the retina. Its cells are soon arranged in a single layer, those on its outer aspect remaining cubical and forming the so-called lens epithelium; while those on the inner or

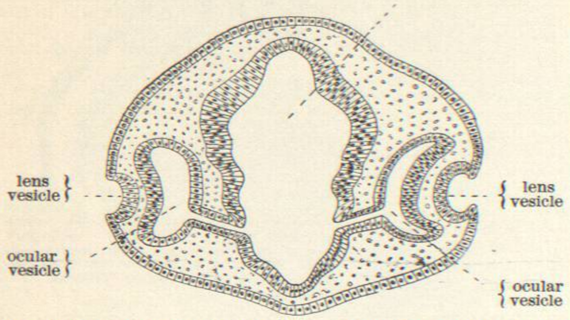


FIG. 1972.—Section of Head of Chick, Third Day of Incubation. (Duval.)

retinal aspect become greatly lengthened and form the lens fibres (Fig. 1976). By this process the cavity of the vesicle is finally obliterated. At the equator or edge of the lens there is a transition region where proliferation is most active. The lens increases in size by the addition of successive layers of fibres which extend from the anterior to the posterior surface. The structureless capsule of the lens is now believed to be a product of the cells themselves and not of mesoblastic origin.

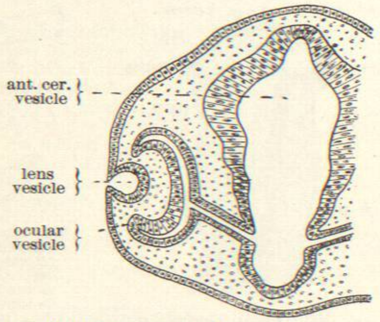


FIG. 1973.—Further Development of Retina and Lens. The lens vesicle is still attached to the epidermis. (Duval.)

Besides the capsule proper the lens is invested during fœtal life by a vascular membrane, the *tunica vasculosa lentis*. The vessels that supply this are derived from the hyaloid artery, a branch of the central artery of the retina, and from the long and short ciliary arteries that supply the iris (Fig. 1977). The supply is especially great around the equator of the lens where proliferation is active. The portion of this membrane that lies in front of the lens stretches over the pupil or mouth of the optic cup, and is known as the pupillary membrane. The tunica vasculosa begins to disappear about the seventh month, but vestiges often remain after birth.

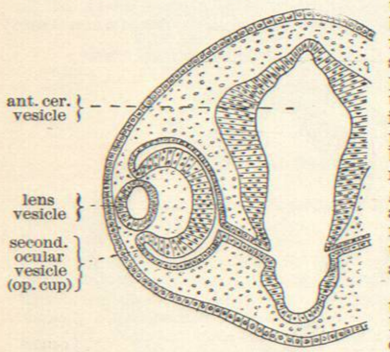


FIG. 1974.—Further Development of Retina and Lens. The lens vesicle has become entirely detached and lies at the entrance to the optic cup. The inner layer to the optic cup has begun to thicken.

Around the optic cup and the lens the mesoderm forms a complete investment in which two layers may be distinguished: an inner, more vascular one, which becomes the choroid coat, the choroidal part of the iris and the pupillary membrane; and an outer, less vascular one, which forms the sclera

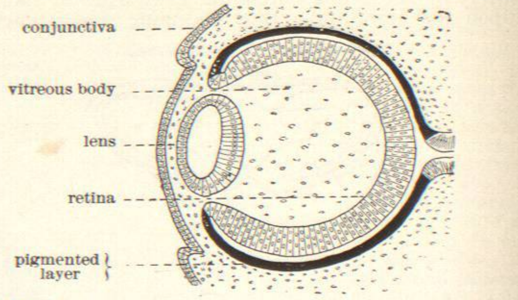


FIG. 1975.—Further Development of the Retina and Lens. The posterior wall of the lens has begun to thicken; the external layer of the optic cup is charged with pigment. (Duval.)

and cornea. In front of the lens a cleft appears which enlarges to become the aqueous chamber (Fig. 1978).

The eyes have first a lateral position like those of fishes, but the growth of the superior maxillary and nasal processes causes them to assume their adult situation. At first the cornea is entirely uncovered, the lids develop as folds of integument.

The nasal duct is formed in the fold between the superior maxillary and nasal processes by the canalization of a cord of infolded ectodermic cells.

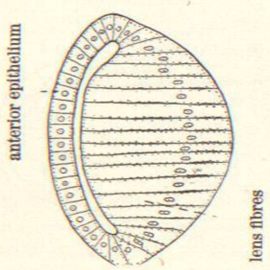


FIG. 1976.—Final Stages of Development of Lens. The cavity of the lens vesicle almost wholly disappears. (Duval.)

*The Outer or Fibrous Coat.*—Analogous to the dura mater of the brain, this tunic completely invests the eyeball except where penetrated by vessels and nerves. It is composed of fibrous tissue irregularly arranged behind, producing the white, opaque sclera, more regularly in front, forming the clear, transparent cornea. It is very scantily supplied with vessels and nerves, but has numerous lymph channels that appear to afford it nutrition. Associated with these and lying in the interstices of the tissue are various specific forms of corpuscles. The density and hardness of the coat efficiently protect the eye and contribute to its shape, which essentially depends, however, upon the tension produced by the enclosed contents.

*The Sclera.*—Four-fifths of the surface of the eyeball

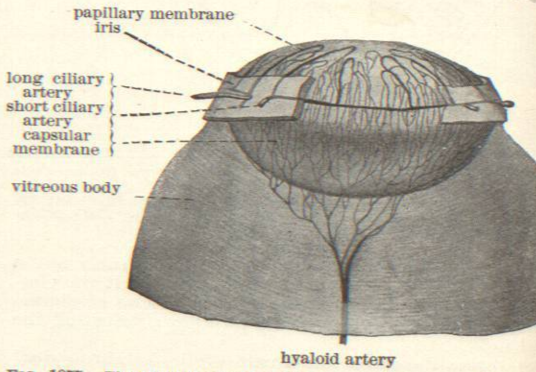


FIG. 1977.—The Vascular Tunic of the Lens in the Fœtus. (Kollman.)





is formed by the dense, opaque structure known as the "white of the eye." Its dead white appearance is due

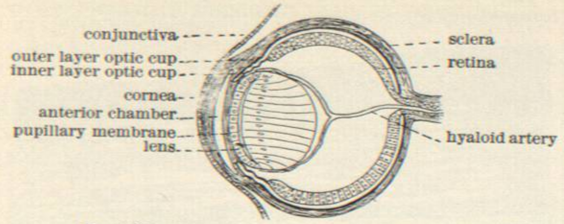


FIG. 1978.—Formation of the Anterior Chamber.

to the interference of light occasioned by the irregularly interwoven bundles of its fibres. In children and the darker races the underlying pigment shows through it slightly, giving it a bluish cast. In old persons it is yellowish from the deposit of fat within it.

