculi were larger or more distinct.

[2] The bodies described both by Assolant and Müller were most probably Malpighian sacculi, softened by keeping, so that their distinct outline and confining membrane had dissolved away, and the bodies appeared only as gelatinous masses,—solid or semi-solid, because the contents of the sacculus, not the sacculus itself, were then only visible.

[3] This colour, seen under the microscope after the blood-corpuscles are dissolved, is owing to the haematin or colouring matter of the blood, which is not destroyed by reagents.

finite characters are revealed by the microscope, by which the pulp is seen to consist of various kinds of particles :—1*st*, Corpuscles and granules, with a few granular cells—elements possessing great general resemblance to the saccular corpuscles ; 2*d*, Coloured particles,[1] (*Fig.* 15,) red or yellow, of a crystalline appearance, unlike any element found in the sacculus ; 3*d*, Peculiar fusiform or spindle-shaped cells. These are placed in a semi-membranous plasma, which is intersected by a capillary plexus, and crossed by bands of trabeculae. (*Figs.* 13 and 14.)

1*st*, The corpuscles of the pulp resemble the saccular corpuscles in being pretty nearly of the same size, in being hollow, nearly circular, translucent, and in containing several granules in their interior.

They differ in perfection and uniformity of appearance, being generally shrivelled and contracted, with dark edges. They often appear to be breaking up into granules, being more or less notched, and angular, and their nucleoli very dark ; their surface, usually grey, sometimes presents a reddish or yellowish tint. They are not very uniform in shape ; and resemble the saccular corpuscles that have been for some time acted on by acetic acid. By the action of acetic acid they become much contracted in size, and their irregular and angular shape becomes more apparent. They convey the idea of corpuscles which have been some time formed, and are beginning to break up ; and they may be noticed in many gradations, from pale smooth corpuscles, identical almost with the saccular corpuscles, to minute angular, almost crystalline particles.

These splenic corpuscles are in great abundance, making up the chief part of the pulp ; but they are equalled or exceeded in quantity by the free dark granular matter which surrounds them and fills the interstices. These granules are very small, some dark-edged, some paler ; most of them are easily soluble in acetic acid, and evidently result from the breaking up of the corpuscles ; others are darker, and resist the action of the acid.

[1] These are the coloured particles described by Dr. Hanfield Jones, and by Kölliker and Ecker, as forms of blood-corpuscles.

The chief part of the pulp consists of these corpuscles and granules, but nucleated cells may also sometimes, though rarely, be seen: these are mostly granular, and often appear to be in the act of breaking up; their nuclei having the usual characters of the corpuscles. I have also several times seen clear cells in the pulp, though they are of very rare occurrence. The splenic corpuscles should be carefully distinguished from the nuclei of the vascular epithelium and tunics, which occur mixed accidentally with the corpuscles, and from a similarity of general appearance may be mistaken for them. The vascular nuclei are recognised by their larger size; their oval or elongated shape; and by their greater paleness, both of surface and outline, before and after the addition of acetic acid. (*Fig.* 14.)

2*d*, Besides the usual corpuscles and granules, there exist in the pulp some remarkable coloured particles, (*Fig.* 15,) nearly always present, sometimes in great abundance, varying from the size of small granules to that of blood corpuscles, and often aggregated in large masses or cells of 1-1000th of an inch in diameter. They are of a deep red colour, or of a dark yellow, and have a dark bold outline, which is sometimes circular, but most commonly angular. Some have the appearance of hollow spherical bodies or cells, but most of them look like crystalline particles: they are insoluble in water, and are changed to a bright yellow colour, and very slowly dissolved, by Aq. Potassae and Ammoniae. These coloured particles bear a great resemblance to the crystals of haematin seen in morbid effusions. They have been taken for degenerating blood corpuscles by some observers (Kölliker), and for cells in which blood corpuscles are formed by others (Ecker, Gerlach). They are more difficult to detect in the human spleen, where they are not constant; they occur nearly always and in large quantity in the spleens of animals; and they are seen in morbid exudations, particularly the typhous exudations in the human spleen. Similar coloured corpuscles are found in the blood in other parts of the body, and they are formed by agglutination of the blood corpuscles after coagulation has taken place. From all the circumstances connected with them, they would appear to be the product not of organic processes, but of physical alteration in stagnant blood, and are only more abundant in the spleen, because more blood is retained after death in its pulp than in the substance of other organs.

3*d*, Caudate or fusiform cells are also seen in the pulp. These consist of a rounded or oval nucleus, somewhat granular, generally a little larger than the spleen corpuscle, and attached to a cell which is very narrow, but extended in length and terminated in a point at each extremity. The length of the cell is 1-950th to 1-540th of an inch; its breadth 1-4000th of an inch at the broadest part; the length of the nucleus is 1-2500th of an inch. Sometimes the cell is prolonged on one side only of the nucleus. The cell-wall is cleared or dissolved by acetic acid, the nucleus being at the same time rendered more distinct. These bodies belong chiefly to the capillaries which may sometimes be seen splitting up into them. Some irregular forms of them are also owing to the broken up epithelium of the vascular tunics; and even splenic corpuscles, with shreds of adhering plasma, assume a similar shape.[1]

The plasma, or semifluid substance, white, transparent, and structureless, by which the particles are held together in the pulp, has a certain degree of consistence or toughness; and, both to the naked eye and under the microscope, when in thin layers, has a somewhat membranous appearance. This cohesion is owing to the large number of capillaries, and to the bands of trabeculae, which split up, apparently accompanying the capillaries, and form a very minute microscopical net-work to support the pulp. The minute capillary vessels[2] are exceedingly abundant, (*Fig.* 13,) in size about 1-3000th to 1-4500th of an inch in diameter: they form very close plexuses, with interspaces of 1-500th of an inch, or less:

[1] Some of these are figured by Kölliker, who is disposed to regard them as muscular.—Cyc. An. and Phys.

[2] The capillaries are apt to be broken up, on making a microscopical preparation, into smaller pieces, which, perhaps, are what Evans and others have described as minute transparent lymphatic vessels. The valves described by Evans in these vessels are perhaps the nuclei.

they display, on the addition of acetic acid, the characteristic oval or elongated granular nuclei, (*Fig.* 14,) and they may often be traced into large venous trunks of 1-700th to 1-500th of an inch in diameter. Veins, with their epithelial lining and internal tunic, containing long slender granular nuclei, are commonly seen in the pulp. Minute arterial branches are rare, being almost exclusively distributed to the sacculi. The larger veins, which are numerous, have no outer fibrous tunic, and appear to the naked eye as wide canals bored in the substance of the pulp, (*Fig.* 2, *d*, and *fig.* 3, *d*) ; while the ramifying arteries and trabeculae divide the pulp into spaces of irregular shape, and not completely enclosed, each of which contains one or several Malpighian bodies imbedded in it. (*Fig.* 3.)

From the semifluid nature of the plasma, and the numerous capillaries and minute fibrous tissue, forming a net-work for it, result the appearances described by authors :—1*st*, The cottony tissue (Winslow, De la Sône) which is presented when the pulp is partially dissolved away by maceration, and the capillaries and fibres are left teased out with some of the plasma adhering to them. 2*d*, The membranous appearance of the pulp in spleens inflated and dried, where, from compression and evaporation of its fluids, the pulp shrivels into the consistence of a membrane, forming the walls of distended venous canals, or of hollow spaces made by rupture of the venous membrane, and extravasation of the air. (Malpighi, Winslow, Bourgery.) 3*d*, The flocculent tufts of injected capillaries, demonstrated by injection and washing. (Ruysch.) 4*th*, The homogeneous mucus, in which the capillaries were supposed to terminate. (Eller.)

Lymphatics and nerves are believed also to terminate in the pulp ; but their course has not been successfully traced.

Probable conclusions.—There are two principal facts in the structure of the pulp, 1*st*, The existence of corpuscles, similar to those in the sacculi, but more irregular and breaking up into granules and plasma ; and, 2*d*, The large amount of capillary vessels, and in particular, the number and size of the veins. These facts naturally suggest the explanation, that the mature sacculi effuse their contents into the pulp, where these undergo certain changes of destruction or disintegration : and that in this condition they are finally absorbed by the capillaries into the venous system. If such were the case, the pulp would correspond physiologically to a duct or reservoir of the secretion of the spleen ; and such secretion being evidently of an albuminoid nature, (consisting of some protein compound,) is absorbed into the circulation, doubtless for purposes of nutrition. Such a theory may serve temporarily to connect the facts above stated, of which it is the most general expression, and must be tested by future observations, for which it may serve as a starting-point. It is a striking analogy, that the ultimate ducts of secreting glands are intercellular passages, (Goodsir,) and very many secretions are reabsorbed into the circulation (recrementitious.) Absorption of nutritive material by capillaries and veins, is believed to take place in the placenta ; and it is remarkable that the umbilical vein which acts as the duct to convey the absorbed nutritive elements into the general circulation, belongs to the portal system, of which the splenic vein is also one of the main branches.

The Malpighian sacculi and the pulp, therefore, form the essential or glandular structure of the spleen, but the other textures exhibit peculiarities in their arrangement and distribution :—1*st,* The tunics, the vascular sheaths or capsulae, and the trabeculae ; 2*d,* The blood-vessels, lymphatics, and nerves.

Tunics.—The external tunic, derived from the peritoneum, envelops nearly the whole of the spleen, being wanting only at the entrance of the vessels (the hilus,) and at a portion of the internal surface posterior to the hilus, which rests on the diaphragm, and is attached to it by cellular tissue. Under the microscope this tunic presents the texture of serous membranes :—1*st,* Most superficially a layer of nucleated hexagonal scales, arranged to form a mosaic-like membrane ; 2*d,* A layer of granular matter, under which dark-edged, elongated, pointed, sometimes twisted cytoblasts, the germinal spots of Goodsir, are seen lying nearly parallel, at regular and minute intervals, on a structureless or basement membrane. Under the peritoneal membrane there is a quantity of common connecting areolar texture, which serves as a basis for the numerous blood-vessels and superficial lymphatics which are placed between the two tunics of the spleen. Of these blood-vessels, there are two kinds: one set proceeds from the splenic vessels before they enter the hilus, and spreads ramifying over the surface of the organ; the other set consists of branches which emerge at different points from the substance of the spleen, piercing the fibrous tunic, and then dividing into several diverging branches.

On separating or tearing off the peritoneal tunic, the following objects are seen connected with the strong fibrous proper membrane:—1*st*, Numerous red points, stigmata of Malpighi, the orifices of blood-vessels torn across in separating the membranes; 2*d*, Foldings or wrinkles of the fibrous membrane when the spleen is not much distended, caused by the mechanical traction of the trabeculae inserted on its inner surface, so that they furnish no evidence of muscularity; 3*d*, This fibrous tunic may be separated into layers. On stripping off all of these, except that which immediately covers and confines the substance of the spleen, and which has a reddish colour from the pulp seen through it, the peculiar structure "mira fibrarum implicatio," noticed by Malpighi and Stukeley, is observed. (*Fig.* 1.) The membrane presents on its outer surface numerous round white prominent points of the size of a large pin's head or larger, scattered pretty regularly at short distances. These consist in thickenings of the membrane where the trabeculae are inserted on the inner surface, and from them fibres radiate in all directions, interlacing with each other, and stronger bands of fibres pass more directly between adjacent prominences. In addition however, a strong layer of fibres passes in the longitudinal direction, and the radiating fibres are merely a mechanical adaptation to give strength to the insertions of the trabeculae, and are no evidence of muscular structure, as Malpighi supposed; nor does the red fleshy appearance of the fibrous membrane depend on anything more than the pulp shining through it, for on being separated it presents the usual opaque white fibrous appearance.[1]

[1] This description applies almost exclusively to the bullock's spleen.

This fibrous tunic is very elastic, and may be stretched to a great extent. Under the microscope, it presents common fibrous tissue, with a large quantity of small elastic fibrous tissue insoluble in acetic acid. Some broad elastic fibres are also seen, and sometimes, especially around minute blood-vessels, the fibrous tissue is arranged in bundles, girded round by a single broad fibre, apparently of the elastic kind.[1] I have not observed the involuntary muscular fibres mentioned by some authors, (Kölliker, Sharpey, &c.) They are certainly not present in any quantity; and as they are not found in the spleens of all animals, they are not sufficient evidence of contractility in this fibrous tunic.

On dissecting off this membrane from the substance of the spleen, the numerous points of insertion of the trabeculae are noticed, at narrow intervals, on its inner surface. These trabeculae are firmly attached by continuous fibres to the proper tunic. They then pass into the pulp to ramify and anastomose with each other.

Vascular Capsula and Trabeculae.—Being of the same structure, these may be described together. In the spleen of the bullock and sheep, the vessels, on entering the organ, carry inwards around them a sheath prolonged from the proper fibrous tunic. The artery and nerves are enveloped in a distinct compartment of this capsula, (*Fig.* 2;) and their strong fibrous investment continued along the arterial ramifications constitutes the arterial or vascular trabeculae, (containing an artery and two nerves in the larger ones.) The rest of the capsula which surrounds the large vein is much less strong; and though at first complete, exhibiting only the perforations corresponding with the venous branches, it soon shews larger open spaces, and degenerates into a mere net-work of trabeculae surrounding and supporting the venous tunic. In the larger branches of the vessels the same arrangement is found.

The trabeculae which divide the pulp into compartments, and support generally the substance of the organ, are best displayed

[1] Similar to those figured by Henlé, Anat. Gén., Plate II. fig. 6, but containing more insoluble fibres.

by washing away the pulp by a stream of water. Their frequent ramifications and anastomoses are thus distinctly seen, and their attachments traced to the vascular capsula, and to the proper fibrous membrane. The trabeculae are of two kinds, arterial trabeculae, (*Fig.* 4, *a*, *b*, *c*) ; *i.e.*, arteries surrounded by the capsula ; and fibrous trabeculae, consisting solely of fibrous tissue, true ligaments. The fibrous texture contains a large amount of elastic fibres ; I have not detected the involuntary muscular fibres, described in the spleens of certain animals by Kölliker.

Of the Splenic Blood-vessels and the Splenic Circulation.— The large size of the blood-vessels in proportion to the spleen is notorious, and the thickness of the arterial walls, and the proportion of the vein to the artery, are equally remarkable. The coats of the splenic artery are thicker than those of the aorta in the proportion of 1312 : 1000 ; and they are capable of supporting a pressure of 41 lbs. The calibre of the vein is five times that of the artery, the usual proportion of veins to arteries being $2\frac{1}{2}:1$, while the venous coats are peculiarly thin, being to those of the iliac vein as 1 : 3·5, and to those of the splenic artery as 1 : 4·812 or 4·336 ; and the calibre of the smaller veins to the smaller arteries within the spleen is said to be 20 : 1, (Schmidt.)[1]

In the human spleen, and in that of the horse and dog, the vessels divide into several branches before entering the spleen. In the bullock and sheep, the vessels enter by single trunks, and their larger divisions take plaçe within the organ ; and in the larger trunks the artery and vein are placed together, enclosed in the same capsula. The peculiarities of the vascular apparatus are most obvious in the bullock and sheep.

1. On slitting up the large veins in the substance of the bullock's spleen, (*Fig.* 2,) it is noticed that the external fibrous tunic is wanting, and that the capsula which supplies its place soon becomes deficient, so that the veins appear as canals bored in the pulp, and lined only by a smooth transparent membrane. In minute structure this membrane consists, 1*st*, of a layer of epithelium placed innermost ; 2*d*, of the proper venous tunic,

[1] Wintringham, Exp. Inquiry. Haller, El. Phys. Heusinger, Enc. Anat.

with its elongated granular nuclei ; *3d*, of fibrous tissue, and dark nuclei elongating into fibres. In the smaller veins the fibrous layer is absent, and the venous tunics lie immediately on the pulp. The artery is placed on the floor of the vein, under the venous membrane, and enveloped along with the nerves in the strong fibrous capsula ; it presents the usual minute structure.

