LECTURES ON THE HISTOLOGY OF THE EYE :

(BEING THE ARRIS AND GALE ANATOMICAL LECTURES.)

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BY

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LECTURE II.

MR. PRESIDENT AND GENTLEMEN,—At the close of Monday's lecture, I had described the anatomy of the apparatus of *accommodation* in the human eye, and was proceeding to notice some of the modifications it presents in other vertebrata, when the hour struck. As some of these modifications are extremely interesting, I propose to take up the subject where I laid it down.

In all mammalia, monadelphous and didelphous, so far as my observations extend—and, through the liberality of the Zoological Society of London, to which I am more indebted than I can express, I have enjoyed unrivalled opportunities of examining the eyes of a very large number of animals—the lens and ciliary muscle do not differ in any essential point from those of man. In all other mammalia, the lens is more spherical than in man. In most, the central planes are three, as in the human foetus; in a few (cetaceans and some rodents), there is but one. The capsule, its epithelium, and the lens-fibres, are essentially like those of man. The ciliary processes are simple; the suspensory ligament and its connections, the arrangement of the ciliary muscle, and the kind of muscular tissue, are such as we find in the human eye.

Birds, however, present very striking differences. In a bird's eye we are immediately struck with the great extent of the ciliary region. It is the stoutest part of the outermost case of the eyeball; its strength is increased by a ring of bony plates, and then behind these by a cartilaginous lamina intercalated in the fibrous sclera. The ciliary processes are fringed and papillose, not simple; and a plaited membrane—the pecten—projects like a wedge into the vitreous humour from the entrance of the optic nerve. All the intraocular muscles are composed of striped fibre, the iris as well as those in the ciliary region. In the iris, the muscular fibres are disposed in two sets, one having a radial direction, the other being circularly disposed. The radial fibres pass between the great circumference of the iris and the pupil, coursing along the back of the iris just in front of the uveal epithelium. These are the dilators of the pupil. In front of them there is a stratum of circular fibres, forming a continuous sheet from the pupil to the attached border of the iris, stouter here and at the pupil, and thinner intermediately. They are easily demonstrated in the iris of any large bird by dissecting off the thick layer of pigmented connective tissue which forms the front of the iris, and which is in great part a derivative of the ligamentous tissue that fixes the border of the iris to the margin of the anterior chamber. It is in this connective tissue that the great blood-vessels and nerves lie. Those circular muscular bundles which bound the pupil are manifestly a constrictor or sphincter pupillæ; but the bundles at the outer border of the iris, in contracting, not improbably compress the corresponding part of the lens, and so tend to increase the convexity of the uncovered part of the front of the lens in the pupillary area, as H. Müller has suggested. This view of their action derives support from the beautiful prints of those bundles which we often find on the lens in dissections.

The primitive muscular fibres of the iris are much finer than those of the voluntary muscles of the limbs, from which they also differ in dividing and combining in nets.

The ciliary region contains two muscles. In the largest raptorial birds these are quite distinct; they are separated by a considerable interval; but in the eyes of smaller birds the muscles are approximated, and in these their distinctness is less obvious, yet I think none the less real. (Fig. 1.)

The foremost muscle (*cr*) was described by Sir P. Crampton, and it bears his name. Behind it is always attached to the sclera, and in front to the cornea, either directly or to a tendinous prolongation of the inner corneal lamellæ. Shortening of this muscle would, therefore, tend to bring these closer together; and as the sclerotic, with its strong horny ring, is the least mobile of the two, the muscle would tend to retract or de-

press the cornea, and to counteract any force operating simultaneously in an opposite direction to increase its convexity. The posterior muscle (*tc*) always passes between the sclera and choroid. Separated by a wide interval from Crampton's muscle in eagles, as I have already said, in many smaller birds it appears, on a cursory examination, to be a continuation of the posterior fibres of this; yet a careful scrutiny always shows that it has distinct attachments. In many birds there is an accessory muscular slip attached anteriorly to a prolongation of the same