Two principal openings occur in the sclera: one in front, where the transparent cornea is set into it like the crystal of a watch into its frame, the fibres of the two mutually interblending; one behind, where the optic nerve enters at the so-called *optic canal* (optic foramen, porus opticus). Strictly speaking the sclera is not wholly deficient in the latter situation, as it is represented by a perforated sheet of connective tissue, the *lamina cribrosa*, through which the fibres of the optic nerve pass. The canal is situated about 3 mm. from the posterior pole on the nasal side and 1 mm. below the horizontal meridian. Since the fibres of the optic nerve lose their medullary sheaths as they pass forward, the canal contracts funnel-wise from without inward, terminating within in a crest-like ridge, the *pecten scleræ*. Other perforations for vessels and nerves occur,

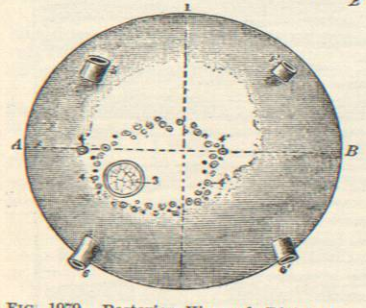

FIG. 1979.—Posterior View of Right Eye, showing Entrance of Optic Nerve. (Testut.) *A*, Nasal side; *B*, temporal side; 1, vertical meridian; 2, horizontal meridian; 3, optic nerve; 4, 4, ciliary vessels and nerves; 4′ 4′, long ciliary arteries; 5, 5′, superior vorticose veins; 6, 6′, inferior vorticose veins.

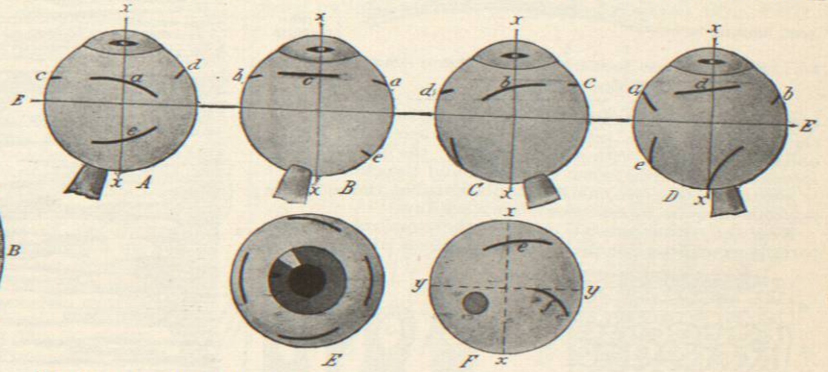

FIG. 1980.—Insertion of the Ocular Muscles upon the Sclera of the Right Eye. Drawn from the determinations of Fuchs. *A*, View from above; *B*, from nasal side; *C*, from below; *D*, from temporal side; *E*, from the front; *F*, from behind; *a*, rectus superior; *b*, rectus inferior; *c*, rectus internus; *d*, rectus externus; *e*, obliquus superior; *f*, obliquus inferior; *E E*, equator; *xx*, axis. In *F*, *y y*, horizontal meridian; *xx*, vertical meridian.

viz.: a posterior ciliary set, arranged about the optic nerve (Fig. 1979), together with those for the long ciliary vessels and nerves lying a short distance farther forward; a middle set, comprising the vorticose veins; and an anterior ciliary set a short distance behind the corneo-scleral junction.

The sclera attains its maximum thickness of about 1 mm. in the vicinity of the optic nerve entrance where it is required to support the most sensitive part of the retina. It grows gradually thinner forward until, just behind the insertion of the recti muscles, it is but 0.35 mm. thick. The tendons of those muscles reinforce it to some extent and at the corneo-scleral junction it measures 0.60 mm.

The recti muscles are inserted by means of flattened expansions that blend intimately with the sclera. The adjoining sketch (Fig. 1980) shows that their insertions follow a spiral line running at a distance of 5 mm. from the corneal margin for the rectus internus, to 8 mm. for the rectus superior. The oblique muscles are inserted in the posterior hemisphere, their lines of insertion being diagonal to the meridians. The striated fibres of the inferior oblique are inserted directly upon the sclera without the intervention of a tendon.

The density of the sclera is considerable, its weight being at least one-sixth that of the entire eye.

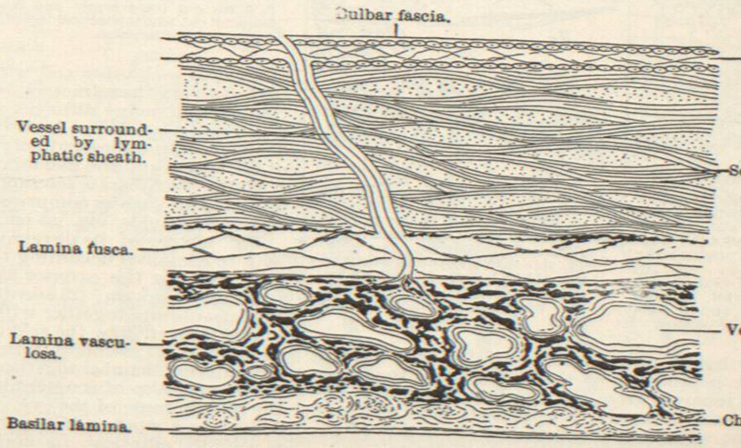


FIG. 1981.—Transverse Section of the Sclera and Choroid. (Testut.)

