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The Eyelids and Lachrymal Apparatus of Birds

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Chicago, Ill.

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THE EYELIDS AND LACHRYMAL APPARATUS OF BIRDS.

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Illustrated.

The arrangement by which the anterior surface of the eyeball of Birds is cleansed and otherwise protected from various forms of injury differs materially from that which one finds in other vertebrates. Even to those who are not specially interested in comparative anatomy and physiology it offers many points of contact with human ophthalmology, and this is the writer's chief excuse for this article. Most of the investigations that form the basis of this paper were made in the physiological laboratories of Stanford University, in conjunction especially with Professor Slonaker. The results of these researches were first reported to the Ophthalmological Congress at Oxford in July, 1914, and published in the *American Encyclopedia of Ophthalmology,* to whose publisher the writer is indebted for the illustrations.

That one may appreciate the part played by the eyelids and the lachrymal apparatus in the vision of birds it is essential not only that the secretion and removal of the tears should be studied but that the disposition of the bulbar and palpebral muscles should be borne in mind.

The *epidermis* covering the avian *eyelids* is more horny than in man. It is attached to the corium by delicate fibres.

The *tarsal plate* of the *lower lid* is composed of closely packed connective-tissue fibres, in which one occasionally finds spindle-shaped or round cells; but none of these can properly be described as cartilage cells. A delicate network of vessels surrounds the tarsal plate.

In some birds a fatty layer, more or less marked, is found in a well-defined space between the lid edge and the upper margin of the tarsus.

The occompanying illustration shows the *lid margins* of the Sparrow to be composed of about 34 (17 in each lid) deeply pig-

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mented, irregular, sausage-like, segments. They are often deeply indented about their middle, thus presenting a picture entirely unlike the lid edges of man.

These segments undergo, during life, apparent changes in size and shape, probably as the result of winking, partial or complete. Close inspection of them shows that some of these segments are

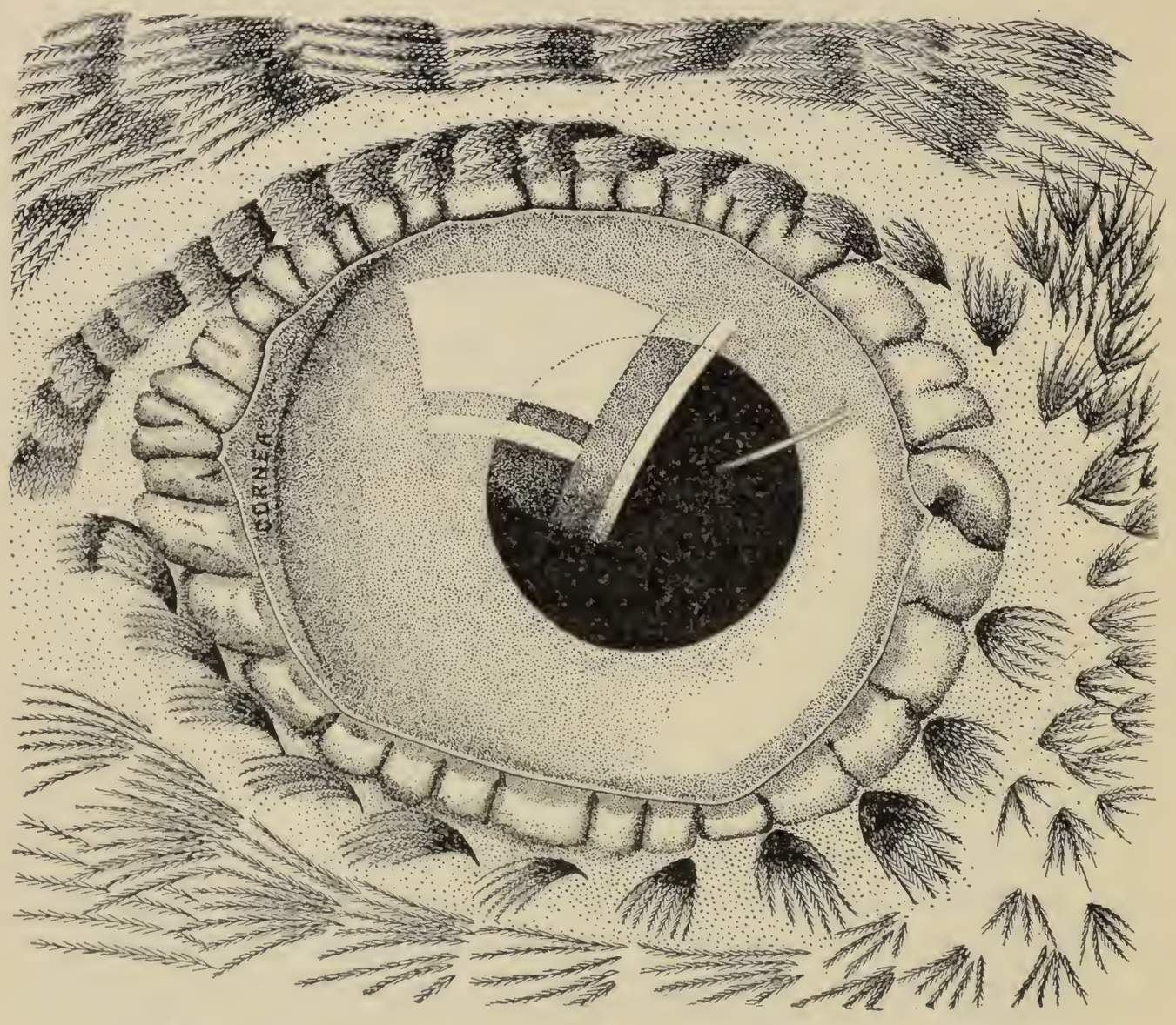

Fig. 1—Drawing from Life (much enlarged) Showing the Convoluted Margins of the Lids and the Arrangement of the Feathers Close to the Palpebral Margin. (Wood and Slonaker).

crossed by indentations which may become entirely smooth again; other parts, smooth and rounded a moment before, may present a creased or divided appearance, so that photographs or drawings of the eye of the Sparrow give varying results so far as the margins of the lids are concerned. In Passer, as in most birds, there is no well defined intermarginal space. A feather (eyelash) is generally placed below each palpebral segment, but the former may be miss-

ing at the outer and inner canthi, while other tufts are scattered over the lid surface.

The *interpalpebral space* varies somewhat in the Sparrow; perhaps it is a little more circular and smaller when the bird accommodates for near vision. The accompanying illustration gives an idea of the average relative size of the pupil and of the interspace during fixation for a near object.