Fig. 1.—Longitudinal Section of Ciliary Region of Eagle's Eye. *c*. Cornea. *p*. Pillars of iris. *i*. Iris. *cl*. Ciliary processes. *v*. Section of blood-vessels. *n*. Sections of ciliary nerves. *cr*. Crampton's muscle. *ch*. Choroid. *b*. Bony plate. *tc*. Tensor muscle of choroid. *ct*. Cartilage.

tendinous band from the cornea, into which the inner ends of the fibres of Crampton's muscle are inserted; and in some birds this muscular slip exceeds that which stretches from the sclerotic to the choroid. The contraction of either or both these muscular slips would tend to draw the choroid forwards upon the sclerotic and tighten it on its contents. They are tensors of the choroid, and the homologue of the human ciliary muscle.

The pecten, which before the ciliary muscles were known was regarded as the agent of accommodation, is not any longer considered so. I shall have occasion to refer to it in my next lecture.

Reptiles have an iris very like that of birds. The primitive muscular fibres of the striped kind are extremely fine; they also exhibit divisions and a flexiform arrangement. They are disposed in two sets—one circular, the other radiating—differing from those of birds mainly in their less development. (Fig. 2.)

Crampton's muscle I have not found in any reptilian eye; but all which I have examined, embracing several chelonians and many lizards and snakes, have a striped tensor of the choroid passing from the sclerotic to this coat, and occupying the same posterior position as its homologue in the bird, and functionally corresponding to the human ciliary muscle.

I have hitherto been baffled in all my attempts to decipher the details of the muscular part of the accommodative apparatus in batrachia. The quantity and blackness of the pigment in the frog's eye have offered,

hitherto, insuperable difficulties. An *unstriped* sphincter pupillæ is generally demonstrable. It is composed of long spindle cells, enclosing an elongated cylindrical nucleus with some granular pigment. How far it extends outwards, and whether the circular fibres reach the periphery of the iris, as in reptiles, I am unable to say. Radial bundles of spindle cells, resembling those of the sphincter, are also certainly present.

Fig. 2.—Iris of a large South American Snake. *pp*. Pupillary border. *cl*. Ciliary border. *r*. Radial muscular fibres. *c*. Circular muscular fibres. *pg*. Pigmented stroma-cells.

The *Conjunctiva* is a thin membraniform web of areolar tissue, with an external epithelium. The structure of the palpebral part differs slightly from that of the ocular. The former is a tougher, the latter a looser tissue. The palpebral part is beset with simple vascular papillæ. The epithelium consists of several layers of cells, the deepest of which are oblong and stand vertically, while the more superficial are flattened and obliquely packed. The meshes of the areolar tissue often enclose large numbers of lymph-like corpuscles. The blood-vessels and nerves are numerous. The nerves are remarkable for the specialised terminations which some of the tubules exhibit—the terminal clubs—Endkolben—named after their discoverer, Krause.

The loose fold of conjunctiva which connects the lid and globe, and also the palpebral part, but more particularly the former, contains small glandiform bodies—minute spherical capsules—enclosed in a net of minute capillary blood-vessels, and, according to some observers, also surrounded by lymphatics. These, when enlarged, form the transparent bead-like grains which characterise a kind of granular ophthalmia, fortunately for us much less frequent in Great Britain than the papillary form of this complaint.

The *Sclerotic*, in conjunction with the cornea, forms the strong intercase of the eyeball which supports and protects the delicate inner coats. It is thickest behind, around the optic nerve; becomes thinner from here to the attachment of the tendons of the muscoli recti, in front of which its thickness again slightly increases. A funnel-shaped canal pierces it behind for the passage of the optic nerve; and it is perforated by many smaller apertures for the transmission of blood-vessels and of the ciliary nerves. Of these inner openings, the only ones which re-

quire notice are those by which the venæ vorticossæ choroideæ leave the eyeball. These pierce the sclerotic obliquely, which renders them valvular—a mechanism which lessens the available opening whenever the pressure on the inner surface of the sclerotic rises unduly, and proportionately retards the egress of the venous blood and raises the pressure still higher.