The sclera is a typical connective-tissue structure, being composed of white fibrous tissue with a few yellow elastic fibres intermingled (Fig. 1981). On boiling it yields gelatin. The bundles are in all parts of it irregularly arranged, though equatorial bands are more common near the corneo-scleral junction. The interstitial spaces are small and cleft like. In their walls are found fixed cells, the scleral corpuscles, in their cavities wandering leucocytes. Pigmented connective-tissue cells occur, especially in the deeper layers, where their aggregation gives a dark-brown color to the tissue, called for this reason the *lamina fusca.* Perivascular and perineural

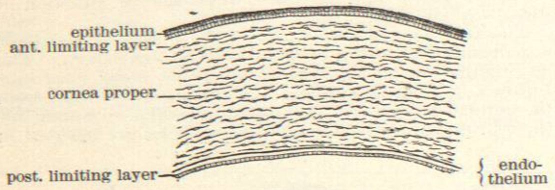

FIG. 1982.—Transverse Section of Cornea Slightly Magnified. (Gerlach.)

lymph channels extend from the periscleral space into the tissue along the interpenetrating vessels and nerves and communicate with a lymph space, the *perichoroidal space,* that occurs between the sclera and the choroid. It is mostly by the lymphatic circulation that the sclera is nourished, as its blood-vessels are very few.

Near the corneo-scleral junction there occurs an equatorially extending channel called the *scleral sinus* or canal

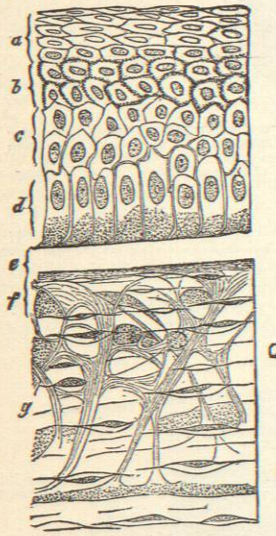

FIG. 1983.—Section through the Anterior Portion of the Cornea of the Calf. (Waldeyer.) *a*, Flattened epithelial cells; *b*, prickle cells; *c*, polymorphous cells; *d*, basal layer of club-shaped cells; *e*, anterior limiting membrane; *f* and *g*, substantia propria of cornea.

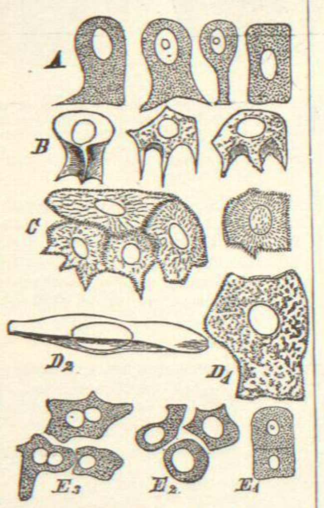

FIG. 1984.—Isolated Cells from the Corneal Conjunctiva. (Waldeyer.) *A*, From the basal layer; *B*, polymorphous cells; *C*, prickle cells; *D*, flattened cells; $D_1$, plane view; $D_2$, side view; *E*, young cells from the middle layers; $E_1$, cell undergoing division; $E_2$, cells with one nucleus; $E_3$, multinucleate cells.

of Schlemm, that is now considered to be of a venous character. It is probably by this avenue that the aqueous humor is removed from the eye and the proper interchange of fluids effected. It appears to have no direct communication with the chambers, and the action of removal must be by intercellular filtration (Leber).

The nerves supplying the sclera are few in number and are derived from the ciliary nerves.

*The Cornea.*—This is also a connective-tissue structure formed of superposed and anastomosing lamellæ, closely

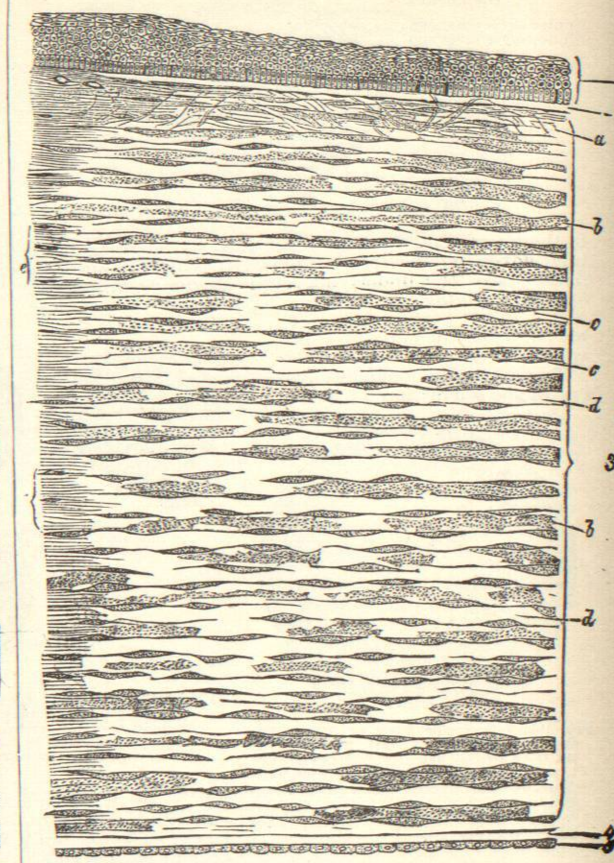

FIG. 1985.—Section through Human Cornea. (Waldeyer.) 1, Conjunctival epithelium; 2, anterior limiting membrane; 3, substantia propria; 4, posterior limiting membrane; 5, endothelial layer; *a*, fibres from anterior limiting membrane entering substantia propria; *b*, fibres cut transversely and fasciculi; *c*, corneal corpuscles; *d*, fasciculi cut lengthwise and therefore appearing homogeneous; *e*, *e*, corneo-scleral junction.

applied to each other and with no substance intervening that can vary the refractive force of its fibres. Although composed of many different units—epithelium, limiting membranes, successive layers of connective tissue, lymph channels, corpuscles and nerves—all have the same index of refraction and the membrane is perfectly transparent. A slight disturbance tending to derange its mechanical adjustment, such as compression or other strains, the absorption of fluids, etc., at once beclouds it.