It will also be noticed that this space is entirely filled by the Sparrow's cornea, a condition entirely unlike that in mammals.

The space is 2.9 mm. wide and 4.5 mm. long. There is no *lachrymal caruncle* or anything to indicate it, nor would one expect it if the higher vertebrate caruncle be a vestigiary remains of the nictitating membrane.

In the great majority of birds we, for obvious reasons, do not speak of an internal and external canthus but of *anterior* and *posterior* canthi.

In Sparrow-like birds the *pigment* of the rounded, dark brown *lid border* does not extend beyond the point where it touches the eyeball, nor does it more than reach the palpebral derma. There is more pigment in the upper lid than in the lower. When closed, the junction of the two lids is well above the pupil, so that the cornea is fully protected. Probably there is no upward rotation of the eyeball in sleep. The lower lid follows the usual law in birds, of being the movable one.

As a general proposition it may be stated that in respect of size, motility, etc., the lids in the Bird and Man are reversed, viz., the lower lid is the more important in Birds; the upper lid in human beings. The naked condition of both avian eyelids is not seen when the eye is open because they are then obscured by the surrounding feathers. The external surface of each lid is quite thin, smooth, whitish-blue and devoid of feathers, except for a few solitary shafts.

Very likely there is no interference with the luminous sense and light-direction sense when the Bird's eye is closed.

There is *no differentiated tarsus in the upper lid,* which is much shorter and thicker than the lower one, although the convoluted cylindrical margin of the upper lid is better shown in the upper than in the lower lid.

Unlike Man and many other mammals, there is no true union of the conjunctivae of the two lids before the bird is born. In the Sparrow (probably in all the Passeriformes) the lids are wide open

during embryonic life, but as soon as the birdlet is hatched the eyes are closed and remain closed for several days. There is no evidence that any organic union occurs between the lid margins in these "born-blind" birds. In all probability the closed eyes are due to tonic contraction of the orbicularis as a light reflex act.

The *muscles of the eyelids* are the *orbicularis palpebrarum,* the *levator palpebrae superioris,* and the *depressor palpebrae inferioris.* According to Leuckart (*Graefe-Saemisch Handbuch d. ges. Augenheilkunde,* Vol. II, 1876, p. 145) and Doenecke, they are all striated muscles. However, Zietzschmann (*Ellenberger's Handbuch der vergl. mik. Anatomie,* I, p. 535) believes the orbicularis to be a smooth muscle. The depressor of the lower lid is much stronger (as one might expect from the fact that the latter is more mobile than the upper) and better developed than the levator of the upper lid. It is certainly attached to the lower margin of the tarsus, but it (probably) also spreads over the anterior surface of the lid plate and is attached there. According to Zietzschmann both muscles are joined at their origin in the depths of the orbit, where they form part of a common muscle mass; although Slonaker has not been able to verify this finding. Slonaker, however, agrees with Zietzschmann that the orbicularis is a smooth muscle, while both the depressor and levator palpebral are striated.

In experimenting with the Sparrow the writer found that the third lid is the only one that closes when an object is "poked" at the bird's eye. The paired lids close very slowly, if at all, under the stimulants used. The physiological experiments bear out what was found anatomically, viz., that the orbicularis is controlled by the sympathetic.

The *orbicularis* is an extremely thin muscle in the Sparrow, as may be seen by examining the accompanying figure. It appears as mere lines on horizontal section, and as small dots in vertical sections. It is attached to the skin and does not, as in Man, spread out and mingle its fibres with neighboring forehead, tarsus (of the lower lid) and lachrymal apparatus muscles.

There is not, so far as the writer could discover, any analogue in the Bird's lid of the human muscle of Riolan.

Although there is every reason to believe that the non-striated orbicularis of *Passer domesticus* is supplied by fibres deriver from the sympathetic, yet the extremely difficult histological problem of establishing this fact, by demonstrating the course of the fibres and determining their origin, has not yet been solved.

In the Hen the *ciliary feathers,* or eyelashes, more nearly re-

semble thick, coarse hairs, and this resemblance to vertebrate cilia is all the more pronounced in that these filiform feathers are inserted at the outer border of the lid margin (sometimes within the intermarginal space) in several irregular rows, which at a few points interlace with the lashes (feathers) of the opposing lid. Moreover, when the lids are closed the inner lid-margins roll in more than is the case with the Sparrow, so that the intermarginal spaces come closer together, although their entire surfaces do not touch, as in Man.

These feather-eyelashes belong to the class of filoplumes, or thread feathers with no true vanes, thirty to thirty-five in number,

Fig. 2—External Eye of the African Ostrich—Struthio camelus. (Wood and Slonaker.)

more being found in the upper lid than in the lower. Of many observations the writer found the average proportion to be 17 to 14. In most instances the plumule of the tuft rises just above the soft margin of the eyelid and is bent or directed away from the anterior canthus toward the back of the head, parallel to a line joining the two canthi. The plumules do not meet or form a screen over the palpebral margins or the interpalpebral space, as in the Ostrich or in Man. In some individuals the tufts are entirely wanting or are inserted irregularly some distance from the margin of the lid.

At the inner canthus and especially on the lower lid the ciliary tufts are (to the number of 5 or 6) directed straight forward.

Scattered over the two otherwise naked lids a varying number—usually half a dozen—of plumules can generally be seen of the same size as those at the lid margins. Sometimes, though rarely, they form a regular second row of cilia along the margin of the lid.

The eyelashes of Sparrow-like birds do not, judging from their position relative to the lid margins, act as a protection to the eye. An examination of them shows they are not prominent enough for this purpose; they are too far removed from the interpalpebral space; they do not overhang the lid margin, and they do not interlock when the eye is closed, as in many of the other vertebrates. They appear in bird life to occupy a place intermediate between the Ostrich, Seriema, and other birds that possess well-developed and useful eye protectors, and the Parrots that have none at all.

Nevertheless the cilia of the Sparrow are more developed than in some other Birds, though less so than in the Ostrich, Seriema and the Birds of Prey.

The eyelashes of most Birds do not take much if any part in the protection of the eyeball during sleep or on other occasions. The Sparrow does not entirely close his paired lids unless the cornea is touched with some blunt object, as a dissecting needle, although any approach of the object increases markedly the contractions of the nictitating muscles.

