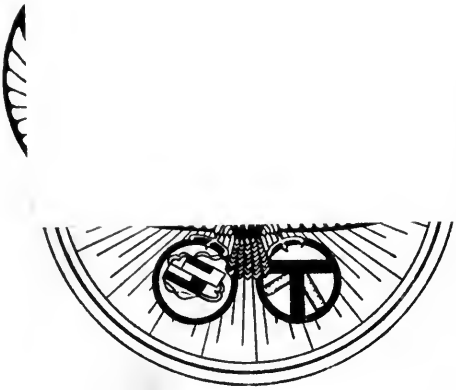

THE EYE

ITS REFRACTION AND DISEASES


The MM Co.

THE EYE

ITS REFRACTION AND DISEASES

DISEASES OF AND OPERATIONS UPON THE
EYEBALL AND ITS ADNEXA

BY

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PREFACE.

In the following pages the author has presented a systematic study of the diseases of the eye in as concise a manner as is consistent with the requirements of the subject. A very comprehensive chapter upon the eye symptoms in systemic diseases, especially valuable to the student and practitioner of general medicine, is included.

The author has omitted some of the newer appliances and drugs in the treatment of the various eye diseases, because they had not proven themselves of any especial value, or because they had not been in use long enough to speak authoritatively concerning them. In other respects the work will be found up to date, and well illustrated as was Vol. I by cuts made from drawings of the author.

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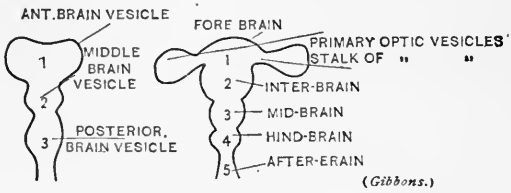
THE EYE, ITS REFRACTION AND DISEASES

CHAPTER I

EMBRYOLOGY OF EYE

The earliest definite trace of the embryo within the embryonal area consists in the formation of the medullary groove. In the neighborhood of the eighth day there arise two folds bounding a shallow median groove, which meet in front but diverge behind, and enclose between them the foremost end of the primitive streak. The medullary plate bounded by these medullary folds grows rapidly in length, the primitive streak always remaining at the hinder end. The medullary folds constantly increase in height, and the included medullary or neural groove becomes correspondingly deeper. The medullary folds soon approximate their free edges along the dorsal aspect of the embryo, and finally close in the neural canal. Fusion begins at a point somewhat behind the anterior extremity of the embryo, and progresses towards the posterior end. The anterior extremities of the medullary folds remain ununited for some time, but soon become expanded, and even before their fusion there is evidence of three distinct dilatations, the primary brain vesicles. The foremost of these, the anterior brain vesicle, occupies the foremost end of the neural canal, and is the largest of the three, the middle and posterior vesicles being less expanded but of greater length. Two lateral outgrowths take place from the anterior brain vesicles, even before the complete formation of the other two brain vesicles. These outgrowths, the primary optic vesicles, soon become constricted from the brain vesicle, which by invagination of its sides becomes converted into two. The hinder brain vesicle also becomes

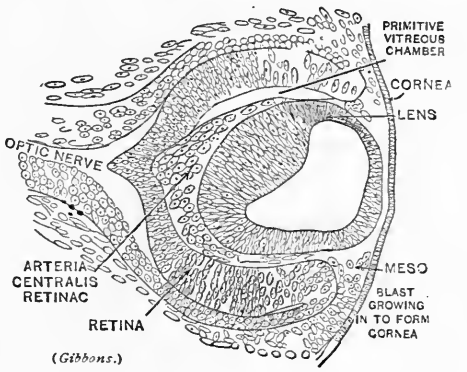
subdivided. There are then at this stage of development five so-called secondary brain vesicles. Designated from before backward, as the fore-brain or prosencephalon; the inter-brain or thalamencephalon; the mid-brain or mesencephalon; the hind-brain or epencephalon, and the after-brain or the metencephalon.



In the fully formed brain these secondary brain vesicles are respectively represented by the lateral ventricles, the third ventricle, the aqueduct of Sylvius, and the fourth ventricle, while from the walls of the vesicles develop the structures surrounding these spaces. At their first appearance the optic vesicles stand at nearly right angles with the long axis of the embryo, and their stalks are short and wide. The stalks soon become constricted from above downwards, and also somewhat inwards and backwards, causing the vesicles to appear to spring from the under part of the fore-brain. The stalks soon become comparatively narrow and constitute the rudiments of the optic nerves, the relations of the optic vesicles have now changed so that they open into the fore part of the thalamencephalon.

In attaining its full expansion the primary optic vesicle encroaches to such an extent upon the surrounding mesoderm, lying between the eye-sac and the surface of the embryo, that an extremely thin stratum separates the vesicle from the surface ectoderm, in birds the intervening mesoderm is wanting and the optic vesicle comes in contact with the surface ectoderm. Each optic vesicle is regarded as possessing four walls, a lateral or outer wall, a mesial or inner wall, a lower and an upper wall. After the vesicle reaches the surface layers it becomes much altered by the invagination of its lateral or outer wall, that in contact with the surface ectoderm. In consequence of the invagination the cavity of the primary optic vesicle is gradually reduced, and finally entirely obliterated by the application of the

lateral wall to the mesial wall. The cavity which results from this involution gradually assumes a cupped form, and is known as the secondary optic vesicle, or optic-cup. The ectoderm lying over the optic vesicle has in the meantime been undergoing proliferation, and sinks into the invaginated optic cup, forming a depression of the surface ectoderm known as the lens pit. The thickened ectoderm entirely fills the optic cup, separated from its walls in mammals by a thin layer of mesoderm. The lens pit increases in depth and its edges finally coalesce, giving rise to the lens vesicle, from which the crystalline lens is developed. The lens vesicle after a short while becomes detached from the surface ectoderm and lies completely surrounded by mesodermic tissue.



The mesoderm overlying the lens-sac gives rise to the stroma of the cornea, while the corresponding ectodermic area becomes the corneal epithelium. After the development of the lens-sac the growth of the inner wall of the latter is not as rapid as the pushing in of the optic-cup, and in consequence a space is soon formed between the lens-sac and the invaginated lateral wall of the optic-cup ; this space is the primitive vitreous chamber. From the beginning of the formation of the optic-cup there is a gradual proliferation of the cells of the invaginated wall of the optic vesicle, which is termed the retinal layer, from the structure to which it gives rise. The outer layer of the optic cup in contrast becomes much attenuated, and rapidly develops pigment within its cells. This layer eventually gives rise to the pigment epithelium of the retina, the inner thickened layer giving rise to the remaining portions of the mature retina. The invagination of the optic vesicle is not limited to its lateral wall, but involves the lower wall and the hollow optic stalk as well. This

inferior groove is spoken of as the chorioidal cleft. It establishes communication between the surrounding mesoderm and the interior of the optic cup, and allows the mesoderm which forms the vitreous stroma to enter the optic-cup. After the mesoderm with its blood vessels has entered the groove formed by the invagination of the inferior wall of the optic cup and stalk, the groove closes by the approximation of its edges. The imprisoned mesodermic tissue in the optic stalk finally gives rise to the connective tissue of the nerve and its blood vessels, to the arteria centralis retinæ.

The crystalline lens when first formed is somewhat elliptical in section with a central cavity of the same shape. There is little difference between its two walls each consisting of a single layer of elongated columnar epithelium, but by the time however, that the lens-sac becomes isolated from the surface ectoderm, there has begun a differentiation between its walls. The hind wall becomes much thicker and tends to obliterate the central cavity by becoming convex in front, and its cells become elongated and fiber-like. The front wall on the contrary becomes thinner and thinner, and its cells more flattened and pavement-like. In a short while the cavity of the lens becomes entirely obliterated. The front wall becomes somewhat thickened at the edge of the lens where it is continuous with the posterior wall, and becomes more and more attenuated over the rest of its extent until it is represented by a single layer of flattened cells, which ultimately form the epithelium of the anterior limb of the capsule of the lens. The subsequent changes undergone consist chiefly in the elongation and multiplication of lens-fibers, with a partial disappearance of their nuclei. During their proliferation they become arranged in the manner characteristic of the mature lens.

The lens-fibers stretch from the anterior to the posterior surface of the lens, their ends being joined along certain radiating lines, which form what is known as the lens-star. The star of the anterior surface of the lens always has its superior limb vertically directed, and the remaining rays diverge laterally at angles of 120 degrees; it therefore represents an inverted Y. The rays of the

posterior star are arranged between those of the anterior surface, the vertical limb being below and the others running upward, and outwards, forming the letter Y. There are other and secondary rays that appear as the lens reaches maturity, giving rise to indistinctness in the adult star. The secondary rays are formed because the lens fibers are no longer able to reach the entire distance between the anterior and posterior surfaces of the lens as are the embryonal fibers.

The lens capsule is probably formed as a cuticular membrane by the epithelium of the lens, but many regard it as a product of the mesoblast. The vitreous humor is a product of the mesoblast, entering the cavity of the optic-cup by the chorioidal cleft, already referred to. It is nourished by the blood vessels that enter with it. It arises as a sort of transudation, but contains not infrequently mesoblastic cells and blood corpuscles. It is a myxomatous tissue, intermediate in its character between connective tissue and the fluid contained in the serous cavities of the body. Surrounding the lens from the second month to the end of gestation there is a particularly vascular tunic formed of mesoblast, known as the tunica vasculosa lentis. This structure nourishes the growing non-vascular lens and finally atrophies at the end of term. The blood vessels of the tunica are derived from those of the vitreous humor.

The anterior central portion of the tunica vasculosa lentis is called the membrana pupillaris, and that situated more peripherally, the membrana capsulo-pupillaris. This structure is best developed about the seventh month. At times it is seen at birth as a persistent pupillary membrane. Aiding in the blood supply of the tunica vasculosa is an arterial twig from the vessels that occupy the primitive optic nerve. This vessel, the hyaloid artery, runs from the entrance of the optic nerve into the eyeball through a central channel in the vitreous to the posterior surface of the lens, it finally dwindles, its canal becoming a lymph channel, the hyaloid canal.

Proliferation of the cells of the outer wall of the optic-cup soon shows a differentiation into cells destined to become the nervous

elements of the retina and those designed for the connective tissue of the retina. The two layers of the optic cup about its lips, so to speak, do not participate in the differentiation that is going on in the more posterior portions, but become fused together. This front portion accompanied by the chorioidal tissue that surrounds it is thrown into folds, the ciliary ridges, while further forward it bends in between the lens and the cornea to form the iris. The original opening of the optic cup is now narrowed to a smaller orifice, the pupil. The mesodermic tissue forming the stroma of the iris becomes more or less pigmented. The forward growth of the anterior lip of the cup contributes the double-layered and finally deeply pigmented epithelium covering the inner surface of the ciliary folds and iris as far as the pupil. (Pars ciliaris retinæ, and the pars retinæ iridica.) The anterior limit of the retinal layer or posterior portion of the optic-cup, that early shows a differentiation in the thickness of its two layers, is well defined and known as the ora serrata.

With exception of the corneal epithelium, the lens and the nervous tunic with its connection with the brain, all parts of the eyeball are formed from the mesoderm that surrounds the optic-cup. The posterior segment of the surrounding mesoderm becomes divided into an outer dense connective tissue-like envelope, which becomes the sclerotic, and an inner coat, which soon can be distinguished by its looser texture and greater vascularity, as the embryonal chorioidal coat. The thin layer of mesodermic tissue that early separates the lens-vesicle from the surface ectoderm becomes cleft, the inner portion of which becomes fused with the pupillary membrane, while outer portion forms the stroma of the cornea and its endothelium, the intervening cleft forming the earliest indication of the anterior chamber. The optic nerves are derived from the at first hollow stalk of the optic vesicles. Their cavities gradually become obliterated by the thickening of their walls, proceeding from the retinal end towards the brain. While the proximal ends of the optic stalks are still hollow, the rudiments of the optic chiasm are formed at the roots of the stalks, the fibers of one growing over into the attachment of

the other. After the cleft through which the mesoderm gains entrance into the center of the nerve closes and the stalk is converted into a solid cord by the thickening of its walls, all connection between the optic nerve and the outer wall of the optic-cup disappears, the optic nerve simply perforating the outer wall, remaining in connection with the inner one.

The most important accessory structures connected with the eye are the eyelids. They are developed as simple folds of the integument with a mesoblastic prolongation between the two laminæ. They are two in number, and their inner surface is lined by the conjunctiva, a modified epiblast covering the cornea and portion of the sclerotic. The lachrymal gland and the lachrymal duct are formed by solid ingrowths of the conjunctival epithelium. The other orbital tissues save the nerves are formed from the mesoderm.

To sum up. From the ectoderm are derived: Conjunctiva and corneal epithelium, the lens, with its capsule (?), and anterior epithelium; the optic nerve; retina, with the pars ciliaris retinæ, and pars retinæ iridica; integument of the lids and glands; lachrymal gland and lachrymal duct.

From the mesoderm: The cornea with its posterior epithelium; sclerotic; chorioid, ciliary bodies; iris and anterior epithelium; vitreous; sustentacular tissue of optic nerve; suspensory ligament of lens, capsule of lens (?) and vessels of the retina; muscular tissue and fascia of lids and of the orbit.

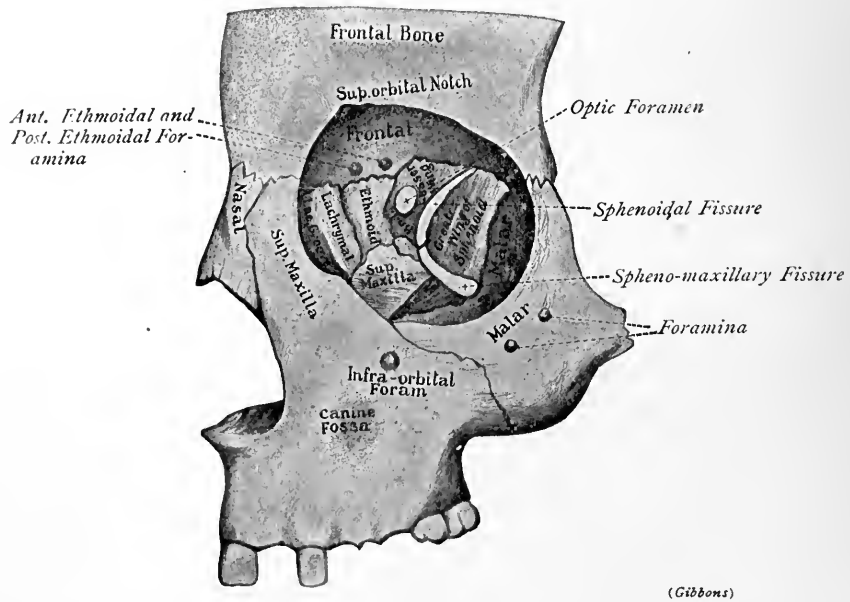
CHAPTER II

ANATOMY OF THE APPENDAGES OF THE EYEBALL

The appendages of the eye are: the orbits, the eyebrows, the eyelids, the conjunctiva, the lachrymal apparatus, the extraocular muscles, the aponeurosis and vessels and nerves of the orbit.

THE ORBITS.

The orbits are two more or less pyramidal-shaped fossæ. Their bases which look somewhat outwards correspond with the facial



plane, their apices are directed backward and inward, and are occupied by the inner extremity of the sphenoidal fissure. Each orbit has a roof, or upper wall, a floor or lower wall, a temporal or external

wall and a nasal or internal wall. The angles between these four conventional walls are not well marked but rounded off, the surfaces pass gradually one into the other, so that the orbits perhaps are more conical than pyramidal in shape.

The roof of the orbit is concave and directed downwards and backwards, formed in front by the orbital plate of the frontal; behind by the lesser wing of the sphenoid. The surface presents internally a depression for the pulley of the superior oblique muscle; externally the depression for the reception of the lachrymal gland, and posteriorly the suture between the frontal and the lesser wing of the sphenoid. The floor is nearly flat and of less extent than the roof; it is formed in most part by the orbital process of the superior maxilla; in front to a small extent by the orbital process of the malar, and behind by the orbital process of the palate. This surface presents at its anterior and internal part the depression for the attachment of the inferior oblique muscle; externally the suture between the maxillary and malar bones; near the middle the infraorbital groove, and posteriorly the suture between the maxillary and palate bones. The inner wall is flat and formed from before backwards by the nasal process of the superior maxillary, the lachrymal; the os planum of the ethmoid, and a small part of the body of the sphenoid. This surface presents the lachrymal groove; the lachrymal crest, and the sutures connecting the ethmoid with the lachrymal bone in front and the sphenoid behind. The outer wall is formed in front by the orbital process of the malar bone; behind by the orbital plate of the sphenoid (greater wing), upon it are two orifices of the malar canals, and the sutures connecting the sphenoid and the malar bones. Each orbit is formed of seven bones — the frontal, sphenoid, ethmoid, superior maxillary, malar, lachrymal and palate; but three of these bones — the frontal, ethmoid and sphenoid — enter into the formation of both orbits, so that the two orbits are formed of eleven bones only. If the long axes of the orbits be prolonged they meet in the vicinity of the sella Turcica, including an angle of about 43 degrees; their posterior poles lie about 18 degrees below the hori-

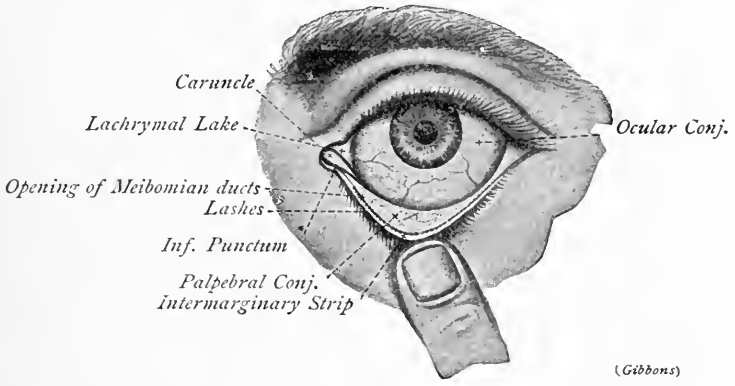
zontal plane. The distance between the centers of the bases of the orbits is on the average 60 mm. The depth of the orbit varies from 40 to 45 mm., being a little larger in the male. The capacity of the average orbit is about 30 cm.

The superior external angle of each orbit presents from before backwards, the suture connecting the frontal with the malar, and with the orbital plate of the sphenoid behind; posteriorly is the foramen lacerum anterius, or sphenoid fissure, transmitting the third, fourth, ophthalmic division of the fifth, and sixth nerves and the ophthalmic vein. The upper inner angle presents the sutures connecting the frontal with the lachrymal in front and with the ethmoid behind. It is perforated by two openings—the anterior and posterior ethmoidal foramina. The anterior of these transmits the nasal nerve and the anterior ethmoidal artery, and the other the posterior ethmoidal artery and vein. The inferior external angle presents the spheno-maxillary fissure, which transmits the infraorbital vessels and nerve, the ascending branches from the spheno-palatine ganglion, and the orbital branch of the superior maxillary nerve. The inferior internal angle formed by the union of the os planum with the superior maxillary and the palate bones, presents no points of interest. Corresponding to the apex of the orbit is the optic foramen, transmitting the optic nerve and the ophthalmic artery.

The eyebrows are two projecting arches of integument, covered with short thick hairs which form the upper boundaries of the orbits.

Anatomy of the Eyelids and Conjunctiva.—The eyelids (palpebræ or blephara) are two movable skin folds placed in front of the eyeball, protecting it in a certain measure from injury by their closure. The lids are reinforced by a development of muscular and connective tissue between their surface laminæ. The eyelids in about the third month of fœtal life are fused along their approximated edges, forming a closed sac surrounding the anterior segment of the eyeball. Before birth the permanent separation of the lids takes place. The skin or ectoderm lining the lids by this time has lost the characteristics of skin, and assumed those of a mucous membrane—the

conjunctiva. The upper lid is the larger of the two and more freely movable, and supplied by a special elevator muscle—the levator palpebræ superioris. The space included between the free borders of the open lids is called the palpebral fissure or opening.



The eye is commonly spoken of as being large or small according to the size of this opening. It resembles an almond more or less in shape; its length is usually 28–30 mm. and its widest point 13 mm. The two palpebral openings are seldom symmetrical. The lids are joined at the outer and inner canthi. The internal canthus is more or less rounded while the outer is sharp, the lids joining at a very acute angle. At the inner or mesial canthus the borders of the lids enclose between them the lacus lachrymalis or lachrymal lake, which space is partially occupied by a reddish, spongy-looking mass, the caruncula lachrymalis. The caruncula is an isolated piece of skin and contains a few large modified sweat-glands, sebaceous glands and a few fine hairs springing from its summit. Some say that it also contains fat cells and involuntary muscle fibers. Externally the caruncle sinks to the level of the ocular conjunctiva. The lachrymal lake is bounded externally by a vertical fold of conjunctiva —the plica semilunaris, or semilunar fold. This fold is the remains in man of the third eyelid or nictitating membrane of fowls and amphibians. There are at times found within the semilunar fold

minute pieces of cartilage and acinous glands—the remains of the crescentic cartilage and gland of Harder found in lower animals. The cartilage of Harder in the lower animals imparts resistance to the third eyelid and the glands lubricate it so that it works smoothly over the eyeball. When the eyes are directed straight ahead the corneæ lie a little external to the center of a line joining the canthi.

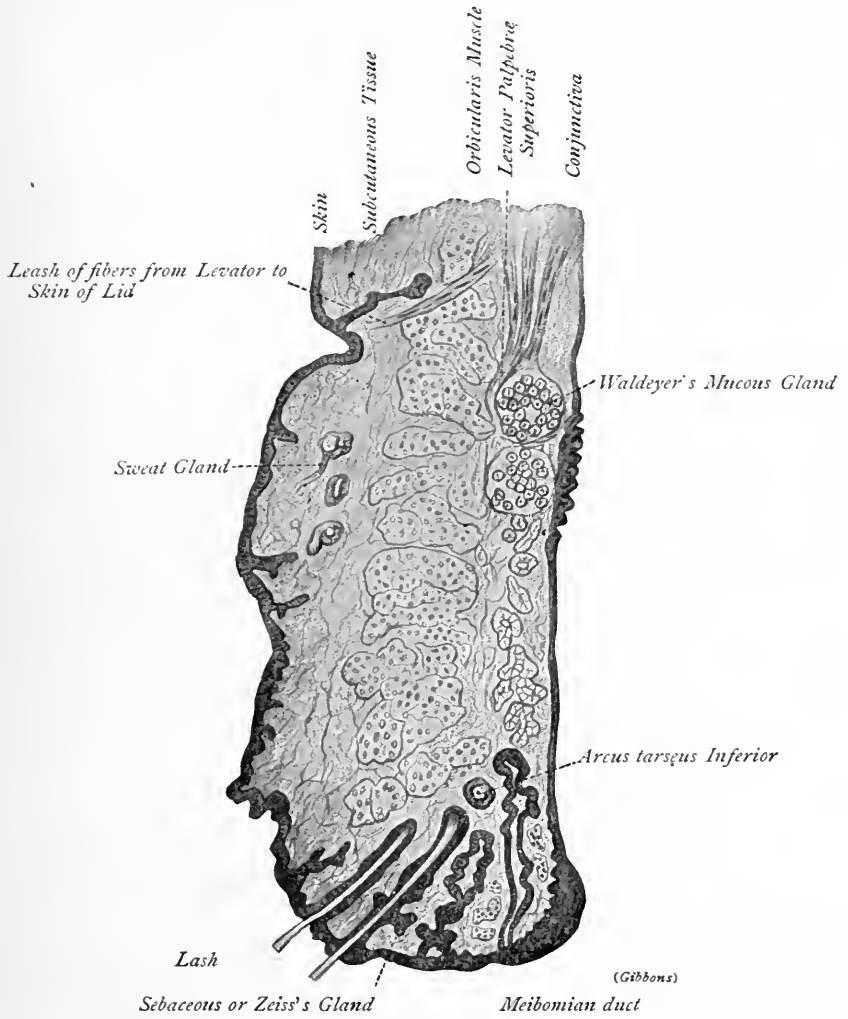
As a rule the nasal canthus lies a little lower than the temporal. The edge of the lower lid as a rule does not quite reach the lower edge of the cornea, while the upper one covers a small variable segment of its upper edge. Closure of the eye is chiefly affected by dropping of the upper eyelid, which makes an excursion of about 3 mm., the distance traversed by the lower lid being somewhat less. When the eyelids are closed during sleep or at other times, especially when forcibly closed the eyeballs are rotated upwards and outwards to escape pressure by the stiff tarsal cartilage, upon the corneæ.

This motion of the eyeball is well seen in a case of Bell's paralysis, when the patient makes an attempt to close the lids. By it the cornea is protected from drying during sleep.

Winking can be performed by will but is usually involuntary, the result of a reflex action, which is excited by the sense of dryness of the eye or by the presence of dust, smoke or what not. The afferent impulse is through the trigeminus, which is the sensory nerve of the eyeball and its adnexa, and is called by some anatomists the sentinel of the eye. The efferent impulse is through the seventh nerve. By the act of winking the eyeball is covered by a layer of lachrymal fluid, preventing its desiccation; it carries the dust away from the eye, and lastly it propels the lachrymal fluid towards the inner canthus and into the puncta. Interference with the act of winking as in cases of seventh nerve paralysis, causes the cornea to become dry, and foreign bodies that lodge upon it are apt to give rise to inflammatory reaction. Tear-drop is also apt to develop, as it is the act of winking that draws the tears into the lachrymal sac.

The margin of the closed upper eyelid is convex downwards, just the reverse of what it is when elevated. The minute anatomy of the

lids from before backwards is as follows: Skin, subcutaneous tissue, orbicularis muscle, tarsal cartilage, Meibomian glands and conjunctiva.



SECTION OF UPPER EYELID.

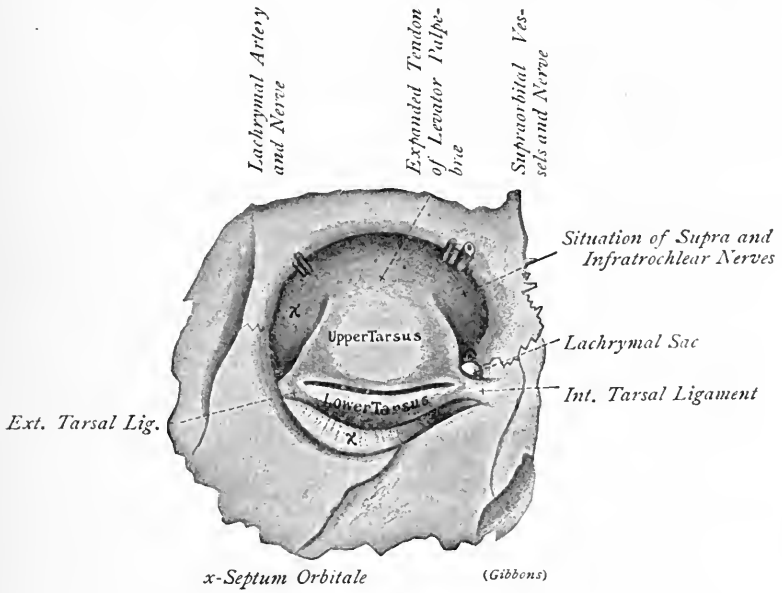
The skin of the lid is like the delicate skin that covers other portions of the body, the hair follicles and hairs are extremely small,

and the subcutaneous tissue is as a rule free from fat. At times the lids become pendant from an abnormal amount of adipose tissue, giving rise to the condition known as ptosis adiposa. The free margins of the skin surface of the lids contain a number of stiff hairs, the eyelashes or cilia usually arranged in two or more rows. Those of the upper lids are longer and more regular than those of the lower lids. The average life of the lashes is probably about four months, the older ones falling and being replaced by newer and more slender hairs. The skin of the upper lids is very lax and in many hangs down in a fold, even to the lid border when the eyes are open. The name of covering fold is given to this redundancy of skin. When the lids are elevated under normal conditions this covering fold is pulled in between the orbital ridge and the root of the lid by a few fibers of the levator palpebræ that are attached to it.

The muscular layer of the lids is formed by the palpebral portion of the orbicularis palpebrarum, which in cross-section appears as a number of irregularly scattered bundles of voluntary muscular tissue. There is a certain amount of muscular tissue found between the ciliary and the conjunctival surfaces of the upper lids, especially near their free borders, called the muscle of Riolan. Imínediately behind the orbicularis muscle is found the tarsus which consists of dense connective tissue in which are imbedded the Meibomian glands. These are long acinous glands arranged parallel with each other and traverse the tarsus from its attached to its free border, upon which they open by a number of puncta placed along the posterior edge of the lid. The glands are longest in the middle of the lid. They are really nothing but large sebaceous glands. They secrete sebum that anoints the edges of the lids, by which the overflow of tears is hindered, and the edges of the lids are protected from maceration by this oily application. Near the convex border, that is the upper border of the tarsus, there is often found acinous mucous glands, called Waldeyer's glands. The upper tarsal plate is greater in extent than the lower plate, measuring about 10 mm. at its widest point. The extremities of the tarsi are united together and to the

orbital walls by bands of fibrous tissue, the mesial and the lateral palpebral ligaments.

The tendon of the levator palpebræ as it expands into the upper lid becomes closely related to the inward extension of the orbital fascia, forming a sort of partition — the septum orbitale, closing in



Tarsal Plates and Orbital Facasia.

the periocular structures, preventing their extrusion. In the upper lid the septum orbitale of palpebral fascia blends with the tendon of the levator, forming together a layer of connective tissue lying between the orbicularis and the conjunctiva above, and is inserted in great measure into the tarsus below, a few fibers run anteriorly to the tarsus. In the lower lids the palpebral fascia joins the tarsus with the fascial expansion connected with the inferior extra-ocular muscles. The middle portion of the aponeurosis of the levator contains involuntary muscle fibers, called the levator palpebralis superioris, or the muscle of Müller. These fibers are inserted into the

tarsus. In the lower lid there are a few involuntary muscular fibers interwoven with the fibers of the orbicularis muscle, constituting the inferior palpebral muscle of Müller. The free margin of the lid presents an external and an internal border. Along the anterior (external) border are arranged the cilia and the sebaceous glands supplying them, called the glands of Zeiss. Along the posterior (internal) edge of the lid open the Meibomian puncta. The intervening zone — that between the margins of the lid — is known as the intermarginal strip. A number of large and modified sweat glands, the glands of Moll, lie midway between the two borders of the lid, and open in close proximity to the hair follicles.

Upon the intermarginal area of each lid dipping into the lachrymal lake is a small papilla — the lachrymal papilla, bearing a small opening upon its summit — the lachrymal punctum (superior and inferior). The lachrymal puncta are the beginnings of small canals that converge behind the caruncle and empty into the lachrymal sac.

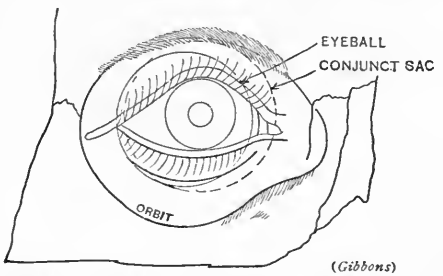
The Tarsal Ligaments. — The external tarsal ligament or the ligamentum canthi externum is simply a rather pronounced accumulation of connective tissue in the substance of the orbicularis and attached externally to the margin of the orbit.

The internal tarsal ligament or the ligamentum canthi internum needs a more precise description. It arises from the frontal process of the superior maxillary bone and first passes straight outward, across the anterior wall of the lachrymal sac. It then bends backwards, winding around the anterior and external walls of the tear sac, and runs backward to the crista lachrymalis of the lachrymal bone behind the sac. The ligament is then formed of two branches which meet at the point where it bends backwards. The anterior branch is situated directly beneath the skin, and is made visible by putting the lid upon a stretch. The posterior branch is brought to view only by dissection. The two branches with the lachrymal bone bound a space which is triangular in section, in which lies the lachrymal sac; the walls of the latter are united to the inner surface of the ligament by loose connective tissue. Some of the fibers of the orbicularis

spring from the anterior and some from the posterior branch of the ligament. The latter fibers are partly continued out beyond the posterior branch of the ligament upon the inner wall of the orbit, and called Horner's muscle. When the orbicularis muscle contracts it draws up the internal palpebral ligament and with it the wall of the lachrymal sac. This sac is dilated by this means and the tears drawn into it.

The Conjunctiva (con, together and jugare, to join) invests the inner surface of the lids and the anterior segment of the eyeball, and thus conjoins the lids and the eyeball, it is therefore divided into an ocular and a palpebral portion. The fold which marks the limits of the conjunctival sac as it passes from the lids upon the eyeball is called the fornix or the fold of transition (retrotarsal fold). When the lids are closed the conjunctiva forms a closed sac.

The palpebral conjunctiva is closely adherent to the underlying tarsus, and on account of its thinness the Meibomian glands are seen through it clearly. The surface of it is smooth and glistening and a few small vessels are seen running here and there. (See figure, p. 11.)

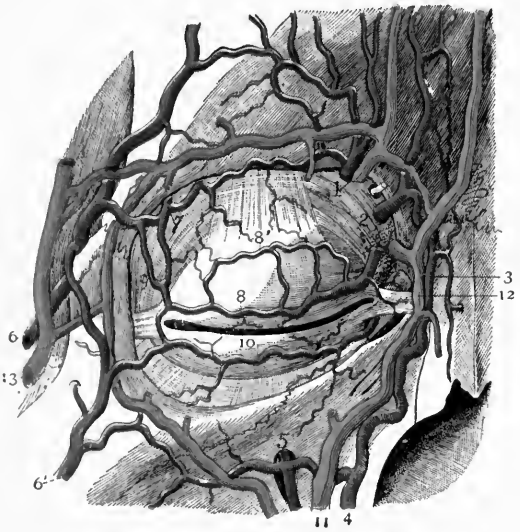


(*Gibbons*)
Relation of Eyeball, Conjunctival Sac and Orbit.

The tarsal conjunctiva is really only perfectly smooth in the young. In old persons it has a velvety appearance, especially upon the upper lid. This condition of the membrane is often spoken of as papillary, but in reality the appearance is not produced by papillæ but due to the fine folds into which the thickened membrane has been thrown. In cross-section these folds give the appearance of newly formed tubular glands, called after their discoverer Henle's glands. A papillary condition of the mucous membrane is always the result of a chronic irritation.

It is covered with a laminated cylindrical epithelium, the mucous membrane proper being of the adenoid type, containing an abundant

quantity of lymph cells, increasing in number when the tissue is disturbed by inflammation. Its glands are acinous mucous glands, found chiefly as has been noted along the upper border of the tarsus. Analogous glands are also found in the fornix conjunctivæ, called Krause's glands. The blood supply of the upper lid is from two arterial arches, the arcus tarseus superior, and the arcus tarseus inferior, lying upon the anterior surface of the tarsus near its upper and lower edges. To reach the conjunctival surface of the lid branches of the inferior arch perforate the tarsus through its entire thickness, 2–3 mm. above the free edge of the lid.



Blood-vessels of the Eyelids (Testut): 1, supraorbital artery and vein; 2, nasal artery, anastomosing with terminal branch of angular (3) of facial artery (4); 5, infraorbital artery; 6, superficial temporal artery; 6′, malar branches of transverse facial; 7, lachrymal; 8, superior palpebral artery, with secondary arch (8′), and anastomoses (9) with temporal and lachrymal; 10, inferior palpebral artery; 11, facial vein; 12, angular vein; 13, superficial temporal vein.

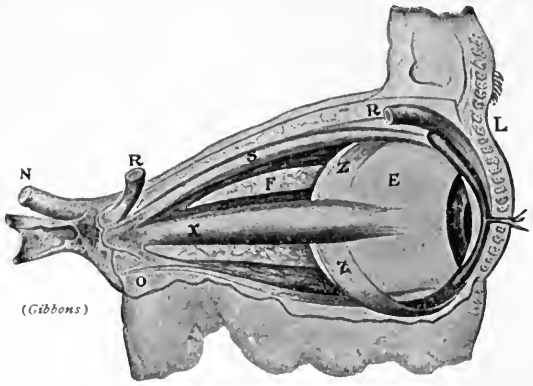
The line along which the vessels come out is marked by a shallow groove upon the conjunctival surface of the lid—the sulcus subtarsalis, or the retro-ciliary sulcus. The region of transition of the conjunctiva is the loosest part of the conjunctiva. It is easily brought into view below by everting the lower lid, but is not so readily seen above, not unless a double eversion of the upper lid be made. The fornix insures the eyeball free motion. If the conjunctiva passed directly from the lids to the eyeball, every movement of the latter would be hampered, as is seen in cases in which the fornix has been destroyed. Through the lower fornix are to be seen a rich plexus of veins,

and white glistening fascia (subconjunctival fascia), which imparts to this portion of the conjunctiva its lighter color. The conjunctiva bulbi covers the anterior segment of the eyeball. It continues over the cornea though altered in its character. This continuity of tissue explains why diseased processes do not stop at the edge of the cornea but continue over the latter, as is seen especially in trachoma and conjunctivitis lymphatica. The conjunctiva corneæ is so intimately adherent to the cornea that it is considered as the epithelium of the latter. Over the cornea the conjunctiva is perfectly transparent and represented by only a few layers of epithelial cells.

The conjunctiva scleræ covers the anterior portion of the sclerotic as a thin pellicle. It is very lax and connected to the sclera by a scanty connective tissue (the episcleral tissue). A great amount of bulbar conjunctiva can be sacrificed and the gap covered by drawing the adjacent conjunctiva up over it. Around the corneal edge the conjunctiva is thin and closely adherent, forming what is called the limbus conjunctivæ (limbus, edge). The conjunctiva of the eyeball is covered with a laminated pavement epithelium, and contains no glands. The blood supply of the ocular conjunctiva is chiefly from the vessels of the fold of transition—the posterior conjunctival vessels. The anterior ciliary vessels also take part in supplying it. The latter vessels come from the muscular branches of the ophthalmic artery, and run under the conjunctiva through which they are visible, until near the edge of the cornea, where they perforate the outer tunic of the eyeglobe to supply the ciliary processes. Before they enter the eyeball however they give off small branches that unite with twigs from the posterior conjunctival vessels to form a number of loops around the cornea, by which the latter is nourished.

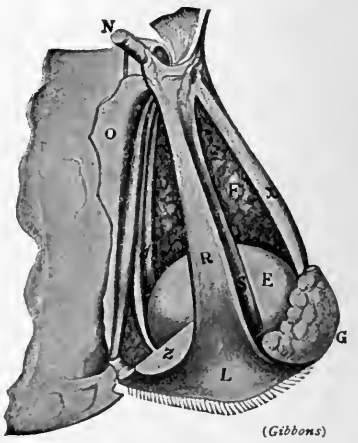
The eyeball occupies the anterior half of the orbit, in such a position that a line joining the margins of the orbit opposite the anterior pole comes in contact with the cornea. The axis of the eyeball makes with that of the orbit an angle of about 42–45 degrees and it lies 1–2 mm. nearer the outer than the inner wall of the orbit, and possibly slightly nearer the roof than the floor. The eyeball with its

vessels and nerves is supported by the extraocular muscles which surround it, and by a fibro-adipose tissue that fills in all the interstices between these structures. Variations in the amount of intraorbital fat are frequent, as an example may be mentioned the sunken or hollow-eyed appearance following sickness. The relation of the eyeball to the conjunctival sac and orbit is shown in the figure on page 17.



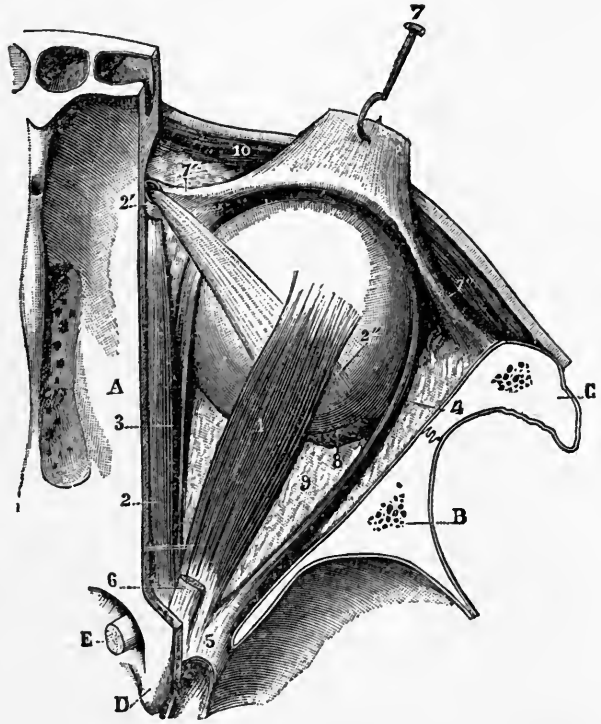
The Orbital Contents seen from Temporal Side.

Extraocular Muscles.—The extrinsic muscles of the eyeball are six in number, four straight and two oblique muscles. The four straight muscles are the rectus superior, inferior, externus and internus. These with the superior oblique and the levator of the eyelid take their origin from a fibrous ring that is attached to the apex of the orbit. This fibrous ring or the ligament of Zinn passes down the inner side of the optic foramen, as far as its lower margin, extends across the inner part of the sphenoidal fissure, being attached to its lower border, again crosses the fissure about its middle and hence runs to the upper margin of the optic foramen. The tendinous expansions of the recti muscles are at first continuous, forming a flattened tube which extends 2–3 mm. before separating into individual tendons.



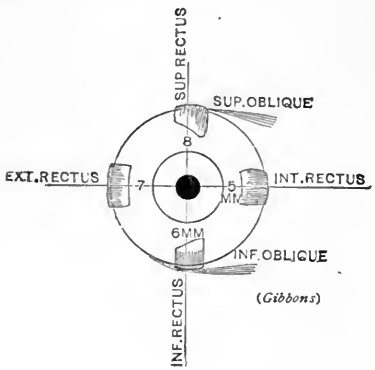
Orbital Contents seen from Above: *E*, eyeball; *L*, upper eyelid; *G*, lachrymal gland; *X*, exterior rectus muscle; *Y*, interior rectus muscle; *Z*, inferior oblique muscle; *Z'*, superior oblique muscle; *R*, levator palpebræ superioris; *S*, superior rectus muscle; *F*, orbital fat; *N*, optic nerve; *O*, portion of orbital fascia.

The recti muscles diverge as they run towards the eyeball, forming a muscular funnel. The optic nerve forms the axis of this funnel and the eyeball its base. The levator palpebræ and the superior rectus muscles arise together from the upper border of the optic foramen; the internal rectus from the inner and lower part of margin of the foramen; the inferior rectus from its lower border; the external rectus arises from two heads. The lower and larger head is attached to the inferior and inner border of the sphenoidal fissure, and to that portion of the ligament of Zinn that stretches across the fissure; the



Ocular Muscles of Right Side, Viewed from Above, After Removal of Roof of Orbit (Testut): *A*, frontal bone; *B*, section of great wings of sphenoid; *C*, section of malar bone; *D*, anterior clinoid process; *E*, optic nerve; 1, superior rectus; 2, superior oblique muscle with its pulley (2′) and its insertion into the eyeball (2″); 3, internal rectus; 4, external rectus; 5, common origin (ligament of Zinn) of muscles; 6, cut tendon of levator palpebræ; 7, 7′, 7″, palpebral expansion of same; 8, insertion of inferior oblique; 9, intraorbital cushion of fat; 10, orbicularis palpebrarum.

upper or accessory head springs from the outer wall of the sphenoidal fissure. Between these two heads is found a small amount of connective tissue and pass the third, sixth and nasal branch of the fifth nerves, along with the ophthalmic veins. Just posterior to their insertion into the eyeball the recti muscles terminate in thin membranous expansions, the fibers of which become intimately woven with the fibers of the sclerotic coat. The lines of attachment are slightly convex towards the corneal margin, and are at varying distances from it, the inner rectus being the nearest to and the superior rectus the furthest removed. The length of the tendons of the recti and the distances of insertion from the cornea, according to Fuchs and Merkel, are as follows:



	Length of Tendon.	Distance of Insertion from Cornea.
Internal Rectus	8.8 mm.	5.5 mm.
Inferior Rectus	5.5 mm.	6.5 mm.
External Rectus	3.7 mm.	6.9 mm.
Internal Rectus	5.8 mm.	7.7 mm.

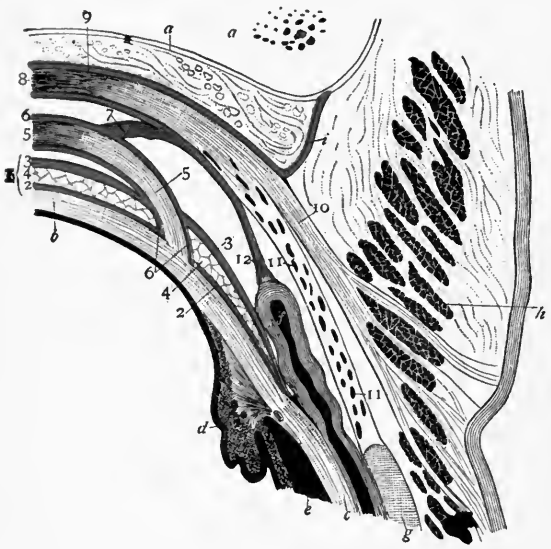
The lines of insertion therefore recede from the margin of the cornea from that of the internus to the superior, with a corresponding diminution in the effectiveness of pull upon the eyeball. The distance of insertions may be taken for practical purposes, 5, 6, 7 and 8 mm. respectively. The superior oblique or trochlearis, arises about two millimeters in front of the optic foramen, it proceeds forward in close relation to the roof of the orbit as far as the trochlear fossa where its rounded tendon passes through the fibrous pulley of the trochlea; it then changes its direction turning upon itself at an angle of 50 degrees and runs outwards and backwards and passing

under the superior rectus becomes attached to the sclera midway between the cornea and the optic nerve entrance, and somewhat external to the insertion of the superior rectus muscle. The inferior oblique muscle is situated within the anterior part of the orbit, arising from its internal wall close to its anterior margin. The origin of the muscle is by short tendinous fibers, it passes upward, backward and outward, between the inferior rectus and the floor of the orbit and is inserted into the eyeball at the posterior and outer part beneath the external rectus. The levator palpebræ superioris is the only other muscle found within the orbit. It arises by a pointed tendon above and in front of the optic foramen, in close connection with the superior. It passes along close to the roof of the orbit and becomes attached to the root of the upper eyelid which it elevates.

Part of its insertion is in front of the tarsal plate, blending with the orbicularis muscle fibers and part which contains non-striped or involuntary muscular tissue is inserted into the upper border of the tarsus, and is called the levator palpebralis superior or muscle of Müller. On account of the manner of insertion of the superior and the inferior recti muscles into the sclera the eyeball is not only elevated or depressed by their action but rotated about an antero-posterior axis as well. The inferior oblique by its contraction overcomes the rotating effect of the superior rectus and the superior oblique that of the inferior rectus, and thus the normally vertical meridians of the eyeballs are kept vertical. The internal and the external recti muscles simply adduct and abduct the eyeball as half of their insertion is above and half below the horizontal meridian.

The innervation of the ocular muscles is accomplished through three nerves. The third or oculo-motor nerve supplies two of the intrinsic eye-muscles, the ciliary muscle and the sphincter of the pupil, and all of the extrinsic muscles save the superior oblique and the external rectus. The abducens nerve (sixth) is reserved for the external rectus, and the patheticus or trochlear nerve (fourth) for the superior oblique. The nuclei of these nerves lie upon the floor of the fourth ventrical.

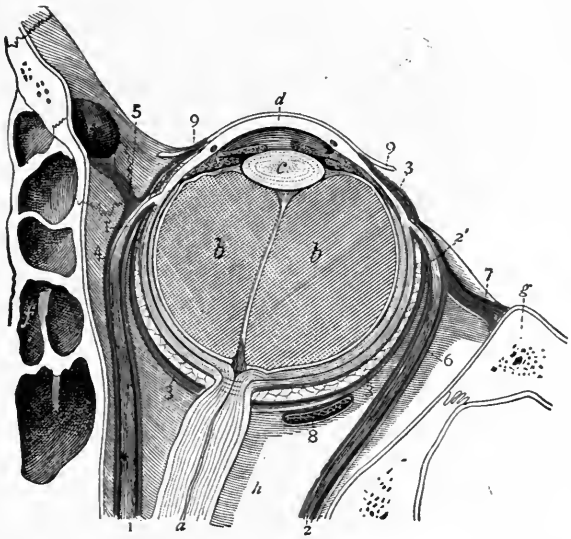
The Orbital Fascia. — The periosteum that lines the orbit is a continuation of the intracranial dura mater through the sphenoidal fissure and is blended with the periosteum around the margin of the orbit. There are numerous trabeculæ extending from the lining of the orbit between the various structures lodged within to which they afford support, and the framework thus formed is largely occupied by the periocular fat which fills the interspaces between the eyeball and surrounding structures. The intraorbital fibrous tissue forms a fascial investment for the posterior two thirds of the eyeball, and is known as the tunica vaginalis oculi, or Tenon's capsule; also called Bonnet's capsule. It is separated from the sclera by a narrow lymph-space, the space of Tenon. This space is bridged by numerous delicate bundles of fibrous tissue, dividing the general space into a number of small freely communicating spaces.



Semi-diagrammatic View of the Relations of the Orbital Fascia with the Superior Muscles (Testut): *a*, frontal bone, with its periosteum (*a'*); *b*, sclerotic; *c*, cornea; *d*, ciliary process; *e*, anterior chamber; *f*, superior fornix of the conjunctiva; *g*, superior tarsus; *h*, orbicularis palpebrarum; *i*, septum orbitale; 1, capsule of Tenon, consisting of its inner (2) and external (3) wall and the enclosed lymph-space (4); 5, 5', 6, respectively the belly, tendon and sheath of the superior rectus; 7, orbital prolongation; 8, levator palpebræ, with its sheath (9) and its conjunctival (10) and muscular (11) insertions; 12, its prolongation and insertion into the fornix conjunctivæ.

The inner surface of the capsule and the external surface of the adjacent sclera and trabeculæ are covered by broad endothelial plates, and thus closely resembling the intracranial subarachnoidean lymph-space. Between the plates lining the space of Tenon are numerous small openings or stomata

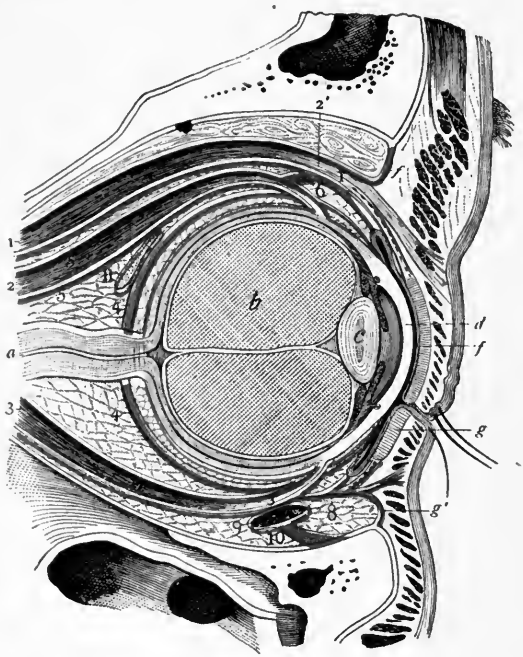
through which the lymph circulates. Tenon's space which surrounds the eyeball closely resembles the serous membrane found in connection with the joints. Its loose connection with the eyeglobe allows of free play of the latter. Posteriorly the capsule extends as far as the entrance of the optic nerve into the eyeball, where it apparently fuses with the outer layers of the sclerotic and the outer sheath of the nerve as the latter blends with the outer tunic of the eyeball. The ciliary arteries and nerves are also excluded from Tenon's space. Anteriorly the capsule lies beneath the conjunctiva with which it is intimately blended, and fused at the edge of the cornea.



Semi-diagrammatic View of the Orbital Fascia of Right Side, seen after Horizontal Section of the Eyeball and Orbit, the Lower Half of the Eyeball being Represented (Testut): *a*, optic nerve; *b*, vitreous body; *c*, lens; *d*, cornea; *e*, section of lachrymal sac; *f*, ethmoid cells; *g*, malar bone; *h*, floor of orbit; 1, 2, internal and external rectus, with their tendons (1′, 2′); 3, capsule of Tenon; 4, sheath of internal rectus with its orbital prolongation (5); 6, sheath of external rectus, with its orbital prolongation (7); 8, inferior oblique, with its sheath; 9, conjunctiva.

The tendons of the extraocular muscles pierce Tenon's capsule at their insertion into the sclera, and are separated from the lymph stream within the space by an endothelial covering. About the openings in the capsule for the tendons of the muscles there is a reinforcement of connective tissue, which is continued back along the muscles for a variable distance, and finally becomes fused with the perimysium. The reflected portion of the superior oblique muscle only is covered by a prolongation of the capsule, it ends by becoming attached to the margin of the trochlea. The sheath cov-

ering the inferior oblique runs as far as the floor of the orbit and there becomes fused with that covering the inferior rectus muscle. The ocular or inner border of the slit-like openings through which the tendons pass are strengthened by a development of connective tissue which passes along the muscles, affording them further attachment to the capsule of Tenon.



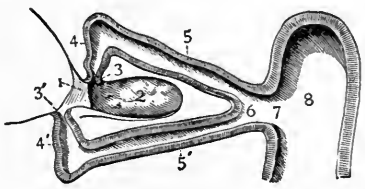
Semi-diagrammatic View of Relations of Orbital Fasciæ as seen after Sagittal Section of the Right Eye; the Internal Half of Orbit *in situ* (Testut): *a*, optic nerve; *b*, vitreous body; *c*, crystalline lens; *d*, cornea; *f*, *g*, upper and lower tarsal plates, with their ligaments (*f'*, *g'*); 1, levator palpebræ, with its tendon; 2, 3, superior and inferior recti, with their tendons (2', 3'); 4, capsule of Tenon; 5, sheath of superior rectus, with its orbital prolongations (6); 7, sheath of inferior rectus, with its orbital prolongation (8); 9, inferior oblique muscle, with its orbital prolongation (10); 11, tendon of superior oblique.

The capsule is also connected with the orbital walls forming suspensory and check ligaments. The suspensory ligament of the eyeball consists of a band of connective tissue in the anterior part of the orbit, attached internally to the lachrymal and externally to the malar bone, its broader central part blending with the capsule of Tenon below the eyeball. A somewhat similar but a less developed band lies above the eyeball, and blends with the sheaths of the superior rectus and the levator palpebræ, its forward extension coming in close relation with the upper lid. The check ligaments are stout bands of fibrous tissue which extend from the fascial sheaths surrounding the external and the internal recti muscles laterally as far as the lachrymal and the malar bones, blending with the extremi-

ties of the suspensory ligament of the eyeball. They limit the action of the inner and outer recti muscles and prevent excessive rotation of the eyeball. A somewhat similar arrangement is found in connection with the superior rectus, but its excessive action is limited by its close relation with the levator palpebræ superioris muscle. The fascial extension from the inferior rectus and oblique muscles is attached to the floor of the orbit on the one hand and blends with the suspensory ligament on the other.

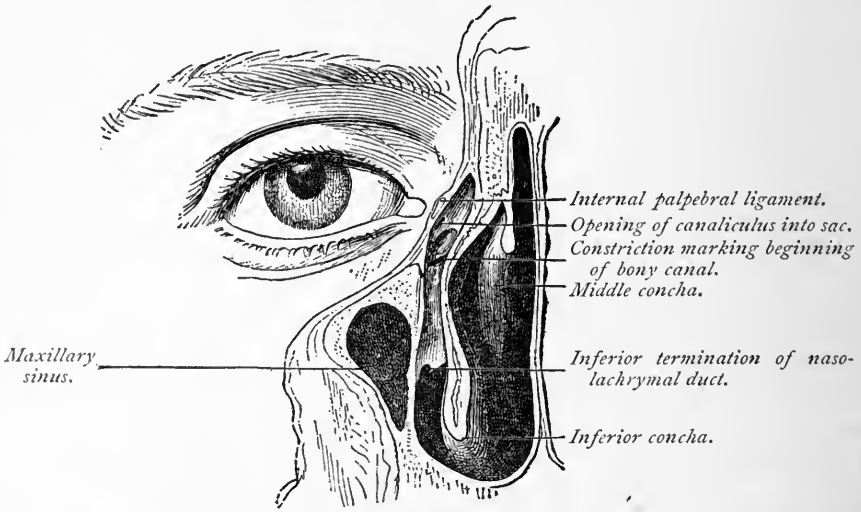
The Lachrymal Apparatus. — The lachrymal apparatus consists of the lachrymal gland (glandula lacrimalis) and its ducts, and the lachrymal passages. The latter consist of the lachrymal puncta, canaliculi, lachrymal sac and nasal duct.

The lachrymal gland is an acinous gland consisting of two portions, the larger of which is known as the superior or lachrymal gland proper, and the smaller portion as the inferior or accessory lachrymal gland. The superior portion of the lachrymal gland lies in a depression in the upper external angle of the orbit, the fossa glandulæ lacrimalis; its excretory ducts pass downward and empty into the external half of the fornix conjunctivæ. The inferior portion of the gland is much smaller and consists of several lobes, only of small size. It lies along the ducts from the gland proper, directly beneath the conjunctiva of the fornix, and can be brought into view, especially in colored people, by strongly elevating the upper eyelid while the eye is turned down and in. The secretion of the lachrymal gland, the tears, contain besides water 1.25 per cent. of salt, and .5 per cent. of albumen. The lachrymal passages begin in the puncta lacrimalia, small openings one upon the margin of each lid, the superior and inferior puncta, and near the free extremity of the lid at a spot where the tarsus terminates. Each



Section Exposing the Lachrymal Channels and Part of the Lachrymal Sac (Testut): 1, plica semilunaris; 2, lachrymal caruncle; 3, 3′, lachrymal puncta; 4, 4′, vertical portions of lachrymal canaliculi; 5, 5′, horizontal portions; 6, fused portion; 7, opening into lachrymal sac (8).

punctum, the opening of a canaliculus, is situated upon a small elevation, the lachrymal papilla. The canaliculi starting from the puncta pass vertically a short distance, when they become bent at right angles and running backward and inward, converge behind the caruncle to empty into the lachrymal sac by a common duct or separately.



Section Showing the Course and Relations of the Lachrymal Sac and Nasolachrymal Duct (Merkel).

The lachrymal sac (saccus lacrimalis) lies at the inner angle of the eye in its fossa upon the lachrymal bone (fossa sacci lacrimalis). The lachrymal sac is bounded on the inside by the lachrymal bone; in front and to the outside by the ligamentum palpebrale internum, which enables us to locate the position of the sac. When the lids are put upon a stretch by drawing them outwards, the palpebral ligament projects, the lachrymal sac then lies directly behind it and its fundus rises just above it. The lachrymal sac terminates in the lachrymal or nasal duct below (ductus lacrimalis) at the point where the cleft of the lachrymal bone merges into the bony canal. This point is the narrowest part of the canal and is called the isthmus and is particularly liable to stricture. The lachrymal duct passes down-

ward, backward and inward, and empties into the inferior meatus of the nose about two inches from the nose-tip.

According to Arlt, the course of the duct can be outlined upon the patient by laying a straight rule upon the cheek in such a way as to lie at its upper part upon the middle of the internal palpebral ligament, and below upon the furrow between the ala nasi and the cheek. In some individuals the lachrymal ducts diverge as they pass downwards into the nose, depending upon the breadth of the root of the nose and the inferior meati. Interposed between the walls of the lachrymal duct and its bony canal is a network of veins similar to the spongy tissue of the inferior turbinated bodies in the nose. By the engorgement of these veins alone the canal may be occluded. The epithelium of the mucous lining of the canaliculi is of the laminated pavement variety, and that of the sac and duct consists of a single layer of cylindrical cells. Acinous mucous glands are found in the duct and less frequently in the sac.

The mucous lining of the lachrymal passages at different places forms sort of folds which project into the lumen of the canal. The largest of these folds is called Hasner's valve, at the lower orifice of the lachrymal duct. This valve however is not capable of closing up the duct; it is simply a fold produced by the obliquity at which the duct passes through the mucous membrane of the nasal fossa.

The proper moistening of the eyeball is not dependent upon the lachrymal gland, but the mucous glands of the conjunctiva itself, Krause's and Waldeyer's glands, participate in keeping the eye moist, so that even after the extirpation of the lachrymal gland there is no unnatural dryness of the eyeball. The manner in which the tears are conveyed to the nose is still a much mooted point. The tears are conducted to the inner canthus, into the lachrymal lake by the act of winking, by the lids closing from the outer canthus inwards.

The tears are caused to enter the puncta through the act of winking. A few fibers of the orbicularis surround each punctum, which are closed by the contraction of the latter muscle and opened by its relaxation, thus drawing the tears into them, again on account of the

arrangement of the internal palpebral ligament and the muscle of Horner (the portion of the orbicularis that runs posterior to the lachrymal sac) the sac is dilated by the closure of the lids and the tears so to speak are sucked into it. The passage of the tears from the sac into the nose is caused chiefly by the elasticity of the sac, causing it to contract when distended with tears. If the lids do not close perfectly, or if the sac has lost its elasticity no matter how patent the duct may be the tears are not conveyed into the nose but run over the cheek. Or, on the other hand, there may be a stricture of the lachrymal duct without interference with the proper passage of the tears into the lachrymal sac, hence it is apparent that the passage of tears into the nose is not caused by the rarefaction in the nose during inspiration, as was formerly held by Weber and Hansen. Under normal conditions there is very little lachrymal secretion that enters the nose, unless the emotions are aroused — secretion and evaporation from the eyeball about balancing.

The Blood Supply of the Ocular Adnexa. — The eyeball and its adnexa are supplied by arterial blood through the ophthalmic artery a branch of the cavernous portion of the internal carotid artery. The ophthalmic gives off two groups of vessels, an orbital and an ocular group. The orbital group consists of the following: Lachrymal, supraorbital, posterior ethmoidal, anterior ethmoidal, palpebral, frontal, and nasal.

The lachrymal is the first and one of the largest branches. It arises close to the optic foramen; at times it is given off from the artery before the latter enters the orbit. It accompanies the lachrymal nerve along the upper border of the external rectus muscle and is distributed to the lachrymal gland. Its terminal branches escaping from the gland are distributed to the upper eyelid and to the conjunctiva, anastomosing with the palpebral vessels. The lachrymal artery gives off one or two malar branches, one of which passes through a foramen in the malar bone to reach the temporal fossa and anastomoses with the deep temporal artery. The other branch appears on the cheek and anastomoses with the transverse

facial. A branch is also sent backward through the sphenoidal fissure to supply the dura mater, which anastomoses with a branch of the middle meningeal artery, a branch of the cavernous portion of the internal carotid.

The supraorbital is the largest branch of the ophthalmic; it arises from the vessel above the optic nerve. It passes forward between the periosteum and the levator of the lid in company with the frontal nerve, and, passing through the supraorbital foramen, divides into a superficial and a deep branch which supply the integument and muscles of the forehead and pericranium, anastomosing with the artery of the other side, with the temporal and the angular branch of the facial. Within the orbit the artery supplies the superior rectus and the levator palpebræ, sends a branch across the superior oblique pulley to supply the tissue at the internal canthus of the eye, and sometimes at the supraorbital foramen transmits a small branch to the diploe.

The ethmoidal branches are two in number. The posterior, which is the smaller, passes through the posterior ethmoidal foramen, supplies the posterior ethmoidal cells, and, entering the cranium, gives off a meningeal branch which supplies the adjacent dura, and nasal branches which pierce the cribriform plate, enter the nose and anastomose with the sphenopalatine. The anterior ethmoidal artery accompanies the nasal nerve through the anterior ethmoidal foramen. It supplies the anterior ethmoidal cells, and frontal sinus, and, entering the cranium, divides into a meningeal branch, supplying the dura, and a nasal branch which descends into the nose. The palpebral arteries are also two in number, a superior and an inferior. They arise from the ophthalmic opposite the pulley of the superior oblique muscle, they encircle the eyelids near their free margins, forming a superior and an inferior palpebral arch, lying between the tarsal cartilage and the orbicularis muscle. The superior palpebral artery communicates with the orbital branch of the temporal artery at the outer angle of the orbit, the inferior palpebral with the orbital branch of the infraorbital, at the inner side of the lid. The con-

junctiva is fed by twigs from these vessels which pierce the tarsus, and a twig continues under the conjunctiva of the eyeball to near the edge of the cornea, where it joins a branch of an anterior ciliary artery to form the circumcorneal loops of blood vessels. A branch also passes to the nasal duct and supplies its mucous membrane as far as the inferior meatus of the nose.

The frontal artery is one of the terminal branches of the ophthalmic. It passes from the orbit at its inner angle, and ascending to the forehead supplies the muscles and the integument, anastomosing with the supraorbital artery.

The nasal artery forms the other terminal branch of the ophthalmic. It emerges from the orbit above the tendo oculi and after giving a branch to the tear sac, divides into two, one of which anastomoses with the angular artery and the other — the dorsalis nasi — runs along the bridge of the nose, and communicates with the artery of the opposite side, to supply this entire surface.

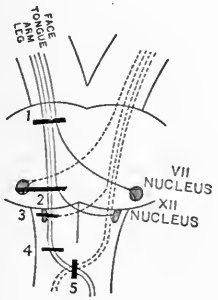
The venous blood from the parts around the eyeball is conveyed into the internal jugular vein by way of the facial vein, or into the cavernous sinus through the ophthalmic vein. The facial vein commences at the side of the root of the nose, being a direct continuation of the angular vein formed by the junction of the frontal and the supraorbital veins. The angular vein communicates with the ophthalmic vein and that forms an important anastomosis between this vessel and the cavernous sinus. The superior palpebral vein empties into the angular while the inferior palpebral vein empties into the facial direct.

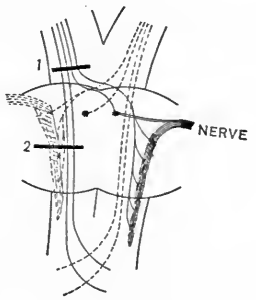
The ophthalmic is a large vein which connects the angular vein at the inner angle of the orbit with the cavernous sinus. It pursues the same course as the ophthalmic artery and receives branches corresponding to those of the artery. Forming a short single trunk it passes through the sphenoidal fissure and terminates in the cavernous sinus.

The Nerve Supply of the Extraocular Muscles. — Before describing the course of the nerves to the ocular muscles and their relations to

the medulla oblongata, a brief description of the fibers of the medulla and of the pons will be given, for we cannot appreciate the effect of a lesion involving the nerves unless we are acquainted with their environment and functions. The following account is taken from Starr's description of the tracts which pass through the medulla. According to this authority there are four tracts which pass through the medulla, namely:

1. The tracts that connect the cerebellum with the cerebrum. They constitute the outer and inner third of each pes and they are to a great extent lost upon the masses of gray matter which is intermingled with them and with the transverse fibers of the pons. They also compose the superior and middle peduncles of the cerebellum. The inferior peduncle of the cerebellum is continuous with the columns of the cord. We also find in the pons fibers passing from one hemisphere of the cerebellum to the other. Lesions in the





(*Gibbons*)

FIG. 1. Lesions of Pons with Crossed Paralysis: Lesion at 1 causes hemiplegia on side opposite lesion; 2, paralysis of body on right side and face on left side; 3, paralysis of tongue on side of lesion and paralysis of body on opposite side; 4, paralysis of extremities of opposite side; 5, paralysis of extremities of both sides.