The history of its development shows that its layers may be classified according to their sources: (1) *conjunctival,* forming the exterior layer of epithelium, derived from the ectoderm; (2) *scleral,* forming the main portion of the structure together with its anterior limiting membrane, derived like the sclera from the mesoderm (mesenchyme); (3) *choroidal,* forming the endothelium lining the anterior chamber together with the posterior limiting membrane, also of ectodermic origin but correlated with the middle tunic of the eye.

Set like a window in the frame of the sclera its outline is slightly elliptical, its horizontal diameter being 11.6





mm., while its vertical one is but 11 mm. The outer and inner surfaces are unequally curved, the inner one

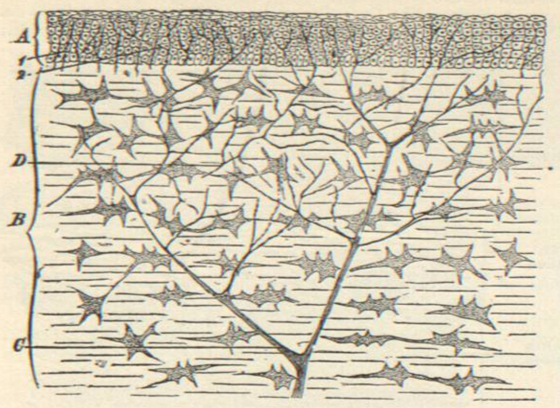

FIG. 1986.—Section of Human Cornea Stained with Chloride of Gold, showing the Corneal Corpuscles and Nerve Endings. (Waldeyer.)

having nearly the curvature of a sphere with a radius of 6 mm., while the outer one has that of an ellipsoid with a horizontal radius of 7.8 mm., and a vertical one of 7.7 mm., even greater variations being frequently observed. The surfaces therefore are not parallel, and the thickness of the cornea varies from 1.1 mm. at its periphery to 0.9 at the ocular axis. It attains its permanent dimensions early; its weight averages 180 mgm., one-fortieth that of the entire eye; and its specific gravity is 1.076 (Davy). Its index of refraction is 1.3523, that of distilled water being 1.3358 (Krause). When boiled it yields a form of chondrin instead of gelatin as does the sclera. Its percentage of water is 72.75.

The main substance of the cornea is a lamellated connective tissue lined both without and within by clear structureless limiting membranes, then clothed without by the epithelium of the conjunctiva, within by the endothelium of the anterior chamber. Thus there are five varieties of tissue to be considered (Fig. 1982).

The corneal conjunctiva is an epithelium corresponding with that of the general surface of the body, but having fewer layers of cells and no corneous layer. The deeper cells are expanded at the base and show signs of mitotic division (see Figs. 1983, 1984). Those of the middle layer ("prickle cells") are surrounded by intercellular passages that permit the circulation of lymph.

The anterior limiting membrane (Bowman's membrane, anterior elastic lamina) is a clear anhistous sheet that lines the cornea under the conjunctiva up to near the margin, sending down into the deeper layers fibres of a similar character. It behaves with reagents like the spiral fibres that encircle connective-tissue bundles, not dilating when treated with acetic acid, and resembles the subepithelial basement layer of many membranes.

The proper tissue of the cornea presents from sixty to sixty-five lamellæ (Fig. 1985) composed of flattened bundles of white fibrous tissue arranged nearly at right angles to each other. Between these is an intricate system of interfascicular spaces or lymph lacunæ connected with each other by fine canals and containing fixed cells, the corneal corpuscles (Fig. 1986). These have a resemblance to the osteoblasts of bone in that they occupy interstitial spaces and apparently send fine branching processes along delicate canals that communicate with other spaces. Wandering cells are also found in the passages of the cornea. At the corneal margin these passages communicate with similar ones in the sclera.

The posterior limiting membrane (membrane of Descemet, of Demours, of Duddell, posterior elastic lamina) is also an anhistous layer but apparently quite different in character and origin from the anterior limiting membrane. Its increase with age, and certain irregularities found on its surface lead to the conclusion that it is produced by the endothelial cells which it supports. At the margin of the cornea it becomes thickened into a ring-like zone, the *annular ligament,* beyond which it can be traced over to the insertion of the iris, as a series of distinct bundles of fibres, the *pectinate ligament,* separated by minute clefts, the *spaces of Fontana* (Fig. 1987).

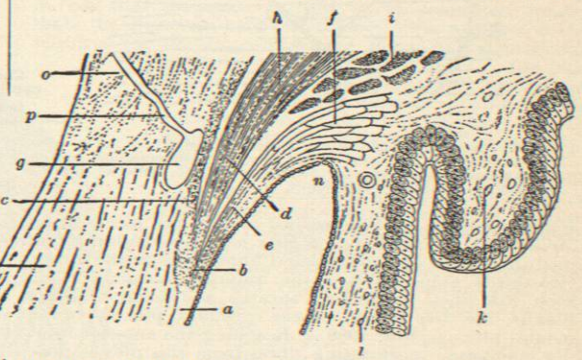

FIG. 1987.—Meridional Section Showing the Connection Between the Cornea and the Middle Coat of the Eye. (Testut.) *a*, Posterior limiting layer; *b*, annular ligament; *c*, scleral fibres; *d*, ciliary fibres; *e*, posterior fibres forming the pectinate ligament; *f*, Fontana's space; *g*, scleral sinus; *h*, meridional fibres of the ciliary muscle; *i*, annular fibres of same; *k*, ciliary process; *l*, iris; *m*, cornea; *n*, angle of the iris; *o*, sclera; *p*, scleral vein.