2. The distribution of vascular branches takes place in two ways : 1*st*, Dichotomously into the main divisions, corresponding to the branches of the splenic vessels before they enter the hilus in the spleen of man, the horse, dog, &c. ; and 2*d*, By a number of minute branches, very small in proportion to the parent trunk. (*Fig.* 2.) These minute branches arise laterally, nearly at right angles, from the main vessels during their course, giving their internal surface a perforated appearance. At the extremities of the main vessels, the minute branches form a terminal tuft or pencil—an arrangement which is very obvious in the human spleen. In the terminal pencils and the minute lateral branches, the same principle obtains of rapid transition from large to minute vessels, without intermediate subdivisions, which appears to be the peculiar method of vascular distribution in the spleen.

The openings of the lateral branches, which form large foramina in the parietes of the vein, have long been noticed, and considered peculiar ; but the arteries on being laid open, exhibit a corresponding arrangement ; their inner surface being pierced at pretty regular intervals with small holes, the orifices of minute branches arising at right angles from the trunk, and passing out with a prolongation of the capsula to form the arterial trabeculae. (*Fig.* 2, *a.*) The arterial and venous circulation is therefore analogous, and follows the mode of arrangement stated above.

3. In the larger dichotomous divisions, the arteries accompany the veins ; but the small veins and arteries, on the contrary, are separate from each other ; the arteries being placed in the trabeculae, which divide the pulp into compartments, while the veins form canals in the pulp within the compartment or space. (*Fig.* 3.) Each compartment might thus be described as a lobule of the

spleen, *i.e.*, as a minute part containing all the essential elements, viz., trabeculae forming the boundary of the space, and containing the small artery belonging to it ; next, the Malpighian sacculus and the pulp, the secreting structures in which the capillaries ramify ; and lastly, the venous foramen into which the capillaries are collected.

4. The numerous capillary vessels have already been noticed in the description of the pulp. (*Figs.* 13 and 14.) The whole blood-circulation in the spleen is therefore characterized by its short circuit, the current of blood passing immediately from large into minute branches, thence into plexuses of capillaries, to be returned by the small veins into the large venous trunks.

It is stated by several observers, (Assolant, Heusinger,) that the system of blood-vessels in the spleen is divided into compartments, so that injection thrown in by one arterial branch returns generally by the corresponding venous branch. Their statement agrees very well with the fact that the smaller vessels do not form anastomoses, the communicating trabeculae being generally fibrous ; and further, it explains some of those partial differences of vascularity and colour not unfrequently observed in the human spleen.

Are there venous cells or cavities in the spleen ? It may be asserted confidently that in the unprepared spleen there is no evidence of cells ; the large size of the veins, the deficiency of the fibrous coat, and the orifices of their branches, are alone observed. The question is therefore reduced to this, What are the appearances agreeing to the description of cells in a spleen injected or inflated ? and how far do these methods of preparation exhibit a natural structure, or, on the contrary, develop an artificial appearance ?

A very large quantity of injection can be thrown into the bullock or sheep's spleen by the veins, so as to distend the organ to three times its former bulk. On examination after the injection has solidified, the increase in size is found to have taken place by the forcible dilatation of the venous canals, which have become of very large calibre. But the parietes of the veins, being supported by substances of unequal strength, viz., by the soft splenic pulp, which yields and is readily displaced by pressure, and by an open frame-work of strong fibrous trabeculae, it consequently happens that the dilatation takes place where the pulp alone supports the venous tunic, while the canal retains its former calibre where the trabeculae surround it. In this way, the whole course of the vein presents, at short intervals, alternate dilatations and constrictions, the projecting trabeculae dividing the canal into sacs or pouches continuous with each other. This sacculated appearance of the larger veins has accordingly been described as a series of cells opening into each other, and has been represented as part of the vesicular apparatus by Bourgery.

Such appearances, however, are evidently artificial ; and it is very improbable that any force produced by obstruction to the natural circulation could give rise to such distention of the venous canals as that produced by forcible injections. In the most congested spleens, I have never observed any tendency towards the sacculated form. These venous cells, therefore, occur only as an artificial alteration of natural structures, and are caused by the mechanical displacement of the soft pulp by a force which the trabeculae are strong enough to resist.

In preparations made by inflation of the veins, and drying, other circumstances come into operation to produce the appearance of cells, in addition to the yielding nature of the pulp under pressure. In particular, the fluid consistence of the pulp causes it, when dried, to shrink to a small part of its former bulk, in fact, to a mere membrane ; while the easy rupture of the venous tunics gives rise to the formation of irregular cavities in the pulp. The usual result of this mode of preparation, therefore, is that the spleen appears composed of hollow cavities or cells, separated by membranous septa. But this condition is certainly not the development of a normal structure, because no trace of these irregular cells is to be found in the unprepared spleen, where it is impossible to suppose that such large spaces could escape detection, if they really existed. Moreover, the force of inflation can be observed to cause extravasation of the air, which raises up the fibrous tissue in little irregular hollow swellings, and sometimes, bursting even through the fibrous tunic, distends the areolar tissue under the peritonæal coat.

In preparations, either by injection or inflation, therefore, the cells are formed artificially where naturally they do not exist; and until the objections to such methods of investigation are removed, the evidence derived from them is invalid. The only fact proved by injection is the important and curious one of the distensibility of the venous canals, and the consequent increase in the bulk of the spleen. Doubtless, the large size and dilatability of the veins must exert considerable influence on the circulation, and, together with the quick transition from large to numbers of small vessels, indicates an analogy with the erectile structures.

Of the Lymphatics of the Spleen.—The lymphatics are numerous, and form a superficial set distributed in plexuses under the peritonæal tunic, and a deep set, which accompany the arteries and nerves, ramifying upon the capsula. Their mode of origin in the organ has not been successfully traced; they can be injected both from the arteries and the veins, but this communication has not yet been explained. Many authors have attached much importance to them, regarding them as the excretory ducts of the spleen, chiefly on account of their number, and some peculiarity in their contents. Their lymph has been asserted to be of a redder colour than elsewhere, and mixed with more red blood corpuscles; but this is denied by other observers. The microscope shows them to contain the ordinary granular lymph corpuscles, and detects no difference from other lymphatics; but the capillaries in the tunics of the larger lymphatics are often seen full of blood corpuscles, which might occasion error in experimenting. The number of splenic lymphatics has certainly been much exaggerated; they are neither large nor very conspicuous in the bullock's spleen, and in the human spleen they cannot be detected without careful preparation. Accordingly, the great abundance of the splenic lymphatics has been denied by very high authorities (Lauth), especially in reference to the large number of blood-vessels distributed to the spleen. When the efferent lymphatics of a lymphatic gland are so obvious, ought not the excretory lymphatics of a large ox's spleen to be of unmistakeable size and number? Moreover, if we compare the number of splenic lymphatics, proportionally to its blood-vessels, with the numerous lymphatics distributed in other glands, and in particular in the liver, there seems no reason why in the one case they should have a special function, which in the other they do not possess. The anatomical proof of their excretory function is therefore deficient; and to establish it, the course and distribution of lymphatics within the spleen would require to be more accurately traced than has yet been done.

Of the Nerves of the Spleen.—The nerves are very abundant and obvious in the spleen of animals, forming, in this respect, a remarkable contrast to the lymphatics. In the bullock's spleen they form generally two large trunks or bundles, placed one on each side of the splenic artery, and invested by its strong fibrous capsula. They accompany the divisions of the arteries in a similar manner, (*Fig.* 4, *b*, *b*,) and appear to be distributed to the vascular tunics. In minute structure they exhibit the appearance of flat bands set with nuclei, which are brought out with great distinctness by acetic acid. A few tubular fibres are also found in these organic nerves.

Of the Splenic blood.—The microscopical appearance of splenic blood presents nothing remarkable. The clots, which are not uncommon, present the fibrillar appearance of coagulated fibrin; and the blood corpuscles are mixed with vascular epithelial scales, and splenic corpuscles accidentally detached.

Splenic venous blood has long been considered peculiar in its constitution; it was for a time thought incapable of coagulation; and, more recently, the clot has generally been affirmed to be softer, and more ready to liquefy than that of other blood. The late researches of Dr. Béclard[1] have proceeded further, and have indicated the relation of the splenic venous blood to that of the systemic veins in respect of each of its constituents, water, albumen, salts, blood globules, and fibrin. The splenic venous blood presented, comparatively, a deficiency

[1] Arch. Gén. de Médecine, Oct., Nov., Déc., 1848. 4e Série, tom. xviii.

in the amount of globules, and an increase in the albumen and fibrin. M. Béclard concluded from this result that the blood globules were destroyed in the spleen, while he believed that they were formed from albumen in the portal vein. But as the destruction of blood globules takes place in the systemic veins, (venous blood containing fewer than arterial,) this function cannot be considered peculiar to the spleen; and the increase of albumen in splenic venous blood appears to be the more peculiar change, and coincides with the supposed formation of a nutritive albuminoid secretion in the spleen. The small quantities used, and the great difficulty of attaining precision in such experiments, renders it unsafe to found any speculations upon them; they open up, however, a new and interesting field of inquiry.

Of Extirpation of the Spleen.—This experiment, often as it has been performed, has yielded no positive result. Animals which have recovered from the operation, have retained good health; and their functions, both of nutrition and reproduction, have been unimpaired. Increased voracity, and frequency of micturition, have most generally resulted; but have not been found in some experiments. Plethora after meals has been stated to occur by Dobson. Greater salacity, imperfect digestion, and numerous other changes, have been much doubted as consequences of the operation, and enlargement of the lymphatic glands or regeneration of the spleen, are generally denied. There is hardly any fact established, except the little injury that is occasioned by removal of the spleen. The experiment to be tried, however, is, whether animals deprived of the spleen can resist starvation as long as other animals; for since the spleen, so far as can be made out, assists in, but is not essential to nutrition, the exposure of an animal wanting the spleen to starvation for some length of time would test the resources of the nutritive system. This comparative trial of resistance to want of food has not, so far as I know, been made.

To complete the anatomical investigation of the spleen, the following departments of inquiry present themselves, but as yet little progress has been made in them.

1. Formation of the spleen in the embryo.—The spleen, along with the thyroid, thymus, and suprarenal bodies, is the remains of the membrana intermedia of the blastoderma. The spleen is single, because it is originally developed in the mesial line.[1]

2. The comparative anatomy of the spleen has yet to reveal the essential elements of the organ in their modifications.

3. The analogy of the spleen to the other vascular glands is gradually becoming more definite in proportion as their structure is better known. The corpuscular elements, consisting of granules and plasma, nuclei and cells, are nearly identical in all of them; the suprarenal bodies being distinguished by the frequent excess of oily granules. In the more complex structures, a great similarity obtains. The vesicles of the thyroid, in particular, resemble closely the splenic sacculi; consisting of an external vascular and fibrous layer, covering a spherical homogeneous membrane, which is lined internally by a more or less complete layer of nucleated cells, and contains plasma and corpuscles in its interior. In the human thyroid, the contained corpuscles are generally in small number; and the vesicles being filled chiefly by a clear fluid, their structure is easily seen; and small vesicles, of various size, are noticed in the interior of some of the large ones, indicating their mode of reproduction. In the suprarenal glands, the similar vesicles are somewhat elongated; and, being placed endwise, greatly resemble tubules, as Ecker has described. In the thymus, the vesicles are modified by constrictions into the form of follicles. (Simon.) In all these modifications, however, the vesicles exhibit the same essential structure which is seen in the spleen and the thyroid.

I shall conclude this paper with the following general statements:—

1. The spleen is a secreting organ; the Malpighian sacculi and the pulp being the secreting apparatus, and shewing all the essential elements of glandular structure.

2. The circulation of blood in the spleen is distinguished by the shortness of its circuit, produced by the sudden transition from large to small vessels.

[1] J. Goodsir, Lectures and Phil. Trans. Part iv. 1846.

3. The secretion of the spleen is probably some albuminoid material.

4. The veins, which are of large size, in great number, and peculiarly dilatable, probably absorb the secreted product, and carry it into the circulation. They would thus have considerable analogy with the umbilical vein, which further agrees with the splenic in belonging to the portal circulation. It is probable that the portal circulation performs a function of nutritive absorption.

5. There is deficiency of anatomical proof that the lymphatics are the excretory ducts of the spleen.

6. There is a close analogy both of origin and of structure between the spleen and the thyroid, thymus, and suprarenal bodies.

Explanation of Plate IV.

Fig. 1. External surface of the internal layer of the proper fibrous tunic of the spleen, seen in situ by the naked eye, or with a magnifying power of 5 diameters.—*a a*, the white round prominences from thickening of the membrane at the insertion of the trabeculae on the inner surface; *b b*, fibres radiating from these prominences, and passing in stronger bands between adjacent prominences.

Fig. 2. The large vein and artery of the bullock's spleen laid open.—*a*, internal surface of the splenic artery, the black points indicate the orifices of the small trabecular branches, given off nearly at right angles to the axis of the vessel; *b*, internal surface of the splenic vein, shewing the foramina or orifices of the small veins, given off nearly at right angles, and piercing through the fibrous capsula, *c*, and through the pulp, *d*.

Fig. 3. Substance of the sheep's spleen seen in section, by the naked eye or magnified 5 diameters.—*a*, the trabeculae, arterial and fibrous, form a framework, whose meshes divide the pulp into compartments, *c c*; filled up by the pulp, in which are situated Malpighian sacculi, *b b*; and venous foramina, *d d*.

These compartments, *c c*, though incompletely bounded, and not inclosed, but continuous with one another, may nevertheless be considered as lobules of the spleen, because they exhibit all the essential elements of the gland, and represent the organ on a small scale.

Fig. 4. A trabecula torn out from the sheep's spleen, with the pulp and Malpighian sacculi adhering to it.—*a*, the trabecular artery; *b b*, nerves; *c*, fibrous tissue, or capsula; these parts compose the larger trabeculae, as seen in Fig. 3, *a*; *d d*, Malpighian sacculi, attached by arterial and fibrous pedicles to the large trabecula, their contained grey particles are represented, one at *d'* has partially burst; they are imbedded in the pulp, *e*; magnified about 40 diameters.

Fig. 5. An entire Malpighian sacculus from the bullock's spleen, magnified 60 diameters, the grey corpuscles are not represented.—*a*, the fibrous pedicle containing an arterial twig, the branches of which pass over the external surface of the sacculus *b*, supply it with vessels, and then terminate as a tuft or pencil in the pulp, *c*.

Fig. 6. Saccular cells and corpuscles unaltered by the action of water, as they appear when an opening is made by bursting or tearing the membrane of the sacculus.—*a*, the clear bright cells, containing nuclei; *b*, free clear nuclei, not altered by water; these have a yellow tinge; *c*, the ordinary grey saccular corpuscles, adhering by plasma, with clear cells resting upon them;—magnified 250 diameters.

Fig. 7. Corpuscles, cells, and granules effused from the Malpighian sacculus, adhering to the plasma at *a*. At *b*, the cells are becoming dark, and some are dissolving by the action of water;—magnified 250 diameters.

Fig. 8. Saccular corpuscles and cells diffused in, and freely acted on by water, which renders the corpuscles clear and spherical, and displays the nucleoli; the cells are either rendered granular, or become faint, and are then dissolved;—magnified 250 diameters.

Fig. 9. Saccular corpuscles acted on by acetic acid, which renders their edges and nucleoli very dark, and well defined;—magnified 400 diameters.

Fig. 10. Portion of the fibrous tunic or membrane of the Malpighian sacculus; an arterial branch and capillaries are seen enveloped in the loose fibrous membrane;—magnified 400 diameters.

Fig. 11. Inner granular membrane of the Malpighian sacculus, divided imperfectly into scales; the ramifying fibres of the fibrous tunic are seen through it;—magnified 400 diameters.

Fig. 12. The saccular cells, (represented free in fig. 6,) forming a layer on the inner surface of the saccular membrane *a*; at *b*, they are seen covering an arterial branch;—magnified 400 diameters.

Fig. 13. Capillaries of the pulp entering a small venous branch of 1-600th of an inch diameter. The irregular splenic corpuscles of the pulp are seen filling the interstices of the capillary plexus;—magnified 400 diameters.

Fig. 14. Similar view, after treatment by acetic acid.

Fig. 15. Different forms of coloured particles of the splenic pulp, varying from dark-red to brownish or yellow. Granules, globular particles, and large aggregated particles; some containing bodies resembling nuclei. These are the coloured corpuscles referred to by Dr. Handfield Jones, Ecker, Kölliker, &c.;—magnified 250 diameters.