FIG. 2. Lesions of Pons with Crossed Anæsthesia: Lesion at 1 in crura cerebri or upper part of pons causes hemianæsthesia of opposite side; 2, lesion in formatio reticularis causes anæsthesia of one side of face and opposite side of body.

superior and middle peduncles of the cerebellum give rise to loss of equilibrium, like those due to cerebellar disturbance, and are not easily recognized.

2. In the second division we have the middle third of the fibers of the pes or crusta which compose the great motor tracts coming down from the motor areas of the cortex. Those for the arm and leg cross at the pyramids at the lower end of the medulla, and form the lateral columns of the cord; about four fifths of the fibers decussate, and the remainder continue straight down the anterior columns of the cord. Besides these fibers we have in the pons special nuclei for the facial and hypoglossal nerves, and the fibers from these also decussate, but at higher levels than the pyramids. Hence, various paralyses of the face, tongue and extremities are possible according to the site of the lesion. The figures illustrate these possibilities.

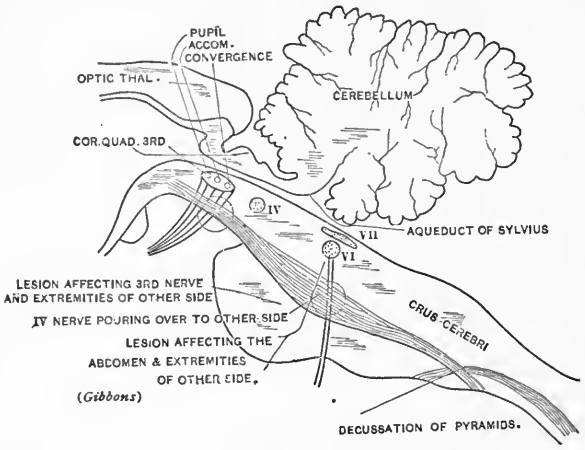
3. The third tract of fibers is that for the muscular sense, and is called the fillet or lemniscus, and composes the interolivary tract in the medulla. It conveys sensation upward. The columns of Goll and Burdoch in the dorsal part of the spinal cord terminate in the nuclei gracilis and cuneatus. The fillet starts from these nuclei, and as it goes brainward, the two bands cross at a point above the pyramids (sensory crossing of Wernicke) and enter the pons. The fillet lies to the outer side in the tegmentum and reaches the cortex after passing through the caudal part of the internal capsule.

4. The sensory tract which transmits sensations of touch, temperature and pain, is in the formatio reticularis in the medulla and pons, and lies just beneath the gray matter of the floor of the fourth ventricle, behind the tracts before described. It is composed of fibers passing in three directions, namely: transversely, the commissural fibers of the brain nuclei; from the ventral nuclei, the fibers of the cranial nerve roots, and longitudinally, the fibers of the sensory nerve tract. The longitudinal fibers can be traced from the gray matter and various columns of the spinal cord, through the formatio reticularis to the tegmentum of the crus, and into the posterior part of the internal capsule. In the medulla the formatio reticularis is divided into two parts by the exit of the nerve roots of the twelfth nerve. The inner part towards the median line contains the continuation of the anterior and antero-lateral columns of the spinal cord and the

interolivary tract already described, The outer part contains the sensory tract now being considered. In the inner two thirds of this outer part pass the fibers which convey impressions of touch, temperature, and pain from the opposite half of the trunk and limbs. In the outer third of this part is found a peculiar structure like the substantia gelatinosa of the posterior horn of the spinal cord, and in this column terminate the fibers of the sensory tract of the trigeminal nerve which turn downward after entering the pons Varolii and terminate at different levels in the pons and medulla.

The outer portion of the formatio reticularis thus contains the sensory tract from the face of the same side. From the appended figures it is evident that a lesion which involves one half of the formatio reticularis in the pons and medulla will give rise to an alternate anesthesia, that is loss of sensation on one side of the body and the other side of the face and head. Alternate anesthesia is as characteristic of a lesion of the formatio reticularis of the pons and medulla as alternate paralysis is of a lesion of the motor tracts of the pons. In the upper part of the pons the sensory tract from the face crosses the median line, and hence a lesion in the formatio reticularis, in the upper third of the pons or in the crus cerebri, will produce a unilateral anesthesia. A lesion that involves both halves of the formatio will give rise to bilateral disturbance of sensation. If a section normal to the axis of the pons through the width of the corpora quadrigemina is made we will expose to view the roots of the third nerve as they gather together to form its trunk. The rootlets traverse and surround a reddish mass of reticular substance called the red nucleus of the tegmentum. This body extends cephalad to the optic thalamus and also receives fibers from the fasciculus retroflexus (Meynert's bundle) and also connects with the cerebellum through its superior peduncle. It has nothing to do with the oculo-motor nerve. All the nuclei of the nerves of the ocular muscles lie beneath the aqueduct of Sylvius, upon the floor of the fourth ventricle on both sides of the rhaphe. The most anterior of them is the nucleus of the oculo-motor nerve, which begins as far forward as the posterior

portion of the third ventricle and extends beneath the aqueduct of Sylvius as far as the posterior pair of the tubercles of the corpora quadrigemina. It consists of a number of nucleoli, each one of which corresponds to one of the muscles innervated by the third nerve. The order in which the separate parts of the nucleus follow each other has not been definitely ascertained but it is known that the most anterior nuclei are set apart for the pupil and accommodation and that next to them come those for the internal recti muscles (convergence) and behind these the other partial nuclei for the rest of the extra-ocular muscles supplied by the third.



Nuclei of Origin of the Nerves of the Ocular Muscles.

The nuclei which are always set in action together, which are those for the pupil, accommodation and convergence are connected and lie furthest forward. The trunk of the third nerve becomes visible upon the anterior border of the pons, and from this point the nerve passes along the outer wall of the cavernous sinus above the other nerves for the ocular muscles, and receives in its course several filaments from the cavernous sympathetic. It then divides into two branches which enter the orbit through the sphenoidal fissure between the two heads of the external rectus muscle. On passing through the fissure the nerve is placed below the fourth nerve, the frontal and lachrymal branches of the ophthalmic, and passing between its two divisions is the nasal nerve. The superior division of the third nerve which is the smaller passes inwards across the optic nerve and supplies the superior rectus and the levator palpebræ. It at times com-

municates with the ganglionic branch of the nasal nerve. The inferior division divides into three branches. One passes beneath the optic nerve to the internal rectus, another to the inferior rectus and the third, the largest, to the inferior oblique, passing forward between the internal and inferior recti. From the latter a short thick branch is given off to the lower part of the lenticular ganglion. All these nerves enter the muscles on their ocular surfaces. The fourth or trochlearis nucleus follows almost directly upon the posterior extremity of the oculo-motor nucleus. The trunk of the nerve appears on the outer side of the crus cerebri, just in front of the pons. It passes forward along the outer wall of the cavernous sinus between the third and the ophthalmic division of the fifth nerve and enters the orbit through the sphenoidal fissure. In the fissure it lies the highest, internal to the frontal nerve at the inner extremity of the fissure.

In the orbit it passes inward above the origin of the levator of the lid and finally enters the orbital surface of the superior oblique muscle. In the cavernous sinus this nerve receives some filaments from the sympathetic. The nucleus of the abducens lies pretty far behind the nuclei of the other two nerves, in the immediate vicinity of the facial nucleus. The nerve fibers pass down between the bundles of the pyramidal tracts and become visible upon the base of the brain at the posterior border of the pons. The nerve passes forward through the cavernous sinus lying to the outer side of the internal carotid artery, being joined by branches from the carotid and cavernous plexuses, by some from Meckel's ganglion and one from the ophthalmic nerve. It enters the orbit through the sphenoidal fissure lying above the ophthalmic vein; it then passes between the two heads of the external rectus muscle and is distributed to that muscle upon its ocular surface.

Numerous connections exist between the nuclei of the nerves of the ocular muscles, which are made by means of the posterior longitudinal fasciculus, *i. e.*, by those fibers which on both sides of the rhaphe run from before backward and connect the nerve-nuclei lying

at different levels. Transverse connections also exist through the passage of fibers from one side to the other. These connect not only mononymous nuclei of the two sides, but connect as well nuclei lying at different levels. Thus it is assumed that fibers arising from the nucleus of the abducens nerve while in part passing to the trunk of the nerve of the same side also in part cross the median line and become associated with fibers arising from the nucleus of the oculomotor nerve of the opposite side. Hence the nerve which enters the internal rectus muscle has a double innervation, from the third and from the sixth nerve. This arrangement probably serves the purpose of giving the internal rectus a double innervation according as it is going to act in convergence or in associated lateral movements. Lesions of the abducens nucleus of one side abolish movements of the eyes to one side, but would not interfere with convergence, while a lesion of the convergent center abrogates convergence, but does not disturb lateral movements of the eyeballs. In this way many conjugate ocular paralyses are accounted for.

CHAPTER III

THE ANATOMY OF THE EYEBALL

The Cornea.—[1] The cornea forms the anterior transparent one fifth part of the outer tunic of the eyeball. The vertical diameter of the

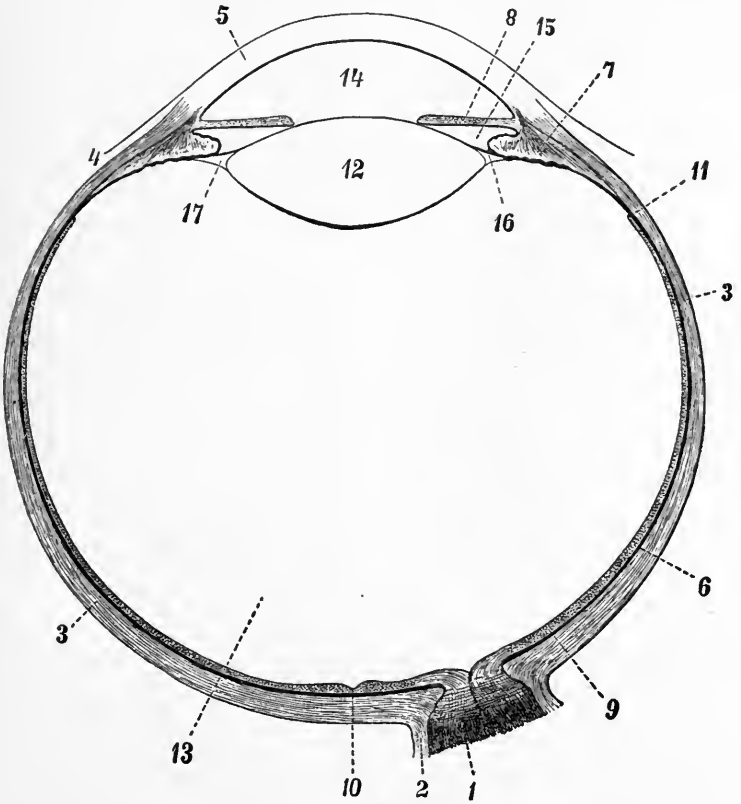


Diagram of Horizontal Section of Human Eye (Merkel-Rauber) : 1, optic nerve ; 2, dural sheath ; 3, sclera ; 4, conjunctiva ; 5, cornea ; 6, choroid ; 7, ciliary body and processes ; 8, iris ; 9, retina ; 10, fossa centralis ; 11, ora serrata ; 12, lens ; 13, vitreous body ; 14, anterior chamber ; 15, posterior chamber ; 16, zone of Zinn ; 17, intrazonular cleft.

[1] From Cornu, a horn.

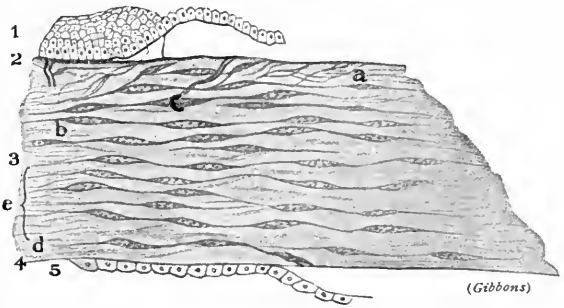
cornea is slightly shorter than the horizontal, being 11 mm. in the former and 12 mm. in the latter direction. It is thinnest at its center, where it is about 1 mm. in thickness, and grows thicker towards its attachment with the sclera. It therefore follows that the curvature of the posterior surface is somewhat greater than that of the anterior. The radius of curvature of the anterior surface of the cornea is slightly less in the vertical meridian than in the horizontal, being 7.8 and 7.9 mm. respectively. The anterior surface of the cornea is then not spherical, but ellipsoidal. The posterior surface is practically spherical and has a radius of curvature of about 6.2 mm.

The index of the refraction of the cornea is 1.3365+, a little above that of water and of the aqueous humor. The transparency of the cornea is due to the close apposition and parallel arrangement of its fibers, and to the evenness and polish of its surface. A perfectly transparent medium may be made almost opaque by roughening its surface and spoiling its polish, for example, ground glass. The apparent projection of the cornea beyond the rest of the eyeball is due partly to its great curvature, but also to a slight flattening of the latter near the equator or edge, and also to the sulcus scleræ, a broad shallow groove in the sclera just posterior to the limbus. There is no line of demarkation between the cornea and the sclera, but the fibers of the former blend into the latter. The sclera as it were overlaps the anterior surface of the cornea, or the posterior layers of the cornea are continued further towards the periphery than the anterior. Almost all morbid changes in the cornea are denoted by a loss of transparency, but there occurs as a physiological condition (usually) in advanced age a ring of cloudiness running near the corneal margin (arcus senilis or gerontoxon corneæ). It first appears under the form of a gray arc, first at the upper, soon after at the lower margin, finally the two arcs unite at the outer and inner side of the cornea to form a perfect circle. The outer boundary of the arcus senilis is always sharply defined, and separated from the limbus by a strip of clear cornea, the inner edge of the arc, however, gradually fades into normal transparent cornea. The cause of the senile arc is the depo-

sition of a colloid material into the substance of the cornea. The cornea differs from other connective tissue in not yielding gelatin on boiling, but a modified form of chondrin.

Microscopically the cornea is composed of five layers, from before backwards as follows: Epithelium, anterior limiting membrane, substantia propria, posterior limiting membrane, and endothelium.

The epithelium of the cornea is derived from the epithelium of the conjunctiva and is of the pavement variety several layers thick, the lowermost or foot cells being cylindrical, then cuboidal and finally flat cells upon the surface. The anterior limiting membrane of Bowman is formed by a matting together of the uppermost layers of the stroma of the cornea which have become devoid of cells. The epithelium is divided from Bowman's membrane by a sharply defined border, and separates readily from it. The stroma of the cornea is made up of a ground substance and of cells. The ground-substance consists of fibrillæ of connective tissue, united by a cement substance into flat bundles, and the bundles are so applied to one another that lamellæ are produced, and by the arrangement of these lamellæ in parallel rows the cornea is built up. The lamellæ are connected together by the interchange of bundles at frequent intervals, so that the lamellæ cannot be stripped off easily and smoothly.



Vertical Microscopical Section of Cornea: 1, epithelium; 2, Bowman's membrane; 3, substantia propria; 4, Descemet's membrane; 5, Descemet's endothelium; *a*, oblique fibers in anterior layers; *b*, lamella; *c*, corneal corpuscles seen fusiform in section; *d*, bundles of fibers cut longitudinally and therefore not appearing dotted; *e*, transition to sclera with more distinct fibrillation.

Between the lamellæ as well as between the individual bundles of fibers irregular spaces of varying sizes exist, which are filled with lymph and are called lymph spaces. These spaces are connected

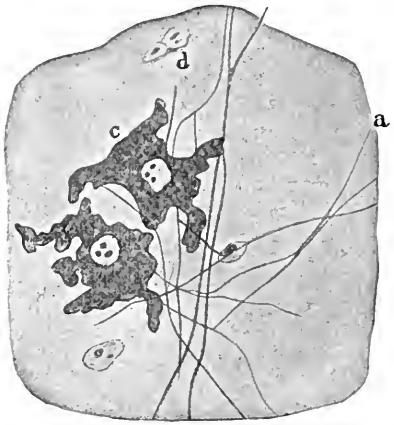
together by numerous canals, the corneal canaliculi, or Bowman's tubes, which permeate the cornea in every direction. As the cornea is devoid of blood vessels it must depend entirely upon the circulation of lymph within its tubes. The cells of the cornea or the corneal corpuscles are contained within the lymph spaces. The cells send feelers or pseudopodia into the canaliculi. The cells are granular and possess large nuclei; they do not entirely fill the lymph-spaces in which they lay but attach themselves to this or that side. The processes of the fixed cells anastomose with each other so that there is formed running through the canals of the cornea, a system of protoplasmic bodies. There are found also a limited number of lymph corpuscles within the stroma, wandering here and there. To these Recklinghausen, their discoverer, gave the name of wandering corneal corpuscles. These cells increase rapidly in number whenever any irritation acts upon the cornea; they escape from the circumcorneal loop of blood vessels and pass into the cornea. The posterior limiting, or Descemet's membrane is a homogeneous membrane forming the posterior boundary of the corneal stroma; it is sharply separated from the stroma and is of an entirely different composition. It is very resistant to chemical agents and likewise to pathological processes. It not infrequently happens that when the entire corneal stroma breaks down into pus, the thin Descemet's membrane will remain intact for some time. The endothelium (Descemet's) is composed of a single layer of flattened hexagonal cells. Embryologically the cornea consists of three superimposed layers, a conjunctival, a scleral and a uveal, each corresponding to one of the membranes adjacent.

According to Schwalbe, the anterior epithelium is the conjunctival portion of the cornea; Descemet's membrane together with the endothelium belongs to the uveal tract while the stroma of the cornea with Bowman's membrane is the continuation of the sclera. In diseased conditions these three divisions show their relations to the adjacent membranes, the epithelium of the cornea suffering in diseases of the conjunctiva and the uveal portion of the cornea in diseases of the uvea.

The Sclerotic (σκληρὸς, hard).—The posterior four fifths of the outer tunic of the eyeball is composed of the sclera. Its shape is nearly that of a sphere, having an annular sulcus at the base of the cornea. The diameter of the sclera equals about 24 mm. The sclera is thickest behind, where it amounts to about 1 mm., and gradually becomes thinner towards the edge of the cornea. Corresponding to the attachment of the recti muscles, it is somewhat thicker than at the edge of the cornea, because the tendons of the muscles reinforce it. Histologically the sclera is very similar to the cornea. It contains lacunæ and canaliculi, and cells as does the cornea but they are not so regularly arranged. Its fibers are interlacing and not arranged parallel as are those of the cornea. The fibrous bundles, generally speaking, run in two directions—from before backwards—meridional fibers, and in a direction concentric with the margin of the cornea—circular or equatorial fibers. The lymph spaces analogous to those of the cornea are found between these bundles. The scleral tissue when boiled yields gelatin, being true connective tissue. The sclera also contains branched pigment cells, which in the fair-skin races are met with only in its deeper layers, and along the vessels or nerves that traverse it. In the colored race pigment spots are seen in the superficial layers of the sclera, especially at the points of perforation of the anterior ciliary vessels.

When the sclera is especially thin as in young children the dark-colored chorioid shows through, imparting to the white of the eye a bluish tint. The sclera has very few vessels of its own, but there are numerous vessels in the loose connective tissue that envelopes the sclera, from which the sclera derives its nourishment. The sclera is pierced by many vessels and nerves—ciliary vessels and nerves—to gain entrance to the interior of the eyeball. It is separated from the underlying chorioid by a lymph space (suprachorioidean lymph-space) and connected to the chorioid by a loose pigmented connective tissue, which in great part adheres to the sclera when the sclera and the chorioid are separated, and is called the lamina fusca or the brown layer of the sclera.

The inner surface of the sclera is grooved for the passage of the long ciliary arteries, and nerves that pass into the posterior segment of the eyeball and run anteriorly to supply the ciliary region. The optic nerve passes through the sclera in the posterior segment of the eyeball, which apparently has an aperture for the passage of the nerve. The inner layers of the sclera are, however, continued as the lamina cribrosa through the foramen scleræ. (See lamina cribrosa.)



(*Gibbons*)

Lamina Suprachorioidea: *a*, elastic fibers; *c*, pigment cells; *d*, nuclei of epithelial cells.

The Iris.[1]—The iris forms the anterior segment of the middle vascular tunic of the eyeball, visible through the cornea as constituting the colored part of the eye. Slightly towards the inner side of the center of the iris is a circular opening, the pupil. The plane of the iris is not quite vertical, as its pupillary border rests upon the anterior surface of the lens, causing a slight convexity of its plane. The thickness of the iridic curtain is about .04 mm. when the pupil is of its normal size. When the pupil is widely dilated the thickness of the iris is nearly doubled. The diameter of the iris is about 11 mm., the pupil being from 3 to 6 mm. in diameter when at rest. The attachment of the periphery of the iris joins the ciliary bodies behind, and it is continuous with the membrane of Descemet through the pectinate ligament in front. The zone of attachment of the iris lies about 3 mm. behind the apparent corneal margin. The thin pupillary border is seldom quite circular but presents a slightly irregular or indentated border and deeply pigmented. The stroma of the iris is chiefly formed of vascular tissue supported by a small amount of a more or less pigmented connective tissue. The color of the iris depends upon its thickness and upon the amount of pigment that the

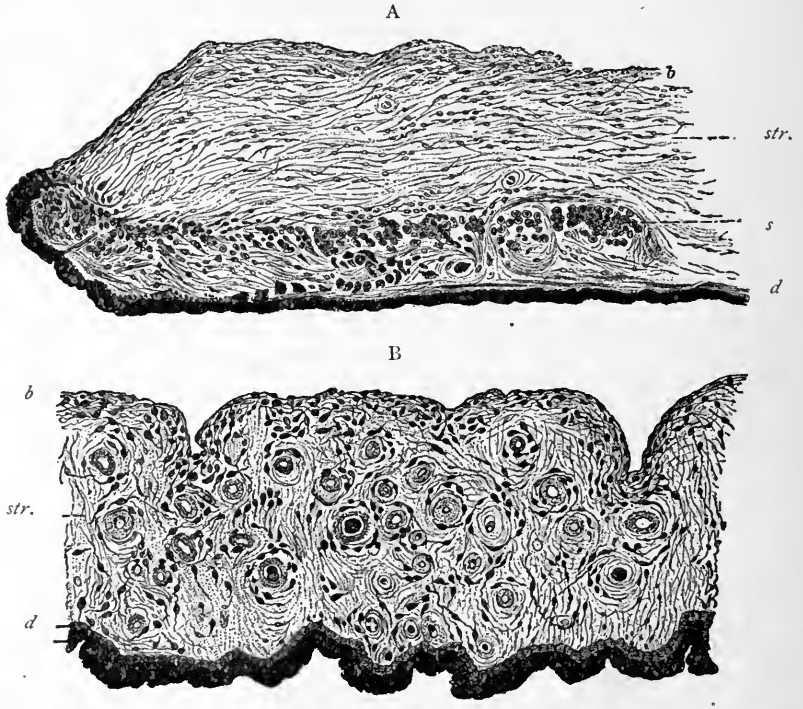
[1] From *ἰρις*, rainbow.

stroma contains. If the stroma is thin and devoid of pigment, the black pigment that coats the posterior surface of the iris shines through and imparts a blue color to the iris; when the stroma is thicker the tint becomes modified to a gray, and with the presence of varying amount of pigment in the stroma deeper shades as green, hazel and brown are produced. The iris is really never black, but of the deepest brown color in the so-called black eyes.

The color of the iridic stroma is not distributed uniformly, but occurs in spots of lighter and darker tints and often arranged in bizarre forms. The color furthermore is often arranged in two distinct zones concentric with the pupil. The pupillary zone 1–2 mm. wide is lighter in dark eyes and darker in light-colored eyes, than the ciliary or peripheral portion which is 3 mm. in width. The boundary zone is often marked with a number of festoon-like ridges, the circulus minor iridis. The anterior surface of the iris is not uniform but formed of a number of trabeculæ, presenting a sculptured appearance. The ridges are fine and close together near the border of the pupil. In inflammation of the iris these ridges become effaced, by the exudation of lymph. The iris is divisible microscopically into five strata or layers, namely from before backwards: An anterior epithelium; anterior limiting membrane; substantia propria; posterior limiting membrane, and a posterior epithelium. The anterior epithelium of the iris is a continuation of the epithelium of Descemet covering the posterior surface of the cornea, and forms part of the lining of the anterior chamber of the eyeball. It consists of irregular polygonal plates arranged in a single layer. It is wanting only at spots which correspond to the so-called crypts of the iris. The anterior limiting membrane does not exist as a distinct layer, but is really a condensation of the superficial layers of the iridic stroma.

The connective tissue cells are here closely packed, the intercellular fibrous tissue being correspondingly scanty. There are a number of communicating interfascicular clefts or crypts, both in the pupillary and ciliary regions forming a system of lymph spaces within the stroma of the iris, in free communication with the anterior cham-

ber. Blood vessels are entirely wanting in this part of the iris. The vascular stroma layer forms the bulk of the iris and consists of a loose connective tissue, supporting numerous blood vessels and nerves, and enclosing a number of lymph spaces as well as involuntary



Sections of the Human Iris: *A*, radial section; *B*, section across the radii (Retzius); *b*, anterior condensed zone, and endothelium; *str*, stroma-layer; *s*, bundles of muscular fibers composing the sphincter pupillæ; *d*, muscle-cells constituting the dilator pupillæ; *r*, pigment layer of iris belonging to retinal tract.

muscle fiber bundles which constitute the sphincter and the dilator of the pupil. The variable and often large amount of pigment contained within the stroma occurs as irregular accumulations of pigment cells, the anterior layer and the pupillary zone as a rule containing the greatest amount of pigment. In very dark irides the pigment is distributed more or less in a uniform manner throughout the substance of the stroma. The sphincter pupillæ consists of a circular

band of involuntary muscle varying in width from .7 to 1 mm. in diameter according to the condition of contraction and about .07–1 mm. in thickness. The muscle does not extend down to the edge of the pupil but there is an intervening zone of the pigmented retinal sheet. The muscle lies in the posterior layer of the stroma behind the blood vessels. Certain fibers are at times seen to assume an arched course and fade away in radial offshoots.

The existence of the second muscle of the iris is still a disputed point. Many competent observers have failed to demonstrate a radially disposed layer of muscular tissue in the iris, concluding that a true dilator muscle of the iris does not exist, although the presence of radially disposed spindle-cells is indisputable. According to the researches of Retzius, Langley and Anderson, it would seem that the presence of a distinct dilator of the pupil has been established, if not forming a continuous sheet, at least as groups of radiating fibers, which collectively constitute the dilator muscle of the pupil. The posterior limiting membrane of the iris is to be regarded as a continuation anteriorly of the membrane of Bruch, extending forward from the chorioid over the orbiculus ciliaris and ciliary processes. It consists of a clear delicate membrane of great thinness, and is often adherent to the deeply pigmented retinal zone. The posterior epithelium of the iris is deeply pigmented, and covers the iris as far as the pupillary border. Morphologically this pigmented epithelial layer represents the anterior portion of the nervous tunic — and is therefore called the pars retinæ iridica. The retinal pigment layer of the iris consists of two layers of cells, which can only be easily distinguished in the embryo, representing the continuation of the two layers of the retina upon the posterior surface of the iris. The anterior stratum of pigment cells arises from the pigment epithelium of the retina, and the posterior from the retina proper. The blood, nervous and lymphatic supply of the iris will be considered later.

Ciliary Bodies. — Immediately behind the iris we find the ciliary bodies. They are exposed to view by bisecting the eyeball and removing the lens and vitreous humor. The retina ends anteriorly in

a jagged line known as the ora serrata. Corresponding to this there is a change in the color of the pigment of the uvea, which is brown behind this line (chorioid) and black in front of it (ciliary bodies). At the anterior portion of this black zone are found the ciliary bodies about 60–70 in number, which are somewhat of a lighter color than the surrounding tissue.

The ciliary processes are like the rest of the uvea covered with black pigment, but which is separated from them in the process of removing the vitreous. The anterior portion of the ciliary body bearing the ciliary process is the folded portion of the ciliary body and is called the corona ciliaris. Posterior to this the ciliary body is smooth and of a uniform black color and is called the orbiculus ciliaris. The outer side of the ciliary body is covered with a layer of gray tissue, the ciliary muscle. The ciliary body is best studied in meridional sections. In such sections the ciliary body appears triangular in shape, with the base or short side looking forward, and giving rise from about its center to the iris. The inner side bears the ciliary process, while the outer side is formed by the ciliary muscle. Examining the ciliary body more minutely we find the following arrangement of its layers:

The ciliary muscle forms the outermost layer; it was discovered by Brücke and was denoted by him by the name of tensor chorioideæ. It consists of two portions distinguished by the direction of their fibers. The external portion consists of longitudinal or meridional fibers, and as these are the ones that Brücke first discovered, they are called Brücke's portion. The antero-posteriorly arranged fibers have their origin in the outer fibrous tunic of the eyeball and their attachment into the external layers of the chorioid. The inner portion of the ciliary muscle consists of circularly arranged fibers, appearing in cross-section in sections of the eye made longitudinally.

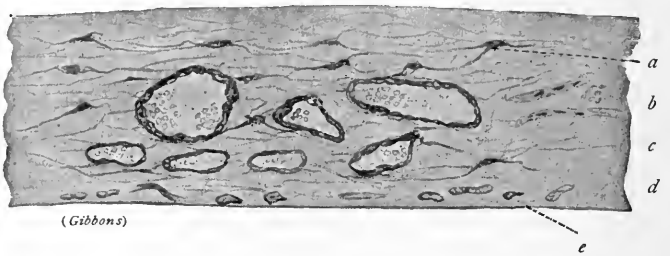
Heinrich Müller discovered this portion of the muscle and hence they are called Müller's portion. The two portions of the ciliary muscle merge into each other frequently. Placed upon the ciliary muscle are found the ciliary processes, consisting of a connective tissue

stroma, which, with numerous branched pigment cells, contains many blood vessels, being the most vascular portion of the eyeball. The inner surface of the ciliary bodies is covered by three layers. The first consists of a hyaline membrane of the ciliary body, a homogeneous membrane; next in order is a layer of pigment-epithelium, and lastly a single layer of cylindrical non-pigmented cells forms the layer joining the vitreous humor. The last two layers are a continuation of the retina, which has become reduced to two layers, a pigmented and a non-pigmented row of cells, and they are therefore called the pars ciliaris retinæ. All three layers pass over upon the posterior surface of the iris, the deepest layer, that of the hyaline membrane, being continued as the posterior limiting membrane of the iris, and the two layers of cells becoming the pars iridica retinæ.

Chorioid (χοριοειδής, like the chorion—on account of its abundant blood supply).—The chorioid is that portion of the middle tunic of the eyeball that extends from the ora serrata to the entrance of the optic nerve. After removing the vitreous its inner surface appears smooth and brown. It is tied loosely to the underlying sclerotic coat, by a lax pigmented connective tissue. Firmer attachments exist at the optic nerve entrance and where vessels and nerves enter it from the sclera, that is in the region of the equator (region of venæ vorticosæ) and about the optic nerve entrance (region of the posterior ciliary arteries). When the chorioid is torn away from the sclera its outer surface presents a ragged appearance, on account of shreds of membrane adhering to it. Microscopically the chorioid is divisible into five layers, which are, proceeding from without inwards:

The suprachorioid consisting of numerous fine pigmented lamellæ lying between the chorioid proper and the sclera. On separating the two part of this tissue clings to the sclera constituting the lamina fusca, and part to the chorioid forming the suprachorioid. Next we find a layer of large vessels, having the characteristics of veins (Haller's layer). These vessels are placed very close together and anastomose freely. The intervals between the vessels, the inter-vascular spaces are richly supplied with pigment cells, and are of a

brown color. Often with the ophthalmoscope, the vessels of the chorioid appear as a plexus of light lines upon a dark ground, which is known as a tesselated fundus as the appearance suggests a pave-

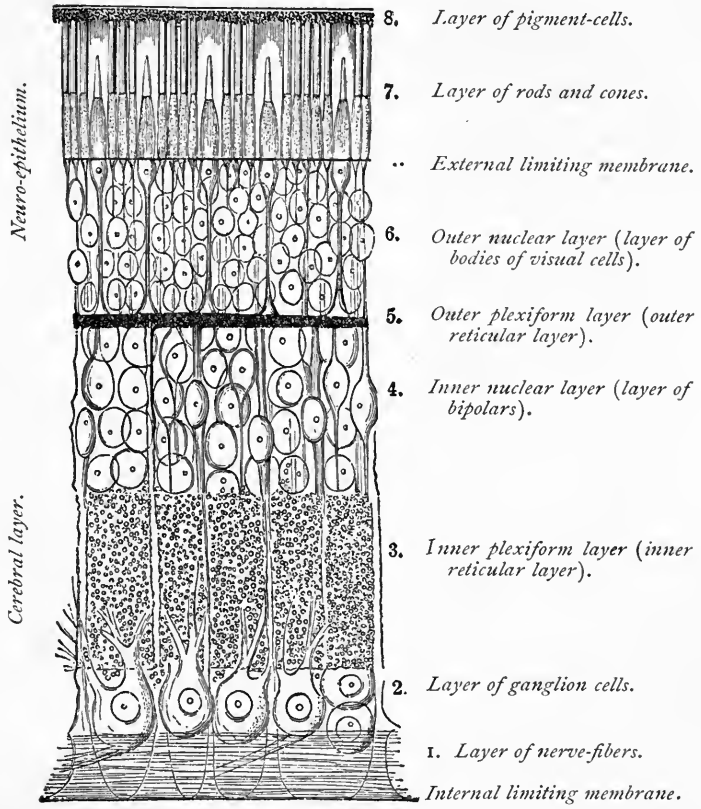


Section of Chorioid: *a*, suprachorioidean layer with branched pigment cells; *b*, Haller's layer of large vessels; *c*, Sattler's layer of medium-sized vessels; *d*, layer of Ruysch or capillaries; *e*, lamina vitrea.

ment or tiling. Still within we have the layer of medium-sized blood vessels (layer of Sattler). This layer is very thin and only slightly pigmented. The layer of Ruysch or the layer of capillaries (chorio-capillaris) forms the innermost layer of vessels. This stratum is formed almost entirely of capillaries which have a very wide caliber, and are so closely placed that the interstices are often narrower than the capillaries themselves. There is no pigment whatever in this layer. Lying next to the retina we have a homogeneous membrane, which is known as the lamina vitrea.

The cells of the stroma of the chorioid are branched, anastomosing connective tissue cells containing numerous pigment granules and an unpigmented nucleus. To this abundant supply of pigment the dark color of the chorioid is due. Lying upon the lamina vitrea is a pigment epithelium, composed of hexagonal cells with pigment granules and a clear nucleus. This pigment epithelium really belongs to the retina, but as it remains upon the chorioid when the retina is stripped from it it was formerly supposed to be a part of the chorioid. The pigment in the stroma cells consists of small amorphous masses, while that in the pigment epithelium consists of small rod-like bodies which are crystalline in character. These crystals are found very distinctly marked in the lower vertebrates.

The Retina. (Latin Rete, a net or veil. Spanish and Italian. Retina.)—The retina forms the innermost layer of the eyeball. In the normal condition it is as transparent as air, none of its parts being visible save its blood vessels. It possesses a purplish-red color



Diagrammatic section of the human retina (Max Schultze).

due to the visual purple contained in the rods. The retina becomes very rapidly opaque after death or when its nutrition is interfered with as when it becomes separated from the chorioid beneath, and at the same time the retina becomes bleached from the influence of the light, so that in the cadaver the retina appears as a thin grayish veil.

There are two points that deserve especial consideration, namely, the optic nerve entrance and the macula lutea. The former appears as a small white or pinkish disc that lies to the inner side of the posterior pole of the eye, and from which the vessels of the retina emanate. The second spot occupies almost the posterior pole of the eyeball, and in its center is found a depression, the fovea of the retina or fovea centralis. When the retina is lifted from the underlying chorioid we find it connected to the latter only at two places. One of these is at the head of the optic nerve and the other at the anterior border of the retina. The latter is zig-zag in outline and hence bears the name of ora serrata. The retina extends further forward on the nasal than on the temporal side. The retina arises from the optic nerve, the fibers of which spread out in all directions, and thus form the innermost layer of the retina, that is the nerve-fiber layer. The fibers then pass through the different layers of the retina, being metamorphosed in their course and finally terminate in the rods and cones. The retina like the cornea lens and the vitreous loses its transparency when affected by pathological changes.

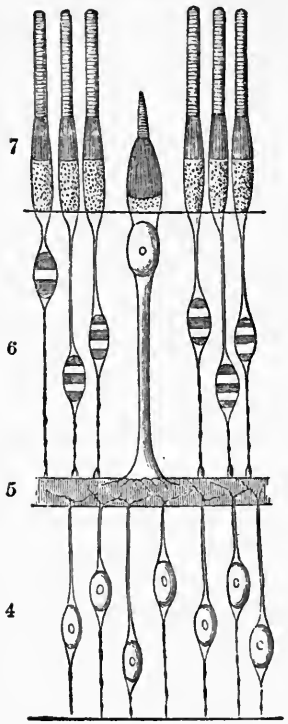
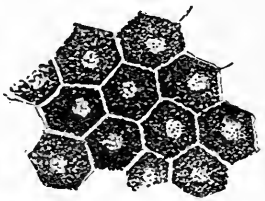


Diagram of the Neuro-epithelial Elements of the Retina (Quain-Schwalbe): 4, bipolar nerve-cells, related to the rod- and cone-visual cells in the outer plexiform layer (5); 6, the nucleated bodies of the rod- and cone-visual cells, containing the rod- and cone-granules (nuclei) and the rod- and cone-fibers (these parts of the visual cells constitute the outer nuclear layer); 7, the layer of rods and cones which represents the outer highly specialized ends of the visual cells: each rod and cone is composed of the outer and inner segment.

The size of the fovea is about 2 mm. in diameter according to the latest investigations. Owing to the absence of rods within the fovea carrying visual purple, this region of the fundus possesses an inherently lighter color than the surrounding portions, at times appearing as a tinted area when viewed with

the ophthalmoscope. The macula lutea was so called from the yellow appearance it presented in contrast to the rest of the fundus. This yellow color is now known to be due to a post-mortem change. Surrounding the fovea there is seen a halo with the ophthalmoscope due to the sloping of the sides of the macula. Morphologically the retina consists of two layers, an outer and an inner layer, corresponding to the external and internal layers of the optic vesicle from which it is derived. The outer layer of the vesicle is represented by the pigment-layer of the retina and the inner one by the remaining parts of the retina. The inner layer is further divided by some into a neuro-epithelial and cerebral layer. The designation of the retinal layers as well as their morphological relations from without inward are as follows :



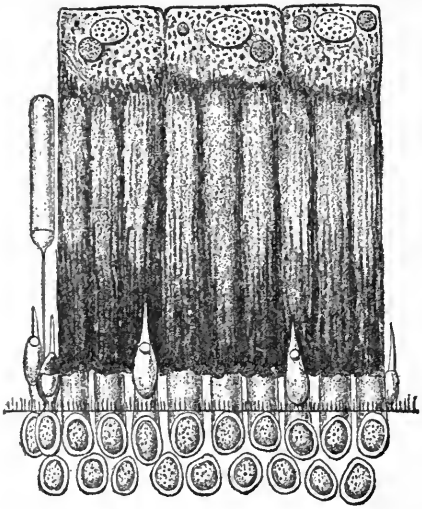
(*Gibbons*)

Cells of Pigment Retinal Layer.

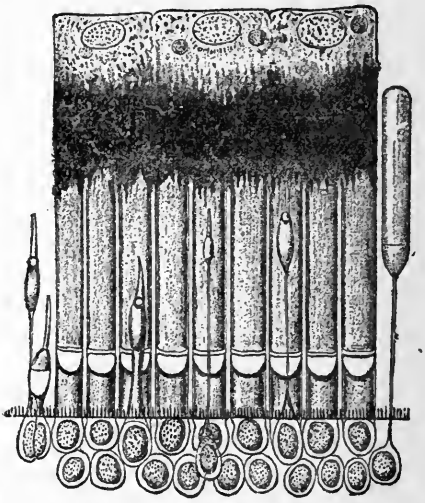
1. Outer layer of the Optic Vesicle.	Pigment layer.	Pigment layer.
2. Inner layer of Optic Vesicle.	Layer of rods and cones.	Neuro-epithelial Layer.
	Layer of bodies of visual cells or outer nuclear layer.	
	External plexiform or outer reticular layer.	Cerebral Layer.
	Layer of bipolar cells or inner nuclear layer.	
	Internal plexiform or inter reticular layer.	
	Layer of ganglion cells.	
	Layer of nerve-fibers.	

The nervous portions of the retina are supported by a modified neurogliar reticulum, the fibers of Müller. The retina in short consists of percipient elements closely applied to a pigment epithelium, and ganglion cells from which nerve-fibers lead to the brain centers.

The pigment which forms the most external layer of the retina is derived from the attenuated outer lamella of the optic vesicle. It consists of hexagonal cells, about .015 mm. in diameter. The outer zone of each cell containing the nucleus is clear, the pigment being confined to the middle and inner segments of the cell. The inner



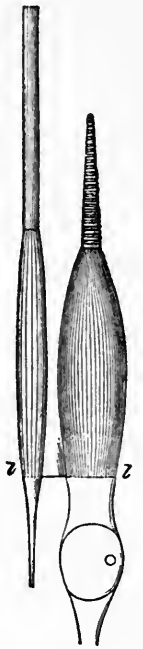
Section of Frog's Retina, showing the Action of Light upon the Pigment-cells and upon the Rods and Cones (v. Genderen-Stort). The retina had been exposed to light for some time before killing; the pigment-cells have extended their protoplasm between the rods and cones nearly to their bases; the cones have retracted.



Section of Frog's Retina, showing Action of Darkness upon the Pigment-cells and upon the Rods and Cones (v. Genderen-Stort). The retina had been kept in the dark for some hours before death, in consequence of which the pigment is retracted toward the nucleated part of the cells and from between the rods. The cones are elongated.

margins of the cells are irregular, and in close contact with the rods and cones, while the external borders are smooth. Under the influence of light the colored particles move towards the rods and cones, between which the protoplasm of the cells extends. When the light is excluded however the colored particles draw back and arrange themselves in the middle of the so-called basal zone. The next layer represents the extremities of two forms of light-perceiving elements,

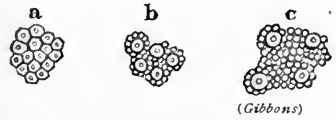
the rod- and the cone-visual-cell. Rods of the human retina when viewed in section under high magnification appear as elongated cylinders about .060 mm. in length and .002 mm. in thickness, and each consists of an outer and an inner segment of about equal length. The outer portion is homogeneous and has a uniform diameter, being probably of the nature of a cutaneous appendage. The external portions of the rods contain the visual purple of rhodopsin, which is distributed evenly throughout this part of the rods. The inner rod-segment has a slightly increased diameter and is of an ellipsoidal form, its external portion is striated and called the rod-ellipsoid, the internal portion is granular and known as the lenticular body. The body of the rod-visual cell lies within the external nuclear zone, and consists of elongated body, the rod-fiber, and a more conspicuous nucleus, the rod-granule. The rod fiber is continuous with the rod and internally extends into the external plexiform layer, ending in a knob-like expansion in close relation with the terminal filaments of bipolar nerve cells. The nuclei of the rod-cells are very large, causing a distinct enlargement of the rod-fibers at their location; they present transverse dark and light stripes, and are surrounded by a very thin layer of cell-protoplasm. The rod-nuclei are not arranged with any degree of uniformity, but are situated in all layers and chiefly form the elements of the outer granular layer. The cone-visual cells are made up in the same manner as are the rod-visual cells, with a specialized outer part, the cone and the cone-cell body, within the external nuclear layer.



A Rod and a Cone from the Human Retina (Max Schultze). The line, *l*, *l*, indicates the position of the external limiting membrane; the portion of the figure unshaded represents parts of the visual cells contained within the outer nuclear layer.

The cone comprises an outer and an inner segment, differing both in length and thickness. The outer segment is thinner and shorter than the inner, more or less conical in shape and about

.0006 mm. at its broadest part. The cones do not extend as far into the pigment layer as the rods, but terminate in blunted cones opposite the middle of the outer segments of the adjacent rods. There is no visual purple within the cones, but their index of refraction is slightly higher than that of the rods. The outer portions of the cones show a transverse marking while the inner segment is longitudinally striated. The cone-visual cell aids in the formation of the external nuclear layer, and consists of an attenuated cell body, the cone-fiber, and a broad nucleus, the cone-granule. The latter are all found directly beneath the external limiting membrane and do not, as is the case with the rod-granules, arrange themselves in different layers. The cone-granule is non-striated and contains a nucleolus. The cone-fibers extend into the outer plexiform layer, and terminate in expanded feet in close relations to arborizations formed by the processes of the cone-bipolar cells. Krause has estimated the number of rods in the human retina to be about 130,000,000; and Salzer, the number of cones to be about 3,360,000. Throughout the retina then the rods are in excess save at the fovea where they are entirely wanting. The rods separating neighboring cones gradually become less as we approach the macular region of the retina.

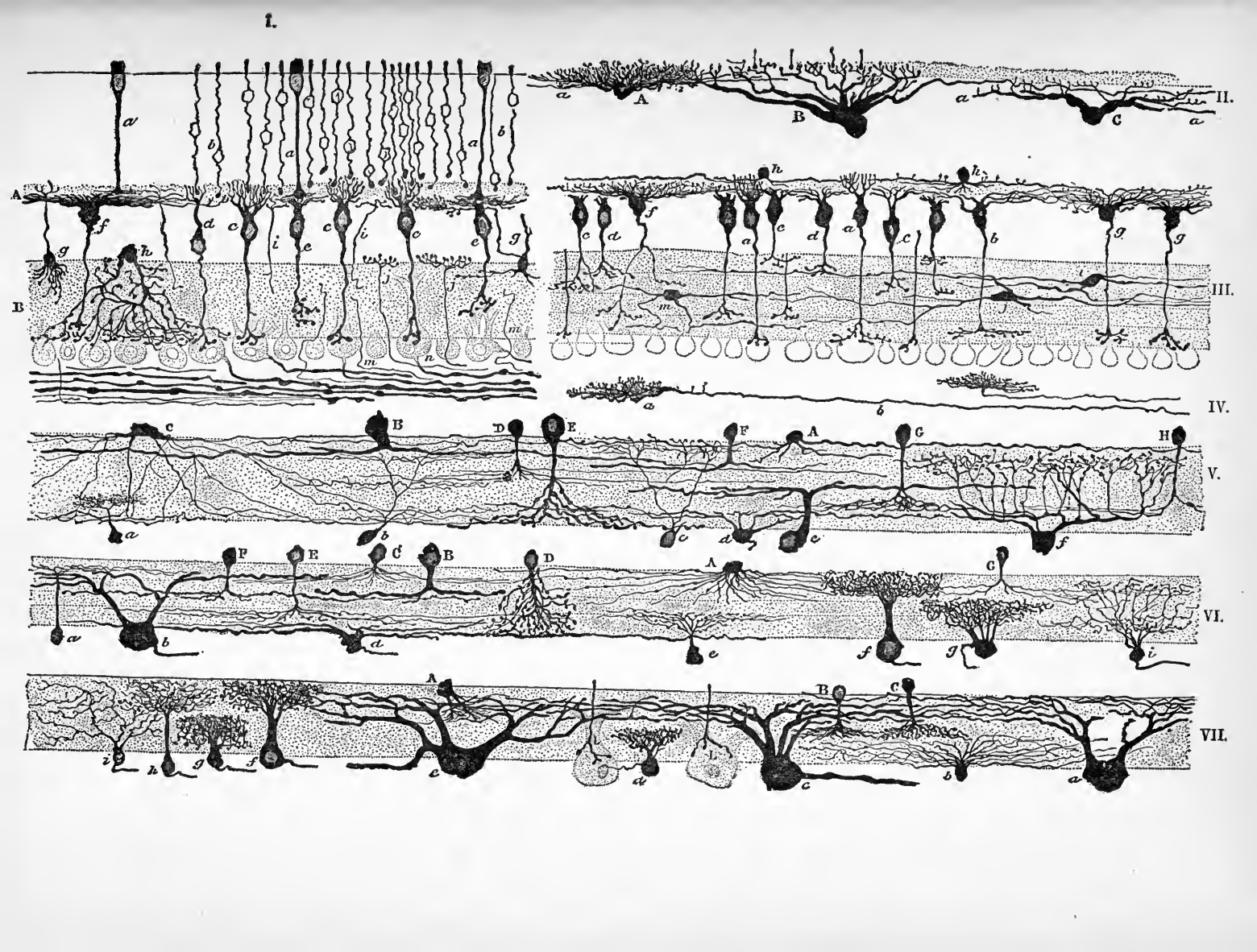


(*Gibbons*)

a, Cones alone present in fovea; *b*, cones separated by single layer of rods in macula; *c*, proportion of rods and cones in periphery of retina.

At the macula the cones are separated by a single row of rods, while in the fovea the cones are alone present. The outer molecular layer is thin and composed chiefly of flattened branched cells with many ramifications; these cell ramifications are united into a close network. As far as this layer the retina may be said to consist of nervous elements, but beyond this of epithelial elements, modified epithelial-cells. The inner nuclear layer is mainly composed of large bipolar cells with large nuclei (inner granules).

The processes of these cells extend inwards through the inner molecular layer, to join with nerve fibers or with processes of ganglion nerve-cells, whilst the outer process is directed outwards and is


I.
II.
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VII.

Elements of the Mammalian Retina after Treatment with the Golgi Silver Method (Cajal):

I. Section of the Dog's Retina: *a*, cone-fiber; *b*, rod-fiber and nucleus; *c*, *d*, bipolar cells (inner granules) with vertical ramification of outer processes destined to receive the enlarged ends of rod-fibers; *e*, bipolars with flattened ramification for ends of cone-fibers; *f*, giant bipolar with flattened ramification; *g*, cell sending a neuron or nerve-fiber process to the outer molecular layer; *h*, amacrin cell with diffuse arborization in inner molecular layer; *i*, nerve-fibrils passing to outer molecular layer; *j*, centrifugal fibers passing from nerve-fiber layer to inner molecular layer; *m*, nerve-fibril passing into inner molecular layer; *n*, ganglionic cells.

II. Horizontal or Basal Cells of the Outer Molecular Layer of the Dog's Retina: A, small cell with dense arborization; B, large cell, lying in inner nuclear layer, but with its processes branching in the outer molecular; *a*, its horizontal neuron; C, medium-sized cell of the same character.

III. Cells from the Retina of the Ox: *a*, rod-bipolars with vertical arborization; *b*, *c*, *d*, *e*, cone-bipolars with horizontal ramification; *f*, *g*, bipolars with very extensive horizontal ramification of outer process; *h*, cells lying on the outer surface of the outer molecular layer, and ramifying within it; *i*, *j*, *m*, amacrine cells within the substance of the inner molecular layer.

IV. Neurons or axis-cylinder processes belonging to horizontal cells of the outer molecular layer, one of them *b*, ending in a close ramification at *a*.

V. Nervous Elements Connected with the Inner Molecular Layer of the Ox's retina: A, amacrine cell, with long processes ramifying in the outermost stratum; B, large amacrine with thick processes ramifying in second stratum; C, flattened amacrine with long and fine processes ramifying mainly in the first hind fifth strata; D, amacrine with radiating tuft of fibrils destined for third stratum; E, large amacrine, with processes ramifying in fifth stratum; F, small amacrine, branching in second stratum; G, H, other amacrines destined for fourth stratum; *a*, small ganglion-cell sending its processes to fourth stratum; *b*, a small ganglion-cell with ramifications in three strata; *c*, a small cell ramifying ultimately in first stratum; *d*, a medium-sized ganglion-cell ramifying in fourth stratum; *e*, giant cell, branching in third stratum; *f*, a bistratified cell ramifying in second and fourth strata.

VI. Amacrines and Ganglion-cells from the Dog: A, amacrine with radiating tuft; B, large amacrine passing to third stratum; C and G, small amacrines with radiations in second stratum; F, small amacrine passing to third stratum; D, amacrine with diffuse arborization; E, amacrine belonging to fourth stratum; *a*, *d*, *e*, *g*, small ganglion-cells, ramifying in various strata; *b*, *f*, large ganglion-cells, showing two different characters of arborization; *i*, bistratified cell.

VII. Amacrines and Ganglion-cells from the Dog: A, B, C, small amacrines ramifying in middle of molecular layer; *b*, *d*, *g*, *h*, *i*, small ganglion-cells showing various kinds of arborization; *f*, a larger cell similar in character to *g*, but with longer branch; *a*, *c*, *e*, giant cells with thick branches ramifying in the first, second, and third layers; L, L, ends of bipolars branching over ganglion-cells.

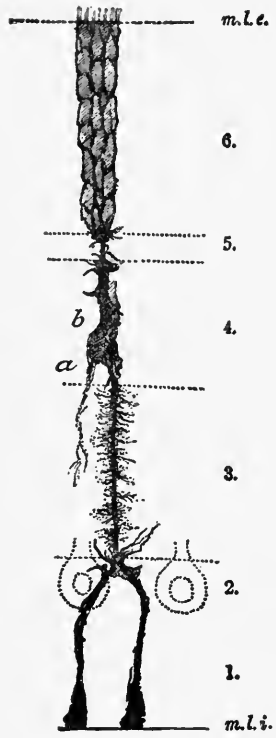
connected with a rod- or cone-fiber. Besides these bipolar cells we find others devoid of processes and resting on or imbedded in the inner molecular layer with which they are probably connected. Others that are larger and rounder are applied to the outer molecular layer. The supporting tissue of the retina has nucleated enlargements in the inner molecular layer. The internal molecular or plexiform layer resembles closely the similar outer zone but is somewhat thicker. It is formed of branched communicating cells. In addition

to this delicate supporting framework this layer contains the descending processes of the cone and the rod bipolar cells, and the ascending dendrites from the adjacent large ganglion cells.

The layer of ganglion cells is next within. The large nerve cells which resemble the cells of Purkinje of the cerebellum are arranged in a single row for the most part over the entire retina, towards the macular region they become more numerous, and in the immediate vicinity of the yellow spot are arranged in a double layer, gradually increasing within this area until they lie eight or nine deep. Towards the ora serrata however they are very sparse and widely separated. These ganglion cells possess richly branched dendrites which pass into the inner plexiform layer and end in relation with the descending processes of the bipolars, and axis-cylinder processes or neurites, which become axis cylinders of nerve fibers converging towards the optic nerve entrance. The layer of nerve-fibers lying next is largely the contribution of the former stratum. After arising from the cells of the ganglion layer the fibers almost at once assume a horizontal course and form large or smaller bundles, which after traveling a certain distance, according to the region of their origin in the retina, converge towards the optic entrance and build up the nerve of vision. The bundles of nerve fibers while pursuing a more or less radial course to the optic entrance, freely intermingle. The presence of the yellow spot disturbs the radial course of the fibers on the temporal side of the optic disc, the region separating the latter from the yellow spot being traversed by a number of delicate fasciculi, about twenty or thirty in number, which possess an almost straight course from the macula to the disc. These fibers form the so-called macular bundle of Michel. The adjacent fibers arch above and below the macula lutea.

The Supporting Tissue. — The fibers of Müller are long stiff fibers which pass through several layers of the retina. At the inner surface of the retina their expanded bases unite to form the so-called internal limiting membrane. The fibers then pass through all the layer until they reach the outer nuclear layer. Here they branch and expand

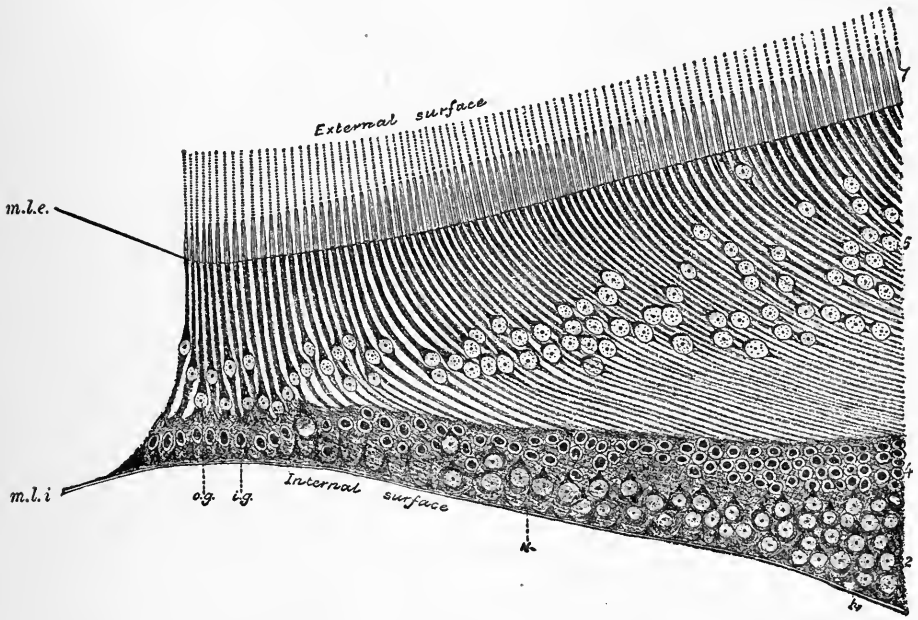
into a sort of reticular tissue that serves to support the rod- and the cone-elements. At the bases of the rods and the cones this sustentacular tissue ceases, and is bounded by a distinct margin which is called the external limiting membrane, but some have described delicate sheaths passing from it around the bases of the rods and the cones. Each Müller fiber possesses a nucleated enlargement in the inner nuclear layer, which is indicative of the original cell nature of the fiber. Within the fiber layer additional supporting cells exist in the form of spider cells. Neuroglial cells with very long and delicate processes, extend from the cell-body between the nerve fibers in various directions. The structure of the retina is much modified in three localities; they are at the entrance of the optic nerve, at the ora serrata and at the macula lutea. The macula lutea is characterized by its greater thickness except at the fovea, secondly by the large number of ganglion cells, which are all distinctly bipolar, and thirdly by the large number of cones that it contains as compared with the rods. In the central fovea itself there are no rods and the cones are very long and slender; moreover all the other retinal layers become much thinned, almost to disappearance, so that the center of the fovea is the thinnest part of the retina. Since there are few rods the outer nuclear layer loses in a great measure its appearance of being composed of closely set nuclei, and the cone-fibers for that reason are very distinct. The direction of all the fibers is very oblique in this portion of the retina.



A Supporting Fiber of Müller after Staining by Golgi's Silver Method (Ramon y Cajal). The extensions of a single fiber are shown in relation to the several retinal layers: 1, layer of nerve-fibers; 2, ganglion-cells; 3, inner plexiform layer; 4, inner nuclear layer; 5, outer plexiform layer; 6, outer nuclear layer; *m.l.e.*, *m.l.i.*, respectively, the external and internal limiting membrane; *b*, nucleus of fiber; *a*, process extending into internal plexiform layer.

The pars ciliaris retinæ commences at the ora serrata, where the retina proper abruptly ends, and is composed of two epithelial layers, but is devoid of nervous structures.

The external layer of cells is a thick stratum of pigmented epithelium, formed of rounded cells and continuous with the pigmentary

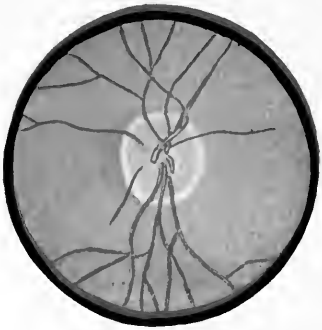


Diagrammatic Section through the Fovea Centralis of the Human Retina (Golding-Bird and Schäfer): 2, ganglion-cell layer; 4, inner nuclear layer; 6, outer nuclear layer, the cone-fibers forming the so-called external fibrous layer of Henle; 7, cones; *m.l.e.*, external limiting membrane; *m.l.i.*, internal limiting membrane; *o.g.*, *i.g.*, outer and inner granules (cone-nuclei and bipolars).

layer of the retina proper, and with the uvea of the iris. The inner layer is formed of columnar cells each with an oval nucleus.

The optic entrance is marked by a light pink colored more or less circular area varying from 1.5 to 1.7 mm. in diameter, called the optic disc or optic papilla. The surface of the disc is broken by the central retinal vessels which pierce the area usually a little to its nasal side and pass over the margin of the disc to gain the surround-

ing retina. The thick bundles of optic nerve fibers which arch over the margins of the interrupted chorioidal and retinal layers to reach the disc, give rise to a slight elevation—the optic papilla, and in consequence of the rapid arching of the fibers the center of the disc comes to lie lower than the margin. This central excavation is spoken of as the physiological pit. The other layers of the retina terminate abruptly at the margin of the optic papilla. The ganglion cells are the first to disappear, while the visual cells continue nearest the nerve, the fibers of the rods and cones assuming a more or less oblique direction.



The Ophthalmoscopic Appearance of the Normal Optic Disc.

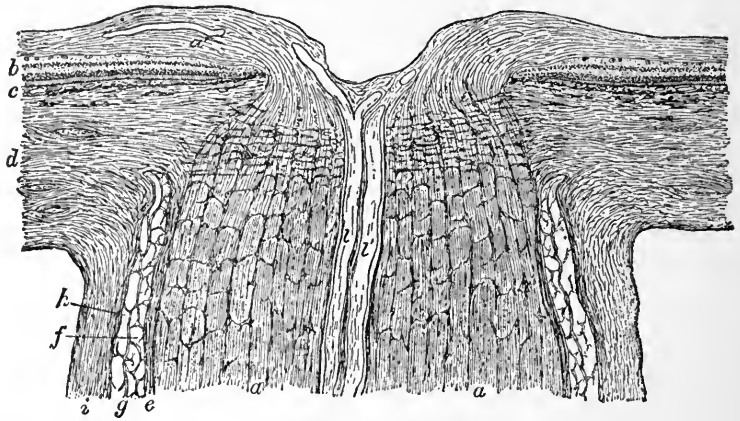
The sensitive layer of the retina is in all probability the layer of the rods and the cones. This theory is strengthened by the experiments of H. Müller on the entoptic vision of the retinal vessels, as well as by observations on visual acuity. The manner in which light is transformed into nervous energy, however, has not been worked out. We know the changes that the retina visibly undergoes under the influence of light, and the functions of the retina are understood, but their mutual relations are not understood. The external segments of the rods of an eye of an animal which has been left in darkness for some time have a purple color. Under the influence of light this purple quickly bleaches, passing through a yellow tint. The cones do not possess this coloring matter and the fovea of the human eye containing no rods is without color. If the eye of a rabbit for example is exposed to a bright object, and the animal then killed suddenly we can obtain a permanent retinal image, to which the name of optogram has been given. The lighter portions of the object will be depicted upon the retina by bleached or colorless lines. If after having caused the purple to fade away in an eye by exposure to light, we leave the animal in darkness, the purple color gradually reappears, provided the retina is in intimate contact with the pigment

cells. It is not necessary that they be the pigment cells of the same eye or animal; if we place the retina of one eye in the place of that of another eye the reproduction of the visual purple is also effected in darkness. Vision does not depend upon the presence of the purple, for the fovea, the most sensitive portion of the retina, contains none, nor does an animal go blind when we allow the visual purple to fade away entirely, and there are certain serpents for instance whose eyes are normally without this retinal coloring matter. Stort thinks that the cells of the retinal pigment secrete the rhodopsin, because it can be seen in them frequently. Under the influence of light Kühne noticed that certain indefinite electrical phenomena took place in the retina. Stort further showed that the internal part of the cones became shorter and more or less swollen, and that they arrange themselves more or less in a row along the internal limiting membrane under the influence of light.

The Optic Nerve.—Formed by the aggregation of the nerve fibers from the retina, it passes from the eyeball through the orbit, and enters the cranial cavity through the optic foramen. The nerve therefore may be divided into three portions: An intraocular, intraorbital and intracranial portions. To get to the retina from the outside the optic nerve must pierce the chorioid and the sclera. The spot where this takes places lies a little to the inner side of the posterior pole of the eyeball. The opening in the sclerotic coat through which the nerve passes is called the foramen scleræ, and presents itself under the form of a short canal which becomes narrower as it passes through the sclerotic. The external layers of the sclera forming about two thirds of its thickness are not perforated by the optic nerve at all but are reflected back along the nerve and become fused with its sheaths. The innermost lamellæ, on the contrary, stretch over the foramen scleræ, and are perforated by numerous openings designed for the passage of the optic nerve fibers. The optic nerve is therefore at this locality traversed by numerous septa of strong connective tissue. This interlacement of fibers through the optic nerve constitutes the lamina cribrosa. The chorioid also stretches

through the optic nerve in a modified form, and aids in the formation of the lamina cribrosa.

At its entrance to the eyeball the optic nerve is narrowed down to a conical shape, so that the part corresponding to the lamina cribrosa



Longitudinal section of optic entrance of human eye (Piersol); *a*, *a*, bundles of optic fibers, which spread out over retina at *a'*, *a'*; *b*, layers of retina; *c*, chorioid; *d*, sclera, continued across optic nerve as the lamina cribrosa; *e*, *g*, *i*, respectively the pial, arachnoid, and dural sheaths of optic nerve, enclosing subdural and subarachnoidal lymph-spaces; *l*, *l'*, retinal blood vessels cut longitudinally.

is the slenderest portion of the nerve. As far as the lamina cribrosa the nerve is white, while in front of it, it is of a translucent gray. In other words, the optic nerve fibers drop their medullary sheaths at the lamina cribrosa, which accounts for the sudden diminution in volume of the nerve.

The lamina cribrosa is the weakest part of the tunics of the eyeball, hence in cases where the intraocular tension becomes elevated, this spot is the first to give way. In the normal eye the lamina is straight or has a slight bulge backward. With the increase of tension it recedes more and more and thus is formed the glaucomatous excavation. The optic nerve lies between firm fibrous walls in the foramen scleræ, a thing that does not occur in any other portion of its course. Hence when swelling of the nerve takes place constriction readily occurs. The portion of the optic nerve which is situated

in front of the lamina cribrosa is called the head of the optic nerve or the optic papilla (it has been described in a former section). The orbital portion of the nerve, that between the eyeball and the optic foramen, makes an S-shaped bend, allowing the eyeball to move freely within its orbit without dragging upon the nerve. We find a confirmation of this in cases where the optic nerve is put upon a stretch by protrusion of the eyeball from the orbit. The more the eyeball is bulged the greater the restriction of its motion.

The trunk of the orbital portion is composed of nerve fibers and connective tissue. It has been estimated that the nerve fibers number about one half a million. Lying between the fibers and supporting them is a neuroglial tissue. The nerve is divided into bundles of fibers that have a more or less parallel course but frequently anastomose. Between the outer surface of a nerve bundle and the inner surface of the septa is a space that acts as a lymph-cavity. The nerve is invested by three sheaths, an internal, middle and an external one. They are designated as the pial, arachnoid and the dural sheaths (Key and Retzius). The inner, or the pial, sheath closely invests the nerve trunk and forms its perineurium, from which there are numerous septa given off which enter the nerve trunk and divide it into bundles. The blood vessels pass into the substance of the nerve with these septa of the pia mater.