The endothelium that forms the posterior boundary of the cornea is a flattened single layer of cells similar to those usually lining serous cavities. It is continuous

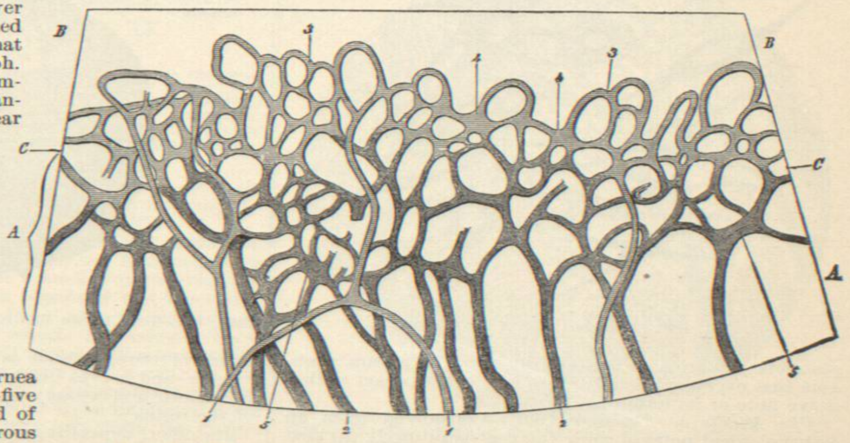

FIG. 1988.—The looped Marginal Plexus at the Periphery of the Cornea. (Waldeyer.)

over the acute peripheral portion of the anterior chamber (known as the *angle of the iris*) with the endothelium lining the anterior surface of the iris.

In the healthy cornea there are no blood-vessels, except just at the margin where vessels from the sclera form a looped network (Fig. 1988). Notwithstanding this wounds of the cornea heal rapidly, nutrition being afforded by the copious supply of lymph.

The nerves that supply the cornea are derived from the anterior ciliary set which form, near the corneo-

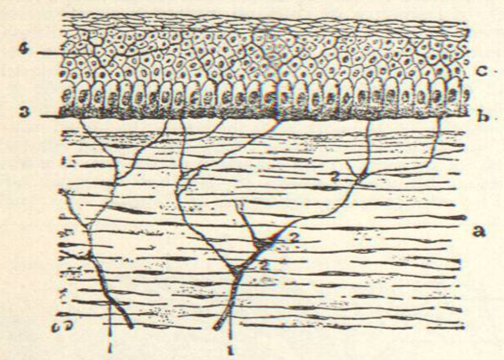

FIG. 1989.—Nerve Plexuses of the Cornea. (Testut.) 1, 1, Two afferent nerve trunks; 2, deep stroma plexus; 3, subepithelial plexus; 4, intra-epithelial plexus; *a*, cornea proper; *b*, anterior limiting membrane; *c*, anterior epithelium.

scleral junction, a close-meshed plexus, the *plexus annularis*, from which sixty to eighty nerves, containing both medullated and non-medullated fibres, pass to the cornea, two-thirds going toward the anterior surface. They soon lose their medullary sheaths and form a second plexus, the *deep stroma plexus* (primary plexus, fundamental plexus) (Fig. 1989). Reaching the anterior limiting membrane, perforating fibres from this plexus penetrate that layer and unite to form a third or *subepithelial plexus* from which again fibres pass between the epithelial cells, forming a fourth, or *intra-epithelial plexus*. From this as well as from the subepithelial plexus terminal filaments are given off on which are formed end organs shaped like rounded bulbs, hooks, loops, and

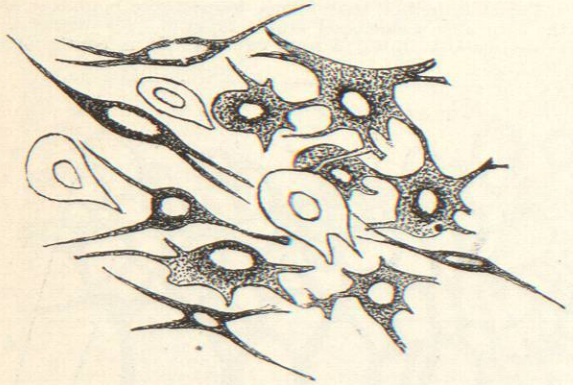
FIG. 1990.—Branched Cells of the Choroid.

platelets. So rich is this supply that it appears probable that every epithelial cell is in actual contact with a nerve fibre or its terminal.

*The Middle or Vascular Coat.*—Considered from an embryological point of view this coat is properly divided into four regions: (1) The choroid proper, comprising the pigmented vascular membrane that extends from the optic-nerve entrance as far as the boundaries of the visual retina where it is limited by a crenulate line called the *ora serrata;* (2) the ciliary choroid, or ciliary body, a thickened portion containing muscular fibres and vascular

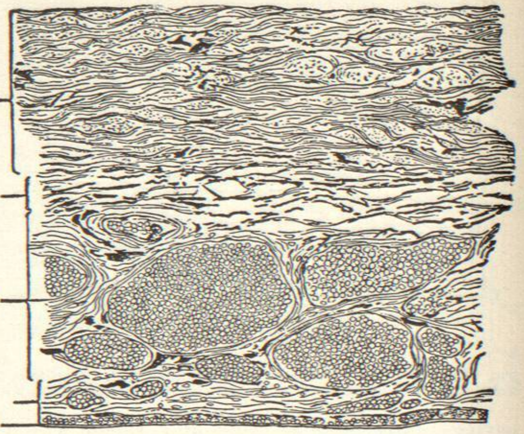

FIG. 1991.—Section of the Human Choroid. (Böhm and von Davidoff.)

plexuses; (3) the choroidal part of the iris, comprising the greater portion of the colored curtain which is stretched in front of the lens; (4) the corneal choroid, comprising the corneal endothelium lining the anterior chamber and its product, the posterior limiting membrane. These last have already been described.

This coat generally offers a marked contrast to the other two by its vascular and pigmented character, and has been compared to the pia mater of the brain. Its function is essentially nutritive, and it supplies the fluids that fill the eyeball and preserve its tension. It is soft, yielding, and easily torn or injured.

*The Choroid Proper.*—This portion of the middle coat, covering about two-thirds of the eyeball, is a loose, vascular, extensible tunic about 0.1 mm. in thickness at the optic-nerve entrance, thinning gradually to about half that at the ora serrata. It is imperfectly separated from the sclera by the suprachoroidal space, intervening

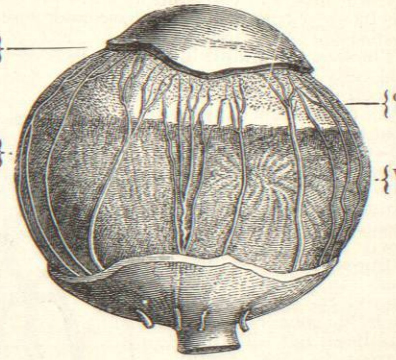

FIG. 1992.—The Choroid Viewed from its Outer Surface. (Merkel.)

bands of fibrous tissue as well as numerous perforating vessels and nerves uniting the two. Its inner surface is smooth and closely applied to the pigmented layer of the retina.