Except during sleep, or in particular emergencies, the paired lids of Birds are rarely closed. Most of the ordinary functions of the human lid are performed by the nictitating membrane. The true lids of the Sparrow may indeed be regarded as *accessory organs*, whose functions are confined to the protection and moistening of the bird's eye only while he sleeps. The writer and Slonaker have not been able to observe the Sparrow with his third lid drawn over the globe (without closure of the paired lid margins) during somnolent hours, as is said to be the case in some Birds of Prey, the Hen, etc. The soft sausage-like rolls of each lid-edge approach one another and close the interpalpebral space in a fashion entirely unlike the eyes of the higher vertebrates. However, even when the edge of the third lid is incompletely drawn over the globe the edges of both lids make slight but quite apparent efforts to close, as if there were slight contractions of the marginal fibres of the orbicularis. These winking efforts are more marked when the membrane sweeps entirely over the interpalpebral space; but in this consensual

contraction of the true lids their margins do not approach one another, and, indeed, rarely reach the sclero-corneal junction.

The interpalpebral line of closure in small Birds is irregular, interrupted and wavy; nor are the two intermarginal spaces accurately opposed to each other, as in Man. The Sparrow probably does not oppose more than one-half his lid-margin in the act of eye-closure, but shuts off his conjunctival sac from the outside world

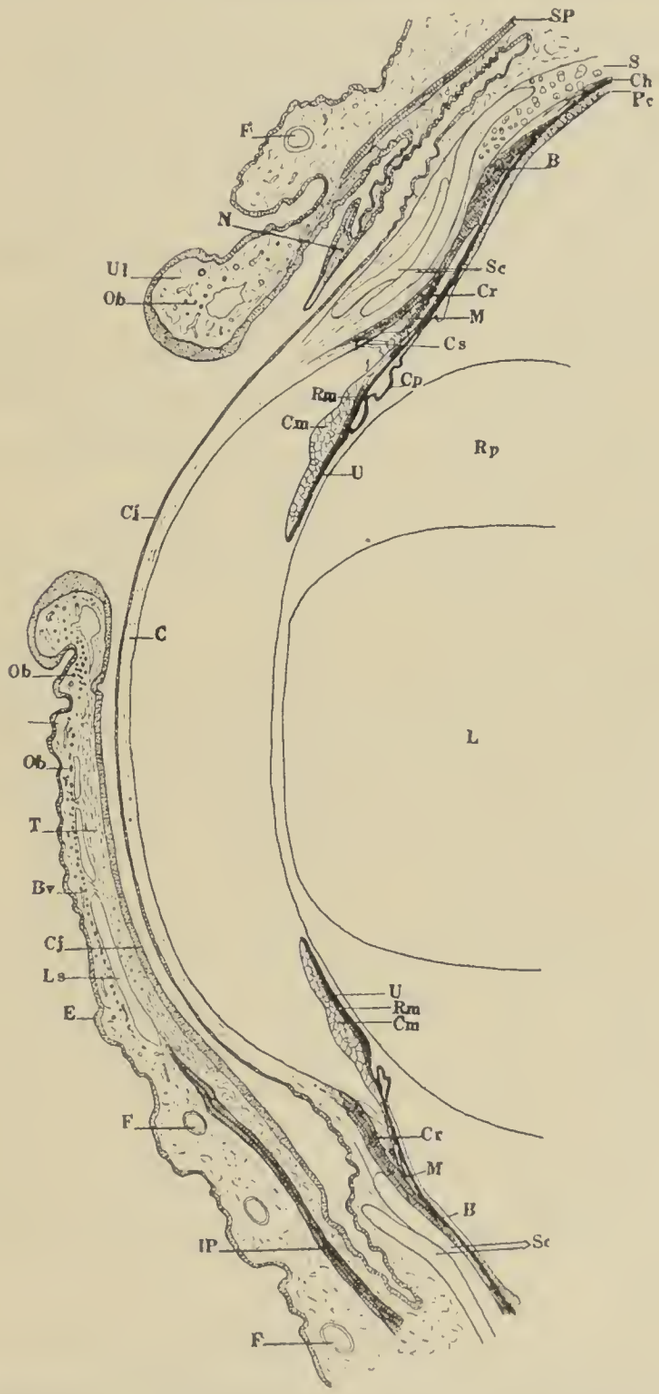

Fig. 3—Vertical Section Through the Anterior Part of the Eye of the Adult English Sparrow. ((Wood and Slonaker.)

B. Brücke's muscle; Bv, blood-vessels; C, cornea; Ch, chorioid; Cj, conjunctiva; Cm, circular muscles of the iris; Cp, ciliary processes; Cr, Crampton's muscle; Cs, canal of Schlemm; E, epithelium; F, feather follicle; IP, inferior palpebral muscle; L, lenticular portion of the lens; Ll, lower lid; Ls, lymph spaces; M. Müller's muscle; N, nictitating membrane; Ob, orbicularis muscle fibres of the lid; Pc, pars ciliaris retinae; Rm, radial muscles of the iris; Rp, ring-like pad of the lens; S, sclerotic; Scl, scleral plates; Sp, superior palpebral muscle; T, tarsus; U, uvea; Ul, upper lid.

by pressing the soft, convoluted marginate rolls into one another. The difference between lid closure in the Sparrow and most of the higher vertebrates is, roughly speaking, that between a roller-desk cover and that of the mouth of a tobacco pouch.

The movements of one nictitating membrane (or third eyelid) is in most birds probably independent of the other, although they generally act together. In an adult, male Sparrow, whose cornea had been irritated by manipulation, the average nictitations of five-minute observations was 55, while in the fellow eye the winking was reduced to 47. In a darkened room the number of nictitations fell to 41. The extremes of numerous observations under various conditions of rest, darkness, bright illumination, after the Bird had flown about the room, after irritating the cornea, etc., were (during rest) 33, and (during exposure to direct sunlight) 61. Under the last named condition, while the nictitating membrane was drawn over the globe rapidly and completely, it was returned to place very slowly, so that the eye was covered by the membrane during a relatively longer period than usual.

In most Birds, the lids of the Sparrow's eye close immediately after or just before death. This, as is well known, is entirely different in Man and many other Mammalia; and the explanation is that the lid-closer is really a smooth, sphincter muscle innervated by the sympathetic, which continues to act after the departure of consciousness and after the eye-openers (innervated by striped muscles) have ceased to be under control of the will.

The *sensory nerve supply to the lid* is also entirely different from that of Man. Slonaker found that it is from the lachrymal branch of the fifth nerve only, which, after giving off branches to the lachrymal gland, divides into two portions, one going forward into the lower lid and uniting with the superior maxillary nerve. As yet unverified is his belief (from dissections of the parts involved) that minute branches from what he calls the *frontal* nerve may send sensory branches to the conjunctiva and to the skin about the external canthus.