VII.—*An Account of some Experiments and Observations made on the Body of an Executed Criminal.* By Dr. Albert Kölliker, Professor of Anatomy and Physiology in the University of Wurzburg.—(Communicated by the Author.)

In Wurzburg, on the 2d November 1850, at forty-five minutes past nine o'clock, the murderer, Henry Schuhman, was decapitated with the sword.

Opportunities of this kind becoming more and more rare, Professor Virchow and I determined to avail ourselves of it, to make observations on the body immediately after death; but especially to institute some experiments on the irritability of the smooth muscular fibre, and researches on the internal structures of the eye.

Notwithstanding our own exertions, and the obliging assistance of the Magistrates, we could not procure the body before twenty minutes past ten o'clock—thirty-five minutes after death, on account of the distance of the place of execution from the Anatomical Institution, (the only locality of which we could avail ourselves.) We nevertheless succeeded, during the first hour, in obtaining results, most of which are of importance.

The following statement contains a full account of our experiments, already communicated to the Physico-Medical Society of Wurzburg; and we have only, in addition, to remark, that they were performed with the kind assistance of our colleague Professor Rineiker, and in the presence of many teachers and students of the University, and of Professor Gerlach of Erlangen, who happened to be here at the time.

The temperature of the apartment in which the observations were made was 11° R. ($56\frac{3}{4}$° F.) The body was very muscular; and its temperature thirty-five minutes after death, in the abdominal cavity, was 31° R. ($101\frac{3}{4}$° F.); in the right cavity of the chest $29\frac{1}{2}$° R. ($98\frac{3}{8}$° F.)

Central Organs of the Nervous System.—At thirty-five minutes after death these organs had already lost all irritability.

By the application of both poles of a very powerful magneto-electrical apparatus to the lower surface of the section, (of the spinal cord), not the slightest result was obtained. On the other hand, by direct application to the muscles, one pole being applied to the spinal marrow, and the other to any part of the trunk or extremities, strong contractions were excited, even to raising of the arms, shortening of the thorax, &c.

Nerves.—In forty-five minutes after death, no effect was perceived on irritating the roots of the oculomotor nerves ; nor any convulsion or movement of the manducatory muscles on irritating the roots of the trigemini.

In one hour and thirty-five minutes after death, the trunk of the crural nerve could not be excited ; but contractions of the sartorius and nectus femoris could be produced by irritation of the branches of the nerve (insulated on slips of glass) distributed to these muscles ; which continued to act in this manner for ten minutes afterwards.

The Muscles of the trunk and extremities, as well as those of the head, exhibited the most lively contractions when the body was first brought in for observation.

In one hour and five minutes after death, the irritability was as yet very considerable ; in half an hour later it was already less ; and in two hours and five minutes after death, at the time when the experiments were concluded, it was very weak, but still perceptible. It is scarcely necessary to mention, that by means of the induction apparatus, contractions were produced in all the muscles, which ceased immediately on breaking the circle ; when the irritability began to decline, there also occurred contractions of a clonic character, and principally in the cremaster, in which they were very distinct, and several thickened contracted parts were perceived on this muscle even after the poles were removed.

The Heart did not contract when we opened the chest, forty-five minutes after death ; although the temperature within the pericardium was, as has been already stated, above 30° R.

The coronary veins contained air. When we galvanized the apex of the right auricle, it contracted very slowly ; and some time after, the whole auricle began regularly to contract, which, however, ceased on the circle being broken. The contractions of the auricle having been once excited, it was only necessary afterwards to apply the pole for the shortest time to its tip, to produce complete contraction. Rhythmic motions, also, similar to the normal, could be obtained by successive applications, and removals of the pole. Irritation of the left auricle and ventricle gave no result; but it is necessary to observe that both ventricles, and particularly the left, were found in a very contracted condition.

Spleen.—We directed our attention particularly to the spleen; having been induced to do so, more especially by the recent communications of Harless.[1] It was the first organ we laid hold of. The splenic vessels were tied, and the spleen having been cut out and insulated, it was irritated by one pole of the apparatus, armed with a metallic plate, one inch in diameter, being laid upon it; while a needle connected with the other, was inserted not far from the plate, (a method by which very complete contraction in the spleen of the dog may be produced;) but in vain, although we moistened the spot on which we wished to produce contractions. We were equally unsuccessful after irritation of three other spots on the two surfaces of the organ. These results coincided with my most recent researches, from which it appears that the human spleen does not possess contractile elements.[2]

The human spleen has hitherto been only twice galvanized, by Harless[3] and by ourselves; but apparently with entirely different results. Harless thought he perceived contractions, while we could see none. Some of our negative results may, perhaps, be considered of no great importance in opposition to those of Harless; but it must be recollected, in the first place, that the body on which we experimented was under observation twenty minutes sooner than the one on which Harless made his researches; in the second place, that the spleen which we galvanized was by no means contracted, but was rather to be considered large,

[1] Jenaische Annalen. 1850.

[2] Art. Spleen.—Cyclop. of Anat. and Phys.

[3] *Loc cit.*

and felt soft, although its surface presented slight inequalities; and in the third place, that almost all the smooth muscles of the other parts of the body still reacted in a very lively manner. It must also be added, that the experiments of Harless afford very insignificant results, and even that his interpretation of these may be questioned. Thus Harless observed, after inserting two needles, half an inch from each other, near the hilus of the organ, "the substance between them rise in the form of a small mound, which was slowly formed, and after interruption of the circle again slowly disappeared:" whence he concludes that the human spleen is contractile; the rather, as the mound in question would not form again, after the experiment had been repeated for the third and fourth time. I must confess, however, that this conclusion appears to me very rash. Because, in the first place, it does not appear to me likely that a contraction of the spleen would produce the rising of a mound-like elevation; and secondly, because I hold it to be very improbable, that a part rendered prominent by contraction under galvanic influence would sink into a state of relaxation *immediately* after the circle is interrupted. In reference to the first point, it is to be remarked, that with the known anatomical conditions of the spleen, no conception can be formed of a rampart-like elevation produced by contraction of the trabecular texture, or of the capsule, in which alone the muscular fibres could have been situated. In fact, too, neither R. Wagner[1] nor I[2] observed any such elevations on the spleens of animals (dogs) in our successful experiments, but we distinctly observed a wrinkling and hardening of the surface, and the formation of ribbon-like and circular firm spots; phenomena easily explained by contraction of the trabeculae attached to the capsule, or of the latter itself. It appears to me, too, that the rapid subsidence of the rampart-like elevation, which Harless saw, is opposed to its having been formed by the contractions of organic fibres; because it is almost the general law of such fibres to continue for a longer

[1] R. Wagner. Götting. Anzeig. Nachrichten von der Universt., &c. Anzeig, 1849. St. 92.

[2] A. Kölliker. Mittheilung. der Zurich. Naturforsch. Gesellschaft. 1850. No. 41. St. 49.

or shorter period in a state of contraction before they again relax. There are certainly organic muscular fibres which soon pass from a state of contraction to that of relaxation, after interruption of the galvanic irritation, as in the iris in Man, and some of the Mammalia ; but in all other instances the directly opposite result takes place. It is known that in the lower animals very prolonged contractions of the stomach, intestines, bladder, blood-vessels, and ducts of the glands occur ; and in regard to the spleen in particular, R. Wagner and I have found this to be the case. The firm wrinkled spots on the surface of the organ remained for a long time after the poles of the battery were removed. The same peculiarity exists in Man, as I have noticed it in the blood-vessels and lymphatics ; and we have had again in the present instance an opportunity of observing it in the bladder, vasa deferentia, ureters, œsophagus, and scrotum. It is, therefore, more than probable, that had the Harlessian elevations on the human spleen been produced by organic muscular fibres, (of the vessels, or of some other part,) they would by no means have disappeared so soon ; and hence I am inclined to express my opinion, that they must be accounted for on some other ground ; the more so when I consider that, according to my investigations at least,[1] the human spleen does not contain organic muscular fibres.

The spleen having been cut through, beautiful Malpighian bodies made their appearance in the greatest abundance. They were nearly half the size of those in the spleens of the Ruminants, arranged very close together, and frequently gathered into groups. They exhibited nothing peculiar, except that their cells were half as large again as the lymph globules in the thoracic duct. The light red pulp and the splenic vesicles shewed no trace of a metamorphosis of the blood-corpuscles.

The skin, under galvanism, rewarded us with very excellent results. Fifty-five minutes after death, one pole of the apparatus was applied to the mons pubis, the other to the scrotum. A minute afterwards the latter, which had previously been quite relaxed, had already begun to wrinkle, and in one minute

[1] Kölliker. Art. Spleen.—Todd's Cyclop. of Anat. and Phys.

and a half there were formed strong closely arranged transverse wrinkles, with weaker perpendicular folds, which were as well expressed as those usually formed during life ; and remained also for a long time after the removal of the poles.

The areolae of the mammae were then irritated, both of them with the most perfect success. A cutis anserina had begun to form in twenty to thirty seconds, on the margin of each areola ; and the latter contracted, with apparent elevation of the nipple, as vigorously as it ever does during life, continuing contracted for five minutes, beyond which we did not continue to observe them.

The skin of the fore-arm, and immediately afterwards *of the thigh*, was irritated one hour and twelve minutes after death. On both a completely marked but *quite local* cutis anserina arose, on a circular area of about one inch diameter ; and there followed erection of the hairs, in this individual, pretty well developed. A cutis anserina also arose on a portion of the skin, which was irritated, after having been cut off from the thigh.

The Iris.—Very remarkable motions of the iris were produced by the galvanic irritation. When one pole was applied forty minutes after death to the lower jaw, and the other to the cornea, the pupil contracted simultaneously with the muscles of the face, uniformly and pretty quickly, and quickly dilated again after removal of the poles ; results which were always obtained on repeating the experiments on both eyes.

The poles (needles) were now placed on the margins of the cornea, or on the surrounding sclerotic. The contraction did not occur ; but the pupil was irregularly dilated.

Several additional experiments shewed, that when the poles were applied to the upper and under margins of the cornea, the pupil became *longitudinally oval ;* on applying them to the right and left margins, it became *transversely oval*, and consequently that a partial contraction of the radiating contractile structures took place. These latter motions also began pretty quickly, and ceased again as quickly.

The Blood-Vessels.—Several experiments with galvanic irritation were instituted on the blood-vessels. At fifty minutes after death a branch of the superior mesenteric vein contracted, but not so much as to obliterate its cavity. Immediately after, the same effect was produced on a beautifully injected lymphatic vessel of the aortic plexus, but to a greater extent. One hour after death, the thoracic duct was galvanized immediately above the diaphragm. It appeared to contract a little, but on account of its deep situation, the effect could not be decidedly observed. We saw, however, very decided contractions in a lymphatic vessel of the lumbar plexus. One hour and five minutes after death, the abdominal aorta and vena cava, (the latter much distended with air,) and the common iliac artery, were irritated without any effect; but immediately afterwards, the great saphena vein, and the lymphatic vessels of the groin, exhibited most beautiful contractions, with obliteration of their cavities, and continuing long after the irritation had been removed. After one hour and ten minutes, the saphena continued as irritable as before; on the other hand, the crural vein contracted feebly, and the femoral artery also in a minor degree, although still distinctly. The trunk of the vena portae, irritated one hour and fifty-two minutes after death, afforded no result.

Excretory Ducts of Glands.—Several of these were irritated. Irritation of the gall-bladder fifty minutes after death yielded nothing which could be safely relied upon. On the other hand, immediately afterwards, the left ureter, having been only touched, contracted with great energy, so that a wave appeared to run down the tube, which became shorter and narrower; in which condition it afterwards remained for a long time. The liveliness of the movement made upon us such an impression, that although we had several other observations yet to make, we immediately seized upon the right ureter, and with it we obtained the same brilliant results. Thirty-five minutes after death the bladder contracted very considerably, but slowly, and remained so. One hour and thirty minutes after death, the right vas deferens was exposed in the pelvis up to the inguinal canal, and irritated. It contracted and shortened itself slowly, but very considerably, so as to become quite straight, although previously it had been very much curved in its course. It even raised itself up, and became stretched (prall) and tense. On seeing this, we were involuntarily reminded of the conceptions physiology forms to herself of the mode in which the fallopian tubes apply themselves to the ovaries; and we were obliged to admit, that if they can act with as much energy as the vasa deferentia, the process was quite intelligible. The other vas deferens contracted also principally in its length, but not so energetically, and continued, like the left, shortened and narrowed for a long time afterwards.

Immediately afterwards, as an experiment, we inserted a needle into the corpus cavernosum of the penis; but even after galvanizing for two minutes, we could not perceive any shortening of the organ. About ten minutes afterwards, however, on having our attention again directed to this region, the penis appeared to be really smaller, and its skin wrinkled, although we could not satisfy ourselves decidedly regarding it. One hour and fifty minutes after death, we still perceived contractions in the epididymus, and also on the lower part of the tunica vaginalis propria, at that part of its external surface on which I have described a layer of organic muscular fibres. It is to be regretted that we forgot the prostate and vesiculae seminales, which certainly would have presented phenomena of contraction. The stomach and intestines, which we irritated fifty-eight minutes after death, did not contract; but the lower part of the œsophagus contracted slowly, and continued so for a long time.

In addition to these experiments, the anatomical and microscopical constitution of some of the organs was studied. The following is a short abstract of the results:—

Retina.—Immediately after receiving the body, we examined on the retina of the left eye the macula lutea and the plica centralis. The eye had been cut through transversely immediately behind the lens, and the part of the retina remaining, the posterior portion of the organ submitted to examination. The plica centralis was missed; but the macula lutea was present, and within it was a darker point, like a small roundish pit, the so-called foramen centrale. The retina itself had a transparent greyish aspect. The pigment of the choroid shining through, and the yellow spot had still more of a brownish yellow colour, with a light yellow border, and without any sharp definition from the surrounding retina. A piece of the retina, taken from the situation of the macula lutea, and laid on a plate of glass, appeared of an *intense citron tint.* This tint, under the microscope, was seen to arise from a homogeneous light yellow infiltration of the ports; so that all the elements of the retina,—cells, granules, (Körnchen,) and bacilli, appeared to be well preserved. The retina of the right eye, which was examined one hour and five minutes after death, also wanted the central fold, but presented a perfectly distinct yellow spot and central foramen. A further examination was deemed unnecessary, the more so as the eye was to be preserved in chromic acid for subsequent researches on the elements of the retina.

Ventricles of the Brain.—Lastly, the ventricles of the brain were examined to ascertain the existence of ciliary movements, but in vain. The cells of the ventricular epithelium were most distinctly seen, but no trace of cilia could be detected.

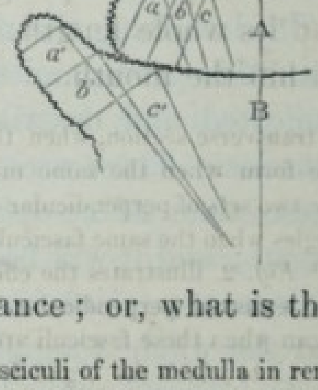
VIII.—*On the Muscular Structure of the Tongue of Man, and certain of the Mammalia.* Part II.—*The Muscular Actions.* By Mr. John Zaglas, Demonstrator of Anatomy in the University of Edinburgh.—(Communicated by the Author.)—*Continued from* p. 19.

In describing the muscular elements of the Tongue I endeavoured to group and to arrange them in their natural order. I indicated and described a cortical and a medullary system of muscles. These are capable of acting independently, but at the same time of co-operating in the peculiar movements of the organ; and it will become obvious that certain anatomical conditions are maintained for similar elementary actions throughout the whole tongue, or over more or less of its extent. In these respects man does not appear to differ essentially from the other Mammalia. The latter, at the same time, exhibit differences among themselves, referable to peculiarities of economy and type.

By directing our attention to the anatomical conditions of the elementary muscular actions already alluded to, as well as to the combinations of several of these, we are enabled to perceive the mechanism of the variously complicated motions of the organ, for, notwithstanding their great variety, they are all produced by the elementary actions co-operating in various combinations and successions, according to the varying central impulses. To obtain this simplicity in the theory of the movements of the tongue the division of the lingual muscular system into Cortical and Medullary becomes necessary; and in addition, its motion, as a whole, demands the consideration of the co-arrangement between the parietal and lingual attachments of the muscles which pass to it from the walls of the buccal cavity.