The sclerotic is principally composed of white fibrous or common connective tissue, in the form of flat fibrillated bundles, closely interwoven in places, which cross one another at every possible angle, but which have a general direction parallel to the surface of the coat. Amongst the fibrillated tissue are imbedded simple fusiform and branched corpuscles, which are more numerous in the young than in fully grown persons.

The blood-vessels of the sclerotic are not very numerous: the most important are, as before pointed out, the recurrent branches of the posterior ciliary arteries, which unite in a small circle which communicates with the vessels of the nerve. Whether the sclerotic has any nerves of its own is doubtful. The ciliary nerves all pass through, and do not appear to furnish any branches within their canals.

In birds, lizards, and turtles, the fibrous sclerotic is strengthened by the addition of bone and cartilage. The bone is chiefly present in the ciliary region, where it forms the well known circle of plates. The osseous tissue contains well developed lacunæ; and, where the plates are thick, they are hollowed by vascular canals, and by medullary spaces enclosing fat-cells. It appears to be evolved out of fibrous tissue. The cartilage is always of the hyaline variety. In the back of the sclerotic in many eyes, the cartilaginous tissue exceeds the common connective tissue.

Optic Nerve.—The optic nerve pierces the sclerotic a little below and at the inner side of the posterior pole of the eyeball; the nerve appearing, at its inner surface, nearly 1" to the nasal side of the fovea centralis retinæ, in the form of a disc, usually circular, sometimes elliptical, and when so, the major axis is generally vertical. The common aperture in the sclerotic and choroid, through which the nerve passes, is a canal narrower anteriorly, where it tightly clasps the nerve, and wider posteriorly, where it loosely encloses it. Around this opening, the choroid and sclerotic adhere very intimately, their fibrous tissues intermingling here concentrically round the nerve. Here, too, the minute recurrent branches of the posterior ciliary arteries distributed to the outer part of the sclerotic, effect a slight communication with the capillaries in the nerve-sheath, and indirectly with those in the nerve itself. Some of these last inosculate with the choroidal blood-vessels in the level of the choroidal opening. Through these collateral channels, when the trunk of the arteria centralis is plugged, a small quantity of blood can enter the retina. The choroidal stroma around the nerve-foramen contains the same stellar pigment-cells which occur in it elsewhere. In some eyes, in this situation these are more plentiful, and richer in pigment; in such eyes, the connective tissue corpuscles of the neighbouring sclerotic are also not infrequently pigmented. This excess of pigment expresses itself in the living eye by an incomplete narrow brown or blackish circle around the nerve-disc. In the place of the choroid and of the inner third of the sclerotic, the nerve-opening is crossed by a fibrous web—the *lamina cribrosa*—which peripherally merges in the connective tissues of these two coats. The anterior surface of this perforated lamina is concave; the posterior, convex. In the living eye, the lamina reveals itself as a white tendinous spot, striped with minute grey dots, the bundles of nerve-fibres lying in its meshes. These details of the lamina are recognisable, in the healthy nerve-disc, in a small central area which corresponds to a depression which I shall presently describe, known as the physiological pit. A sharply defined image of these details of the lamina overstepping this limit, and reaching towards or even to the edge of the nerve-disc, is a sign of atrophy.

The nerve-fibres in the trunk of the nerve behind the lamina cribrosa are of the opaque or double-bordered kind, while in and in front of the lamina they are pale and transparent. Behind the lamina, each nerve-fibre consists of an axis-cylinder, a delicate external tubular sheath (the homologue of the sarcolemma of a primitive muscular fibre) and an intermediate cortical substance or medulla—the white substance of Schwann. At the lamina, the medulla ceases; the axis-cylinder, with perhaps a very attenuated prolongation of the sheath, passing forwards into the nerve-disc and retina. The greatly reduced bulk of the nerve-trunk in the lamina, and the transparency of the nerve-bundles in the nerve-disc and retina, are due to this change in the constitution of the primitive fibres.