Its color, depending on the pigment deposited in its cells and the amount of blood in its vessels, is a dark or





reddish-brown, somewhat lighter in the old than in the young.

The general substance or *stroma* of the choroid is composed of interwoven trabeculæ of connective tissue, both white and elastic, supporting a large number of blood-vessels and containing many irregularly branched, pigmented cells (Fig. 1990). The outer layer, being more loosely woven and containing fewer vessels, is known as the *lamina suprachoroidea;* that next to it, containing the largest vessels, is the *lamina vasculosa;* the next layer having an extremely rich network of capillaries is the *lamina choriocapillaris;* while the anhistous limiting membrane that separates this from the retina is the *lamina basalis* (Fig. 1991).

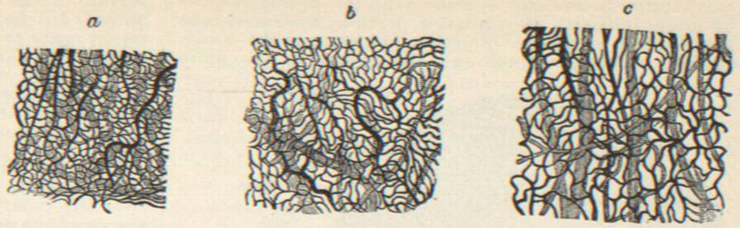

FIG. 1994.—The Capillary Network of the Choroid. *a*, Near the optic-nerve entrance; *b*, about the equator of the eyeball; *c*, near the ora serrata. The veins are striated longitudinally, the arteries transversely, the capillaries are black. The latter are only half as broad as they ought to be.

While the suprachoroidea is not itself remarkably rich in vessels and nerves, its loose tissue affords an avenue by which they readily penetrate to their ultimate destina-

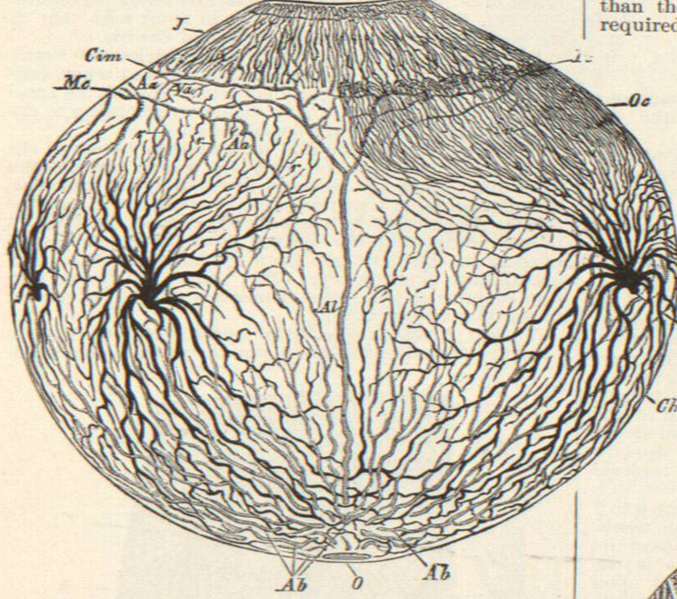

FIG. 1993.—Partially Diagrammatic Representation of the Course of the Vessels in the Choroid. (Leber.) *Ch*, choroid; *J*, iris; *Mc*, ciliary muscles; *Pc*, ciliary processes; *Oc*, ciliary ring; *O*, optic nerve entrance; *Ab*, short posterior ciliary arteries; *Al*, long posterior ciliary arteries; *Aa*, anterior ciliary arteries; *Cim*, greater arterial circle of iris; *Vv*, vorticose veins; *r*, *r*, recurrent arteries.

tions. The long ciliary arteries and nerves lie almost wholly in this layer in their transit forward to supply the iris and neighboring structures (Fig. 1992).

The arteries of the lamina vasculosa (Fig. 1993) are derived mainly from the short ciliary set that penetrate the ball by about twenty small branches in the vicinity of the optic nerve. The main vessels of this layer are, however, the vorticose veins, from four to eight large trunks formed by converging whorls of vessels. They are usually arranged in a nearly symmetrical manner in four sets nearly ninety degrees apart, and penetrate the sclera obliquely near the equator. Owing to this oblique penetration their discharge is liable to be interfered with by pressure from without, particularly from the action of the ocular muscles. In the deepest part of this lamina are found wavy bundles of elastic tissue, a vestige of the *tapetum* that causes the metallic sheen observed in the eyes of many lower animals under certain conditions of reflected light.

The choriocapillaris or membrane of Ruysch (Fig. 1994) is a close-meshed network of capillaries, so close, in fact, that the space occupied by the vessels is greater than the intervals between them. This appears to be required for the nourishment of the closely contiguous percipient layer of the retina, *i.e.*, the rods and cones, to which the proper arteries of the retina do not penetrate. The vorticose veins begin in this layer by capillary whorls, sometimes called the *stars of Winslow* (Fig. 1995).

The basilar lamina, also known as the vitreous membrane, or the membrane of Bruch, is structureless or nearly so, and appears to be analogous to the basement membrane of epithelium.

The long and short ciliary nerves send vaso-motor twigs to the choroid, and lymphatics gather fluid from its numerous interspaces.