One of the most interesting organs of the avian eye is the *third eyelid* or nictitating membrane. Funagalli has furnished an elaborate description (*Internat. Monatschr, f. Anat.*, 1899, p. 129) of the minute anatomy of this membrane, as found in the Hen and Pigeon. Slonaker and the writer have not, so far, entirely investigated the nerve and blood supply of the Sparrow, but agree with Funagalli and other investigators that the nictitating membrane

is composed of (1) an anterior epithelial layer, (2) a middle connective tissue layer and (3) a posterior epithelial layer.

The anterior epithelial layer has the appearance of typical pavement epithelium. The deep layers are more cylindrical in form, while the superficial are more flattened and show oval nuclei. Pigment cells begin in the deep cells but get less and less in amount as the surface is reached.

The *middle layer* constitutes the true substance of the nictitating membrane and is largely made up of elastic fibres interwoven with connective tissue fibres. The former are most numerous immediately under the epithelial layer. The middle layer is provided with numerous blood-vessels, nerves, and a number of tubular, solitary glands. Slonaker and the writer have not been able to find the latter in Passer, but we do recognize there glands which are sometimes straight, and sometimes globular, like sweat glands. Their openings are on the anterior surface of the membrane.

The *posterior epithelial layer* is composed of cylindrical epithelium two and three layers deep. The deepest cells are polyhedral in shape, while the more superficial have long prismatic elements. This layer of the conjunctiva is finally continued as modified anterior corneal epithelium.

According to Fumagalli, the elastic fibres of the third lid run in all possible directions through the connective tissue bundles to form a thick network, which may be resolved into three layers. Furthermore, a bundle of these fibres is shown extending from the base to the apex of the lid. It lies in the deep portions of the connective tissue, directly on the posterior epithelial layer. From this deep, basement or foundation layer of larger fibres there stretch at right angles to it more delicate fibres through the whole width and thickness of the membrane, and terminate in the cells of the anterior epithelial layer.

This strong, deep-lying bundle becomes thicker the nearer one approaches the free border, until it forms two or three fibrous bundles measuring 123 microns wide that eventually becomes part of the tendon of the pyramidalis muscle.

Fumagalli finds that posteriorly the elastic connective nerve-fibre bundles are so disposed as to form a subepithelial network from which still finer fibrils extend, some of which terminate in end-corpuscles.

Slonaker and the writer, after considerable time spent in an investigation of the subject, conclude that the nictitating membrane is a conjunctival duplication—a thin, translucent membrane com-

The free margin of a portion posterior to it is set with pigment posed of delicate connective tissue interspersed with elastic fibres running in various directions.. It has a firm, thickened, free margin. but no hyaline cartilage cells. This latter provision enables the free border to be closely applied to the cornea, so that when it sweeps over the latter it carries with it some of the fluid secretion of the Harderian gland and thoroughly cleans and moistens the corneal surface. The presence of elastic fibres gives to the third lid the qualities of a thin rubber band; when put upon the stretch it flies back instantly the moment the traction or "pull" is released.

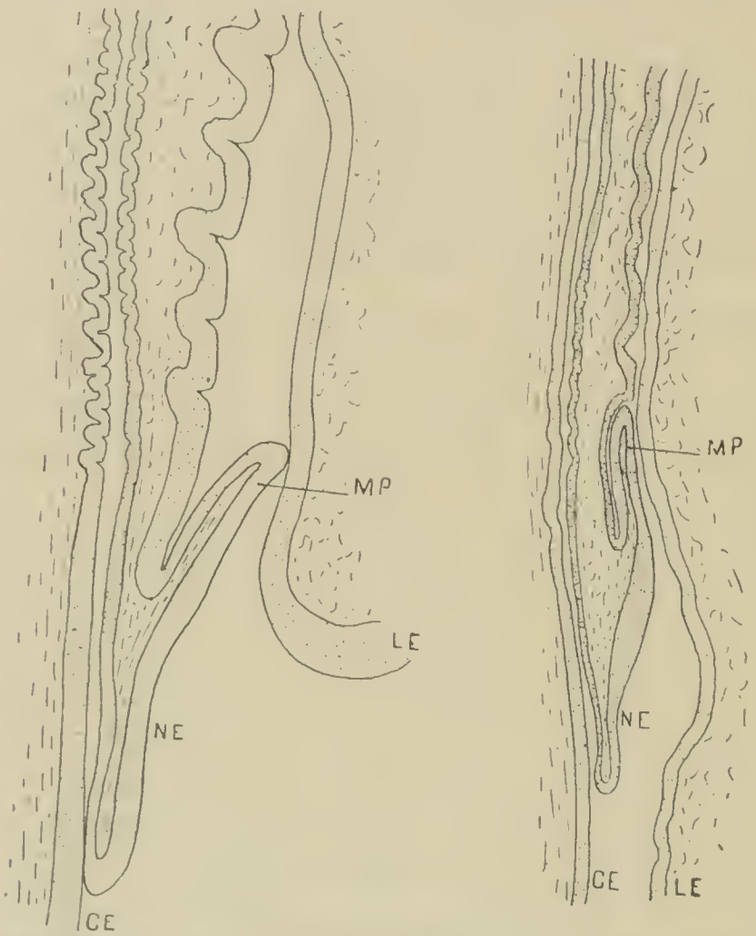

Fig. 4—Enlarged Camera Drawings Showing the Marginal Plait of the Nictitating Membrane, Both Extended and Compressed. (Wood and Slonaker.)

MP, Marginal plait; NE, epithelium of the nictitating membrane; CE, conjunctival epithelium; LE, lid epithelial lining.

cells. but this marginal pigmentation is much less marked in the Sparrow than in other birds—the Snow Goose and Ostrich, for instance. A section of the third lid at right angles to the free border (see the illustration) shows the latter to be triangular in shape, like half an arrow-head. and to be thrown into folds both on its anterior and posterior surfaces. Interesting, also, are the basal folds of conjunctiva, somewhat like the folds of transmission of the human conjunctiva, disposed so as to allow of considerable and rapid excursions of the membrane back and forth over the eyeball.