Exceptionally, as a congenital error, some bundles of opaque nerve-fibres reach the inner surface of the nerve-disc, and are even prolonged for some distance into the retina. It is not a very uncommon defect. The opaque nerve-fibres produce a white patch, which is to be distin-

guished from other similar white patches due to exudations on its brush-like feathered edge. After emerging from the anterior surface of the lamina cribrosa, the bundles of transparent nerve-fibres bend away on all sides (quaqueversally) from a central point, and, curving over the edge of the choroidal foramen, spread out on the inner surface of the retina. In doing this, they leave a central void, a little hollow—the physiological pit. This pit is usually in the centre of the nerve-disc, but not always so; and, when eccentric, the vasa centralia usually also perforate the disc eccentrically. A normal physiological pit never, however, is so eccentric as to touch the contour of the disc.

The physiological pit is, then, a small, gentle, funnel-like hollow in the centre of the nerve-disc, perforated by the vasa centralia, appearing as a bright hollow spot, in which, with an enlargement of twelve or fifteen linear, the meshes of the lamina cribrosa and the ends of the bundles of opaque nerve-fibres are plainly discernible.

Blood-Vessels.—At a variable distance from the eyeball, the trunk of the optic nerve is pierced by a branch of the ophthalmic artery, which soon gains the axis of the nerve, and, running forwards through the lamina cribrosa, perforates the optic nerve-disc, in which it divides into two primary branches, which bifurcate, and, passing across the boundary of the disc, are distributed to the retina. In the disc we can distinguish first a short vertical piece of the arterial trunk, and next the branches making a large angle with the trunk, and following the surface of the disc. The capillaries of the nerve-trunk, and those distributed to its disc-like intraocular end, are very numerous; they are sufficiently so to redden the disc when they are distended with blood—a thing which no amount of hyperæmia of the retinal capillaries ever does in this membrane.

The very slight diminution which the arteria centralia undergoes, from its origin to its final division in the disc, shows that it mainly ministers to the nutrition of the retina. It gives, however, in its course, *small* twigs for the nutrition of the nerve outside the eyeball; and these, reinforced by others derived from minute nameless arteries distributed to the sheath, ramify in the septa between the nerve-bundles.

The veinlets accompanying the primary branches of the arteria centralia in the retina do not, as a rule, coalesce in a single trunk in front of the lamina cribrosa; but they pierce this separately, and first unite in or behind it.

Sheath.—In the arrangement of its sheath, the optic nerve differs from all the other large nerve-trunks. They have but one tightly fitting tube of connective tissue—the external neurilemma; but the optic nerve has a double sheath. It has a thin tightly fitting sheath, representing the sheath of other nerves, from the inner surface of which septa are produced inwards between the nerve-bundles, constituting the internal neurilemma or frame, which holds the bundles together, and carries the nutrient blood-vessels.

In front of the lamina cribrosa, in the nerve-disc, the neurilemma is of the more delicate kind, to which Virchow has given the name *neuroglia*. Its fibres have two principal directions—one transverse to that of the nerve-bundles, and therefore parallel to those of the lamina cribrosa; the other vertical to the front of the lamina and free surface of the nerve-disc. These last fibres correspond to the radial connective tissue fibres in the retina. This sheath itself and its septal prolongations consist of common connective tissue—fibrillated bundles, with corpuscles interspersed. In front, this division of the sheath blends with the lamina cribrosa, and with the inner third of the sclerotic.

The outer sheath is continuous posteriorly with the dura mater, so that coloured fluids injected into the space between the two sheaths soon find their way backwards into the cranial cavity. In front, the outer sheath is continued into the outer two-thirds of the sclerotic. The outer and inner tubes are loosely connected by a very open areolar tissue, composed of curling fibres and coarser bundles with large fusiform nucleated corpuscles imbedded in them. These give the interstitial or areolar spaces the appearance of having an epithelial lining. They play an important rôle in neuritis, and in the evolutions of morbid growths.

The space between the sheaths has been lately described as a lymphatic cavity. In severe injuries of the head, blood is sometimes extravasated into it.