I now proceed to consider, in the first place, the actions of the medulla, as it extends in successive layers of perpendicular and transverse fasciculi, from the root to the tip of the tongue. In the perpendicular fasciculi we everywhere meet with conditions for approximating the upper and under surfaces of the organ; in the transverse fasciculi, for approximating the lateral margins. These are the general actions of the medullary fasciculi; but as the two perpendicular muscles pass the transverse, upwards and inwards, and upwards and outwards, in a somewhat oblique direction, interesting peculiarities of action result, which demand some attention. Those fasciculi of the external and internal perpendicular systems which meet one another at the dorsal surface of the tongue do so at the angles, (*a*, *b*, *c*, *Fig.* 1,)[1] and therefore draw their common points of attachment downwards in a diagonal direction, the angles (*a′*, *b′*, *c′*, *Fig.* 1) becoming wider in proportion to the compression of the contained substance; or, what is the

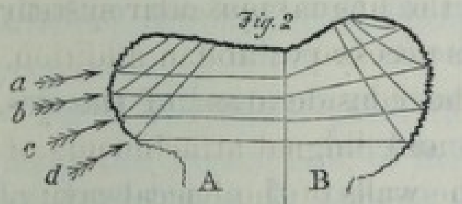
Fig. 1



[1] *Fig.* 1. illustrates the action of the perpendicular fasciculi of the medulla in rendering the tongue broader and in curling up its margins. A, the form of the tongue

same thing, the dorsal extremities of these fasciculi becoming fixed, (as will be explained afterwards,) the lower attachments of the external perpendicular must deviate from the mesial line, and at the same time ascend upwards. Thus the two perpendicular muscles, while flattening the tongue, tend at the same time to curl its margins upwards; these two effects being inversely as the contraction of the transverse muscles. I shall return to the subject of the curling up of the margins of the tongue, when another and perhaps more effectual element in producing it comes under consideration.

When the external perpendicular and the transverse muscles act together, the margin of the tongue must approach the mesial plane, and at the same time bulge out, so that the organ becomes rounded. (B, *Fig.* 2.)[1]



It would appear that in a simultaneous action of the three muscles, (M. perpendicularis externus, internus, and transversus,) the lateral halves of the tongue must be separated by a longitudinal dorsal groove, exhibiting an approach to two separate cylindrical bodies. This one may verify on his own person by protracting his tongue in a pointed form.

Lastly, I must allude to the elongation of the organ—another very important effect of the simultaneous contraction of the medullary muscles. It must be obvious that in proportion to the diminution of its transverse and perpendicular, its longitudinal dimensions must increase. This effect may also be verified, by attempting to render the tongue cylindrical throughout its whole length, when it will be found difficult to retain it within the mouth.

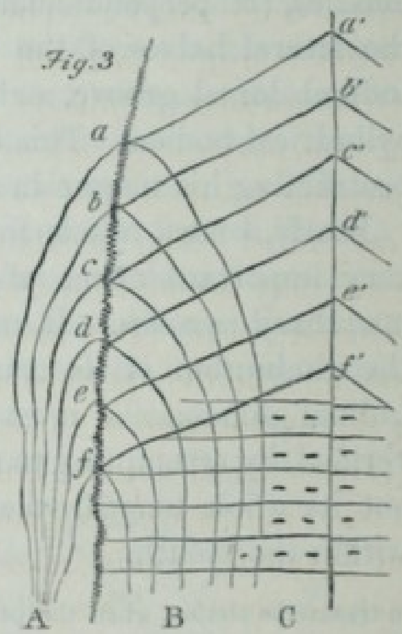
in transverse section, when the perpendicular muscles are in a passive condition; B, the form when the same muscles are in action; *a, b, c,* the acute angles at which the two sets of perpendicular fibres meet in the former condition; *a′, b′, c′,* the obtuse angles when the same fasciculi are in action.

[1] *Fig.* 2. illustrates the effect produced by the conjoined actions of the transverse and external perpendicular fasciculi of the medulla: A the flattened form of the organ when these fasciculi are passive; B, on the opposite side of the diagram, the form into which the organ is thrown by the simultaneous action of the two sets of fasciculi; *a, b, c, d,* the diagonal directions of the resultant movements.

In the medullary muscles of the tongue, as in muscles generally, action is accompanied by a degree of stiffness proportioned to the strength of contraction. On this circumstance depends one of the functions of the lingual medulla, without which none of its actions, movements, or positions could be conceived. Let the shape of the tongue be what it may, it must possess the conditions of a lever, if the animal has the power of directing it to particular points. Under the conception of a lever, the medulla may be considered as a transmutable skeleton capable of becoming jointed or rigid in any part, more or less extensive, according to the relaxation or contraction of its muscular elements. The surrounding muscles can thus most conveniently act upon it, in producing its movements in position.

Of the actions of this kind performed by surrounding muscles, those of the cortex must first be considered.

The cortex has been shewn to consist of a net-work of fasciculi, through the meshes of which the fasciculi of the medullary muscles reach their attachments to the peripheral fascia. Amidst these medullary fasciculi, however, the principal bundles of the cortical muscles traverse the surface of the tongue in a definite order, as has been described in my former paper.



I would now direct attention to two series of forces capable of being exerted along the margins of the tongue, and proportioned to the great accumulation of fibres there.

If at any distance from the root of the tongue the margins become fixed at two opposite corresponding points, (*a*, *Fig.* 3,[1] and an-

[1] *Fig.* 3. illustrates the actions of the stylo-hyo-glossal system of fasciculi joining the margin from A above, and from B below the tongue; C, the medulla; *a*, *b*, *c*, *d*, *e*, *f*, and corresponding points on the opposite margin of the organ, the series of fixed points on the two margins; *a'*, *b'*, *c'*, *d'*, *e'*, *f'*, the series of fixed points in the mesial line of the upper surface.

other corresponding point on the opposite margin of the organ,) it is evident that from these two points three pair of forces may act upon four other points. Two mesial, (*a′*, *Fig.* 3, and another point on the lower surface of the organ,) where the respective fasciculi deviating from the marginal tracts must arrive from opposite sides; and two marginal, as distant from the first, as the next point of attachment for the fibres. (*b*, *Fig.* 3, and another corresponding point on the opposite margin of the organ.)

If four pair of marginal points (*c*, *d*, *e*, *f*, *Fig.* 3, and corresponding points on the opposite margin) now become fixed, the series of actions become proportionally increased, and so on in proportion.

From the mesial point the action can only be propagated along the mesial line, to the next point requiring to be fixed, which will then be enabled to sustain the action of the respective pair of lateral forces. Thus the series of actions may be repeated to the tip. The tip itself, besides being acted upon by the marginal fasciculi directly, is also under the influence of the terminal diffusion of the mesial accumulations; or in tongues possessing such arrangements, it is moved both by the marginal fasciculi, and by the brushlike terminations of the cortical cords. The peculiar activity required by the tip of the organ may account for the peculiar mode in which the muscles terminate in it. But may such an arrangement not be necessary for the due performance of the tactile function of the tip in the exploration of the cavity of the mouth?

The cortical actions hitherto considered have been referred to fixed and moveable points on the marginal and mesial lines; but secondary combinations of actions may also occur at intermediate points. This is effected by the noto-glossus, a muscle the action of which must now be particularly considered. By means of its fasciculi, the margins of the organ are connected with more central points, in an opposite direction to the main tracts of the cortex hitherto considered. It appears to be principally intended to act upon the margin, which it reverts or rolls up; and is thus in direct opposition to the conjoined action of the external perpendicular and transverse muscles. It thus appears that this muscle is highly useful in continuing the activity of the tip of the organ round the margin ; and when not controlled by the muscles last mentioned, it can curl the margins upwards ; and therefore I observe it to be well developed in the Carnivora, as has been already noticed by its discoverer.[1]

There are two other muscles, the lingualis and chondro-glossus, the actions of which must be considered here, as their terminal portions enter into the structure of the cortex of the organ.

The lingualis has already been attended to as a powerful agent in the movements of the apex of the human tongue, as it is more or less in all short tongues. But in proportion as the ruminant type of tongue preponderates, or as expressing better the morphological conditions, in proportion as the apical part elongates, this muscle becomes situated more posteriorly, and loses its influence on the tip. The peculiarity of its disposition becomes at the same time more apparent ; although I must add, its strength seems to decrease. The gibbous protrusion becomes likewise more marked, owing principally to accumulation of fat. Recollecting also that posteriorly the lingualis is connected to the dorsum radicis, there appear to be sufficient grounds for concluding, that in the existence of such a muscle the preliminary act of deglutition is involved ; for every variety exhibited by this muscle in animals corresponds to peculiarities in their deglutition, requiring such a tract of lingual fibres ; while, if a slight allowance be made for the chondro-glossus, no other muscle of the tongue seems fitted for such purposes in deglutition. A short consideration of the mechanism of the first stage of deglutition may here be necessary to justify the allotment of such a formation to the lingualis ; but this I shall defer till the actions of some other muscles necessary to the process come under consideration.

The chondro-glossus seems calculated to afford directly fixed points for the actions of the dorsal cortical part. But it is chiefly, perhaps, useful in depressing the root, with a tendency

[1] Bauer, *l. c.*

to revert the organ, and in this manner to co-operate in deglutition.

In proceeding to the consideration of the muscular attachments of the tongue to the surrounding parietes, the genio-glossus appears in the first place opposed in action to the muscles which arise from behind the root; and the actions of the pharyngo and palato-glossus are again to be distinguished from those of the hyo and stylo-glossi.

The hyo-stylo-glossal system has its fasciculi so disposed as to touch the margins of the tongue from above and from below, (A B, *Fig.* 3,) and exerts its forces so as to draw the organ backwards in a diagonal direction, or with a tendency of its root to pass between the greater horns of the hyoid bone.

When this system is counteracted by the genio-glossus, the tongue will be kept at a certain distance from the hyoid, in which condition the organ may describe a cone under the consecutive influence of these muscles.

But another condition essential to the theory of the lingual movements, exhibits itself in the active condition of the muscles now under consideration, viz., the provision of fixed points, whence the cortical fasciculi may commence their series of actions.

In the allusion already made to the function of the genio-glossi, I have in some measure anticipated the principle of the mechanism of these muscles. They can undoubtedly assist by their posterior fibres in the projection of the tongue; and in accordance with the observations of Theile, retract it by means of their anterior. But their primary action is, as it appears to me, to react against the posterior radical and dorsal portion of the cortical muscles, which draw the tongue backwards and upwards, and thus to fix certain portions of the organ at an appropriate distance from the surrounding parietes, and from the hyoid bone. Starting-points are thus afforded from which the organ can perform its movements by means of the medullary and cortical fasciculi.

On the same principle, other actions of these muscles may be deduced, particularly an important one in deglutition, which I shall afterwards consider. The explanation I have now given of the function of the genio-glossi muscles is corroborated by the varieties which these muscles present in different animals. They are proportionally most developed in the human tongue; less in the whole of the Quadrumana and Carnivora; and least in the Ruminants, as may be observed in comparing *Fig.* 2 with *Figs.* 12 and 13, *Plate* 1; in the last of which these muscles are most insignificant. These muscles are carried far forward in the tongues of Carnivora, to afford such fixed points beyond the mouth and between the teeth as may enable the apex of the organ to act in the lapping of fluids. These fixed points are maintained by the combined actions of the anterior fibres of the genio-glossi and superior muscles of the cortex, supported by the propulsive efforts of the medulla from behind. In the Ruminants these muscles are situated far back, the tongues in these animals requiring to be fixed at a certain depth in the oral cavity, so as to enable the lingual medulla to produce the necessary protrusion, to which effect the advance of the genio-glossi towards the tip would rather seem to be opposed. In the tongues of herbivorous animals generally, the comparative coarseness of the epithelial covering, and the smoothness of the dental apparatus, render apparently any such precaution as we meet with in the Carnivora against injury from the latter unnecessary.

In Man and the Monkeys they are well developed in proportion to the importance of the organ in exploring and applying itself to the parietes of the mouth during mastication, but particularly in Man during articulation.

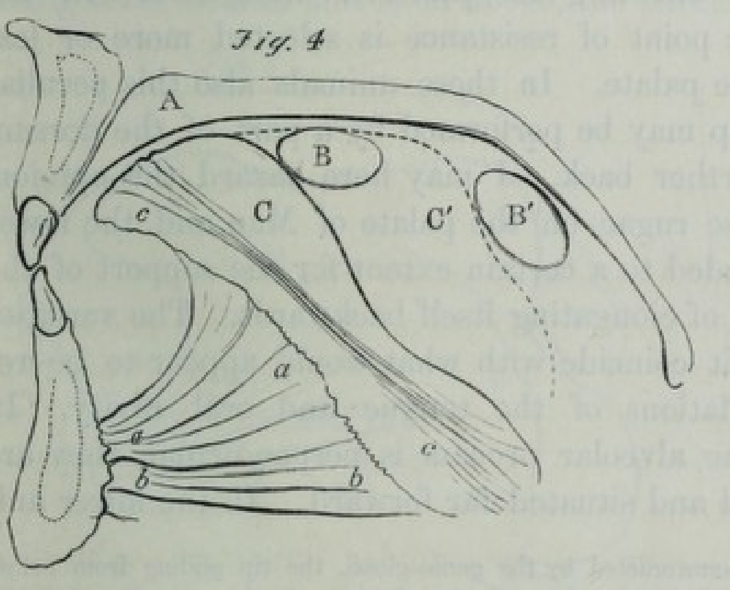
The palato and pharyngo-glossi muscles, which I have separated functionally from the other antagonists of the genio-glossi, appear to me to be principally engaged in the act of deglutition. Their opposite extremities are fixed or moveable according to their relations to the bolus in its passage, and to the condition of the neighbouring muscles engaged in the act of deglutition.

I have now explained what I ventured to term the elementary actions of the muscles of the tongue. From these elementary actions any complicated act, voluntary or instinctive, may be deduced and reconciled with the structure of the organ.

I shall next endeavour to describe the mechanism of what is termed the first act of deglutition; for, although not directly included in my subject, it exhibits in different animals peculiarities in structure and action illustrative of the economy of the tongue.

When the food has been masticated, or has been brought into the mouth in a condition for being swallowed, it is gathered together on the dorsal surface of the tongue by the action of its tip, of the lips and cheeks, and, as it would appear, to a considerable extent by atmospheric pressure. From this position it is now the function of the tongue to convey it to the isthmus faucium, whence the constrictors of the pharynx begin to act in deglutition.