In the study made by Slonaker and the writer on the eye of the Sparrow and other Birds they found Slonaker's *marginal plait* (see cut) not only in numerous sections of the Sparrow's third lid, but in all the other Birds so far examined; it is certainly well marked in such unrelated species as the Sooty Tern, the Red-Headed Woodpecker, and in various Pigeons. Strange to say, Fumagalli (Ueber die feinere Anatomie des dritten Augenlides, *International. Monatsschr. für Anatomie und Physiologie,* Vol. 16, p. 129, 1899) makes no mention of this important structure, and, although the whole subject is by him elaborately illustrated by well executed

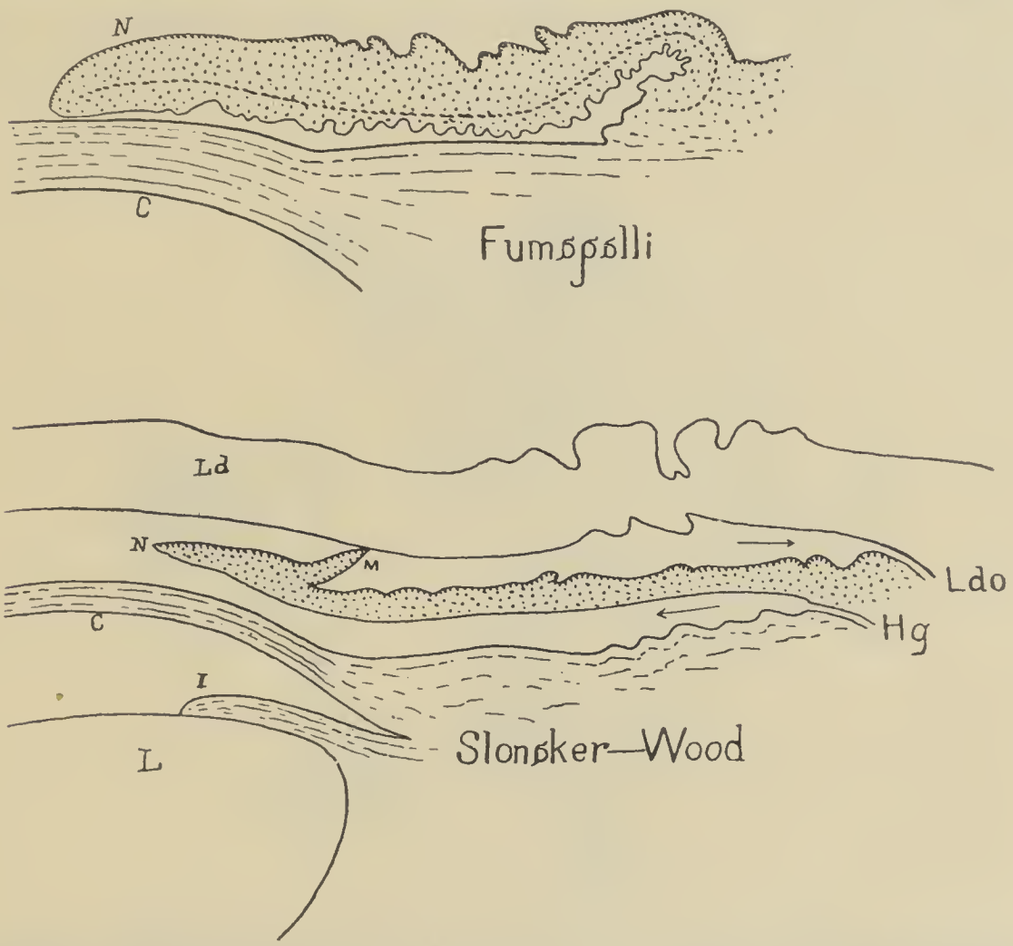

Fig. 5—Section of the Third Eyelid of a Pigeon, Showing Especially Slonaker's Marginal Plait.

The upper picture is from the work of Fumagalli, the lower as found by Slonaker-Wood.

plates, he pictures the Pigeon's accessory eyelid as lacking in the marginal plait.

All vertebrates possess at least six extraocular, bulbar muscles—four *recti* and two *obliques*. Birds have two more (that control the movements of the third eyelid) viz.: the *quadratus* muscle and the *pyramidalis,* which are inserted into the posterior hemisphere, behind the scleral insertion of the recti muscles.

Confirming the observations of Kalt (*Encyclopédie Francaise d'Ophtalmologie,* Vol. III) and others, Slonaker and the writer

found the quadrate muscle to be larger and better developed than the pyramidalis.

The *musculus quadratus* is inserted into the sclerotic just behind the insertion of the rectus superior muscle. Its attachment fills in the space between the superior and internal recti muscles on the superior edge of the latter. From this insertion all its fibres are directed toward the optic nerve. The free extremity of the quadrate muscle is about one-third as large as its size at insertion. Consequently it presents a triangle with a truncated apex rather than a square, as its name indicates. At this point, instead of having another insertion, fixed or mobile, the muscle abruptly ends in a tendon which folds on itself to form a fibrous loop, intended for the passage of the pyramidalis tendon.

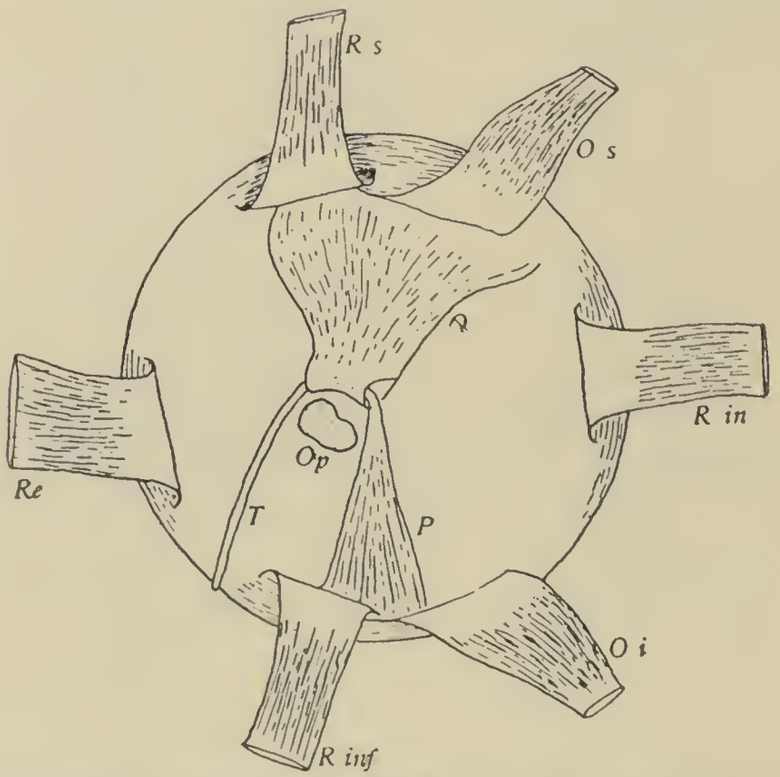

Fig. 6—Posterior View of the Left Eye of the Sparrow with the Rectus Superior (Rs), Inferior (R inf), Externus (Re), Internus (R in), and the Superior (OS) and Inferior (Oi). Oblique muscles laid back to show the arrangement of the Quadratus (Q), Pyramidalis (P) and Tendon (T) in relation to the Optic Nerve (Op). x 8. (Wood and Slonaker.)