*The Ciliary Body.*—The wavy line of the ora serrata marks the limit of the layer of rods and cones of the retina and of its trophic layer, the choriocapillaris (Fig. 1995). From this line to the border of the iris curtain the middle tunic of the eye is marked by finely radiate striæ resembling cilia, hence the name that has been applied to this region. The posterior portion,

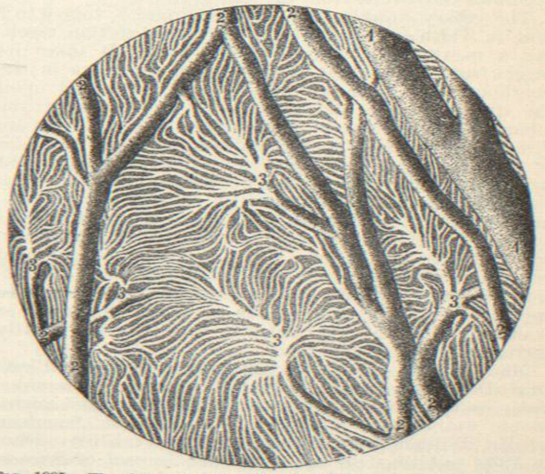
FIG. 1995.—The Origin of the Choroidal Veins. (Arnold.) 1, 1, One of the larger veins; 2, 2, communicating veins, 3, 3, "Stars of Winslow," or vortical whorls of capillaries by which the veins arise from the choriocapillary layer.

comparatively smooth, is known as the *ciliary ring* or orbiculus ciliaris; the anterior portion, thickened and plicated in a meridional direction, is known as the *corona radiata*. Between these and the sclera, in the more

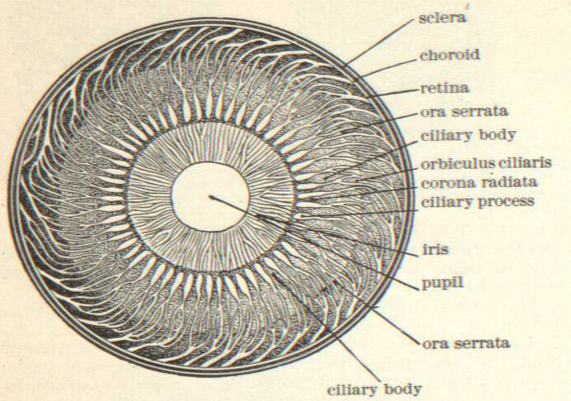


FIG. 1996.—The Ciliary Body as Seen from Behind. × 3.

superficial portion of the middle coat, lies an annular band of muscular tissue, known collectively as the *ciliary muscle*.

The ciliary ring, about 4 mm. broad, is formed of nearly straight, unbranched vessels for conveying blood either forward to the corona radiata or backward to the vorticose veins, united by a loose stroma like that of other portions of the middle coat. The basilar layer is continued forward and is even somewhat thickened.

The corona radiata is the zone lying between the margin of the ciliary ring and the outer margin of the iris. It derives its name from the radiate arrangement of its characteristic features, the *ciliary processes*, club-shaped plications from 2 to 3 mm. in length and 0.12 mm. wide, that lie in a meridional direction (Fig. 1997). They resemble the glomeruli of the kidney in containing convoluted blood-vessels, and doubtless assist in the production of the aqueous humor. The suspensory ligament of the lens (zonula ciliaris) extends backward over them as far as the ora serrata, some of its fibres springing directly from the stroma of the processes. A marked interval separates the corona from the iris.

The ciliary muscle (Fig. 1998) occupies a zone 6 to 7 mm. in width and triangular in meridional section, reaching a maximum thickness of 0.8 mm. It takes its origin from the annular ligament and the sclera in the neighborhood of the scleral sinus and is inserted upon the stroma of the middle coat in the region of the ciliary body and beyond. Its most superficial fibres are directed meridionally and constitute the *tensor choroidea* of Brücke; those next succeeding approach more and more a radial direction as they get deeper; and the deepest of all are arranged equatorially, constituting the *compressor lentis* of H. Müller. The office of the muscle is to draw the choroid forward and thus relax the suspensory ligament of the lens, which, being no longer held tense, assumes a more convex shape suitable for the refraction of diverging rays from objects near at hand. In myopic eyes the circular fibres are fewer in number or wanting, while in hypermetropic eyes they are greatly increased.

Many ancient anatomists (Eustachius, Scheiner, Plempius, Descartes) suspected that this structure was muscular, but the first to demonstrate it from actual microscopic examination appears to have been an American oculist, William Clay Wallace of New York City, who, in 1835, published in the *American Journal of Sciences and Arts* an article "On the Accommodation of the Eye to Distances," saying :

"At the base of the ciliary processes, upon the inner surface of the choroid coat, there is a range of muscular fibres. In the sheep the fibres of the upper portion run transversely to the ciliary processes; those of the lower portion run parallel to them."

Brücke, to whom the credit of the discovery of the meridional fibres is usually given, did not describe the muscle until 1846, and H. Müller, usually credited with the discovery of the equatorial fibres, published first in 1855.

The muscle is supplied by the long ciliary nerves from the nasal branch of the ophthalmic and by the short ciliary from the ciliary ganglion. These form within the substance of the muscle a ring-like plexus, the *ciliary plexus* (orbiculus gangliosus), from which pass fibres of apparently motor function, ending free between the muscle cells, vaso-motor fibres, and also sensory fibres with terminal end organs. Some of the latter are believed to impart an accurate appreciation of the contraction of the muscle.

*The Iris.*—This colored diaphragm, pierced with its central aperture, the pupil, hangs freely but not quite vertically in the aqueous chamber, its outer or ciliary border attached just behind the corneo-scleral junction, and its free or pupillary border resting a little anterior to the other upon the lens. Behind, its tissue is continuous with that of the ciliary body, in front with that of the pectinate ligament and the angle of the iris.

Its diameter is from 10 to 12 mm., its thickness 0.4 mm. when lax, increasing to double that amount when contracted. The pupil, slightly eccentric toward the nasal side, varies from 1 to 8 mm. in diameter, according to the state of contraction of the iridial muscles.

It will be remembered that the pupillary border of the iris forms the edge of the optic cup, which here doubles back upon itself and becomes invested by the vascular, mesodermal layer that produces the choroid. Hence the iris is composed of two genetically distinct portions: a retinal one, secondarily derived from the ectoderm, belonging to the optic cup proper; and a choroidal one, mesodermic in origin (Fig. 1999). Since the retinal portion contains no percipient elements it will be convenient to consider all together.