The external, or the dural, sheath is of greater thickness and surrounds the nerve loosely. By reason of this there is left between the pial and the dural sheath a space known as the intervaginal space. The arachnoid prolongation from the same membrane surrounding the brain, continues down along the nerve and divides the intervaginal space into two, an outer and an inner space—the subdural without and the subarachnoid space within. It was formerly supposed that these sheaths fused with the tissue of the sclerotic coat upon reaching the eyeball, as they appeared so to do in microscopical section.

Very careful investigation reveals the fact that this is only partly the case, but that there exists a direct communication between the

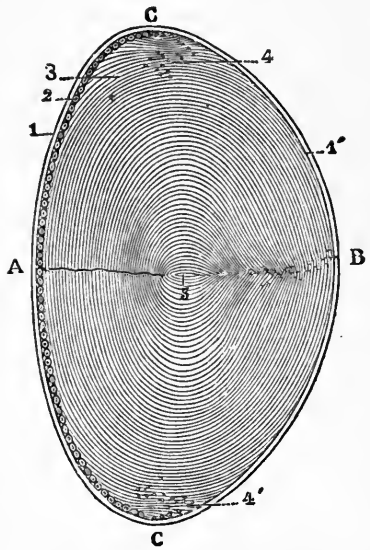
subdural lymph space and Tenon's lymph space that invests the sclera, and between the subarachnoid space and the supra-chorioidean lymph space, that between the sclera and the chorioid coat of the eyeball. The spaces are furthermore in direct communication with like spaces of the cranial cavity, and any rise of tension in the latter quickly expresses itself by a dilation of the lymph spaces surrounding the optic nerve. The optic nerve leaves the orbit by way of the optic foramen, having the ophthalmic artery lying to its inner side. The nerve in this locality is easily constricted by swelling of the nerve or narrowing of the canal through which it passes. The latter often occurs in fractures of the skull passing through the apex of the orbit. The intracranial portion of the optic nerve is scarcely one centimeter in length and extends from the optic foramen to the optic chiasm. In this part of its course it is enveloped alone by the pial sheath as the other two membranes after passing through the optic foramen become continuous with the outer two membranes of the brain. The two optic nerves join in the chiasm lying in the optic groove upon the body of the sphenoid bone, and directly in front of the infundibulum. On leaving the chiasm the optic tracts (now called) pass backward, diverging as they go and, winding aroúnd the crura cerebri, arrive at the internal geniculate bodies. The fibers then pass to various parts of the cerebral cortex. The pathway of visual impressions will be dwelt upon in a subsequent part.

The Crystalline Lens. — The crystalline body is the most important part of the refractive apparatus of the eyeball and, as has been seen, is almost entirely the agent of accommodation. The crystalline or lenticular body is circular in outline and biconvex in section. The lens supports the pupillary margin of the iris in front and rests in a depression in the anterior part of the vitreous behind — known as the patellar or lenticular fossa. The lens is supported by the zonula of Zinn, called its suspensory ligament, which is however really the tendon of the ciliary muscle, between the fibers of which the lens is held. The lens consists of a soft compressible crystalline material that has no color in youth, but which assumes a yellowish tint with

advancing years. The change in color is first noted at its center, and imparts to the nucleus of the lens an opalescence. In early life the lens is about the same consistency throughout, but as it becomes older the nucleus by a process of drying becomes harder. The lens is ectogenous or grows by surface deposit. The lens has no blood vessels, so its nutrition is carried on by an intercellular transmission of fluid. The lens imbibes nutrition both from the vitreous and from the aqueous, both of which are truly modified lymphs.

Around the equator of the lens there are a number of stomata, which open into canaliculi traversing the substance of the lens. With each accommodative effort (swelling of the lens) aqueous flows into the substance of the lens, and passes out again as the lens assumes its former shape, and so the lenticular circulation is provided for. It will be seen that the change of shape of the lens is to that structure what the systole of the heart is to the other organs of the body. If the aqueous or vitreous gains access to the lens substance in undue amount however it acts as solvent upon the lens fibers, so the mechanism that normally keeps out the hurtful agents while allowing entrance to those that are destined to nourish the lens is a wonderful one. The soft lens is enclosed within its delicate elastic capsule, which is very resistant to reagents, such as alcohol and acids and as well to putrefaction. It is strong but brittle and readily torn by sharp instruments. When incised its cut ends roll in instead of out, as would be expected. The front portion of the envelope of the lens is thicker than that behind, which has given rise to the designations of anterior and posterior capsules. The anterior capsule is lined by an endothelium which gives birth to the lens fibers. The lens within its capsule measures about 9–10 mm. transversely, being larger in old and large subjects but not varying much in size in different sized eyeballs; its average thickness is about 4 mm. The radii of curvature of the anterior surface during near and distant vision are respectively 6 and 10 mm., those of the posterior surface for the same condition are respectively 5 and 6 mm. The length of the meridian of the lens measures 12 mm. Its specific gravity is about

1121; its weight .22 gm. and its index of refraction averages 1.42 as the lens is not equally refractive throughout.

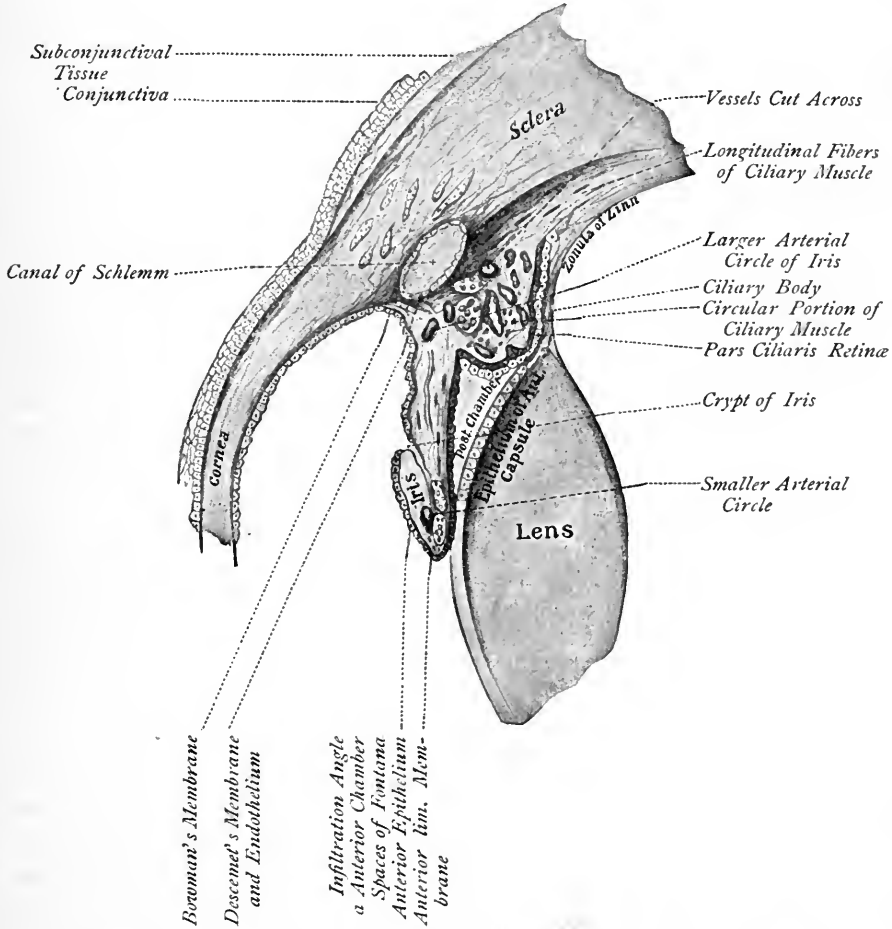


Meridional Section through Human Crystalline Lens (Babuchin): *A*, anterior, *B*, posterior surface; *C*, *C*, equatorial region; 1, 1′, anterior and posterior capsule; 2, epithelium beneath anterior lens-capsule; 3, lens substance composed of fibers; 4, transition zone where cells of anterior epithelium are converted into lens-fibers; 5, nucleus.

The anterior pole of the lens lies about 3.5 mm. behind the apex of the cornea and the posterior pole 7.6 mm. The antero-posterior lens axis deviates from that of the eyeball from about 3 to 7 degrees, and there is usually some vertical decentration as well, but to a less degree. The epithelium of the lens capsule lies only beneath the anterior lens capsule, and consists of a single layer of polyhedral flattened cells. These elements morphologically represent the anterior wall of the lens sac. On approaching the margin of the lens the cells of the capsule become elongated, and finally become converted into young lens-fibers, in what is called the transitional zone. As the changes are confined to a particular zone, a sort of spiral figure is produced by the elongating cells and their nuclei to which the name of lens-whorl has been applied. These fibers which compose the lens are long and riband-shaped, with finely serrated edges; in transverse section they appear prismatic. Many of the superficial fibers are nucleated, as they were originally developed from the cells of the epithelium of the capsule.

The length of the fibers varies, those upon the surface being distinctly longer than those forming the center of the lens; the former extend about two thirds of the meridional distance from pole to pole, while the latter correspond to the length of the lens axis. The lines of apposition of the lens fibers held together by the lens-cement sub-

stance produce a star-shaped figure to which the name of lens-star is given. Upon the anterior surface of the lens the cleavage lines form the figure of an inverted Y, and those of the posterior surface of a



Semi-diagrammatic Representation of the Anterior Portion of the Eyeball. (*Gibbons.*)

figure Y. From the arms of each figure there are given off many branches which together form the star. There is no distinct evidence that the lens fibers ever multiply or regenerate; all seem to arise from the epithelium of the capsule.

The Aqueous Chamber.—The chamber of the aqueous humor is that cavity in the anterior portion of the eyeball bounded in front by the cornea, and behind by the lens and its suspensory ligament. This cavity is subdivided into a posterior and an anterior chamber by the iris. The cavity is filled by a watery lymph, the aqueous humor, which is poured out from the vessels of the iris and ciliary processes. The quantity usually present is about 275 cu. mm. and its specific gravity about 1.0053; its index of refraction nearly that of the cornea, 1.337. It consists of about 98.6 parts of water, a small quantity of solids, extractives and proteids. It contains no morphological element save a few migratory leucocytes. Upon the amount of the aqueous humor depends largely the intraocular tension, and hence the maintenance of the lymph as provided for is of the utmost importance. The angle between the cornea and the root of the iris needs especial attention. This angle is known as the infiltration angle of the eyeball, because it is here that the aqueous leaves the eyeball. The membrane of Descemet that faces the internal surface of the cornea with its epithelium is carried over to the root of the iris and mingles with its tissue, forming the so-called pillars of the iris. As it passes from the cornea to the iris, it breaks up into finger-like projections and is then called the ligamentum pectinatum, the clefts between being known as the spaces of Fontana. The aqueous humor percolates through this spongy tissue, which has a free access to a circular channel running around the base of the cornea called Schlemm's canal. Schlemm's canal communicates directly with the anterior ciliary veins and these finally carry the aqueous into the ophthalmic vein. This is the only instance in the body where the lymph is poured directly into a blood stream. The infiltration angle of the eye is encroached upon by dilating the pupil and opened by contracting the pupil.

When the pupil is dilated the tissue of the iris is crowded up into the angle between it and the cornea, and thus the escape of aqueous is in a measure interfered with, while on the other hand by contracting the pupil the iris is drawn away from this area, and furthermore

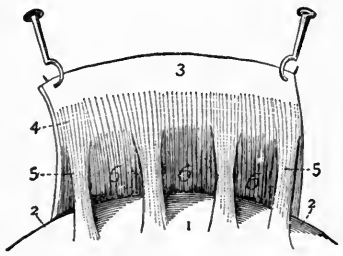
through the contraction of the meridional fibers of the ciliary muscle the root of the iris is retracted and the aqueous allowed a freer exit.

The Cavity of the Vitreous.—The vitreous chamber is that space included between the lens and its suspensory ligament in front and the fundus of the eyeglobe behind. It contains the vitreous humor, which appears as a semifluid and perfectly transparent mass whose general form resembles that of a flattened sphere, the anterior pole of which is modified by the presence of the lenticular fossa into which the crystalline body fits. The function of the vitreous is thought to be that of a support for the retina, rather than to act as a refracting medium, since its index of refraction is almost identical with that of the aqueous, being 1.336. The vitreous body consists of two parts: a fine connective tissue framework and a fluid tissue held in tis meshes. The fluid portion consists of 98.5 per cent. of water, a small amount of extractives, salts, proteids and nucleo-albumin, which is practically the composition of the aqueous humor. The delicate envelope of the vitreous is called the hyaloid membrane, from which there pass into the substance of the vitreous delicate trabeculæ. The vitreous is really a very watery connective tissue. The adult vitreous contains a few stellate cells which are very prominent at one time in its development. The morphological elements of the fully-formed vitreous are very meager and consist of a very few atrophic connective tissue-cells and wandering leucocytes, which are especially numerous under the hyaloid membrane where they constitute the subhyaloid cells.

These cells are derived from the vessels in the vicinity of the optic nerve entrance and ora serrata. The central part of the vitreous body is penetrated by a canal, the hyaloid canal or the canal of Stilling or of Cloquet. This central canal extends from the entrance of the optic nerve to near the posterior pole of the crystalline lens. In fœtal life it carries a blood vessel from the central artery of the retina to the posterior surface of the lens to nourish it. In the fully formed eye the central vessel of the vitreous is represented by a connective tissue cord enclosed within the canal, which serves to carry lymph. The channel as a rule begins in an enlargement called the area of Marte-

giani, which is equal to the optic disc in size. The hyaloid membrane is wanting over that portion of the vitreous which surrounds the patellar fossa; within this locality the peripheral condensation of supporting tissue alone supports the gelatinous tissue within.

The Supporting Apparatus of the Crystalline Lens.—The crystalline lens is held in place by a series of delicate bands, which pass from the vicinity of the ora serrata over the ciliary processes to be attached to the equator of the lens. These fibers compose the suspensory ligament of the lens or zonula of Zinn. The sustentacular tissue of the retina together with the hyaloid membrane gives rise at the ora serrata to the zonula. It was formerly taught that part of the suspensory ligament passed anterior to the lens while a part passed posterior to it and became fused with the capsule of the lens, thus forming a circular canal bounded by the two layers of the ligament and the edge of the lens, the canal of Petit. No such canal exists as the portion of the suspensory ligament passing posteriorly exists only as a band of fibers here and there. Under magnification the suspensory ligament of the lens is seen to be composed of a number of interlacing fibers that bridge the space between the lens and the ciliary processes. Some of the fibers of the zonula are attached to the ciliary processes and are therefore called the cilio-capsular fibers, while others are attached to the orbiculus ciliaris and are called the orbiculo-capsular. Some of the fibers on reaching the lens become fused with its capsule, while others pass part of the way upon the surface of the lens before becoming attached. There are a number of accessory fibers in the zonula, those which pass from the ciliary processes to the long zonular fibers, and those which extend from point to point within the ciliary zone. The numerous clefts



Diagrammatic View, from Posterior Surface, of the Insertion of the Zone of Zinn into the Capsule of the Lens (Testut): 1, posterior lens surface; 2, its equator; 3, zonula; 4, 5, the anterior and posterior bands, inserted into the corresponding surfaces of the lens-capsule; 6, the interfascicular spaces, formerly regarded as the canal of Petit.

in the zonula allow the fluids of the vitreous to drain into the posterior chamber or the products of the latter to pass into the vitreous chamber.

The eyeball and adnexa are supplied with blood by the ophthalmic branch of the cavernous portion of the internal carotid artery. It enters the orbit through the optic foramen below and to the outer side of the optic nerve. The ophthalmic vein leaves the orbit by the sphenoidal fissure, and empties into the cavernous sinus. The branches of the ophthalmic artery are divided into the orbital and the ocular.

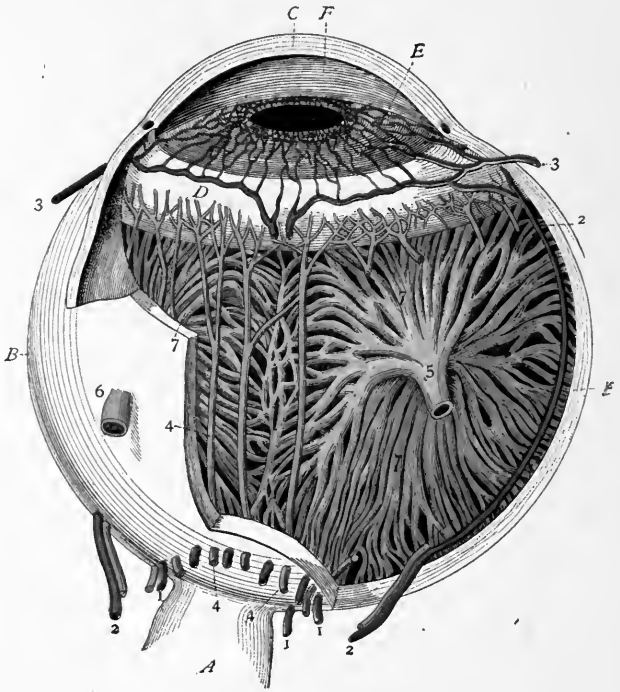
Orbital Group.	Lachrymal. Supraorbital. Post. Ethmoidal. Ant. Ethmoidal. Palpebral. Frontal. Nasal.	Ocular Group.	Muscular. Anterior Ciliary. Short Ciliary. } Post. Long Ciliary. } Ciliaries. Arteria Centralis Retinæ.

The orbital group has been considered in a former section.

All the arteries supplying the eyeball are divided into *two sets, the retinal and the ciliary.* These two systems do *not anastomose* except at the *optic nerve opening.* The retinal system is based upon the distribution of the central artery of the retina, a small twig that arises from the ophthalmic close to the optic nerve entrance, usually in common with a ciliary artery. It pierces the nerve just posterior to the eyeball, runs along its axis to appear on the interior of the eyeball. As a rule it enters the eye on the nasal side of the optic papilla, from a depression called the physiological excavation, at the bottom of which is a *larger* opening called the porus opticus, through which the vessels enter.

On the face of the optic nerve the main stem divides into the retinal vessels, running chiefly upwards and downwards and branching in an arborescent fashion. The retinal arteries are end arteries, *i. e.*, there is no anastomosis. If the branch of the artery supplying a certain area becomes stopped, that area degenerates on account

of lack of blood supply. During fœtal stages the central stem of the artery continues forward to the posterior surface of the lens, con-



Diagrammatic View of Principal Blood Vessels and Nerves of the Eyeball (Testut): *A*, optic nerve; *B*, sclera; *B'*, viewed in section; *C*, section of cornea; *D*, ciliary muscle; *E*, iris; *F*, anterior chamber; 1, short posterior ciliary arteries; 2, long posterior ciliary arteries; 3, anterior ciliary arteries; 4, ciliary nerves, 5, one of the large venæ vorticosæ; 6, vena vorticosa after piercing the sclera; 7, vasa vorticosa of the choroidal tunic.

tained in a canal running through the middle of the vitreous body, called the central canal or the canal of Stilling. This canal remains in the fully formed eye as a lymph channel; the artery having disappeared. The central artery of the retina is accompanied by its vein lying to its outer side.

The ciliary system of vessels supplies the remainder of the eyeball, and is divided into the posterior and the anterior ciliary vessels. A number of short arterial twigs, coming off independently, or as several

large trunks from the ophthalmic, pierce the eyeball about the optic nerve. These arteries are also called the posterior ciliary. They pass through the sclera to supply the chorioid. As they pierce the sclera, a few twigs are given off which anastomose with a few branches from the artery of the retina.

These twigs unite to form an arterial circle about the optic nerve, called the arterial circle of Zinn, from which the nerve substance in part gets its nutrition. It is further supplied by a circle of vessels surrounding it in the chorioid formed by several recurrent branches of the post ciliaries (circle of Haller). There are two long twigs or branches that enter the eye along with the short ciliary arteries, the long ciliary. The latter continue around between the sclera and the chorioid, lying in grooves in the former, to the iris, at the root or periphery of which the two vessels unite to form a large arterial circle, circulus arteriosus major iridis. From this large circle a number of twigs are given off, which converge towards the pupil, around which they unite to form a smaller arterial circle, circulus arteriosus minor iridis.

The posterior arteries are unaccompanied by veins. The anterior ciliary arteries are usually 6 to 8 in number. They are seen beneath the ocular conjunctiva of a purplish color, do not fade on pressure, and disappear from sight near the edge of the cornea by entering the eyeball. The anterior ciliaries are branches of the muscular branches of the ophthalmic. They run along beneath the ocular conjunctiva in the episcleral tissue to near the edge of the cornea, where they enter the interior of the eye to supply the ciliary bodies. Just as they pierce the sclera they give off some small branches that continue on, to the edge of the cornea, and join branches from the long or posterior conjunctival vessels to make up the circumcorneal loops.

The circumcorneal loops nourish the cornea. These anterior ciliaries are accompanied by veins. There are likewise venous circumcorneal loops. The conjunctiva is fed by the palpebral arteries which pierce the tarsal cartilage to reach it. There are several long ones that continue around the fold of transition to the edge of the cornea,

where they join the branches of the anterior ciliaries to form the circumcorneal loops before spoken of.

The Venous Circulation.—The retina has its veins. The venous blood from the entire *uvea* that is in the greater part is collected in veins of the chorioid that converge to either one of four centers, one under each rectus muscle. From these centers or vortices large veins arise and piercing the sclera diagonally leave the eyeball. These veins are the venæ vorticosæ. A small part of the venous blood from the iris and the ciliary bodies only leaves the eyeball by way of the anterior ciliary veins. The conjunctiva and lids, of course, have their veins.

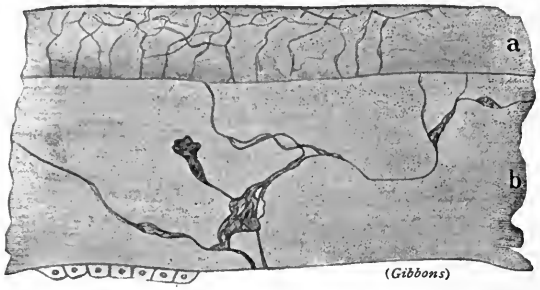
The Lymphatics of the Eyeball.—The lymphatic channels of the eyeball may be divided into two systems, an anterior and a posterior system. The anterior lymph system is that of the aqueous humor, consisting of the posterior chamber, the anterior chamber, spaces of Fontana, canal of Schlemm, and the adjacent lymph channels in the cornea and sclera. The posterior lymph system is further divided into two distinct systems, that of the chorioid and that of the retina. The lymph from the chorioid is collected into the perichorioidal lymph space, that between the chorioid and the sclera, and poured into Tenon's space (episcleral lymph space) through channels surrounding the venæ vorticosæ; the lymph then passes into the subdural space about the optic nerve. The retinal system of lymph spaces is represented by the retinal perivascular lymph spaces surrounding the retinal vessels, and by the hyaloid canal within the vitreous. These channels communicate with the lymph clefts within the optic nerve, which in turn are connected with the subarachnoid lymph cavity of the brain by way of the subarachnoid lymph channel surrounding the optic nerve.

The Nervous Supply of the Eyeball.—The eyeball is supplied with sensation by the first division of the fifth nerve, through the lenticular or ophthalmic ganglion. This is a small ganglion about the size of a pin's head, of a reddish gray color, situated at the back of the orbit between the external rectus muscle and the optic nerve,

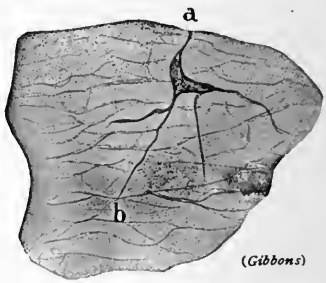
lying usually to the outer side of the ophthalmic artery. It is enclosed in the loose orbital fat. Its branches of communication or roots are three in number, a sensitive, a motor and a sympathetic root. The longest root is that derived from the nasal branch of the first division of the fifth nerve, and joins its superior angle. The second or short root is rather thick and often is divided into two parts; it is derived from the branch of the third nerve that supplies the inferior oblique muscle and is connected with the inferior angle of the ganglion. The third or sympathetic is a slender filament from the cavernous plexus of the sympathetic. The branches of distribution of the ophthalmic ganglion are the short ciliary nerves. These are ten or twelve delicate filaments which arise from the fore part of the ganglion in two bundles, connected with its superior and inferior angles. They run forward with the ciliary arteries in a wavy course, one set above and the other below the optic nerve, pierce the sclerotic in the back part of the eyeglobe around the optic nerve entrance, pass forward in grooves on the inner surface of the sclera, and are distributed to the ciliary muscle and the iris. The ciliary muscle and the iris are also supplied by the long ciliary nerves. The long ciliary nerves are two or three in number, they are given off from the nasal branch of the ophthalmic as it crosses the optic nerve, they join the short ciliary nerves and pass with them through the sclerotic into the eyeball.

Within the ciliary muscle the anterior branches of the short and the long ciliary nerves form an annular plexus known as the orbiculus gangliosus. The sensory fibers are largely subscleral in their distribution; the vaso-motor fibers are distributed to the walls of the blood-vessels; motor fibers distributed to the fibers of the ciliary muscle, and some fibers terminate in the interfascicular tissue of the ciliary muscle. The nerves of the iris are derived from the orbiculus gangliosus. After entering the iris the nerve twigs soon become united to form a plexus in the iridic stroma from which the different portions of the iris are supplied, namely the vessels, muscles and stroma.

The nerves of the chorioid are derived from the branches given off from the ciliary nerves as they pass anteriorly between the fibrous and vascular tunics of the eyeball. They are both medullated and non-medullated and form a wide-meshed plexus in the lamina supra-chorioidea, from which numerous non-medullated twigs proceed to the vessels of the chorioid which they especially supply. The nerves



Vertical Macroscopical Section of Cornea showing Nerve Plexuses : *a*, epithelium ; *b*, stroma.



Subepithelial Nerve Plexus of Cornea : *a*, branch of primary plexus ; *b*, branch giving rise to subepithelial plexus.

of the cornea pass into it from the periphery, losing their medullary sheaths as they enter the corneal substance. They form a primary plexus in the substantia propria, and a secondary or subepithelial plexus immediately under the epithelium of the anterior surface, and a terminal plexus of fine fibers in pencil-like tufts that ramify and become lost between the cells of the epithelium. The nerves of the sclera consist of a few twigs derived from the ciliary nerves as they pass between the sclera and the chorioid.

CHAPTER IV

EXTERNAL EXAMINATION OF THE EYE

Examination of the Patient and External Examination of the Eye.—A systematic method of examining each patient should be employed so that no diseased condition of the eye will be overlooked, and so that an accurate record may be kept. The patient should be allowed to tell his story and then the physician proceeds to the direct examination of the eye. The surfaces of the lids should be inspected for swollen veins, a very common occurrence in inflammation of the eyeglobe; their edges for inflammation, parasites and misplaced lashes; the puncta for patency, pressure being made at the same time at the inner canthus over the lachrymal sac to express from it through the puncta any contained fluid. The upper and the lower conjunctival cul-de-sac should be examined for any secretion, foreign bodies or evidences of inflammation; the caruncles for swelling, and the conjunctiva for the information to be derived from the appearance of its blood vessels. The cornea should then be carefully inspected for any roughening of its surface or loss of transparency of its substance; the pupil as to its size as compared with its fellow —provided both eyes are not the seat of disease, and for mobility on exposure to light; the tissue of the iris for the evidence of inflammation denoted by change of color and loss of the normally trabeculated appearance. The eyeball should then be palpated, and any change in the intraocular tension or tenderness noted. By following this routine one will not overlook an iritis for instance even if he does find an injected conjunctiva. Only in the absence of disease in the cornea and iris is one justified to make a diagnosis of conjunctivitis, because in all cases where the cornea and iris (sclera and ciliary bodies) are inflamed do we have an injected conjunctiva on account of the anastomosis in the circulation of these structures. An iritis

for instance is always more or less accompanied by a reddened conjunctiva. The same appearance without the signs of an iritis is found in cases of conjunctivitis.

To examine the conjunctiva of the upper lid it must be everted. In order to evert the upper eyelid the following rules should be observed. Have the patient look down (he should not close the eyes) and then with the thumb and index fingers of the left hand take hold of the lashes, draw the lid forward away from the eyeball, place the end of the thumb of the right hand or a pencil point above the tarsus, turn the edge of the lid back over the thumb, while this is simultaneously depressed. If there happens to be no lashes in the upper lid, the lower lid is pushed beneath its edge in such a manner as to act as a wedge on which the upper lid is turned back.

Blood Vessels of the Conjunctiva.—In the normal condition only a few conspicuous blood vessels are to be observed, but when the tissue becomes inflamed there are many more visible. The blood supply of the anterior segment of the eye may be divided after Nettleship into three systems.

1. *Posterior Conjunctival Vessels whose Congestion Produces a Brick-dust Red Color.*—They shift with the conjunctiva, when the latter is caused to move over the eyeball by rubbing the edge of the lower lid against it, and fade upon pressure to refill when the pressure is relaxed. This form of injection is usually associated with more or less secretion of muco-pus from the conjunctiva, indicating conjunctivitis.

2. *Anterior Ciliary Vessels*, formed by the perforating and the non-perforating arteries and veins. The perforating branches supplying the iris and the ciliary bodies and the non-perforating together with branches from the conjunctival vessels giving rise to the circum-corneal loops.

The non-perforating episcleral branches are invisible in health, but produce when injected a pink zone in which the individual twigs are invisible surrounding the cornea (ciliary congestion, circum-corneal injection), not moving with the conjunctiva, nor fading on pressure.

The perforating *veins* and their non-perforating branches when congested create a zone of dusky hue, concentric to the cornea as seen often in cases of glaucoma or appear as deep-seated patches of lilac, pointing to inflammation involving the sclera or the ciliary bodies.

3. *Anterior Conjunctival Vessels* and the plexus of capillaries surrounding the cornea, derived from the anterior ciliary vessels, and through which anastomosis between systems 1 and 2 takes place. Their congestion produces a circle of bright red, often partly upon the edge of the cornea which is especially seen in cases of interstitial keratitis. Congestion of all systems may be commingled or there is frequently a new formation of vessels especially upon or within the corneal stroma, in diseases of the cornea.

The Temperature of the Conjunctival Cul-de-sac is normally about 95.99 or about two degrees lower than that of the rectum. For this reason many organisms do not flourish in the eye as they do in other sites where the temperature is higher; especially is this the case with the tubercle bacillus, the eye having a greater immunity than any other organ of the body. There is an average increase of .9° to 1° in inflamed eyes, the highest temperature being reached in cases of panophthalmitis and acute iritis. The taking of the temperature of the eye is of no practical utility.

Inspection of the Cornea reveals inflammation, ulceration, opacities and foreign bodies. Slight irregularities of the surface of the cornea are detected by placing the patient in front of a window, while the eyes are made to follow the uplifted finger held at a distance of about one foot. The image of the window-bars reflected from the cornea will be broken if they cross an uneven spot. A better method still is to employ Placido's disc. If the circles in the reflected image of the disc are broken or distorted, there is irregularity of the surface present.

Minute abrasions and ulcers which are difficult to see may be readily located by dropping into the eye a concentrated alkaline solution of fluorescein (Grübler's fluorescein, 2 per cent.; bicarbonate of soda, 3.5 per cent.), which stains any tissue a green color that is

devoid of epithelium. Coloration takes place around a foreign body, and the outlines and extent of an ulcer are mapped out. Fluorescein was introduced into ophthalmology by Straub, and it is an exceedingly valuable diagnostic agent.

The Width of the Cornea.—This may be approximately measured by holding a small rule marked in millimeters in front of the eye, or with Priestley Smith's keratometer, which consists of a scale placed between two plano-convex lenses. The observer places his eye at the principal focus of the combination and, holding the scale before the eye of the patient, observes the number of millimeters the cornea subtends on the scale. The average horizontal diameter of the cornea is accordingly seen to be 11.6 mm.

Sensibility of the Cornea is tested by gently touching the cornea with a piece of cotton thread or wisk of cotton. If sensation is perfect, the touch will at once be followed by the act of winking. The fellow eye should be similarly examined as a control experiment. If the cornea is found insensitive the forehead and the face should be examined for areas of anesthesia with a moderately blunt-pointed pin or esthesiometer. Thermic and tactile sensation should both be examined.

The esthesiometer consists of a pair of dividers with blunted points. The two points are pressed upon the skin and the distance between them necessary for them to be distinguished as two as shown upon a scale attached gives the degree of tactile sensation at the spot.

The sensibility of the cornea is found altered especially in rise of tension of the eyeball and in fifth nerve paralysis. The method of examining the eye by oblique illumination has already been described. It should never be omitted, as minute abrasions, foreign bodies, nebulæ and in short all changes in the cornea are seen. The character of the aqueous, depth of the anterior chamber, color of the iris, form of the pupil, pupillary membranes, etc., and opacities in the axis of the lens, and finally the anterior portions of the vitreous can be studied by focusing deeply. Dr. Jackson has recently put upon the market a binocular magnifying lens. Two lenses are placed side

by side, so that the visual lines pierce the lenses at their centers. The claim is that this lens allows one to better estimate the depth of an opacity within the media of the eyeball. Any lesion of the cornea or iris may be magnified by employing a watch-maker's glass or a so-called corneal loop. This is an ordinary watch-maker's glass mounted with a steel band to be placed around the head. Corneal microscopes have not proven themselves practical. With them traces of former vascularity in the cornea, pigment spots upon the lens and all minute changes in the anterior segment of the eyeball may be studied, but little advantage is gained for the good of the patient.

The Color of the Iris. — Blue and gray are the colors usually seen in the irides of the inhabitants of northern countries, brown occurs next in frequency and various admixtures of these colors producing various shades of yellow and green. Taking the whole population of the globe very dark brown irides, the so-called black eyes, are the most frequent. The color of the iris of the new-born child with rare exception is of a light grayish blue. The color of the iris becomes fixed at about the third month; in the meanwhile a variable amount of stromal pigment is being developed. At times one sees a slight difference in the shade of the two irides, or less frequently a marked difference in the color of the two eyes, one being brown and the other blue or gray. Under these conditions it is said that the color of one eye is that of the eyes of one parent and the color of its fellow that of the eyes of the other parent. Irregular spots of pigment are now and again seen in the iris, constituting the so-called *piebald iris*. Chromatic iridic asymmetry is more common in neuropathic subjects, for example in chorea and epilepsy. Discoloration from inflammation causes a blue or gray iris to appear green, and a brown one, reddish, and at the same time the trabeculæ upon the anterior surface of the iris are more or less effaced by the effusion of lymph.

The Pupil. — The pupil varies in size according to the amount of light and also to the accommodative and convergent effort. The size of the pulpil is furthermore influenced by age, and by the character of the refraction of the eye. The pupil is smaller in old age, in blue

eyes and in hyperopia. The average diameter of the pupil is 4.14 mm., varying from 2.44 mm. to 5.82 mm. Under ordinary conditions of equal illumination the pupils are of equal size, but may vary slightly in size in health. A marked difference in the size of the two pupils is however pathological. The width of the pupil may be approximately measured by holding before it a rule numerated in millimeters, but as Jackson pointed out, the distance subtended upon the rule is less than the width of the pupil in proportion as the distance of the observer's eye is less to the rule than to the pupil of the observed eye. The simple pupillometer, consisting of a metallic disc perforated by a number of openings of various sizes and numbered according to their diameters in millimeters, gives more accurate results. The pupillometer is held close to the eye, and the disc rotated until the circle that matches the size of the pupil is reached. The keratometer of Priestley Smith can also be used.

Simple Pupillometer.

The Reactions of the Pupil and the Methods of Testing Them.— The light employed should not be more intense than that to which the retina is accustomed. Therefore except under special conditions the methods of passing a flame in front of the eye or reflecting light into it from a mirror are inaccurate.

We test the reflex action of the pupil or the mobility of the iris to ascertain whether there are any adhesions between the iris and the lens capsule behind (posterior synechiæ) or immobility from paralysis or atrophy of the iris, or to ascertain the sensitiveness of the retina or visual center to light. There are five normal pupillary reflex actions (reactions) as follows:

1. If a patient be seated facing a window and one eye is covered and then uncovered, the pupil of that eye will be seen to shrink as the light enters it. This is called the direct reflex action of the pupil, and is brought about by the muscular contraction of the sphincter of the pupil, following the stimulation of the optic nerve.

2. It will be observed that the other pupil acts in the same manner as that of the eye shaded and uncovered during the test, that is, it will dilate when the fellow eye is screened and contract when exposed to the light. This is known as the consensual or indirect pupillary reflex action. Under normal conditions the pupils will be equal even with one eye shaded. The efferent impulse in the pupillary reflex arc travels forward to each sphincter pupillæ from the nuclei of the third nerves, contracting each pupil, when the light is thrown into either eye, the afferent impulse traveling backward along the optic pathway of that side. In pathological conditions however in which one eye sees poorly from disease of the conducting apparatus its pupil is usually larger than the pupil of the fellow eye.

3. If a patient is told to suddenly direct his eyes at a near object from a distant one, the pupils are seen to contract. This is the associated action of the pupils (convergence-reaction). The accommodation undoubtedly increases the pupillary action, but it does not take place under the influence of accommodation alone, but it does occur with convergence without the act of accommodation, although not quite to its full extent.

4. The next is known as the skin-reflex or pain-pupillary reaction. The patient should sit with the light shining in the eyes so that both pupils are well contracted, and then some cutaneous nerve is stimulated, preferably one in the neck by pinching the skin or better by using a faradic brush. The reaction consists in a dilatation of the pupil due to a stimulation of the sympathetic. A more decided result at times is obtained if the eye to be watched is screened while the light falls into the fellow eye.

5. Finally, the action of the pupils to myotics and mydriatics may be tried, especially the mydriasis produced by cocaine, which in the normal eye should cause nearly full mydriasis and widening of the palpebral fissure through stimulation of the sympathetic.

The contraction of the sphincter of the pupil is entirely reflex and needs the parts for its performance necessary for any reflex act, viz., a sentient surface, the retina; an afferent nerve, the optic; a nerve

center, the center of the third nerve situated in the gray matter of the floor of the fourth ventricle, and an efferent nerve, the motor oculi. The dilatation of the pupil is determined by the activity of a more or less continuously active center in the medulla oblongata, which sends its impulses to the iris through the fibers of the sympathetic. The precise course of these fibers in man has not been determined. We know that they pass from their origin successively through the cervical cord, the anterior roots of the first and second dorsal nerves, the upper thoracic ganglion, the cervical sympathetic, the upper cervical ganglion to the ophthalmic division of the fifth nerve, the nasal nerve, thence through the long ciliary nerve to the iris. As long as light falls into the eyes the oculo-motor nerve keeps up a certain tone or contraction of the sphincters of the pupils, but when the eye is in darkness there is no longer any afferent impulse passed back to the center and the pupil dilates or becomes at rest, strictly speaking. Some suppose that the action of the sympathetic is antagonistic to that of the oculo-motor, as the section of the oculo-motor nerve is followed by a dilatation of the pupil. That this is not the case is proven by the fact that atropia instilled in the eye or stimulation of the sympathetic in the neck produces still wider dilatation. The dilatation of the pupil following paralysis or injury to the third nerve (oculo-motor) is mostly due to loss of tone in the sphincter of the pupil.

Inasmuch as the visual pathway forms the afferent path in the pupillary reflex arc it will be described here.

The optic nerve fibers from each right half of the two retinæ pass backward through the optic chiasm to the tract upon the same side, the fibers from the left halves following the left optic tract. The optic tracts wind around the crura cerebri, and terminate, each in two roots, upon the corpora geniculata externa and interna, and upon the posterior part of the optic thalamus which is called the pulvinar. Some fibers also terminate in the anterior part of the corpora quadrigemina, which are not concerned however with the act of vision but belong to the pupillary reflex arc. The parts referred to are called

the primary optic centers, or visual ganglia. In them are found numerous ganglion cells in which the fibers of the optic tracts lose themselves, and from them a new set of fibers begin and pass backward through the posterior part of the internal capsule to the cortex, under the name of the visual radiation or fibers of Gratiolet, or of Wernicke. Passing through the internal capsules they cross sensitive fibers coming down from the hemispheres, are closely massed and then spreading out like a fan, rise upward and winding around the tip of the lateral ventricle finally reach their destination in the cortex at the lower part of the median surface of the occipital lobe. From the corpora quadrigemina anterior proceed fibers to the oculomotor nuclei in the floor of the fourth ventricle; a few fibers also pass brainward and end in the occipital cortex. The pupillary reflex pathway is then as follows: The retina, optic nerve, chiasm, optic tract, corpora quadrigemina, special fibers to the third nucleus, the third nucleus, the third nerves, the lenticular ganglia, ciliary nerves, and sphincter muscles of the irides.

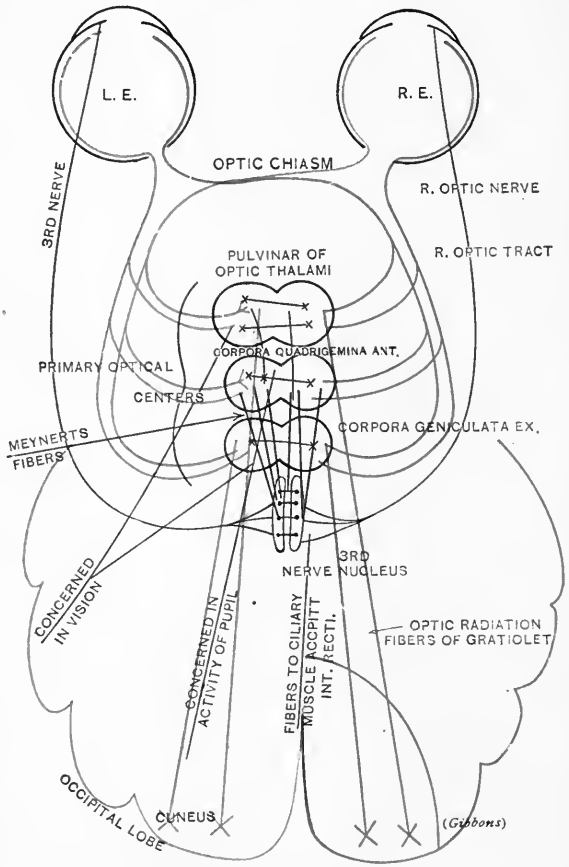


Diagram of Pupillary Reflex Arc and Visual Pathway.

When light enters either eye it spreads forward to both pupils, causing them to contract. Inasmuch as posterior to the corpora quadrigemina the afferent pupillary reflex pathway is separate from the visual pathway any lesion of the latter causing blindness does not affect the former, and in consequence the afferent impulse in the reflex arc is not interfered with, and the pupils remain active to light; a lesion anterior to the primary optic centers however involves the afferent tract of the pupillary arc as well as the visual pathway and therefore the pupils do not respond to light thrown into them in cases of blindness caused by involvement of the visual tracts anterior to the primary optic centers.

The Pupil in Disease.—As McEwen points out there are six possibilities that should suggest themselves to the examiner who is about to investigate pupillary action, namely: The action of drugs, ocular disease or optical defects, spinal or sympathetic lesions, localized cerebral lesions in special centers or tracts, abeyance of brain-function, and cerebral irritation. Magnus divided the pupillary reflex tract into the following three portions for the convenience of locating the position of a lesion involving the tract:

1. The centripetal part which includes the optic nerves, the optic chiasm, optic tracts and the connecting fibers to the cortex. If there is an interruption of the conducting power of one optic nerve, say the right, illumination of the pupillary area on that side fails to cause a contraction of the pupil, either in that eye or in its fellow. If the light is thrown into the left eye however the left pupil will contract (direct action) and the right or the affected one as well (indirect action). Lesions affecting the chiasm and the optic tract are associated with hemianopsia, and the special pupillary phenomenon that belongs to this condition (Wernicke's phenomenon), while lesions involving the optic pathway between the corpora quadrigemina and the cortex, although accompanied by probable changes in the field of vision, are unassociated with pupillary changes.

2. The part of the reflex arc that carries the light impulse from the corpora quadrigemina to the oculo-motor nuclei in the floor of

the fourth ventricle (Meynert's fibers). If both sides are affected neither pupil will respond to light falling in either eye, but there is normal action to accommodation and convergence (Argyll-Robertson pupil).

3. The centrifugal portion of the reflex arc, including the nucleus of the sphincter of the iris, the third nerve, and the termination of the third nerve in the iris. If the right nucleus is affected, the direct light reaction of the right pupil is abolished, and also its indirect action. Light directed upon the pupillary area of the left eye is followed by an action of the pupil in that eye. Pupillary action in that eye also follows light stimulation of the right eye but to a less degree. The pupils act normally to the acts of accommodation and convergence but they are unequal in size, the right one being the larger. If the trunk of the right oculo-motor is affected, there is loss of direct light pupillary action, and also when the light is directed into the left eye as well as the loss of accommodation upon the right side. Light falling into the left eye produces a normal direct action, and consensual action is also present in the left eye when the light is made to enter the right eye. The pupils will be of unequal size, the right being the larger. The same condition of affairs is seen if the endings of the third nerve in the iris are affected upon one side.

Mydriasis, or Dilatation of the Pupil. — This occurs in rise of the intraocular tension, *i.e.*, glaucoma, in cases of non-conductivity of light as in optic nerve atrophy, in diseases of the orbit and under the influence of certain drugs, chief among which is atropia. It is also seen in fright, anemia, lowered nervous tone, neurasthenia, aortic insufficiency, and in irritation of the cervical sympathetic. It also appears in vomiting, forced respiration (due to the carbonated blood stimulating the center of the sympathetic) and in anemia of the brain, as in syncope, and is claimed by some to be present in persons of low mental development. In diseases of the nervous system dilatation of the pupil, when of cerebral origin, is indicative of an extensive lesion, and when of spinal origin, irritation of the part, according to McEwen.

The dilatation of the pupil is usually divided into irritation and

paralytic mydriasis. The first is caused by irritation of the pupil-dilating centers or fibers, and the latter caused by a paralysis of the pupil-contracting centers or fibers, or a failure of a stimulus to pass from the retina to the center. The former (irritation mydriasis) is most often seen in hyperemia and irritation of the cervical portion of the spinal cord, in spinal meningitis, and tumors of the cord or of cranial cavity, in acute mania, and late in tabes dorsalis and progressive paralysis of the insane. The latter or iridoplegia (paralytic mydriasis) is found in diseases at the base of the brain affecting the third nerve, in pressure of the cerebrum due to hemorrhage, tumors, advanced thrombosis of the sinuses, or abscesses, and frequently in the late stages of meningo-encephalitis. It is present in acute mania when there is edema of the cortex, and in cerebral softening. Hemorrhage into the centrum ovale and peduncles of the cerebrum also produces mydriasis.

Myosis or Contraction of the Pupil. — This occurs in congestion of the iris, in paralysis of the sympathetic, irritation of the fifth nerve, in plethora, and in certain fevers, in venous obstruction, mitral disease, and under the influence of certain drugs, chief of which is physostigmin. If the myosis is of cerebral origin, it indicates an irritative stage of the affection, if of spinal origin, a depression, paralysis or even destruction of the part.

Contraction of the pupil like dilatation is divided into irritation and paralytic myosis. The first is caused by an irritation to the pupillary contracting center or fibers and the latter to a paralytic affection of the dilating pupillary center or fibers.

Irritation Myosis is found in inflammatory affection of the brain, and its coverings, that is in meningitis, abscess (at first the myosis is on the side of the disease) and incipient sinus disease. Myosis passes into mydriasis if the products of the disease become excessive, hence the serious prognosis in cases of myosis that are followed by mydriasis. Myosis is seen in the early stages of cerebral tumors, in small hemorrhages in the cerebellum, and frequently at the onset of apoplexy. Berthold uses myosis to differentiate apoplexy from em-

bolism. The convulsions arising from meningo-encephalitis are accompanied by myosis, says McEwen, while those of epilepsy are usually associated with dilated pupils. Pressure upon the pons is accompanied by myosis.

Paralytic Myosis (spinal myosis) occurs in lesions of the cord above the dorsal vertebræ, occurring especially in tabes dorsalis. At first the pupil reacts to light and to convergence, but later fails to act to the stimulation of light, forming the so-called Argyll-Robertson pupil, that is the pupils fail to react to light but retain their action to accommodation and convergence. Under these conditions the lesion is probably in the fibers that pass from the optic nerves to the oculo-motor nuclei. Turner says that a lesion in the fore part of the oculo-motor nuclei in the Sylvian gray matter gives rise to myosis and reflex iridoplegia at the same time. Paralytic myosis is also present in paralysis of the insane, pseudo-dementia paralytica of syphilitic origin, disseminated sclerosis, and at times in multiple neuritis. Mydriatics only partially dilate the pupil affected with paralytic myosis, but cocain according to Heddeus readily expands the small pupil of reflex iridoplegia. Myotics contract it to its utmost.

Unilateral Reflex Iridoplegia is that condition in which one pupil is unaffected by varying degrees of illumination, but reacts to accommodation, the unaffected pupil answering to a separate light stimulus of each eye. It may exist as a mydriasis or not, but frequently the pupil is larger than its fellow. It is at times seen in tabes dorsalis and in syphilitic cases, and probably due to a lesion in the sphincter nucleus. Cases in which the pupils acted to light but failed to act to accommodation and convergence have been observed, and are supposed to be due to disease in a special part of the oculo-motor nucleus. This phenomenon is called Reversed Argyll-Robertson Phenomenon.

Unequal Pupils, or Aniscoria, are but infrequently present in health. If there is a high degree of anisometropia, especially if one eye is myopic the pupils are as a rule unequal in size (that of the myopic eye being the larger). If there is present a wide dilatation

of one pupil and no disease of the eye the instillation of a mydriatic must be suspected. Unequal pupils are seen in diseases of the nervous system, in dental diseases and in aneurysm. In cerebral diseases unequal pupils denote a unilateral or focal disease. They are common in tabes, disseminated sclerosis and in paralytic dementia. Varying inequality of the pupils according to Von Graefe is a serious premonitory symptom of insanity.

Special Pupillary Phenomena.— The hemianopic pupillary inaction, or Wernicke's sign, has been referred to in the section on the field of vision. It is loss of pupillary action to light when the light falls upon the blind portions of the retinæ.

Haab's Reflex, or the cerebral cortex reflex, consists of a marked bilateral pupillary contraction which takes place, if in a darkened room a patient directs his eyes to a bright object already present in the field of vision without change in the accommodation.

Gifford called attention to the contraction of the pupil that takes place when an attempt is made to forcibly close the lids, and explains this as the result of an overflow stimulus from the seventh to the third nerve.

Hippus consists of a rhythmical contraction and dilatation of the pupil without any change in the fixation or illumination of the eye and is normal to the eye to a small extent. It occurs very much exaggerated, or spontaneously in neurasthenia, disseminated sclerosis, spinal sclerosis, hysteria, psychical disturbances, epilepsy and in the early stages of acute meningitis.

Tension. — The sclera is distended normally by a pressure equal to that of 25 to 30 mm. of mercury. This intraocular resistance is what maintains the shape of the eyeball. The term tension indicates intraocular resistance, and is demonstrated by palpating the eyeglobe with the finger-tips. The middle and ring fingers of each hand are placed firmly upon the brow of the patient and the thumbs upon the malar bone, then with the index fingers the examiner palpates the eye through the closed upper eyelid. The patient must look down, and the examiner must place his finger-tips above the stiff tarsal

cartilage, pressure is then made downward and backward, care being taken not to push the eyeball directly into the orbit, and alternate pressure is made first with one finger then the other as in palpating an abscess and the amount of resistance to indentation noted. Every one should make himself familiar with the feel of the normal eyeball, otherwise he will never be able to appreciate an alteration in tension of a diseased one. In diseases of the uvea the tension should be frequently estimated, and especial attention paid to any elevation of tension, as this constitutes the most valuable symptom in glaucoma, a disease that does considerable damage to the sight on account of its insidious onset and because it is so frequently overlooked. Rise of tension or hypertony is denoted thus: Tn. + 1; + 2; + 3, according to the degree of hardness, and decrease of tension or hypotony, by minus signs, −1; − 2; − 3.

As has been said increase of tension is glaucoma. Decrease of tension is found in cases where there is a leak in the eyeball, as after injuries, in synchisis or fluid vitreous from a uveitis and after cataract extraction. Some advise that the finger-tips be placed directly upon the eyeball, below the cornea as the patient looks up, when estimating tension, but this method offers no direct advantage over the other method, that of palpating the eye through the closed lid. For the exact measurement of the intraocular pressure various instruments after the principle of manometers have been devised, but have so far been used in the laboratory only, as they were practically inapplicable on account of the danger to the eyeball. One arm of the instrument was connected with a canula and the other introduced into the eyeball. Modifications of these instruments have been made to which the name of tonometers have been given. They measure the tension of the eyeball by recording the amount of pressure necessary to indent it.

Proptosis, *Exophthalmus* (*Exophthalmos*) or protrusion of the eyeball may be caused by orbital disease, tenotomy, paralysis of the extraocular muscles, and Grave's disease, while enlargement of the eyeglobe is due to conditions within the eye, as myopia, intraocular

tumors, rise of tension in young eyes. If the condition is unilateral the amount of bulging may be roughly estimated by observing the relative positions of the apices of the corneæ with each other and with the line of the brows. More accurate information as to the degree of proptosis may be obtained by holding a rule with its zero mark against the outer margin of the orbit and then sighting across it the mark opposite the apex of the cornea. Upon this principle Dr. Jackson has devised a very handy proptometer. It consists of two scales mounted upon a cross bar so that the degree of proptosis if bilateral can be compared. Ambialet devised a rather complicated apparatus for measuring proptosis. Two adjustable arms are brought in contact with the upper and with the lower margins of the orbit and the observed eye is fixed by looking in a mirror. With it the horizontal position of the eyeball can be determined as well as any asymmetry in the formation of the orbit.

In some cases the eyeball is sunken (enophthalmus) as in ptosis, wasting of the orbital fat in debilitating diseases, and the eyeball is actually smaller than normal in high grades of hyperopia and congenital failures of development. There is no difficulty to decide whether an eyeball is too large or too small, or whether it is bulging or sunken, if the size of the cornea and the depth of the anterior chamber are taken into consideration. Thus: in increase in size of the eyeball, there is an increase in all of its parts; the cornea looks larger than normal and the anterior chamber too deep, the pupil too large and so on, while if the eyeball is simply bulging, the parts are normal in size but the eyeball is too far forward.

Finally the position and motions of the eyeballs should be examined. Any deviation of the visual axis of one or the other eye should be noted and then with the head stationary the patient should follow with the eyes the examiner's uplifted finger as it is moved through different portions of the field of fixation. Both eyes should follow the finger readily. The finger is then made to approach the eyes in the median line, to test the power of convergence.

CHAPTER V

DISEASES OF ORBIT

CONGENITAL malformations of the orbits have been described in all degrees from a trifling defect in a portion of their bony walls to complete absence of these cavities. There are four well-known anomalies which will be considered, namely: Anophthalmos, absence of one or both eyes; microphthalmos, small eye; megalophthalmos, large eye; cyclopia, fusion of both orbits and their contents.

Anophthalmos (congenital) is a rare condition, and is usually bilateral.

Monophthalmos, or unilateral anophthalmos, is rarer still. In most cases of anophthalmos the palpebral fissure is contracted, the conjunctival sac small, and the eyeball entirely absent or, as is more often the case, represented by a small irregular fleshy mass, to which all or some of the poorly developed extrinsic eye muscles are attached. The orbits are always smaller than normal and the adnexa, if present, illy developed. The lack of development does not alone involve the orbits and their contents but the optic nerves, tracts and chiasm, corpora quadrigemina, and sometimes the adjacent parts of the cerebrum are deficient. In the few cases of monophthalmos that have been observed, the one eye was well-developed. This anomaly is explained by the failure of the primary optic vesicle to bud or, having done so, its failure to form the secondary optic vesicle. The orbits have been symmetrically placed in all cases, which fact differentiates it from cyclopia.

Cyclopia is a fusion of both orbits and their contents, with a single eyeball situated in the middle line just above the root of the nose. This single eye may be larger or smaller than is normal, but in all cases shows evidence of the fusion of the two eyes. The same is true of the adnexa. The ethmoid bone is rudimentary or absent, the olfactory

nerves are wanting, and the cerebrum is so imperfectly formed that most cyclops are still-born, or die within several hours after birth.

Microphthalmos.—Eyes which are considerably smaller than is normal at birth seldom have much useful vision. The faulty development may involve one or both eyes, and is supposed to be due to some intra-uterine pathological condition rather than to simple arrest in development.

In microphthalmos the eyeglobe is usually spherical, but sometimes slightly flattened from below. The cornea is smaller than normal and its margins illy defined, and its curvature is usually the same as that of the sclera. The other parts of the eyeball are correspondingly diminished. The space between the lids is unduly narrow and the lids themselves are deprived of their proper function, as they lack the support of the eyeglobe. The changes in the interior of the eyeball are of a degenerative character, like those found in cases of atrophy of the eyeball from other causes. Vision is extremely poor or entirely wanting.

Megalophthalmos is an extremely rare anomaly in which the cornea and the anterior chamber are larger than normal. This condition is sometimes called hydrophthalmos anterior. The condition is caused by an intra-uterine rise of tension in the eyeball at a time when the cornea is less resistant than the sclera, and therefore becomes distended while the posterior segment of the eyeball remains unaffected in its development.

DISEASES OF THE ORBIT.

The orbit is the seat of the following diseases: Periostitis, caries and necrosis, cellulitis (abscess), tenonitis, thrombosis of vessels, tumors which grow (1) from the tissues of the orbit, (2) from the periosteum or its bony walls, of the orbit, (3) from the cavities or tissues close to the orbit, and (4) pulsating exophthalmos.

THE GENERAL SYMPTOMS OF ORBITAL DISEASE.

Exophthalmos, from increase in contents of orbit.

Loss of motion of eyeball, due to the change in the tissues around it.

Redness, swelling and edema of lids, especially when the cellular tissue of orbit is inflamed.

Chemosis of conjunctiva, general or local, over a certain portion of the eyeball nearest the area of disease.

Fluctuation, at times, in abscess of orbit.

Pain, especially when an attempt is made to rotate the eyeball and upon palpation. Tenderness of the orbital margins is common in periostitis of the orbit.

Disturbed vision is secondary to an intraocular inflammation if it occurs.

Diplopia, or double seeing, arises from the fact that the eye is pushed out of its normal place by the encroachment of the disease upon the cavity of the orbit. If there is pressure exerted upon the ciliary ganglion by a growth or cyst we have in addition to the signs enumerated a dilated pupil and paralytic ciliary muscle.

Periostitis of the orbit occurs in two forms, the acute and the chronic, and may be circumscribed or diffuse, according to the amount of area involved.

Etiology.—Scrofula, syphilis and rheumatism, injuries, sudden changes of temperature, or the disease is idiopathic. The disease usually affects the outer margin of the orbit, and abscess formation is very apt to occur.

Symptoms.—Swelling, edema and redness of the lids, chemosis, commencing at the equator of the eyeglobe; pain on pressure upon part of the orbital margin affected. If pus is present fluctuation will be discovered. If the inflammation of the periosteum is deep in the orbit it is difficult to distinguish it from orbital cellulitis. The symptoms are violent, most intense headache, fever, vomiting and much prostration. The chronic form of orbital periostitis is far more frequent than the acute, and is practically always strictly circumscribed. It runs a course of months or years. The symptoms are all less intense than in the acute form, and the swelling of the lids is rather of the nature of a simple edema. The periostitis may undergo resolution, but usually terminates in abscess of the orbit. Caries of the

bone adjacent to the pus formation is apt to occur, and there is always danger of the inflammation spreading to the cranial cavity. If the disease involves the bony margin of the orbit, there is apt to be a distortion of the lid following, especially is this result common in children.

Treatment.—If the case is seen early, leeches (natural or artificial), applied to the temple and cold application over the eyelids may, with a saline purge, arrest the inflammation. If pus has formed, which is difficult to tell many times, the cold will increase the pain; heat should then be applied, but incision should not be long delayed, and in no case should the abscess be allowed to undergo a spontaneous rupture, although this does sometimes occur with preservation of a perfect eyeball. If pus forms the temperature will rise and blood-count will show leukocytosis. If there is a syphilitic history, mercury and iodides should be given, and if there is a rheumatic taint salicylates are indicated, although they have been found to be of little use in these cases. Subconjunctival injections of bichloride solution (1–1,000) exert a favorable and very rapid effect in hastening the suppuration, in reducing the dense infiltration of the orbital tissues and aid in restoring the circulation in the strangulated parts.

Method of Opening an Orbital Abscess.—A straight narrow bistoury is used and the incision is made over the point of fluctuation, or over the point of greatest swelling and tenderness, near the margin of the orbit. If necessary make the incision right through the lid. There need be no fear of entering the orbit too deeply if the knife is made to hug the orbital wall. The wound is then drained for a few days with a piece of gauze and hot compresses of bichloride, 1–4,000, are kept upon the eye, for one hour in every two, until the most of the inflammation subsides. If pain is very intense a free incision may properly be made even before the formation of pus, and the case treated in the manner outlined above.

Caries and Necrosis are always preceded by periostitis. The portion of the orbital wall affected may break down and brain abscess follow. It is seldom seen in the adult, but is rather common in chil-

dren. A fistulous opening is usually found upon the outer margin of the orbit leading to an area of softened bone, which is detected by use of the probe. Ectropion or drawing out of the lid from cicatrization occurs in most cases. Necrosis is less frequent than caries, but belongs to adult life.

Treatment. — The fistulous opening and cavity should be cleansed several times a day, with some antiseptic solution. A weak solution (1 to 30) of hydrochloric acid may be used for the purpose of dissolving the decayed bone. The surgeon should be extremely careful in the use of instruments, when the roof of the orbit is involved lest he penetrate the orbit and contaminate the cranial cavity, or injure its contents by the instrument suddenly slipping through the decayed and softened area of bone. The removal of the diseased bone may be undertaken when near the surface. This affection is very chronic in its course and appropriate tonic treatment is in order.

Cellulitis (phlegmon or abscess of the orbit) does not always present the same picture, as it may be acute, chronic, unilateral or bilateral, and the inflammation may terminate in resolution or go on to abscess formation. In the milder cases there is some swelling of the lids, slight amount of exophthalmos, diplopia, dull pain, and not much constitutional disturbance. Acute phlegmonous orbital cellulitis comes on with a chill, fever and a deep-seated pain, aggravated by the movement of the eyes. There is intense headache, and the loss of mobility of the eyeball may be complete. The lids are enormously swollen, red and edematous, the conjunctiva is red and chemotic, simulating closely the appearance of a purulent conjunctivitis or panophthalmitis, but the lack of secretion from the conjunctival cul-de-sac and the fact that the pupil retains its red reflex with the ophthalmoscope, serve to differentiate it from these maladies. The vision may be spared, but not infrequently there ensues a neuro-retinitis, and this in turn passes into atrophy of the optic nerve and blindness. Pressure of the products of inflammation upon the eyeball at times gives rise to dilatation of the pupil, anesthesia, or ulceration of the cornea, and now and then from the spread of the

infection we have panophthalmitis. Extensive intraocular changes may take place, due to the arrest of the retinal circulation with consequent edema and hemorrhages of the retina. Finally an abscess forms, and fluctuation may be gotten, if so, usually below the inner portion of the supraorbital ridge. At times the disease is more chronic and involves only a part of the orbital cellular tissue, beginning in the neighborhood of a periostitis or foreign body in the orbit.

Etiology. — At times the cause is not ascertainable and then we call it idiopathic. Among the known causes may be mentioned, sudden changes in temperature, scarlatina, typhoid, meningitis and facial erysipelas. The latter gives rise to the severest types of the disease and it is often bilateral. Diseased teeth and suppuration in the accessory nasal sinuses at times give rise to it. If it occurs in pyemia, septicemia, and in panophthalmitis there is always more or less diffuse inflammation of the orbital cellular tissue. There is reason to believe that the too prolonged application of cold to the eye may give rise to an orbital abscess.

Prognosis. — There is always a tendency to cerebral complications in the acute cases, which, if they occur, almost certainly terminate fatally. These are: meningitis, cerebral abscess, and thrombosis of the cerebral sinuses from the extension of phlebitis from the orbital veins. If associated with pyemia or septicemia the prognosis is correspondingly bad. One orbit has been known to become involved from the other by way of the cavernous sinus.

Treatment. — Rest in bed is essential. Cold in the early stages, saline purge, aconite internally, and artificial or natural leech to the temple. If improvement is not soon noted, within twenty-four hours say, change is to be made to hot applications and supporting treatment employed, or this plan may be employed from the beginning if the patient is much depressed. If there is reason to believe that pus has formed it should be let out at once. This is best done with a Graefe cataract knife, with the dull edge of the blade facing the eyeball.

Tenonitis, or inflammation of the oculo-orbital fascia as a primary disease, is extremely rare indeed. It was formerly supposed to be a

serous exudation into Tenon's capsule of rheumatic origin, but influenza and diphtheria also are known to give rise to it at times. Its characteristic feature is a very watery chemosis, which is out of proportion to the other symptoms of the disease. The chemosis may be limited to the site of attachment of one of the recti muscles. There are also present more or less the other signs of orbital disease as given above.

Treatment. — Hot fomentations, salicylates, potassium iodide, and sweats by means of pilocarpine internally. Squint operations which are done without the proper cleanliness may give rise to an orbital abscess, or to a tenonitis.

Thrombosis of the Cavernous Sinus. — During phlegmonous inflammation of the orbit, thrombosis of the orbital veins frequently occurs, and there may be an extension from them to the cavernous or other sinuses of the brain. Thrombosis of the cavernous sinus itself produces symptoms very like those produced by an abscess of the orbit. When the inflammation spreads to the cavernous sinus there are apt to be added the following symptoms to those of orbital abscess: Haziness and anesthesia of the cornea and partial or complete ophthalmoplegia. These symptoms are caused by pressure upon the nerves running to the orbit as they pass along the sinus.

Tumors of the Orbit. — Neoplasms that occur within the eyeball are not included among orbital tumors, save when they recur in the orbital tissues after the removal of the eyeball. Tumors of the orbit like those in other sites may be primary, metastatic, congenital, malignant or benign. The eyeball is of course always more or less displaced according to the size and position of the growth. The exophthalmos may increase until the lids are no longer able to close over the eyeball, and even become dislocated behind its equator.

The Prognosis depends upon the size, position and nature of the growth. The treatment consists in the complete removal of the growth when possible, unless the growth originates in some vascular tissue. The benign tumors may be removed without sacrificing the eyeball, but malignant tumors call for a complete emptying of the

orbit. Let us now consider the subject according to the tissue involved.

1. *Tumors Originating in the Tissues of the Orbit.*—Of these the cystic tumors compose a large majority. They are sebaceous, serous, blood, dermoid, echinococci and cysticerci cysts. Besides we have simple and cavernous angiomata, lymphangiomata, lipomata, echondromata, lymphomata and sarcomata, which take their origin from the connective tissue of the orbit. Carcinoma of the lachrymal gland has never been observed. Most tumors affecting it are of an adeno-sarcomatous type, but not malignant. A differential diagnosis in tumors of the orbit, is mostly impossible before operation.

Treatment.—Cystic growths can be cured by puncture and irrigation of the sac with astringent and irritating solutions, as iodine, nitrate of silver and so on.

Electrolysis has been successful in the hands of some in removing orbital growths, especially nevoid and erectile tumors. About ten cells are used and a needle or needles attached to the negative pole plunged into the growth; the positive electrode being placed upon the face near the site of the growth. The current should then be gradually increased until some discomfort is felt, and the seance continued for ten to twenty minutes. Long seances with weak currents are supposed to do as much good as shorter ones with stronger currents.