The *pyramidal muscle,* which is much smaller, is inserted under the anterior half of the inferior rectus muscle and on a line 3 or 4 mm. in front of the edge of the muscle. It then reaches the anterior surface of the optic nerve and ends in a tendon which passes through the loop encircling the superior surface of the optic nerve, then enters a groove in the sclerotic, where it is held by a contraction of the capsule of Ténon. It then passes from within out, between the inferior and the posterior recti muscle—nearer to the latter—interrupts the bony circle about the nerve (in the Owl it is

attached to an apophysis of the bony circle) and reaches the posterior-inferior angle of the third eyelid, to which it is joined and of which it formed an integral part.

At this point the (flat) tendon of the pyramidalis lies in a groove—almost a tube—on the eyeball. It now enters behind the conjunctiva, pierces the lower sac at a point slightly posterior to the median plane of the eye, and is attached mostly along the free border of the third lid, as a rope is bound to a sail. The fibres of the tendon are, some of them, also spread out fan-like and are lost in the tissues of the nictitating membrane.

As the posterior-superior attachment of the third lid to the globe is posterior to the vertical plane and well up in the superior cul-de-

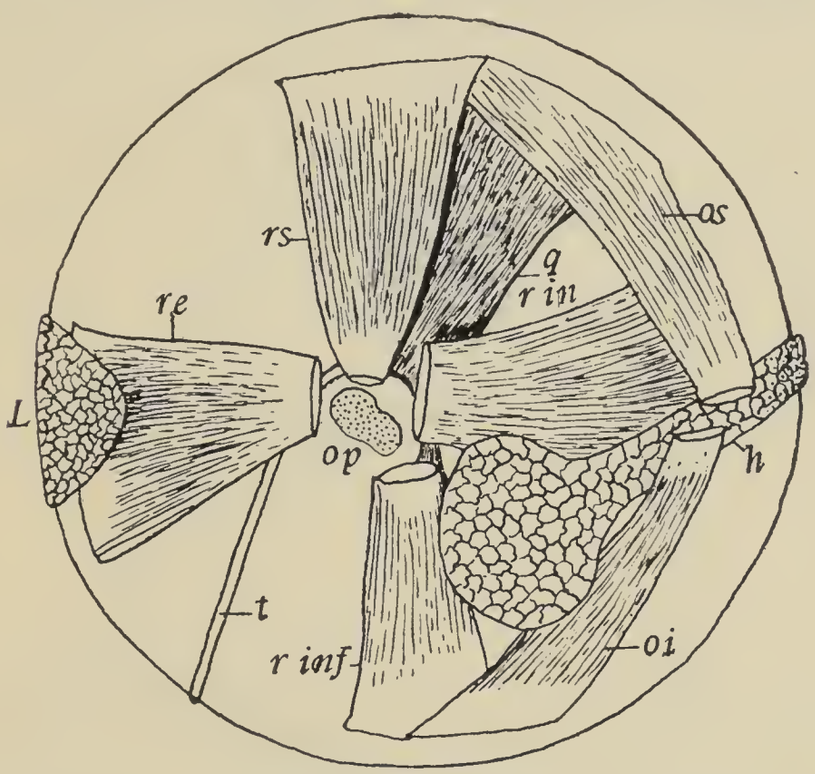

Fig. 7—Posterior View of the Left Eye of the Sparrow Showing Arrangement of Muscles and Glands. x 8. (Wood and Slonaker.)
L, Lachrymal gland; h, Harderian gland; re, rectus externus; ri, rectus internus; r inf, rectus inferior; rs, rectus superior; oi, obliques inferior; os, obliques superior; q, quadratus; t, tendon from pyramidalis muscle to nictitating membrane; op, optic nerve.

sac, it will be readily seen that the down-and-out pull of the tendon of the pyramidalis must cause the free border of the nictitating membrane to glide over the globe toward the posterior canthus. In ordinary contractions it seems to be drawn over to the sclera.

Like the external rectus, the quadrate and pyramidal muscles are innervated by the sixth pair.

Generally speaking, the oculomotor apparatus of Birds' eyes is not endowed with great power and the movements of the eyeballs are much restricted. The protective muscular apparatus is, however, highly developed.

The *histology and physiology of the free border of the third lid of Birds* have to do with the cleansing of the cornea, so that it shall be free of foreign matter and continuously moist and transparent. The accompanying semi-diagrammatic cut shows the free margin of the Sparrow's nictitating membrane, both at the center and toward the upper cul-de-sac. In this situation it preserves its usual structural characters, that of a plate of dense connective tissue covered before, behind and at its border by conjunctival epithelium. In the first figure the slightly pigmented, irregular border presents the general outline of the barb of a fish-hook, or of an anchor with one of its flukes cut off close to the shaft. The relations of the processes (really a marginal band) of the free border to the surround-

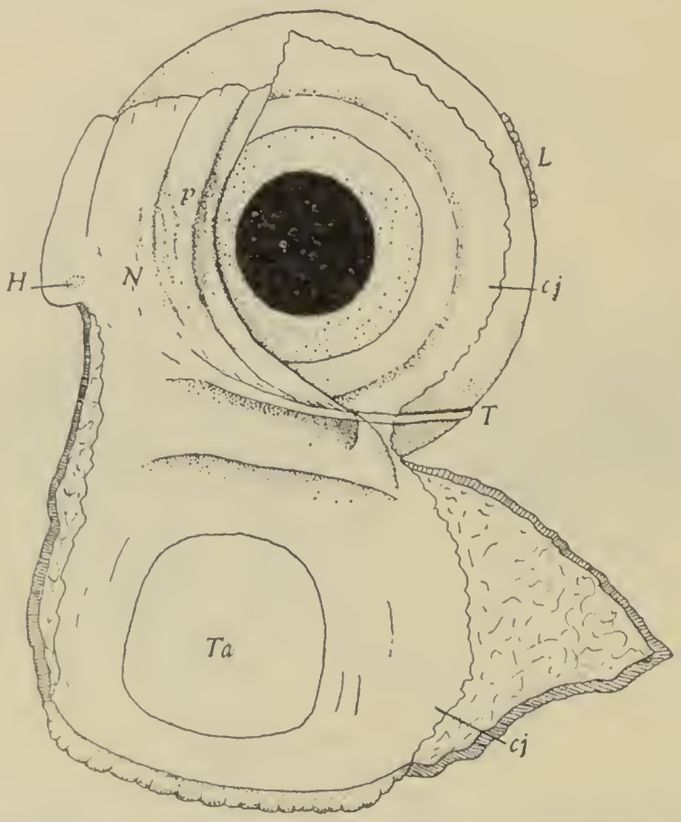

Fig. 8—Left Eye of the Sparrow with the Lower Lid Dissected Loose and Turned Down to Show the Opening of Harder's Gland (H) Beneath the Nictitating Membrane (N) and the Attachment of the Tendon (T), which Moves the Membrane. x 8. (Wood and Slonaker.)