This lingual action in deglutition consists of a number of elementary operations, which, although running continuously into one another, may be grouped together as occurring, in Man at least, in three distinct periods. The first period includes such operations, already alluded to, as are necessary for placing the alimentary mass on the dorsum of the tongue, and on a spot as near the apex as may be suitable; for the distance from the tip seems to be selected according to the bulk, and perhaps also the quality of the morsel. In the second period the muscles of the organ act as in reverting its tip, which then slides backward along the palate, (*Fig.* 4,)[1] pushing the



[1] *Fig.* 4. illustrates the movements of the tongue during the second period of the first act of deglutition: A, the palate; B, B′, the bolus in different positions; C, the tongue represented in entire outline, and in the act of reversion under the influence

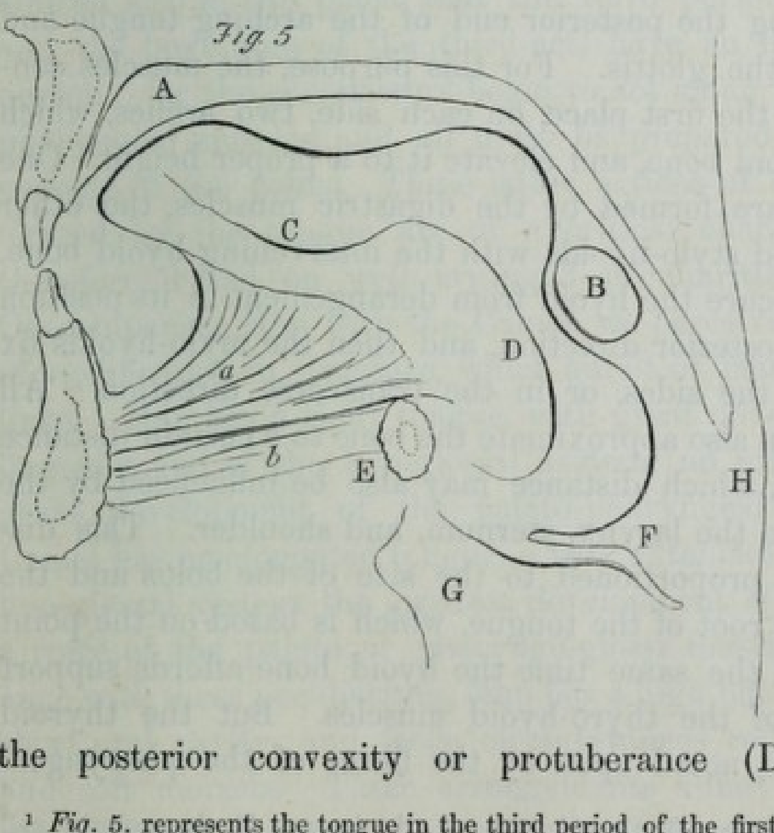
morsel towards the fauces. The muscles then change the direction of their action, removing the organ forward, the tip again gliding along the palate, but with a gradual increase in the extent of surface applied against it in a direction from behind forwards, and from below upwards, successive portions of the mass of the tongue being gradually elevated against the palate, emerging as they do so from behind and below the bolus, to positions directly in front of it. The whole of the operations of this second period may be repeated, until at last the bolus or mass of food is collected underneath the soft palate, and between it and the gibba of the tongue. The third period now commences, in which the tongue performs its final act in deglutition. This consists in planting its apex against some part of the palate; after which it endeavours to elongate itself, and thus conveys the bolus backwards into the fauces. In man the apex of the tongue is planted against the incisive portion of the superior alveolar process as a point of resistance for effecting its posterior elongation. In the lower animals the point of resistance is selected more or less backwards on the palate. In these animals also this peculiar function of the tip may be performed by a part of the dorsum of the tongue further back. I may here hazard the opinion, that the transverse rugae on the palate of Man and the lower animals, are intended to a certain extent for the support of the tongue in the act of elongating itself backwards. The varieties which they exhibit coincide with what would appear to be required in the relations of the tongue and oral cavity. In man, in whom the alveolar process is perpendicular, they are slightly developed and situated far forward. In the lower ani-

of the dorsal cortex, counteracted by the genio-glossi, the tip gliding from before backwards along the vault of the palate, pushing the bolus in the same direction; C′, the tongue represented in dotted outline, and in the act of emerging from beneath the bolus near the position B′, in a series of waves which arise on its dorsum from before backwards, as it evolves itself and glides forward by the action of the medulla, to plant its tip against the incisive alveoli, and previous to its more complete elongation backwards in the third stage of the process, an elongation also effected by the medulla; *a a*, one portion of the genio-glossus incurvating the tongue; *b b*, the other portion of it fixing the root of the organ; *c c*, the lingualis arching the tongue upwards against the palate, and acting the part of a tie-beam.

mals, in which the alveolar process is small or oblique, the rugae are situated farther back, and are more fully marked, particularly in those which swallow bulky and comparatively rough morsels, as in the Ruminants and Solipeds.

By directing our attention to the actions of the muscles in this complicated operation, we may perceive the peculiarities in the performance of each of them. The importance of the medulla becomes particularly obvious in affording sufficient elasticity for arching the tongue upwards, backwards, and forwards, with the proper velocity, for pressing it against the palate. The usefulness of the genio-glossi also is evident in controlling antagonists, and, in co-operation with them, in gliding the tongue along the palate in the required direction. But in the tongue of man the importance of the genio-glossi is also very evident in the last stage of deglutition, during which other muscles also exhibit actions of much interest. When the tongue is appropriately arched by the lingualis, and by the other muscles acting from behind and from above, the anterior portion of the genio - glossus acts so as to break the arch into two portions, turned in opposite directions, one in front, (C, *Fig.* 5)[1] with its convexity downwards, the other behind, (D, *Fig.* 5) with its convexity upwards. At the time when the posterior convexity or protuberance (D, *Fig.* 5,) is

Fig 5



[1] *Fig.* 5. represents the tongue in the third period of the first act of deglutition: A, the palate; B, the bolus; C, the anterior; D, the posterior incurvation of the

actually produced by the uncontrolled action of the posterior muscles, the anterior (C, *Fig.* 5) is only in the act of formation, during which the medulla, endeavouring to elongate itself, impinges against the palate, and so pushes back the posterior (D, *Fig.* 5) to the isthmus faucium. At this stage the palato and pharyngo-glossi appear to be of great use, for now the tension of the velum and pharynx allow them to draw the root of the tongue towards the bolus, and in so doing (evidently in antagonism to the lingualis and chondro-glossus, which depress the root) they tend to unfold the sinuosity between the root of the tongue and the reverted epiglottis. This enables the root of the tongue to push the bolus back more efficiently, and at the same time enables the epiglottis more effectually to protect the laryngeal opening, already carried far forwards and beneath it.

This stage in the act of deglutition is of the shortest duration; and the most prominent feature in it is the fixation of the hyoid bone and the root of the tongue, for the double purpose of steadying the posterior end of the arching tongue and for protecting the glottis. For this purpose, the muscles concerned form, in the first place, on each side, two arches, which suspend the hyoid bone, and elevate it to a proper height. One pair of arches are formed by the digastric muscles, the other by the genio and stylo-hyoids with the intervening hyoid bone. These arches secure the hyoid from derangement in its position in the antero-posterior direction, and then the mylo-hyoids fix the bone from the sides, or in the transverse direction. All these actions can also approximate the bone to a certain distance from the palate, which distance may also be influenced by the muscles between the larynx, sternum, and shoulder. This distance is always proportioned to the size of the bolus and the exertions of the root of the tongue, which is based on the point thus fixed. At the same time the hyoid bone affords support to the action of the thyro-hyoid muscles. But the thyroid cartilage is also acted upon by the fibres of the pharyngeal

organ; E, the hyoid bone; F, the epiglottis; G, the larynx; H, the posterior wall of the pharynx; *a*, the anterior fibres of the genio-glossus; *b*, the genio-hyoid.

constrictors which are attached to it, from which arrangement it is not only drawn forwards and upwards by the thyro-hyoids, but also in an intermediate direction, or backwards and upwards ; so that the pomum Adami is lowered or elevated, so as to be balanced beneath the body of the hyoid bone, while the superior horns are elevated. By ascertaining this movement on one's own person, and examining the arrangement of the parts on the dead subject in an erect position, we are brought to the conclusion, that during the last period of the first act of deglutition, the tongue has its curved root so far advanced into the pharynx, that for solid food no epiglottis is required to protect the glottis. This body, however, with its lateral folds, appears to be of great use against accidents ; and in preventing fluids gliding down along the mucous membrane.

In the act of swallowing, two points of contact between the tongue and palate may be felt, one at the tip, and the other far back ; while between the two there is the feeling of a vacuum, or rather of a want of any feeling whatever. It must be noticed also in this place, that the third period of the second, and the beginning of the third act, have an inseparable connexion ; for the constrictors begin to act along with the glosso-pharyngeal muscles, and all must be prepared for the abrupt passage of the bolus. These latter actions of deglutition performed by the tongue are of a critical character, and are, therefore, based on well arranged peculiarities of structure. On comparing Man with the Camel, we perceive two extremes of modification in structure, which admit of many intermediate links. Man has a short tongue, with great development of the lingualis, and of the hyo-glossal system, no gibba proper, but great development of the palato-pharyngeal muscles. The Camel has an elongated tongue, a very extenuated lingualis, and hyo-glossal system, the greatest development of gibba, but not a trace of the palato or pharyngo-glossi muscles. In accordance with these peculiarities, Man has a high but proportionately short oral cavity, and feeds on substances reducible to small and soft morsels. These arrangements admit of no gibba to occupy space in the mouth ; they imply developed agencies for arching the tongue, and for carrying it upwards and backwards against the palate and pharynx. The Camel has a low oral cavity, it is so at least for a great distance in front. It must possess, therefore, a tongue capable of elongation, to grasp its food, which is converted into a rough and voluminous morsel. Its mouth admits of no extensive incurvations; but posteriorly a great gibbosity finds a convenient position; while anteriorly the elongated tongue may throw itself into several successive incurvations, and in straitening itself push the morsel backwards with great power: by which means also the gibba may be pushed very far back, and fairly into the pharynx. This is a modification of the lingual action in deglutition, presenting an interesting contrast with the corresponding function of the tongue in Man.[1]

[1] Notices on the muscular structure of the tongue are to be found in the general treatises on anatomy; the most correct information on the whole being contained in those of more recent date, (Blandin, Cruveilhier, Krause, Quain, &c.) To the following monographs recourse may be had:—

C. F. Bauer, "Ueber den Bau der Zunge," in Meckel's Archives for 1821.

Blandin, "Sur la Structure de la Langue," in Archives Gén. de Médecine for 1820.

P. N. Gerdy, "Recherches, Discussions, et Propositions d'Anatomie," &c. 1823.

F. G. Theiles' Treatise on Myology in the Encyclopédie Anatomique, tom. iii. Traduit par A. J. L. Jourdan. Paris, 1833.

Of the older writers, Galen and Vesalius ought not to be neglected.

M. Malpighi, Epistola de Lingua, in op. omnia. Lond. 1686.

F. Casserius, Pentaesthescion. Venet. 1609.

J. Westbrecht, Observ. Anat. ad Hist. et Actionem Musc. labiorum, &c., in the Comment. Academ. Petropolet. Vol. ix.

H. I. Isenflamni, Dissert. de motu Linguae.

For the organ in general, the article "Tongue," by Mr. H. Hyde Salter, in Todd's Cyclop. of Anat. and Phys. may be consulted. This article contains a copious Bibliography.

The systems of comparative anatomy of Cuvier and Meckel record numerous details of muscular structure in the tongues of the lower animals; and Prof. Owen's paper on the Giraffe, in the 2d vol. of the Trans. of the Zoolog. Society, contains an interesting account of the tongue of that animal, remarkable for the extent to which it can be protruded, and for its prehensile power.

IX.—*Note of the Observation of Cilia in Grantia.* By Wm. Murray Dobie, M.D., Annual President of the Royal Medical Society of Edinburgh.—(Communicated by the Author, March 1850.)

The present somewhat dubious position of the Sponges in the systems of naturalists, leads me to hope that the following isolated observation may not be without its value, as an additional proof of the distinctly animal nature of these organisms.

In the end of last February, while residing for a short time at Marshalmeadows, near Berwick-on-Tweed, I had an opportunity of examining perfectly fresh specimens of a species of Grantia, in which very distinct and vigorous currents were in constant operation. Having scraped a portion of the gelatinous covering from the interior wall, and laid this on a piece of glass, and covered it with a thinner piece, I viewed the specimen through an achromatic microscope, amplifying about 150 diameters. The field of view was crowded with the minute granular cellules of the sponge, which, although they do not always show a distinct nucleus, are, I have no doubt, of the same nature as nucleated particles in general. These cellules were in a state of active and independent motion, and, when aggregated into masses, very much resembled some of the Compound Monads. When a single particle was seen isolated, the motion was of a jerking character, suggesting at once the existence of cilia, if they could have been seen. I now proceeded to a more accurate scrutiny. Another specimen was selected; a portion of the gelatine was diluted with water pressed from the interior of the sponge, and the whole covered with a film of glass of 1-120th of an inch in thickness. This I viewed with a very excellent 1-8th of an inch lens, by Smith & Beck, magnifying 450 diameters. The size and apparent motion of the cellules being thus greatly increased, I now could, without much difficulty, detect extremely attenuated cilia attached to every particle in the field of view, and lashing with considerable vigour. When the light and focus were adjusted with great care, I was able to sketch a considerable number of the individual particles. The average length of each cilium was equal to three times the diameter of the cellule to which it was attached. No perceptible difference in thickness could be observed throughout its entire length. Each cellule very strongly resembled some species of Monads. The motion ceased in all the particles very soon after separation from the general mass. I was able to repeat this observation several times in the Grantia. In the Halichondria, which I found at the same time, no currents could be seen. Only in one example could I find anything resembling ciliated particles, and that very imperfectly. No further opportunity presented itself for continuing these observations.

From this it seems evident, that in the Grantia the whole inner surface is lined with a ciliated epithelium, and that the currents are produced by the motion of these filaments.

I have little doubt that cilia will eventually be found to exist in all marine sponges, where currents are in operation, provided sufficient care be taken to examine the cellules, in perfectly fresh specimens, with first-rate instruments.

The evidence for the animality of the Porifera is, I think, more conclusive than some naturalists of the present day are inclined to admit. I feel assured that few botanists would be disposed to claim for these organisms a truly vegetable nature. The following peculiarities taken together seem sufficient to establish their true animal nature :—the existence of distinct currents in definite directions; vibratile cilia; ciliated locomotive gemmules; peculiar animal smell of burnt gelatinous matter. I may also mention the observations of Milne Edwards and Andouin on the Irritability of Tethea.[1] Dr. Johnston informs me, that some very recent observations on a large foreign species tend remarkably to confirm the statements of Andouin and M. Edwards. Dujardin's interesting observations on Spongilla also tend to prove the sponge an animal.[2] He noticed the remarkable property which detached portions of the granular matter of spongilla possess, of spreading into "*Expansions variables en lobes arrondis, comme certaines amibes.*" Both Dujardin and Pro-

[1] Hist. Nat. du Litt. de la France, vol. i. p. 78.

[2] Dujardin, Hist. Nat. des Infusoires, p. 305.

fessor Allen Thomson have observed cilia in the fresh water sponge; but the existence of cilia in marine sponges has, so far as I am aware, been always denied. In conclusion, I will only allude to Mr. J. A. Carter's interesting observation of species of spongilla in the water-tanks in Bombay.[1] Mr. Carter confirmed and considerably extended Dujardin's observations, but did not detect cilia. All these circumstances being considered, the animality of the Porifera will not, I think, be so equivocal as the following concluding sentence of Professor Rymer Jones's late article on the Porifera seems to intimate: "The admissibility of sponges into the animal series is indeed extremely problematical, and we doubt not, that among naturalists of the present day, the balance of opinion would be unfavourable towards retaining them in the rank, which they at present occupy in zoological classification."[2]

Note of the Observation of Cilia in two Species of Grantia.
(Second Notice, communicated by the Author, July 1851.)

(Plate V. *Fig.* 1.)

In the month of February 1850, I made a few observations on Grantia compressa; and having discovered the existence of Cilia, embodied the observation in the "Note on Grantia" which forms a part of the present paper. My friend Dr. Johnston of Berwick having informed Mr. Bowerbank that I had observed cilia in Grantia, that gentleman proceeded to Tenby, in South Wales, in the autumn of last year, mainly for the purpose of verifying my observation. A short time afterwards, I had the gratification of learning from Mr. Bowerbank himself, "that he had been able to get a view of the cilia in situ." He expressed his opinion, that they would fully account for the currents in Grantia, and would ultimately be discovered in other genera. He informed me likewise, that the cilia were "situ-

[1] Notes on Sponges. Trans. Med. and Phys. Soc. Bombay, No. 8. Reprinted in Annals and Mag. of Nat. Hist., New Series, April 1848. A second paper on the same subject appeared in the third volume of the Annals, 1849.

[2] Cyclopædia of Anat. and Phys. vol. iv. p. 70.

ated in the cavity intervening between the incurrent orifices and the commencement of the honey-comb-like cells which line the inner surface of the sponge, and are in fact confined to that space." Mr. Bowerbank made use of thin sections at right angles to the long axis of the sponge; but on this it is unnecessary for me to say more, as Mr. Bowerbank has recently informed me that he read a paper on the subject to the Microscopical Society shortly after his return from Tenby; which paper is to be published in the Transactions of that Society.

In February and March 1851, I was again residing at Marshalmeadows. I found a locality in which the Grantia compressa existed in myriads in every stage of growth, and had thus frequent opportunities of examining it. The Grantia botryoides was also abundant; and I found that cilia of a kind exactly similar to those of G. compressa could be detected in every specimen I examined.