Perhaps a better plan is to introduce two platinum needles, one for each pole. The distal half of each needle is coated with shellac to protect the skin or conjunctiva at the points of puncture. The needle attached to the positive pole is first introduced about the center of the growth. The needle attached to the negative pole is then made to penetrate the tumor in several places around this, allowing it to remain in place each time several minutes. Several needles may be attached to the negative pole, and all the needles placed around the central one before the current is turned on. General anæsthesia is required, as the operation is very painful. In adults these tumors may be thoroughly excised or the electric cautery may

be used to supplement the knife and scissors. Tumors that have infiltrated the orbital tissues and eyeball cannot be removed without sacrificing the eyeball, and an understanding should always be had with the patient before operating, that, if such a condition presents itself, you should be allowed to remove the eyeball. Tumors of the optic nerve can be reached through a vertical incision of the conjunctiva over the inner side of the globe. The internal rectus tendon is to be secured by a suture (preferably a black one to distinguish it) and held out of the way by an assistant. The tendon is then detached from the eyeball. With the closed blades of a pair of curved scissors the tissues are to be separated down to the apex of the orbit and around the growth. A strabismus hook is then passed around the nerve as a guide and the nerve is divided close to the foramen. The growth is then grasped with a vulsellum-forceps and brought forward by reversing the eyeball, and detached close to the sclerotic. Bleeding is free and should be controlled by pressure with the finger, and irrigations of perchloride solution 1–3,000.

If the tumor is outside the muscle funnel it may be reached by a free incision parallel to the orbital margin, over the most accessible part of the tumor. All the deep dissection should be done with the handle of a scalpel or with the closed blades of scissors. Many growths may be successfully removed in this manner.

Kronlein's Operation.—This operation is devised to expose and remove tumors situated far back in the orbit without sacrifice of the eyeball. It is as follows: A crescentic incision is made around the outer circumference of the orbit. The periosteum is divided to a like extent and freely detached from the outer wall of the orbit as far as necessary. A wedge-shaped section of the orbital wall is then made, the base of the wedge corresponding to the orbital margin, and its apex to the inner extremity of the inferior orbital fissure. To do this the zygomatic process of the frontal bone is chiselled through, as well as the intervening bone between this and the fissure. In the same way the base of the orbital process of the malar bone is divided, and the incision continued backward to the fissure. The

loosened portion of bone together with the tissues attached to its surface are now drawn towards the temple. The depth of the orbit is now exposed. The growth is removed, the bone replaced and the skin wound sutured. A suitable dressing is then applied.

Hydatid Cysts (*Echinococcus and Cysticercus Cysts*). — Cabaut observed hydatid cyst in 35 cases among 165,000 patients with eye diseases. The age of the cases ranged from 2 to 55 years, the majority being about 20 years old. In 24 a preceding trauma was noted, usually a blow upon the eye. The cysts vary in size from a hazel-nut to that of a baseball, the average size being that of a walnut. The cyst never suppurates nor penetrates the cranial cavity. Excision of the sac should always be preceded by puncture of the cyst with a hypodermic syringe to make certain between this condition and meningocele.

2. *Tumors which Spring from the Bony Wall of the Orbit* comprise sarcomata or fibro-sarcomata which occasionally arise from the periosteum. Thickening of the periosteum due to inflammation in it at times closely simulates a tumor, especially if associated with a hyperostosis of the underlying bone. Exostoses are a rare form of orbital tumor characterized by a very slow growth, extreme hardness and fixation to the adjacent bone. They usually grow from the periosteum near the margin of the orbit or from the adjacent cavities. They consist of an external ivory-like shell of bone and are of a spongy structure within. They are idiopathic, congenital or traumatic.

Treatment (*of Exostoses*). — Removal with drill, or hammer and chisel. This operation is attended with much danger if the growth involves the roof of the orbit.

3. *Tumors which Arise in the Cavities or Tissues Close to the Orbits* are: Encephalocele or meningocele, a very rare form of tumor containing cerebro-spinal fluid with or without brain substance. It consists of a congenital hernial protrusion of the contents of the cranial cavity, caused by a defective ossification or dehiscence of some part of the orbital wall, usually at the fronto-ethmoidal suture. It appears as a smooth, fluctuating and at times pulsating swelling,

not adherent to the skin, and presenting since birth at the upper inner angle of the orbit. It is frequently mistaken for a dermoid cyst. It is not amenable to any form of treatment and so a correct diagnosis is essential. Nevi, lupus, and epitheliomata originating in the skin of the eyelids at times extend to the orbital tissues. Polypoid growths originating in the nose or its accessory cavities as well as sarcomatous, cancerous, or osteoid growths in the frontal, sphenoid, maxillary sinuses and accessory nasal sinus mucocele simulate orbital tumors.

The character of the proptosis and the condition of the adjacent parts will usually reveal the true nature of the affection.

Pulsating Exophthalmos is as the name indicates a pulsating tumor of the orbit rich in blood vessels, originating within the cranial cavity immediately behind the orbit.

Symptoms.—Proptosis of both eyeballs usually, though it may be unilateral, and pulsation which may be felt and at times seen. A distinct bruit is heard when the stethoscope is placed over the closed eyelids or brow. There is swelling and passive hyperemia of the lids and conjunctiva. The retinal veins are distended and tortuous, and there are apt to be sooner or later retinal hemorrhages with secondary optic nerve atrophy, with consequent impairment of vision. The exophthalmos and bruit are increased by stooping. There is usually a pulsating tinnitus aurium; pain in head and eyes on stooping, which are diminished by compressing the carotid artery.

Pathology.—This condition is nearly always due to a formation of an aneurysmal varix in the cavernous sinus, the carotid artery pouring blood directly into the orbital veins. The trouble is usually brought about by blows or falls upon the face or come on spontaneously with a sudden snap in the head during a constrained position. At times there is a spontaneous rupture of the carotid into the cavernous sinus, especially in women during childbirth. Certain pathological curiosities in the form of aneurysm of the ophthalmic artery, pulsating angioma, or medullary osteo-sarcoma of the orbital walls have been known to give rise to a pulsating exophthalmos.

Treatment.—So long as there are no urgent symptoms nothing should be done, as in a certain number of cases a spontaneous cure is obtained. If there is severe pain, alarming epistaxis, or impairment of vision, the common carotid artery should be ligated, or in case of less urgent symptoms intermittent pressure upon the carotid, rest in bed and full doses of potassium iodide may be tried.

Recurring Orbital Hemorrhage may first call one's attention to vascular and renal disease. Hemorrhage in the orbit is attended with headache, exophthalmos and later discoloration of lids and conjunctiva, and the motions of the eye are somewhat restricted. Resorption usually takes place and the eye returns to the normal.

Exophthalmic Goiter, also called Basedow's disease, Grave's disease, and cardiac exophthalmos, is really a general disease but will be considered, inasmuch as nearly all cases are attended by a variable amount of protrusion of the eyeballs.

Symptom-complex.—The symptoms of cardio-thyroid exophthalmos may be divided into primary and secondary. The primary symptoms are five in number, namely: Enlargement of the thyroid; increased frequency of heart beat, and exophthalmos, and to this classical triad may be added general nervousness and a fine tremor —two symptoms which are rarely absent. In typical cases all five symptoms may be found associated with some of the numerous secondary manifestations. The exophthalmos may be entirely absent, and the enlargement of the thyroid so slight as to escape notice, but it is rarely absent; there is always an increased frequency of the pulse however. The exophthalmos is not the first symptom to appear but develops subsequently to the tachycardia. Exophthalmos is present in about four fifths of all cases, its onset is gradual, but in exceptional cases it may become very distinct in a few days. Both eyeballs are usually equally affected, but it may appear first in one and remain more prominent in that one. In such cases the right eyeball is usually the one more affected. In very rare cases one eyeball alone is affected, which is usually upon the side of the larger lobe of the thyroid. The protrusion of the eyeballs may be so great

as to actually dislocate them from the orbits. The exophthalmos frequently varies from time to time in the same case, being more marked when the action of the heart is increased. The exposure of the cornea due to the proptosis may lead to secondary changes. The cornea may become inflamed and ulcerate or slough. The following signs differentiate exophthalmic goiter from other varieties of exophthalmos.

V. Graefe's Sign.—This symptom consists of a defective descent of the upper eyelids when the eyeballs are directed downward. In health when the eyes are directed downward, none of the white of the sclerotic above the cornea comes into view, but in a fair number of exophthalmic goiter cases the upper eyelids remain more or less in their elevated positions and do not follow the downward movements of the eyeballs, thus exposing above the corneæ some sclerotic. According to Ramsay the lids at times accompany the movement of the eyeballs part of the way, and are then suddenly elevated as if by spasm of the levators. V. Graefe's sign is found in about one third of all cases. It is supposed to be due to a spasmodic contracture of the involuntary muscular fibers of Müller, which normally aid the levator palpebræ superioris to elevate the upper lid.

Dalrymple's Sign.—Owing to the persistent retraction of the upper lid, the palpebral fissure is widened, the eye having the appearance of one under the effect of cocaine. Retraction of the lower lid has been observed in three cases.

Stellwag's Sign consists in the imperfect winking movements of the lids. In 1883 Möbius drew attention to a deficiency in the power of convergence in a certain number of cases of exophthalmic goiter. It is independent of any ocular paralysis and does not give rise to diplopia, the patient being unaware of it. It is not caused by the proptosis. Various forms and degrees of paralyses of the extra-ocular muscles have been observed in a certain number of cases. A weakness of all the eye muscles, which is often present, may be due to a mechanical stretching. The paralysis of a single muscle is very uncommon. The pupils are equal in size and respond well. The

fundus of the eyeball is usually normal, although pulsation may be noticed at times in the retinal veins, and infrequently there is a slight edema of the optic disc.

Tremor is present at one period or another in all cases. The tremor affects the flexor and extensor muscles of the wrist, but not the intrinsic muscles of the hand, so that when the hand is held out with the palm downward, the hand moves as a whole, but the fingers do not vibrate. The average rate of vibration, according to Marie, is eight and one half a second. The whole body trembles more or less like the hands, and is usually bilateral save in cases of monolateral exophthalmos. There is usually a general nervousness, the patient is apprehensive and excited by trifles. Sleep is disturbed, memory becomes defective, melancholia or mania may ensue and the patient finally dies from failure of the heart or from malnutrition.

Etiology.—Women are much more liable to suffer with exophthalmic goiter than men. In men the disease is rare, but when it does occur it is very acute and severe. It is said to be ten times as frequent in women as in men. It usually occurs between the ages of fifteen and thirty for women, and between thirty to forty-five years of age in men. The earliest age at which it has been observed is two and one half years. Exophthalmic goiter is often hereditary and occurs in neurotic families. As predisposing causes may be mentioned anemia, quinsy, rheumatism, acute illness, loss of blood, sexual excess, pregnancy, parturition, lactation, alcoholism and syphilis. Organic heart disease precedes the disease in a few cases and amenorrhœa is not uncommonly present.

Prognosis.—Complete recovery takes place in some cases. Recovery or death may take place any time between six weeks and five years, and in a few the symptoms may continue for twenty years before death.

Pathology.—In the thyroid gland there is an increase in the amount of secreting gland tissue, to which the increase in the size of the gland is due. There is an abundant secretion of colloid material, which is absorbed instead of being stored up. In old cases there

is often a considerable amount of interstitial thyroiditis leading to more or less atrophy of the glandular tissue. The disease may involve all parts of the gland or only one lobe. The vessels are abundant but not more so than natural to a gland that has undergone such evolution.

The hand detects a whirring sensation and strong pulsation when placed upon the goiter associated with exophthalmos, which differentiates it from the simple goiter. There may also be heard over the gland a loud rasping bruit. The carotid arteries are distended and pulsate strongly. The heart beat is increased in force and frequency, usually being above 100 and excitable. There is always some enlargement of the left ventricle of the heart and in many valvular disease. In certain cases lesion of the medulla oblongata and cervical spinal cord have been found, as hemorrhages, or atrophy of the nerve-cells or fibers, and changes in the cervical sympathetic ganglia have been described. The distinct nature of the disease is not understood. The eyeballs are too prominent for several reasons, namely: From an increase of orbital fat; from dilatation of orbital veins, and from contraction of the muscular tissue of Müller which fills the inferior orbital fissure, due to an irritation of the sympathetic.

Treatment.—Unfortunately treatment has little influence over the disease. The malnutrition is combated by strengthening diet and by means of iron, arsenic, and quinine. The tachycardia is somewhat relieved by digitalis, and bromides of potash and cold water douches administered for the nervousness. The long-continued employment of the constant electric current to the cervical sympathetic frequently does good. The exophthalmos needs treatment *per se* only when the cornea is endangered by the faulty closure of the lids. In such case we bandage the eye at night so that the cornea will be covered during sleep.

If the bandage proves inefficient we perform an operation upon the lids so as to permanently close them at the outer canthus. The operation of tarsorrhaphy or blepharorrhaphy (external) is performed

as follows: The border of the upper lid is seized with a pair of forceps near the outer canthus; the lid is transfixed at the canthus with a narrow scalpel two millimeters below the eyelashes, in such a manner that the back of the blade of the knife faces the outer canthus while its point emerges from the intermarginal surface of the lid just in front of the openings of the ducts of the tarsal glands. The knife is then pushed along with a sawing movement and a narrow strip of lid containing all the lashes is cut away. The lower lid is now treated the same way, and the two opposing denuded surfaces are carefully united by means of several silk sutures, and the lids are kept immobilized by a bandage for two or three days, when the stitches are removed. When the tension of the protruded lids is very considerable one may unite the lids at the inner canthus temporarily with sutures without denuding their edges. Excision of the superior ganglion of the cervical sympathetic or Jannesco's operation for glaucoma has been tried in a number of cases of exophthalmic goiter by surgeons both abroad and in this country and a few cures have been reported, but the results have not been encouraging enough to warrant it in every case.

INJURIES OF THE ORBIT.

Injuries of the orbit include fracture of its walls, penetrating wounds, lodgment of foreign bodies, and contusions. An injury may give rise to hemorrhage or to pus formation, and loss of sight by rupture of the eyeball or by injury directly or indirectly to the optic nerve. According to circumstances there is apt to be exophthalmos and diplopia from displacement of the eyeball.

Hemorrhage.—When abundant causes immediate exophthalmos, ecchymosis of the lids and conjunctiva. The latter often occurs in fractures involving the base of the skull in the anterior fossæ, and is occasionally seen in cases of scurvy, hemophilia, and from violent coughing or straining of any nature. It now and then happens during an operation for cross-eyes.

Injury to the Orbital Margins is common from crushing blows upon this part. If the injury is great there is produced a distinct unevenness of or a portion of the margin may be detached.

The fracture of the margin may extend to any part of the orbit, even to the optic foramen, in which case blindness may be sudden from laceration of the nerve, or slowly progressing from pressure exerted by callous formation, or from hemorrhage into the sheaths of the nerve.

Emphysema is common in wounds of the orbit and indicates a fissure of the septum of bone between the orbit and one of the nasal accessory cavities. The swelling thus produced will be sudden, elastic, and crepitant. The exophthalmos produced by emphysema can be reduced by pressure, but if due to effusion it can not be so reduced. Injuries of the orbit may recover perfectly after absorption of the exudate or blood, or a fatal issue may result from an infection of the orbit passing to the brain.

Foreign Bodies.—If they are aseptic they may remain indefinitely without creating much reaction. Foreign bodies in the orbit are very difficult to locate. At times they may be placed by X-ray examination after the manner of locating a foreign body in the eyeball by the Sweet Method (*quod vide*) and should be removed if possible through the original wound after enlarging it if necessary.

Injuries to the Optic Nerve.—Injuries of the nerve from direct violence or from fracture of the orbital walls lead to atrophy of the nerve and blindness. At times such injuries are followed by proliferating retinitis.

Luxation of the Eyeball.—This condition is said to exist when the eyeball is so bulged that the lids close behind it. Large foreign bodies thrust into the orbit, self mutilation by the insane, and assaults in which the eyeball has been prized out of the orbit by the thumb or fingers of the assailant, have been known to cause this condition. Luxation may occur during the growth of an orbital tumor. If the eyeball is dislocated through accident it should be immediately replaced, and a tarsorrhaphy done to prevent its recurrence. It may

be necessary to slit the outer canthus of the lids to replace the eyeball.

Traumatic Enophthalmos.—In some cases immediately after an injury or after several weeks or months an enophthalmos appears. It may be due to a local lesion of the sympathetic causing paralysis of Müller's orbital muscle, or to trophic disturbances with atrophy of the orbital tissues. A blow upon the upper margin of the orbit without direct injury to the eye frequently causes such a result. Enophthalmos may also arise from cicatricial contraction within the orbit, or from fracture and depression of the orbital floor.

CHAPTER VI

AFFECTIONS OF THE EXTRA-OCULAR MUSCLES

Squint, Nystagmus and Paralysis of the Ocular Muscles. — Squint (strabismus, cast, heterotropia or cross-eyes) exists when one eye deviates from the object of attention; or it may be described as a failure of the visual lines to intersect at the fixation point. The eye that fixes is called the fixing eye and the one that deviates, the squinting eye. Either eye can fix an object anywhere in the field, but binocular fixation fails. In residual squints following operations and in squints of long standing the arc of rotation of the affected eye is frequently shortened. The defect is not in the motility of either eye, but in the lack of coördinating power with its fellow. Associated movements are performed but the deviation or fault between the visual lines is always maintained in all directions of the gaze; for this reason the squinting is known as strabismus concomitans. In non-comitant deviations the deflection of one visual axis is marked in some directions of the gaze while for other directions the conditions are normal. The latter is seen in cases of paralysis of the extraocular muscles. A muscular anomaly in which one muscle is stronger than its antagonist, moderate in amount, and one which is habitually overcome by muscular effort and revealed by special tests only is spoken of as heterophoria or inefficiency of the ocular muscles (latent squint). If the vision of one eye is poor for any reason or if the refraction of the two eyes differs widely, and binocular single vision is impossible the faulty eye deviates in the direction of the strongest acting muscle, and we have squint or heterotropia. The deviation may be constant, intermittent if present only at times, and periodic if regularly occurring under certain conditions, for instance whenever accommodation is used. It may occur always in the one eye (monolateral) or first in the one and then in the other

(alternating). One eye may turn in (strabismus convergens, esotropia); out (divergens, exotropia); up (sursumvergens, hypertropia) or down (deorsumvergens, katatropia), or there may exist a mixture of these conditions. If the good eye is screened the squinting eye (unless vision is exceedingly poor) straightens, and there develops in the sound eye behind the screen a cast the same in kind and amount as existed in the fellow eye. The squint as it first exists is called the primary squint, while that which develops in the sound eye back of a screen is spoken of as the secondary squint. Decided squints are readily detected, but not so if small in amount. To decide whether there is a squint or not have the patient look at a finger held at a distance of a foot or so from the eyes and then cover first one eye and then the other. If there is heterophoria present each eye will move equally to fix the object when the screen is removed; if there is a squint present in one eye or the other, that eye will not move on being uncovered; if neither eye makes a redress movement when uncovered but remains misdirected there exists an alternating squint; if each eye remains straight behind the screen there is balance of the extraocular muscles. (See page 408, Vol. 1.)

Methods of Measuring the Amount of Deviation in Squints.—The simplest method is as follows: We cause the patient to fix his gaze upon an object placed in the median line and at a distance of several meters from them. Suppose the right eye fixes properly while the left one deviates, we then denote by an ink dot upon the lower lids the position of the outer margin of each cornea (in case of inward squint). We now cover the fixing eye (the right), telling the patient to continue to look at the object, which he does by straightening the left eye; we once more mark the position of the outer edge of the cornea of this eye by a dot upon the lower lid; the distance between the two dots then gives the amount of deviation in millimeters, that is the amount of primary deviation. As the left eye makes a movement of redress to fix, the right one moves inward behind the screen in a position of secondary deviation. We now note the position of the outer edge of its cornea, and thus find the magnitude of the sec-

ondary deviation, which is equal to the primary deviation — a point of difference between concomitant and paralytic squint (non-concomitant), since in the latter the secondary is always greater than the primary deviation. (One millimeter of linear deviation = 5° of arc.) The amount of linear deviation is determined with a millimeter rule or strabisometer, an especially devised curved rule which adapts itself to the curve of the eyeball.

This method of measurement (v. Graefe's) is inaccurate and can only be done when the squinting eye has enough vision to properly adjust itself. A more accurate method and one that can be used for all eyes is to ascertain the amount of angular deviation with the perimeter (Javal). The patient is placed before the instrument with the squinting eye at the center of curvature of the arc, while the other one fixes a distant object on a line joining the center of curvature of and center of the arc.

A lighted taper is then carried along the arc until it is reflected from the summit of the cornea of the deflected eyeball, the angle of the arc is then read off. If the eye deviates so far inward as to be behind the nose, a prism, with its angle in, may be placed before it and half of its angle added to the number of degrees given by the perimeter. A simpler method is that of Hirschberg. The observer sits facing the patient and holds a lighted candle about one foot in front of him, screening his own eye from the light. From each eye of the patient is seen the catoptric image of the flame from the cornea. The eye at the center of whose pupil the image appears is the fixing eye—on the other cornea the reflex is excentric. Its place varies as the patient gazes at the candle or afar off. The point at which the reflex seems to be gives an approximate measure of the squint, and five degrees can be distinguished if the pupil is supposed to be about 3.5 mm. in diameter. If the reflex be only a little way removed from the center, that is about half way to the edge of the pupil, the deviation is less than ten degrees (varying with the angle gamma, that between the corneal axis and the line of fixation). If at the pupillary edge, the angle will be 12° to 15°. If at a

point midway between the edge of the pupil and the limbus, the deviation equals about 25°. If at the edge of the cornea, the quantity is about 45° to 50°. If outside the cornea the reflection is blurred or multiple and the angle may reach 60° to 80°. By this test there may seem to be a deviation in normal eyes at times, an outward deviation in high hyperopia (usually), if the corneal axes lie to the outer side of the lines of fixation; that is if the angle gamma is large and positive as we speak of it, on the other hand if the axes of the cornea lie to the inner side of the lines of fixation, as occurs in high myopia as a rule, there will be an appearance of convergence. In the second instance the angle gamma is spoken of as negative. If diplopia is present or can be developed, the extent of the squint can be determined by the method of tangents (Swanzy). Hirschberg and Landolt constructed diagrams to be hung upon the wall on a level with the eyes of the patient, who sat about three meters from the wall. The diagrams were marked with vertical and horizontal lines drawn to correspond to the tangents of angles from 5° to 60° at the distance they were to be used.

The zero was placed exactly opposite the squinting eye while to the right and to the left the numerations reached 60°. One eye of the patient (the squinting one) has a red glass placed before it, and a candle flame is held at 0°. The patient is then told to indicate the position of the image belonging to the squinting eye, and the number on the chart corresponding to this then gives the degree of strabismus. Whenever diplopia is present, the degree of prism needed to fuse the two images is the measure of the squint. Priestley Smith achieved the same result by an ophthalmoscopic mirror and a tape measure. The light is placed above the head of the patient, and one end of the tape one meter long is held by the patient against the cheek below the squinting eye, the other end of the tape is fastened to the handle of the ophthalmoscope. The good eye fixes the mirror and the observer notes the position of the reflection, which should be near the center of the pupil. The light is then shifted to the other eye and the position of the reflex from its cornea noted. The patient

is then directed to follow the finger of the observer's free hand as it passes in the direction necessary to bring the corneal reflex central. The distance between the mirror and the finger is the tangent of the angle of deviation, and is measured by a tape line fastened at one end to the handle of the mirror and which slips through the fingers of the moving hand.

A tolerably accurate method of detecting lack of fixation of one eye is the following also advocated by Smith, but many have employed it without knowing that Priestley Smith ever described the method. Light is reflected into one eye of the patient as he fixes the root of the observer's nose and the position of the catoptric image noted. Without any change in position the light is then passed to the fellow eye and the position of its reflex noted. The light is quickly flashed from one eye to the other, and the positions of the reflexes compared. Usually the reflection from each cornea under normal conditions will be a little nearer the inner edge of the pupils, because the line of fixation does not coincide with the axis of the cornea. A non-symmetrical position of the two reflexes denotes the failure of one eye to fix. If the discrepancy always remains the same and affects each eye alternately, we conclude that each eye has the power of fixation but binocular single vision is lost. If one eye deviates in spite of the urgency to fix the light, we conclude that that eye has extremely poor vision, and that binocular fixation will be impossible, by operation or otherwise.

Convergent Squint.—In this form of squint the visual line of one eye is directed to the object fixed, while the visual line of the other eye is deviated inward and intersects that of the sound eye at some point nearer than the object of fixation. As the visual lines cross in front of the eyes, this squint is called crossed. If both eyes see it is evident that there must be diplopia, inasmuch as they are directed to different points in space, and an object at any one place will therefore be focused upon non-corresponding points of the two retinæ. The image will fall upon the macula of the fixing eye, and upon the nasal retina of the deviating eye. Inasmuch as the nasal retina is

stimulated by objects in the temporal field, the deviating eye will project the image in the temporal field, or towards its weaker muscle, as is always the case. (The image of the deviating eye is seen in the direction of its weaker muscle.) The diplopia is then uncrossed, or as we say simple or homonymous (crossed squint, uncrossed diplopia).

Divergent Squint is that condition in which the visual line of the deviating eye lacks the necessary inward movement to intersect the visual line of the fellow eye at the object. The visual lines diverge in front of the eyes, for which reason this variety of cast is called an uncrossed squint. As the squinting eye is turned out the image of the object falls upon its temporal retina and the object corresponding to the image is projected or placed in the nasal field. The image of the right eye is then on the left of the image of the left eye, or the images are crossed, or there exists crossed or heteronymous diplopia (uncrossed squint, crossed diplopia).

Vertical Deviations.—If vertical deviations give rise to diplopia, the upper image belongs to the lower eye (image towards the weak muscle). Vertical deviations without a lateral deviation are rare. Most all internal casts have a slight upturning as well (Schweigger). Hansell says that esotropia is always associated with hypertropia when functional.

Diplopia really only occurs at the commencement of strabismus; it soon disappears and afterwards can only be evoked by certain means if at all. This is in contrast with paralysis of the muscles in which diplopia is so very annoying. A person with a squint fails to see double because he learns subconsciously to withdraw his attention from the impression conveyed by the squinting eye, or he suppresses the image as we say. This act of exclusion is a psychical act. The squinting eye really does see but its vision does not excite attention, just as many are able to use an optical instrument with both eyes open and yet regard only what the eye back of the ocular of the instrument sees. The man with a squint then has monocular vision, and his appreciation of depth and distance in a great measure is

interfered with, as he has not stereoscopic vision in the proper sense of the word.

The Visual Acuity in the squinting eye is always less than in the good eye, especially when the squint has existed for any length of time. There is no doubt that a certain degree of enfeeblement of sight exists before the squint, which constitutes one of the elements in the development of the squint. The longer the squint lasts the more and more enfeebled does the sight become, since deterioration develops from non-use (amblyopia ex anopsia). This amblyopia finally reaches such a pitch that reading is impossible, the sight often being reduced to counting fingers at short range. Such an eye can no longer fix and remains stationary when the sound eye is covered. Whether the eye casts because of an amblyopia or whether amblyopia ensues from the cast is still a mooted point. Undoubtedly each theory is correct, that is there are cases belonging to each. Some amblyopic eyes will improve after the correction of the squint, and exercise, while others will not. If the vision is less than 20/100, it is most likely that the eye is congenitally deficient in vision, while if the vision is 20/100 or better, the case is one of amblyopia ex anopsia and improvement is expected from treatment.

Etiology.—Strabismus develops from an inefficiency when there is no longer any need of binocular vision, as in cases where the sight of one eye has been impaired, or when the refraction of the two eyes differs to such an extent that fusion of the retinal images is impossible. Under these conditions the guiding sensation ceases to act, and each eye tends to rotate in the direction of the strongest acting muscle. As one eye must fix, the poorer seeing eye is turned aside. A squint is an inefficiency which has become manifest. The most frequent causes leading to strabismus through deterioration of vision are: Errors of refraction in one eye alone, or to a higher degree in one eye than in its fellow; in conjunction with such an error there usually exists also a congenital amblyopia; opacities in the refracting media, particularly in the cornea and lens, or intraocular diseases. It is seldom that perfectly blind eyes remain straight.

The laity ascribe all sorts of causes to squint—as to faulty placing of the light in the sleeping apartment, to fright, to a fall, to the fact that the child once looked over its head at its nurse, or what not.

Strabismus Convergens.—Hypermetropia is found in about three fourths of all cases of internal squints. Donders was the first one to determine this fact and it is explained in the following way: Hyperopes have to make an unusually strong effort at accommodation for a given distance; they need the same amount as the emmetrope plus the amount of their hyperopia, but it is impossible for most eyes to separate accommodative effort from convergence. If both eyes turned in to the extent called upon by the excessive accommodation in use for a given distance, neither one would be directed at the object. They would be converged for a near point and accommodated for a more distant one. Soon the internal recti gain a functional preponderance. This preponderance develops into squint if single binocular vision is interfered with, all of the convergent effort falling upon one eye, which is in all cases the one with the poor vision, while the good eye is allowed to retain its fixation.

Convergent strabismus usually develops between the ages of two and six. It is at first noticed, as a rule, only when near objects are looked at (periodic squint) and may continue so, but is apt to become constant. It now and then happens that children with internal squints outgrow them about the age of puberty, but the sight by this time has been permanently weakened and single binocular vision is never restored.

Strabismus Divergens.—In this myopia plays the same part as hyperopia does in the former. About two thirds of all persons with divergent squints are myopic. The cause is this: The myope to see near objects needs little or no accommodation at all according to the degree of myopia, and hence the stimulus to convergence is feeble, or there is a functional inefficiency of the interni. To this is added organic causes which lessen the capacity of the interni. Such are increased length of the eyeball, acting as a mechanical impediment to convergence. For these reasons myopes are especially liable to

divergent strabismus especially if the vision of one eye is poorer than that of its fellow. Divergent strabismus is a rarity among small children since myopia does not develop among them, but later on — during youth when myopia develops. If the sight is rendered poor by accident or disease in childhood, there is most apt to develop an internal squint, while the same condition in the adult gives rise in most instances to a divergent squint. In myopes the convergence first becomes incompetent in fixation of near objects, and one eye deviates out. This periodic squint may remain or develop into a permanent external squint. Spontaneous cure never occurs in divergent squint, but it tends to grow worse with increasing years.

Squint does not so readily develop in the highest errors of hyperopia as it does in those of medium amount, as in the former there is not the same effort exerted to correct the error by accommodation, the individual subconsciously discovering the impossibility of the task. In the highest degrees of myopia however the development of a squint is inevitable. Even the strongest interni are unable to maintain convergence necessary for the short range at which myopes of high degree must carry on their near work, hence in the close inspection of objects nearby one eye must deviate out, even though the eyes remain in their correct positions for medium and great distances.

TREATMENT OF CONVERGENT CONCOMITANT SQUINT.

Spectacle Treatment. — In all cases of convergent squint atropia should be used until the accommodation is thoroughly paralyzed, and then glasses ordered which neutralize the error of refraction. In the majority of cases the hyperopia is associated with a certain amount of astigmatism. Retinoscopy should be employed in ascertaining the proper glasses, inasmuch as the squinting eye most frequently has very little vision and the test with the trial lenses is therefore unsatisfactory. The proper correction should always be placed before the amblyopic squinting eye, as it frequently happens that the vision is improved by stimulating the retina with accurate focusing, and not a plain glass placed before it as is the habit of some, especially those

dependent upon a subjective test. In young patients and especially in cases of periodic, or squints of short duration, glasses alone effect a cure. This is most apt to be the case if atropia causes a disappearance of, or lessening of the squint. One should not decide whether glasses will cure or not until they have been worn two months. A complete cure is established by glasses in about 10 per cent., and a cure continues as long as spectacles are worn in 33 per cent. The amblyopic eye should be trained by frequent exclusion of the fixing eye from the visual act, and by the following methods:

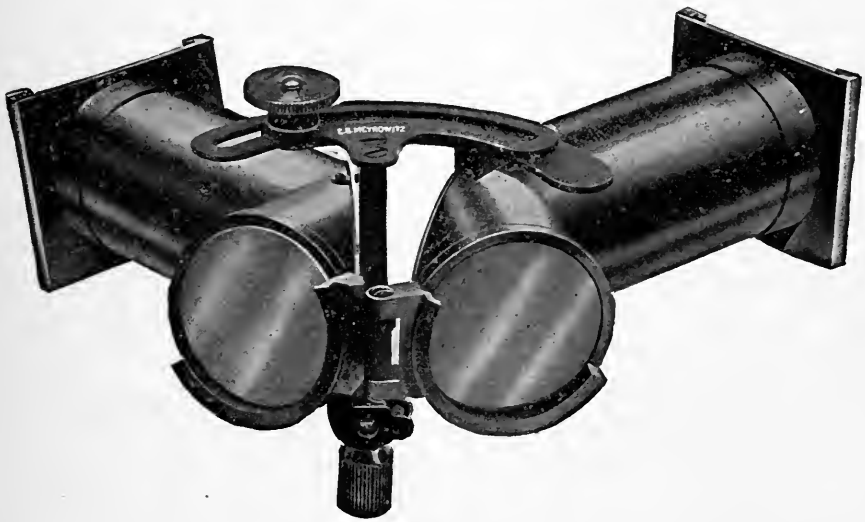
Orthoptic Training was devised by Javal in treatment of squint. It consists in producing diplopia and then in training the eyes to fuse the double images. It is suited to squints of moderate degrees and especially to residual squints following operation. It requires considerable care and patience to carry out its details, and the treatment is only possible when the patient sees double or when he can be trained to see double, that is to take account of the image formed in the faulty eye. The ametropia is then fully corrected and the exercise is performed as follows:

In an ordinary stereoscope instead of the views two objects of some very simple design are introduced, for instance two vertical lines one above and the other below the same horizontal line (Volkmann), or two crosses. The instrument should be so arranged that these two objects may be moved closer together or separated, or placed at a distance equal to the interpupillary distance.-

When they are separated the distance of that between the two pupils, their fusion simply necessitates parallelism of the lines of fixation. This is only possible in the absence of any accommodative effort and so the ocular of the stereoscope is provided with a convex lens of six diopters, which enables the emmetropic eye to accurately focus the object, without the aid of accommodation at the distance of 16 cm., the length of the instrument. The majority of patients are unable to fuse when the eyes are directed in parallel lines, but generally show a certain amount of convergence in fusing. The patient is now asked to find the distance at which fusion of the two objects

is possible. The objects are then separated more and more until fusion is possible with the least amount of convergence. When single binocular vision is obtained with parallelism of the lines of fixation, an attempt is made to develop it for a point which requires a certain degree of convergence. To provoke a convergence of one-meter angle, the objects are brought together one centimeter. (This varies somewhat according to the interpupillary distance.) In order to make the patient use an amount of accommodation equal to this amount of convergence, the strength of the convex lens at the eye-piece is lessened one diopter. The trials are continued in this way until the two images are fused without any lenses in the instrument and the objects 6 cm. apart. An emmetrope would therefore have to remove the lenses and an ametrope simply have his error corrected to fuse the images when six meter-angles and six diopters of accommodation are in use. Seances should be held once a day and continued until fatigue is experienced.

Exercise Without the Stereoscope.—There often exists a portion of the field of fixation in which there is single binocular vision.



Worth's Amblyoscope.

Exercise is undertaken to increase this part. We place a candle in the part of the field in which the patient fuses and gradually carry it towards the other part; when the patient sees double we begin again.

Worth devised an instrument which he called the amblyoscope for the education of the fusion faculty in children and subjects of strabismus. It consists of two tubes, of the shape seen in the cut, joined by a hinge. These tubes are made of a short tube joined to a longer one at an angle of 120 degrees. At the free end of the long tube there is a mirror and at the free end of the short tube there is a lens whose focal length is equal to the distance of the reflected image of the object glass. The hinge allows the instrument to have a range of adjustment of from sixty degrees of convergence to about thirty degrees of divergence. The object glasses are covered with translucent paper, upon which are figures of three classes; namely, bird and cage, mouse and trap and so on; part of figures upon each object glass, so that fusion is necessary to interpret the whole picture and stereoscopic pictures. The patient has his proper refraction correction adjusted and the pictures of the first class at first employed and the patient told to bring the bird into the cage or what not, then the second class of pictures are employed and the patient tries to fuse them into a single ocular perception and so on. There are no new principles involved in the use of the amblyoscope. The rationale of the test is the same as that with the stereoscope, that is bringing the points of stimulation upon corresponding portions of the two retinas to awaken fusion and then by the aid of fusion to cause the eyes to assume their proper positions in the head by developing the weaker muscles. After fusion has been gotten by exercise, or operation and exercise, bar-reading and the exclusion of the good eye by a screen are employed, as presently to be explained, to develop the vision in the faulty eye. Exercise treatment must be continued for months to show much improvement.

Operative Treatment.—If other treatment fails or if for any reason there is little prospect of it succeeding, operative measures are resorted to in the form of a single or bilateral tenotomy of the interni

with or without advancement of the externus. An operation should not be performed before the sixth year, or time when glasses can be worn, and should never be done until the refractive error has been fully corrected and glasses worn for two months. Before operation the surgeon should estimate the amount of cast, the presence or absence of diplopia, the visual acuity and the power of the external recti. Schweigger says that exercise of the externi by alternately turning the eyes first to the right then to the left is useful as a preliminary to the operation for squint. A single tenotomy of an internal rectus corrects a squint of about 15°. It is better to leave a residual squint of about 3° after a tenotomy, otherwise there is apt to result an external deviation later. This is less apt to occur if a simultaneous tenotomy is done upon both interni, taking half of the squint out of each eye, and the child allowed to pass the age of six years before operating. If the squint equals 20° or 30° a bilateral tenotomy should be done at one sitting or the second operation performed after the lapse of several months if the squint is of moderate amount. The effect of a tenotomy may be increased as Knapp advised by passing a suture through the superficial layers of the sclera, close to the margin of the cornea and dragging the eyeball out towards the temple, fasten the suture with a piece of adhesive plaster to the temple. If the squinting eye has no vision and the squint more than 30° it is usually necessary to combine tenotomy with an advancement of the external rectus. The effect of a tenotomy depends a great deal upon the amount to which Tenon's capsule is divided. If a decided effect is required one should clip all the connection that can be found between the muscle and the eyeball and the muscle and the overlying Tenon's tissue. By doing the latter the muscle is allowed to recede further and therefore after reuniting to have less power over the eyeball. If the result is too great, a suture is introduced and the eyeball held towards the nose until healing is established. If there exists an upward or downward deviation at the same time it may be corrected at the same time or later by a tenotomy of the appropriate muscle.

Strabismus deorsumvergens or sursumvergens is to be corrected by operating on the rectus superior or the rectus inferior. If the squint is great in amount and one tenotomy does not suffice to straighten the eye a second one is done on the opposite rectus muscle of the fellow eye. Thus, the superior rectus of one eye and the inferior of the other one. The obliqui are not suitable for interference. Division of the superior rectus acts by association upon the elevator of the eyelid, and is followed therefore by an elevation of the lid, exposing an unusual amount of sclera above the cornea. This fact may be utilized if there is a partial ptosis. In mixed forms as strabismus convergens with a vertical deviation the tissue on the side of the vertical meridian to which the eye most deviates is divided freely.

Divergent Concomitant Squint.—Treatment of this variety of squint includes the adjustment of proper correcting lenses and operative measures. The total error, myopia or myopic astigmatism should be corrected.

The sort of operation depends entirely upon the amount and cause of the deviation, and upon the vision of the deviating eye. Either a single or a double tenotomy upon the externi may be performed or this operation combined with an advancement of the internal rectus of the squinting eye. If the sight in the eye is so poor that there is no possibility of binocular vision, the effect of an operation is solely cosmetic. It is a question whether there is ever any marked improvement in the sight of the eye. It may occur however if the fellow eye becomes blind, so it would seem the proper thing to do to bandage up the good eye for an hour or so each day and compel the patient to see with the poor eye. Binocular vision results in about 20 per cent. of cases after operation and orthoptic exercise. We can ascertain whether binocular vision exists and also apply exercise by aid of the stereoscope and also by bar-reading.

Bar-reading is performed thus: A piece of cardboard several inches wide is held between the patient's eyes and the printed matter to be read. If binocular vision exists the piece of cardboard

does not interfere at all with the reading, as first one eye then the other one is used, but if the patient is only seeing with one eye the cardboard obscures portion of the print and the patient is unable to read without moving the head from side to side.

Spastic Strabismus occurs now and then in chorea, hysteria, epilepsy and in meningitis. It may be an exaggeration of spastic heterophoria, which see (Vol. 1).

Spasmodic squint is occasionally idiopathic, and may be associated with ametropia, thus an external squint with hyperopia and *vice versa*. There is usually a false spasm or overaction occurring in the associated antagonist of a paralyzed muscle. Thus a patient with a paralysis of the right external rectus muscle who tries to look to the right makes an excessive effort, which causes the left eye to move to the right very greatly and in a spasmodic way. Spasm sooner or later occurs in the antagonist of a paralyzed muscle, which ultimately leads to structural change in the latter (contracture).

Nystagmus consists in a very rapid oscillating movement of the eye in some one direction. It usually affects both eyes, the oscillation of the two being equal and in the same sense. The nystagmus is called horizontal, vertical, rotatory, or mixed according to the nature of the oscillations. The commonest form is horizontal or lateral nystagmus. Nystagmus is caused by alternate discharges from the centers of coördinate movements of the eyeballs. In lateral nystagmus, for example, there is first a discharge from the center, turning both eyes to the right and then one turning both eyes to the left. It now and then occurs only in some one direction of the gaze as when trying to look far to one side, or when the attempt to fix the eyes is made.

Causes. — Visual defects, as cataracts, opacities of the cornea, and diseases of the retina and chorioid, congenital or acquired soon after birth, before the patient has learned to properly direct his eyes. It is acquired later in life as a symptom of disseminated sclerosis, ataxia (rarely) in inflammation, degeneration, hemorrhages and tumors of the brain and cord, especially in cerebellar tumors. It occurs in

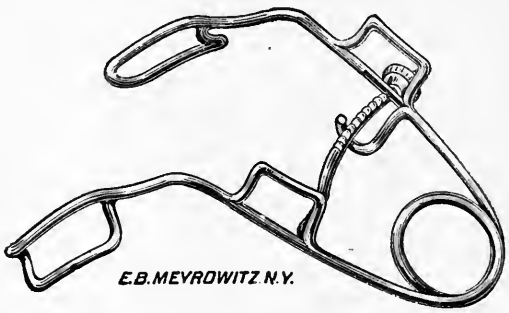
miners and those who work with their eyes in a strained position, and with poor light. It is at times found to be associated with disease of the semicircular canals. In those cases acquired late in life objects appear to dance before the eyes, which is absent in the congenital cases. Nystagmus may disappear if the optical defect giving rise to it can be removed, and miner's nystagmus gets well if the patient changes his occupation, otherwise the condition is not susceptible of amelioration.

OPERATIVE TREATMENT OF SQUINT. TECHNIQUE.

The following operations have from time to time been devised for the relief of squint. The tendon of an ocular muscle may be entirely loosened from the eyeglobe and if the lateral and immediate relations with the fascia of Tenon are not torn up it still remains in connection with the eye and can exert an active influence over it though somewhat reduced. If, however, after dividing, the tendon cuts are freely made in the lateral regions, the muscle will lose its control over the eyeball, because it recedes into the orbit, and if any connection remains it will be through the medium of some band that has escaped division. Motais has shown that after a tenotomy the reattachment of the muscle is more through the medium of the conjunctiva and capsule of Tenon than by the tendon, and that both in retroplacements and in advancements of the muscle the fascia, and especially its lateral prolongations, is the most important factor.

Tenotomy of the Internus.—The operation now adopted for convergent squint is the one devised by V. Graefe. It is the easiest of all the operations, and is performed in the following way: After cocainization the lids are separated by a speculum, the patient is instructed to look well towards the temporal side or an assistant seizes the conjunctiva close to the outer border of the cornea and rotates the eye directly outward in the axis of the commissure. The operator then grasps the conjunctiva over the insertion of the muscle (5 mm. from the edge of cornea), raises it, and makes an incision, either in the vertical or horizontal direction, large enough to permit

the easy introduction of a hook. The conjunctival tissue is now incised so as to expose the tendon of the muscle, and a hook is passed beneath the tendon, care being taken to secure the entire tendon. The tendon is then severed close to the sclera by means of a pair of scissors. The hook is then introduced and brought forward towards the cornea above and below to discover if any fibers have escaped uncut. If all have been severed the hook should pass forward under the conjunctiva to the edge of the cornea. If the patient can still converge there are some fibers still intact or Tenon's capsule must be divided. This is done by raising the flap of conjunctiva and Tenon's tissue and snipping in different direction with the scissors so that all the bands of adhesion between the muscle and Tenon's tissue will be divided. If too much effect has been produced a suture should be inserted in the cut end of the muscle and the latter brought out through the conjunctiva close to the cornea and tied. A suture may then be placed in the conjunctival wound or not according to the fancy of the operator, and a bandage applied for twenty-four hours. The sutures may be removed on the fifth day. The eyes should be under the effect of atropia, which by relaxing accommodation will partially do away with the tendency of convergence and thus allow the muscle to more quickly and firmly reattach itself to the eyeball. The instruments necessary for this operation are shown in the accompanying cuts.



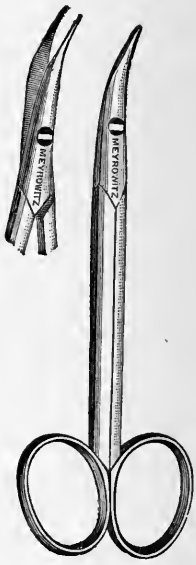
Dr. Koster's Eye Speculum: A very simple self-releasing eye speculum has been devised by Professor Koster, of Leyden, Holland. As shown in the cut, it will be noticed that it is constructed on the lines of the wire speculum, but is provided with a serrated cross bar, which by the pressure of the lids is brought against one of the arms of the speculum, and there held in position until the pressure is relieved by the counter pressure of the fingers of the operator upon the two finger rests, which pressure immediately relieves the bar and permits the instantaneous closing of the speculum. The adjusting screw is simply intended to control the opening of the speculum.

The Subconjunctival or Critchett's Method.—The conjunctiva is raised over the lower border of the rectus muscle with a fine-toothed forceps, and an opening large enough to admit a hook and scissors made. The opening should be too large rather than too small. The subconjunctival tissue is then divided by short snips with the scissors, and undermined in the direction of the caruncle. The hook is now

Fixation Forceps.

Hooks.

Stevens's Tenotomy Forceps.



Stevens's Tenotomy Scissors.

introduced on the flat and brought forward under the tendon. Its point is then elevated until it raises the conjunctiva in a tent-like manner. The muscle-tendon is then severed by several snips of the scissors. The hook is then swept around to see if there are any undivided fibers left. If a more decided effect is desired Tenon's

capsule may be cut above and below. No suture is needed in the conjunctiva. The eye may be kept bandaged for twenty-four hours or bandage dispensed with entirely. This operation is not as good as the previous one as the tendon can not be seen but only felt; you are therefore working in the dark. It is never good surgery to work through a button-hole.

Snellen makes a vertical incision over the tendon of the muscle. Then after he has opened Tenon's capsule large enough to admit scissors he picks up the center of the tendon and makes a button-hole in it. Through this opening he introduces a hook, and cuts the lower portion and then the upper portion of the tendon close to the sclerotic. This operation does not interfere with the capsule of Tenon, or the indirect insertion of the muscle into it, but nothing is gained thereby. If insufficient effect is found the day after the operation the eye may be cocainized and a hook passed under the tendon and it severed from the sclera by pulling the hook towards the cornea. The only danger in the operation of tenotomy aside from infection is perforating the sclera, which is reduced to a minimum if the tendon is divided by successive snips with the scissors. Frequently after a tenotomy of the internus the caruncle appears more or less sunken. This can be avoided in a measure by making the conjunctival incision horizontal, or by placing a suture in the wound if the incision is made vertically. The choice of these several operations is Von Graefe's.

Tenotomy of the Externus is performed just as the tenotomy of the internus. The external rectus is situated farther from the cornea (2 mm.) than the internus, its insertion is narrower and it is more lax than the inner muscle. The effects of its division are not so marked as those after section of the internus and are therefore more often disappointing. It is often necessary to tenotomize both externi at once.

Gruening's Method.—Division of both externi at one sitting. Where the divergence is not more than 2 mm. the tendons are divided at their insertions. If the deviation is more than 2 mm. the tendons are divided at a distance from their insertion equal to the

degree of squint; thus when the degree of cast equals 5 mm. each tendon of the externi is divided at that distance from their points of insertion and the stump excised. After closing the wound of the conjunctiva, a suture is passed through both interni, on a line with the horizontal meridian of the cornea and tied over a piece of cotton over the bridge of the nose. This position is maintained for twenty-four hours. Verhoeff has devised a form of partial tenotomy which he calls a "gradual plastic tenotomy." Each edge of the tendon is divided at its insertion and again 5 mm. from the insertion. Half way between these points the central fibers are divided. Such partial division he claims is followed by a lengthening of the tendon.

Prince's Advancement Forceps.

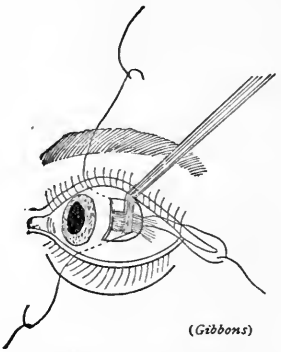
OPERATIONS OF ADVANCEMENT AND RESECTION.

To Correct Faulty Squint Operations.—Such operations present difficulties not found in other cases. The conjunctiva over the former incision is usually firmly cicatrized to the subconjunctival tissue and sclera, which is especially the case when the original conjunctival wound was not closed with a suture, but allowed to granulate. The insertion of the muscle is often very thin and hard to find, on account of its new and often abnormal insertion. The sclera is exposed and the muscle brought into view by cutting away the cicatricial tissue. A hook is now passed beneath the muscle, which is raised until it can be caught with a catch forceps, like the one shown in the cut, and its connection severed.

A thread armed with three needles, one in the middle and one at each end, is now taken, and the middle needle passed through the muscle from its under surface, passing through the conjunctival tissue over the muscle. The more decided an effect is desired, the nearer the caruncle the needle is made to penetrate. If the muscle is broad enough for the insertion of one thread through its upper border and another through its lower border, this is the better plan because it spreads the muscle and gives it a

more secure attachment to the sclera. The needle on the upper end of the thread is now passed under the conjunctival tissue and brought out through the latter four millimeters above the vertical meridian of the cornea. The lower needle is likewise carried under the conjunctiva, below the vertical meridian of the cornea and brought out. All three needles are now taken off after the thread is cut in the middle. The upper and lower ends are now tied over the conjunctiva more or less taut, according to the result desired, the operator and assistant each taking one of the threads and tightening them simultaneously. Both eyes are bandaged for two or three days after the operation.

This is the method that is usually employed. If there is desired a very decided effect the portion of the muscle between the clamp and its insertion is excised. An over-correction is always made because after the removal of the sutures the muscle recedes a little. If after two or three days there is an over-correction the threads are removed, and after cocainizing the eye a delicate hook is introduced into the wound and the attachment of the muscle loosened sufficiently to overcome the defect; otherwise the stitches are allowed to remain in five or six days.



De Wecker's Advancement Operation.

Noyes's Operation (*Primary Squint Operation*).—Suppose an internus is to be advanced. The externus is first tenotomized; then seize the insertion of the internus with a fixation forceps including all that can be gotten in one bite; sever the insertion freely and extend the cut above and below the insertion of the muscle into the conjunctiva to the extent of 10 mm. or so. Fasten the forceps to the tissues by shutting the spring catch, lay it aside and then remove a vertical oval of conjunctiva in front of the insertion of the muscle leaving a strip about 6 mm. wide next to the cornea. Lift the muscle and pass a needle through its middle as far back as the effect desired. With the needle in place cut off the superfluous material in front of it and

draw it through. The other two needles are introduced one through the upper portion and the other through the lower portion of the muscle. There are now three threads through the muscle fascia and conjunctiva. The needles at the other ends of the thread are passed forward beneath the conjunctiva, taking hold of the superficial layers of the sclera, so that their points emerge at the limbus. The middle thread is tightened first and then the other two. If there is much crumpling of tissue caused by tying the sutures, it may be cut away, but this is usually unnecessary as the roughness will smooth out in a short time. A bandage is applied for twenty-four hours, and sutures left in for five or six days.

Schweigger's Operation of Resection.—The conjunctiva and conjunctival tissue over the muscle to be advanced are incised vertically. A hook curved on the flat and with an olive point is now passed under the muscle, and the entire tendon exposed to view; a second hook is passed under the muscle in the opposite direction. The two hooks are pushed in opposite directions, thus exposing a considerable length of muscular tissue. Two double-armed catgut threads are now prepared. One needle is passed under the upper edge of the muscle and pierces the same a little below the middle, the other is passed from the lower side and pierces the muscle a little above the middle. Each thread is then tied, thus including the entire muscle. The portion of the muscle between the threads and the insertion is then cut away. The amount to be resected is measured with a millimeter rule. The two needles are then passed through the insertion or stump of the tendon, and through the superficial layers of the sclera. The threads are now tied and the conjunctival wound closed with silk sutures. The opposing muscle is tenotomized before the sutures in the muscle to be shortened are tightened.

Prince's Single-Suture Advancement.—This method is called the pulley-suture operation. The author of the operation at first made a pulley or loop in the episcleral tissue, near the corneal margin and the sutures through the muscle were passed through this loop. This method was later modified to the following operation:

An incision is made over and parallel to the muscle that is to be advanced. The tendon is then secured by an advancement forceps, separated from the sclera and advanced, allowing the conjunctiva to retract. Two needles, one on each end of an iron-dyed silk suture, are passed from within outwards through the capsule, muscle and conjunctiva at a variable point depending upon the amount of displacement desired, thus securing the middle portion of the muscle in a sling. The portion of the muscle about two millimeters anterior to the sling is exsected unless a very slight effect is desired. The sclera is now fixed with a fixation forceps, and each needle is introduced into the episcleral tissue, 2 mm. from the margin of the cornea. Both ends of the suture are now brought together, and the first portion of a surgical knot made, and tightened to make a slight over-correction. The suture should remain four days. The operation is like the others usually combined with a tenotomy of the opposing muscle.

Landolt's Method of Advancement.—Landolt believes that an advancement is preferable to a tenotomy in all cases. Landolt says an advancement causes the eye to enter its muscular investment, from which a tenotomy causes it to escape. It prevents an advancement of the eyeball and preserves the function of the muscle. However there is more danger of rotating an eyeball from advancement than from a tenotomy operation, a thing which at times causes a very annoying form of diplopia. Advancement is especially adapted to very amblyopic eyes, in which the cosmetic effect of an operation is all that can be desired.

After exposing the muscle two threads are inserted, one through the upper and one through the lower border of the muscle, more or less behind its attachment. The attachment is then severed and the threads passed under the upper and lower borders of the cornea, when necessary as far as its vertical diameter. The threads are then knotted. An assistant turns the eyeball in the direction of the muscle to be advanced.

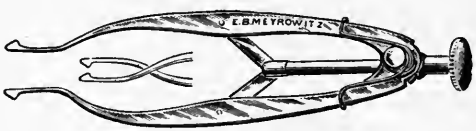
Stevens's Operation of Tendon-Shortening.—An opening is made as for tenotomy, then a pocket is made under the conjunctiva

towards the cornea, according to the amount of effect we wish to produce. The central portion of the tendon is then seized by means of a pair of forceps and it is dissected from the eyeball. The tendon is then caught behind the section by means of a fixation forceps with a catch and drawn through the opening in the conjunctiva, when one needle of a doubly-armed thread is passed through the middle portion of it. The other needle is made to penetrate the conjunctiva at the extreme end of the pocket and the thread drawn through. Another suture is inserted in a like manner a little to one side of the first, allowing a little bridge of tissue between the two threads. The ends of the threads are then drawn upon, pulling the tendon into the pocket and the threads tied over the little bridge of tissue intervening. The sutures are allowed to remain for four days.

Advancement of the Capsule, De Wecker's Method. — A vertical incision as long as the corneal diameter is made over the tendon. If the error is high, an elliptical piece of conjunctiva is excised. An opening is made in the capsule and a hook inserted through this from above downward. The hook is passed clear under the tendon until its point is free on the other side. The tendon is then divided above and below, leaving about the middle third intact, and then the capsule is incised above and below. Two double-armed threads are employed in the following way: One end of the thread is passed through the incision in the capsule from the inner surface so that it pierces the divided portion of the muscle, capsule and conjunctiva, the needle on the other end is carried through the incision under the capsule through the superficial layers of the sclera and brought out at about 5 mm. above the vertical meridian of the cornea. The other thread is introduced in like manner below. The threads are then tied. Knapp suggests that a third suture be used through the equatorial flap of the conjunctiva.

Savage's Muscle-shortening Operation is done as follows: A vertical incision is made over the insertion of the muscle and another at right angles to it along the lower border of the muscle. This triangular flap of conjunctiva is now dissected up and held to one side by an

assistant. A puncture is now made through the capsule at the lower border of the muscle and a hook passed through it under the muscle, and then a puncture made above the muscle for the exit of the hook. A doubly-armed thread is then selected. One needle is passed through the muscle from its outer surface and brought out at the lower border of the muscle, the other needle is passed in the same way and brought out beneath the upper border of the muscle. The capsule is included in this stitch. Needle one is then passed through the tendon of the muscle from the ocular side, and is brought out through the conjunctiva over its insertion; needle no. 2 is passed in like manner through the upper portion of the tendon. In tying the suture the muscle is doubled upon itself by drawing the portion of the muscle included in the loop of the thread forward towards its insertion. The conjunctival flap is then allowed to fall back in place. As in other advancement operations the opposing tendon is partially or wholly divided. The knuckle of muscle made by the operation undergoes absorption.



Dr. Todd's New Tendon Tucker. The tendon is first exposed by turning back a flap of conjunctiva. Having the prongs of the instrument crossed, one of them is inserted under the tendon, the other remaining over the tendon; the screw at the distal end of the instrument is then turned, causing the prongs to separate and the tendon to be tucked upon itself. The prongs are thus out of the way when the absorbable catgut sutures are inserted through the three layers of tendon and tied, one at the upper border and the other at the lower border of the tendon; after which are inserted what Dr. Todd terms the guy sutures. These are silk sutures which are passed through the three layers of tendon back of the absorbable sutures and into the episcleral tissue above and below the cornea; these sutures also include the conjunctival flap.

The tendon tucking operations done by means of specially constructed forceps which are placed upon the tendon and closed, thus tucking it and holding it until the sutures are introduced, are in no wise preferable to this method, if as good. Todd's tendon tucker is shown in the cut. There yet remains to be described Trousseau's new operation of "capsular ligature." The tendon of the muscle is grasped with the forceps without opening the conjunctiva and a curved needle introduced near the limbus is passed

under the tendon and brought out a sufficient distance from the insertion. The suture is then drawn up and tied. Like in the other methods a tenotomy of the opposing muscle may or may not be done.

Choice of Operation.—The operator should choose the operation best suited to his own ideas, as all are intended to accomplish the same purpose. Muscle resection as recommended by Schweigger, Noyes and others frequently gives excellent results, but the operation of DeWecker or that of Savage is probably the best for the following reasons if the eye has any useful vision.

The eyeball is not apt to be turned upon its antero-posterior axis and an annoying form of diplopia caused thereby, or strain thrown upon either the superior or inferior oblique muscles. There is also danger that the knots may slip, or that the threads may cut through the conjunctiva before firm adhesions have taken place between the muscle and the sclera, and thus the muscle may be pulled back even beyond the point of its original attachment, and the condition be worse than before. In DeWecker's operation the middle fibers of the tendon which are not divided will prevent the tendon's going back too far if the sutures are cut through.

Lateral Displacement of Insertion of a Muscle.—Dr. Jackson has recently devised an operation to overcome this defect. Attempts have been made to remedy a torsional defect of the eyes by a tenotomy of the superior rectus muscle but this has frequently failed to make the patient more comfortable. Jackson, after tenotomy of the superior rectus, gives it a new insertion further back and to the temporal side of its former insertion. The operation is performed as follows: An incision is made through the conjunctiva 8 mm. back from the limbus beginning over the nasal third of the tendon and extending 3 or 4 mm. beyond its temporal margin, its temporal end being further from the cornea. Through this incision the tendon is secured upon a hook. A suture is then passed through the tendon at the junction of its middle and inner third. It is then passed beneath the tendon and made to enter the superficial layers of the sclera at the outer border of the muscle; it is then carried about 3

mm. and brought out again, then passed back under the temporal edge of the tendon and brought through the tendon at the junction of the outer and middle thirds. The tendon is then divided and the sutures tied. The amount of required displacement in the individual case is important. Assuming the radius of the eyeball to be 12 mm., each mm. measured on its surface represents a deviation of 5° or the equivalent of a 10° prism. The displacement of insertion should be made to equal double the amount of deviation to be corrected. To correct an extorsion of 5° and an elevation of 10° the insertion of the muscle must be carried outwards 2 mm. and backwards 4 mm.

Complications of Squint Operations.—There is more or less bleeding in every case, but it readily absorbs and needs no treatment but hot fomentations. Hemorrhage into Tenon's capsule when it occurs does not lead to serious results, but is apt to vitiate the effects of the operation. Compresses and cold applications should be used if it occurs. At times granulations become exuberant in the wound. They should be excised and their base cauterized with the silver stick, and the eyeball immediately flushed with a weak solution of salt. The threads may break or cut through after the operation. Orbital abscess and panophthalmitis may occur from sepsis if the surgeon is uncleanly.

PARALYSIS OF THE EXTRA-OCULAR MUSCLES.

Paralysis may affect a single muscle or several muscles and in different combinations. Paralysis of a single muscle most usually affects either the external rectus or the superior oblique, because each one of these muscles is supplied by a separate nerve (abducens and trochlearis). All the other ocular muscles are supplied by the oculo-motor nerve, for which reason a paralysis involving any one of them singly is of less frequent occurrence. Some or all of the muscles supplied by the third nerve may be affected at once. Complete oculo-motor paralysis (ophthalmoplegia oculo-motorius) presents a very characteristic picture. The upper eyelid hangs down (ptosis), and must be elevated by the finger to allow a view of the

eyeball, which is turned strongly to the outside and somewhat down, because the external rectus and the superior oblique — the two muscles that are not paralyzed — draw it in this direction. The pupil is dilated and immobile to light and convergence (iridoplegia) and the eye is adjusted for its punctum remotum and can not be adjusted for near objects (cycloplegia). A slight degree of exophthalmos exists because three of the recti muscles have lost their tone. The paralysis may affect both eyes and other muscles be involved so that various combinations are formed of which the following are the most frequent: All the eye muscles in one or both eyes are paralyzed, so that the lids hang loosely down, the eyes are directed immediately forward or drawn down and out, there is dilatation of the pupils and paralysis of accommodation (ophthalmoplegia totalis). The paralysis may affect only the external eye muscles, while the internal muscles, the ciliary and sphincter pupillæ, are spared (ophthalmoplegia externa). This is a more frequent variety and is caused by the arrangement of the nerve-nuclei below the aqueduct of Sylvius. This arrangement is that the nuclei for the pupil and accommodation lie furthest forward, and are frequently exempt from lesions involving the more posterior nuclei of the other muscles.

Ophthalmoplegia externa can therefore only be of central origin. Ophthalmoplegia interna forms the converse to ophthalmoplegia externa, as only the internal eye-muscles are paralyzed. We frequently see this form produced artificially by atropine. There are certain combined paralyses that do not affect individual muscles but associated movements of the eyeballs, as the ability to turn the eyes to the right or to the left or to converge. Such are known as conjugate paralyses (Prevost). In cases of paralysis of dextro-version or lævo-version the eyes follow an object when moved towards the paralyzed side as far as the middle line, but both eyes now stand still, being unable to move further in that direction. Under such conditions one may suppose that he was dealing with a paralysis of one external rectus and one internal rectus, but this can be disproved by causing the patient to converge, which he can do very well. The

cause of associated paralyses are lesions in the centers of associated movements of the eyeballs.

Etiology. — Paralysis of the ocular muscles is the result of a lesion situate anywhere in the course of the nerve-tract from its beginning in the cortex of the cerebrum to the termination of the nerve in the muscle itself. According to the site of the lesion the paralysis is spoken of as intracranial or intraorbital. In the former the focus of disease may affect the centers of highest rank which lie in the brain cortex (cortical paralysis), or association-centers, or the centers of lowest rank. They are the nerve nuclei upon the floor of the fourth ventricle (nuclear paralysis). The fibers which run from the nuclei to the surface of the brain and unite there to form the trunks of the nerve may also be affected (fascicular paralysis), or the nerve-trunks themselves may be affected in their passage along the base of the skull (basal paralysis). Orbital paralyses are those in which lesions are found involving the nerve trunks from the entrance of the nerves into the orbit to their terminations in the muscles themselves. In order to locate the site of the lesion causing the paralysis we take into account the nature of the paralysis.

The nerves or nuclei may be attacked by a primary disease, an inflammation or degeneration, but most frequently are involved secondarily as a result of a disease in their vicinity, such as exudates in meningitis, thickenings of the periosteum, neoplasms, hemorrhages, injuries and so on, by which the nerve or nuclei are inflamed or pressed upon. Among the changes in the circulatory system that are supposed to be the cause of an occasional paralysis of the ocular muscles may be mentioned atheroma, aneurism and thrombosis. The usual cause of the lesion is one of the following: Syphilis, diabetes, rheumatism, diphtheria, poisons, diseases of brain, diseases of spinal cord and ataxia, injuries, congenital abnormalities, reflex causes, grippe, herpes zoster and pertusis (from hemorrhage).

Syphilis is the most frequent cause, giving rise to about one half of all cases. The resulting paralysis may be basal or central. It occurs usually after the sixth month, being one of the later manifes-

tations and is due to a gummatous infiltration. The third nerve is the one usually affected by it. Paralysis of the extraocular muscles usually follows acquired syphilis, but may be found as the result of inherited syphilis. The paralyses caused by *rheumatism* are probably always peripheral. They are rarely associated with acute articular rheumatism, but occur in rheumatic subjects after exposure to cold.

Diphtheria usually affects the ciliary muscle, but one of the external eye muscles may be paralyzed, which is generally the external rectus. The condition may be bilateral. In a few cases we find paralysis of convergence.

Diabetes, Grippe and Pertusis usually affect the external rectus. The poisons which give rise to ophthalmoplegia are the following: Tobacco (chronic tobacco-poisoning), alcohol (acute and chronic alcoholism), lead, ptomaine (alantiasis), gelsemium, chloral and carbonic acid.

A Tubercular Meningitis is the commonest brain lesion giving rise to an ocular paralysis. It also occurs in paretic dementia, multiple sclerosis and in bulbar paralysis, and from tumors of the brain.

In ataxia the paralysis is often temporary, but relapses are frequent. The Argyll-Robertson pupillary phenomenon is often present (75 per cent.). (The Argyll-Robertson pupil means that syphilis has attacked the central nervous system.)