Cj, conjunctiva; L, lachrymal gland; p, pigment portion of the nictitating membrane (shaded portion); Ta, outline of tarsus.

ing parts are interesting. It would seem as if the space behind the process or band is obliterated by the traction on it of the pyramidal muscle when the membrane is swept over the cornea. The corneal detritus (mixed with the Harderian secretion) is then pushed before the shelving margin of the membrane—like a rubber scraper, or the sharp margin of the lids in Mammals.

On the return journey, when the pyramidalis and quadratus are passive and the elastic fibres are in action, a quite different condition is apparent. The margin of the pectinate fold now rises and

presents a dam-like arrangement behind which the corneal debris, tears and viscid fluid from Harder's gland have meantime lodged. This mixture is now carried or pulled upon the outer margin and external surface of the third lid (instead of being pushed) toward the entrance of the lachrymal canals. The tip or point of the fluke of the marginal anchor and, consequently, the marginate band of the nictitating membrane is, where it touches them at all, in close opposition to the conjunctival lining of the true lids.

It will readily be seen that this disposition of the parts greatly facilitates the rapid transportation of lachrymal debris in the direction of the drainage outlet, the true lid preventing fluids from finding their way over the marginal band and onto the cornea.

This barb-like, or plicated arrangement, at the free border of the nictitating membrane has never been lacking in any of the

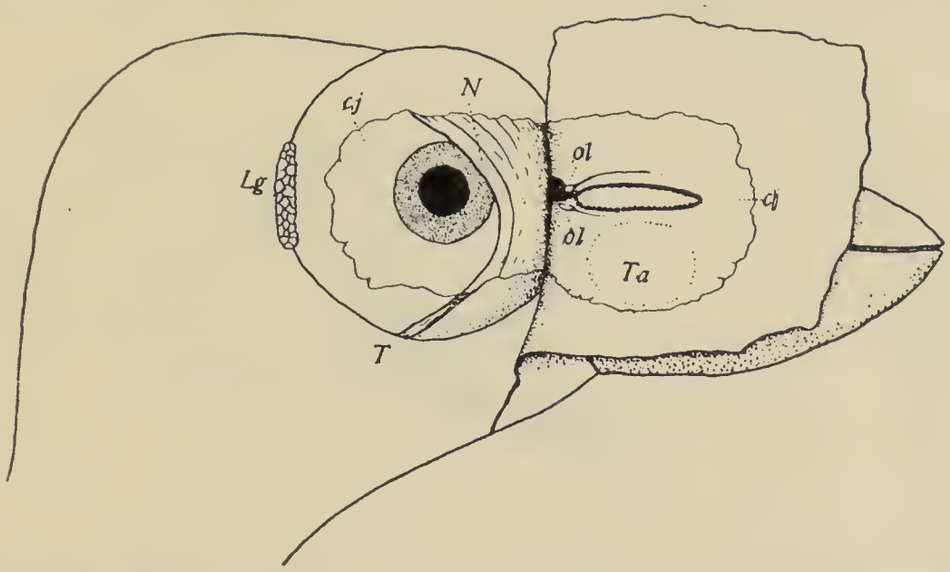

Fig. 9—English Sparrow with the Lids Dissected off and Turned Forward to Show the Openings of the Lachrymal Canals, ol. on their inner surface; cj, conjunctiva; Lg, lachrymal gland; N, nictitating membrane; T, tendon from the pyramidalis muscle to the nictitating membrane; Ta, outline of tarsus. x 4. (Wood and Slonaker.)

hundreds of sections examined; it is difficult to understand, therefore, why they are omitted from the drawings and photographs of Fumagalli and others who picture the minute structures of this organ.

Furthermore, neither Slonaker nor the writer has been able to find in Passer the smooth muscle fibres in the free border of the nictitating membrane described by Doenecke (*Inaug. Diss.,* Leipzig, 1899 and *Internat. Monatschr, f. Anat. u. Physiologie,* 1899, p. 129).

Another important organ of the lachrymal apparatus of Birds lies at the superior-internal angle of the eye. This is the *gland of Harder,* or the deep gland of the third eyelid, whose excretory canal opens below the nictitating membrane. Its color is yellowish, and

the secreted product is viscid. This gland is larger than the lachrymal gland, and belongs to the tubular-alveolar type.

According to Sardemann (*Beiträge zur Anatomie der Tranendruse,* Inaug. Diss., Freiburg, 1887), the *lachrymal gland* in Birds lies in the outer angle of the eye about the equator of the globe. Its size depends more than anything else upon the size of the animal. It has a thin capsule and is of lobular structure. Inside each lobule one finds a collecting space connected with tubular ducts lined by cylindrical cells with round or flat nuclei. There is no true lachrymal sac.

In the Hen the *lower canaliculus* is the smaller of the two canals and is slightly and almost immediately in front of the anterior canthus. Its flattened opening, continuous with the peripalpebral

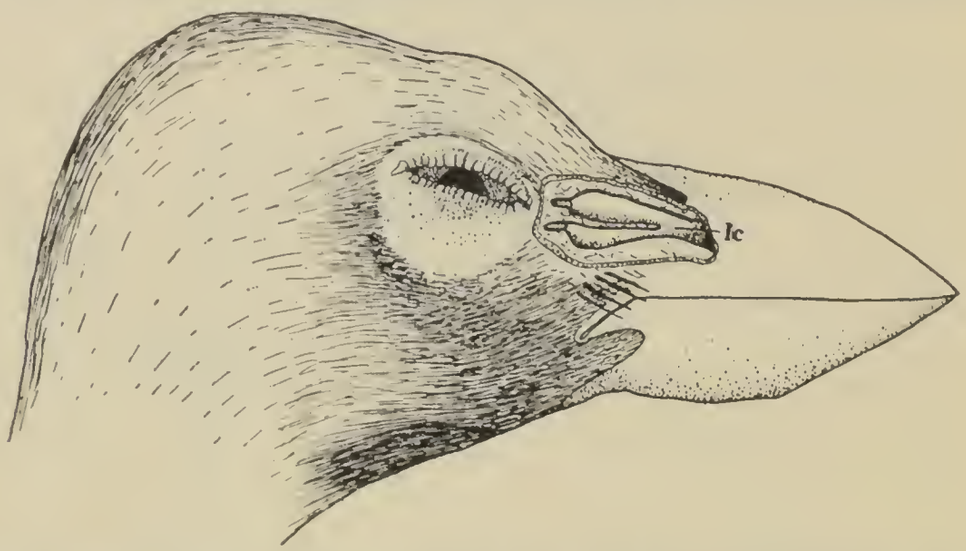

Fig. 10—Side View of the English Sparrow with the External Walls of the Lachrymal Canals, ic, Removed. x 4. (Wood and Slonaker.)