Viewed closely, the anterior surface will be seen to present two concentric zones, *pupillary* and *ciliary*, sepa-

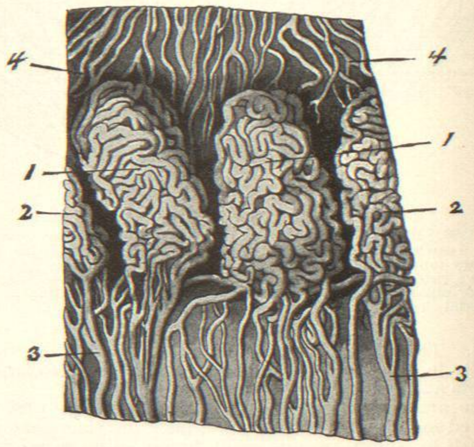


FIG. 1997.—Injected Ciliary Processes Viewed from Behind. (Sappey.) 1, 2, Venous plexuses composing the bulk of the projections; 3, 3, efferent trunks tributory to the vorticose veins; 4 4, venous radicles from the iris. × 40.

rated by a festooned line, the *lesser arterial circle*, that indicates the former attachment of the pupillary membrane (Figs. 2000 and 2001). Both zones are marked by radial striæ, caused by vessels and nerves: those of the pupillary zone being fine and close, *radii minores;* those





of the ciliary zone larger, *radii majores*. The pupillary border shows a thin black line slightly beaded where the striæ reach it. In the pupillary zone there are found between the striæ minute clefts that penetrate the stroma and communicate with lymph spaces. The ciliary zone is furrowed by concentric ridges that indicate where folds are formed during dilatation.

Pigmented cells scattered through the stroma impart

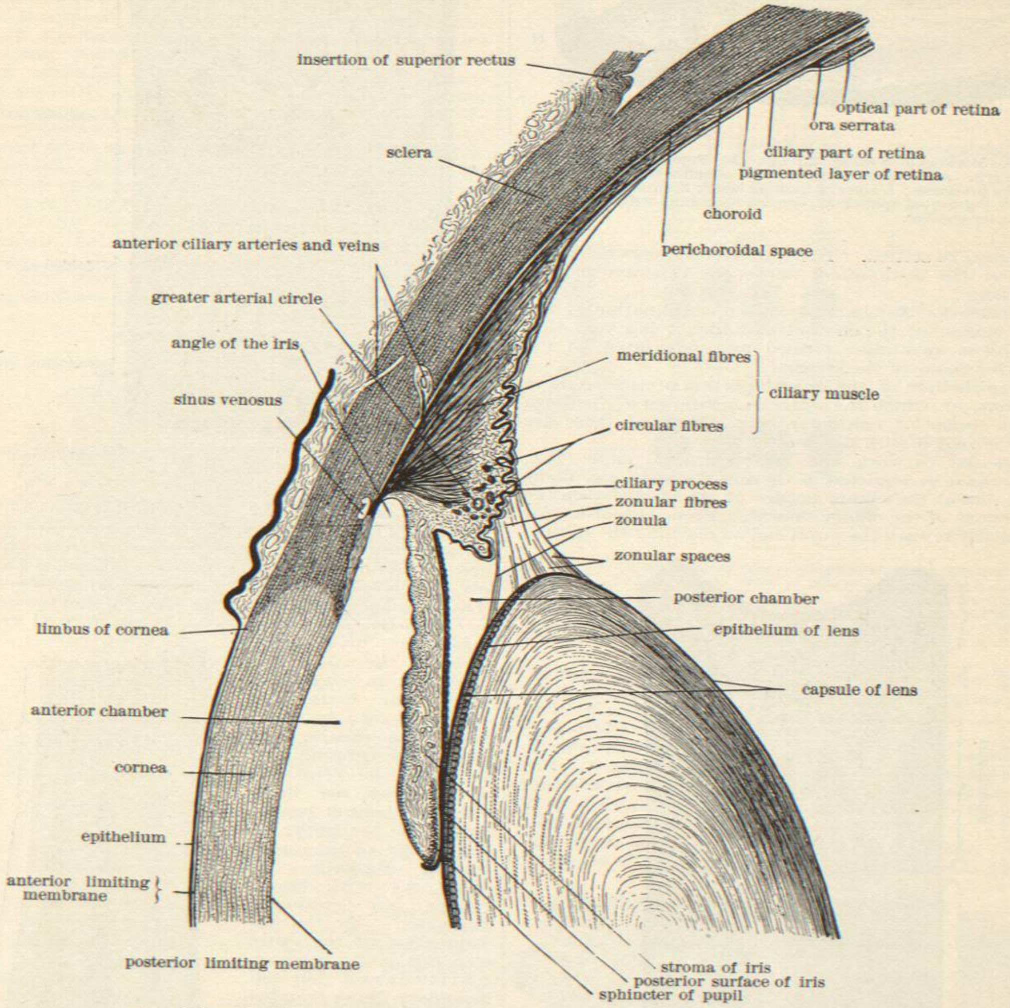


FIG. 1998.—Meridianal Section of a Portion of the Anterior Part of the Eyeball. (Toldt.)

color. When these are scanty the pigment of the posterior epithelium shows through, producing the color characteristic of blue or gray eyes according to the thickness of the translucent stroma. The stroma pigment is scattered in flecks, producing various tints of green, yellow, or brown which when very deep is called black. In albinos pigment is absent even in the posterior epithelium and the iris appears reddish from the hue of its blood-vessels.

The posterior surface (Fig. 2002) presents a series of radial ridges cut by concentric lines into rectangular spaces. W¹ʰhin the pupillary zone these ridges (*contraction folds*) are increased in number. The color of the posterior surface is normally uniform and dark from the pigmented retinal epithelium.

In minute structure the iris consists of a choroidal portion, composed of a loose stroma condensed both externally and internally to a boundary membrane and clothed also anteriorly with the endothelium of the anterior chamber, and of a retinal portion, composed of two layers of pigmented cells corresponding to the doubled margin of the optic cup.

The anterior epithelium, clear and transparent, is like that lining the posterior surface of the cornea.

The anterior boundary layer is composed of delicate interlacing bundles essentially similar to the connective tissue of the stroma.

The stroma is much like that of the choroid, being composed of numerous vessels and nerves united by loose connective tissue, with interstitial lymph spaces and muscular fibres. The latter are condensed near the pupillary margin to an annular band, the *sphincter pupillæ*,