Injuries may tear the muscle or divide the trunk of the nerve, or the paralysis may arise from a periostitis of the orbit or fracture of its walls. The external rectus is the muscle usually affected by con genital paralysis.

The site of the lesion may be located in many cases by the following scheme, taken from Fuchs, although it is at times impossible to say just where the trouble is located:

1. Lesions of the cerebral cortex, association centers, and the fibers connecting these parts with one another, and with the nuclei never cause paralysis of individual muscles, except at times ptosis.

2. *Lesions of the Association-Centers* give rise to conjugate paralyses. They occur in diseases of the crura cerebelli ad pontem, or

the pons, and of the primary optical centers, namely: The corpora quadrigemina, corpora geniculata, and optic thalami.

3. *Lesions of theNuclei in the Floor of the Fourth Ventricle* produce mostly paralysis of several muscles, attacking one muscle first. May be unilateral or affect both eyes. In most cases the pupil and ciliary muscle are spared as their nuclei lie furthest forward in the floor of the fourth ventricle. Causes are: Syphilis, diphtheria, influenza, tabes, disseminated sclerosis, trauma, and alcohol, tobacco, lead, and carbon monoxide gas poisoning. Paralysis of individual muscles may be due to a nuclear lesion. It sometimes occurs in tabes and disseminated sclerosis, but ophthalmoplegia interna can only be of nuclear origin. The facial and the abducens may be paralyzed at the same time, as their nuclei lie very close together.

4. *Fascicular Paralysis* is caused by involvement of the nerve-fibers between their nuclei and their emergence at the base of the brain, so-called Meynert's fibers. It gives rise to crossed or alternate paralyses as of the oculo-motor of one side and the extremities of the other (Weber's syndrome). The lesion in this case is in the lower part of the pedunculus cerebri. An alternate paralysis of the abducens and the extremities argues a lesion in the posterior part of the pons.

5. *Basal Paralysis* occurs when (1) a whole series of cranial nerves on one side, as the first, second, third and seventh were paralyzed, one after the other; (2) when an associated affection of the trigeminus begins under the guise of a neuralgia; (3) when one eye is perfectly blind while its fellow still sees and the ophthalmoscope fails to discover the cause of the blindness; (4) when there is a coexisting olfactory paralysis, which points to a lesion in the anterior fossa of the skull.

6. *Orbital Paralysis.*—The diagnosis of orbital paralysis is made from the accompanying symptoms referable to the orbit, as follows: Pain or tenderness upon pressure, exophthalmos, palpable tumor in orbit, history of trauma, optic neuritis from pressure.

7. *Congenital Paralysis.*—The abducens is the muscle nearly always affected. Contracture of the opposing muscle does not set in

in cases of congenital paralyses. At times the oculo-motor nerve is affected, in one or all of its branches. Congenital paralyses are frequently caused by the absence of the muscle on the affected side, or it is poorly developed.

Diagnosis.— Paralyses of the extra-ocular muscles (paralytic squint) are made evident by the following symptoms:

1. *Limitation of Movement.*— In paralysis of an ocular muscle the excursion of the eyeball towards the side corresponding to the action of that muscle is limited, or entirely abrogated. If, for example, the right external rectus muscle is paralyzed the right eye can only be brought to the median line in dextroversion. If there is a paresis the motility is of course affected to a less degree. Paralyses of the obliques are not recognized by limitation of motion of the eyeball at all. In such cases where the muscles have a complicated action we make a diagnosis from the sort of diplopia there is. If in a case of paralysis of the external rectus muscle of the right eyeball, the patient looks at an object situated to the right side, the left eye fixes properly while the right eye lags behind, and consequently its visual axis shoots off to the left of the object, or the eye has an internal squint (strabismus paralyticus, or lusticus. The term lusticus comes from luscus, squinting, and is at the present only used in connection with paralytic squints).

Squinting in paralysis of the ocular muscles only takes place when the eye is turned in the direction of the sphere of action of the implicated muscle or muscles, and becomes more pronounced the further the eye is moved to that side, but in all other directions of the gaze the eye does not squint. This fact distinguishes ordinary or concomitant from paralytic squint. The measure of the deflection of the faulty eye is the angle made by its visual axis and the line drawn from the object through the nodal point of the eye, and is called the *primary deviation.* While the patient regards the object placed to the paralyzed side a screen is put before the sound eye. The eye with the paralyzed muscle then takes up the task of fixation, provided it can be brought to bear upon the object; if not the patient moves

the head a bit until the eye can be brought to bear upon the object. If the eye behind the screen is then looked at we see it turned strongly inward, much more so than the other eye had been previously. The deflection of the sound eye when covered is spoken of as the *secondary deviation*, which exceeds the primary deviation in magnitude. This fact is accounted for as follows: When both eyes were open and the gaze directed to the right the right external rectus and the left internal rectus both apparently received the usual impulse to turn the eyes to the right, but the right eye lagged behind in proportion as its external rectus was improperly innervated. When the left eye is covered the patient can fix the object to the right by sending an abnormally great impulse to the external rectus, but he can not do this without sending the same impulse to the left internal rectus muscle which carries the left eye too far to the right. The best way to measure the amount of the primary and the secondary deviations is to mark the position of the external margin of the cornea each time with an ink-dot upon the lower lid, as before described.

2. *False Orientation.*—With the paralyzed eye the patient does not see objects in their true position in space. If in a case of right external rectus paralysis, the patient looks at an object situated in the sphere of action of the paralyzed muscle and is told to grasp the object quickly, he will usually carry his hand too far to the right, as the object is seen too far to the right (Von Graefe's groping test). In walking by the aid of the paralyzed eye this phenomenon comes to light, the patient supposing every object further to the right than it really is, steps too far to the right, and then discovering his error withdraws his foot, then deviates anew to the right and so on. The explanation of this phenomenon is as follows: In orientation there are two factors, namely, the ocular muscular sense which enables the person to tell the direction of his gaze and the portion of the retina of the eye influenced. (See orientation, Vol. I.) In paralysis the object is falsely localized, as the patient is not aware of the position his eye occupies. He supposes that the eye has turned in obedience to his will as it always had, and realizing that a very strong impulse

is necessary to direct the eye to the object, he supposes the object to be very far to that side. The object is always seen too far in the direction of the paralyzed muscle, that is too far to the right if the right external rectus muscle is the paralyzed one.

3. *Diplopia* (*Binocular*). — This always occurs in any case of squint —concomitant or paralytic—when vision is performed simultaneously with the two eyes. (It is relieved by closing one eye.) The explanation of diplopia has already been given (Vol. I.). By the position of the double images in the diplopia of paralysis of the ocular muscles, we decide which muscle or muscles are implicated. The restriction of motion, false orientation and diplopia only make their appearance when the eyes are moved in the sphere of action of the paralyzed muscle and become more and more marked as the eyes are moved further towards that side.

4. *Vertigo* results from the false orientation and diplopia. It disappears at once when the paralyzed eye is covered. In fact the patient hits upon this himself and comes to consult you with his paralyzed eye covered, or he will carry the head obliquely.

5. *Maintenance of an Oblique Position of the Head.* — A patient in whom for an example, the right externus is paralyzed, keeps his head turned to the right. When he looks forward with his head in this position both eyes are turned somewhat to the left, so that the right externus does not come into play. For every variety of paralysis there is a definite position of the head, which diminishes the vertigo and double seeing, and which is characteristic enough to make a diagnosis upon. The more recent the paralysis the more marked are the symptoms. If the paralysis gets well after not too long a time, the symptoms disappear and normal single binocular vision is restored. If on the other hand the paralysis does not get well at all or only after a very long time we find the following condition of affairs. Groping gradually ceases as the patient learns by his experience not to overreach objects as he subconsciously discovers that the innervation to his paralyzed eye corresponds to much less motion than that of his sound eye. He ceases to see double because he

learns to suppress or not to take into account the image formed in the squinting eye. Contracture of the antagonist of the paralyzed muscle gradually sets in and draws the eye towards its side. Thus in paralysis of the right external rectus the right internal rectus finally becomes shortened and draws the eyeball in towards the nose. The paralytic squint then becomes manifest over a larger area than it did before, perhaps over the entire field of fixation. The contracture may persist after the paralysis has been cured and prevent binocular fixation. Such cases resemble concomitant squints so closely that it is at times impossible to decide upon the true nature of the squint.

In order to decide which muscle is paralyzed in a given case reference is made to the following scheme:

Rotation is limited in the direction of the affected muscle and diplopia increases in the region of action of that muscle.

Diplopia caused by lateral rotations of the eyeballs in the median plane.

Images homonymous, paralysis of the external rectus of the eye towards which there is the greatest separation of images.

Images heteronymous, or crossed: Paralysis of the internus of the eye towards which rotation causes the least separation of images.

Diplopia produced by vertical rotation above the median plane.

The higher image belongs to the affected eye.

Images homonymous, paralysis of the inferior oblique of that eye.

Images crossed, paralysis of the superior rectus of that eye.

Diplopia caused by rotation below the median plane.

The lower image belongs to the affected eye.

Images homonymous, paralysis of the superior oblique of that eye; images *crossed*, paralysis of the inferior rectus of that eye,

It frequently happens that in case of paralysis of an oblique or superior or inferior rectus muscle that the image of the squinting eye (apparent image) slants, because each of these muscles act partly as rotators of the eyeball, and when one of them is impaired the vertical meridian of the retina is no longer kept vertical. If the tilting of the upper end of one image inwards increases as the eyes are rotated above or below the median plane, paralysis of a rectus is suggested;

if the upper end of one image tilts outwards, increasing with the rotation above or below the median plane, paralysis of an oblique is suggested. (In vertical diplopia the images are homonymous when the obliques are involved and crossed when the recti are paralyzed.)

Practical Application of the Test.—A red glass is placed before one eye of the patient to distinguish the image seen by each eye. A small lighted candle is then taken and holding it in the median horizontal plane in front of the eyes of the patient, at about a foot's distance it is moved from side to side, while the patient keeps the head stationary so that the eyes rotate. The patient follows the movement of the light with both eyes open and as soon as the paralyzed muscle is called into use, he sees double. The examiner then ascertains whether the images are crossed or homonymous by locating the red-colored flame. Thus suppose the red glass is before the right eye, and the patient sees the red image to the left, there is then crossed diplopia. Crossed diplopia argues an uncrossed or external squint, or paralysis of an adductor. Either the right or the left internal rectus then is the muscle implicated. If when the candle is moved to the left there is the least separation of the two images the left internal rectus is the paralyzed muscle, and *vice versa*. If rotations in the median plane fail to develop a diplopia, or after its nature has been ascertained, the candle is then moved up and down in the median line. If, when the patient looks up, the red image appears the higher, supposing the red glass to be before the right eye, the right eye is the one affected, because as that eye is unable to follow the light its image falls lower and lower in the eye as the light is elevated. If the red light is likewise to the right of the other one, there is present homonymous or uncrossed diplopia, which argues a crossed squint, or a paralysis of an abductor, and at the same time an elevator which is the inferior oblique muscle of the right eye. If on moving the candle to the right side there is uncrossed diplopia, an abductor is seen to be involved, and the one on the side towards which there is the most separation of images. Suppose this takes place to the right, then the right external rectus muscle is paralyzed. Mixed

paralyses are not so easy to locate but the same plan is followed. Thus: Suppose that on looking to the left, diplopia develops and also on looking down. Suppose that to the left it is crossed, the right internus is then paralyzed, and on looking down it is crossed.

We are then dealing with a paralysis of both the internal and the inferior recti of the right eye. (The apparent image is always seen towards the side of the paralyzed muscle.) The diagnosis as to which muscle is paralyzed is especially difficult under the following conditions:

1. When several paralyses are combined, particularly in both eyes, and the paralyses are partly complete and partly incomplete.

2. When there was previously present a heterophoria, which is converted into manifest inefficiency or squint when paralysis sets in, as binocular vision becomes impossible despite the attempt at fusion.

3. When the two eyes have unequal visual power and the better eye is the one affected. The latter is then used to fix while its fellow goes into secondary deviation. Under these conditions the sound eye may be supposed to be the paralyzed one.

4. When in old paralyses a contracture of the antagonists has taken place. And again in old paralyses the apparent image is frequently suppressed.

Measurement of the Paralysis. — It is desirable to accurately measure the degree of paralysis in order that one may determine whether treatment is proving beneficial or not. Measurement is made by aid of the double images; the region which these occupy being displaced further toward the periphery of the field of fixation and the distance between them becoming smaller and smaller as the paralysis decreases.

The simplest way of estimating the position and the degree of separation of the double images is by placing the patient at a distance of two or three meters from a wall upon which a point lying directly opposite one of his eyes has been marked as the point of departure. Starting at this point we carry an object in different directions; the patient following it with his eyes all the time. We

denote on the wall the point at which the object begins to appear double by making a mark and also the degree of separation of the images in different directions of the gaze. By repeating this test from time to time, we can ascertain any alteration in the diplopia. Inasmuch as we know the distance of the patient from the wall and the distance between the double images as projected upon the wall, we can calculate the angle of primary strabismic deviation (Landolt).

Landolt's apparatus for studying false orientation in paralytic squints is valuable. It consists of a vertical blackboard in the middle of which is painted a vertical white line. Another board is fastened to it by means of hinges in a horizontal position. The free end of this second board has a concavity which fits the neck of the patient. The white line is seen in front of the patient and the lower part of the board and his arms are hidden from his view by the horizontal board. On the under side of the horizontal board is a scale the zero of which corresponds to the white line. To the right and to the left of this are represented the tangents of angles for a radius equal to the distance which separates the eyes of the patient from the white line, which is 70 cm. One eye of the patient is covered and he is asked to touch the spot corresponding to the prolongation of the white line below the horizontal board, and the degree of false orientation noted.

By aid of the perimeter we can obtain the angle of deviation directly without calculation. We seat the patient as if we were going to take the field of vision of the paralyzed eye, then by carrying the object along the arc we can determine the point at which it begins to appear double. Or by the perimeter we can measure the field of fixation and from the amount of limitation judge of the degree of paralysis. Stevens's tropometer may also be used to measure the excursions of the eyeball. (Vol. I.) Again:

We may try to find the prism that in any given direction of the eyes will fuse the double images. The angle of strabismus then amounts to one half of the refracting angle of the prism, since for weak prism the law that they deflect rays of light through an angle

equal to half the angle which the refracting edge encloses holds good. So if the double images are united by a prism of 30°, the strabismic deviation equals 15°. During these tests the patient should move the eyes alone and not the head.

Recurrent Oculo-motor Paralysis.—In pregnancy and less frequently in syphilis and diabetes there may be a sudden onset and recovery of ophthalmoplegia with a subsequent recurrence. The nerves involved being weak are overcome by the toxin in the circulation and recover after its excretion.

Treatment.—The course of a paralysis of the ocular muscles is very chronic. The beneficial effect of treatment is seldom seen sooner than six to eight weeks, and many are incurable altogether. Relapses are not infrequent. Old paralyses in which contracture of the antagonist has resulted no longer hold out any prospects of a cure. In such cases a result can be gotten only by operative measures, that is by advancement of the paralyzed muscle and tenotomy of its antagonist. Complete paralyses with marked decrease of motility are even incurable by operation.

Medicinal treatment depends upon the cause. Syphilitic and rheumatic paralyses offer the best prognoses. If of syphilitic origin, potassium iodide in increasing doses is indicated, and if rheumatic, we give sodium salicylate and employ diaphoresis by means of pilocarpine. In other cases we give sweats, tonics and wait. Exercise of the paralyzed muscle with prisms is said to do good (Fuchs), but it is difficult to see how, when the paralysis is caused by a nerve-lesion.

The patient should be relieved of the annoying diplopia with which he suffers while undergoing a cure, by wearing a ground glass or shade before the paralyzed eye. Prisms in spectacle frames are of little use in overcoming the diplopia, as the amount of deviation varies with the direction of the gaze.

CHAPTER VII

DISEASES OF THE EYELIDS

Occasionally we meet with a partial or entire absence of the eyelids as a congenital defect. It may be unilateral or occur on both sides.

Lagophthalmos is a defect in which the eyelids are entirely wanting and the orbit divested of any covering for the eyeball. The term is also applied to an abnormal shortness of the lids which prevents their proper closure, and in cases of paralysis of the orbicularis palpebrarum muscle, on account of which it is impossible to close the eyelids.

Cryptophthalmos is the condition in which the eyeball is concealed by skin stretched over the orbital cavity. The eyeball may be absent, but then the name does not apply.

Coloboma Palpebræ (*Cleft-Eyelid*) is a congenital fissure of the eyelid usually triangular in shape with its base towards the lash margin of the lid. It is usually found in the upper lid but at times affects the lower, and may be present in both lids on both sides. The cleft is rounded off at its margins and extends through the entire thickness of the lid.

It is most frequently seen with hare-lip. Coloboma of the eyelid, whether congenital or acquired, can usually be repaired by freshening the edges of the cleft and suturing. If the rent is large, the lid may be split into two portions, an anterior and a posterior layer, and the skin layer slid one way and the conjunctival layer the other, and sutured to the edges of the gap, which have been freshened. (See Landolt's operation for the restoration of a partially destroyed upper lid.)

Symblepharon is an adhesion between the eyelids and the eyeball, either partial or complete. Another rare congenital defect is adhesion

of the lids together by their borders, called *ankyloblepharon.* The margins of the lids at the outer canthus are at times adherent, producing what is known as *blepharophimosis.* The treatment of these conditions is like that of similar acquired defects which is described later.

Ectropion (*Congenital*) is an eversion of the lash-margin of the lid, usually accompanied with an enlargement of the eyeball.

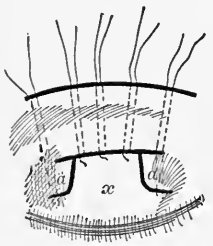
Entropion is a condition associated with an inturning of the lash-margins of the lids, frequently associated with microphthalmos.

Epicanthus is a more frequent congenital anomaly. It is caused by a redundancy of skin over the bridge of the nose, which covers the inner canthi. It is usually associated with a flat nose. Slight degrees often disappear as the child grows. Microphthalmos, squint, ptosis and anomalies of the tear-passages frequently coexist. Epicanthus is remedied by an operation, in which the redundant tissue is removed from the bridge of the nose, and the wound sutured (Knapp). The skin is pinched up in a vertical fold with a cross-bar forceps and excised with a sharp knife.

Congenital Ptosis, or drooping of the upper eyelid, may be on one side or bilateral. The eyelid can not be raised save by wrinkling up the forehead. It is corrected by the following operative measures, which are also indicated in acquired ptosis. Such patients learn to elevate the lids by wrinkling up the brows, calling into action the occipito-frontalis muscle. The aim of the following operations is to increase the vicarious action of the frontalis muscle upon the lids.

Panas's Operation.—The upper lid is stretched upon a horn-plate or blepharostat, and a transverse incision following the furrow above the lid is made through the skin and muscle to expose the tarso-orbital fascia. From near either extremity of this incision a vertical incision is carried downward to a point 2–3 mm. below the upper border of the tarsus, where one incision is made to run horizontally too near the tear-point while the other one is carried towards the outer canthus. The flap x thus outlined is dissected up from above so as to expose the tarsal border (see figure). An incision slightly

convex and about 2 cm. in length is now made just above the eyebrow, through all the tissue down to the periosteum. The brow is now undermined, and the skin lid-flap x is scarified and pushed under this bridge and attached to the upper edge of the upper incision by sutures. Hotz advises cutting off edges at a' so that the skin will not pucker. In order that the traction of the sutures shall not cause the lid to turn out, an additional suture is passed on each side through the tarso-orbital fascia and conjunctiva near the upper border of the tarsus, but not including the skin. They are carried under the skin and attached to the upper margin of the wound above the brow. The eye is bandaged and sutures allowed to remain for four or five days. If the flap is too short there is produced a lagophthalmos, and if too long the operation fails to accomplish the desired result. Allport improved Panas's operation by cutting upper and lower corners off of flaps a, a, and thinning the remaining flaps. He also scarifies the flap x on its cutaneous surface and thus gets better union. The great objection to Panas's operation is that it destroys the sulcus below the brow. Sourdille claims his operation connects the lid with the frontalis muscle without producing this deformity.

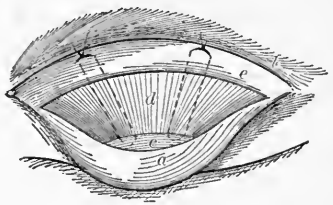


PANAS'S OPERATION FOR PTOSIS (*Gibbons*)

Sourdille's Operation.—A curved incision is made along the upper margin of the orbit. The fascia enclosing the orbital contents is then divided and the levator tendon secured by two sutures. It is then cut off posterior to the sutures. The tissues of the brow are now undermined and the sutures carried through the frontalis tendon and tied over a roll of gauze. The sutures are allowed to remain in seven or eight days.

Wilder's Operation.—This method is less frequently employed, but gives excellent results. By it the tarso-orbital fascia is folded on itself, and an adhesion established between it and the frontal muscle. An incision one and one half inch long is made a little above and parallel with the margin of the orbit down to the periosteum, being so placed

that the resulting scar is concealed by the eyebrow. The skin and orbicularis muscle are now separated from the fascia by careful dissection, until the tarsus is brought into view. Two fine sutures of catgut or silk armed at either end with a curved needle are then passed in the following manner: About the juncture of the outer and middle third of the lid and a little distance from its free edge a needle is introduced in the tarsus deep enough to get a firm hold, and drawn through. Several gathering stitches are then made upward towards the wound through the upper lip of which the needle is finally passed. The other needle on the thread is passed in a similar manner about 3 mm. from the first and parallel to its course and emerging in the tissue above, thus making a loop by which the lid may be drawn up. The second thread is passed in the same way, making a loop at the junction of the middle and inner third of the tarsus. The required elevation of the lid is now made by drawing the threads and tying them. The wound under the brow is now united by fine sutures. If the action of the levator palpebræ is not entirely lost, its tendon may be advanced, or resected, as practiced in operations for squint.



a WILDER'S OPERATION
a LOWER LIP OF WOUND
b UPPER " " "
c TARSUS
d TARSO ORBITAL FASCEA
e MARGIN OF ORBIT

(*Gibbons*)

In the Eversbusch Operation the tendon is folded upon itself. It is done as follows: A horizontal incision is made midway between the lid margin and the eyebrow down to the fascia. The tissues are then dissected up to expose well the tendon which is blended with the tarso-orbital fascia. Four millimeters above the upper margin of the tarsus a central fold is taken in the tendon with a doubly-armed needle and both needles carried down between the tarsus and the orbicularis muscle and brought out at the lid margin and tied over a bit of rubber tubing. A similar suture is passed through the nasal and temporal portions of the tendon respectively. The skin-wound is closed by sutures before the tendon sutures are tied.

Snellen's Operation.—The upper border of the tarsus is exposed by a transverse incision and the fibers of the orbicularis are pushed upward and downward. The exposed fascia is then incised at some distance from the tarsal plate and three or four needles are pushed through the tendon and passed from above downward to emerge again through the upper border of the tarsus. The piece of tendon between the border of the tarsus and sutures in the tendon is then excised and the sutures tied.

Wolff's Operation combines tendon resection with tendon advancement and is therefore preferable to the former alone. The same primary incision is made, and lifting up the tendon the surgeon makes a vertical button-hole through the tendon where it expands into the lid at each side. Through these holes two strabismus hooks are then passed under the tendon. One hook is pushed towards the insertion of the tendon and the other one pushed as far as possible in the other direction. A portion of the tendon between the two hooks is then excised after sutures are passed in the following manner:

Two double-armed catgut sutures are put through the tendon just below the upper hook and the tendon then cut. Both ends of each suture are then carried behind the stump of the tendon, through the point of its insertion and tied. The amount of tendon resected should be equal to the amount of drooping of the lid.

Each of the five layers of the lid may be the site of a diseased condition. Thus various skin diseases affect the integument of the lid. The subcutaneous tissue is liable to develop inflammation resulting in the formation of pus. Its muscles may be paralyzed or thrown into spasm; the tarsus itself becomes inflamed; the glands cystic, and the mucous lining affected by catarrh. The lashes may be affected by diseases of hair-covered localities.

The diseases commonly affecting the skin of the eyelids are as follows:

Exanthematous Eruptions.—Ulceration of the lids due to variola is not uncommon. The hair follicles, sudorific follicles and glands are the parts usually attacked. There usually results cicatricial

ectropion with loss of lashes, giving rise to the appearance termed madorosis, or tylosis.

Vaccine Blepharitis occasionally occurs from infection from a vaccination ulcer. It affects the border of the lids and is characterized by the rapid formation of an ulcer, with much swelling of the lids and enlargement of the preauricular and submaxillary glands with fever and malaise. The vesicle appears with the characteristic pitted center and the pustule is quite characteristic. In the later stages the ulcer frequently resembles a syphilitic ulcer. Ankyloblepharon to a greater or less extent is apt to result from the extended ulceration. *Treatment:* Keep the eye clean with antiseptic washes, and the lids apart to prevent adhesions. The ulcer may be benefited by touching it with a two or three per cent. solution of silver nitrate or formalin, 1–10.

Eczema may appear associated with a general eczema of the face or upon the eyelids alone. It occurs from irritating discharges from the conjunctiva and in children and old people from rubbing the secretions of the eye upon the lids. It is occasionally seen from the use of atropine (atropine blepharo-conjunctivitis). It is most frequently seen in cases of epiphora and ectropion, due to the tears running over the cheeks excoriating the surface. *Treatment:* In ulcerative form painting the skin with a two to ten per cent. solution of nitrate of silver is effective. Yellow oxide ointment (2 grs. of yellow oxide of mercury to one drachm of vaselin) well rubbed in twice daily often does good. Zinc ointment or Hebra's diachylon ointment spread on a piece of muslin and applied constantly does good. If these fail to cure after the cause is corrected, try two per cent. ichthyol ointment.

Erythema, or hyperemia of the skin of the lids, is usually due to external irritation, as heat (sun-burn), traumatism and irritating poisons. Passive hyperemia in which the superficial veins of the lids are dilated, and tissue red and edematous, may result from the too long-application of a bandage. It is also seen for a day or so after cataract operations and operations upon the iris, and is then associ-

ated with a mild degree of inflammation of the uvea. It occurs early in cyclitis and panophthalmitis. In the active state it is associated with diseases of the conjunctiva and cornea. There is no treatment required for the symptomatic form, but to remove the cause if possible. In simple burns of the lids a saturated solution of sodium bicarbonate or of alum will relieve the pain. Dermatitis venenata is usually caused by the *Rhus toxicodendron*, or poison-ivy; *Rhus venenata*, or poison sumach; *Rhus diversiloba*, or poison oak. The disease may express itself as a simple erythema, or there may be a few scattered pustules, or there may be a diffused swelling of the skin, with the formation of vesicles, pustules or blebs. *Treatment:* Wash the parts well to get rid of poisonous principles, then keep the parts well covered with a two to four per cent. solution of creolin in water, or with a solution of carbolic acid in water, one half drachm to the pint or with lotio nigra.

Xanthoma (*Xanthelasma, Vitiligoidea*) is a cutaneous new growth appearing as one or more elevated or flat yellowish patches, occurring chiefly upon the upper eyelids towards the inner canthi. They occur as flat and as nodular lesions. They do no harm save to look ugly. They are usually found in middle-aged women, and after growing a while become stationary. Their cause is not known. *Treatment* is to excise the patches or to destroy them with the cautery or electrolysis. According to Villard and Bosc the latter is the best treatment. Eight milliampères are used and the treatment continued two to four minutes. The cathode is attached to the needle and anode held in the patient's hand.

Milium.—Milium, grutum or strophulus albidus is a disorder of the sebaceous glands characterized by small globoid whitish elevations, situated beneath the epidermis, looking not unlike little grains of rice embedded in the skin. They are non-inflammatory and have no subjective symptoms. The contents of these bodies may degenerate and thus form the so-called cutaneous calculi. They are frequently seen upon the eyelids of young infants, and are of congenital origin. *Treatment:* The little masses may be removed with a skin

curette after incising the skin over them. The base of the excavation should be touched with caustic to prevent recurrence.

Molluscum Epitheliale (Molluscum contagiosum; Molluscum Sebaceum).—Epithelioma molluscum is characterized by the presence of firm roundish bodies about the size of a small pea when fully developed, and varying from a whitish waxy hue to a dark pink color. They may be pedunculated or imbedded in the skin. They are umbilicated and upon the top of each there may be seen a dark spot through which the cheesy contents pass on pressure. They may disappear spontaneously or suppurate, or terminate by ulceration. The cause of them is not known. As they are seen in members of the same family and among children in asylums, the idea of contagiousness has arisen. The molluscum bodies are formed of degenerated epithelial cells produced by the contagium, which some believe to be a parasite belonging to the order of coccidia. *Treatment:* The disease is easily removed by curetting, and touching the base of the excavation with caustic.

Ulcers of the lids may arise from burns and various injuries, and also from lupus, tuberculosis, syphilis, herpes and epithelioma.

Lupus (lupus vulgaris) affecting the face or nose, may involve the eyelids secondarily. In the beginning there is the appearance of yellowish or brownish-red papules embedded deeply in the skin. These papules fade upon pressure. They finally appear upon the surface in the form of yellowish or apple-jelly-like tubercles and nodules which are much softer than the healthy tissue and can be easily scraped off (lupus tuberculosis). These apple-jelly-like excrescences are found in all stages of the disease and may occur about the borders of an ulceration or as new developments. They are very characteristic. The tubercular stage after a varying length of time undergoes change, giving rise to the different forms of lupus. The tubercles may become absorbed and disappear by desquamation (lupus exfoliativus), or ulcerate (lupus exedens), or exuberant granulations may arise (l. hypertrophicus), or warty growths may develop (l. verrucosus). The commonest termination is that of ulceration.

The ulcers are of an irregular shape with well-defined margins and red bleeding surface, and give rise to little or no pain. The scanty secretion gives rise to the formation of brownish crusts. The resulting scars are thick, fibrous and unsightly, and give rise to a decided ectropion. The disease as a rule begins in childhood between the third and sixth years, but may be seen at any age. It most usually begins upon the nose. It may either affect the mucous surfaces of the eye primarily or by continuity of tissue. It is of slow growth and occurs chiefly in those of scrofulous tendencies. The tubercle bacilli is frequently demonstrable in scrapings taken from the lesion, and it is to be regarded as a true form of skin tuberculosis. This disease must be differentiated from tubercular and serpiginous syphiloderm. The latter usually begins in adult life however; the lesions are more numerous and extend more rapidly. The ulcers are deeper and with clean-cut edges and give rise to an abundant secretion. It also may be taken for an epithelioma. It is diagnosed from the latter in the following way: Epithelioma occurs only in those past middle life; ulceration begins at a single spot, and there are no apple-jelly-like nodules present. The edges of the resulting ulcer are hard, everted and undermined. The prognosis is uncertain and relapses are frequent. *Treatment:* Internal administration of tonics and fresh air. The local treatment aims to destroy the affected areas. To this end a caustic solution of formalin may be employed (1–10) to paint the ulcer as often as the resulting slough separates. Salicylic acid in 4–10 per cent. solution in castor oil has also been recommended. The use of caustics is in order, such as nitrate of silver stick, caustic potash, arsenous acid, pyrogallic acid, nitric acid or sulphide of zinc. The very best treatment is doubtless either scarification after the manner of Pick, of Prague, or to curette away as much of the diseased tissue as possible and then thoroughly apply pyrogallic acid in a thirty per cent. ointment. Dr. Pick recommends that a number of parallel incisions be made across the patch extending into the healthy skin all around. Other incisions are made at right angles to these. After several such operations the lupus patch is converted

into a yielding healthy cicatrix, in which are here and there scattered a few minute lupus nodules; these are destroyed by the actual cautery. The treatment of lupus by the Finsen light and exposure to concentrated sunlight, after the tissues have been injected with a solution of eosin, have recently yielded very promising results.

Syphilitic Ulceration.—The tubercular syphiloderm constitutes one of the commonest types of tertiary syphilitic eruption. The ulcers are especially prone to attack the face, back and neighborhood of the joints, and are now and then seen upon the eyelids. They consist of dark-red, firm, rounded tubercles or nodules, deeply seated and involving the entire structure of the skin. The lesion may disappear by resolution, and then the skin is left pigmented and depressed, or they may ulcerate and give rise to small shallow ulcers, covered with crusts. In the gummatous syphiloderm the lesion first appears as a rounded nodule the size of a pea situated beneath the skin and at first freely movable. They grow slowly and attain a considerable size. They attach themselves to the underlying tissue, and the skin above. The surface then becomes inflamed, thin and finally breaks down, a deep clean cut ulcer being formed which secretes a fœtid bloody pus. This ulcer can be differentiated from others found upon the lids by the history of syphilis, and the benefit derived from increasing doses of potassium iodid internally, and failure to find in scrapings from the ulcer tubercle bacilli or cancer cells.

Epithelioma (*Carcinoma*).—Skin cancer may attack the eyelid primarily or extend from the nose, its commonest point of origin. There are three varieties of the growth, namely: The superficial, the deep-seated, and the papillomatous. The three varieties will be described separately.

Superficial Variety of Epithelioma.—This form is spoken of as rodent ulcer or Jacob's ulcer. It usually begins as a yellowish waxy-looking papule about the size of a pin's head, occurring singly or in an aggregate of several. They at times originate in a wart, mole or in the seborrheal spots seen often upon the faces of the aged. After a while as the result of scratching or picking an abrasion

occurs, which becomes covered with a brownish crust. The ultimate result is the formation of a gradually growing ulcer, although it may remain stationary for a long period of time. New foci of the disease begin to form about the circumference of the primary ulcer which in turn break down into ulcers and so on. The ulcer produced has an irregular ouline, irregular surface, covered with a viscid secretion, imparting a glazed appearance to it, or drying to form a crust. The border is hard, waxy-looking and well defined from the healthy tissue, and has crossing it a few small blood-vessels. The ulcer may heal at different points, and small cicatrices are then found in the neighborhood of the active ulceration. The lymphatics are not affected and the health remains good a long while after there has been extensive destruction of tissue. Pain is nil, or very little.

The Deep-Seated Variety of Epithelioma consists of a small nodosity situated deep in the skin and subcutaneous connective tissue of a dark-red color. It is firm and hard to the touch and surrounded by an areola and is accompanied by extensive infiltration of the surrounding tissues. The ultimate outcome is ulceration, though years may elapse prior to this. The ulcer formed looks very like the one caused by the superficial form of the cancer. It has an uneven surface, everted, purplish edges, and bleeds freely. This form is painful from its onset, and extends rapidly into the depths of the tissues. The lymphatic glands sooner or later become involved, a cancer cachexia is established, and the patient dies from metastatic growths of the internal organs.

Papillary Variety of Epithelioma may develop from a wart or have its origin in one of the preceding forms. It may have a firm hard base or else spread out from a narrow neck, or not unlike a cauliflower excrescence. From the fissures between the papillæ there exudes an offensive sanguinolent discharge. The tissues finally break down and an ulcer forms and then the disease takes the usual course. If the disease is unchecked it involves all the tissues of the eyeball and orbit, and converts them into an unsightly ulcerating

cavity. Epithelioma is more common in men than in women and after middle life. Epithelioma is apt to be confounded with lupus vulgaris, an ulcerating syphilide and verrucæ.

Differential Diagnosis.—In lupus vulgaris the tubercles have a characteristic apple-jelly-like appearance, and never occur singly; the ulceration is superficial and begins at different points; the edges of the ulcer are flat and not indurated; scarring is constant, and the disease usually begins in childhood. Warty growths begin at any age; there is no infiltration about them, and they do not break down or tend to ulcerate. The ulcerating syphilide is more rapid in its progress; the ulcer has clean-cut edges; there may be a tendency to heal in the center while spreading in the periphery, and internal administration of KI is curative.

Lepra.—Leprosy or elephantiasis græcorum not infrequently affects the eyelids, its site of predilection being the face. The eruption begins with erythematous, shiny, infiltrated, hyperesthesic areas of a reddish brown color varying in size. Tubercles arise from these maculæ after a varying lapse of time, and coalescing form large nodular masses of a reddish brown color. The massing of great numbers upon the face has led to the term leontiasis. The tubercles may remain unaltered or ulcerate or undergo involution, or the anesthetic form may be added. That is the patches become covered with scales, with raised borders and anesthetic. The eyebrows and lashes drop out, and the lids are much distorted, their borders turning in or out as the case may be.

Elephantiasis Arabrum is a chronic hypertrophy of the skin and subcutaneous tissue. The cause of the disturbance is occlusion of the lymphatics, the result of inflammation due to the presence of the filaria sanguinis hominis. The lids reach enormous proportions, and from their mere weight prevent the opening of the eye. The upper lids are the ones usually affected. The excessive tissue may be removed so as to allow the patient to open his eyes.

Ephidrosis and Chromodrosis are two rare skin diseases which are at times seen affecting the eyelids. The first signifies an excessive

sweating of the eyelids. It may be confined to the lids or be an accompaniment of unilateral sweating of the face.

Chromidrosis or Seborrhœa nigricans, or the secretion of a variously colored perspiration, is at times seen upon the lids, when it is known as palpebral chromidrosis. It consists of a bluish black discoloration usually upon the lower lid. It is somewhat oleaginous and can be wiped away. At times it may be genuine, but is usually practiced as a fraud by hysterical subjects. Locally lead water and glycerine are said to be of service. The existing anemia and debility should be treated in the proper manner.

We shall now consider suppurative diseases of the lids.

Abscess or Phlegmon.—This is an acute swelling of the eyelid somewhat localized. It is usually indurated in the center and accompanied by much redness and edema of the skin and is tender on pressure. Finally fluctuation appears usually between the lash border and the brow. Abscesses result from injury, from disease of the walls of the orbit, or they may arise from infectious diseases. They are at times seen accompanying grippe. If the abscess is not opened early it may lead to much distortion of the lid with eversion of its lash border or to lagophthalmos. *Treatment:* Before pus has formed ice applications may abort the abscess. If the inflammation continues to increase, hot application should be used to hasten pointing. An incision should then be made through the center of the abscess and parallel to the lid border so that the fibers of the orbicularis are not divided. The cavity may then be washed out with hydrogen dioxid or bichlorid (1–4,000) until recovery takes place.

Furuncles and Carbuncles present about the same clinical picture save there develops a core or central slough and should be treated like abscesses.

Anthrax Pustules.—Malignant pustule is an acute specific disease which leads to a gangrenous condition of the skin, caused by inoculation with the bacillus anthracis. The disease occurs among those employed about animals and in those dealing in skins of animals affected with splenic fever or charbon. The disease begins two or

three days after inoculation with a red papule upon which a vesicle or pustule develops. This soon ruptures, leaving a black gangrenous surface. The gangrenous process spreads rapidly and is soon accompanied with symptoms of acute septic infection. Death results within a week, unless the disease is arrested. In favorable cases the slough is cast off and replaced by a cicatrix which distorts the lid. Cicatricial ectropion or lagophthalmos is the result and an operation is needed to restore the lid. Treatment is not brilliant; most cases die. The diseased area should be removed thoroughly by excision and electric cautery and dressed with moist, hot bichlorid compresses (1–4.000). Stimulants should be freely used internally.

Herpes Zoster Ophthalmicus is a neuropathic affection having its cause in inflammation and degeneration of the ganglion of Gasser, or of the branches of the trigeminus or of both. It is called by the French Zona Ophthalmic. It has been extensively described by Hutchinson and Hybord. Any of the branches of the fifth nerve may be implicated, and a vesicular eruption occurs along the distribution of the diseased nerve twigs. It therefore happens that vesicles occur on the eyeball as well as upon the skin, and ulceration of the cornea, acute conjunctivitis and iritis may take place. These results especially follow implication of the nasal branch of the ophthalmic nerve.

The eye is not infrequently lost from irido-cyclitis originating as a neuropathic affection of the fifth. Some say small abscesses have been observed in the ocular muscles. The initial symptom is intense pain in the side of the face and eyeball. The skin becomes red, swollen and tender in a few hours, and a few vesicles make their appearance usually near the inner angle of the brow, then upon the forehead and side of nose. Together with these vesicles there are dark livid spots of irregular outline and sloughing center to be found in very severe cases, evidences of trophic disturbances in the affected region. The pain increases, the eyeball becomes suffused, watery and painful to light. A characteristic thing about the disease is the sudden cessation of pain after it has reached such a height. This is

caused by a paralysis of the fifth nerve ensuing from the diseased condition in it. The affected portion of the forehead and brow as well as the eye is now found to be anæsthetic to the touch. The vesicles formed become limpid and pustular, and finally dry in crusts which when removed expose an ulcerating surface. Permanent scars remain after healing. If the cornea becomes affected the case is greatly complicated, the ulcers resulting in more or less permanent opacities. Palsy of the ocular muscles and atrophy of the optic nerve may follow herpes. The cause of the trouble is obscure but it is an inflammatory affection of the nerve. After a varying length of time sensation returns to the parts, preceded perhaps by a period of hyperesthesia, or facial neuralgia. *Treatment:* Nothing relieves the pain like dry heat, and this is best applied by binding a Japanese pocket-stove over the eye. If this fails to afford relief morphia gr. ¼ or heroin gr. ⅙ should be given internally. The vesicles should not be punctured and the ulcer allowed to heal beneath the crusts. Inflammation of the cornea and iritis require the measures elsewhere described. One should constantly be on the lookout for any corneal complication or iritis as they occur without any pain, and hence without the patient's knowledge, and may lead to destruction of the sight if overlooked. There is no local application that does much good, but the vesicles may be sprinkled over with powdered rice-starch, or some other drying powder, and the parts protected with an absorbent cotton pad.

Diseases of the Palpebral Muscles.—The muscles of the lids may be affected with spasm or paralysis.

SPASM AND TICS OF THE LIDS.

Spasm of the Orbicularis (*Blepharospasm*).—This manifests itself by screwing of the lids tightly together. It may be an accompanying symptom of some other eye disease, or it may be a disease *per se*.

Symptomatic blepharospasm accompanies all irritative stages of the eye. It is found in connection with the presence of foreign bodies in the conjunctival cul-de-sac with trichiasis and in various forms of

ocular inflammation, as keratitis, iritis, etc., being of a reflex nature. The violence of the blepharospasm is by no means in proportion to the severity of the disease of the eye, so we can not draw any conclusion as to the duration or extent of the ocular trouble from it. It at times renders the examination of the eye difficult, if not entirely impossible. It is usually most violent and most obstinate in conjunctivitis lymphatica. By the pressure of the spastic lids upon the cornea, the nutrition of the latter is interfered with, the lids become edematous and finally spastic entropion or ectropion develops. The treatment consists in removal of the ocular disease lying at the root of it. While this is being accomplished, the patient should have a one per cent. solution of holocain muriate to use in the eye every two to four hours. *Essential blepharospasm* is distinguished from the former by the fact that the eyes themselves are found to be perfectly normal. In young females particularly it manifests itself by the eye suddenly shutting and remaining closed as if in sleep (blepharospasmus hystericus). This condition simulates ptosis or paralysis of the levator of the eyelid, but is differentiated by the resistance offered to passive opening of the eye, due to the spasm.

In cases of hysterical blepharospasm it is often possible to find so-called pressure-points, points upon the body somewhere upon which pressure will open the eyes as if by magic. It was V. Graefe who first called attention to this fact. The pressure-point is in the majority of cases in the region supplied by the trigeminus, especially at the points of exit of the supraorbital and infraorbital nerves. The point may be in the throat or nose or somewhere else upon the body. The patient will be aware of the presence of the pressure-point in many instances and will call the attention of the physician to the fact.

In elderly folks the spasm is most apt to be clonic, that is, there is constant winking (nictitans). Less frequently a tonic spasm occurs which keeps the eyes tightly closed all the time (blepharospasmus senilis). Senile blepharospasm is often one of the symptoms of a general facial spasm (tic convulsif). Hysterical blepharospasm gets well after a while. Mental suggestion does more for it than any

other one thing. A placebo should be prescribed as mental treatment. The lid spasms of the aged resist treatment for a long time and are often incurable. Bromide of potash internally does more good than anything else.

A spasm of the lid is a motor reaction from an actual irritation through a spinal or medullary spinal reflex tract. A tic is a psychomotor affection and is of cortical origin — a function movement exaggerated and inopportune (Meige). According to Meige there also exists a tic of the intra- and extraocular muscles. *Treatment* of tic consists in abstaining from movement, "training in immobility" during increasing periods. The training may be carried on before a mirror. The prognosis is more favorable *in the young*. Several cases of spasmodic retraction of the upper lid have been reported by Chevallereau and Chaillons. On looking down the lids remained elevated. There were no other signs of Basedow's disease and none of hysteria.

Paralysis of the Orbicularis. — The paralysis is only apparent when the patient attempts to close his eye. It is then seen that he is unable to do so, principally because the lower lid cannot be raised. If the paralysis is a recent one no changes are noticed when the eye is open. The failure on part of the lids to close is particularly apparent in the inner half of the lids. In consequence of the incomplete closure of the lids there is epiphora, which may constitute the only complaint of the patient. After awhile the lower lid falls away from the eyeball and sinks lower and lower (ectropion paralyticum). The cornea is exposed during sleep and is apt to become inflamed (keratitis elagophthalmo). Paralysis of the orbicularis is caused by a lesion of the facial nerve and is therefore seen in cases of Bell's paralysis.

As a rule we have to do with a peripheral lesion of the nerve, due to cold, a rheumatic diathesis, suppurative middle ear disease, otitis interna, tumors at the base of the brain and specific trouble. In central (nuclear) facial paralysis the oral branches of the nerve are chiefly implicated, and the orbicularis often spared. The muscles do

not hang flabby as they do in peripheral paralyses, and contractility to the induced electric current is not lost. If the trouble is at the base of the brain, the acoustic nerve of that side will most likely be implicated at the same time and we will have an accompanying deafness (nerve deafness). If the trouble be in the ear, there will be an otorrhea, present or past, and alteration of taste on that side. Food will taste salty, and the patient will be unable to differentiate bitter and sweet. In the most favorable cases, several months are apt to pass before a cure is wrought. *Treatment:* If there is a specific history obtainable KI should be used in combination with mercury internally. Symptomatic treatment consists in the application of electric current, both the galvanic and faradic. As long as the patient is unable to properly close the eye, it should be bandaged every night to prevent the development of keratitis and ectropion. In severe cases the bandage should be constantly worn. If the paralysis proves to be incurable tarsorrhaphy must be done to facilitate the closure of the lids. The operation of tarsorrhaphy has already been described.

Levator Palpebræ Superioris.—Paralysis of the levator of the lid manifests itself by a drooping of the upper eyelid (ptosis). There may be only a barely noticeable depression of the lid to a prolapse of it to a degree that it hangs down quite flaccid and devoid of wrinkles, and covers the whole eyeball. Of course vision is interfered with unless the patient lifts the lid with the finger. In paralysis of the third nerve this is a good thing as the paralyzed eye is then excluded from the visual act and annoying diplopia prevented. Patients with ptosis will usually throw the head back so that by the downward rotation of the eyeball the pupil comes to lie in the palpebral fissure even though lowered. The forehead at the same time will be wrinkled in the effort to voluntarily raise the lid. Ptosis may be congenital or acquired. Acquired ptosis is the result of paralysis of the third nerve, which supplies the levator of the lid. It seldom occurs alone save in central disease, but is usually associated with paralysis of some of the ocular muscles supplied by the third nerve.

The causes of ocular paralyses have already been enumerated and their treatment considered.

Congenital Ptosis has been considered and is due as a rule to an absence of or faulty development of the levator palpebræ superioris.

DISEASES OF THE GLANDS OF THE LIDS.

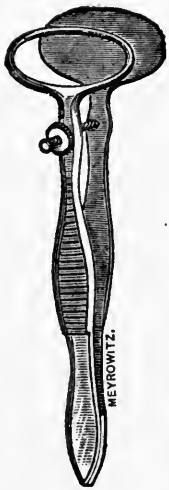
Hordeolum, or Stye. — Hordeolum externum or hordeolum Zeissianum is a suppuration within and around one of the sebaceous glands supplying a lash (Zeiss's gland). There is first noticed a sticking pain in the lid upon winking, which is accompanied by more or less inflammatory edema. (Inflammatory edema differs from simple edema in that the skin is red, fading on pressure in the former.) The swollen and tender spot lies near the border of the lid. The swelling increases and the skin over the inflamed area becomes red, infiltrated and shows a yellowish discoloration, and finally perforates near the border of the lid with a discharge of a drop of pus. After perforation the inflammatory symptoms soon abate and the process is at an end in seven to ten days from the beginning of the trouble.

In the beginning the disease may be aborted by massaging the spot with a hard warm substance, as with the bowl of a warmed spoon. The pressure and heat cause the cyst to discharge through the duct of the gland. The old method of the laity of rubbing a stye with a gold ring is not without foundation in truth. The drawing of a few lashes from the most tender spot (where pus is developing) sometimes will empty the sac and bring the disease to a cure. If these measures fail, the treatment consists in the use of warm compresses, to convert the hard infiltrate into pus the more quickly. When the yellow color of pus is seen beneath the skin, an incision is made through the mass, and thus the attack is shortened several days. Any blepharitis that may be present should be treated, so as to prevent the recurrence of styes. Styes now and then occur in crops, in which case the refraction should be examined and any error corrected, and an antiseptic salve, two grains of yellow oxide of mercury to one drachm vaseline, well rubbed into the edges of the lids every night.

Hordeolum Internum is a suppuration in a Meibomian gland and hence is at times called hordeolum Meibomianum. The course of this disease is the same as that of hordeolum externum. The Meibomian glands being larger than those of Zeiss and enclosed in dense connective tissue of the tarsus, the inflammatory symptoms are more violent, and it takes a longer period for the pus to be evacuated. The pointing takes place upon the conjunctival surface of the lid, showing through the conjunctiva as a yellowish spot. It may be discharged through the orifice of the gland but more frequently takes place through the conjunctiva. Perforation through the skin only occurs in cases in which the obstruction in the duct of the gland inflamed is below the tarsal cartilage. Hordeolum externum and hordeolum internum are really the same process—as the Meibomian glands after all are nothing but modified sebaceous glands. The causes of hordeolum internum are like those of hordeolum externum: Strumous diathesis, blepharitis marginalis, by causing occlusion of the ducts of the glands, and refraction errors. Treatment is like that for hordeolum externum, *i. e.*, massage, application of heat and incision when pus forms.

Chalazion, Tarsal Tumor, or Tarsal Cyst, is a chronic affection of a Meibomian gland. It is simply an occlusion cyst and gives rise to a slow growing hard lump in the lid. It occurs in most cases without any inflammatory symptoms whatever and is unnoticed by the patient until it becomes quite large. In some cases there is a moderate amount of inflammation which subsides and leaves the lump. After the cyst has existed for a month or so it bulges the skin of the lid and produces a considerable disfigurement. Upon palpation the tumor is felt to be quite resistant, and that it is adherent to the tarsus while the skin is freely movable over it. On everting the lid we find the conjunctiva over the cyst somewhat reddened, thickened and protruding, perhaps the whitish secretion within can be seen shining through the conjunctiva. Later on the tumor assumes a grayish appearance as seen through the conjunctiva and finally perforates and discharges a thick, viscid turbid fluid, corre-

sponding to the central softer portions of the tumor. The main portion of the growth consisting of spongy granulation remains behind, for which reason after the tumor is opened it does not at once disappear. On the other hand it diminishes very gradually and in the meantime the granulation tissue may project as a polypoid growth of the conjunctiva. This mass should be excised. It requires months for the tumor to entirely disappear. Chalazion is analogous to acne rosacea of the skin in which the sebaceous glands play the same part as do the Meibomian glands in chalazion. Chalazion is found more frequently in the adult. The lump annoys the patient by being disfiguring and also by keeping up an irritation of the eyeball on account of the bulging of the conjunctiva produced by the tumor. *Treatment:* If the cyst is of medium size, its contents are turned out and sac well curetted, while if very large and especially if most of the lump is made up of thickened sac wall, the tumor should be dissected out en masse. The instruments needed as a rule are the following, shown in the cuts: Ring forceps; sharp-pointed knife and curette.



Desmarre's Ring Forceps.

Skeel's Serrated Scoop.

The lid is grasped with the ring forceps so that the ring includes the tumor upon the conjunctival surface. The lid is then everted and a crucial incision made in the tumor. After the fluid contents of the tumor have escaped, the curette is taken and all the granulation mass scraped away. A nitrate of silver caustic stick may then be introduced and the interior of the sac cauterized. Even then the tumor does not disappear completely, because its thick capsule remains. There is no bleeding until the forceps are removed and

then the tumor fills with blood and appears even larger than it was before the operation. The tumor then begins to shrink in a few days and finally disappears. If the operation is not thoroughly done the lump is apt to return. If the chalazion is very large it is removed through the skin by careful dissection and the skin wound sutured.

Infarcts of the Meibomian Glands.—We frequently see, especially in the elderly, on everting the lids, bright yellowish spots shining through the conjunctiva. These consist of inspissated contents of the Meibomian glands which accumulate in the ducts and distend them. Now and then they are transformed by the deposits of lime salts into hard bodies (lithiasis conjunctivæ). These bulge the conjunctiva and frequently perforate it with their sharp edges and thus act as foreign bodies in the eye. In such cases they must be removed from their beds after an incision is made in the conjunctiva. The lime deposits are seen in great numbers in those of a rheumatic or gouty diathesis.

Tarsitis is usually a chronic affection of the tarsus, characterized by a thickening of the lid. In acute cases there may be a sloughing of the tissues. Associated with conjunctivitis and blepharitis in scrofulous subjects, there is often found a thickening of the tarsus. Syphilis is the most frequent cause of the disease. It is among the tertiary symptoms and assumes the gummatous form. The lids become gradually thickened without other disturbance and the patient is annoyed by the increased weight of the lids, being unable to properly open the eyes. If the lower lid is affected, its weight usually pulls it away from the eye, giving rise to an ectropion and epiphora. The disease is obstinate, but usually gets well. If of syphilitic origin KI should be used in increasing doses, or perhaps better results are gotten if it is given combined with mercury, preferably the biniodide, one eighth of a grain, three times daily. If not specific in origin, any discoverable constitutional disturbance should be corrected by the proper means. Locally the remedies of blepharitis are useful.

Blepharitis Marginalis (*Blepharitis Ciliaris*, *Blepharo-adenitis*, *Tinea tarsi*, *Sycosis tarsi*).—Disorders of the lash borders of the lids

are among the most common diseases of the eye. The inflammation ranges from a hyperemic condition of the lid borders to a disorganization of its tissues. There are three varieties of blepharitis marginalis.

1. *Simple Blepharitis* (*Blepharitis Hyperemica*) is denoted by a dusky appearance of the edges of the lids, and is caused by a hyperemia of the cutaneous capillaries near the free margin of the lid. The common and almost sole cause of this variety is an error of refraction or muscular anomaly, and treatment consists in the correction of these.

2. *Squamous Blepharitis* (*Blepharitis Seborrhœica*).—In this, besides the red lid borders, there are to be found fine bran-like scales among the cilia. These scales drop off if the eyes are rubbed. The lashes also easily fall away but are perfectly reproduced. The skin beneath the scales is hyperemic but not moist nor ulcerated. At times the secretion is waxy in nature and glues the lashes together, but the lid borders are not ulcerated.

3. *Ulcerated Blepharitis* (*Blepharitis Ulcerosa*).—In this variety there is the formation of crusts along the lid borders. When the crusts are removed by washing there are to be seen a number of minute ulcers. From the center of many of the ulcers projects a lash. On drawing the lash there is often found adhering to its root a small drop of pus. The ulcers extend into the hair follicles and cause falling of the lashes which are stunted and misplaced if they are replaced, by the cicatrization following the healing of the ulcers. The lashes may be turned backward against the eyeball, which they scratch with every movement of the lid, giving rise to the condition called trichiasis or wild hairs. Perhaps the entire lid border is left bald (madorosis). As a result of the continued ulceration there develops a gradual eversion of the border of the lower eyelid. The conjunctival surface is then exposed and the tears run over the face, increasing the irritation. To this condition the name of blear-eye or lippitudo is given. Sooner or later the lid becomes increased in thickness, due to the chronic inflammation, and thus the upper lid becomes more or less drooping (hypertrophic blepharitis).

The causes of blepharitis are local and constitutional. The local causes are: Refraction errors and muscular anomalies; Irritation from smoky or vitiated atmosphere, injuries, chronic conjunctivitis, naso-pharyngitis, and diseases of the lachrymal passages. Among the general causes are: Anemia, tuberculosis, syphilis and malnutrition from any cause whatever. The disease as a rule is a chronic one but there are certain cases especially those depending upon eye-strain which are very acute. The picture is somewhat as follows: The edges of the lids become dusky, and there is felt a soreness in them on winking. Very soon, perhaps the next day, the lid borders are very red, the skin for some distance upon the lid is dry, infiltrated and scaly. Numerous crusts form along the lid margins but there is no ulceration. There is a true eczema of the lid borders (blepharitis eczematosa). The treatment of this variety does not differ from that of the others.

Pathology.—The staphylococcus is the organism usually found in the pustules that form along the lid borders and break down into ulcers. Now and then the microsporon of sycosis is found (trichophyton). And still less frequently we find the demodex follicularum. The inflammatory process involves chiefly the cilia and their glands.

Prognosis is not favorable in the majority of cases for a permanent cure, for in spite of all you do it persists in some and the only thing to do is to keep it within bounds by appropriate treatment. In others the disease is outgrown as the patient grows older.

Treatment.—The general health should be built up if nutrition seems below par, and glasses adjusted if there is present any error of refraction or accommodation, or muscular anomaly. The tear duct and the nose should be examined and any abnormalities corrected. Excessive use of the eyes should be prohibited. For the milder cases some non-irritating ointment gives the best result. The scales should first be removed after soaking them with a bicarbonate of soda solution (gr. 10 to oz. 1) to soften them, or H_2O_2, and then a little of the ointment rubbed into the cilia and along the margins of lids once or

twice daily. The one per cent. ointment of the white percipitate is most useful in the milder cases. If a more stimulating ointment is desired the yellow oxide of mercury ointment may be used, in strength of one or two grains to the drachm of vaseline. It is essential that the salve be well rubbed up so that there will not be any irritating particles of the drug left. To do this properly the oxide of mercury should first be rubbed up in olive oil or liquid vaseline and then the vaseline added. If this ointment fails to do good or, as it is very irritating to some, exaggerates the condition, then try 10 grains of aristol to 1 drachm of vaseline. In the ulcerative variety the minute ulcers should be touched with the nitrate of silver caustic point, and all diseased cilia epilated so as to allow the remedies employed access to the follicles. In the pustular or ulcerative form the accumulations should be pressed out from the lid margins. Renolds advocates a thorough application of carbolic acid to the lid margins. Some acid is dissolved with alcohol. A needle is dipped in this solution and with it all of the scales are scratched off. The whole lash border is left whitened and it soon exfoliates. The application is repeated in ten days. This is followed by a luxurious growth of lashes. The treatment of the sequelæ of blepharitis, namely trichiasis, phlyctenules and ectropion, will be dealt with later.

Phthiriasis is very apt to be confounded with blepharitis squamosa by the beginner. It is often associated with it and is caused by the presence of lice among the lashes. The margins of the lids appear dusky and on close inspection there are to be seen the black ova of the nit, as well as a few well-developed lice adhering to the lashes close to the border of the lid. Treatment consists of rubbing mercurial ointment into the lashes. The yellow oxide ointment is also efficient. The particular variety of louse which is found upon the eyelids is the crab louse or pediculus pubis.

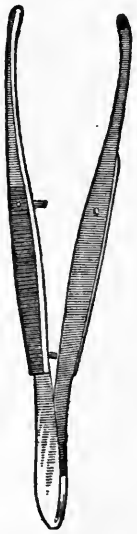
ANOMALIES OF POSITION AND CONNECTIONS OF THE LIDS.

Trichiasis is the condition in which the cilia, instead of projecting forward, are directed more or less backward and come into contact

with the eyeball. It may affect all or only some of the cilia and be present in one locality only, or occur all along the lid border (total and partial trichiasis). The inverted cilia are usually fine and without color and often consist of short stumps. These wild hairs constantly irritate the eyeball and give rise to photophobia, lachrymation and a constant feeling as if something was in the eye. Superficial opacities of the cornea result, due to a callous thickening of the epithelium caused by the constant irritation. There are also developed a number of fine blood vessels in the superficial layers of the cornea simulating pannus trachomatosus. Recurrent corneal ulcers are frequent and the patient is constantly annoyed until the faulty lashes are eradicated. The causes of trichiasis are: Trachoma, blepharitis, styes, ulcerations of lid, diphtheritic conjunctivitis, burns, wounds and operations upon lids.

In the regressive stages of trachoma or granular lids, the conjunctiva undergoes shrinking from cicatrization, thus pulling the skin surface of the lid backward over the free border of the lid, putting the cilia in a more or less false position. As contraction continues, the whole lid border becomes curved in towards the eyeball. The condition is then spoken of as entropion.

Under the name of distichiasis is designated a congenital condition, in which there are two rows of lashes, one normally placed and the other, which is imperfectly developed, turned against the eyeball. It may be present in all four lids.

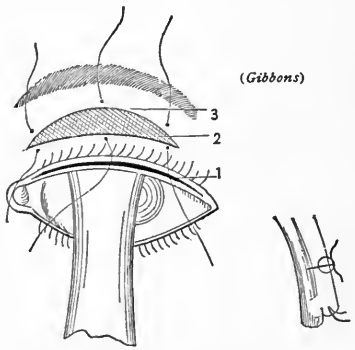


Cilia Forceps.

Treatment of Trichiasis.—The improperly placed cilia may be drawn (epilated), but inasmuch as they are reproduced this operation has to be repeated about every two weeks. The cut shows a pair of epilation forceps.

The lashes are located and drawn by aid of a watch-maker's glass, as they are often too fine to be seen with the naked eye. The forceps are applied to the lash to be drawn and gentle traction made, otherwise the hair is broken and the stiff stump left which may escape

attention, but continue to irritate the eyeball. It now and then happens that a patient presents himself with all of the lashes which were entirely normal drawn, with the supposition that he was suffering with wild-hairs. In the mind of the laity wild-hairs are the cause of all ills of the eye. If there are only a few wild-hairs it is better to destroy them by electrolysis, and cure the case once for all. A fine needle is attached to the negative pole of a galvanic battery, and a sponge electrode to the positive pole. The needle is then introduced into the hair follicle, a thing which hurts a great deal, and the sponge placed upon the cheek below the eye. The current is then gradually increased until bubbles are seen coming from about the lash. This means that there has been a disorganization of the tissues at the root of the hair. The needle is then withdrawn and the lash pulled. For electrolysis we need a tension battery. The difference between a tension and a cautery battery is the way in which the cells are coupled together. The object of a tension battery is the development of electro-motive force. To make a tension battery the carbon of one cell is connected with the zinc of the next, and so on throughout the series. For electrolysis it takes about thirty Leclanche cells. If the majority of the lashes are turned in, one of the following operations should be done.



Jaesche-Arlt Operation. 1, Intermarginal Incision; 2 and 3, Skin Incisions Between when Integument is Excised.

Jaesche-Arlt Operation. — The lid is supported upon a horn spatula or blepharostat placed beneath it. Its intermarginal portion is then split into two layers, the anterior of which must contain all the hair follicles. A second incision is then made about 5 mm. above the lid border, through the skin, and a third is carried from one end of this incision to the other in a curved manner. The intervening integument is then dissected away. The margins of the gap are then drawn together with fine sutures, and the bridge of tissue con-

taining the lashes is thus elevated and turned away from the cornea. The incisions upon the skin surface of the lid should go down to the tarsal cartilage but not through it. The fibers of the orbicularis should not be disturbed when dissecting away the flap. If the flaps after the operation look blue the eye should be dressed with hot bichloride compresses, and frequently changed to prevent sloughing. The stitches are removed at the end of the third day.

Following the suggestion of Watson a few operators transplant a strip of skin or mucous membrane to the intermarginal space. Hotz recommends the following method: The lid border is split as before. A transverse incision is then made through the skin of the lid and orbicularis muscle just below and parallel to the upper margin of the tarsal cartilage. The strip of muscular tissue which covers the upper portion of the tarsal cartilage is then excised. The lid-skin is then united with the upper border of the cartilage by three sutures. Each passes through the edge of the skin, then through the upper border of the cartilage and finally through the upper edge of the cutaneous wound. When the sutures are tied the skin of the lid is drawn up and fastened to the upper border of the tarsus. The intermarginal incision is converted into a gaping wound several millimeters in depth. A piece of skin is then taken from behind the ear a little larger than the raw surface to be covered. The graft is spread out and gently pressed into the groove, and, after thorough irrigation with normal salt solution, both eyes are bandaged. During the first two weeks the epidermis of the graft is repeatedly shed and it is advisable to keep the parts well lubricated with vaseline.

Skin graft in this operation is preferable to mucous membrane, because the intermarginal space is normally faced with skin and not with mucous membrane, and because skin-graft is less likely to mortify and also makes a more substantial lid border. On the other hand, the fine hairs in the skin-graft at times irritate the cornea, but if taken from behind the ear the graft never grows many hairs. The graft should be cut obliquely just into the corium. The hairs that

irritate the eye after the operation are usually those left in the posterior layer of the intermarginal surface.

Van Millingen Tarso-cheiloplastic Operation.—The intermarginal space is split from end to end as in the Arlt operation. The incision is made deeper in the middle and tapers off at the ends so that there will be the greatest amount of gap in the middle of the lid border. The gap is kept open by sutures passed through folds of skin, and by means of these the lid is prevented from closing for twenty-four hours at least. As soon as bleeding ceases, a strip of mucous membrane, of the same length as that of the lid and 2–2.5 mm. in width, is taken from the inner surface of the under lip and placed at once in the gap at the intermarginal space. The graft is pressed into place with a pledget of cotton soaked in weak sublimate solution. Sutures are superfluous and do more harm than good. The lid is then covered with linen containing a thick layer of iodoform and vaseline (gr. x–℥i) and this covered with cotton wool. Both eyes should be bandaged for twenty-four hours and the sutures allowed to remain in the lid until the second day.

Entropion.—By entropion we mean a turning in of the lid border. The distinction between trichiasis and entropion is one of degree. An exaggerated trichiasis becomes an entropion. The evil consequences of entropion are those of trichiasis, only to a greater extent. There are two varieties of entropion, namely, the spasmodic and cicatricial, according to the causation. Spastic entropion results from the overaction of the palpebral portion of the orbicularis muscle, and is usually associated with irritation of the conjunctiva or cornea, and is seen in old folks when the eye has been kept bandaged for any length of time, and also associated with blepharospasm. The cicatricial type results from shrinking of the conjunctival surface of the lid caused by trachoma, diphtheritic conjunctivitis, burns, injuries, etc. *Treatment:* Spasmodic entropion is cured by treating the cause, the conjunctivitis, keratitis or what not. While the cause is getting well one may use holocaine hydrochlorate in one per cent. solution or weaker, to keep the eye comfortable. Holocaine is a local anæsthetic

which is free from any of the ill effects of cocain. It does not alter the ocular tension, change the size of the pupil nor interfere with the accommodation, and is perfectly safe to use every two hours or even oftener to keep the eye comfortable. If the lid still persists in turning in, its skin surface should be painted with several layers of collodion. Or, a fine suture may be passed through a fold of skin, thus drawing the lid away from the eyeball. The cicatricial type needs operative treatment, and may be dealt with in one of the following ways. Not only must the lash border of the lid be everted, but the curve of the tarsal cartilage must be altered as well by the operation for entropion, to succeed.