Before giving the results of my more recent observations, I shall make a few extracts from writers, who have paid attention to this subject. Indications of currents through the orifices of the sponge, were first discovered by Ellis and Mr. Thomas Bell, and their observations were confirmed and elucidated by Dr. Grant. The ciliated locomotive gemmules of sponge were discovered by Dr. Grant so far back as the year 1825.

Dr. Grant, in discussing the motions of fluids in the "Poriferous Animals," makes the following remarks:—"Ellis imagined that he saw, on putting the living poriferous animals upon the sea-shore into a glass of sea-water, the orifices contracting or dilating, and this mistake led him to suppose that the large orifices or vents through which the streams of the living animals rushed out were both mouths and ani; that they were the only orifices connected with the production of currents, or with the nutrition of these animals. No such motions have ever been distinctly seen in any adult poriferous animal. The strongest stimuli that have ever been applied to the adult animal have failed in exciting the slightest perceptible motion in any part of its texture. Taking these animals in the living state, and putting them under water, to observe by their rapid streams that they are in perfect health and vigour, and then proceeding to puncture them with sharp instruments, upon watching the result, you will not perceive either a trembling motion or any contraction of the part, neither, after a time, will you see a depression formed at the point you have irritated. If you cut these animals into minute portions with sharp instruments in every direction, you cannot destroy their vitality, but you will perceive they still go on with the usual currents." In speaking of the gemmules, Dr. Grant further remarks,—" Notwithstanding the inertness of these animals in their muscular substance in the adult state, yet, when they are newly-formed gemmules, and just detached from the parent's body, they possess the power of rapid locomotion, and swim for a considerable time through the water by the rapid vibration of cilia, which are perfectly visible and largely distributed over the greater part of their body. These cilia continue in rapid vibration until the minute gemmules have fixed and begun to spread upon the surface of the watch-glass; the vibratile cilia then gradually cease their motions, and entirely disappear."[1]

Professor Sharpey, in his admirable article on Cilia in the Cyclopædia of Anatomy and Physiology, observes, that "in the various species of sponges, water, the element in which they live and grow, passes in currents through pores and canals in their substance in a continuous manner, entering at one place and issuing at another. This phenomenon has not been directly traced to the agency of cilia; it comes nevertheless to be considered here, as such an agency is highly probable; and at least the motion of the water is not owing to any contraction of the canals in which it flows, but is obviously caused by some other kind of impulsion communicated to it by the surface along which it passes."[2]

Dutrochet believes that the cause of the regular currents of the sponge may be ascribed to the phenomena of endosmosis.[3]

[1] Lectures on Comparative Anatomy, Lancet, 1834, vol. ii. pp. 259, 260.

[2] Cyclopædia of Anat. and Phys., vol. i. p. 612.

[3] L'agent immédiat du Mouvement vital dévoilé, 1826, p. 179; Annales des Sciences naturelles, 1828, tom. xv. p. 205.

Professor Rymer Jones considers that all the hypotheses hitherto suggested to account for the currents are unsatisfactory. He says, that "ciliary movement might be supposed to be the cause of this phenomenon, were it not that no observer has been able to detect, even with the most powerful microscopes, the presence of cilia in the aquiferous canals."[1]

Dr. Johnston, in his beautiful work on "British Sponges," gives an interesting account of the phenomenon in Halichondria. At the time that work was published, he was inclined to consider the motion analogous "to that imbibition and influx of water into the bodies of Radiated and Molluscous animals, which takes place through the skin and through certain canals."

Two recent observers of Spongilla deserve especial mention, viz., M. Dujardin and Mr. H. J. Carter. Dujardin has ascertained, that the cellular masses of Spongilla have the property of putting forth variable expansions after the manner of the Proteus or Amœba; other masses of particles from the glutinous matter of the parent sponge are provided with cilia of extreme tenuity. He observes, "Qu'on soumet au microscope les parcelles flottantes et celles qui adhèrent à la plaque de verre, on reconnaît que ces parcelles sont pour la plupart munies de filaments vibratiles d'une ténuité extrême, analogues à ceux des Monadiens, et qu'elles ont en outre la faculté d'émettre des expansions variables en lobes arrondis, comme certaines Amibes; ce sont surtout les parcelles dépourvues de filaments vibratiles et reposant sur la plaque de verre qui rampent à la manière des Amibes au moyen de ces expansions diaphanes arrondies; les autres nagent dans le liquide, ou bien si elles reposent sur la plaque de verre, l'agitation continuelle qu'elles éprouvent empêche que leurs expansions ne soient visibles." Mr. H. J. Carter has contributed precise and interesting information on Spongilla, which confirms the researches of Dujardin just mentioned. Speaking of the nature of Spongilla he remarks:—"Its claims to animality or vegetability with those of the other sponges have been canvassed over and over again by the ablest physiologists, and yet remain undecided. Still this subject does

[1] Cyclopædia of Anat. and Phys. Art. Porifera, vol. iv. p. 68.

not appear to me to have been viewed in a proper light; for late discoveries seem to show that there exists no line of demarcation between the animal and vegetable kingdoms; but that, on the contrary, the one passes by gentle and at last imperceptible gradations into the other. From the existence of cells as the principal component parts and the elaborators of the most complicated forms of animal and vegetable structures, and the intimate connexion that obtains between these little organisms in both kingdoms in their isolated and independent existences, and in their simple and composite forms, of which I take Spongilla to be one, the time appears to have arrived for abandoning the question of the animality or vegetability of Spongilla, for the more philosophical consideration of the position it holds in that transitionary part of the scale of organized bodies, which unites the animal and vegetable kingdoms." Notwithstanding of this, I think that Mr. Carter's very interesting observations tend to shew that even Spongilla, despite its many vegetable characteristics, lies within the territory of the zoologist. Mr. Carter, after describing the manner in which the germs (which have recently formed the contents of the seed-like bodies) become eliminated, further states, that they become parcelled into insulated groups, which after some changes disappear, and their disappearance is followed "by a successive development of proteans or active polymorphic cells." These proteans are sometimes 1-800th of an inch in diameter, but their average size is 1-3000th of an inch. The form assumed by the largest is that of the diffluent Proteus, and the form of the smallest resembles that of the vermiform Proteus, which progresses after the manner of a worm. Mr. Carter considers them "but a higher condition of the sponge-cell *in situ;* they are larger, more active in their component parts, and more active as a whole, and appear to possess a greater share of intelligence." (!!) Again, in a concluding remark, "Spongilla is closely allied to both the vegetable and animal kingdoms; but it is for those best acquainted with the chain, which unites these two great conventional divisions, to assign to it its proper link."

In a letter which I have received from Professor Allen

Thomson of Glasgow, he gives the following account of his observations on Spongilla :—" I did not take any notes of the observations to which you refer on the cilia of Spongilla ; but I remember very well, that four or five years ago, in observing small detached fragments of the fresh water sponge from Duddingston Loch, I noticed the minute fragments to move on the field of view, so as slowly to change place while they also turned about somewhat. On applying a magnifying power of 400 diameters, I found that the motions were occasioned by one or more cilia attached to the gelatinous minute bodies which constitute the substance of the sponge. The cilia were extremely delicate, and at this distance of time I cannot venture to mention the size either of the cilia or of the fragments to which they were attached."

I now proceed to my own observations ; and, in the first place, I notice the manner of observing the phenomenon. The easiest plan is to remove with a fine knife a minute portion from the inner wall of the sponge, and to surround it with a little sea-water, or, what is better, with some of the semifluid gelatinous matter contained in the interior of Grantia. The advantage of this plan of procedure is, that the manipulation requires less time and skill than the production of good cross sections ; and I deem it nearly as satisfactory in its results, for the ciliated particles can thus be admirably seen *in situ* attached to the spicular skeleton. The uniform direction of the current, and the great activity of the cilia, when the specimen under examination is quite recent, cannot fail to convince any one, that, in Grantia at least, the motion of fluids must be caused by ciliary action. The cilia are so arranged as to lash in the direction of the excurrent orifices ; and although the microscopic demonstration of this be very difficult, it is of little consequence, as, if such an arrangement did not exist, it is evident, that the flow could not be continuous, nor, in fact, could any regular currents exist at all.

When a piece of Grantia compressa or G. botryoides is examined in the way described, with a good lens of considerable power, the minute monad-like epithelial cellules may be seen floating in large irregular masses, sometimes attached to the spicula; an insulated particle is occasionally seen wriggling through the water in the manner of an independent animalcule. These cellules cannot properly be said to have a distinct nucleus; but they are probably of the nature of nucleated particles, or ciliated epithelium. Their shapes are very various, round, ovate, cuneate, and irregular; several forms are represented in *Fig.* 1, *Plate* V., which is taken from a sketch made at the moment of observation. I am inclined to believe that these cellules line the whole interior wall of Grantia, as well as the inside of the cells; but of course I say this with all due submission to such an observer as Mr. Bowerbank. In no part of the inner wall from which I could remove a slice have I failed to detect them; indeed, the result of my observations is the conclusion, that, wherever the gelatinous matter of the sponge is spread, there these ciliated cellules exist, and that in nearly every stage of the sponge's growth. The particles are usually colourless and semi-transparent, and contain in their interior one, two, or three large granules. Clear round vesicles, containing a few granules, and larger in size than the ciliated particles, are to be seen scattered throughout the field of view; besides these, there are many minute cellules, granular, and molecular elements. The cilia are attached to the epithelial particles; this gives them so strong a resemblance to Monads. My subsequent researches have led me to correct an incompleteness in my former description. At the time my first observation was made, I could only detect one cilium on each of these Monad-like cells. More careful examination has shewn me, that several cilia are attached to each particle. I have frequently observed three, and am inclined to consider that more than this number may be attached to a single cellule. Each cilium is an extremely delicate filament, which tapers very gently from base to apex; but no perceptible flattening can be observed. In my former "Note" their length is somewhat underrated. Under favourable circumstances, I have recently seen them five or six times longer than their epithelial cell.

Their vibratory movement is so rapid, when recently removed from a fresh specimen of sponge, that it is impossible for the eye to follow the motions of the individual cilia. The ciliary action can then only be recognised by the rapid rolling of detached masses of cellules, and the agitation of loose particles floating in the neighbourhood of fixed portions of the sponge. This indicates the direction of the current produced by the ciliary vibration. In a few minutes the activity of the motion becomes slackened, and glimpses may now be caught of the individual cilia, and of their fanning, lashing, or flogging motion. When seen to advantage on an isolated cellule, they are observed to bend rapidly forward, and, as if by their own elasticity, slowly to extend themselves again. The full length of the cilium can be best appreciated at the moment it is regaining the extended position preparatory to a fresh lash or vibration.

A curious fact in the history of the cilia of Grantia is the short duration of their vitality after removal from the parent sponge, compared with the long-continuing action of the cilia of molluscous animals, &c. The vibratile action of the former usually begins to flag in ten or fifteen minutes. It is only when peculiar care is taken, that it is possible to observe the continuance of the motion for more than an hour. This, no doubt, has hitherto been one of the great impediments in the way of their discovery. Another obstacle has been the want of a finely defining lens with good adjustments for focus and light. This difficulty is now removed by the skill of modern opticians. I may mention that, in order to see the cilia, I had in the first instance to employ a lens of one-eighth inch focus. Since becoming familiar with the object, I have several times been able to get distinct views with Smith and Beck's quarter-inch glass, and in one or two instances have seen the cilia with a lens of a four-tenths inch focus magnifying with the long eyepiece not much more than one hundred diameters. I believe it is found by observers both with the telescope and microscope, that an object which it has required a high power to discover, can afterwards be distinguished with a much feebler optical aid.

Lastly, with regard to the nature of sponges, it may be said, that nothing analogous to a ciliary motion and currents of the character described has ever been found in the vegetable kingdom. This being established, I think there can scarcely be a doubt that the Spongiadae are really animals, though certainly of a very low type of structure.[1] The observations of Dujardin and Mr. Carter shew the great resemblance which Spongilla bears to the amœba or proteus. Indeed, to build up a sort of sponge we have only to conceive a multitude of amœbae spread over the interior of a coriaceous, calcareous or silicious skeleton. Here we should have an animal, every particle of which, like spongilla, has the power of changing its form and throwing out variable expansions. It would be, indeed, a creature less highly organized than the fresh-water sponge, as it would be entirely destitute of cilia, which are present in spongilla.[2] In the marine sponges we find a higher type of organization than this; instead of the glutinous, almost homogeneous matter of spongilla, we have distinct ciliated cellules, producing a vigorous circulation of fluids through a complicated skeleton; while at an early stage of its growth the young animal possesses powers of independent locomotion, and is clothed with vibratile cilia, after actively swimming about for a season fixes it itself; then it loses its primary cilia, and, in the course of its growth, these become replaced by a new set, specially adapted to carry on those currents, which, from the more expanded dimensions of the sponge, have become necessary to its nutrition, respiration and life.

[1] Though ciliated spores (Phytozoa) are found in the vegetable kingdom, still the locomotion of the sponge gemmule, its spicular skeleton, and subsequent changes, bear a far stronger analogy to the mutations of some much more highly developed animals. To take a single example: the young of the Stephanoceros Eichornii, after escaping from the egg, possesses a set of strong cilia specially adapted for locomotion; but as soon as the young animal becomes fixed, the primary cilia are lost, and in their place five arms become developed, clothed with cilia of a perfectly different character, and fully adapted to the change in its mode of life.

[2] Professor Goodsir, in his Lectures on Comparative Anatomy in the summer of 1849, pointed out an interesting analogy between the compound Monad Anthophysa Vegetans, (Volvox Vegetans, Müller.) and the Spongiadae. In this animal we have masses of ciliated cellules (Monads) situated at the tips of the ramifications of a horny skeleton secreted by the Monads themselves.

X.—*On the Tongue of the Chameleon, and the Mechanism of its Projection and Retraction.* By Mr. JOHN ZAGLAS, Demonstrator of Anatomy in the University of Edinburgh. (Communicated by the Author.)

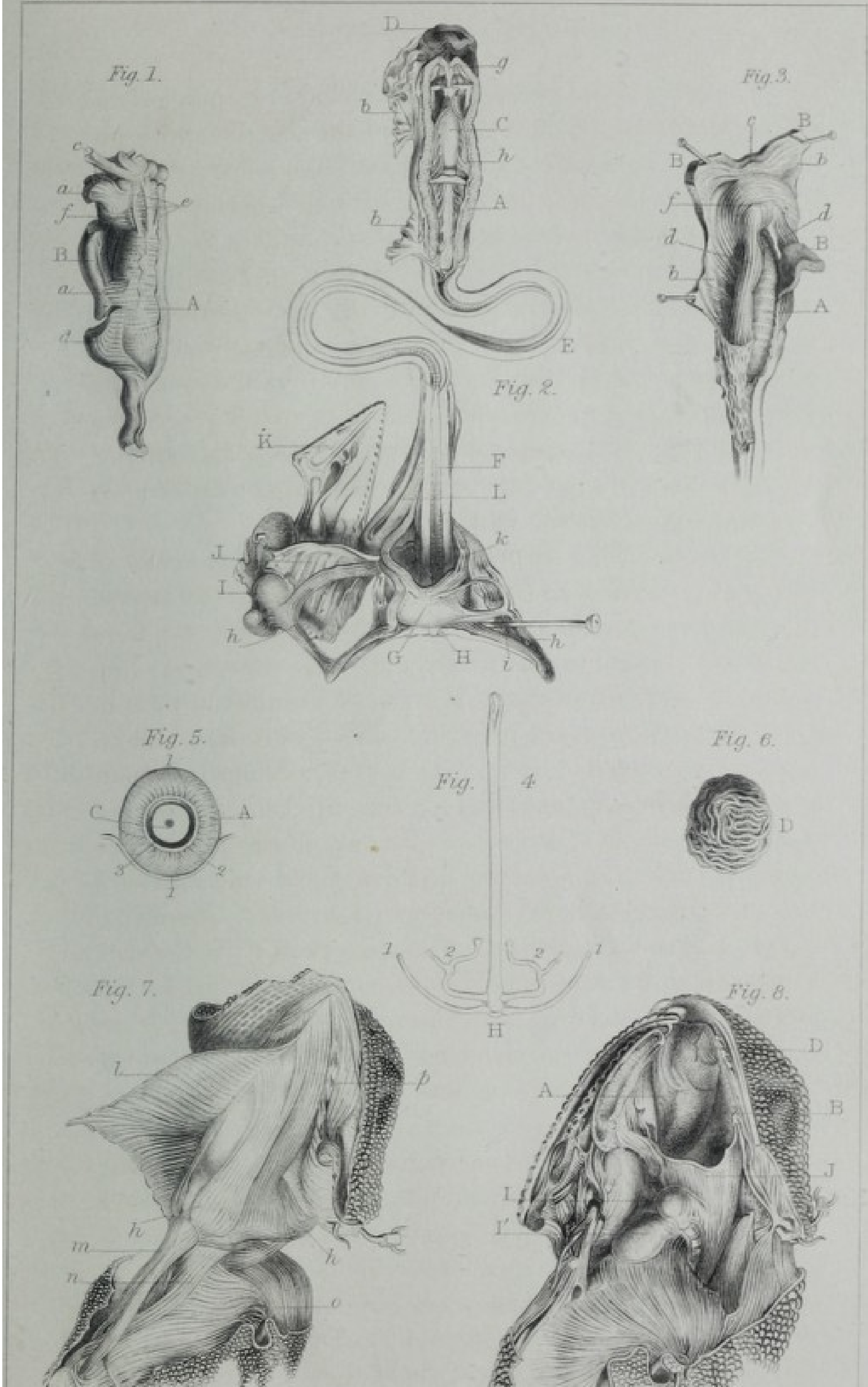
IN the Chameleon the hyoid bone and its muscles are essential constituents of the Tongue; which in addition consists of an elongated slender cord, with a short thick cylindrical body attached to its distal extremity, and corresponding, in position only, to the tip of other tongues. These three parts of the organ I shall, in the following description, call the *Sling*, the *Cord*, and the *Projectile.*

The Sling—A pouch-like production of the mucous membrane of the mouth underneath the pharynx, covering the hyoid bone and its muscles, constitutes, in connexion with the latter elements, the somewhat complicated apparatus of the sling. *a*, The hyoid bone presents a body and two pair of horns. (*Plate* VI. *Fig.* 4; *Fig.* 2, F, H.) The body is an osseous bar one and a half inch long, extending horizontally forward on the floor of the mouth, as far as the symphysis of the jaw. At its anterior extremity it becomes cartilaginous, and there is no other bone or cartilage in the tongue itself. The posterior extremity is somewhat enlarged, and presents two notches on each side for the reception of the two pairs of horns.