In describing the sclero-choroidal foramen, I mentioned the occasional excess of pigment here giving rise to a dark circle around the nerve-disc, visible in the living eye. The presence of pigment in the disc itself is still more exceptional. I do not allude to pathological formations, but to congenital conditions. In some mammalia, however, the neuroglia of the optic disc is always granule-pigment, dotted along the connective tissue fibres and in corpuscles. In these eyes, the pigment-corpuscles are often most numerous along the vessels and in the loose tissue in the sheath close to the globe; but the greatest deve-

lopment of pigment here is in birds, from whose optic nerve entrance a large plaited membrane stands forwards into the vitreous body towards the back of the lens, with a forward and downward inclination. The upper edge lies below the level of the fovea centralis. Its general figure is four-sided; but it varies somewhat, as do also its size and the number of plaits.

It is a vascular sheet, consisting of larger vessels and a very close capillary net overlaid with a pigmented epithelium resembling that of the choroid. Its base blends with the lamina cribrosa, and is perforated by the escaping bundles of nerve-fibres. I am unable to offer you any account of its functions. Before the ciliary muscle was known, it was formerly thought to be the factor of accommodation; against this, however, is the absence of muscularity. H. Müller suggested that it may subserve the nutrition of the vitreous humour, in the absence of a retinal vascular system. But there are very large eyes with correspondingly bulky vitreous humour and no retinal vascular system, without pectens; and this throws doubt on Müller's suggestion. Although reaching its maximum development in birds, the pecten is not restricted to them. It is present in lizards. In the gecko, iguana, and chameleon, it is a little sword-like process, having an intimate structure identical with that of the bird's pecten, but externally unlike this in its surface being smooth, and not plaited. Some snakes also have pectens; I have found it in the boa constrictor and viper, but absent from the common snake.

A METHOD OF ANTISEPTIC TREATMENT

APPLICABLE TO

WOUNDED SOLDIERS IN THE PRESENT WAR.

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HAVING been requested to furnish some rules for the antiseptic treatment of wounded soldiers in the present war, I venture to suggest the following plan, in the hope that it will combine efficiency with the simplicity and facility of execution essential under such circumstances.

Wash the wound thoroughly, and also the surrounding skin, with a saturated solution of crystallised carbolic (phenic) acid in water, one part of the acid to twenty of water, introducing the fluid by means of a syringe, and manipulating the parts freely so as to cause the lotion to penetrate into all the interstices of the wound; and at the same time squeeze out such clots of blood as it may contain. The fluid should be introduced repeatedly to insure its thorough penetration. Tie any bleeding vessels with properly prepared antiseptic catgut, cutting off the ends of the thread near the knot. If the surgeon do not possess this article, the arteries should, if possible, be secured by torsion; but for the sake of cases in which a ligature would be absolutely indispensable, some silk or linen thread should be kept steeping in a strong oily solution of carbolic acid, or, if very fine silk be used, it may be rendered antiseptic by steeping for a few minutes in the watery solution. When silk or linen is employed, the ends of the ligatures should be left projecting at the wound. While the antiseptic lotion is in the wound, extract if possible any foreign material that may have been introduced, such as a bullet or a portion of the patient's clothes; and if any spicula of bone exist entirely detached from the soft parts, remove such as can be readily reached, disregarding those which are of very small size or inconvenient of access.* Then place upon the wound two or three layers of oiled silk smeared on both sides with a solution of carbolic acid in five parts of any of the fixed oils—olive, almond, linseed, etc.—the oiled silk being made large enough to cover the raw surface completely and slightly overlap the surrounding skin. Next apply, without loss of time, lint, charpie, or cloth (linen or cotton), well steeped in the oily solution of the acid, the cloth or lint being folded sufficiently to produce a layer at least a quarter of an inch in thickness, and extending a considerable distance, say three inches, beyond the oiled silk in all directions, the outer layer being made somewhat larger than the rest, so that the margin of the mass of cloth may be thin. Cover the oily cloth with a piece of thin gutta-percha tissue sufficiently large to overlap it on all sides by an inch or more, and retain it securely in position

* Gun-shot wounds should not be stitched; but, where sutures are required, silk, steeped in oily solution of carbolic acid, will answer sufficiently well. After the introduction of the last stitch, distend the wound once more with the watery solution, by means of the syringe, and then continue the dressing, as in the text.