The Simplest of the Procedures is that of Burow.—It is especially useful for entropion of the upper lid following trachoma. It is done as follows: The upper lid is everted and the gray scar-line that runs parallel with the lid border is exposed (this scar is the characteristic scar of trachoma). At the temporal side of this scar-line an incision is made large enough to admit a small grooved director, which is now pushed to the nasal side of the lid between the skin and the conjunctiva, care being taken that the point of the director is kept well beneath the line of cicatricial tissue. The portion of the lid thus elevated is divided in its whole length. No dressing is required. Cold compresses may be used for a few hours to allay any irritation. The operation is always immediately successful but frequently has to be repeated.

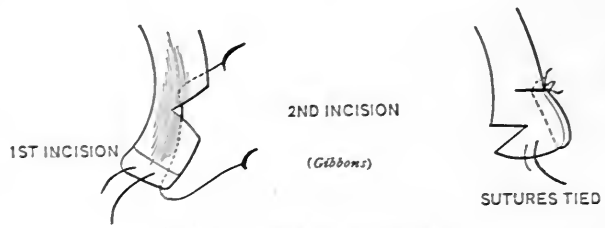
Streatfield removes a wedge-shaped piece of cartilage with its superjacent skin from the lid close to its border and allows the wound to granulate.

Snellen's Operation is Done as Follows: An incision is made several millimeters above the lash border of the lid and throughout its length, down to the tarsus. The muscle and skin are then separated from it and pushed aside, and a wedge-shaped piece is cut from the tarsus, as in the Streatfield operation. The border of the lid is now everted and kept in position by threads passed as follows: The needle is made to enter the lash border of the lid, and is brought out through

the upper edge of the wound in the tarsus. The lash border of the lid, in other words, is attached to the upper edge of the groove in the tarsus. The skin may or may not be closed with sutures.

The Hotz-Anagnostakis Operation.—A transverse incision is made from canthus to canthus through skin and subjacent tissues, but instead of being made near the border of the lid as in the other operations it follows the upper edge of the tarsal cartilage. The incision begins about 2 mm. above the border of the lid at either end and reaches a distance of 6–8 mm. from the free border in the middle of the lid. A narrow bundle of muscle fibers is now excised, with a pair of scissors. The sutures must include nothing but the skin and the upper border of the tarsus. They are passed through the skin at the lower border of the wound and then through the upper border of the tarsus and returned through the tarso-orbital fascia just above the border, and finally through the upper wound border. A middle and two lateral sutures are placed.

If the deformity of the lid is very great a canthotomy should be done to relieve the tension upon the stitches. The sutures are removed on the third or fourth day. The constant association of entropion and trichiasis makes their surgical treatment in many cases identical.

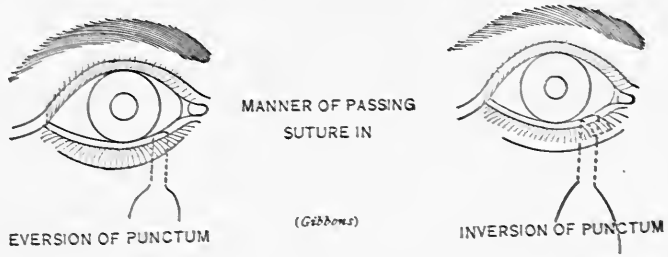


Green's Operation for Ectropion.

Green's Operation is performed as follows: A Graefe cataract knife is passed through the lid from the within out near the inner canthus and about 4 or 5 mm. posterior to the lash border of the lid. The lash border is then separated from the rest of the lid and hangs down, attached only at the canthi. A piece of skin, subcutaneous tissue, muscle and tarsus is then taken from the outer surface of the lid, just above the first incision. The skin wound is then closed by sutures passed through the upper border of the skin wound, includ-

ing the upper edge of the tarsus in the wound, to give the lid border a firm attachment and brought out below among the lashes. Three sutures are usually passed. By this operation the conjunctival surface is lengthened by gaping of the incision made through it and the skin surface is shortened and tarsus bent from the eyeball by tying the sutures.

Ectropion, or eversion of the lid, so that the conjunctival surface is exposed, is either partial or complete. It is caused by shortening of the skin surface of the lid, from cicatrization following injuries and burns (cicatricial ectropion), by hypertrophy of the conjunctiva, causing it to roll out over the edge of the lid, by paralysis of the orbicularis through loss of tone in the lid, and from senility due to absorption of subcutaneous fat, and consequent loss of tone of the lid, the weight of the lid simply dragging it from the eyeball (senile ectropion). On account of eversion of the puncta lachrymalium, the tears do not find their way into the nose, but flow over the cheek, which they in time cause to become eczematous and leathery. This in turn increases the ectropion. From exposure of the conjunctiva to the air and constant soaking with tears, it develops a chronic muco-purulent inflammation. The cornea is also apt to suffer from maceration and improper action of the lids in cleansing it. Ulceration occurs and the vision is rendered poor on account of the opacities left behind after the ulcer has healed.



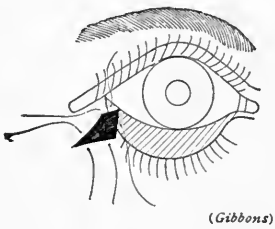
There is a form of ectropion usually occurring in children with conjunctivitis and in diseases of the cornea and is associated with blepharospasm. That is spastic ectropion. The lid being everted

during examination remains so until replaced. Ectropion usually affects the lower lid, but occurs also in the upper lid.

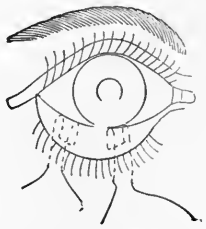
Eversion of Punctum is a condition in which the lower punctum, instead of facing backward and dipping into the lachrymal lake, is directed upward. This condition is really an incipient ectropion and best treated by Snellen's suture method.

Treatment.—In the spasmodic form of ectropion replacement of the lid suffices, but to do this it may be necessary to perform a canthotomy, which is done as follows: With a thumb and first finger of one hand, the ligament of the external canthus is put upon the stretch and then one blade of a pair of straight strong scissors with probe points is inserted between the eyeball and the ligament, and the latter divided by closing the scissors. If the spasm has not been overcome, the wound is continued towards the temple through the fibers of the orbicularis. It is then left to granulate.

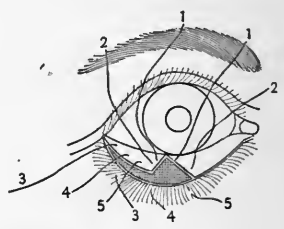
In ectropion associated with relaxation of the tissues as in senile ectropion, we excise a V-shaped piece from the lid. The lid is pulled



Adams's Operation for Ectropion.



Snellen's Suture Method for Ectropion.



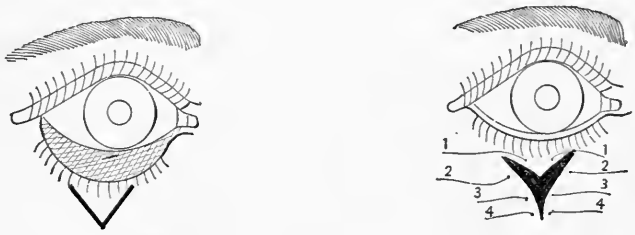
Kühnt-Müller's Operation for Ectropion.

away from the eyeball with a pair of fixation forceps and the piece excised from it near the outer canthus (Adams). The edges of the wound are brought together with a hare-lip pin or with suture.

Snellen's Method is to draw back the everted lid by passing sutures through the conjunctival surface of the lid near its free border and passing them deeply they are brought out upon the cheek and tied over a piece of rubber tubing. The threads are tightened from day to day until they cut through. Others advise that a narrow strip of

mucous membrane be excised from the lid parallel to and near the free border of the lid, but all these measures usually fail because the lid border is not shortened by the operation. A very satisfactory lid-shortening operation is that of *Kühnt and Müller*.

A deep incision is made into the intermarginal space with an iridectomy knife in the middle of the lid and the lid split into two portions between that point and the outer canthus. From the conjunctival portion a triangular piece is exsected, with its apex towards the fornix. The V-shaped wound is then closed with two sutures and the long stretch of skin margin is gathered up, and sewed to the shorter mucous margin of the lid. Where the sutures are tied there is a puckering of the skin but it smooths out before very long as cicatrization takes place. In cicatricial ectropion the lid must be carefully freed from its adhesions, so that it can be brought into place without the least tension, and the deficient portions built up by plastic operations. The operation by which we construct a new lid is called blepharoplasty. If the lower lid is the one everted and the cicatricial portion is small it may be restored by the operation of



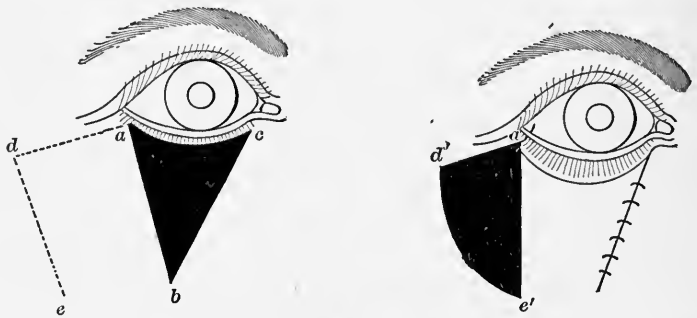
Wharton Jones's Operation for Ectropion. (Gibbons)

Wharton Jones, or the so called V, Y operation, which is performed as follows: A horn spatula is placed in position (between the lower lid and eyeball) to protect the eyeball and a V-shaped incision is made. The flap is now sufficiently loosened to allow the lid to be replaced. The lower part of the wound is now drawn together with sutures converting the V into a Y. The triangular flap must include the cicatrix which originally produced the ectropion.

If the cicatrix is extensive the operation consists in dissecting out the scar and filling in the gap with a skin graft. Many blepharoplastic operations have been devised, and the one to be employed depends in each case upon the amount of cicatricial tissue present, or in other words the amount of raw surface that must be covered after the lid is put in place. The Arlt operation for ectropion of the lower eyelid is very much like that of Jones, being a combination of the Jones and Adams operations. That is after making the V incision, including the cicatricial tissue, and dissecting up the flap the lid border is shortened by taking a V-shaped piece from it at the outer canthus. If the greater portion of the lid has been destroyed we make use of *Diffenbach's or Burow's Method.*

Diffenbach's Method.—This may be best understood by reference to the accompanying cut.

The diseased tissue is removed in a triangular flap (*abc*), and the raw surface covered with a flap taken from the cheek (*ade*). The remaining gap (*a'd'e'*) is covered by undermining the tissue of the cheek and drawing it over or better with Thiersch grafts.



Diffenbach's Operation for Cicatricial Ectropion. (*Gibbons*)

Burow's Method is illustrated in the cut below. The diseased area is removed in a triangular flap. The horizontal incision is carried up upon the temple. A triangular piece of skin is exsected from the temple as shown in the cut, and the flap beneath it loosened and slid across to the inner canthus.

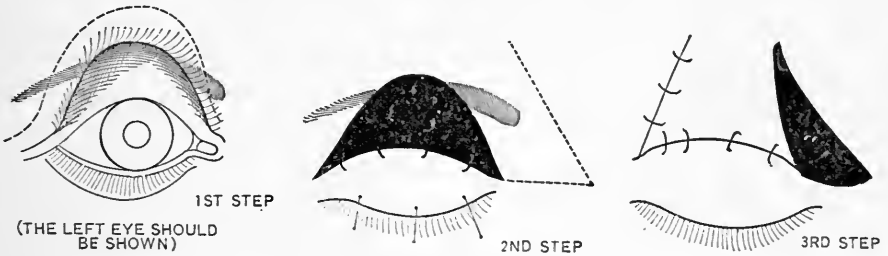
If one of these plans can not be adopted Wolfe's method of grafting a skin-flap without a pedicle upon the wound should be practised. It is as follows: The edges of the lower and upper eyelids are united by several ligatures. A pattern is then cut out of paper, the

Burow's Operation for Cicatricial Ectropion.

shape of the raw surface to be filled, and one third larger (to allow for shrinking of the graft). The pattern is then laid upon the inner surface of the forearm and the graft excised. It is then held upon the forefinger and all the areolar tissue trimmed off until it presents a white surface. It is then pressed into place and covered with a moist piece of gauze wrung out of hot water, and the eye bandaged. The eye should not be disturbed for three days and then the gauze should be well soaked before removal so that it will not stick to and pull away the graft. The lids are allowed to remain sutured for six weeks. This operation is vastly superior to those in which a graft with pedicle is used, because in those if the graft sloughs the face is worse scarred than before. Operations for cicatricial ectropion of the upper lid present an additional problem, that of securing mobility. Flaps with pedicles give too great a thickness to the lid. Wolfe's grafts succeed well at times but the lid looks heavy and its movements are impeded. *The Thiersch Method* of skin-grafting gives the best cosmetic results. The lid is perfectly freed from its adhesions, drawn down and fastened to the cheek by several sutures, passed through the lid border. The wound is then covered with compresses wrung out of warm salt solution (one half per cent.).

The grafts are then cut from the inner side of the arm. The skin is drawn tense, then with the blade of a razor laid flat upon the well wet skin, as thin a shaving as possible is taken. The graft should not extend deeper than the papillary layer. The blade of the razor is constantly kept wet with salt solution and the piece of epidermis floated along by an assistant as it is removed from the arm. The lid surface is now cleansed of all blood and the skin-shaving transferred directly to it from the razor blade. Plenty of salt solution is dropped upon the razor to keep the graft floating. The graft is placed upon the raw surface by tilting the razor and allowing it to float off; as the edge of the graft comes in contact with the wound the razor is gradually withdrawn. After the whole wound has been covered with these shavings, two layers of silk protective, moistened with salt solution, are placed over it. One layer is placed in the transverse direction and the other one in the vertical, each being long enough to overlap the edges of the wound and applied in strips about two inches wide. These strips are covered with compresses, kept wet with salt solution. The sound eye is then bandaged. The first dressing remains two days. Fresh strips of protective and compresses are then applied. After four days the bandage is removed from the sound eye, and after one week the ligatures are cut and the grafts daily rubbed over with a two per cent. iodoform ointment. The grafted skin undergoes a shrinkage of about one fourth of its area, but if this has been anticipated by the operator and the grafts made extra large, it will not affect the appearance of the lid. If the eyebrow is partially destroyed and the supra-orbital region largely covered by scar tissue, Hotz makes in his operation the new skin for the lid out of this scar tissue. The procedure is as follows: From near the inner canthus an incision is carried obliquely upward upon the brow and then curved downward towards the outer canthus. The flap outlined is now dissected from the underlying tissue down to the border of the everted lid, with which it is left connected. The lid is then released from all cicatricial connection and placed in its normal position, and the cicatricial skin flap attached to the upper border of

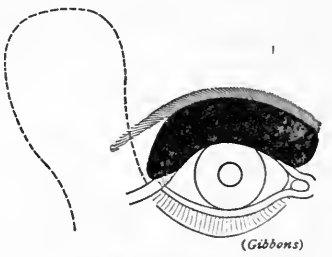
the tarsus by several sutures. The resulting wound above the lid is covered by a skin flap taken from the temporal side. The remaining raw surface upon the temple is allowed to granulate.



Hotz's Operation for Ectropion.

The great advantage of this operation is that it fastens the new lid skin to the border of the tarsus and thus makes it an integral part of the lid. Any cicatrization that may take place in the supraorbital region therefore does not affect the position of the lid.

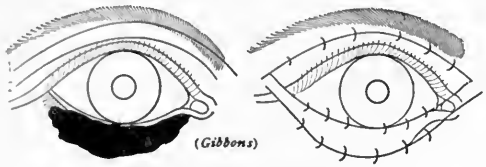
Everbusch's Method of Making an Entire New Lid.—A skin flap of suitable size and shape is cut from the vicinity and both the raw surface left and the under surface of the flap are covered with Thiersch skin grafts. The flap is then put back into its original place, after a piece of silk protective is placed over the wound, until Thiersch grafts are adherent. The scar tissue along the upper orbital margin is then exsected and the skin flap laid across the eyeball, and its edge which is freshened up is sewed to the wound along the orbital margin. If there is any conjunctiva present it is carefully dissected up and used to line the new lid.



Fricke's Operation.

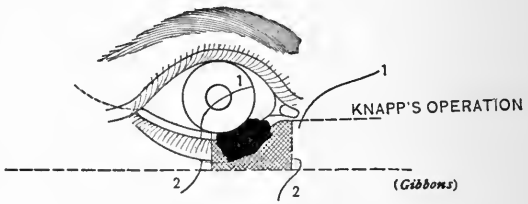
Fricke's Method.—A tongue-shaped flap is taken from the temporal region, and twisted upon its pedicle to occupy the raw surface upon the lid. The adjacent tissue is then undermined and the edges of the wound approximated as much as possible.

Landolt's Method. — For restoration of the lower lid two parallel incisions are made through the skin and muscle of the upper lid reaching a few millimeters from either canthus. This bridge of tissue is dissected from the tarsus and drawn down to take the place of the lost lower lid. Its lower edge is sutured to the skin along the margin of the orbit and its upper edge to the conjunctiva. After union has taken place the connections with the upper lid are divided.



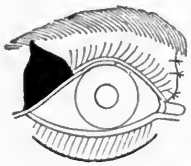
Landolt's Operation.

If only a portion of the lid is gone we can, as suggested by Knapp, draw over the remaining portion of the lid to cover the defect. A skin flap is then drawn from the opposite side to join the transplanted lid portion.



Knapp's Operation.

For Partial Destruction of the Upper Lid Landolt Devised the Following Plan: Suppose that the nasal portion of the upper lid is lost. The surgeon then splits the remaining lid into two layers, the anterior containing the skin and muscle and the posterior tarsus and conjunctiva. An incision is then made through the anterior layer obliquely upward and the portion between it and the inner canthus slid over the posterior layer, and united to the original wound margin with sutures. The triangular wound of the lid left is covered with Thiersch skin grafts.



Landolt's Operation for Partial Destruction of Lid.

Ankyloblepharon results from burns, injuries and ulcerations of the borders of the lids, by which two opposing raw surfaces are produced. It is usually associated with symblepharon, or adhesion of the lid to the eyeball. The movements

of the lids are hindered by the adhesion of their borders, and the palpebral fissure is diminished in size. In total ankyloblepharon there is complete occlusion of the palpebral fissure. *Treatment* consists of separating the lids by an operation. If the adhesion extends as far as the canthus, the border of the lids must be covered with conjunctiva, otherwise the adhesion will re-form. Adhesions are prevented by frequent passage of a probe between the lids.

Blepharophinosis (adhesion of lid-borders at the outer canthus) is relieved by the operation of canthoplasty, as follows: The lids are divided with blunt pointed scissors. They are then separated widely by an assistant. The conjunctiva is then loosened from the underlying tissues. The operator grasps the conjunctival border of the wound and draws upon it until he feels the resistance of the ligamentum canthi externi, a small pair of curved scissors is then carried into the wound and the ligament felt for and cut. The conjunctiva can then be readily brought forward and stitched to the skin margin of the wound. The sutures must be tied very loosely as there is considerable swelling and they will otherwise cut out before the proper time. There is no need of a bandage, and the sutures are removed on the fourth day.

Symplepharon. — By this we mean a cicatricial connection between the conjunctiva of the lids and that of the eyeball. In that case when we attempt to draw the lid away from the eyeball, we observe that a band extends from the inner surface of the lid to the eyeball. The band may be attached to the conjunctiva scleræ, or to the cornea, or both. If the adhesion extends posteriorly and reaches the fornix, the condition is called symblepharon posterius, otherwise it is called symblepharon anterius. In the latter case a probe can be passed beneath the adhesion. Symblepharon posterius is not often curable by operation, while the anterior variety is readily amenable to treatment. Now and then we see a total adhesion between the lids and the eyeball, following extensive burns of the eye. Symblepharon develops whenever two opposed denuded spots of the conjunctiva, that of the eyeball and that of the eyelid, come in contact with each other and

remain so for any length of time. The causes of symblepharon are burns, injuries, diphtheria and ulcers of all kinds. Following an attack of trachoma there is a gradual shrinkage of the conjunctiva, which may finally obliterate the lower fornix. The conjunctiva of the eyeball in this case passes directly to the lid, and when the lid is drawn away it is drawn out into transversely disposed folds. This variety also occurs after pemphigus of the conjunctiva. The excursion of the eyeball is hindered by adhesion of the lids to it and is kept more or less irritable. The adhesions are more or less disfiguring when they extend into the palpebral fissure. Complete closure of the eye is also now and then interfered with and the evil effects of a lagophthalmos are produced. As a rule in total symblepharon there is complete blindness for the disease, or injury that has been violent enough to cause complete adhesion of the lids to the eyeball has destroyed the cornea and at the same time glued the edges of the lids together. As a rule the bulging or ectatic cornea can be seen and felt behind the adherent lids as the eyeball is moved about. The only thing accomplished in such a case by an operation is to make it possible to introduce an artificial eye. Symblepharon can be dealt with in one of the following ways:

The instruments necessary for the operation are: A speculum, spatula, fixation and dissecting forceps, probe, scissors, needles, sutures and needle-holder. Cocaine is all that is necessary for the simpler operations but general anæsthesia is more satisfactory for the more tedious ones. If the adhesion is very narrow it is severed close to the eyeball, and the conjunctiva of the latter undermined and drawn over the wound. Or it may be severed close to the lid and the raw end tucked under the conjunctiva at a point removed from the raw lid surface, through a slit made in the ocular conjunctiva and held in place by a suture. If the adhesion is extensive, one of the following plans should be tried:

Arlt's Method.—The lid is separated from the eyeball and the dissection is carried well back into the fornix. A suture armed with two needles is then passed through the separated end of the con-

necting band of tissue; the needles are passed from the bottom of the fornix through the lid, and brought out upon the cheek. Tightening the sutures over a piece of rubber tubing draws the flap down

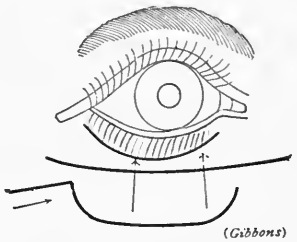
Teal's Operation for Symblepharon.

and brings the conjunctival surface opposite the raw surface of the eyeball.

Teale's Operation.—Flaps are made from the adjacent conjunctiva and slid over the raw surface, the raw areas left from making the flaps are covered by drawing the wound together with sutures. See figures.

Riverdin recommends that small denuded areas be covered with mucous membrane taken from the mouth or lips.

The following operation is that of Harlan, and is useful in extensive adhesion of the lower lid: The adhesion is freely dissected until the upward movement of the eyeball is unimpaired. An external incision is then made through the lower lid along the margin of the orbit, separating it from its connections save at the extremities. A curved incision is then made in the skin below the lid, with its concavity upward, and the outlined flap separated. This flap is then pushed through the primary incision and its raw surface brought into contact with the raw surface of the inner surface of the lid, and its epithelial surface next to the eyeball. It is held in position by suturing its edge to the edge of the lid. The raw surface upon the skin is covered by making a horizontal incision and forming a sliding flap.



Harlan's Operation for Symblepharon.

Hotz recommends that large raw surfaces be covered with Thiersch skin grafts. The eye should be bandaged for three or four days. Recently there has been devised the following operation for reconstructing the fornix in symblepharon posterius. The adhesions are freely divided and an incision made in the conjunctiva between the lid and the eyeball that is at the site of the fornix. An artificial eye-shell is then taken and both surfaces covered with Thiersch skin grafts, with the epithelium surfaces next to the shell. The shell is then inserted, the lids sewed together and the eye kept bandaged for three or four days. It may be necessary to repeat the operation, as some of the grafts will not grow.

Wolfe Suggests that a Rabbit's Conjunctiva be Used to Cover the Denuded Areas. — The rabbit is anæsthetized, and the size of the graft required calculated. Four sutures are then introduced, one in each corner of it, before it is separated, because after it is removed from the eyeball, it rolls upon itself and is hard to manage. The graft is then rapidly transferred to the human eyeball and stitched in situ.

Lagophthalmos (acquired). — By lagophthalmos in this case is meant an incomplete closure of the lids. In the lesser degrees closure of the lids is still possible by squeezing the lids together, but during sleep the eyes remain open, because there is no effort to keep them closed. In the higher degrees it is impossible to close the eyes at all. The evil consequences of lagophthalmos result from the eye being insufficiently covered. If a patient with a moderate amount of lagophthalmos attempts to shut the eye, the eyeball will be seen to roll up and to conceal the cornea beneath the upper lid. The same thing occurs during sleep, but to a less extent, hence the only part of the conjunctiva scleræ that is constantly exposed is that situated below the cornea. As a result this portion of the conjunctiva becomes dry and inflamed and the patient suffers with a chronic conjunctival catarrh. In the higher degrees, the cornea is likewise exposed, which may affect it in two ways; either it dries where it is exposed and becomes necrotic (keratitis e lagophthalmo), or the epithelium of the cornea becomes epidermoid and thicker, so that the

deeper layers of the cornea are protected from the drying process (xerosis corneæ). The sight in either instance is implicated. Another result of insufficient closure of the lids is epiphora, since the complete closure of the lids is requisite for the normal conduction of the tears. The causes of lagophthalmos are: Shortness of the lids, due to loss of a portion of the lid through accident, or disease, or a congenital defect; ectropion; facial paralysis, in which case the lower lid particularly suffers, as it is not raised when the lids are closed; debilitating diseases in which the patient's nervous system is obtunded, so that the eyes remain open and the reflex act of winking is no longer present, and finally in undue prominence of the eyeballs as in exophthalmic goiter or orbital growths.

Treatment.—Removal of the condition which prevents the complete closure of the lids. Under this head belong blepharoplastic operations for the relief of ectropion, treatment of Bell's paralysis and so forth. While a cure is being wrought, the eye must be bandaged to protect it from the evil consequences of the disease. In the lighter cases it is only necessary to wear the bandage during sleep, but in cases of greater extent and especially if the cornea is already attacked, the bandage should be worn all the time. If a cure is not hoped for, as in Basedow's disease, a tarsorrhaphy operation is indicated, by which the palpebral fissure is shortened and the borders of the lids are brought nearer together and the closure of the lids thus facilitated.

Tumors of the Lids include sarcomata and carcinomata among the malignant growths; tarsal, sebaceous, dermoid and cysticercus cysts, warts, cutaneous horns and vascular tumors among the benign.

Sarcoma as a primary growth develops in the connective tissue of the lid and is usually found in childhood, and is most frequently of the spindle-cell variety. At first the neoplasm resembles a chalazion; the skin is freely movable over it. Soon it becomes adherent to the under and overlying tissues of the lid, and breaks down and ulcerates. There are absent the inflammatory signs that would be present in a suppurating Meibomian cyst producing the diffused swelling present,

and the growth is of a dark color. Microscopical section reveals the true nature of the growth. Sarcoma also arises from any of the subepithelial tissues, and may be of the round-cell, spindle or mixed variety. Pigmentation is now and again seen. The growth should be removed early. Even after complete extirpation return occurs in forty per cent. of cases.

Carcinoma of the eyelid occurs in the form of epithelioma growing from the skin of the lid, and has been already considered.

Sebaceous Cysts occur especially in the superior or external orbital portions of the eyelids. They develop from the sebaceous follicles of the skin, and contain an oily material, and now and then fine hairs. They have well-formed sacs, which should be removed by dissection to prevent recurrence.

Dermoid Cysts occur in the same region, and cannot be differentiated before removal. They should be treated by complete extirpation.

Cysticercus Cysts of the lids are very rare indeed. They resemble sebaceous cysts, but their contents are fluid. The remains of the parasite may also be discovered in the contents of the cyst.

Vascular Tumors or Nevi are usually congenital but frequently grow rapidly after birth. They are found in the lids under two forms: Telangiectases and cavernous tumors. The former occur as bright red spots situated in the skin of the lid, while the latter occur beneath the skin, through which they show as a bluish swelling. They consist of a convoluted mass of dilated blood vessels, which can be felt and compressed through the skin. Nevi frequently pass backward and involve the conjunctiva or tissues of the orbit. They should be removed as early as possible. The best mode of treatment is excision unless we have to sacrifice a great deal of skin, in which case cicatricial ectropion is feared; again there is frequently considerable bleeding which young children stand badly, so that the majority in young subjects are to be treated by cauterizing them with fuming nitric acid or heat. Electrolysis is frequently successful in the cavernous tumor. The blood becomes coagulated in the vessels

from the passage of the electric current, and the vessels thus obliterated, causing the growth to undergo atrophy.

INJURIES OF THE EYELIDS—BURNS AND WOUNDS.

Burns of the eyelids are usually produced by hot water, or steam, by lime, lye, and by explosion of gunpowder.

Hot water produces an intense erythema or blistering. A saturated solution of sodium bicarbonate or alum locally will relieve the pain. If the burn is of the second degree, that is if vesiculation is present, the vesicle should be opened but care taken not to remove the cuticle, and the surface dusted over with bicarbonate of soda. Lye and lime burns should be treated by application of some bland oil (olive oil). After gunpowder burns all loose powder should be picked from the skin with a fine needle or destroyed by touching with a fine electric cautery needle (Jackson) and the ordinary applications made. The eyeball seldom escapes injury in bad burns of the lids.

TRAUMATISM OF LIDS.

The commonest result of a blow upon the eye is the so-called black-eye. The subcutaneous ecchymosis gradually disappears after a week or ten days. The frequent application of hot water is all that is needed. If the patient feels sensitive about the matter he may go to an artist and have the skin about the eye painted a flesh color. The paint is easily removed after absorption of the spilt blood has taken place.

Ecchymosis is also seen as the result of a fracture of the base of the skull. If the fracture has passed through any of the accessory nasal cavities there will also be an emphysema of the lids present, which is left to take care of itself.

Cuts of the eyelid should be repaired by accurate approximation of their edges with sutures, if they are large enough to damage the lid by cicatrization.

Edema of Lids usually results from a blow, owing to the loose connective tissue they contain. It is also seen with severe conjunctival

inflammation and associated with a septic uveitis. It occurs from use of arsenic as a medicine and in cardiac and renal disease, and is at times associated with menstruation or may be idiopathic in its nature. It sometimes resembles urticaria in its recurrence and sudden onset. This last variety is at times found associated with migraine.

Treatment.—Treat the underlying cause if one can be found. Locally dilute lead water or laudanum water with a pressure bandage if swelling is great.

Emphysema of Lids occurs when a fracture of the orbit has passed through an accessory nasal sinus. A soft swelling which crackles under pressure is the result. The swelling increases rapidly when the patient holds his nose and attempts to blow. No treatment is required except a pressure bandage when in considerable amount.

CHAPTER VIII

CONJUNCTIVAL DISEASES

Congenital Anomalies. — Pigment spots like moles sometimes occur in the conjunctiva, accompanying moles of the face.

Dermoid Tumors occur upon the ocular conjunctiva, at the caruncle and at the upper outer quadrant of the globe. They may be pigmented and are now and then associated with coloboma of the lids. Dermoid cysts have also been found.

Nevi of the conjunctiva occur in two forms, telangiectatic spots and cavernous tumors. The former are flat and of a bright red color. The latter are of a dark blue color and bulge the conjunctiva. They increase in size when the child cries or when the head is lowered.

Lipomata accompany coloboma of the lids or occur alone beneath the conjunctiva. The caruncle may possess an abundant supply of hairs (trichosis carunculæ). The term *ophthalmia* (conjunctivitis) is used to indicate an inflammation of the conjunctiva. The following classification of ophthalmia will be adopted: Simple conjunctivitis, catarrhal conjunctivitis, purulent conjunctivitis, croupous conjunctivitis, diphtheritic conjunctivitis, phlyctenular conjunctivitis, vernal conjunctivitis, follicular conjunctivitis, granular conjunctivitis, Parinaud's disease, chronic conjunctivitis, lachrymal conjunctivitis, larval conjunctivitis and toxic conjunctivitis.

Besides these we have the following diseased conditions to deal with: Amyloid disease, xerosis, pterygium, pinguicula, abscess, chemosis, emphysema, lymphangiectasis, syphilis of conjunctiva, tumors, leprosy, lupus, tuberculosis, herpes, pemphigus, ulcers and injuries.

Conjunctivitis (syndesmitis) furnishes thirty per cent. of eye diseases. The general features of an inflammation of the conjunctiva

are: Injection of the conjunctiva of a brick red color fading upon pressure if it extends to the eyeball, and associated with a certain amount of secretion. Lacrimation and photophobia are unimportant symptoms, occurring in various degrees according to the sensitiveness of the patient.

The conjunctival diseases known to be due to a specific organism are: Acute conjunctivitis, due to the pneumococcus, described by Morax; acute epidemic conjunctivitis, Koch-Week's influenza bacilli; purulent ophthalmia, gonococcus of Neisser; diphtheritic conjunctivitis, Klebs-Loeffler bacillus; tubercular conjunctivitis, organism of Koch; leprosy of conjunctivitis, lepra bacillus. Some observers claim a specific organism for the following, but they have not been positively identified: Phlyctenular conjunctivitis; trachoma; membranous conjunctivitis and xerosis epithelialis.

The normal conjunctival sac contains about a dozen varieties of organisms which are very attenuated and with little pathogenic qualities, unless the tissues become bruised or irritated.

Simple Conjunctivitis (dry catarrh, hyperemic conjunctivitis). — Conjunctivitis simplex affects the lid conjunctiva. It is manifested by an increase in redness, without any secretion or appreciable increase in the thickness of the membrane.

Etiology. — The causes of this affection are numerous, among which are: Exposure to winds, cold, heat, glare of light, smoky, dusty or irritating atmosphere, and entrance of minute foreign bodies into the conjunctival cul-de-sac. Using the eyes by poor light, refraction and muscular errors, too constant use of the eyes, lachrymal disease and blepharitis are also causes.

Pathology. — There is no decided pathological change. The blood vessels of the palpebral conjunctiva are enlarged and overfull, with a slight increase in the fixed cells, and scanty infiltration.

Symptoms. — The lids feel heavy, and feverish. There is tendency to lacrimation when the eyes are used for any length of time especially by artificial light. There is frequently a feeling as if something was in the eye.

Diagnosis is made from the symptoms and appearance of the lids.

The Prognosis is favorable if the cause can be eradicated.

Treatment.—Removal of the cause, correction of errors of refraction and muscular anomalies. The patient should be instructed as to the proper arrangement of the light in regard to his work, that is the light should not shine in the eyes, but be placed above or behind the head and fall upon the work so that no shadows are thrown across his work. This is especially necessary if electric or Welsbach light is used. The mildest astringents should alone be used, such as borax in two per cent. solution.

Catarrhal Conjunctivitis (muco-purulent conjunctivitis).—We meet with this inflammation in various degrees and phases. In some there is injection of the blood vessels of the lid conjunctiva with a limited amount of secretion of catarrhal matter, while the vessels of the ocular conjunctiva are little if at all over-full, or there may be little redness but an abundant serous effusion beneath the ocular conjunctiva, occurring principally in young delicate subjects, with a slight amount of sticky secretion, or as is usually the case there is an increase of vascularity of both the lid and the ocular conjunctiva, and there is more or less effusion in and beneath the ocular conjunctiva. The redness of the eyeball fades upon pressure and the effusion moves about more or less when pressure is exerted upon it through the lid. The lids are more or less swollen, their margins red and the patient is unable to fully open the eyes. The special symptom is however a secretion which glues the lashes into bundles and agglutinates the lids during sleep. The secretion is a mixture of serum, pus, mucus, epithelium cells and tears. It collects in flakes and spreads in thin layers upon the tarsal surfaces. This variety of conjunctivitis is at times epidemic and is then vulgarly spoken of as "pink-eye."

Symptoms.—The lighter reflex of the lower fornix is effaced, the conjunctiva appearing more or less homogeneously red and velvety. The individual blood vessels of the lids are obscured by the increased redness. The injection of the eyeball appears of a red brick-dust

color, fading upon pressure. The injection frequently extends quite to the edge of the cornea but the individual capillaries are seen and the color is red, in contra-distinction to the injection of the circum-corneal loops of vessels in corneal and iris disease, in which case the color is pinkish and individual vessels are not visible. In conjunctivitis pressure causes the eyeball to blanch clear to the edge of the cornea. There is the feeling of heat and of sand in the eyes, and more or less lachrymation. The vision is interfered with by mucus crossing the cornea. The symptoms are usually worse on awaking in the morning. Both eyes are affected simultaneously or in quick succession. There is a form of inflammation called by the English ophthalmologists catarrho-rheumatic ophthalmia, which seems to be a mixture of a conjunctivitis and diffuse inflammation of the episcleral tissue. The secretion is more watery than sticky, and there is a deep as well as a superficial injection. There is pain in the eyeglobe, with some headache, and the eyeball feels tender to the touch. There is decided photophobia, and lachrymation. It is said to occur more frequently in gouty and rheumatic individuals.

Etiology. — The disease is often a part of an acute coryza, or hay-fever. It occurs epidemically in an acute form, especially in the spring and autumn, and is wide spread.

Koch, of Germany, and Weeks, of New York, individually studied the micrography of the disease and in 1886 Koch isolated a bacillus, and three years later Weeks grew the bacillus in pure culture from the secretions of the eye. This organism, called the Koch-Weeks bacillus, resembles that of mouse-septicemia in form, and is frequently associated with the pseudo-diphtheritic or xerosis bacillus. It is also acknowledged by Morax and Beech to be the contagium of acute contagious conjunctivitis.

The pneumococcus of Fränkel is an infrequent cause of the disease, although Gifford claims that it is present in very many instances. The diplococcus of Morax and Axenfeld is also a cause. Others occur from vitiated, dusty or smoky atmosphere, or are associated with certain exanthems, as measles (being an important prodrome),

scarlet fever and small-pox, or again is seen together with blepharitis, abscess of the lid, mucocelè or lachrymal abscess, etc.

Diagnosis. — If one is uncertain from the severity of the symptoms as to the true nature of the inflammation a microscopical examination of the secretion should be made. Failure to find the gonococcus after several examinations will settle the diagnosis.

Prognosis is favorable. The disease tends to a spontaneous cure in several days to as many weeks. Now and then small marginal ulcers of the cornea develop, but heal readily, and no serious impairment of vision ever occurs.

Treatment does much to cut the attack short and render the patient more comfortable. In the milder cases the following prescription is all that is needed:

Borax . . . . . gr. 10
Camphor water . . . . . dr. 2
Water . . . . . dr. 6
Sig. — Two drops in eyes every two to four hours.

In the severer types, the following is used:

Adrenalin sol. (1–1,000) . . . . . dr. 1
Zinc sulphate . . . . . gr. ½
Water . . . . . dr. 7
Sig. — Two drops in each eye every two to four hours.

In addition the eyes must be frequently washed with warm water and kept free of discharge. When the inflammation is very well marked and after the occurrence of secretion a drop or two of a two per cent. solution of silver nitrate instilled at the beginning of treatment will aid materially in effecting a cure. The patient is then given the following prescription to use at home:

Zinc sulphate . . . . . gr. 1
Adrenalin sol. . . . . dr. 1
Water . . . . . dr. 7
Sig. — Two drops in eyes every two to four hours.

In very sensitive patients a weak solution of cocaine or better holocaine may be instilled several times during the day, for the relief of the grittiness. In many cases the disease is contagious, so the patient should be told to use his own towel, and to otherwise be careful not to spread the disease. If there is much swelling of the lids, cold applications should be made frequently, before secretion, and hot bathing used after secretion forms. The habit among the laity of binding tea-leaves to the eyes over night is a bad one, as it retards recovery, and frequently increases the inflammation. Smearing the edges of the lids with vaseline on going to bed does away with the disagreeable feature of the lids being stuck together in the morning. In the so-called catarrho-rheumatic ophthalmia, heat should be used to relieve the pain, and a weak solution of atropia instilled several times a day. No astringents should be used until secretion is well established, and then one of the foregoing preparations employed according to the amount of secretion.

Purulent Conjunctivitis, Blenorrhœa, or Pyorrhœa, is more acute and of greater severity than the foregoing types. It occurs most frequently in infants at or soon after birth, and in adults. The disease is essentially the same in each case and arises from a contagium, and endangers the welfare of the eye through implication of its cornea. The disease as manifested in the baby and in the adult will be considered separately for sake of convenience.

Ophthalmia Neonatorum (Purulent Ophthalmia of the New-born). —The lids of the new-born infant remain red and somewhat sticky for a day or two, but simple cleanliness or washing with a solution of borax in water (one teaspoonful to the pint) will be all sufficient. Now and then there is slight swelling of the lids and a limited amount of catarrhal secretion from the conjunctiva. The fornix is thickened and swollen in some cases. As long as this continues the eye keeps red and watery. Borax water and cleanliness are all that is needed. If the hypertrophy continues after the child is a month or so old, the swollen tissue should be painted with a solution of nitrate of silver (gr. x to oz. 1) once a day, care being taken to

keep the solution from the cornea by applying it sparingly and washing the eye afterwards with a solution of table salt (gr. v to oz. i) to precipitate any free silver nitrate in form of the insoluble chloride of silver. These cases are often considered by some general practitioners as typical ophthalmia neonatorum cases and they point to their cures with pride as a proof that the ophthalmologist overestimates the seriousness of mattering eyes in the new-born. The cornea never becomes implicated in such cases and they are that far innocent.

True Ophthalmia Neonatorum may be present at birth, the eyes of the child having been infected in utero. Indeed the child may be born with ulcerated or sloughed corneæ, showing that the disease has existed for some time. Just how the eyes chance to become infected before birth is not understood. The fœtal membranes evidently are primarily the seat of the disease. More frequently the disease manifests itself on the third or fourth day but may be delayed as long as the eighth, in which case it is likely however that there has been a post-partum infection. At the beginning the secretion is comparatively thin, but ere long becomes thick and creamy, indicating an abatement in the activity of the process. There is frequently decided swelling of the lids and the ocular conjunctiva adjacent to the cornea becomes infiltrated and edematous, although not as frequently in the child as in the adult. This chemotic conjunctiva overhangs the edge of the cornea which it endangers by pressure. The lid conjunctiva and that of the folds of transition become thickened and spongy, with ridges and prominences, and cleft by fissures between enlarged papillæ. This tumidity increases from the edges of the lids up to the fornices. The cornea may remain clear, but it is in great danger, from the maceration of its conjunctival covering by the pus, with subsequent infection; from direct spread of the inflammation to its structure; from the inability to properly clean the eye on account of the swollen lids and infiltrated conjunctiva surrounding the cornea and pressing upon its nourishing vessels. The danger of corneal complication is slight in the child as compared

with what it is when the disease affects the adult eye, because the lids in the latter case become much more infiltrated and heavy and press upon the cornea, the conjunctiva more chemotic, and the eye less resistant. The place of ulceration of the cornea may be anywhere. Its invasion may first show as a diffuse haziness, or as a single spot of infiltration, or the whole cornea may suddenly break down and slough away. The number that go blind from this disease varies in different localities from 20 per cent. to 79 per cent., so that its prophylaxis is a very important matter.

Etiology.—The origin of the contagion is morbid vaginal secretions which come into contact with the eyes of the child during the passage of the head through the parturient canal, or as the writer thinks is more frequently the case the eyes are infected after birth by the washing of the child's head and face. During the passage of the head the eyes are tightly closed and smeared over with the cheesy vernix, and infection improbable except in delayed births. Inoculation of the eye with healthy vaginal secretion is without effect. In the great majority of cases the gonococcus of Neisser is the specific organism of the disease. Urethral infection with pus from a typical case of ophthalmia neonatorum will give rise to a urethritis. Lochial secretions may at times be the cause. A suppurating navel is also a possible source of post-partum infection.

The cases caused by the true pyogenic organisms, streptococci or staphylococci are apt to be mild ones; on the other hand one of these organisms present with the gonococcus gives rise to the severest cases. Gonococci in pure culture are seldom found, and such cases are rather mild in comparison. The xerosis and diphtheritic bacilli are not infrequently found along with the gonococci.

Prophylaxis.—The prophylactic measures to be employed are as follows: If the mother is found to have a leucorrhœa of more than the usual amount prior to the beginning of labor, she should have vaginal douches with a three per cent. carbolic solution, especially if the gonococci are demonstrable in the secretion. A copious douche should be given after labor has been begun with plain water, so as

to mechanically wash away any secretion. This method is objected to by some obstetricians on the ground that the secretions of vagina are necessary for the proper performance of labor, and that any effort to sterilize the canal is dangerous to the welfare of the woman.

That ante-partum douching is an important prophylactic feature the writer is convinced, as demonstrated by the remarkable manner in which the percentage of cases falls when it is employed. Of course the proper thing is for the obstetrician to ascertain beforehand, especially in hospital practice, whether the female has any abnormal vaginal discharge or not prior to labor.

After the birth of the child, the nurse should wash the eyes of the child first, and then place a piece of cotton (not absorbent) over each eye, and hold them in place while she washes the head and face of the child. As the washing is usually done, the nurse gathers up the organisms from the scalp and face and deposits them in the eyes as she passes over these parts frequently in succession. If there has been demonstrated gonorrhœa in the mother or if it is suspected, in accordance with the recommendation of Crèdè a single drop of a two per cent. solution of nitrate of silver is dropped into the eye upon the lower lid. Crèdè said to drop the solution from a glass rod upon the cornea so that it would be evenly distributed, but this endangers the welfare of the cornea, and not infrequently a haze will develop showing how irritating the silver nitrate was to it (this haze finally disappears). In the lying-in hospital at Leipsic where Crèdè himself instituted the method, the number of cases fell from 7.5 per cent. to .5 per cent. Many ophthalmologists use a one per cent. solution of silver nitrate fearing a too decided caustic effect of the stronger solution. One eye is usually affected before its fellow, so that every attempt should be made to prevent the transference of the infection to the fellow eye.

Crèdè experimented with various solutions, such as one per cent. solution of corrosive sublimate, sterilized water, iodine trichloride, carbolic acid, silver nitrate in one per cent. and two per cent. solutions. All were of benefit in materially reducing the number of cases of

ophthalmia neonatorum, but none as effective as the two per cent. solution of silver nitrate, except perhaps the one per cent. solution of corrosive sublimate and that was too irritating for most eyes.

Treatment.—If seen at the very beginning when the swelling of the lids and a watery secretion are the chief symptoms, nothing but cold applications and careful cleaning should be employed. Cold evidently lessens or destroys the vitality of the germs in a great measure. For the cleansing boric acid in half-saturated solution may be used (gr. x–℥ i). The cleaning should be often enough to keep the eyes free of pus, *day and night.* The lids are opened and closed by the attendant and the pus worked up from the fornices by burying the ends of the thumbs gently beneath the orbital ridge, then with a wet piece of cotton, the lids are everted and the conjunctival surface carefully and gently cleansed. This must be repeated in some cases every quarter to half an hour, according to the amount of secretion after the disease is well established.

It is unwise to use cotton wrapped around match-sticks or tooth-picks or what not in cleaning the eyes, as the operation has to be repeated so often that there is great danger in abrading the cornea and thus making an inroad for organisms. The cold applications consist in laying pledgets of cotton, that have been soaked in iced water or laid upon a block of ice, upon the eyes and changing them every two minutes. As soon as the secretion grows thicker and the swelling of the lids less, we are to resort to the use of silver nitrate solution in varying strengths. Usually ten grains to one ounce is the strength used. This is not to be dropped into the eye or upon the everted lids as it will endanger the cornea if repeatedly so applied. But a small mop made with cotton and a wooden tooth-pick, is dipped into the solution and passed up under the upper eyelid which has been everted, care being taken to ever press the mop from the eyeball so that the cornea is not injured. The everted surface of the lid is then painted over.

The lower lid is similarly treated. The mop must be pushed well into the fornices, because there the germs often have their hiding

places. To properly treat the eyes, the physician takes the head of the child between his knees while the nurse supports the body of the child upon her lap. If the cornea is at all hazy the eye should be washed with salt solution after the silver has been applied. The silver solution is applied once in the twenty-four hours. If after a few days the secretion is no less and the swelling of the lids persists, a stronger solution of silver nitrate is used, that is one of twenty grains to the ounce of water, but this must never be allowed to come into contact with the cornea. For several hours the secretion is held in check, after awhile flocculent portions of the eschar and secretion reappear, when cleansing is again in order. By the use of too strong solutions of silver, or their too frequent application, it now and then happens that the discharge becomes almost nil, but the chemosis and swelling of the lids persist; the silver should then be stopped. The newer silver compounds have lately been extoled as superior to silver nitrate in ophthalmia neonatorum both as a prophylactic and curative agent, especially protargol which is used in from 10–20 per cent. and argyrol in 10–25 per cent. solutions. Their action is non-caustic and non-irritating and they are said to have a superior penetrating power. Whether they are more efficacious than the silver nitrate in solution the writer is not altogether sure, as he has had many cases that did well with each and those that did badly with each. If the physician can not see the patient very often I think a ten per cent. solution of protargol or argyrol may be given for home use, to be instilled three times a day without any fear of danger to the integrity of the cornea.

The organisms hide themselves away in and between the deeper layers of the conjunctival epithelium, and a superficial caustic which will cause the exfoliation of the superficial cells, and thus expose the germ, as nitrate of silver will do, seems indicated. The fact that the new silver compounds are less irritating than silver nitrate does not argue that they are more beneficial in the treatment of purulent ophthalmia nor does the fact that they contain more silver. If they are more germicidal and possess greater penetrating powers so that the organ-

isms in the deeper layers of the epithelium will be reached by the drug then they will prove themselves in time to be superior to the more irritating silver nitrate solutions.

One can not tell the action of a drug upon the tissues and its efficiency either by its chemical composition nor germicidal power. Clinical observation can alone decide as to the relative value of the various silver compounds. A less irritating compound is more needed in the prophylaxis of the disease than in its treatment, as not infrequently even weak solutions of the nitrate of silver give rise to a very considerable irritation. However with the best care possible some eyes go out from this disease, while again others get well on almost any method. It is not always easy to get a good view of the cornea, which should be carefully watched for ulceration. To separate the lids and expose the cornea a Desmarre's lid retractor like that in the cut is used, one for each lid. Care must be exercised in intro-

Desmarre's Lid Retractor.

ducing this instrument not to wound the cornea. The upper lid is elevated as much as possible with the finger and the blade of the elevator pushed beneath it, while constantly keeping it from the eyeball.

In the event of the cornea becoming affected whether by opacity or ulceration, the treatment continues as before, and in addition a solution of atropia is instilled several times daily to secure dilatation of the pupil and the cold is replaced by hot applications. Cotton compresses are soaked in hot water and are applied for 15 min. to 1 hr. in every two hours according to the way they are borne. They are changed often enough to keep them hot. If the ulcer threatens to perforate, a careful paracentesis at its thinnest point will sometimes do good, by lessening the amount of iris that will pouch

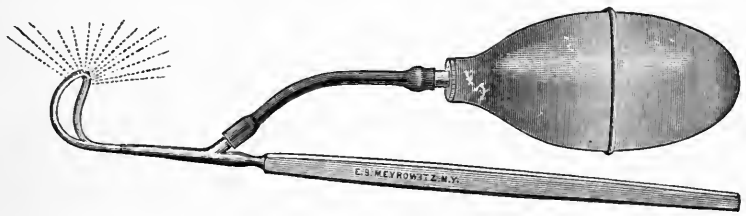
through the opening in the cornea like a hernia. As the aqueous flows out of the eye the iris is washed up to the opening in the cornea and even partly through it. This temporarily affords relief but the sight suffers permanently. The protruding iris should never be excised but may be punctured with a fine needle held at a tangent to the lump. Some have gotten very good results by dusting the everted lids frequently with powdered iodoform, by the use of yellow oxide salve ; permanganate of potash solution (1–500 to 2,000), H_2O_2 (1–4) ; bichloride, 1–4,000 and formalin, 1–2,000. Either of these agents may be used instead of boric acid solution after cleansing. Vian and Fromaget both urge the treatment of ophthalmia neonatorum with permanganate of potash solutions. Vian advises a ten per cent. solution to be applied to the conjunctival cul-de-sac twice a day. He claims for it rapidity of cure, no damaging effect upon the cornea and less painful than solutions of silver and lack of danger of aggravating a membranous deposit upon conjunctiva. Fromaget uses one fourth to one half per cent. for irrigating the eye. The stains upon the skin produced by the solutions are removed with a ten to thirty per cent. solution of sodium bisulphite. The duration of the disease in favorable cases is from four to six weeks. Sometimes the conjunctiva takes on extreme hypertrophy ; the secretion almost ceases and the cornea may be clear, but the swelling does not subside. Silver and other caustic solutions in this case do harm. Keeping the eyes well greased with vaseline, by putting a little between the lids every few hours seems to do much good in these cases. Iodoform, five grains to one ounce, may be advantageously combined with the vaseline. The eyes should be cleansed less often as the discharge grows less. Now and then the upper lid becomes everted and on account of the swollen conjunctiva of the fornix remains so, and as soon as reduced everts again. A free canthotomy must be done, or if there is no discharge, the lids stitched loosely together. In a few cases the infiltration of the lids persists for months after the subsidence of the diseases with more or less tendency to become everted.

Conjunctivitis Purulenta Adultorum.—Purulent ophthalmia or conjunctivitis as it occurs in the adult is essentially the same disease, as affects the eyes of the infant. In the vast majority the source of contagion can be traced to the genitals of the patient, who may either be suffering with an acute or chronic specific urethritis or vaginitis, or the infection has been conveyed from a similarly diseased eye, or by direct contact with soiled handkerchiefs, towels, clothing or rags. Severe cases of catarrhal conjunctivitis may present the clinical picture of an incipient purulent ophthalmia, and the latter ofttimes is taken at first for an exaggerated catarrhal conjunctivitis. If there is any reason from the severity of the symptoms to suspect gonorrhœal infection, or if the pus is distinctly yellow the secretions from the eye should be examined microscopically for the organism of gonorrhœa. The right eye is as a rule the one affected primarily, as most individuals use the right hand in the toilet of their genital organs, and as the right hand is also used to scratch the right eye, it thus acts as a direct transfer of the contagion. The specific organism occurs in groups of twos and fours, within the pus cells or in isolated groups, and are also found at a considerable depth in the epithelium of the conjunctiva. Many half-grown children in which the disease varies in severity between that in the infant and that in the adult, have at the same time a specific vaginal or urethral discharge, contracted through towels or wash cloths used by adults in the home who are suffering with gonorrhœa. The more active the organisms at the time of the infection the more violent will be the ocular inflammation. The physician and nurse should always be on their guard lest they infect their own eyes.

Care must be taken in opening the lids which ofttimes are distended with pus or the examiner will get a spurt of pus in his own eyes. The hands must be carefully washed in strong bichloride (1–1,000) after each cleaning of the eye. If a drop of pus should accidentally spurt into the eye of the attendant, he should immediately wash the hands, and then the eye, and neutralize the pus by instilling a drop of a two per cent. solution of silver nitrate into

the eye. Pus diluted to 1–1,000 still contains decided contagious properties. It has also been shown that one fourth per cent. of silver nitrate solution by its coagulating effect upon albumen renders the infection practically innocuous. The symptoms are like those before described in the same disease in the infant, except more severe. The lids are more swollen and much infiltrated, so much so in fact that it is impossible to open them to get a fair view of the cornea. The ocular conjunctiva also participates to a greater degree in the inflammation and chemosis soon develops. Unlike that in the child, the chemosis is dense and infiltrated. When the secretion is wiped away from the lids the conjunctiva bleeds. Ulceration of the cornea most often begins near the limbus, where the chemotic conjunctiva overhangs it and causes a pocket for pent-up pus. The duration of the disease is from four to twelve weeks.

Treatment.— From the beginning the treatment must be active. The patient should go to bed. If there is intense initial swelling, several leeches may be applied to the temple, or the artificial leech used to abstract several ounces of blood. Continuous cold should be applied by frequently changing compresses wet with iced water or laid upon a piece of ice. To keep them cold, they must be changed every minute. If pain is occasioned by the cold, it should be modified by using compresses less cold. It is very difficult to properly clean the eye which should be done every fifteen minutes to



Callan's Lid Irrigator.

half hour after secretion forms; on account of the great swelling and infiltration of the lids. A Callan lid irrigator greatly facilitates this. The bulb is filled with some bland antiseptic solution, boric acid, ten

grains to one ounce, or bichlori 1–6,000. The instrument is then held between the thumb and index finger, the bulb resting between the other fingers and the palm of the hand; and pushed gently beneath the upper lid well up into the fornix; the bulb is then squeezed. By this means we are able to thoroughly cleanse the eye quite up into the fornix, which is seldom reached by the ordinary methods. If there is very much tenacious secretion present the lid irrigator may be attached to an irrigating jar and considerable fluid used in cleansing the eye. The instrument should be handled very gently so that the conjunctiva is not wounded. It should not be used oftener than three or four times a day, and the eye cleaned in the interim in the usual manner. Cleaning the eye can be greatly facilitated by the use of a diluted solution of hydrogen peroxid; it should not be used stronger than one to four parts of water. Its use as an antiseptic has recently been proposed by Landolt. By the evolution of its oxygen the pus is brought down from the fornix, and can be then wiped away. It is not irritating to the eye provided it is free from sulphuric acid. If it is decidedly acid in reaction it should be neutralized with sodium bicarbonate. Putting vaseline hourly between the lids preserves the corneal epithelium. Should the cornea become involved, atropia solution should be instilled three or four times a day. Cauterization of the corneal ulcer seldom does any good (unlike ulcer from other causes), but if it is rapidly progressive, its surface may be touched with a solution of nitrate of silver in the strength of sixty grains to the ounce, applied with a small mop made by twisting a tiny piece of absorbent cotton tightly about a wooden tooth-pick. In the gonorrhœal ulcer nitrate of silver is the best caustic and its use as a caustic in corneal disease is almost limited to this condition. As long as the cornea is intact cold applications are indicated, but when it breaks down cold is contraindicated, because then we want as much blood in the parts as possible so that nourishment may be carried to the ulcer and the effete matter carried away. Cold constricts the vessels, both the blood vessels and lymph vessels, and interferes with nutrition. The only thing that cold does is in a

measure to prohibit swelling of lids and conjunctiva, and perhaps lowers the vitality of the infection, but nutrition of the tissues is lowered, while hot water hastens absorption. The eye may recover with perfect vision and a normal conjunctiva, but frequently there is more or less hypertrophy of the conjunctiva which persists for weeks. The resistance of the eye has been so lowered by the disease that it is subjected to repeated catarrhal inflammations of the conjunctiva for some time. When only one eye is affected great care should be exercised that the infection does not get into the sound eye. The patient should never be allowed to touch either eye.

When the well eye needs wiping, it should be done by the nurse after she has thoroughly cleansed her hands. Bandaging the well eye to protect it is harmful, as the eye is very apt to develop a catarrhal inflammation of its conjunctiva under the bandage and its resistance is then lowered so that a tiny amount of infection that it could otherwise tolerate, finds a soil favorable for its development. Buller's shield likewise is not only ineffectual but experience has shown it to be hurtful. Buller's shield is a watch glass held in place over the eye by means of adhesive plaster strips.

An indication to be borne in mind in severe cases is the relief of pressure by incising the swollen tissues, and unloading the blood vessels. Tyrell was the first to lay stress upon scarification of the chemosis. After scarifying the chemotic conjunctiva the infiltration does not flow away because of its plastic nature, but the tension upon the circumcorneal loops of vessels is lessened to a considerable degree. The incisions should be made radiating from the edge of the cornea, in the course of the circumcorneal vessels so that as few of them as possible will be divided. A canthotomy to relieve the pressure of the lids upon the cornea somewhat should always be done if the cornea is threatened. Critchett resorts to a medial section of the upper lid to facilitate cleaning of the eye and to relieve pressure upon the cornea. The resulting deformity he repairs subsequently. That this is good treatment in extreme swelling and infiltration of the lids there is no doubt.

It would be impossible to mention all the various methods and drugs used in the treatment of gonorrhœal ophthalmia in a treatise of this kind; suffice it to call attention to several methods other than those already described which are still in vogue with certain ophthalmologists. The use of bichlorid has not long since been again revived in the treatment of this malady. It is used in two ways: It is applied to the everted lids in 1 to 500 strength, often enough to hold the suppuration in check. Great pain is produced. A local anesthetic, best holocaine, is then instilled and cold compresses placed upon the eyes. Another method is to put the patient to sleep, and then to scarify the conjunctiva, and rub into it the solution of bichloride by means of a tooth-brush. This procedure causes a remarkable abatement of the secretion, but there is great swelling of the lids. The treatment is repeated at intervals of several days for two or three times. The conjunctiva of both eyeball and lids is scarified and brushed by others. This treatment is effective according to those who have employed it, but now and then the case is complicated by formation of a number of fine adhesions extending from the lids to the eyeball. It is customary among the French ophthalmologists, especially in hospital work, to use the mitigated nitrate of silver caustic stick in the treatment of these cases. The plan of treatment is somewhat as follows: An extensive canthotomy is done, the lids everted and rubbed over with the caustic stick, and then washed with salt water. When the eschar separates, the operation is repeated if suppuration is renewed. Brilliant results have been obtained in the Hospital des Infants of Paris by this method. The treatment being so harsh it would seem that many cases under this plan get well despite the treatment.

In the severer cases of purulent ophthalmia in the adult and those of mixed infection, a pseudo-membrane forms upon the palpebral conjunctiva, often extending to the ocular conjunctiva. It is ascribed to the too energetic use of silver nitrate solution, to the presence of staphylococci, streptococci, Klebs-Loeffler bacilli and diplococci. When it occurs the secretion should be examined for the diphtheritic

bacillus and if found antitoxin administered. It is useless to remove the membrane, as it is quickly reproduced. If of pyogenic origin powdered caroid should be sprinkled in the eye several times a day. This drug is the most active artificially digesting agent upon the market and is otherwise inert. Cases complicated with a pseudo membrane are very apt to be followed by corneal involvement.

Clinically, simple, catarrhal and purulent ophthalmia are gradations of the same diseases. In simple conjunctivitis, the lid conjunctiva is alone injected, there is no swelling of lids or conjunctiva, and practically no secretion; in catarrhal, the next severer type, the ocular conjunctiva participates to a degree in the inflammation, there is slight swelling of the lids and conjunctiva and a puriform secretion, while in purulent ophthalmia there is great swelling of the lids and ocular conjunctiva which is much involved in the inflammation and there is abundant purulent secretion. There is no involvement of the cornea in the simple variety of the disease; it is infrequently involved in the catarrhal, but very often so in the purulent form.

Croupous Conjunctivitis (*Membranous Conjunctivitis*).—This term is applied to those cases in which there is a formation of pseudo-membrane upon the conjunctiva, associated with a scanty flaky serous discharge in which the Klebs-Loeffler bacillus is not demonstrable. It is probably pyogenic in origin and usually is associated with severe inflammation in the conjunctiva, chiefly gonorrhœal ophthalmia, and following burns with acids and steam. It is at times the disease *per se*, in which case the cause is not known, though it is regarded by many as a mild grade of diphtheria. The pseudo-membrane consists of fibrin which includes within its meshes, conjunctival epithelial cells, leukocytes, and red blood corpuscles. The conjunctiva is thickened, the epithelial layer reduced in thickness, and the blood vessels are numerous and enlarged.

Symptoms are not characteristic. There is a sense of a foreign body in the eye, a slight serous discharge, some photophobia and lachrymation. The membrane is grayish-white and is found to the greatest extent upon the lid conjunctiva. It can be readily detached.

but leaves a bleeding surface. The membrane is not as intimately incorporated with the tissues however as that of diphtheria. When detached it is rapidly regenerated.

Diagnosis is made by the absence of the Klebs-Loeffler organism in the discharge, and lack of constitutional disturbances. In most cases of diphtheria of the conjunctiva, the nose or the throat is likewise the seat of the disease.

Prognosis is good in about half of the cases. The membrane is apt to persist for several weeks in favorable cases. The cornea remains clear for a long time, but may become the seat of ulceration, and be partly or entirely destroyed.

Treatment is not very satisfactory. The membrane may be allowed to remain and the eye very frequently bathed with a mild antiseptic solution such as boric acid solution, bichloride in 1 to 4,000 strength or what not. After each bath the eye should have powdered caroid flicked into it and a bandage applied to retain the powder, with the hope that the membrane will be dissolved. Some claim good results by removing the membrane and cauterizing the bleeding conjunctival surface with the mitigated nitrate of silver stick. After the resulting eschar separates the conjunctiva is found devoid of membrane in a certain number of cases. A saturated solution of chlorate of potash, iodoform in powder and quinine have been suggested, but are of doubtful utility.

Diphtheritic Conjunctivitis (*Membranous Conjunctivitis, Diphtheritic Conjunctivitis*). — As the name indicates this disease is a true diphtheria of the conjunctiva. It affects all ages except the new-born, but is most frequent in children. Both eyes are generally involved.

Etiology. — The direct cause of the disease is the essential germ of diphtheria, the Klebs-Loeffler bacillus. The disease of the conjunctiva is usually secondary to diphtheria of the throat or nasal passages. The eye is affected by direct contamination of the conjunctiva with the secretion containing the organisms, or occurs by extension through the nasal duct.

Pathology. — There is primarily a congestion of the vessels of the

lids and conjunctiva, which is followed ere long by the exudation of a plastic material into the tissues of the lids and upon the surface of the conjunctiva. A partial destruction of the conjunctival epithelium is necessary for the exudate to find its way to the surface. The pseudo-membrane consists of fibrin, holding within its meshes leukocytes, red-blood cells, epithelium cells, and diphtheritic bacilli. The membrane adheres very closely to the tissues and is detached with some difficulty, leaving a rough bleeding surface.

Diagnosis.—It is only necessary to diagnose diphtheria of the conjunctiva from one other condition and that is croupous conjunctivitis. Microscopical examination of the secretion from the eye, and cultivation experiments will decide. If cover-glass preparations do not reveal the presence of the diphtheritic organism, cultivation and inoculation experiments may be tried.

Symptoms.—The onset is rather sudden. The lids begin to swell rapidly and at the end of twenty-four hours they are four or five times their natural size. The skin of the lids is dark red and shiny and the lids are more or less infiltrated, making it impossible to open or evert them. On raising the lid its inner surface is seen to be covered with a pseudo-membrane, which frequently extends to the ocular conjunctiva. This membrane is darker in color than that of croupous conjunctivitis on account of admixture with blood. The preauricular lymph glands become swollen and tender and the patient feels quite unwell. There is a rise of several degrees of temperature and much prostration. There is usually much headache. Gradually the lids become softer and the secretion more purulent, and the membrane separates in large or small pieces. Corneal complications are very frequent, as the pellicle upon the conjunctiva interferes very much with the nutrition of the eye. About fifty per cent. of cases are complicated by corneal disease. Symblepharon of varying degrees, and ankyloblepharon are apt to result.

Great care should be taken to prohibit the spead of the inflammation to the fellow eye in case only one eye is affected, and the nurse for her own sake should not fail to thoroughly cleanse her hands

after handling the patient. Cold applications should be used until the lids are less hard. A free canthotomy is always in order to deplete the lids and also to relieve the pressure upon the cornea. The eye should be kept clean with some antiseptic solution, bichloride solution 1–4,000 being as good as any, and after each cleaning a small amount of pepsin, trypsin, or better still caroid powder should be placed upon the conjunctiva. The one all important thing is that the patient receive a dose of diphtheritic antitoxin, as soon as diagnosis is made, and if no improvement is noted in twenty-four hours a second dose. In favorable cases the membrane disappears in 48 to 72 hours, and no other treatment is needed to effect a cure.