The posterior pair of horns (*Fig.* 4, *i*) are osseous; cylindrical in their upper two-thirds, in the lower third antero-posteriorly flattened and curved outwards, and so inclined as to form, by junction with the body, a reversed arch in a plane at right angles to it.

The anterior pair of horns (*Figs.* 4 and 2) are articulated to the body immediately in front of the posterior. These horns consist each of three comparatively thin pieces, which radiate from a common central portion, and are so arranged that two of them, the inferior and superior, lie nearly in the surface of curvature of the posterior horns. The anterior piece, which is transversely compressed, undulates for a certain distance for-

to face p. 138.



J.D. Bell, delt. W. Douglas. Sculpt.

TONGUE OF CHAMELEON

wards, and in the same plane, when it bends inwards to terminate in a disk-like dilatation. The inferior piece articulates with the hyoid body, thus forming the basal part of the horn. The superior is free, and lodged amongst muscles. The anterior is attached to the upper surface of what is to be immediately described as *the lingual pouch.* The anterior piece, and the proximate portions of the other, are cartilaginous, what remains being osseous.

b, The lingual pouch. (*Fig.* 2, G.) The pharynx (*Figs.* 2 and 8, J) presents a wide opening over this pouch, and a portion of the pharyngeal floor projecting, in the form of a shelf, into the oral cavity, for about a quarter of its length ; the shelf being formed by a duplicature of the mucous membrane of the mouth, stretched parallel to the floor of the latter, and ending in a free crescentic margin, the horns of which are prolonged along the rami of the lower jaw, towards the symphysis, which, however, they do not reach. Thus a pouch is formed underneath the pharynx, into the bottom of which the tongue is implanted, and which, if seen from without, (when the pharynx is dissected off as in *Fig.* 2,) presents a shape not unlike a thimble, but posteriorly prolonged into two conical processes, by means of which it is attached to the basilar pieces of the anterior horns of the hyoid. Through this attachment, and the anterior pieces undulating on the sides of the pouch, and inflected upon its upper aspect, the anterior pair of horns act as a skeleton in maintaining the form of the pouch. The body of the hyoid bone in piercing the pouch from behind causes the mucous membrane to reflect itself over the tongue. The crescentic duplicature of this membrane contains, in addition to the cartilaginous structures already mentioned, muscles to be afterwards described, and also the larynx.

c, Muscles of the Sling.—Such muscles as are known to occupy the submental and anterior region of the neck, are well developed in the Chameleon, for the obvious purpose of supporting the heavy tongue, and acting upon the hyoid bone ; but there are also some muscles peculiarly disposed so as to act upon the pouch.

Beneath the integument a thin cutaneous colli muscle is met with, arising from the skin above the shoulders and from a line extending to the symphysis of the jaw, and meeting its fellow in the mesial raphe; its fibres having a transverse direction.

The mylohyoid arises from the internal surface of the lower jaw, with the same direction and insertion as the last muscle, but is shorter and stronger, and has no attachment to the hyoid bone. (*Fig.* 7, *l.*)

Between the sternum and hyoid bone a strong sternohyoid arises, presenting two portions, of which one is inserted to the basis of the hyoid bone, the other to the distal end of the great horn. (*Fig.* 7, *m n.*)

The thin and slender omohyoid presents nothing peculiar.

The geniohyoid is very large and strong, having one attachment to the anterior half of the inferior margin of the lower jaw, the other to the whole extent of the great hyoid horn; it could easily be described as consisting of several portions, of which one has an attachment to the posterior superior radius of the small hyoid horn. (*Figs.* 2 and 7, *h.*)

A comparatively strong muscle arises from more than the anterior third of the margin of the lower jaw, which, concentrating its fibres and running backwards, occupies the sinus of the semilunar margin, formed by the duplicature of the mucous membrane, described as separating the pharynx from the pouch of the sling. It meets its fellow of the opposite side at the middle of this margin by means of a tendinous intersection. (*Fig.* 2, *k.*) This is the only arrangement which could be compared to a genio-glossus.

Two other sets of fibres, feebly indicated, are perceived; one arising from the posterior inferior radius of the small hyoid horn, and spreading over the pouch, proceeding over its conical processes of attachment in a fan-like arrangement. The other consists of fibres descending from the pharynx to embrace the pouch, somewhat analogous to a pharyngo-glossus.

The only muscle proceeding from the hyoid bone to the tongue proper is a cerato-glossus, which arises from the distal extremity of the great horn, and, descending between this horn and the lesser, pierces the pouch, along with the body of that bone, on the side of which it runs on to the cord. (*Fig.* 2, *i.*)

The Cord.—The natural length and breadth of the cord are represented in *Fig.* 2. Its constituents are the continued mucous membrane exhibiting a parchment-like appearance, a central tube, a vascular membrane surrounding the tube, and muscular fibres occupying each side between the vascular and mucous membrane.

The central tube is narrow, with proportionally strong walls, consisting of longitudinal and circular elastic fibres. It begins at the body of the hyoid bone, as if it were a continuation of the perichondrium of its anterior extremity. The manner in which it terminates will be stated in the description of the elastic body which forms a constituent of the *Projectile.*

Character of the peculiar movements of this kind of Tongue.—I would not have taken any particular notice of the structure alluded to as the vascular membrane, but for the well-known theory which refers the projection of this Tongue to the agency of erectile texture. Cuvier deeming it unnecessary to refute other hypotheses which were not based on anatomical data, dwelt on the theory of vascular erection as one supported by analogy. In the vascular system, however, he found nothing to warrant this explanation; and being, moreover, supported by dissection, he had a strong impression in favour of muscular action of the vascular.

In fact, the vascular membrane consists of a loose net-work of vessels, most of them apparently venous, without any appearance of cavernous sinuosities or aponeurotic structures to afford that resistance so necessary for a vascular erection. Besides, the existence of a vascular plexus is well accounted for in an organ where the circulation must be accommodated to its varying conditions, while erection is not compatible with the uses of the tongue either in this or in any other animal. Erections would depend, in point of quickness, on the size of the tongue in relation to that of the heart, on the quantity of blood which would be driven into it at one impulse, and on the celerity of circulation. It could only have produced, during the projection of the organ towards the object aimed at, a more or less interrupted vacillating and uncertain movement, which would be more likely to frighten away than to secure the fly, with which shy animal the Chameleon appears to be well acquainted, according to Mr. Houston's observations on two living individuals.

The vascular membrane is in immediate contact with the mucous membrane on the mesial line of the upper and under surface of the cord, so that, on the upper surface more particularly a mesial groove is formed, which separates the bulging margins from one another, and in which the muscles of the cord are contained. These muscles are two sets of fibres forming the continuation to the above mentioned hyo-glossal muscles. Their fasciculi seem to arise repeatedly from the mucous membrane, and to be inserted at certain distances, in the meantime exchanging filaments and producing on each side a muscular net-work in the form of a cord, which reaches the projectile, where we shall follow them to their terminations.

The Projectile.—This is the most mysterious, but hitherto most imperfectly described part of the Tongue. It is generally cylindrical, measuring somewhat less than one and a half inches in length and about four lines in diameter, posteriorly rounded, and attached to the cord, anteriorly presenting a conical transverse excavation, the margin of which exhibits a superior and an inferior lip. The colour and degree of solidity of its surface indicate certain spots corresponding to the internal disposition of parts. The sides are of looser consistence, and of a greyish appearance, extending upon the dorsal surface so as to leave there only a spindle-shaped spot of greater firmness and darker colour, and indicating the position of a large muscular cylindrical body, or of as much of it at least as is not covered by looser muscles. On the lower aspects of the characteristic lateral surfaces circumscribe two spots of the same appearance as the superior, a posterior quadrangular, and an anterior triangular and longer, the base of which reaches the under lip of the projectile. Of these spots the quadrangular indicates the part by which the same cylindrical body is in contact with the under surface of the projectile, while the triangular is produced by a separate body of similar structure, but of a semi-conical form. In the cleft between the two bodies the mucous membrane insinuates itself to line the above mentioned excavation, assuming a peculiar appearance, and forming, in concert with muscles, a distinct organ within the projectile. This organ, the muscles on the flanks, and the two muscular structures above alluded to, along with a peculiar elastic body contained within the cylindrical mass, are the constituent parts of the projectile.

a, The hollow cylindrical body. (See A in *Figs.* 1, 2, 3, 5.) To this hollow body allusion has already been made as containing a peculiar elastic structure. It is open both in front and behind, the posterior opening being round and small ; the anterior a transverse cleft, separating that extremity into two pointed lips, of which the superior is much longer than the inferior.

The cavity of the cylindrical body presents dimensions nearly double the thickness of its walls, and is lined by a strong tunica albuginea, (*Figs.* 5 and 2,) very remarkable, as detaching itself from the walls of the cylinder, opposite to the beginning of the cleft above mentioned, in order to form a conical diaphragm, which, however, it does not complete. The cone being truncated (*Fig.* 2) a thin layer of membrane is continued over the remainder of the internal surface, which also appears loosely to shut up the cleft. Externally the body is invested by a thin fascia, strongly supported by the parchment-like mucous membrane at the spots above mentioned. (*Fig.* 5, *i i.*)

The muscular constituents are situated between the internal and external walls of the hollow cylinder, (*Figs.* 2 and 5.) They consist of short but coarse fasciculi, joining the two respective surfaces at nearly right angles : apparently they are stretched in the direction of the radii of the cylinder, but in reality somewhat curved to the left or the right, whence two sets may be distinguished. Each set forms portions of rings which are situated in planes oblique to the axis of the cylinder, whence it results that, in a transverse and perpendicular plane, fibres of both sets will be met with crossing each other. (*Fig.* 5.)

Of the lips of the hollow cylinder the superior is longer and more slender, ending in a tubercle. From this tubercle a small but proportionally strong muscle arises to traverse the cavity of the body in the direction of its axis, and to be inserted into the extremity of the elastic body. (*Fig.* 2, *g.*)

The elastic body.—From its nature and connexions this body presents the aspect of a separate body in the economy of the projectile. I have met with it in two modifications, but *Fig.* 2 represents it in its more perfect state, and a description of it in this form may be given. Its thickness is nearly one and a half line, admitting of very free motion within the cavity of the cylinder. Its posterior extremity is rounded and situated at the somewhat narrower opening of the cavity of the cylinder, while the anterior is short, conical, and loosely insinuated into the conical depression of the imperfect diaphragm, formed by the inflected investing membrane of the cavity, and receiving at its apex the insertion of the above-mentioned small muscle, a little beyond the hiatus. Between the walls of the cavity and the body fibres may be perceived more or less coarse, having no regular arrangement, but the same general direction, which is from behind forwards and outwards, or from the wall of the cavity forwards and inwards towards the body. These fibres are rather delicate fasciculi of areolar tissue intermingled with elastic and a few striated-muscular fibres ; at least the latter are repeatedly perceived under the microscope, notwithstanding every precaution to avoid taking them from any neighbouring part ; but this arrangement also was opposed to such a conclusion, the fibres becoming shorter and denser at the extremity of the body, the connexion of the latter with the inflected membrane is stronger, but the two structures are not blended. With regard to the structure of this body, it may be generally said to present two layers of broad elastic fibres, rupturing with abrupt extremities, and curling strongly, and communicating with one another in a continuous long-meshed net-work ; the one layer is longitudinal and external, the other circular and internal. In the centre a small tube runs, so that, upon the whole, although it somewhat resembles an artery, the cavity of which might be imagined to be nearly obliterated. Under appropriate manipulation, too, this body, as well as its fibres, evince great elasticity.

The second variety met with was that of a body in the form of a direct continuation of the central tube mentioned amongst the constituents of the cord. In the first specimen this tube seemed connected with the investing membrane of the cavity of the cylindrical body; while in the second, where the body was somewhat thinner, it was continuous through the elastic body, and the latter presented itself as the cord increased in its transverse dimensions: no other difference could be perceived.

The semiconical body. (*Figs.* 1 and 3, *B.*) The denomination nearly indicates the shape of this body, the position of which has already been mentioned as corresponding to the inferior brownish triangular spot. Its flat surface looks towards the hollow cylindrical body. It is quite solid, and in structure does not at all differ from the walls of the latter, the attachments of the fibres being on corresponding joints of its semiconical and flat surfaces.

Muscles of the Projectile.—From the description already given of the relative position of the two muscular bodies to one another, and to the conical involution of the mucous membrane, the arrangements of these muscles may be determined.

a, A flat, short, and broad muscle arises from near the apex of the semiconical body, and goes upwards and forwards to the corresponding surface of the hollow cylinder, posteriorly touching its fellow of the opposite side, anteriorly diverging from it. (*Fig.* 1, *a.*)

b, Two sets of fibres, forming a considerable layer, arise from two lines nearly parallel to one another and to the axis of the projectile. These lines are the lateral limits of the coloration mentioned as occupying the flanks of the projectile: the upper running along the whole length of the hollow cylinder, the lower extending on the sides of the semiconical body, and partly on the lower surface of the cylindrical body. Each line sends a layer of fibres to be inserted on the other, which cross the space obliquely from behind forwards. This system, while acting, must strongly approximate the two bodies to each other. (*Fig.* 3, *b.*)

The muscular fibres of the cord are continued on to this element of the projectile, which seems to consist of a peculiar disposition of the former rendered necessary in this locality; at the same time some more superficial fibres form behind a thin layer, still preserving the reticular appearance.

c, The most anterior fibres of the system (*b*) form a peculiar muscle, or a sphincter for the funnel-like excavation. They arise from the anterior extremities of both bodies embracing the mucous membrane, and unite with one another in the sinus of the duplicature forming the lips of that excavation. (*Fig.*3,*c.*)

d, The muscle *b* being removed, another very strong muscle —the strongest of all the muscles in the projectile—appears. It arises from the flank of the hollow cylindrical body, from the posterior thirds of the two above mentioned lines, whence, becoming narrower and more compact, it proceeds forwards to curve at last under the cone formed by the mucous membrane, on the lower surface of which it is inserted, uniting with its fellow of the opposite side. (*Fig.* 3, *d d.*)

e, Other three narrow, but proportionally long muscles, are seen underneath the muscles *b*. They arise from the angle of the cleft dividing the anterior third of the hollow cylinder into two lips, and from the margin of the upper lip; they are inserted upon the circumference of the cone of mucous membrane, or on the lips of the excavation. (*Fig.* 1, *e.*)

f, From the margin of the upper lip a thin layer of muscular fibres takes its origin, stretched under the muscles *e*; and which, converging and proceeding outwards and backwards, winds around the apex of the cone of mucous membrane between the two muscles *d*, to be inserted on the under surface of the membrane in common with these muscles. (*Figs.* 1 and 3, *f.*)

The Mucous Membrane of the Projectile.—The whole apparatus of the projectile is covered by a parchment-like mucous membrane, the continuation of that on the cord. The portion, however, lining the anterior excavation and its lips, is of quite a different appearance, suddenly becoming velvet-like. On closer inspection we perceive this appearance to be produced by two systems of folds, into which the membrane is thrown for the increase of its surface. The one system of folds, which is more developed, presents circles concentric to the apex of the conical excavation; each fold is subdivided in two parallel ones by a narrow and shallow cleft, having the intervals between one another much broader and deeper. It is in these intervals that the second system of folds is hid, crossing them transversely at distances nearly as long as themselves. Thus the whole presents a very regular aspect, that of concentric zones of alternating double folds and quadrilateral alveolae, which is attempted to be represented in *Fig.* 6, the mucous membrane being turned inside out.