groove, is about 2 mm. wide. The *upper canaliculus,* separated from its fellow by a narrow bridge of tissue, has an opening about twice the size of the inferior entrance. It lies appreciably above and still farther toward the front of the beak than the lower opening.

A thin partition of soft tissue divides the two canals for a distance of 3 mm., when they join to form the lachrymal duct, whose calibre is equal to that of the combined upper and lower canaliculi. As in the Sparrow, the Hen has no well-defined lachrymal sac (as in Man), nor are there true puncta supplied with a suction apparatus, the openings into the tear canals being evidently mere drainage vents. On the other hand, the communication with the buccal cavity is large and unobstructed, so that the tears are readily swept into the throat with every excursion of the nictitating membrane and of the true lids.

The course of the tears, *i. e.,* the secretion mainly of Harder's gland, is quite different from the lachrymal drainage in Man. Although several writers speak of the avian lachrymal fluid as passing into the nose through the lachrymal canals, or of passing into the posterior nares, these statements are misleading, if not untrue. The accompanying figure, representing dissections of a number of avian species, demonstrates that unless one includes the median cleft at the roof of the mouth as an integral part of the nares, the lachrymal duct of Birds has little to do with the nasal passages, but is an isolated tube carried through and past the nasal structures, terminating in and emptying directly into the oral cavity (mouth). The buccal or oral cavity, as is well known, is a receptacle that includes and is not separated from the choana, the pharynx and the larynx.

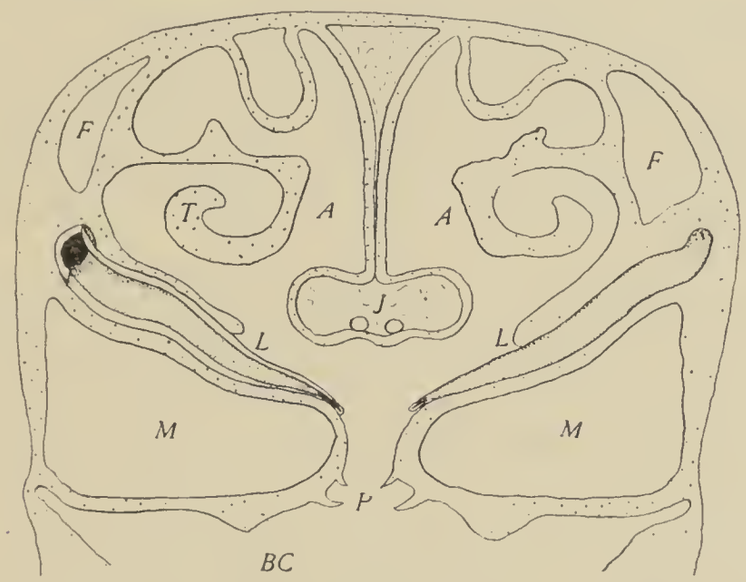

Fig. 11—Enlarged View of a Cross Section of the Head at the Base of the Beak about 2 mm. Anterior to the Eyes to Show the Lachrymal Ducts. The lower Mandible has been Removed. (Wood and Slonaker.)

AA, Right and left air passages connecting external nares and the buccal cavity, BC, through the choana, P; F, frontal sinus; J, organ of Jacobson; L, lachrymal ducts which open by horizontal slit-like openings into the choana; the anterior wall of the right duct has been cut away; M, maxillary sinus; T, turbinals.

Hoffman (Die Tränenwege der Vögel und Reptilien. *Inaug. Diss.,* Halle, 1882) observed on the lids peculiar grooves leading to the punctal openings, evidently intended as accessory drainage gutters, to assist in directing and carrying the lachrymal secretions into the canaliculi.

The orifices of the canaliculi, upper and lower, are, as stated, not placed on the lid margins at the anterior canthus, but generally open a few millimetres from it by gaping mouths that are unprovided with connective tissue plates or muscle fibres, as found in Man. Minute shallow grooves, better shown in the Hen, lead from the canthus around and close to the margins of both lids and form a

gutter-like conduit for the purpose of conveying the lachrymal fluid in the direction of the puncta. These openings are relatively large and always communicate with correspondingly large canaliculi, which in the Sparrow are about 2 mm. long. They join to form a large fibrous tube, lined with epithelium, the lachrymal duct, that runs directly downward and forward toward the median line until it opens into the choanal slit, the marginate spines of which direct its contents backward into the esophageal opening.

In the Sparrow a probe 1 mm. in diameter can readily be passed through the lachrymal duct and this probably represents the lumen of the tube. The canaliculi are about 1 mm. long, while the length of the common duct may be set down as 3.6 mm.

Slonaker and the writer have not been able to demonstrate the presence of ciliated epithelium in the duct mucoca.

The openings analogius to the human *puncta* are irregularly rounded; the upper one being distinctly larger and more patent than the lower. Corresponding to these, Slonaker's *peripalpebral groove* is deeper, longer and better marked at the conjunctival margin of the upper lid than at the corresponding border of the lower lid.

The principal facts to be remembered about the lachrymal drainage in Birds are (1) that the free margin of the third lid is anchor- or half-spear-shaped; (2) the free edge probably pushes before it—scraper-like—the Harderian fluid, thus cleansing the cornea on the contraction of the pyramidalis and quadratus muscles; (3) at the instant of rest this same secretion, supplemented or not by the lachrymal fluid, is pulled (bucket-like) back and emptied into the canaliculi; (4) during the performance of this act it is to be remembered that at the end of even the most complete excursions of the nictitating membrane the lower edge of the lower lid advances only about half a millimetre, while, although there is a simultaneous twitching of its palpebral margin, the upper lid apparently does not come forward at all.

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