Phlyctenular Conjunctivitis (*Conjunctivitis Phlyctenulosa; Scrofulous Ophthalmia, Lymphatic Conjunctivitis; or Eczema of the Conjunctiva*).—This affection in its simplest and typical form is made manifest by the formation of a more or less red prominence upon the limbus conjunctivæ, surrounded by a zone of injection. This is the efflorescence. It is conical in shape at the beginning and covered by the epithelium of the conjunctiva. After a short while the epithelium is shed from the apex of the cone-like body and a superficial ulcer of the conjunctiva is formed lying above the surrounding level. The ulcer finally comes to lie upon the level of the surrounding conjunctiva by a continual breaking down, when it speedily becomes clean and covered with epithelium. The duration of the disease is about one to two weeks. The conjunctiva not adjacent to the papule is not reddened, so that the disease is a purely local one and not like those heretofore described in which the whole conjunctival surface participated in a measure. Clinically the picture of phlyctenular conjunctivitis is somewhat as follows: There are several or more efflorescences present at the same time, varying in size, and the fewer there are the larger they grow. When numerous they are very small; often the limbus is completely surrounded by these tiny nodules. These small papules disappear in a few days without any disintegration. The injection surrounding each nodule becomes confluent, so that the disease is differentiated from catarrhal conjunctivitis by the presence of

the papules. The efflorescence may occur at any part of the ocular conjunctiva and also upon the cornea, in which case the affection is spoken of as a phlyctenular keratitis, although the process is the same as when the conjunctiva proper is affected. The further removed the phlycten is from the limbus the larger it is apt to be.

Etiology. — Poor health and unhygienic surroundings predispose to this disease. The ingestion of pastries and sweets ofttimes gives rise to the disease among the children of the well to do, which are not exempt. There is frequently present a naso-pharyngitis, or rhinitis of a purulent nature in children subjected to repeated attacks of phlyctens, the infection traveling to the eye by way of the nasal duct. There seems to be little doubt but that the specific infection is the staphylococcus pyogenes aureus or albus, from cultivation experiments made from the contents of phlyctens. Not infrequently children with phlyctens suffer with a moist eczema of the lids, ears, face or scalp. It frequently follows the exanthems, as measles and scarlet fever. Finally phlyctenular conjunctivitis or keratitis may be associated with menstruation in young females.

Pathology. — The phlyctenular nodule is formed by the elevation of the conjunctival epithelium from the underlying basement membrane, the vessels are injected and there is an increased number of leukocytes in the adjacent tissues. The nodule itself is composed of a collection of lymph cells and a limited amount of fluid; later the contents resemble pus.

Symptoms. — There is some mattering, slight watering and dread of light, but these latter are not prominent symptoms unless the cornea is the seat of a phlycten as it often is in phlyctenular conjunctivitis. There is frequently some enlargement of the preauricular glands. The objective signs have already been described, and by them we make a diagnosis.

Diagnosis. — Phlyctenular conjunctivitis must be differentiated from vernal conjunctivitis, from episcleritis, from herpes, and from trachoma affecting the ocular conjunctiva.

In vernal catarrh the elevations are larger, of waxy appearance,

do not ulcerate and persist for quite a while. There is a history of yearly recurrence and much itching, and the lid conjunctiva is papillated. Episcleritis gives rise to a single nodule which does not ulcerate, is not associated with mattering, but photophobia and lachrymation, and is more chronic in its course, and seldom occurs in children. In herpes the vesicles are transparent and appear in clusters, and they do not as a rule select the limbus. Trachoma of the ocular conjunctiva is always associated with trachoma of the palpebral conjunctiva.

Prognosis is good. Recurrences are frequent.

Treatment.—In recurrent attacks, the nose and throat should have attention, and refraction or muscular anomalies corrected. The patient should live upon plain, nutritious food. Iron, arsenic or strychnin internally are of service. Locally we employ the yellow oxid of mercury salve (gr. 2 to dr.). A bit of the salve is placed between the lids night and morning and the upper lid rubbed about over the eyeball to rub the salve well in. The massage of rubbing does part of the good in hastening absorption.

It now and then happens that a phlyctenular ulcer of the conjunctiva is overlooked and the eye remains injected, painful and mattery, under symptomatic treatment. If a few drops of solution of fluorescein are instilled the ulcer will stain green. It should then be cauterized by touching it with formalin in full strength, after some cocaine has been instilled to relieve the pain. The use of the yellow oxide salve is then continued, and a cure follows in a few days.

Vernal Conjunctivitis (Catarrh); Fruehjahr's Catarrh (Sæmisch); Spring or Autumnal Catarrh; Phlyctæna Pallida (Hirschberg).—This is a form of conjunctivitis that recurs and persists during the warm weather. It may persist for years and leads to characteristic changes in the conjunctiva. It was first described by Arlt in 1846 who considered it a form of phlyctenular conjunctivitis. Desmarre subsequently described it under the name of hypertrophie perikeratique. Sæmisch gave the disease the name of vernal catarrh, and called attention to its prominence during the hot weather.

Symptoms.—The conjunctiva of the lids (the upper especially) is covered by broad, flat papillæ which are separated from each other by shallow furrows. The appearance is not unlike a flag-stone pavement. Over the whole there is a bluish cast as if covered by skimmed milk as first pointed out by Vetsch. The changes in the ocular conjunctiva are still more decided and striking. The conjunctiva of the limbus, especially that in the palpebral fissure, becomes hypertrophic, gelatinous, uneven and at times brownish (especially in colored people), and overhangs the edge of the cornea, but does not become adherent to it, as it can always be elevated with a probe. These nodules never ulcerate—but may persist for years.

The limbus of the cornea may become thickened and encroach upon the cornea, forming a narrow ring of grayish-yellow opacity slightly elevated above the surrounding cornea. The inner edge of this zone is sharply circumscribed while the outer edge blends gradually with the tissue surrounding. This area of infiltration does not show any tendency to broaden and involve the central area of the cornea. After the disease has subsided the thickening disappears in great measure but some opacity is left in the cornea.

In some cases there is no change in the palpebral conjunctiva at all or *vice versa*. The picture of the disease differs according to the locality in which it is observed. With us, the limbus variety without lid changes is the commonest form, the palpebral variety is seldom met with. The patient experiences no inconvenience during the winter, but as soon as the first warm days of spring come, the eyes grow red and watery, and he is greatly tormented by an intolerable itching. The symptoms once more abate at the beginning of cool weather.

Etiology.—Nothing definite is know as to the cause of the affection. Some believe it to be a form of trachoma, others that it is a specific disease, but no specific microörganism has as yet been discovered. Both eyes are affected. The male sex suffers more. No age is exempt save very young children, one year old and under. The conjunctivitis accompanying hay-fever has none of the characteristics of this disease.

Pathology.—The papillæ of the tarsal conjunctiva are very hard and consist of areolar connective tissue, with a peculiar hyaloid degeneration of the cells of the connective tissue and of the vessels. The epithelium covering the papillæ is thickened and to this is probably due the bluish cast over the conjunctiva. The growths about the limbus are connective tissue, rich in cells and blood-vessels. The epithelium is also thickened and projects down into the parts below in the form of connective tissue plugs.

Diagnosis.—The history of the case is of the greatest value in making a differential diagnosis, for in no other variety of conjunctivitis do we have recurrence and persistence of the disease to the same extent. The affection may be confounded with trachoma, follicular or phlyctenular conjunctivitis or with amyloid disease of the cornea. The elevations of the tarsal conjunctivitis of vernal catarrh are larger and flatter than those of trachoma. The same is true of follicular conjunctivitis, and there are comparatively few symptoms and no change of the limbus conjunctivæ. The pericorneal elevations in vernal catarrh do not break down nor ulcerate as phlyctens, and they have the appearance of new growths. Malone emphasizes the difference between this disease and trachoma in the distribution of leucocytes. In vernal conjunctivitis they are diffused through the tissues, while in trachoma they occur in distinct masses and never invade the deeper fibrous layer of the conjunctiva. The majority of infiltrated cells are eosinophile corpuscles. In breaches of the epithelium they occur in the exudation. Their presence in the exudate may be used as a means of diagnosis. Herbert found that the eosinophiles were increased in the blood from 10 to 20 per cent. of the total leucocyte count.

Prognosis is unfavorable as far as a speedy cure is concerned. It is apt to persist for several years before a cure is established. While this is the rule there are a fair number of cases that will not have but one attack. The earlier the disease is seen the more effective is the treatment, for nothing seems to do good after the conjunctiva has become much altered.

Treatment.—If the limbus nodules are very large and overhang

the edge of the cornea they may be excised or destroyed by cauterization with the actual cautery. Electrolysis at times does good. Van Milligen recommends the use of dilute acetic acid as a collyrium in solution (2 gtt. to 1 oz.). Randolph advises salicylic acid in the form of an ointment (3 gr. to 1 oz.) or collyrium (5 gr. to 1 oz.). The writer has gotten very decided benefit and not a few cures from the use of the following salve applied twice daily to the conjunctival cul-de-sac:

Powdered copper sulphate	1 part
Cocain muriate	1 part
Vaselin	100 parts. M.

A small bit of this ointment is introduced between the lids and the eyeball massaged well through the upper eyelid. Many observers have reported favorably upon the X-ray treatment of this disease. The manner of using the X-rays will be described under the head of treatment of trachoma.

Follicular Conjunctivitis (*Conjunctivitis Follicularis Simplex*). — This affection is characterized by the formation of small, oval, pale or light red elevations in the conjunctiva of the fornices arranged in rows. A few granulations are found upon the tarsal conjunctiva.

Etiology. — According to Wells the disease is contagious, though no specific organism has as yet been isolated. It occurs sporadically now and then, but usually affects those inhabiting crowded quarters, as inmates in boarding schools, pest-houses, etc.

Pathology. — The granular appearance of the conjunctiva is due to enlargement of the lymphatic follicles of Krause, which are situated immediately beneath the epithelium of the conjunctiva, and are invisible in a normal condition. The enlarged follicles are composed of masses of lymph cells enclosed within delicate connective tissue capsules, in which a few small vessels ramify.

Symptoms are not pronounced. Follicular conjunctivitis may exist for months unknown to the patient until some day when he happens to see the mass of frog-spawn-looking granulations by everting the

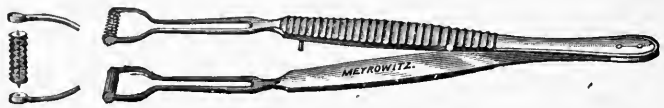
lower lid. There is very slight or no secretion. The follicles are usually more numerous in the lower fold of transition. What brings the patient to the doctor is usually a feeling of weakness about the eyes as the patient expresses it, and a feeling as if something was in them. At times the follicles are so numerous that they cause the fornix to roll out as a mass of spawn when the lid is everted. The ocular conjunctiva is infrequently invaded in its upper portion, beneath the lid.

Diagnosis should be made from trachoma. In follicular conjunctivitis the granules are lighter in color, more oval, and occur almost entirely in the fornices, and are transient, and are not followed by cicatricial changes.

Prognosis is good. A cure under proper treatment results in several weeks.

Treatment.—The follicles should be expressed with a suitable forceps as shown in the cut.

The manner of using the forceps is as follows: The lid is everted; one blade of the forceps is then placed well up in the fornix and the



Krapp's Roller Forceps.

other upon the conjunctival surface of the lid. The contents of the follicles are then squeezed out by stripping the forceps from the lid. The operation is repeated until all the visible follicles are emptied. In case of the lower lid one blade is placed down in the fornix while the other one is placed upon the skin. The retrotarsal folds may be treated separately if needed, by further everting the lid and grasping them with the forceps. Care should be taken that the material from the follicles does not squirt into the eyes of the operator. To protect his eyes he should wear spectacles with large plain lenses. The conjunctival cul-de-sac is then thoroughly irrigated with a Callan lid irrigator, using boric acid solution, or bichlorid 1–4,000, and cold

compresses kept upon the closed lids for two hours, to prevent much swelling and pain. Subsequently a solution of borax, ten grains to one ounce, should be used every two hours. If the patient objects to operative measures, the follicles may be touched every two days with a sulphate of copper crystal.

In the meanwhile ichthyol ointment, two per cent., may be used at home night and morning. A bit is placed between the lids and the eyeball massaged through the closed lids. Instead of the copper sulphate crystal, the ointment of powdered copper sulphate before referred to may be used, that is:

Copper sulphate, powdered	1 part
Cocain muriate	1 part
Vaselin	100 parts.

Tannic acid and glycerin, 30 grains to one ounce, as a collyrium, to be used two or three times daily, is highly recommended by some.

Granular Conjunctivitis (*Trachoma; Egyptian Ophthalmia; Military Ophthalmia*). — Granular ophthalmia is an infectious disease of the conjunctiva, giving rise to the formation of certain lymphoid bodies within the conjunctiva which cause it to lose its smooth appearance and to become rough and papillated, and is followed by characteristic changes in the lids and cornea. It occurs as an acute and also as a chronic affection.

Etiology. — Michel and Sattler claim that trachoma is due to a micrococcus, resembling the gonococcus but of diminutive form. They succeeded in causing the disease in animals' eyes by inoculation of the conjunctival cul-de-sac with cultures of this organism. To produce these results however it was necessary to greatly reduce the resisting power of the animals by half starving them, so that the results of the experiments are questioned, inasmuch as it is known that poor hygienic surroundings and improper food have much to do with the development of the disease. The trachomacoccus has not been identified by others, and Mutermilch denies its existence. Noiszewski has described a fungus resembling the microsporon fur-

fur (organism of chromophytosis), active in rabbits, and certain parasitic protozoa have been found by Pfeiffer in trachoma secretion, so that the bacterial origin of the affection has not yet been satisfactorily proven. There is no doubt however that the disease is contagious, or rather infectious, especially when associated with a free discharge. Transfer of the secretion to another eye, especially if there is present some conjunctival inflammation, gives rise to its kind. There seems to be some connection between trachoma and gonorrhœa of the conjunctiva. The chronic blenorrhœa which develops from an acute blenorrhœa is very similar to the papillary form of trachoma, so much so that the two cannot be distinguished from each other with certainty (not even microscopically), so that some observers believe trachoma to be produced by the transfer of infectious material from an eye affected with chronic blenorrhœa (gonorrhœal conjunctivitis). Goldzieher reports an epidemic of trachoma in a school produced by a new-comer who had lost his sight from acute blenorrhœa. Sattler and Fuchs both report cases of trachoma occurring in attendants upon those affected with purulent ophthalmia. The Jews, Irish, Poles and inhabitants of the East possess a marked predisposition for the disease. The Indians of this country are also frequently affected while the negro enjoys a comparative immunity, but not to the extent that Burnett supposed. Trachoma is often spoken of as Egyptian ophthalmia on account of its great frequency in Egypt. It is much more prevalent there than in Europe, probably explained by the climatic and hygienic conditions of that country. Except for the fact that trachoma of Egypt is oftener complicated by catarrhal or purulent conjunctivitis it is identical with that of Europe. The disease develops more frequently in low-lying damp districts, while an elevation of 1,000 feet or over enjoys comparative freedom from the disease. It occurs most frequently among the poor and those crowded together in barracks, tenement houses, etc.

Symptoms.—According to early descriptions of the disease it ran a very acute course. Such cases have become very rare since the infectious nature of the disease has been recognized and epidemics

have ceased, and the number of cases occurring in the schools of Cairo and other places where the disease is especially prevalent has fallen from 85 or 96 per cent. to 34 per cent. in six years. In spite of the most rigid care in an institution a certain small percentage of cases (two to eight per cent.) depending upon the influx of new ones will be found. The *symptoms* of acute form are as follows: The patient complains of sensitiveness of the eyes to light, and of watering. The lids are found agglutinated the next morning. The lids appear half closed on account of considerable swelling and partly because of the photophobia. On everting the lid the tarsal conjunctiva and that of the fold of transition are seen to be much thickened and reddened, and its surface uneven, being thrown more or less into folds between which there are seen rounded and fleshy looking granules. The bulbar conjunctiva is quite red, and may be slightly chemotic. There is an abundant purulent discharge and the cornea frequently becomes ulcerated. The process terminates favorably or terminates in the chronic form. The chronic granulations (so called from appearance to granulations in a wound) on the other hand may appear without any antecedent inflammation. There is little or no mattering. The eyes are slightly sensitive to the light, and watery, and the lids drooping. The characteristic changes are due to a hypertrophy of the mucous membrane, which occurs under two different forms. The first consists in the development of so-called papillæ, or elevations upon the surface of the conjunctiva of the lids only. The papillæ cause the conjunctiva to appear velvety or when large and numerous impart to it a raspberry appearance. This kind of hypertrophy is called the papillary form (papillary trachoma). It is always most pronounced in the conjunctiva of the upper eyelid which must always be everted to properly diagnose trachoma. The second form of hypertrophy is characterized by the presence of the so-called trachoma granules. These are pale red, grayish, or yellowish translucent bodies which elevate the surface of the conjunctiva in the form of roundish nodules. These granules are at times described as appearing like frog-spawn or grains of boiled sago

beneath the conjunctiva, but they are usually of a pink or red color, and of a fleshy appearance. They occur in greatest numbers and larger in the fold of transition, than upon the lid conjunctiva. The granules now and then are seen in the ocular conjunctiva and in the semilunar fold. This form is called granular trachoma. In the vast majority of cases these two varieties occur in the same case, rarely separately. Usually the most prominent feature of the tarsal conjunctiva is papillary hypertrophy and in the fornix, granular proliferation. The patient sooner or later in the majority of cases is annoyed by corneal complications, the commonest of which is pannus. Pannus trachomatosus consists in the formation of a vascular connective tissue growth that pushes its way from the edge of the cornea towards its center, between the epithelium and Bowman's membrane. At the site of the pannus the surface of the cornea is uneven and studded with a number of fine projections, and there is a grayish, superficially situated, translucent mass, traversed by numerous blood-vessels. These vessels spring from the vessels of the conjunctiva which pass over the limbus upon the cornea where they branch in an arborescent fashion. The pannus begins at the upper margin of the cornea, and usually stops about the center of the cornea in a straight horizontal border; now and then it covers the entire cornea. The iris very frequently takes on inflammation after the pannus has developed to a considerable extent. The vision is disturbed as soon as the pannus reaches the pupillary area of the cornea, according to the density of the growth. Ulceration of the cornea frequently develops within the pannitic area, or in part of the cornea otherwise normal. If the ulcer develops in the pannus it is usually situated at its free border.

Pathology.—The papillary growths of the conjunctiva are caused by an increase in the extent of the surface of the conjunctiva by which it is thrown into folds between which correspondingly deep clefts are formed. These folds appear under the form of papillæ in cross microscopical section. The papillæ are filled with leukocytes, and the epithelium over them is much thickened. The clefts between

the papillæ were at one time considered tubular glands, and hence the formation of new glands in the conjunctiva was alleged in trachoma. This form of hypertrophy is in no wise limited to trachoma. It is found in very long continued irritation of the conjunctiva from any cause, as in chronic conjunctivitis, in ectropion, upon the portion of the conjunctiva that is exposed to the air, etc. Papillæ form in vernal catarrh, but as has been seen they are large, compressed and flat. Very decided papillary hypertrophy is seen in blenorrhœa when it has persisted for some time, which has given rise to the classing of papillary trachoma as chronic blenorrhœa by some writers. The granular form of hypertrophy is caused by the formation of lymphoid deposits in the conjunctiva. These collections of leukocytes are surrounded by a delicate connective tissue envelope from which off-shoots traverse the substance of the follicle. The capsule is present according to Ræhlmann only in follicles which have existed a very long time. The transformation of the conjunctiva into connective tissue proceeds as follows: Many of the cells composing the trachoma bodies are absorbed, the remaining becoming converted into spindle cells, which with the fixed connective tissue cells of the part become connective tissue fibers which form plugs or masses in the conjunctiva at the former seat of a follicle. It is erroneous to suppose that the follicles rupture and discharge their contents and then fill up with scar tissue. That the lymph cells give rise to a considerable amount of connective tissue in the transformation has its proof in the fact that when they are expressed the resulting cicatrix is considerably less.

Histological examination of pannus shows it to be a layer of newly formed, soft tissue, extremely rich in cells and greatly resembles the infiltrated trachomatous conjunctiva. The tissue is rich in vessels, occurring in alternately thicker and thinner layers, for which reason the pannus has a nodular appearance.

At first the parenchyma of the cornea is protected by an intact anterior limiting membrane, but finally it gets to be destroyed in places, and then the pannus penetrates into the corneal tissue proper.

The complete restoration of transparency of the cornea has then become impossible. A recent thin pannus is called a pannus tenuis; if very vascular, pannus vasculosis; if of considerable thickness it is then spoken of as a pannus crassus or pannus carnosus. An old pannus devoid of vessels is a pannus siccus. Pannus is caused partly by the irritation of the roughened lids upon the cornea, but chiefly by infection of the corneal epithelium from contact with the upper lid. The cornea is not affected by continuity of tissue because the bulbar conjunctiva is seldom implicated. The papillary and the granular form of trachoma are one and the same disease because inoculation experiments give rise at one time to one form and at another time to the other, the infectious material being taken from a case of either variety.

Course.—After the hypertrophy has reached a certain height, it begins to disappear, a cicatricial, and contracted condition of the conjunctiva taking its place. The morbid process has then come to an end, and in this way only is trachoma cured. According to the plan of treatment and the duration of the case depends the amount of cicatrization of the conjunctiva. The cicatricial change in the tarsal conjunctiva is made manifest by the formation of a few whitish striæ, emerging in the midst of the thickened and reddened conjunctiva. These bands become more and more numerous, and unite to form a network.

A very characteristic scar is finally left upon the conjunctiva running parallel to the free border of lid, along more or less of its extent. These scars are indelible marks of a former attack of granular conjunctivitis. The conjunctiva of the fornices likewise undergoes a shrinkage and transformation into connective tissue, but the external phenomena are different, inasmuch as we do not see the bands of connective tissue as we do in the tarsal conjunctiva, but the fold becomes gradually thinner, flatter and paler, and of a delicate bluish luster, showing the cicatricial character of its superficial layers. As long as the pannus does not affect the substance proper of the cornea so long is it possible for the cornea to again become transparent by

the retrogression of the pannus. The severity by no means bears a definite relation to the objective changes; cases with little conjunctival change and slight amount of pannus develop corneal ulcers, and iritis and leave the eye more or less damaged after the diseased process has become arrested, and *vice versa*.

Sequelæ.—Trachoma as a rule is followed by certain sequelæ affecting the lids, conjunctiva or cornea. The lids become distorted and the lashes misdirected, from the contraction of the cicatrizing conjunctiva, which is constantly shrinking and drawing the lash border of the lid in, but the distortion is mainly produced by changes in the tarsus itself. The tarsal cartilage is as much the seat of trachoma in severe cases as the conjunctiva itself. It becomes softened, infiltrated with round cells, and is thicker than normal, especially near its free border along the line that the blood-vessels to the conjunctiva pierce the cartilage. The inflammation makes its way along these vessels from the conjunctiva to the tarsus. Cicatricial contraction which succeeds the infiltration and makes the entire tarsus thinner and narrower, is greatest at this place and produces there an angular bending of the tarsus, corresponding to which is seen a horizontal line of scar tissue running upon the conjunctiva tarsi. The internal margin of the lid which is in health sharp becomes rounded off. The lashes no longer look forward but downward and backward and scratch the surface of the cornea (trichiasis). By the increase in the distortion of the lid its entire lash border is inverted (entropion). In the lower lid the opposite position of the lash border is sometimes seen as the result of trachoma. The hypertrophied conjunctiva crowds the border of the lid outward, and the contraction of the orbicularis suffices to complete the eversion of the lid. By the contraction of the conjunctiva the folds of transition gradually become smoothed out or effaced, the conjunctiva passing directly from the lid to the eyeball. This is especially the case in the lower fornix. To this condition the name of symblepharon posterius is given. When the conjunctiva becomes much contracted and atrophied in consequence, it fails to contribute to the moisture of the eyeball through

its own secretion. A feeling of dryness develops. There appear upon the conjunctiva several dry-looking patches, to which the lachrymal fluid does not adhere (xerosis). This condition spreads until perhaps the entire conjunctival surface is so affected. The cornea likewise suffers from deficient moisture. Its epithelium becomes thickened, dry and hence opaque; thus is produced the distressing picture of xerophthalmos, the worst termination of granular conjunctivitis.

Opacities form in the cornea as after-effects of both ulcers and pannus. A fresh pannus can be resorbed and the cornea establish its transparency, but if it becomes transformed into connective tissue or makes its way into the substance of the cornea, the latter is forever more or less opaque. The round cells in the pannus are absorbed in part and in part become spindle cells and finally connective tissue fibers, at the same time there is a hyperplasia of the connective tissue cells of the pannus. The pannus becomes thinner, its surface smooth and its vessels disappear, and finally the pannus is converted into a thin membrane of connective tissue that covers the surface of the cornea. When the pannus affects the greater part of the cornea, the latter softens and often yields before the intraocular pressure, by bulging (keratectasia e panno).

Prognosis.—Trachoma is a disease as a rule extending over years, and which in many cases renders those attacked half or totally blind. According to the tables of Magnus, trachoma causes 1.3 per cent. of blindness from eye diseases. It is said that two in five soldiers in the old Egyptian army went blind from acute trachoma.

Diagnosis.—This is not difficult as a rule. It must be distinguished from gonorrhœal ophthalmia, both in the acute and chronic form, from folliculosis and vernal catarrh.

Acute trachoma may be differentiated from acute gonorrhœal ophthalmia by the presence of the gonococcus in the discharge from the latter, by the presence of a specific urethritis or vaginitis in the patient, or by the fact that the disease occurs in the new-born, as trachoma seldom affects young children or infants. Folliculosis differs

from trachoma in that the granules are lighter in color, more rounded, arranged in rows and confined almost entirely to the fornices, is not associated with pannus nor sequelæ. Vernal catarrh is distinguished by its recurrence in warm weather, by an intolerable itching, and by the broad, flat granulations upon the tarsal conjunctiva only and by the hyperplasia in the conjunctiva adjacent to the corneal edge.

Treatment.—This is prophylactic, medical and operative. Isolation should be practiced as long as discharge from the eye persists. In the acute form, when there is much mattering the eye should be cleaned frequently as in purulent ophthalmia, and a two per cent. solution of nitrate of silver applied to the everted lids once or twice a day according to the severity of the case. Cold applications to the lids are beneficial, especially after the use of the silver. Between times the eye should be irrigated freely with a solution of bichloride, 1–4,000, or boric acid solution, or have some dropped into the eye. The eye-bath glass shown in the cut is a very useful appliance when the patient must clean his own eye. The glass is half filled with the solution, applied to the eye which is kept open and the head thrown back. The eye is then opened and closed while immersed.

Eye-Bath Glass.

When the acute symptoms have subsided or if the disease has been chronic from the start stimulating astringent applications are made to the conjunctiva. Alum crystal, blue stone, or mitigated silver nitrate stick may be used to touch the granulations every other day. The sulphate of copper is generally employed and gives the greatest satisfaction. A mild astringent solution is given the patient to use at home. Not all cases tolerate this plan of treatment. The ointment of powdered copper sulphate and cocaine may be given to be used at home, night and morning and gives excellent results in fresh cases. Ichthyol ointment (two per cent.) is highly recommended by some in the treatment of trachoma. It is used night and morning, a bit being placed between the lids. Bock strongly urges

the use of copper citrate (cuprocitrol) in the treatment of trachoma. The best results are obtained in the chronic cases. The drug is employed in a ten per cent. salve and a bit of this is placed in the conjunctival sac and allowed to slowly dissolve. This line of treatment affords 60 per cent. of cures. Wright testifies to its value in trachoma but agrees with Arlt that it does not cure trachoma more quickly than other non-operative measures. It causes less discomfort to the patient than other methods however, except the ointment of copper sulphate and cocain referred to above. Protargol has been extoled by a few as especially useful in the treatment of trachoma but in the opinion of the writer it is inferior to the more irritating silver nitrate in solution. Kalt believes that the ulcers so frequently met with in the disease are due to the coexisting catarrhal condition present and recommends a thorough irrigation of the conjunctival sac twice a day with 1–3,000 permanganate solution to prevent the formation of an ulcer or to cure it if present. He uses a pint or more fluid at each treatment and instils cocain if a blepharospasm is present or produced by the irrigation. The surgical treatment is of the greatest importance in the early stage of the distinctly granular cases. The roller forceps described in a former section are used when the follicles are closely set, otherwise they are expressed between the thumb nails, or by means of Noyes' trachoma forceps.

Noyes' Trachoma Forceps. Curved Up and Down.

General anæsthesia is to be preferred in most cases. The operator should wear protecting spectacles. The following is the operation of Lindsay Johnson for granular lids: The lid is everted over a horn spatula and held tense by a double hook inserted near its edge. With a tri-blade scalpel or scarifier the conjunctiva is incised parallel to the free border of the lid from end to end. The entire surface of the conjunctiva is then incised, by parallel incisions. An electrolyzer

with two blades connected with a twenty-cell battery is then passed through the incisions made with the scarifier. About 30 ampères of current are used and a thick creamy foam arises from the blades. The lids are then washed, mopped with a 4 per cent. solution of cocain, dusted with calomel and smeared with an ointment of hydro-naphthol, 1–800. Iced compresses are used for several hours to prevent swelling. There is considerable sloughing for 48 hours. After treatment consists in the use of the betanaphthol ointment, once daily.

The French surgeons have advocated the operation of *grattage*, which is performed as follows: The lid is everted and the conjunctiva scarified thoroughly. The surface is then scrubbed with a nail brush saturated with a 1–500 solution of bichlorid. The conjunctiva is severely torn but the resulting scar-formation is less than would have been from the transformation of the trachoma bodies. The lids are treated with cold compresses. A very old method of treatment is that revised in 1847 by Galezowski, that is excision of the conjunctival cul-de-sac. It is done as follows: The lid is everted and two strong threads are passed through the hypertrophied fornix. It is then detached from the lid, and then from the eyeball, and the wound allowed to granulate. Bleeding is profuse, but stops by the use of adrenalin. Ptosis at times follows the operation from interference with the attachment of the levator palpebræ. The operation should be condemned, as nearly all cases can be cured by other more gentle means. The operation of course gives rise to a symblepharon posterius with its evil consequences. Expression is the operation par-excellence when the granulations are spawn-like, and grattage preferable when they are denser and beginning to cicatrize.

Weeks' Grattage Knife or Scarifier.

X-RAY TREATMENT.

Mayou, Stephenson, Walsh and others speak encouragingly in regard to the treatment of trachoma by means of the X-ray. They

claim less deformity of the lids than by other methods, less pain and more thorough clearing up of the pannus. No serious burns of the eyeball have thus far been reported but several cases of burns of the lids. Sixteen or seventeen exposures are usually needed to effect a cure. Some claim better results with the soft tubes, while others prefer the hard tubes. The seances are continued two minutes and repeated every day for a week and then omitted for a few days and afterwards made at longer intervals. The eye should be placed at eight or nine inches from the anode and the lids and portions of the face nearer the tube protected by means of a lead mask.

Treatment of Sequelæ.—The treatment of entropion has already been considered, and the changes that take place in the cornea (pannus) will be dealt with under the head of diseases of the cornea. If ulceration of the cornea ensues, atropia (gr. iv–ʒ i) should be instilled and the eye bathed often with hot water. Nothing else is needed. The ulcer will heal as the trachoma improves.

Parinaud's Conjunctivitis, Lymphoma of the Conjunctiva (*Goldzeiher*).—This is a very rare disease occurring in those who have to do with animals or hides. It was first described by Parinaud and later by Gifford in this country.

Symptoms.—Considerable swelling of lids; muco-purulent discharge; numerous small subconjunctival abscesses in the lid which inside of two weeks give rise to large polypoid granulations upon the tarsal conjunctiva. The preauricular and retro-maxillary glands are enlarged and tender, and they not infrequently suppurate. The disease usually affects only one eye and lasts from several weeks to as many months.

Etiology.—The affection is of animal origin, but a specific organism has not been isolated. Streptococci are present in the pus from the eye and in the inflamed lymphatic glands. Some believe the disease allied to tuberculosis of the conjunctiva but in the subepithelial zone of infiltration neither giant cells nor tubercle bacilli are demonstrable and inoculation experiments are negative.

Prognosis is good, unless corneal complications ensue (ulceration) which are unusual.

Treatment.—The patient should be warned to be careful that he does not spread the infection by using a towel or what not in common with others. In the beginning of secretion, nitrate of silver should be applied to the tarsal conjunctiva once a day and an astringent solution zinc sulphate, gr. 1 to oz., instilled every two hours. When the subconjunctival abscesses form they should be opened, and curetted, and a stick of nitrate of silver introduced into the cavity to destroy all infection. The polypoid masses should be excised and their bases touched with the silver stick. Suppurating preauricular glands should be curetted.

Chronic Conjunctivitis (*Chronic Ophthalmia*).—By chronic conjunctivitis we mean a persistent, congested and irritable condition of the palpebral conjunctiva associated with a scanty muco-purulent discharge. It is always accompanied by hypertrophy of the caruncle.

Etiology.—The disease results from uncorrected errors of refraction; naso-pharyngitis; atresia of the lachrymal passages; habitual exposure to dusty or irritating atmosphere. In topers a chronic redness of the eyes is common, and in old people there is frequently a flabby, slightly congested condition of the conjunctiva present, with a scanty secretion.

Treatment.—The cause should be removed. The lachrymal and nasal passages should be examined and any abnormality treated. Errors of refraction should be corrected. One of the following applications may advantageously be made to the conjunctiva once in two days, according to the benefit derived. Nitrate of silver, one per cent. solution; glycerol of tannin, dr. ½ to oz. 2; sulphate of copper or alum crystal if there is folliculosis or much hypertrophy. The patient is given a solution of adrenalin and zinc to use at home every four hours (adrenalin, 1–10,000; zinc sulphate grain 1).

Lachrymal Conjunctivitis is an inflammation of the conjunctiva accompanying acute or chronic dacryocystitis (mucocele), and is due to the presence of an irritating secretion from the lachrymal sac con-

taining streptococci. The inner third of the palpebral conjunctiva is most altered and the lower fornix and lid to a greater extent than the upper. The eye appears suffused with tears and muco-pus, which flow over the cheek, and the conjunctiva has a sodden appearance. The cornea is prone to become ulcerated. The ulcer usually forms in the lower portion of the cornea, the part that is constantly bathed with the muco-pus from the lachrymal sac. The patient not infrequently suffers with recurrent ulceration until the lachrymal disease is cured.

Diagnosis is made by pressure over the lachrymal sac. If the case is one of lachrymal conjunctivitis, muco-pus will pass into the conjunctival cul-de-sac through the puncta.

Prognosis is directly dependent upon the cure of the lachrymal disease and upon the degree of implication of the cornea.

Treatment.—The dacryocystitis must be treated in the manner stated under the head of that subject. The conjunctivitis is treated as an uncomplicated muco-purulent conjunctivitis, and if ulceration of the cornea occurs, atropin is to be instilled, and the eye frequently cleansed of secretion, to lessen as much as possible the infection of the ulcer.

Larval Conjunctivitis.—This occurs under the form of a very intense acute conjunctivitis due to the presence of the larvæ of the Wolfhart fly or blow fly, in the conjunctiva the same as found at times inhabiting the nasal chambers. The fly may deposit the eggs upon the eyes of persons sleeping out of doors during the hottest parts of the day. The symptoms quickly disappear after the removal of the worms.

Toxic Conjunctivitis is that caused by the chemical action of certain substances, among which are the following: Atropin and infrequently the other mydriatics, myotics, chrysarobin, calomel, aniline dyes, bites and portions of certain insects.

Some individuals can not tolerate atropin even in the weakest solution. After one instillation it produces marked itching with edema of the conjunctiva and skin of lower lid especially (atropin blepharo-

conjunctivitis). If no more atropin is instilled the trouble subsides in 24 to 48 hours. If a non-sterile solution of atropia (and other drugs) be used in the eye for some time, a folliculosis frequently ensues which gets well promptly when the cause is removed, so some regard the disease of schizomycetic origin, others think it of chemical origin.

Calomel when dusted into the eye of those taking iodine in any form is transformed into an iodide through the action of the tears, and at times produces marked conjunctivitis with superficial ulcerations. The irritation from caterpillar hairs causes a characteristic form of trouble. The hairs give rise to grayish or semitranslucent nodules, looking not unlike tubercles. They may invade the conjunctiva cornea, and even the iris (ophthalmia nodosa).

Treatment is to remove the irritating substance, and to bathe the eye frequently with a diluted lead water (subacetate of lead, ℥i to ℥i), otherwise treat pro re nata.

Amyloid Disease of the Conjunctiva (*Amyloid Degeneration*). — This is a very rare disease seldom seen in the States, and has hitherto been chiefly observed in Russia and the adjacent countries. It was first described by Oettingen in Dorpat. It consists of a degeneration of the conjunctiva causing it to look yellowish, translucent like wax, non-vascular and very brittle. There is associated with this a thickening of the conjunctiva which causes it to be thrown into folds, looking not unlike new growths. These folds may overlap the cornea and obstruct vision. The affection begins in the fold of transition and later passes over to the lids and eyeball; in the lids the tarsus subsequently becomes implicated in the degeneration. Leber has described a recurring and spreading form of the disease, characterized by the appearance of raised whitish patches, the centers of which contain deposits of lime. He calls this disease *conjunctivitis petrificans*.

Symptoms. — The patient is unable to properly open his eyes on account of the swollen and distorted eyelids. When the lids are separated as far as possible, the waxy conjunctiva is seen to form a rigid prominence all around the cornea. The cornea may be clear or

covered with pannus. The fold of transition protrudes as the eyelids are separated and the plica semilunaris is much swollen and misshapen. These various swellings are so friable that they often tear when an attempt is simply made to open the lids for examination, but they bleed very little. The disease runs a course of years, and finally the patient becomes blind from inability to open his lids or the cornea becomes opaque and pannitic.

Pathology. — The subconjunctival tissue is found abundantly infiltrated with round cells, then a hyaline and finally an amyloid degeneration sets in. Sarcomatous tissue may be an element in the growths, and bony deposits frequently occur in the masses.

Diagnosis. — Diagnosis is easy, as no other disease presents the same appearances. In doubtful cases fresh sections may be tested for the starch reaction with iodin.

Etiology. — The true cause of the malady is unknown. It attacks folks of middle life and both eyes are affected. Not infrequently it is preceded by trachoma, but occurs also in otherwise healthy eyes. It is not an expression of amyloid degeneration of the internal organs for the individuals attacked by it are sound as far as the rest of the body is concerned.

Prognosis is favorable if no sarcomatous tissue is present.

Treatment. — Medical treatment is powerless. The growths upon the conjunctiva must be removed to such an extent that the lids can be opened and vision rendered possible. It is not necessary to remove all the diseased tissue as it generally atrophies of itself afterwards.

Xerosis (*Atrophy of the Conjunctiva, Xerophthalmos*). — Xerosis is a condition in which the conjunctiva is dry and shiny and is not moistened by the lachrymal secretion. There are two varieties of the affection: That due to cicatricial degeneration of the conjunctiva (X. parenchymatosa, essential atrophy of the conjunctiva), and xerosis accompanying some general disease (x. superficialis, x. epithelialis, x. triangularis, x. infantilis).

The first variety is commonest after trachoma. It also occurs following pemphigus, diphtheritic conjunctivitis, burns, and exposure

of the conjunctiva to the atmosphere as is the case in ectropion and lagophthalmos. It may be partial or complete. The dryness of the conjunctiva in xerosis is due to the obliteration of the secreting tissue of the conjunctiva and not to a deficiency of the lachrymal fluid, for there is in the beginning of the disease often an excess of tears, and the disease has never been known to occur after extirpation of the lachrymal gland. It is true that the secretion from the lachrymal gland becomes very little and may finally disappear entirely during the progress of the disease but this is due to the closure of the lachrymal ducts from shrinkage of the conjunctiva, and a fatty metamorphosis of the gland itself. The affection is usually seen in those of mature years. It is incurable. Xerosis due to a general disease appears both in a mild and in a severe form. The former is characterized by the appearance of triangular masses of foamy or lardaceous secretion, not moistened by the tears, usually located upon the margin of the cornea in the horizontal meridian. The bases of the triangular areas are placed next to the cornea. Night-blindness (hemeralopia) accompanies it. This form of xerosis is seen in children and in adults, and is the result of inanition. It is seen in those deprived of proper food, as in sailors, soldiers, prison inmates, etc. In children with wasting diseases a very severe form occurs associated with keratomalacia, and is to be looked upon as malnutrition of the eye due to the general condition, and is an evil omen, rendering the prognosis of recovery of the child extremely grave.

Etiology.—Kuschbert, Neisser and later Leber described a special microörganism occurring in the secretion of xerosis. It is found under the form of short rods adhering to the surface of epithelial cells. Others do not support their views, as the organism has been found in the conjunctival secretion under other conditions, but it still may be the pathogenic cause, for it is not the form of the organism only, but its environment and the toxicity of its toxin that makes it pathogenic at one time and not at another.

Prognosis in the mild form of xerosis is favorable. Infants suffering from the severer forms seldom recover.

Treatment is directed to improve the nutrition of the individual. To relieve the sense of dryness about the eye a collyrium of liquid vaseline or albolene may be used.

Pterygium is a fleshy mass of hypertrophied conjunctiva, more or less triangular in shape ; growing usually from the inner canthus, although at times from the outer by its base and attached to the cornea by its apex. Its borders overlap the conjunctiva, allowing a probe to be passed beneath it to a variable distance. The apex of the growth advances upon the cornea in a horizontal meridian, but rarely passes the center of the cornea.

Etiology. — According to Fuchs irritation of the conjunctiva first causes a pinguicula, then pterygium. Miners, stone-masons and those inhabiting regions where there is much alkaline dust, present the condition most frequently. The degenerative process in the pinguicula makes its way into the limbus and finally upon the cornea. The pinguicula grows up over the edge of the cornea and drags the conjunctiva after it. The advancing degeneration of the cornea may be recognized by the haziness which proceeds in advance of the head of the pterygium. A form known as pseudo-pterygium is caused by burns, injuries and ulcerative processes upon the margin of the cornea. The conjunctiva adjacent becomes chemotic and overlaps the denuded area. Its epithelium exfoliates and the conjunctiva becomes adherent to the cornea. Pseudo-pterygium unlike the true growth is stationary.

Pathology. — A vascular progressive pterygium is called pterygium crassum, and a thin attenuated non-vascular retrogressive growth as a pterygium tenue. A pterygium is almost identical with the conjunctiva of the eyeball, consisting of loose connective tissue, rich in vessels and with more or less round cell infiltration according to the degree of irritation. A few blood-vessels and round-cell infiltration proceed in advance of the growth. The epithelium over the growth is thickened. Bowman's membrane beneath the pterygium is destroyed and indeed the growth makes its way into the superficial layers of the cornea, so that the cornea does not regain its transparency after removal of the pterygium.

Prognosis is good but recurrences frequent.

Symptoms. — There are no symptoms unless the pterygium becomes inflamed, save disturbance of vision late in the progress of the growth. When the pterygium reaches the pupillary area of the cornea vision is disturbed by the opacity and also by the occurrence of irregular astigmatism. In advanced cases the mobility of the eyeball is interfered with and the lids hampered in their movement over it.

Treatment is operative. Simple ablation of the growth was formerly practiced, but recurrences were extremely frequent. To Arlt belongs the credit of first calling attention to the necessity of covering the denuded area adjacent to the cornea with conjunctiva. There are many methods of operating, the chief among which are the following: The growth is grasped near the corneal margin with a pair of small rat-tooth forceps, raised up and a cataract knife inserted beneath it. Then with a few strokes of the knife the growth is shaved off of the cornea. The body of the pterygium is then divided by two snips of the scissors near the caruncle, one above and one below, converging towards the caruncle. This V-shaped incision is then sutured.

In order that the growth will not return, the denuded area adjacent to the cornea must be covered with conjunctiva, but in drawing it over the wound it must not overlap the edge of the cornea, or it will adhere and the pterygium be reproduced. A vertical incision should therefore be made through the conjunctiva above and below the wound tangentially to the edge of the cornea, so that the conjunctiva above and below the cornea will not be dragged upon when the wound is closed. Deschamps advises that after the head of the pterygium is removed, the cornea should be scraped with the knife to remove any remnants of the growth, or the area of attachment cauterized with the actual cautery or by carbolic acid to prevent its return. Prince grasps the growth and by a number of slight jerks tries to pull the growth from beneath Bowman's membrane and from between the corneal fibers. He claims that no opacity remains, and that no inflammation of the cornea ensues. The cautery should not

be used, as its use leads to a denser opacity and it is difficult to limit its action. Instead of treating the body of the growth as outlined above, which is the method of Savage, it may be transplanted beneath the conjunctiva above or below, by dissecting up the latter and holding the head of the pterygium beneath it with a suture, or as Knapp advised the body of the growth may be split and half transplanted above and half below the cornea. Hotz and Boeckman unfold and spread out the growth after the subconjunctival tissue has been thoroughly removed. Hotz places a Thiersch skin graft upon the raw surface adjacent to the cornea after separation of the head of the pterygium. Hobbs and others raise the neck of the growth from the eyeball with a squint hook passed beneath it and burn the neck of the growth through with an electric cautery. The subconjunctival tissue is then drawn out and excised. The wound is then closed by a cross stitch. There is no dressing needed in the after-treatment of pterygium, and sutures are removed upon the fourth or fifth day. If the eye becomes mattery, borax, gr. x to ʒ i, may be used to bathe the eye every two to four hours. If the patient is annoyed much by the stitches, holocain, one per cent., solution may be used and bandage applied. The operation first described, or Hobby's, is the preferable one.

There are two other operations to be described which give excellent results; they are Hobby's and McReynolds'.

Hobby's Operation is performed as follows: The conjunctiva is incised along the upper border of the pterygium, a vertical incision is made at right angles to this from the edge of the cornea. The growth is now separated from the cornea and the vertical incision in the conjunctiva prolonged to a little below the lower border of the cornea. An incision is then made along the lower border of the growth and the latter dissected from the eyeball. The upper flap is now loosened and brought down and fastened to the edge of the lower flap by several sutures. Inasmuch as pterygia often reappear along the line of conjunctival union this is an ingenious operation.

McReynolds' Operation.—This is a modification of the transplan-

tation operation and is done as follows: The pterygium is divided close to its apex; the conjunctiva along the lower margin of the growth is then divided and loosened and the growth pushed into the pocket thus made well into the fornix and held there by sutures passed through its head and the overlying conjunctiva.

If a gap is produced by excision of the body of the pterygium which is too large to be covered by drawing the adjacent conjunctiva over it, a graft may be taken from the ocular conjunctiva of the fellow eye, or from the inner surface of the lip. It need not be large enough to entirely cover the area and is held in place by a few stitches.

Pinguicula is the probable progenitor of pterygium. It consists of a yellowish mass in the ocular conjunctiva adjacent to the edge of the cornea and usually to its inner side although not infrequently as well to the outer side of the cornea in the horizontal meridian. The growth is very common in the dark skin races and in those exposed to a dusty and irritating atmosphere, hence in millers, stone-masons, railroad employees, etc.

Pathology.—The yellow color of the pinguicula was formerly supposed to be due to a fatty metamorphosis of the conjunctiva but is now known to be due to a hyperplasia of the white and elastic connective tissue fibers of the conjunctiva, together with the deposition of a colloid substance. The epithelium over the growth is much thickened.

Diagnosis is made without difficulty. When the conjunctiva becomes red and inflamed, the pinguicula often stands out as a grayish-yellow mass. The pinguicula does not allow the red color of the injected conjunctiva to shine through as does the rest of the conjunctiva, and the former therefore stands out from the rest of the conjunctiva in the form of a light-colored spot, which beginners at times confound with a small pustule of the conjunctiva or with a diphtheritic deposit upon the conjunctiva.

Symptoms are entirely wanting. The individual notices the growths upon his eyes and comes to consult you in regard to them.

Treatment is nothing at all, unless excision which may be done

when the pinguiculæ are very large, for cosmetic purposes only. The growth is picked up with a forceps and snipped off. The wound does not require suturing.

Abscess of the Conjunctiva is a very rare condition which sometimes results as the sequel of a wound of the conjunctiva. A bulging of the conjunctiva caused by a collection of pus in the orbit should not be confounded with a conjunctival abscess.

Treatment. — The abscess should be opened.

Chemosis is the condition in which the conjunctiva adjacent to the edge of the cornea becomes thickened and raised, forming a wall of swollen tissue around the cornea. Chemosis may be active or inflammatory, or passive or non-inflammatory.

Etiology. — Chemosis occurs most frequently in purulent ophthalmia. It not infrequently accompanies to a less extent a pronounced inflammation of the cornea. A certain amount of chemosis is seen following infected wounds of the eyeball; in purulent irido-cyclitis and panophthalmitis. Chemosis with edema of the lids after cataract extraction or iridectomy is a sign of a certain amount of infection. It may follow administration of potassium iodide, or accompany an attack of urticaria. The non-inflammatory type is seen at times in women during their menstrual epochs; in nephritis, and in alcoholic and gouty subjects.

Pathology. — A section of the tissue in inflammatory chemosis shows an intense infiltration of white cells into the subconjunctival tissue at the margin of the cornea, and there are a number of newly formed blood-vessels. In the non-inflammatory type, the infiltration is very much less and there are no newly formed blood-vessels, but the condition is more one of simple edema.

Treatment. — The chemosis is scarified by incisions radiating from the edge of the cornea — if great in amount. The infiltrate does not flow away, but the incisions lessen the amount of pressure upon the circumcorneal loops of blood-vessels, and thus allow better nutrition to the cornea. Otherwise the chemosis is left alone, as it subsides with the accompanying inflammation.

Emphysema of the Conjunctiva. — Subconjunctival emphysema is characterized by a non-inflammatory swelling, which emits a peculiar fine crackling sound upon pressure. It is caused by the entrance of air beneath the conjunctiva from injuries to the lids, communicating with the lachrymal passages or from fracture of the margin of the orbit extending into one of the accessory nasal cavities.

Diagnosis is made by having the patient make an attempt to blow through the nose while he holds it shut. The tumor will then increase in size. Pressure reduces it, and a crackle is perceived.

Treatment. — There is no treatment called for, as the condition gets well spontaneously.

Lymphangiectasis Conjunctivæ consists of a small cluster of anastomosing lymph vessels or vesicles in the conjunctiva. It is most common in the outer part of the conjunctiva. The vesicles are transparent, and movable with the conjunctiva. The cause is unknown, but it occurs in those suffering with chronic conjunctivitis the most frequently. The condition consists in a dilatation of the lymph channels.

Treatment. — The tops of the vesicles may be snipped off with scissors.

Syphilis of the Conjunctiva. — Chancres occasionally develop upon the ocular conjunctiva or in the fold of transition, either from extension from the lids or as primary affections. Papillar syphilides and gummata have also been observed. There is a type of conjunctival inflammation seen in those with pronounced syphilis, called syphilitic conjunctivitis appearing as a stubborn catarrh, or folliculosis developing in rather an anemic and colloid-looking conjunctiva. Local treatment is of no avail but the trouble disappears under constitutional treatment.

Tumors of the Conjunctiva. — These may be congenital, acquired, benign or malignant.

Benign Growths — Congenital — Dermoid, Telangiectasis, Cavernoma.

- Benign Growths
  - Acquired
    - Fibroma,
    - Lipoma,
    - Myxoma,
    - Osteoma,
    - Granuloma,
    - Papilloma,
    - Simple Cysts,
    - Cysticercus Cysts,
    - Echinococcus Cysts.
- Malignant Growths
  - Epithelioma,
  - Sarcoma.

Benign, Congenital Tumors.—Dermoid tumors develop as a rule near the corneo-scleral margin. They are slightly elevated, vary in size and have a few hairs projecting from them. They are less frequently seen presenting between the eyeball and the upper lid in the outer portion of the orbit. They at times contain considerable fatty tissue and are then called *lipomatous dermoids.*

Telangiectatic Tumors and Cavernomata are benign but increase in size as the child grows and frequently recur after removal. Telangiectasis conjunctivæ is usually associated with a like condition of the lids.

Acquired Benign Tumors.—Fibromata most frequently develop upon the conjunctiva of the upper eyelid, as a result of chronic conjunctivitis. They are multiple, compressed, being elevated about one or two millimeters.

Lipoma is seen as a soft, yellowish mass, usually in the fornix, between the superior and the external recti muscles. If the mass of fatty tissue is large enough to be disfiguring, we divide the conjunctiva and take enough of it away so that none will be visible in the palpebral fissure. It is unnecessary to do a radical operation.

Myxoma develop as polypoid masses at the site of a wound or sinus.

Osteoma is a rare form of tumor developing in the ocular conjunctiva.

Granulomata develop from granulating surfaces. Granulomata or polypi are most frequently seen at the site of a chalazion which has broken through the conjunctiva or in the conjunctival wound following a tenotomy. They not infrequently become more and more constricted at their base, and finally fall off. Polypi at times are also seen in the fold of transition. In their nature they are small fibromata which push the mucous membrane before them. If large they are frequently ulcerated upon their surface.

Papillomata may occur on any part of the conjunctiva, but are oftenest seen at the caruncles. They are often taken for granulation tissue. They frequently recur after removal. Papillomata are often confused with polypi of the conjunctiva, but their surface is papillary or nodular and not smooth like that of a polyp.

Simple Cysts with clear contents are due to chronic conjunctivitis, and are most frequent near the openings of the lachrymal ducts, in the fornix and at the inner canthus. They are dilated lymphatic vessels (lymphatic ectasiæ). *Cysticercus Cysts* are usually large and present a white spot upon their outer walls, marking the attachment of the larvæ of the tænia solium or tape-worm.

Echinococcus Cysts, or those caused by the tænia echinococcus or tape-worm of the dog, frequently extend far back into the orbit. Young bladder cysts and hooklets are found as part of their contents.

Treatment of Benign Tumors in General is excision as early as possible, and cauterization of their base with silver nitrate. If the privilege of excision is denied, electrolysis should be tried. In a great number of cases if properly performed it will be successful.

Malignant Tumors.—Epithelioma of the conjunctiva usually accompanies epithelioma of the lid, but may be a primary affection. Epithelioma appears as a small reddish elevation, which soon becomes irregular and ulcerated, with slightly raised edges and a congested base.

Sarcomata may be pigmented or not, and spring from the fold of transition in the form of polypoid tumors. They are of extremely rapid growth. They not infrequently appear upon the limbus, where

they appear as a reddish or pigmented spot. The cervical glands sooner or later become enlarged and metastases occur in remote parts of the body.

Treatment of Malignant Tumors.—Early and thorough removal of the diseased tissue with the knife or cautery. If the trouble is far advanced enucleation, and exenteration of the orbit (These operations will be described later.) If the growth is at all advanced it is impossible to remove it and save the eye, as the conjunctiva must be extensively sacrificed; and in that case there occurs extensive cicatricial formation which distorts the eye or renders it immobile, and of no use for visual purposes. Besides it often happens that the growth has made its way into the interior of the eyeball, along the anterior ciliary vessels before it has progressed much upon the surface, and is therefore soon reproduced at its former site after removal.

Lepra of the Conjunctiva.—In nearly all cases leprosy of the conjunctiva is seen in general leprosy of the face. The alterations produced in the conjunctiva are: Anæsthesia, inflammation, pterygia and tubercles. On account of the anæsthesia of the conjunctiva and cornea as well, external irritants give rise to pterygia in the former and to ulceration with opacities in the latter. In the mixed and tubercular types of the disease, nodules or tubercles form around the cornea, and later grow down into the substance of the sclera and cornea; appearing not unlike a new growth upon the latter. Iritis accompanies the change in the cornea and the eye is finally lost from the breaking down of the nodules.

Lupus or Tubercular Conjunctivitis.—Tubercle of the conjunctiva manifests itself as a primary and as a secondary affection. As a primary disease it is extremely rare. It is to be considered such when there is no discoverable tubercular inflammation of the adjacent parts or other organs of the body. It is more frequently secondary to lupus vulgaris of the skin of the lids, to tuberculosis of the nose, pharynx, larynx or lungs; the infection making its way to the eye through the nasal duct or adjoining lymph glands or conveyed by soiled handkerchief or hands.

Symptoms.—Tubercular conjunctivitis usually attacks only one eye. There is no pain. The patient is made aware of trouble with his eye by swelling of the lids, scanty purulent secretion, and subsequently by a diminution of visual power. This occurs without exception in the young and runs a very chronic course. The appearances differ somewhat when tuberculosis of the conjunctiva appears as an extension from adjacent mucous or cutaneous surfaces (lupus vulgaris) or when it has occurred as a direct infection of the conjunctiva. In the first instance it appears as an elevated, irregular patch or patches, having uneven and ulcerating surfaces, from which small polypoid granulations project. These patches are as a rule met with upon the lid conjunctiva but may be present upon the ocular conjunctiva as well. When the trouble is the result of direct inoculation the early stage is marked by a distinct congestion of the conjunctiva and the appearances of numerous small discrete, grayish nodules in the ocular or palpebral conjunctiva, especially in the sulcus subtarsalis the commonest locality, which do not present an ulcerated surface. The ulcerating variety gradually passes entirely over the eyeball and the cornea becomes covered with a sort of pannus. The ulcer may extend through the entire thickness of the lid. The lymphatic glands in front of the ear on the same side become enlarged quite early, and finally those beneath the jaw and in the neck.

Etiology.—The specific cause of the disease is the tubercle bacillus of Koch. It seems from the researches of Valude that an abrasion of the epithelium is necessary for the inception of the organism and hence the disease. A particle of dust containing bacilli gets into the conjunctival cul-de-sac, and with its sharp edges produces a small superficial lesion of the conjunctiva with consequent infection, so that tubercular lesions frequently begin in the region of the sulcus subtarsalis, where small foreign bodies are most readily retained.

Pathology.—The tissues of the neoplasms show loss of epithelium at the site of the ulcer, granulation tissue, granular detritus, newly formed connective tissue elements, giant cells with numerous leukocytes, with a limited number of tubercle bacilli.

Diagnosis.—The diagnosis may be established in doubtful cases by examining cover glass specimens of scrapings or sections from the ulcers or nodules for the tubercle bacilli, or by inoculating guinea-pigs with scrapings from the tissues. The granular variety of the disease may be taken for trachoma or the ulcers for syphilis or epithelioma. In trachoma the lymph glands are not involved, and the follicles yield to treatment with sulphate of copper, which has no effect upon tubercular conjunctivitis. From syphilis it is told by the absence of a specific history and absence of other lesions upon the body; from epithelioma by the age of the patient.

Prognosis is good if the patient is otherwise free from tuberculous invasion.

Treatment.—The diseased parts should be completely excised if possible; ulcers curetted and cauterized, and the wounds thus made covered every day with powdered iodoform, which is particularly efficacious in tuberculous processes. The Finsen light and X-ray treatment are to be resorted to in exaggerated or stubborn cases.

Herpes Conjunctivæ.—Herpes febrilis or catarrhalis as we see it upon the skin now and then occurs upon the conjunctiva, and still more infrequently it is seen upon the cornea. The occurrence of herpes zoster upon the eye has been long recognized but the occurrence of the febrile variety was not known until Horner in 1880, and Arlt a year later, called attention to it.

Diagnosis.—It is differentiated from herpes zoster on account of the agonizing pain that accompanies the efflorescence of that affection. There will be the usual eruption upon the face, occurring in the course of some febrile or debilitating disease, as pneumonia or typhoid. The vesicles upon the conjunctiva will usually be overlooked as they are seldom seen distended but broken and their former site marked by a small conjunctival ulcer, with shreds of epithelium hanging to it and a local hyperemia.

Treatment is not needed unless there is an accompanying mattering of the eye, then the usual remedies for conjunctivitis are indicated. Herpetic eruption of the cornea will be considered later.

Pemphigus is a very rare disease of the conjunctiva characterized as is the disease in other localities by the formation of bullæ, which are perfectly transparent. The bullæ rupture and leave a raw surface upon the conjunctiva of the lids and eyeball. As these areas heal the membrane becomes atrophic, other patches occur, further atrophy takes place and finally the condition known as symblepharon posterius results. The conjunctival surface becomes dry and shiny (xerosis), the cornea opaque and vision is lost. According to Horner the disease occurs once in about 23,000 eye cases.

Etiology. — The cause of pemphigus is unknown. In about four per cent. of cases there is a history of syphilis. Individuals of all ages are attacked although it is commonest at the extremes of life. Pemphigus of the eye may accompany p. vulgaris or p. foliaceus.

Pathology. — The conjunctival epithelium being thin is cast off very early leaving the raw surfaces. A deposit of fibrin soon forms over the affected area, transforming the red raw surface into a grayish patch.

Symptoms. — The disease is essentially a chronic one. There is little or no secretion. Vision decreases with the advance of atrophy of the conjunctiva.

Prognosis. — The disease usually results in loss of vision.

Treatment is of little or no avail. Arsenic internally is said to do good. General hygienic and tonic treatment is always indicated.

Ulcers of the Conjunctiva. — Ulcers of the conjunctiva occur in the following affections: Tuberculosis of the conjunctiva, phyctenular conjunctivitis, diphtheritic conjunctivitis, from burns and caustics, as a result of certain exanthems, as variola, measles, etc., pemphigus, epitheliomata, syphilis.

Injuries of the Conjunctiva. — Foreign bodies which embed themselves in the conjunctiva are difficult to remove. Cocain should be instilled and an effort made to dislodge the body with a spud or point of a needle. If this fails, the conjunctiva including the foreign body is picked up with a pair of rat-tooth forceps and snipped off with scissors.

Bruises and wounds of the conjunctiva of the eyeball are accompanied by an extravasation of blood under the conjunctiva (ecchy-

moma subconjunctivale, subconjunctival ecchymosis). Ecchymosis is distinguished from inflammatory redness of the conjunctiva, by its uniformly red coloration, in which the network of injected conjunctival vessels can not be recognized, and also by its failure to fade upon pressure, and its sharp limitation. Ecchymosis is seen after certain operations especially squint operations and may be spontaneous in decided inflammation of the conjunctiva. In old people whose arteries are brittle, it is very common for them to awake in the morning and find that they have a blood-shot eye. The rupture of a conjunctival vessel occurs in such cases upon the least exertion. Children with whooping-cough frequently develop an ecchymosis from the effort of coughing. A special significance is attached to those cases of ecchymosis which develop after injuries to the skull. We have then to do with a fracture at the base of the skull, the blood oozing forward through the orbit until it lodges beneath the conjunctiva. After blows upon the eye there is usually more or less edema of the conjunctiva with the extravasation of blood beneath it. Subconjunctival ecchymosis is absolutely free from danger, but it is very alarming to most people. A pinguicula with the bright red area of ecchymosis stands out as a bright yellowish spot upon the red background. The margin of the ecchymosis is separated from the cornea by a narrow gray line, that is the limbus conjunctivæ, which is too closely adherent to the underlying sclera to be lifted up by the effused blood. Now and then the iris seems discolored, appearing not unlike an iritis after extravasation of blood beneath the conjunctiva, for instance a blue iris appears greenish. This is due to the extension of a thin layer of blood between the corneal lamellæ, through which the iris is viewed. Subconjunctival ecchymosis becomes absorbed in a week or ten days. A solution of borax or what not is prescribed for the benefit of the patient and not for the eye as it needs no treatment save frequent bathing with hot water. Subconjunctival injection of 4 to 6 minums of normal salt solution will shorten period of resorption several days. The eye is cocainized. The upper lid is elevated with the finger, and the needle of the hypodermic syringe

pushed beneath the ocular conjunctiva as near the center of the spot of ecchymosis as possible. It is not necessary to raise the conjunctiva with a pair of forceps to introduce the needle. The conjunctiva is raised by the injection in the form of a bulla, which subsides in twelve hours or so. A bandage is applied for several hours. Subconjunctival injection of fluid does good by causing the lymphatics to work vigorously to get rid of the extra amount of fluid in the tissues, and with the escape of the salt solution some extravasated blood is carried away.

Wounds of the conjunctiva if of any considerable extent should be sutured after cleansing as well as possible with a wisk of cotton and boric acid solution. Burns are commonly caused by unslaked lime or acids. Slaked lime however is also decidedly caustic. Burns of the conjunctiva are serious on account of the probable development of symblepharon. If the substance is lime all particles must be removed, which is best done by flooding the eye with water. If the agent is an acid, it should be neutralized by a weak alkali bicarbonate of soda solution. The subsequent treatment calls for the instillation of olive or castor oil, and atropia to prevent iritis if the cornea has been injured. The atropin may be incorporated with liquid vaseline or albolene and used as a collyrium.

Edema of the Conjunctiva is inflammatory and non-inflammatory. The former is associated with various inflammations of the eyeball and its adnexa as follows: Erysipelas and hordeolum of the lids; tenonitis, phlegmon and periostitis of the orbit; dacryocystitis; acute purulent conjunctivitis; of the eyeball itself, purulent keratitis, iridocyclitis, purulent chorioiditis and panophthalmitis. The conjunctiva will often be decidedly more edematous in the palpebral fissure as there the pressure exerted by the lids is wanting.

Non-inflammatory Edema is caused by hydremia or by stasis. It therefore occurs as a symptom of kidney or cardiac trouble, and is fugitive in its nature (edema fugax). Certain females have a decided edema of the conjunctiva coming a few days before their sickness and persisting until its close. A peculiar sort of edema is that

caused by the leakage of the aqueous humor beneath the conjunctiva after a small perforation of the sclera in its anterior portion or of the cornea. This edema disappears after cicatrization has taken place. If a sinus forms from failure of the wound to close, the edema too persists, a condition called cystoid cicatrix, and which is seen most frequently after cataract operations. The edema is seen in the region of the fistulous opening or below, having sunken to the lowest part of the conjunctival cul-de-sac.

Affections of the Caruncle. — The caruncle and semilunar fold are more or less swollen in all inflammations of the conjunctiva in general, but may undergo localized inflammation, and enlargement to which the name of encanthis is given. It may be acute or chronic, and go on to the formation of an abscess. Swollen and congested caruncles are commonly seen in people suffering from eye-strain, especially from inefficiency of convergence. The caruncle is red and elevated and a leash of vessels is seen running from it towards the cornea. The caruncles should be carefully examined for foreign bodies or the lids inspected for misplaced cilia that rub against them whenever the patient complains of irritation, lachrymation and inability to use the eyes, when no other cause is ascertainable. Inasmuch as the caruncle is a piece of misplaced skin there may be an excessive development of hairs upon it, a condition called trichosis carunculæ. Adenomata, carcinomata and sarcomata have been seen upon the caruncle.

Argyria Conjunctivæ (Argyrosis). — The long continued use of nitrate of silver solution upon the conjunctiva leads to a discoloration affecting both the tarsal and the ocular conjunctiva, most marked in its lower half. The color varies from a light to a deep brown. The conjunctiva, especially that of the lower fornix, is apt to be hypertrophied. This staining of the conjunctiva is more or less indelible. Some good can be done by the frequent instillation of iodid of potash solution or hyposulphite of sodium in strength of one part to ten of water. By the prolonged use of these the conjunctiva is bleached somewhat.

CHAPTER IX

DISEASES OF THE LACHRYMAL APPARATUS

We shall first consider affections of the lachrymal gland and its ducts and then those of the excretory or drainage apparatus, including the puncta, canaliculi and lachrymal duct. The gland is rarely the seat of disease, while disease of the drainage apparatus is very frequent, forming about two per cent. of eye diseases.