I have only dissected the tongues of three specimens of this animal, and it so happened that all three presented some deviation from what may be considered as the standard. One of them was a preparation in the University Museum, injected with quicksilver to shew its vascularity, and which was everywhere permeable to this metal, the weight of which apparently caused a general extravasation. This is the tongue described as the second variation in the relation of the elastic body to the central tube. That of the first variation in the relation of these structures existed in an animal in which it had been kept projected, and which I have already described. The elastic body presented its posterior extremity rounded, smooth, and with no appearance of laceration whatever. This circumstance, combined with that of its not being an injected tongue, (for this would have implied the suspicion that the disjunction of the two structures was artificial,) led me to state them as varieties. The question now presenting interest is, Whether this is constant, and involving a specific difference, or if it only indicates an individual variety?

I was therefore anxious to examine another specimen, wishing also to observe the Tongue *in situ.* Professor Goodsir gave to me a third animal, which apparently was of a different species. But this chanced to be that which I am about to notice as abnormal, and which, perhaps, must be so regarded till subsequent investigations prove the contrary.

In the bottom of the pouch of the sling in this specimen, and surrounding the body of the hyoid bone, a set of folds were observed in the form of a rosette. I could detect no muscular fibres in the interior of these folds; but in front of the folds there were several pad-like swellings, upon the whole circular, but running into one another, and consequently separated by incompletely circular clefts. The pad-like aspect of these swellings depended on the muscular fibres which were found in their interior; the direction and character of the muscles being exactly those of the normal cord when sheathed on the hyoid bone. On attempting to extend this Tongue, it could not be effected; and on cutting through the projectile, I found the cause of this to be the complete deficiency of the elastic axial tube of the cord, as well as of the elastic body of the projectile. The place of the latter in the cavity of the muscular body was occupied by the style of the hyoid bone, which reached as far forwards as, and was connected to, the apex of the upper lip of the extremity of the Tongue.

Mechanism of Motion.—The muscles attached to the hyoid bone and the pouch of the sling, are certainly the usual muscles met with in this region, but modified in this animal for peculiar actions. This may also be the case, at least to a certain extent, with those of that very anomalous structure—the projectile; but there is as yet no means of appreciating what must be referred to modification of a more general type, and what has been added for the particular economy of this animal. Under these circumstances, general morphological considerations cannot obviously be entered upon, but from a physiological and zoological point of view, we may dwell with advantage on the peculiarities of this tongue. The more so, as the anatomist will find that two tissues, the muscular and the elastic, have been had recourse to for establishing a principle of action quite different from what is met with elsewhere; while the zoologist may perceive in this mechanism how far in allied animals scope is given for deviation from the ordinary functional principles. I shall now endeavour to explain the mechanism of function in this form of tongue.

Projection, prehension, and retraction are the chief points here requiring explanation. With regard to projection, I believe that the construction already described implies the admission of the following theory. The projectile being conceived to contain in itself the chief means to the mechanism of motion is supported by the sling-apparatus. The hollow cylindrical body, whether in a more active or more passive state, can only produce differences in the consistence of its muscular walls, the parieties of which are connected with each other at nearly opposite points by muscular fibres. And this also is all that can be predicated regarding the semiconical body considered alone. But if each of these bodies, or both together, have, from the above-mentioned arrangement, the power of assuming a sufficient degree of elasticity, and be acted upon by a muscle attached to their extremities, this muscle will convert each of them into a bow of which it is the cord; thus a double bow is produced, having two curves on a common cord. On a sudden relaxation of this cord the curvatures will straighten themselves with more or less impetus, according to the assumed degree of elasticity, but no locomotion will be produced, unless one extremity of the double bow react against some resisting body, for the tendencies of the two extremities would annihilate each other. A simple experiment may illustrate this, for proof is scarcely needed: Take a small rod of some elastic substance, for instance, a piece of whalebone, and converting it into a bow by means of a thread; cut this thread with a sharp instrument; it will be seen that, if both extremities of the bow are free, the whalebone will remain nearly upon the same spot, but if one of them react against some resisting surface, it will spring in the direction of the free extremity.

That this theory really expresses the operation in the projectile of the tongue of the Chameleon becomes obvious from the agreement of all its arrangements with such a purpose. We have seen the two muscular bodies convertible into bows, and looking for a cord we perceive on each side a strong muscle (*Fig.* 3, *d*) extremely well adapted for the purpose; for it originates on the posterior extremity of the hollow cylinder, runs between it and the semiconical structure, and is attached upon the bottom of the introversion of the mucous membrane, to which both anterior extremities of the muscular bodies are attached. But to constitute the double arch above alluded to, it is necessary that the posterior extremity of the semiconical body should be acted upon. This is effected by the muscles, (*Fig.* 1, *a* ;) and it appears that this extremity gets its contre-coup on the cylindrical body, while bent.

The system of fibres on the flanks of the projectile, marked *b*, must be extended or relaxed during the time that the two muscular structures present their incurvations to each other ; and its contractions must therefore coincide with the relaxation of the cord. Having such attachments, it must be conceived to be an arrangement for preserving parallelism of the two bodies, while acting ; and it is apparent that it accelerates the opposite motions of their extremities, so as to reinforce their impetus. Its considerable development, added to the want of any perceptible service it could afford, scarcely admits of a doubt as to its function.

The elastic body seems to be of great service for the same end, and perhaps in two ways. In the *first* place, being bent along with the hollow cylinder it comports itself in the same way when disengaged ; *secondly*, the muscular fibres between it and the lining membrane of that body may condense its substance, when acting, and thus increase the impetus during relaxation. In both cases the impetus may perhaps be increased by the small muscle (*Fig.* 2, *g*) by which it is attached to the upper lip of the cylinder, and may probably be transmitted to this body through the inflected lining membrane.

It would appear, that by the duplicity of the bow-apparatus in the projectile it has been arranged so as to impart a straight direction to the course of that body ; this being necessary to enable the animal to aim at its prey with effect. The service of a cord being trusted to two muscles, and perhaps to a third one, derivable from a partial action of the muscle (*Fig.* 3, *b*,) upon the anterior extremity of the semiconical body, the arches also act separately, producing slight motions, which seem to be the means of accommodating the projectile to the cavity of the mouth.

The projectile, when in the mouth, lies in the sling, the arrangement of which obviously implies the function of the organ, while the bottom of its pouch is well fitted to oppose resistance to the exertions of the hollow cylinder in the contre-coup. But it may be justly demanded, what is the position of the projectile with regard to the body of the hyoid bone? In a state of repose the body of the hyoid seems to pierce it, as exhibited in *Fig.* 8; but, at the moment of projection this cannot be the case, it being incompatible with the formation of the bows. I therefore believe that preparatory to projection the projectile rests upon the hyoid as upon a rail on which it slides off.[1]

[1] A considerable time after I had written the foregoing paper, Professor Goodsir directed my attention to Rusconi's Memoir in Müller's Archives, 1844. (Beobachtungen am Afrikanischen Chamaeleon. Von Dr. Mauro Rusconi.) The observations of Rusconi on the actions which occur in the living animal during the protrusion of its tongue appear to have been made with great accuracy; and what he states agrees so closely with the results at which I have arrived regarding the mechanism of motion, from the consideration of the anatomical structure of this remarkable organ, that I should be neglecting the strongest support which such direct observations afford to my views, were I to omit to quote them on the present occasion. Rusconi says—"I therefore directed my attention to the abdominal parietes, in order to ascertain whether they remain motionless or suddenly contract while the animal projects its tongue, and satisfied myself that their contraction is considerable, but gradual. I then examined the neck with great attention, and observed, what as yet has not been mentioned by any one, that when the animal is intending to project its tongue, its neck begins to contract, and, moreover, becomes gradually smaller, so that its usual goitre-like protrusion ultimately disappears. After having satisfied myself regarding the abdomen and neck, I proceeded further to observe the mouth; and I distinctly saw that there are two movements of the tongue, in two distinct periods. During the first the animal directs its head and eyes towards the insect, elevates its throat, opens its mouth, and by and bye brings the anterior part of the tongue out of it. (A drawing shews that this is almost the anterior half of the projectile.) This having been accomplished, it darts the tongue against the insect with the velocity of an arrow, and as quickly retracts it, carrying with it the adherent prey." From these statements of Rusconi it appears, that the animal, before darting out its tongue, disengages the projectile from the body of the hyoid bone, or at least as much of it as may be necessary for the arching of the muscular bodies, so that on straitening themselves they may afford the necessary impulse. All the dissections from which the descriptions in the foregoing paper have been drawn up were made on specimens preserved in spirits in Professor Goodsir's collection; but Dr. Cobbold having lately provided me with a specimen recently dead, I have ascertained that the cord, as well as the projectile, may be sheathed with the greatest facility on the body of the

Prehension.—After the projectile has been brought in contact with the prey, by the co-operation of so many contrivances, it must secure it; and for this purpose a viscid matter is secreted from the anterior excavation, which seems to be made the more important, as great care has been taken to increase the surface of the mucous membrane of the latter. But, in addition, the membrane and muscles, as described, present a separate apparatus of prehension, the mechanism of which needs no particular description.

Retraction.—Authors have more or less neglected to explain the retraction of this Tongue, thinking apparently that muscular fibres, arranged in a longitudinal direction, are in general sufficient for the purpose. Considering, however, the length of the projected Tongue, and the arrangement of the muscles of the cord, some difficulty arises in conceiving how it becomes so much shortened as to return into the mouth. The difficulty, nevertheless, vanishes, if we consider with what facility atmospheric pressure could be substituted for muscular action in such a worm-like organ. The lips of the animal are well adapted for such suction.

Explanation of Plate VI.

Fig. 1. A, The hollow cylindrical body: the dotted lines indicate the series of attachments of the muscular fibres of the ring-like segments; B, the semiconical body at its basis cut off from the lip of the projectile; *a*, the muscle described under that letter; *c*, portion of the muscle described under the letter *b*, going to the sphincter of the lips of the terminal cavity; *d*, *e*, *f*, muscles described under these letters.

Fig. 2. A, The hollow cylindrical body longitudinally slit through; C. the elastic body *in situ*, and connexions; E, the cord; F, the body of the hyoid bone; G, the pouch of the sling; H, horns of the hyoid bone; I, larynx; J, pharynx; K, palate; L, lower jaw; *b*, muscle described under that letter;

hyoid bone, and can as easily be disengaged again. The disengagement of both parts of the tongue is absolutely necessary for the projection of this organ. The opposite condition seems not only to be intended for the accommodation of the tongue, which would otherwise be retained in the mouth incompatibly perhaps with comfort, but also in order to render it instrumental to the act of deglutition.

g, muscle between the superior lip of the cylinder and the elastic body; *h*, geniohyoid muscle; *i*, hyo-glossus muscle; *k*, muscle between the lower jaw, and the pouch of the sling.

Fig. 3. A and B, as in fig. 1; *b*, *c*, *d*, *f*, muscles described under these letters.

Fig. 4. H, Body of the hyoid bone; 1 and 2, posterior and anterior horns.

Fig. 5. Transverse section of the hollow cylindrical body magnified.—A, Walls of the cylinder: disposition of muscular fibres exhibited; C, elastic body; 1 1, external coat of the hollow cylindrical body completed by the strong parchment-like mucous membrane; 2, internal coat; 3, space between hollow cylindrical and elastic body.

Fig. 6. The mucous membrane in the anterior excavation of the projectile everted to shew the two sets of folds.

Fig. 7. *h*, Genio-hyo-glossus muscles; *l*, cutaneous colli muscle; *m n*, sternohyoid muscles; *o*, omohyoid muscle; *p*, mylohyoid muscle.

Fig. 8. The oral cavity opened by removal of the lower jaw from one side: taken from an animal in which the projectile could not be projected, and is described as abnormal.—A B D, indicate the position of the parts marked by these letters in figs. 1, 2, 3; I, larynx; I′, laryngeal sac; J, pharynx.

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" On the Microscopic Structure of the Scales and Dermal Teeth of some Ganoid and Placoid Fish." By W. C. Williamson, Esq. Communicated by Edwin Lankaster, M.D., F.R.S.

"On the Development and Varieties of the Great Anterior Veins in Man and Mammalia." By John Marshall, Esq. Communicated by Professor Sharpey, F.R.S.

"On the Structure of the Dental Tissues of Marsupial Animals, and more especially of the Enamel." By John Tomes, Esq. Communicated by Dr. Grant, F.R.S.

"On the Motion of Gases." Part II. By Thomas Graham, F.R.S.

[Reported in Philosophical Magazine, Supplement to vol. xxxv.]

December 21.—The Bakerian Lecture "On the Diffusion of Liquids." By Thomas Graham, F.R.S.

[Reported in Athenæum, Jan. 12, 1850.]

II.—LINNEAN SOCIETY.

November 20, 1849.—"The Structure and Development of the Elaters and Spores of Marchantia Polymorphia." By Mr. Henfrey.

December 18, 1849.—A Continuation of Mr. Huxley's Paper "On the Anatomy of Diphydeæ."

January 15, 1850.—A Continuation of Mr. Huxley's Paper "On the Structure and Anatomical Relations of certain Families of the Medusæ."

III.—ROYAL SOCIETY OF EDINBURGH.

17th December.—Note on the Refraction and Dispersion of Light within the Eye. By Professor J. D. Forbes.

7th January.—On the Muscular Structure of the Tongue. By J. Zaglas.

21st January.—An Account of some Monstrosities. By the late Dr. J. Reid.

INTELLIGENCE AND MISCELLANEOUS ARTICLES.

To the Editor of the Annals of Anatomy and Physiology.

Glasgow College, 14*th January* 1850.

Dear Sir,—I think it may be of interest to some of the readers of your Annals to learn, that there are two Preparations in William Hunter's Anatomical Museum belonging to this College, in which the more recently discovered bodies of Pacini are very clearly shewn in the cat's mesentery. The learned founder of the museum, or some one of his associates in the construction of the museum, had noticed the peculiarity of these bodies, and had apparently put up the preparations for the purpose of shewing them, but without being aware of their relation to the terminal twigs of the mesenteric nerves, as appears from the following description of the preparations in the Catalogue:—"Portions of Intestine and Mesentery of the Kitten; shewing in the course of the Arteries and Veins small Lacteals, and *small oval bodies*, most probably absorbent glands."

In preparing the mesentery of the cat for the purpose of shewing these bodies, I have seldom seen them more clearly displayed than in the Hunterian Preparations. We must suppose that no microscopic examination of the specimens had been made, otherwise the nature of the small oval bodies could not have failed to be revealed to such accurate and experienced observers of the absorbent vessels and glands as William Hunter, Hewson, and Cruickshank.—I am yours, &c.

Allen Thomson.

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