Dacryoadenitis or inflammation of the lachrymal gland may be either acute or chronic.

Etiology.—Dacryoadenitis occurs more frequently in childhood, and in adult life more frequently in women than in men. Galezowski reports an epidemic of it associated with mumps. It may arise from traumatism, cold, rheumatism, gout, syphilis and septicemia. It is usually unilateral, but may occur on both sides.

Symptoms.—There is severe pain accompanied by a mild febrile reaction with more or less restlessness in acute cases. The lids, especially the upper, are greatly swollen and the conjunctiva chemotic. The eyeball may be displaced downward and inward and its motion limited and painful. The general appearance of the eye is that of acute purulent ophthalmia minus the secretion. On account of the pain and swelling of the lids a view of the lachrymal gland can not be gotten. The inflammation subsides in a few days or goes on to the formation of pus, the pus making its way through the lid or into the conjunctival cul-de-sac.

In Chronic Dacryoadenitis the enlargement of the gland may be felt through the lid and frequently seen, especially in colored people in whom the lachrymal gland is very prominent. It is brought into view by elevating the upper lid and having the patient look down and to the opposite side. Mumps of the lachrymal gland is usually bilateral.

Treatment.—If the case is seen early several leeches should be applied to the lid and brow, followed by iced compresses. The bowels should be freely moved by salines (pyrophosphate of soda, gr. 20, every two hours). If the cold aggravates the pain, hot compresses or the Japanese hot-box should be substituted. For the further control of pain if necessary heroin or morphin may be given. If there is a rheumatic history salicylate of sodium must be energetically employed internally, and KI and mercurial inunctions pushed if there is any evidence of specific trouble. Should the case go on to suppuration, the abscess should be evacuated through an incision in the lid or conjunctival sac as seems best. In chronic inflammation of the gland the local application of compound iodin or mercurial ointment to the brow with the internal administration of alterative tonics is indicated.

Fistula of the Lachrymal Gland has been observed as a congenital anomaly, but is usually the result of trauma or suppurative dacryoadenitis. There is a fistulous opening through the integument of the upper eyelid through which tears flow and excoriate the lids and cheek. It is difficult to cure. If the fistula is closed the lachrymal gland frequently becomes inflamed as the result. The best manner of treatment is to convert the external opening into one upon the conjunctival surface of the lid, as suggested by Bowman. It is done as follows: A threaded needle is passed a short distance into the fistula, and then brought out upon the conjunctival surface of the lid. The needle upon the other end of the thread is passed through the lid close to the external orifice of the fistula; the two ends are now tied tightly and the thread left to cut its way out. Before passing the sutures the edges of the fistula are freshened to secure closure.

Dacryops or cyst of the lachrymal gland is a rare condition caused by stoppage of some of the ducts of the gland. It has been observed as a congenital defect. Upon everting the upper lid a translucent, elastic swelling is seen consisting perhaps of several lobules. The contents of the cyst when drawn off (with a hypodermic syringe) is found to contain sodium chlorid, which is evidenced by the fluid causing a precipitate in a solution of silver nitrate.

Treatment consists in establishing free drainage through a permanent opening between the cyst and the conjunctival cul-de-sac. This is accomplished by cutting away part of the cyst wall, and passing a probe frequently to keep the wound open, or better still, as suggested by V. Graefe, is to pass a suture through the cyst and allow the thread to cut its way out.

Lachrymal Calculi or Dacryoliths. — Concretions called dacryoliths now and then form in the lachrymal gland. They cause mechanical irritation and should be removed through an incision in the conjunctiva. They are diagnosed by their hardness.

Prolapse of the Lachrymal Gland (hernia of the lachrymal gland, dislocation of the lachrymal gland). — May be spontaneous or as is more often the case the result of injury to the parts adjacent. Noyes, Mauthner and Briere report cases of spontaneous luxation. Briere's case was associated with caries of the orbit. Other causes of spontaneous luxation are: Relaxation of the investing capsule of the gland, enophthalmos and phthisis balbi.

Treatment. — The gland should be reduced if possible and held in position by a compress. To replace the gland an incision through the upper lid along the margin of the orbit is needed. If reduction can not be accomplished the gland should be removed.

The gland may be removed in one of the following ways: It is exposed by an incision through the upper eyelid parallel to the margin of the orbit; drawn out by means of a tenaculum and severed from its attachments with scissors or knife. Inasmuch as this operation involves a more or less complete division of the levator palpebræ superioris, ptosis is apt to result. The plan suggested by Velpeau is therefore probably the better plan, that is to divide the external canthus, evert the upper lid, and cut down upon the gland from the superior conjunctival cul-de-sac.

Hypertrophy of the Lachrymal Gland. — Congenital hypertrophy of the lachrymal gland has been observed. The enlargement of the gland is more common in children, and may become so great as to endanger the sight through stretching and compression of the optic

nerve. The hypertrophied gland commonly contains a number of dacryoliths. The hypertrophy is at times of syphilitic origin.

Treatment.—If the enlargement of the gland is so great as to endanger the integrity of the eyeball, it should be removed. Otherwise the internal administration of KI, and local applications of compound iodin or mercurial ointment should be thoroughly tried.

Atrophy of the Lachrymal Gland is observed in certain cases of xerophthalmos. In fifth nerve paralysis lachrymation is abolished, but the gland does not atrophy.

Tumors of the Lachrymal Gland.—The following growths are observed in the lachrymal gland: Adenoma, myxoma, adeno-sarcoma, lympho-sarcoma, spindle-cell sarcoma, epithelioma, cylindroma, chloroma and carcinoma. As they increase in size they interfere with the movements of the eyeball, giving rise to diplopia, and later to exophthalmos. They destroy sight by stretching and pressing upon the optic nerve. They rarely invade the eyeball, but may extend to the brain, causing death. Early and complete removal of the gland with the growth is of course the treatment.

Diseases of the Drainage Apparatus.—Any portion of the drainage apparatus may be the seat of a diseased condition, but one symptom accompanies them all, and that is tear-drop (epiphora, stillicidium lachrymarum). Instead of the tears flowing into the nose as they should they overflow the cheek, giving rise to an irritated and eczematous condition of the integument; it also leads to a chronic inflammation of the conjunctiva (lachrymal conjunctivitis) and blepharitis. At first the tear-drop may be noticed only when the patient is in the wind or when he stoops for awhile a few tears flow over the cheek.

Abnormalities of the Puncta include atresia, inversion and eversion.

Atresia is congenital and acquired; when the former it is associated with an absence of the canaliculus. As an acquired condition it is seldom seen save after a destructive inflammation of the lid margins at the inner canthus. A partial atresia is seen in chronic hypertrophic conjunctivitis of ectropion, and in senility. In acute

conjunctivitis there is often sufficient swelling to occlude the puncta for the time being.

Treatment. — The occlusion of the punctum may be readily overcome if the canaliculus is not involved. For this purpose a hat-pin with a somewhat blunted point is taken and a hole drilled with it at the site of the punctum which is indicated by a small depression. Somewhat larger probes are introduced every day or so until the punctum remains patulous. To introduce the probe the lower lid is made taut by drawing it towards the temple.

Malpositions of Puncta. — Malposition of the upper puncta does not occur save in cicatricial ectropion, and symblepharon of the upper lid, but faulty positions of the lower puncta are very common.

Eversion of Punctum. — By eversion of punctum is meant a condition in which it is no longer applied to the eyeball, but looks up or out. It occurs in Bell's paralysis, due to loss of tone of the lid, in ectropion, exophthalmos and in senile relaxation of the palpebral tissue.

Treatment (of uncomplicated eversion of punctum). — A suture is passed into the conjunctival surface of the lid below the punctum, several millimeters from the border of the lid, and carried beneath the conjunctiva to a point below the margin of the orbit and brought out upon the skin. The needle upon the other end of the thread is passed in a similar manner parallel with the first, and the ends of the suture tied over a bit of gauze or rubber tubing (Snellen's suture). The suture is allowed to remain for a week, until adhesive inflammation fastens the lid in its new position. The punctum should be slightly inverted by tying the thread tightly, as the result lessens after the suture is removed.

Inversion of Punctum occurs in entropion, symblepharon, enophthalmos. As in eversion, epiphora is the result.

Treatment (of uncomplicated inversion of punctum) is the reverse of that for eversion, that is the suture is passed through the lid from the skin surface and brought out below and tied.

Atresia of the Canaliculi. — Stricture of the canaliculi is at times

seen as a congenital defect, but more frequently it is associated with a stricture of the nasal duct or traumatic in origin. It is common to find a closure of the canal at its juncture with the sac in cases of atresia of the nasal duct. Dacryoliths are occasionally found in the canaliculi. They are formed of concretions of lime together with a fungus identical with the leptothrix buccalis according to some observers; others deny this and suppose a cilia or small foreign body of some kind to be the nucleus around which the lime is deposited.

Foreign bodies such as eye-lashes, beards of wheat, and cinders find their way at times into the canaliculi. If they project from the punctum they may be withdrawn, otherwise the canal must be slit. Haffner reports a case of ascaris lumbricoides in the lower canaliculus.

Dacryocystitis or Inflammation of the Lachrymal Sac occurs as an acute and chronic affection. The former is spoken of as lachrymal abscess and the latter as mucocele, or blenorrhœa of the lachrymal sac. Inasmuch as mucocele in the vast majority of cases precedes abscess formation in the sac it will be first described.

Mucocele is a collection of muco-pus or catarrhal secretion in the lachrymal sac. It originates from a stoppage of the lachrymal duct by which the tears are prohibited from entering the nose. The tears are constantly formed and carried into the sac where they stagnate, decompose and irritate the mucous lining of the sac causing it to secrete an abnormal amount of mucus. The contents of the sac grows more and more turbid and finally resembles pus. Mucocele is therefore nothing more than a catarrhal inflammation of the mucous membrane of the lachrymal sac.

Symptoms. — The patient complains of a watering eye, which is often revealed to the observer by a collection of tears along the border of the lower lid and at the inner canthus of the eye. A lump forms upon the side of the nose just below the inner canthus (*i. e.*, below the tarsal ligament), pressure upon which causes muco-pus to pass through the puncta upon the eyeball, or to enter the nose if the canaliculi or puncta are closed. There is no pain and no inflammatory swelling of the adjacent tissues. There is often present a

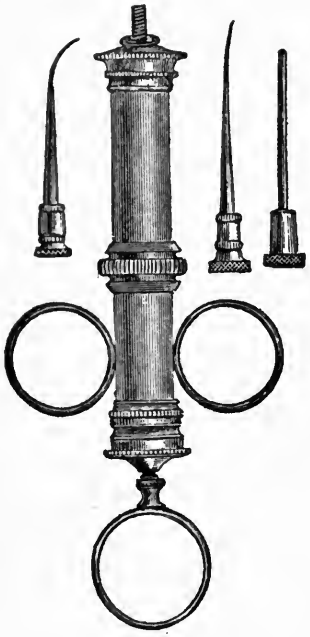
chronic inflammation of the conjunctiva with some mattering and not infrequently corneal ulcers develop in the lower portion of the cornea, where its epithelium is macerated by the tears. The epithelium exfoliates and infection of the cornea follows, as the secretion from the sac is usually rich in pus-cocci.

Etiology.—The stricture of the lachrymal duct as a rule develops from an affection of the nasal cavity. Under this head belong the various forms of coryza, acute and chronic. The swelling of the mucous membrane of the nasal cavity extends by continuity of tissue to the lachrymal duct, being particularly due to the engorgement of the numerous veins lying beneath the latter, which in itself is sufficient to stenose the duct. In ozena there is no swelling but a cicatricial contraction of the mucous membrane leading to a constriction of the duct. Ulcers of the nostrils as those associated with syphilis and tuberculosis of the nasal cavities lead to cicatricial contraction and closure of the duct. Tumors, chiefly polypi and hypertrophied inferior turbinals, conceal the lower orifice of the duct, and prevent the drainage of the tears. In ozena we often find a bony stenosis from caries and exostosis of the adjacent bony framework of the canal.

Prognosis.—A spontaneous cure may result, if the stenosis of the duct subsides. The tears drain into the nose and at the same time the catarrhal inflammation of the mucous lining of the lachrymal sac subsides. This occurs very rarely however. The disease is essentially a chronic one. The secretion after a while becomes less purulent and more mucous and viscid, and finally ceases altogether from atrophy of the mucous membrane. The distended lachrymal sac then contains simply a clear fluid, the tears, but the epiphora continues. To this condition the name of hydrops of the lachrymal sac is given. By this time the sac has lost its elasticity (atony of the sac) on account of its constant distention, and in consequence the epiphora continues even when the stricture in the duct has been overcome. Mucocele is a contra-indication for operations upon the eyeball on account of the liability of infection.

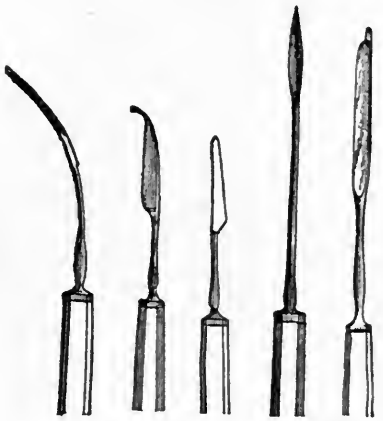
Treatment.—This must be addressed first of all to the nasal dis-

ease at the root of the trouble, if it still exists. This is most frequently neglected, no attention being paid to the nose at all in cases of epiphora. As regards the lachrymal sac itself, the patient should be told to evacuate it very frequently by pressure with the finger at the inner angle of the eye. By this accumulation of tears with their decomposition and dilatation of the sac are prohibited. The sac should be treated by frequent irrigations with an antiseptic astringent solution, such as bichlorid of mercury 1–4,000, with one grain of zinc sulphate to the ounce, or sulpho-carbolate of zinc, 10 gr. to 1 oz. of water, or what not. The liquid is injected through the canaliculus with a syringe supplied with a slender canula with a right angle bend in it at the point. The patient should be given some to use at home. Several drops should be instilled at the inner canthus three or four times a day after the sac has been emptied by pressure. If this treatment does not effect a cure in the course of several weeks, more radical measures are to be employed. One canaliculus is slit up, converting it into an open gutter, and then successively larger and larger probes are passed through the lachrymal duct until it remains patulous. The lower canaliculus is the one usually chosen, but the writer is partial to treating the stricture of the nasal duct through the slit upper canaliculus, as suggested by Bowman. The lower canaliculus is the more important of the two in conveying the tears into the sac, and this function is entirely destroyed in slitting it, thus converting it into an open gutter that runs up and in and in consequence of its course conveys few tears. It is also much easier to pass a probe into the duct through the upper canaliculus; whichever one is chosen, a slender probe-pointed knife



Anel's Lachrymal Syringe.

is taken, and passed into the punctum, and then turned and pushed towards the lachrymal sac until its probe point comes in contact with the inner wall of the sac, which is made evident by the knife meeting firm resistance against the lachrymal bone. If the point of the knife is not properly in the sac but caught in a fold of mucous membrane, the lid will be dragged upon and follow the movement of the knife as it is moved backward and forward. The point of the knife is now kept against the inner wall of the sac and its cutting edge turned towards the mucous surface of the lid while the handle is elevated or depressed, etc. Thus the canal is converted into a groove, lying upon the conjunctival surface of the lid near its border. Several forms of canaliculus knives are shown in the cuts below. The probe point of the knife should be small and its shank short so that the knife cuts well up into the sac. A straight knife is preferable.

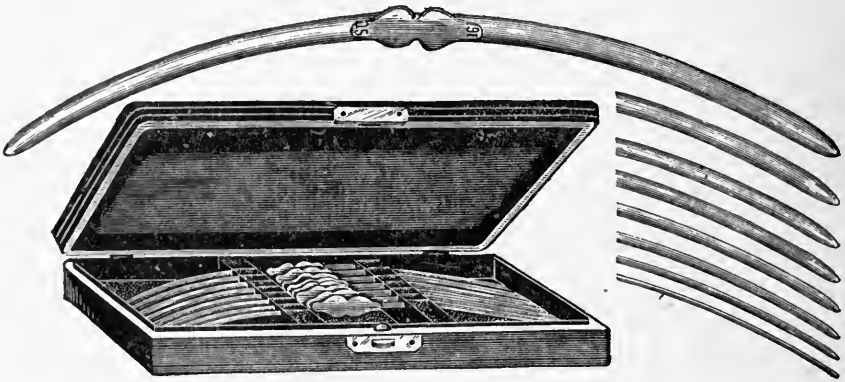


Weber's Curved. Weber's Straight. Noyes- Stilling's. Agnew's Noyes'.

Canaliculus Knives.

To make the operation as painless and as bloodless as possible a solution of adrenalin and cocain is first injected into the canal through the punctum (cocain muriate, gr. 5; adrenalin sol. (1–10,000) dr. i). The canaliculus is slit to facilitate the introduction of sounds into the lachrymal sac. The smaller sized sounds can be passed without slitting the canaliculus. In mild cases and especially epiphora without mucocele the writer is partial to this method of treatment for as noted above the slitting of the canaliculus destroys its function. For sounding the lachrymal duct we employ Bowman's or Theobald's sounds, which are of different sizes; Bowman's are numbered from one to six and Theobald's from one to sixteen. Great care should be exercised in the passage of the probe for the first few times especially, so that the mucous membrane of the

sac or duct is not torn by catching the end of the probe in a fold of it; otherwise you defeat your end, by subsequent cicatrization and contraction of the duct. No great amount of force is required to introduce a probe, if so it is likely that mucous membrane is being pushed before it. The slenderest probe is at first used. It is passed along the slit lower canaliculus until its end comes against the inner wall of the sac. Its free end is then raised until it lies against the superior orbital ridge over the supraorbital notch; the probe is then directed to the furrow between the ala nasi and the cheek, marking the direction of the lachrymal duct. This position of the probe is maintained as it is slowly pushed down the duct until its end rests upon the floor of the nose. If the sound has properly entered the

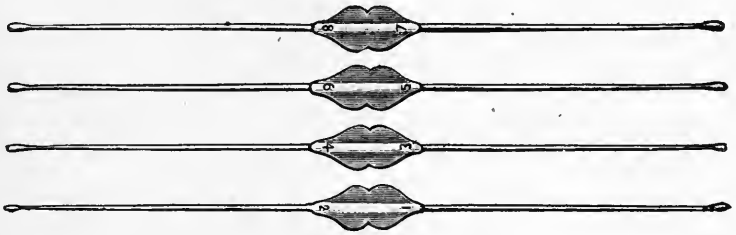


Set of Theobald's sounds.

nose it can be felt with another sound passed through the anterior naris beneath the inferior turbinal about two to two inches and a half from the tip of the nose. In case the upper canaliculus has been slit, it is only necessary to elevate the upper lid, and to pass the probe directly into the sac by sliding it along the slit canal as it passes behind the caruncle.

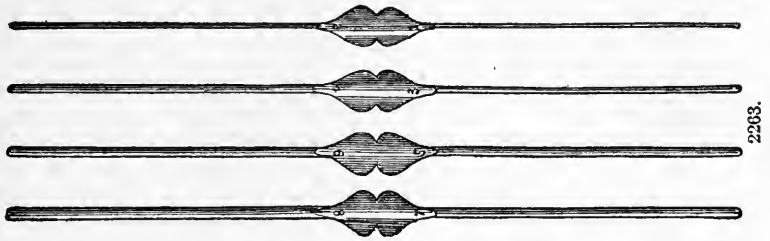
Before each probing a few drops of the cocain and adrenalin solution mentioned above should be passed into the sac and the probe lubricated with an antiseptic lubricant. The probe is allowed to

remain in situ ten or fifteen minutes, and then withdrawn. While removing the probe the lid is pulled away from the eyeball and held firmly against the orbital ridge. We repeat the sounding every day or every other day, gradually using larger and larger sounds. The sounding should be continued at intervals of several weeks for some time after the stricture of the duct has been overcome, as it will otherwise soon close up again.



Set of Bowman's sounds — two mounted on one handle.

The average size of the nasal duct in the cadaver according to measurements by Theobald is about 4.5 mm., so that to restore the patency of the canal it is necessary to employ larger probes than



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Set of Williams' sounds with probe points.

those used by Bowman, the largest of which measures only 1.5 mm. in diameter. The Theobald series of sounds is a very useful one, the largest of which is 4 mm. in diameter. It will not often be necessary to use such a large sound however to cure the case.

The most favorable cases are those which are caused by a simple swelling of the mucous membrane lining the canal; cicatricial contraction of the duct is less favorable, and complete closure of the duct

especially by exostosis is the least favorable. A bony stricture of the duct can only be overcome by aid of mallet and gouge. A slender gouge is passed into the lachrymal sac after the manner of a sound (the patient being under a general anæsthetic), turned and passed into the duct to the point of stricture which is cut through after causing the position of the gouge to conform to the direction of the naso-labial line. A stout piece of lead wire (style) is then introduced and its end bent over the edge of the lower lid. Styles and tubes are frequently used in the treatment of stricture of the lachrymal duct, and with good success, in fact treatment by means of permanent probes or styles is less objectionable to the patient than sounding, as it is unnecessary to subject him so frequently to sounding, which is always painful. Lead styles are preferable to lachrymal tubes made of silver or gold, as the tube soon becomes filled with concretion, and does not drain any better than the style, and again it is not safe to allow the shank of the tube to rest in the split canaliculus, and it will most surely work itself down into the sac and give considerable trouble in getting it out. If it should happen that a style or lachrymal tube works its way into the lachrymal sac it may be recovered by means of a blunt hook passed down beside it and turned beneath the crook in the style or tube. If it is of malleable material (lead) it may be pushed down into the nose with a sound. Otherwise it should be extracted through an opening in the anterior wall of the sac.

After ascertaining the proper length of style needed the wire is cut and its ends rounded off with a knife. It is then introduced and the upper end bent over the edge of the lower lid, care being taken that the curve is not sharp enough to cause the end to burrow into the skin of the lid. The style is allowed to remain for a week or two, then removed, the sac washed out and a larger style introduced. Styles are thus worn for several months and removed. A sound should then be passed once every two weeks for several months more and then treatment discontinued. Some ophthalmologists desire to accomplish the dilatation of strictures rapidly, as is done by

Weber, Theobald, and Stilling. The former two begin the treatment with large sounds, while the latter cuts through the stricture with a canaliculus knife or one designed for the purpose passed into the duct, and then introduces a large sound. By these methods of treatment however the mucous membrane of the sac or duct or both is wounded and hence repaired by cicatrix, which is sure to contract and to sooner or later obliterate the duct. Gradual dilatation is therefore to be preferred. Some cases can not be cured by sounds or styles. Even when the duct will allow the introduction of the larger sounds the epiphora continues. This is the inevitable result if the lining of the sac is injured and its elasticity destroyed. If such give rise to considerble annoyance, the destruction of the lachrymal sac is called for together with the exsection of the lachrymal gland.

Removal of the sac relieves the patient of the danger of corneal infection, but the epiphora continues and is even more annoying because when the sac was present a portion of the tears drained into it, but now all run over the lid. The gland should therefore be removed along with the lachrymal sac. The eye does not suffer unduly from dryness in consequence and the procedure is perfectly safe. The sac can be destroyed by obliteration or exsected. In either case the sac is opened by an incision made in front through the skin. The operation is performed according to the method of Petit as follows:

The internal palpebral ligament is put upon the stretch by drawing the lids toward the temple. The point of a small scalpel is then introduced directly beneath the center of the ligament. The cutting edge of the knife points downward and the handle is held so that it would bisect a line drawn from the apex of the nose to the outer margin of the orbit. The knife is then made to penetrate the skin and the anterior wall of the sac. When the point of the knife is felt to strike the lachrymal bone, the handle is elevated as high as the forehead. The knife is now pushed forward so that its point enters the upper portion of the lachrymal duct, the wound in the anterior wall of the sac being at the same time enlarged. The knife is now withdrawn and the wound enlarged upwards and downwards, thus

exposing the mucous lining of the sac throughout its whole extent. The mucous membrane of the sac is now dissected out through its entire extent. To be certain that all has been removed we employ a sharp spoon to curette the cavity thoroughly. The external wound is now closed with sutures and the walls of the sac held in apposition by a compress bandage. If we had wished to obliterate the sac, after making the external opening a little Vienna or London paste is introduced into the sac and the wound left to granulate. The operation of extirpation is more difficult than that of obliteration but gives a shorter period of treatment.

By extirpation or obliteration of the lachrymal sac the patient is relieved of the danger of acquiring an abscess or ulcer of the cornea and of phlegmonous inflammations in the sac itself. The manner of removing the lachrymal gland has already been described. In one who suffers with a mucocele a violent inflammation in the sac and adjoining tissue may suddenly develop, giving rise to a lachrymal abscess (acute dacryocystitis).

Acute Dacryocystitis (*Lachrymal Abscess*).—Acute dacryocystitis consists of a purulent inflammation in the connective tissue surrounding the lachrymal sac. The skin in the vicinity of the sac becomes swollen and reddened, the swelling extends to the eyelids and before long the region of the lachrymal sac is excessively tender to pressure. The conjunctiva at times partakes of the inflammatory reaction and becomes edematous and chemotic. After some days the skin at the apex of the swelling becomes yellowish from pus beneath it and perforates, when considerable amount of pus is evacuated. The swelling now soon abates and the discharge becomes more mucoid, and finally clear like water. The perforation through the skin remains as a fistula through which the contents of the sac drain. As long as the lachrymal fistula remains patulous the patient is free from any more attacks of inflammation but when the fistula closes the tears again collect in the sac and the process is repeated. Acute dacryocystitis seldom occurs unless preceded by blenorrhœa of the lachrymal sac (mucocele).

Etiology. — Pus organisms gain access to the lachrymal sac from the nose, and possibly from the conjunctival cul-de-sac at times, where they multiply and finally penetrate the walls of the lachrymal sac and give rise to abscess formation in the adjacent connective tissue.

Treatment. — No attempt should be made to overcome the stricture in the lachrymal duct while the parts are swollen and painful. If we see the case in its incipiency, we may try to abort abscess formation by gently pressing the fluid from the sac, and injecting an antiseptic solution (boric acid, bichlorid, formalin, permanganate of potash solution or what not) and then bandaging the eye with iced compresses for one half hour in every hour. If the inflammation has passed the initial stage we then hasten the formation of pus by hot moist applications (compresses) and as soon as fluctuation makes itself apparent we incise the anterior wall of the lachrymal sac or the point at which pointing occurs. This fistula must be kept open by a piece of gauze and the sac washed out through it daily with one of the antiseptic solutions mentioned above. As soon as the suppuration has come to an end we slit up the canaliculus and treat the case as one of mucocele. If the fistula fails to close after the stricture of the duct has been overcome we cauterize its edges.

Pre-lachrymal Abscess consists of a swelling above the internal palpebral ligament, and a little external to the lachrymal sac with which it has no connection. It may be associated with a fistulous opening from which pus exudes. It is caused by blows at the inner angle of the eye and by caries of the lachrymal bone. In children with congenital syphilis the same thing occurs without injury.

Diagnosis. — This condition is distinguished from a true lachrymal abscess, by the fact that there is no interference with the passage of tears, and by the absence of acute inflammation.

Treatment is that of an abscess, with internal administration of mercurials if specific history is obtainable.

CHAPTER X

DISEASES OF THE CORNEA

THERE are certain abnormal conditions consisting in alteration of the corneal curvature, which are either congenital or acquired, and which do not result from inflammation of the cornea. Such are astigmatism, conical cornea and so forth. Inflammation may affect any of the layers of the cornea, causing opacities of various kinds, infiltrations of serum or pus or ulcerations taking on diverse forms and often leading to total destruction and perforation of the cornea, or to a change in its shape. Blood-vessels at times are formed in the superficial or deep layers of the cornea, as the result of inflammation. In very chronic cases of inflammation there occurs a sort of sclerosis of the cornea, which appears as a yellowish degeneration. At times there is a calcareous deposit in the cornea, and still more rarely pigment deposits.

The term keratitis or corneitis is used to designate an inflammation of the cornea. Inasmuch as the cornea is devoid of blood-vessels, cell proliferation and cell migration are especially conspicuous factors in corneal inflammation. The epithelium may exfoliate or proliferate, the deeper cells divide and their nuclei undergo the various changes of karyokinesis (Fleming). Regeneration occurs rapidly and may be associated with the formation of blood-vessels. Often in cases where there has been a loss of substance of the cornea the epithelium is first reproduced, giving rise to small facets or indentations in the cornea. In inflammation of the parenchyma of the cornea the leukocytes wander into the numerous canals traversing the cornea, from the neighboring blood-vessels which are the circumcorneal loops. The leukocytes often arrange themselves in rows and under oblique light give rise to the fine straight lines which are seen after wounds of the cornea. The fixed corneal corpuscles also undergo changes;

they multiply and form concentric groupings. The fibrillæ soften and disintegrate. If the number of lymph corpuscles is not too great they are absorbed and transparency of the cornea is restored; on the other hand there is a necrosis of the tissue, on the surface giving rise to an ulcer and to an abscess if within the substance of the cornea. Such lesions heal with the formation of cicatrix or scar. We can at once then divide corneal disease into suppurative and non-suppurative, or those that heal by loss of substance and cicatrization and those that undergo absorption, the cornea regaining its transparency. Ulcer of the cornea is the type of the first variety and interstitial keratitis that of the latter.

Germs as a rule find entrance into the cornea through breaches in the epithelium. The gonococcus of Neisser frequently gains access to the cornea in gonorrhœal conjunctivitis, leading to its destruction. In many important diseases of the cornea germs and their toxins play an important part in the inflammation. The posterior limiting membrane of the cornea shows great resistance to destructive tendencies. Its epithelium may exfoliate, proliferate or undergo fatty degeneration. Preliminary to the account of the various inflammations of the cornea it will be well to group together the symptoms which are common to all forms. These are subjective and objective. The subjective symptoms are: (1) Lachrymation or watering of the eye to a considerable degree, unassociated with any mattering unless there is a coexisting conjunctival disease; (2) photophobia or pain on exposure to light. As a rule the patient is comfortable in the dark unless there is hyperemia of the iris. Cases of inflammation unassociated with pain on exposure to light imply paralysis of the fifth nerve, as in neuropathic and malarial inflammations and in extensive mycotic processes. Photophobia is a reflex through the fibers of the fifth nerve in the cornea which are irritated in the inflammatory reaction, to the optic and to the seventh nerve, the latter of which, acting upon the orbicularis, causes a closure of the lids ofttimes resulting in blepharospasm. The patient will notice a certain amount of obscuration of vision independent of the photophobia and lachry-

mation due to edema of the epithelium of the cornea in peripheral lesions. If the diseased area is central the vision will of course be further implicated. The objective symptoms are: Loss of transparency of the cornea, associated with loss of luster or polish of its surface over the area of infiltration, especially in ulcerative processes, giving rise to exfoliation of the epithelium. The surface rotundity is destroyed in ulcerations, but not interfered with in interstitial inflammations. Again the two are differentiated by the instillation of fluorescein (or other aniline dye). If the epithelium is lost the area of infiltration stains green, remaining unstained if the inflammation is beneath the surface of the cornea (Grübler's fluorescein, two per cent.; carbonate of soda, 3.5 per cent.).

There is injection of the circumcorneal loops of vessels, giving rise to a characteristic pink zone surrounding the cornea whenever it is irritated. As has been pointed out this pink zone does not fade upon pressure and its individual blood-vessels are not visible. There is always an associated injection of the conjunctiva due to the free anastomosis between the conjunctival and the ciliary vessels. This injection of the conjunctival vessels when great often obscures the circumcorneal injection. A primary and isolated inflammation of the cornea is rare, though the participation of other tissues may be so slight as to escape notice. As has been noted there is always more or less conjunctival injection present and when the inflammation in the cornea is violent the conjunctiva and lids become edematous. The iris and even ciliary bodies become inflamed in marked keratitis, often being intense enough to bring about the destruction of the eye. Hypopyon or a collection of a purulent exudate at the bottom of the anterior chamber forms a frequent symptom in suppurative keratitis. It occurs under the form of a yellowish mass in the lowest part of the anterior chamber, which because it is fluid is limited above by a horizontal line, and when fresh is seen to change its place, seeking the lowest part of the chamber when the head is tilted to one side. In other cases the mass is viscid or pultaceous and has a convex upper border and does not alter its position with the movements of the head.

If not plainly visible it may be made so by letting a little water brim over the edge of the lower lid. Hypopyon usually originates from the cornea and iris as well, both being inflamed and pouring out the exudate into the aqueous chamber.

It is not formed by perforation of the cornea and drainage of pus into the anterior chamber. That a portion of a hypopyon originates from the uvea is proven by the fact that the mass in the anterior chamber often contains pigment granules within the pus cells. Hypopyon frequently disappears spontaneously, resorption taking place chiefly through the meshes of the ligamentum pectinatum. The more fluid the pus is the more apt is it to be carried off. At times the mass becomes organized and fastens the iris to the posterior surface of the cornea. In abscess of the cornea a fine filament of pus is at times seen extending from the posterior surface of the cornea from the spot corresponding to the abscess down to the hypopyon. Some claim to have seen the descent of pus between the lamellæ of the cornea to the formation of a hypopyon. According to these authorities the compression of the pus between the layers of the cornea accounts for the fact that the hypopyon occasionally has a flattened form and a convex upper border, for which reason this condition is called onyx or unguis, being compared to the lunula of the finger-nail. Onyx is however nothing but a hypopyon of a peculiar form, which extends up upon the posterior surface of the cornea to a greater extent than upon the surface of the iris, as proven by the fact that the onyx disappears when the anterior chamber is opened in incising a corneal abscess, and not a collection of pus between transparent layers of the cornea as frequently described.

Vascularization of the Cornea.—In inflammations of the cornea we frequently observe the formation of blood-vessels in the cornea, growing into it from its margin. This occurs most frequently during healing of ulcers of the cornea. At the time when the exudate is being absorbed or when the ulcer is cleaning as we say vessels start out from the part of the limbus nearest the ulcer to surround it and to aid in its repair. These vessels lie in the most superficial layers

of the cornea and disappear after healing has been established. From very extensive cicatrices however the vessels never entirely disappear. The formation of vessels in the substance of the cornea in interstitial keratitis is a part of the clinical picture of the disease.

There is a kind of vascularization which differs from both of these called pannus. The vessels do not lie in the cornea itself but in a newly formed tissue upon its surface, and of which they form a part. It is very important to know whether the vessels in the cornea are superficial or deep, since by this fact alone we can often tell what sort of keratitis we are dealing with. The signs which enable us to distinguish the two kinds of vascularization are as follows:

Superficial Vessels.	Deeply Situated Vessels.
Spring from the network of the marginal loops of the limbus, and can be followed from the cornea into the limbus and then into the conjunctival vessels.	Spring from the scleral vessels close to the margin of the cornea and hence appear to come suddenly to an end at the limbus, as they disappear behind the latter to enter the sclera.
They are well defined and have a vivid red color.	They are not distinctly visible, and have a dirty red hue, being veiled by the clouded layers of the cornea lying in front of them.
They branch in an arborescent fashion. The surface of the cornea is uneven from the fact that the vessels raise up the epithelium that lies over them.	The vessels form fine twigs that run parallel to each other (besom form of branching). The surface of the cornea is lusterless but not uneven.

The newly formed vessels in the cornea seem to be present at times in an empty state. For instance a corneal cicatrix may have very few vessels or none at all, and suppose that an operation involving the cornea is made for iridectomy or cataract extraction or what not, thus producing a certain amount of irritation. Then on the next day it not infrequently happens that the scar and even the adjacent clear cornea is permeated with blood-vessels. Since these could not have been formed in so short a time the conclusion is that the vessels were already present but in an empty state, and had again become

filled with blood. After an interstitial keratitis minute vessels which are invisible to the unaided eye are frequently present and persist for a number of years, to the detriment of vision.

As has been before mentioned the cornea is a direct continuation of the other coats of the eyeball—of the conjunctiva through its epithelium; of the sclera through its substantia propria; of the uvea through its endothelium. The pathological importance of this connection is manifested in the various forms of keratitis. Keratitis will be considered under two heads: suppurative and non-suppurative. In each class a number of different forms belong, as follows:

Keratitis Suppurativa.	Keratitis Non-Suppurativa.
Ulcer,	Superficial Forms: Pannus,
Abscess,	Keratitis with the formation of vesicles.
Keratitis e lagophthalmo,	Deep Forms: Interstitial keratitis,
Keratomalacia,	Deep keratitis,
Keratitis neuroparalytica.	Sclerosing keratitis,
	Keratitis starting from the posterior surface of the cornea.

Ulcer of the Cornea.—Corneal diseases form about 21 per cent. of all the diseases of the eye and of this number ulcers of the cornea form the greatest proportion. Special importance attaches to ulceration of the cornea, because a clinically insignificant ulcer will often distort the surface of the cornea enough to put the eye out of service from the irregular astigmatism produced; not only so but the sight may be entirely lost from formation of dense scars. Ulcers of the cornea are more common in adults and especially in elderly folks if we exclude the variety caused by phlyctens of the cornea.

Ulcers of the cornea may be classified as follows: (1) Primary, having their starting point in the cornea itself; (2) secondary, when the result of an affection of the conjunctiva or disease of the lachrymal apparatus; (3) malnutrition ulcers, secondary to a disease of the eye which interferes with the nutrition of the cornea, as uveitis, or glaucoma.

Primary ulcers usually arise from traumatism (traumatic ulcers) from boughs of trees, splinters of wood or what not, or from lesions produced from small foreign bodies getting in the cornea, by beards of grain (harvester's keratitis) or from bits of oyster-shell (oyster-shucker's keratitis). They occasionally result also from the appearance of the efflorescence of smallpox or measles upon the cornea.

Secondary ulcers may follow any conjunctival inflammation. They are quite the rule in gonorrhœal, diphtheritic and trachomatous conjunctivitis. Less frequently they are found associated with catarrhal conjunctivitis (catarrhal ulcers), especially in the elderly suffering with a chronic catarrh of the conjunctiva. The direct cause of the formation of ulceration of the cornea is the entrance of micro-organisms into the substance of the cornea through abrasions of its epithelium. A few are purely traumatic unassociated with infection or to a limited extent only. Such are spoken of as simple ulcers, and are told by the grayish-white color of the infiltrate, in contradistinction to the puriform color of the exudate in infected ulcers. The infection is introduced at the time of injury of the cornea, or comes from the organisms normally resident in the conjunctival cul-de-sac which do no harm under normal conditions or pass to the eye from the nose by way of the lachrymal passages. That the latter is more frequently the source of contamination in ulceration of the cornea than is usually supposed there is no doubt. The infection in secondary ulcers is found in the conjunctival secretion. The organisms usually active in corneal ulcerations are: The staphylococci and streptococci. In serpent ulcers we find the pneumococcus in great abundance. The cause of the corneal ulceration in cases of gonorrhœal ophthalmia is the gonococcus. In certain ulcerations Leber found a variety of aspergillus.

Symptoms and Course of Ulcers of the Cornea in General.—In the beginning there is a cloudy spot upon the cornea, and the surface over it is dull. This is an infiltrate. Soon the overlying epithelium is exfoliated and by the breaking down of the corneal tissue from the pressure of the infiltrate and also from the toxins generated in the

infected area, an excavation in the corneal substance is produced. This ulcerated area is at first surrounded by an area of infiltration, causing the base and the walls of the ulcer to be opaque. The infiltrate may arrange itself in striæ extending into the clear cornea from the point of ulceration. To this form of ulceration (when its base and sides are infiltrated) we give the name of foul ulcer or progressive ulcer.

In a favorable case only so much of the corneal tissue sloughs out as was primarily too much infiltrated to live, and the ulcer rapidly becomes clean or regressive, without spreading. A regressive ulcer is told by the disappearance of the infiltrate about it, that is by reëstablishment of transparency of the cornea at the site of the ulceration. When the process of ulceration has come to a stop, the site of the ulcer is represented by a shallow pit or facet with transparent sides and base, but its surface is still lusterless. In a few days the epithelium is regenerated and the facet becomes polished in consequence (facet ulcer). After the ulcer has become entirely clean cicatrization begins. Vessels extend from the nearest point of the limbus to the site of the ulcer. The site of the ulcer again becomes cloudy from the mass of the cicatrix; at the same time the facet becomes constantly shallower, and finally reaches the level of the surrounding corneal surface. At times the cicatrization ceases a little short of the level of the surrounding cornea and there remains a permanent facet in the cornea. When the cicatrization has been slight, the tissue is almost transparent, and the scar is only seen by examination of the corneal reflex. On the other hand, it now and then happens that the cicatrix rises above the surface of the surrounding cornea. Such occurs in cases in which the cornea has become too attenuated or thinned to withstand the push of the intraocular pressure and bulges forward. This bulging may disappear owing to the subsequent contraction of the cicatricial tissue, but it may remain permanent (ectatic cicatrix, keratectasia ex ulcere). The formation of ectatic cicatrix is most frequent after a perforating ulcer of the cornea. It not infrequently happens that simultaneously

with the breaking down of the cornea, the inflammatory cloudiness keeps spreading, new portions of the cornea being constantly attacked and breaking down. This progression of the ulcer may take place in the depth of the cornea or upon its surface. In the former case the cornea may be perforated; in the second case larger and larger areas of the cornea are destroyed, and extensive opacities produced. It at times happens that the ulcer keeps spreading in one direction while on the other side it heals just as fast until it has crept over the entire cornea (serpiginous ulcer). At some time during its course there appears a hypopyon (hypopyon-keratitis). During the progressive stage of an ulcer there are symptoms of irritation of the cornea, as circumcorneal injection, lachrymation, photophobia and pain if the hyperemia or especially inflammation has extended to the iris. The pupil will then be small and acts poorly to light, and the tissue of the iris somewhat discolored, and there is a turbidity of the aqueous humor. These symptoms subside as the ulcer becomes clean. In certain ulcers during their height there is little irritation, constituting what are called torpid ulcers, but which are dangerous as they are apt to be neglected. They are seen chiefly in the aged.

Whenever an ulcer perforates the cornea the case is much complicated. When the perforation takes place the patient suddenly experiences great pain and feels a warm liquid (the aqueous) gush out of the eye over the cheek, after which the pain grows decidedly less severe. The rupture of the thin floor of the ulcer may take place during some bodily effort as in stooping, coughing, sneezing, or by tightly screwing the lids together, crying, etc., or perforation may take place spontaneously. After perforation has taken place the anterior chamber is found obliterated in consequence of the escape of the aqueous humor. The iris and when in the region of the pupil the lens also are applied to the posterior surface of the cornea. Frequently the iris is pushed through the opening in the cornea, giving rise to a dark-colored protrusion (staphyloma). The eye feels quite soft. At times prior to perforation a keratocele (or descemetocele)

forms, that is the disease progresses to Descemet's membrane which offers great resistance to the progress of the ulceration, and is protruded through the opening in the overlying layers of the cornea by the intraocular pressure in the form of a transparent vesicle.

When this vesicle ruptures the perforation is complete. It happens infrequently that the ulcer heals without the rupture of the keratocele which remains projecting above the surrounding cornea, itself transparent but surrounded by a ring of opaque cornea. After perforation takes place not only the pain subsides but the ulcer not infrequently begins to regress, and it rapidly becomes clean. The reason for this is that the circulation and consequent nutrition of the cornea is favored by the decrease of intraocular tension. The manner in which the opening in the cornea heals is dependent upon its position in regard to the pupil. If the opening is found excentric as is usually the case it is soon covered by the iris which is washed up into the opening by the escaping aqueous humor. If the opening is quite small the iris simply applies itself to the opening, prohibiting the further escape of aqueous, and the anterior chamber of the eye is restored as the aqueous collects. In the majority of cases of course the iris remains adherent to the posterior surface of the cornea and in consequence the pupil is distorted, that is drawn out towards the point of adhesion.

If the perforation is larger the iris is pushed as a hernia through the opening. The protruded portion soon becomes covered with lymph and it becomes vascular and after a varying length of time becomes cicatrized, and contracting settles down to the level of the surface of the surrounding cornea, its place being occupied by a dense white scar (leucoma). A prolapsed iris loses its natural color and always looks black, on account of the black pigment of its posterior surface showing through its attenuated stroma. If the whole cornea has sloughed out, the whole iris is prolapsed (total prolapse of iris). The pupil is usually closed up in such cases by a mass of exudate. If the perforation of the cornea takes place with great force the hernia of the iris is greater in extent. If the perforation is situated near the

center of the cornea the pupillary portion of the iris becomes adherent to it, and the pupil may be permanently closed by the formation of cicatrix. There is then produced occlusio and seclusio pupillæ, with their evil consequences. The contraction of the scar tissue during cicatrization may be so excessive as to become flatter than the surrounding cornea. This flattening may extend beyond the scar into the transparent tissue of the cornea (applanatio corneæ). If the whole cornea has been destroyed by suppuration and the whole iris has prolapsed, the latter finally becomes reduced to a small and perfectly flat cicatrix which occupies the place of the cornea (phthisis corneæ). The healing of a prolapse of the iris with the formation of a flat cicatrix is a happy outcome as the eye gives its owner no further trouble. The case is different when the cicatrix becomes ectatic, which occurs in the following manner: The prolapsed iris becomes covered with cicatricial tissue but which is not dense enough to withstand the outward push of the intraocular pressure, and bulges with the included iris (staphyloma corneæ). The larger the perforation and the more restless the patient is the more likely is such a result to occur.

If the perforation is exactly central and small so that it can not be covered by the iris, that is corresponds in position to the pupil, cicatrization takes place by a slow outgrowth of connective tissue from the edges of the perforation. The lens during this time is applied to the posterior surface of the cornea, and the anterior chamber remains open a long time. After the opening in the cornea becomes closed the aqueous collects and the cornea advances to its former position. The lens may bear permanent marks of its contact with the cornea in the form of a circumscribed opacity upon its capsule at its anterior pole. The perforation of the cornea may remain permanently open especially if from bad behavior of the patient the delicate membrane occluding the opening is repeatedly ruptured. A fistula of the cornea is thus formed. The anterior chamber remains absent and the eye soft, until infection finally enters the eyeball and a destructive inflammation of the iris and ciliary bodies ensues, or the cornea

becomes flatter and flatter and the eyeball softer and goes blind from a detachment of the retina. If the fistula closes a rise of tension is apt to take place with a renewed rupture of the occluding substance.

After the escape of the aqueous humor the tension posterior to the crystalline lens causes it to move forward to the cornea, a movement which puts great strain upon the zonula of Zinn. If the perforation of the cornea takes place very suddenly, and especially if the fibers of the zonula have been rendered fragile by disease, it ruptures. The lens in consequence assumes an oblique position or may even be extruded through the corneal opening if it is large enough. Intraocular hemorrhage is at times the result of the rapid diminution of tension within the eyeball due to the sudden escape of the aqueous humor. Hemorrhage is especially apt to take place if the tension was previously elevated, in which case there is more or less degeneration of the vessel walls.

With the escape of the aqueous there is a rush of blood into the intraocular vessels, causing their walls to give way if weakened by disease. The entire contents of the eyeball may be extruded by the hemorrhage and the patient may almost bleed to death. The opacity caused by the cicatrization grows less in time. The resulting scar is less likely to clear up the deeper into the substance of the cornea the ulceration progressed, and *vice versa* (hence scars from perforating wounds of the cornea never clear up) and again the younger the individual is the more the scar clears, so that scars caused by ulceration in early life as from ophthalmia neonatorum often clear up in a remarkable manner.

Treatment of Corneal Ulcers in General.—All that is needed in the simpler ulcers as those associated with catarrhal conjunctivitis in children or in old people with chronic conjunctivitis (small marginal ulcers) is that the eye be protected from the light by means of a pair of smoked glasses or eye shade, and kept under the influence of atropin until the ulcer cleans. The atropia lessens the pain by its sedative as well as by its mydriatic action. If there is much pain a one per cent. solution of holocain muriate may be instilled as often

as every two hours. It promptly relieves the pain, is a good antiseptic and does not like cocain cause the exfoliation of nor interfere with the regeneration of the corneal epithelium. For the latter reason cocain should never be used to relieve pain in an eye especially if affected with a corneal or conjunctival disease. In corneal disease there is always danger of the inflammation spreading to the iris, a thing which should ever be borne in mind during the treatment of a keratitis; on account of the free anastomosis of the blood-vessels of the iris and the circumcorneal loops. Any congestion in the latter is readily reflected to the former, and the pain is increased, if not an actual inflammation produced.

All ulcers should be examined for the presence of small foreign bodies, and removed if still present. Cilia that are inturned and scratching the cornea must be removed. The cause of the ulceration must be sought and if found in an inflammation of the conjunctiva or tear passages it must be treated, and under such treatment the ulcer advances towards recovery. In ulcers resulting from catarrh, trachoma and gonorrhœal ophthalmia, we should not desist from cauterizing the conjunctiva if called for, but great care should be taken to keep the caustic from the cornea, by flushing the eye well with normal salt solution if silver nitrate solution has been used. We should not cauterize with the copper sulphate crystal as it is too irritating, and lead salts should not be used as they frequently lead to incrustations of lead upon the cornea. In the severer forms of ulceration of the cornea a protective bandage should be applied. The object of the bandage is to keep the lids closed and quiet without exerting any pressure upon the eyeball; the cotton is therefore made thin over the eyeball and heaped up in the hollows about the eye so that when the bandage is tied it does not exert any pressure upon the eye itself. Immobilization of the lids prohibits them from scraping across the floor of the ulcer and causing pain and constant irritation with every wink. The bandage also acts to keep the ulcer from exposure to dust and irritating substances in the air. The bandage should be kept on until the ulcer becomes clean. If the floor of the

ulcer or cicatrix bulges the bandage must be applied with a little pressure upon the eyeball by heaping up the cotton upon the eyeball and then tying the bandage tightly, until the cicatrix is sufficiently strong to withstand the intraocular pressure. If there is any discharge from the conjunctival sac a bandage is contraindicated, as the bandage retains the secretion in constant contact with the ulcer. If the ulcer has a purulent look, showing that it is infected, and especially if it is progressive we employ still other remedies, such as the application of heat to the eye, cauterization of the ulcer, paracentesis, etc.

Moist heat is preferred in ulcer associated with any secretion from the conjunctiva applied in the form of moist hot compresses. A light linen cloth folded several times or pad of absorbent cotton is taken and wrung out of water as hot as the hand can bear it and placed upon the closed lids. It must be changed often to be kept warm. The heat may be retained for a while longer by covering the compress with a pad of dry cotton and oiled silk. The objection to these however is their weight. The compresses are applied for an hour and left off for the same length of time.

If the eye is free of secretion dry heat which is much less troublesome to apply may be used. It is best applied by means of the Japanese pocket-stove. As soon as the pain is allayed or the cornea is well vascularized the application of heat should be omitted. The conjunctival sac should be cleansed and kept as sterile as possible with a solution of boric acid, bichlorid, 1–4,000, or formalin, 1–2,000. The ulcer itself should be touched with 1–60 formalin solution or nitrate of silver (20 gr. to 1 oz.) or with tincture of iodin in full strength where there is suspicion of infection, and especially in dendritic ulcers every second or third day. If these measures fail to stop the progress of the ulceration, the lesion should be cauterized with full strength carbolic acid applied with a cotton mop or by the electric cautery (Gayet). The latter is preferable when a very decided and certain action is desired. If the operator is careful not to touch any more tissue than that involved in the ulcerative process

the resulting scar is not greater than would have been the case had the ulcer cicatrized without the cauterization. Cocain renders the operation painless, and fluorescein should be instilled to outline the area to be cauterized. In rapidly progressing traumatic ulcers, Knapp recommended several years that the edge of the ulcer, just in the healthy cornea, should be punctured all around, about 1.5 to 3 mm. apart, with a cautery point heated to a dull red heat. Trichloracetic acid, in 20 per cent. solution, as a caustic in corneal ulcers is attested by Bulson. He thinks it more efficient than carbolic acid and safer than the cautery. The ulcer may be curetted under a boric acid spray from a syringe as recommended by De Wecker and Santarnecchi, until all the sloughed material is removed and then the edges and floor of the ulcer painted with a solution of sublimate (1–2,000); iodoform dusted upon its surface, and a dry sterile bandage applied.

Mules recommends that an iodoform-gelatin wafer be applied to the ulcer and the eye bandaged. A potent remedy for combating rapidly spreading ulcers of the cornea is paracentesis of the anterior chamber, which is done as follows: The eye is cocainized with a four per cent. solution of the drug, or in case of a child or nervous individual general anæsthesia is preferable. For such short operations bromid of ethyl is the anæsthetic par excellence.

The eyeball is then grasped with a pair of fixation forceps as near the point to be opened as possible. The paracentesis needle is entered just within the corneo-scleral border, at right angles to the surface, and as the blade enters the anterior chamber, the handle of the instrument is depressed to avoid wounding the iris or lens. The opening should be made gradually and a sudden evacuation of the aqueous avoided, otherwise there is danger of the retina becoming detached or of intraocular hemorrhage, especially in diseased eyes. The needle should be gradually withdrawn so that the iris does not sweep into the wound. The bandage is then replaced. Paracentesis not only prevents the extension of the ulcer but threatened perforation of the cornea. If we do not desire to bring about perforation of the cornea artificially as in cases of ulcers associated with an infec-

tious conjunctivitis, we take care to have the patient keep quiet, that is we make him go to bed so that the perforation may take place slowly and as little of the iris as possible be driven into the opening. Instead of making the paracentesis at some indifferent point it may be made through the floor of the ulcer as recommended by Saemisch. The operation is done with a Graefe cataract knife, which is entered with its cutting edge straight forward a little to the outside of the external border of the ulcer or abscess in a healthy portion of the cornea; then the knife is pushed into the anterior chamber and made to penetrate the cornea again a little to the inner side of the ulcer. The ulcer now lies upon the edge of the knife, and is divided by several to-and-fro motions of the knife. If the ulcer is associated with an abscess of the cornea the edges of the wound must be opened daily by passing a blunt sound between them. After the section is completed hypopyon if present is removed.

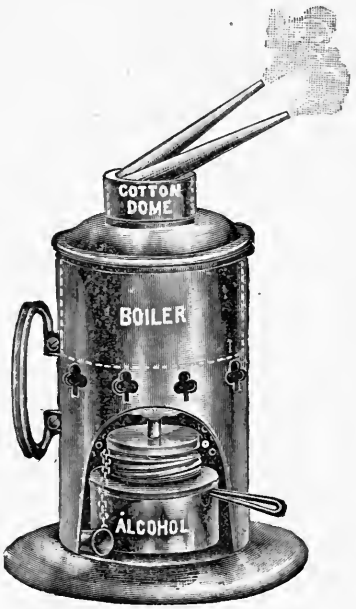
There are two things to be desired after perforation of the cornea has taken place, namely: that the iris does not adhere to the cornea and that a firm and flat cicatrix is formed. If the perforation is small the iris will not protrude but become adherent to the inner surface of the cornea. In such cases rest in bed, atropin and pressure bandage is the proper treatment. The iris is infrequently pushed away from the cornea by the accumulation of the aqueous humor, remaining attached by a tag of tissue only. If the iris has prolapsed it should be excised if there is no mattering about the eye. If there is fear of intraocular infection on account of a conjunctival or lachrymal disease the hernia had better be left to cicatrize. Reposition of the protruded iris is not possible on account of the adhesions about the perforation unless seen immediately after it happens, when an attempt may be made to replace it with an iris repositor. A staphyloma is excised as follows: The eye is cocainized, then with a small sound the adhesions between the staphyloma and the corneal opening are separated.

The iris is then drawn out of the wound as far as possible and excised with a pair of iridectomy scissors. This is Leber's operation.

This iris will now no longer be attached anywhere but will recede into the anterior chamber, and the coloboma will have free pillars as after a regular iridectomy. Excision after the manner described is only possible in fresh protrusions, in those not over forty-eight hours old, on account of the firm adhesions which form after the iris has been prolapsed for a longer period. Excision is also contraindicated in very large prolapses. In such a case we excise a small portion or puncture the hernia every other day for a few days and apply a pressure bandage. In case of a total prolapse it is advised to split the iris transversely, and after opening the capsule of the lens to expel it. In keratocele rest and pressure bandage are employed. Ultimately the puncture of the vesicle may be required. In fistula of the cornea the patient should be confined to bed with a light bandage applied to both eyes. A miotic should be instilled in order to diminish the tension of the anterior chamber. An iridectomy has a good effect but is difficult to perform until the anterior chamber has been restored. It may be done as follows: Two punctures are made in the corneo-scleral border with a paracentesis needle, opposite to one another, then a small linear probe-pointed knife is made to transfix the anterior chamber through these openings, and the operation completed in the usual manner. Some advise cauterizing the edges of the fistula, but this is not without danger. If cauterization is done it should be done with the electric cautery, so that no irritating substance enters the anterior chamber and comes in contact with the iris tissue. The cautery point should be heated to a bright red heat and then the margins of the opening lightly touched; care being taken not to destroy too much tissue nor to enter the anterior chamber.

Our treatment in the later stages of ulceration has for its aim the complete filling in of the excavation with cicatrix and having the latter as transparent as possible. For both we employ irritant antiseptics. We begin with the weaker remedies and gradually pass to the stronger ones if these are well borne. Bichlorid solution 1–4,000, t. i. d., calomel (powdered) flicked into the eye once every other day, and yellow oxid of mercury ointment (gr. i or ij to ℥i) used once

daily, at the same time performing a sort of massage by rubbing the eyeball through the closed upper lid are the remedies usually employed. Hot applications also do good. The irritant substance may be dissolved in water, heated and sprayed upon the cornea from an atomizer, or as is better, the medicament may be applied by means of a small steam atomizer as recommended by Bissell. Adler recommends electrolysis for clearing corneal opacities. A small metallic-tipped double electrode is used. It is placed upon the corneal scar and a weak constant current made to pass through it for five or ten minutes every other day.



Bissell's Steam Atomizer for Treating Keratitis.

The local use of caroid powder is claimed to be followed by a wonderful clearing of corneal scars but has not proven itself of value in the writer's hands. Buller has very recently advised ligation of the canaliculi in cases of infected ulcers of the cornea. A suture of No. 2 iron-dyed silk is passed around each canaliculus 2 millimeters to the inner side of each punctum. The threads are drawn tightly enough to occlude but not to cut through the canaliculi. There is no difficulty in opening the canals after they have been ligated for quite a while, nor does the temporary closure lead to disturbance from increased accumulation in the tear sac. The operation is indicated whenever the puncta lachrymalia have an unhealthy appearance or exude the slightest trace of mucus or pus. More cases of suppurative keratitis owe their infection to the lachrymal passages than is supposed. Subconjunctival injection of normal salt solution or of bichlorid solution 1–8,000, at times is followed by immediate improvement. The operation has already been described. It does good by making the

lymphatics work more energetically to carry off the extra amount of fluid in the tissue, and thus leads to increased metabolism.

Treatment of Hypopyon or Hyphæma. — Most collections of inflammatory material or blood in the anterior chamber can be hastened to disappear by use of rotatory massage of the eyeball through the closed lids, followed by application of heat, and pressure bandage. Great care should be taken not to infect the mass if one opens the anterior chamber to evacuate the hypopyon, as it frequently consists of sterile pus, that is of dead white cells with a certain amount of fibrin minus infection, and does not endanger the welfare of the eyeball. The internal administration of KI is also of service.

CHAPTER XI

DISEASES OF THE CORNEA—*continued*

THE following ulcers of the cornea need special mention:

Rodent or Mooren Ulcer is a superficial ulcer of the cornea of serpiginous nature. It attacks old people and frequently both corneæ are at once affected or are attacked in succession. The disease is rare. The ulcer is of the infected variety and extends rapidly on account of the poor nutrition of the cornea incident to old age. The ulcer usually begins at the upper margin of the cornea, with marked inflammatory symptoms. It is limited from the normal cornea around by a gray infiltrated margin which is undermined. The latter symptom is characteristic of ulcus rodens. After a while the ulcer becomes clean and cicatrix becomes covered with numerous vessels. When the case appears nearly well the symptoms of irritation return, and the ulcer pushes its way further towards the center of the cornea. This order of intermissions and exacerbations continues until the whole surface of the cornea has been invaded.

The cornea is everywhere deprived of its superficial layers and remains clouded throughout its entire extent, so that the sight is greatly reduced. The ulceration thus creeps along the surface, but does not penetrate the substance of the cornea. Perforation from ulcus rodens has never been observed. There is only one thing that does the ulcer any good and that is the actual cautery. Before physicians were acquainted with the use of the cautery in eyework the disease was considered incurable. If the margin of the ulcer is destroyed by the cautery the ulcer itself is cured. The canaliculi should also be ligated to prohibit further infection from the tear passages, and the conjunctival sac kept as sterile as possible by frequently flushing it with warm boracic solution (10 gr. to 1 oz.).

It will be recalled that the epitheliomatous ulcer of the lids is also

named ulcus rodens, but with the ulcus rodens of the cornea it has no connection. The latter disease is not malignant in any sense and to save confusion it should be spoken of as Mooren ulcer of the cornea.

Ulcus Corneæ Serpens or Sæmisch Ulcer of the Cornea (Hypopyon Keratitis (Roser), Ulcus Septicum (Stellwag)) is the most serious disease of the cornea with which we have to deal. Besides the purulent ulceration of the cornea there is in 80 per cent. pus in the anterior chamber. Vision is always interfered with and in about 20 per cent. the eye is entirely lost. It appears oftenest among the old and debilitated but does occur in the young.

Etiology.—In most cases the history of an injury is gotten, especially from chips of stone or metal flying from a workman's hammer. Infection takes place at the time of injury or subsequently, being in many cases supplied from the lachrymal passages, especially if they are inflamed. About 25 per cent. of ulcus serpens are complicated with a dacryocystitis or an infectious conjunctivitis. The disease can be produced in rabbits by inoculation with pus organisms—a further proof of its infectious nature. The disease is more apt to follow trifling injuries to the cornea with infection than more extensive wounds that are comparatively clean as pointed out by Stromeyer in 1873. The disease may be acute in its symptoms although it usually runs a torpid course, none the less destructive however. This form of ulceration, as are all traumatic ulcers, is closely allied to abscess of the cornea. They are abscesses so superficially situated that in a short time they rupture and are converted into ulcers. They, like abscesses, are distinguished by their color, which is yellow like pus, by their greatly infiltrated margin and by the early involvement of the iris.

The difference both in the appearance and course of ulcus serpens from ordinary purulent ulcers of the cornea argues that there is a particularly virulent infection with pus-cocci or the organisms find a more favorable nidus for their development than is usually afforded.

Diagnosis is to be made between ulcus rodens and ulcus serpens corneæ. Both destroy sight, the former by creeping over the entire cornea and converting it into scar tissue, the latter through the early

onset of an uveitis as well. The scar of the cornea is dense in ulcus serpens and interferes much with vision, but the eye is also in danger of a septic irido-cyclitis. Ulcus serpens also penetrates into the substance of the cornea, while ulcus rodens never perforates the cornea. The former begins near the center of the cornea, is more or less circular, with a dimpled and partially transparent center, while the latter is marginal with overhanging edges, and surrounded by numerous blood-vessels. Hypopyon is also much more frequent in ulcus serpens.

Treatment should be begun early and should be vigorous. It consists of the measures outlined in former section, as atropia, bandage and heat, but operative treatment must likewise be initiated without delay. This consists in cauterization with the actual cautery after the ulcer has been curetted, or in incising according to the method of Saemisch already described. By the incision any pus pent up between the layers of the cornea is liberated but there is danger of prolapse of the iris as in perforating ulcers and if it occurs should be treated in like manner. It is wise therefore to at first resort to curetting and cauterization, and if the progress of the ulcer is not arrested thereby or if the hypopyon is great in amount to open the anterior chamber through the floor of the ulcer.

In desperate cases a small amount of iodoform in form of powder or pencil may be introduced into the anterior chamber through the opening in the cornea, as advised by Goldzieher, and followed by good results. Under this treatment the healing of the ulcer is more rapid and clearing of the cornea is better than is usual in such cases treated by other methods.

Ring Ulcer.—Ring ulcer is a progressive ulcer which begins at the edge of the cornea and extends around the periphery of the latter. There is frequently very little infiltration accompanying it, so that the ulcer has a strangely transparent appearance. It occurs in the old and feeble and makes rapid havoc with the eye. There is very little pain and slight amount of hyperemia. The cornea is frequently perforated and the iris prolapses. The scar of the cornea

left resembles the opacity of arcus senilis, but can be differentiated from it by the fact that the arcus senilis is very regular in outline, and is separated from the edge of the cornea by a strip of transparent tissue, which is not the case with the scar following ring ulcer.

Atheromatous Ulcers are those which form in old scars which have undergone degeneration with the deposition of fat or lime salts, or when exposed to mechanical injury. They are very common and annoying in eyes blind from gonorrhœal ophthalmia, in which the corneæ are ectatic. In such cases the ulcer forms at the apex of the ectasis from the rubbing of the lid over it. They are recurrent and may lead to perforation of the cornea, and panophthalmitis.

Tuberculous Ulcer of Cornea will be considered under the head of tuberculosis of the cornea, and syphilitic ulcer under the head of syphilis.

Resorption Ulcer (Central Non-irritative).—This variety of ulcer occurs most frequently in trachoma. It is distinguished by the absence of much irritation, very slight amount of infiltration and by its central position. Its site is marked by an excavation in the surface of the cornea and is easily overlooked. It very often fails to entirely fill with cicatrix and there is left a permanent facet of the cornea.

It causes great reduction in the sight on account of the great amount of irregular astigmatism it gives rise to. Eyes blind from absolute glaucoma are very prone to corneal ulceration which like atheromatous ulcers of the cornea are due to poor nutrition of the cornea, evidenced in glaucoma by the loss of sensation. Considerable hypopyon at times accompany these ulcerations and the eye may become very painful from involvement of the iris and ciliary bodies. Enucleation is the best treatment as the ulcers are especially annoying on account of their recurrence. There yet remains to be described two rather rare forms of corneal ulceration, namely: Dendritic and filamentous keratitis.

Dendritic or Malarial Keratitis (*Ulcer*) (*Hansen-Grut's Ulcer of the Cornea, also Called Horner's Ulcer*).—Dendritic ulcer of the

cornea is a superficial ulcer of a serpiginous type characterized by its peculiar arborescent form.

Symptoms and Course. — Examination of the affected eye reveals a narrow whitish line or point upon the cornea consisting of a subepithelial exudate. Kepp says the line is very frequently seen to be made of a row of small points. The lesion can not be distinctly made out without the aid of a magnifying lens. At the end of three or four days branches from the line of ulceration begin to form either by sprouting or by new points of infiltration beginning and growing into the line. The appearance is then that of a broad branching trough. Vascularity never occurs. The trough of ulceration finally becomes filled with débris, and at times projects above the surface of the cornea. The ulceration is very superficial, and rarely causes hypopyon or iritis. The disease is in vast majority of cases monocular.

The ulceration extends if unchecked by treatment until the whole surface of the cornea has been involved. The ulcer advances in one direction while it heals in another. There is at times very severe pain in and about the eyeball, but as a rule the ulceration causes very little annoyance. Very little if any opacity results as the disease is essentially one of the epithelium.

Etiology. — The commonest cause of the disease is the presence of the tertian or quartan variety of the malarial organism in the circulation. It is also observed following yellow fever and grippe. It is supposed by some to be specific in origin in a few cases.

Treatment. — Protective bandage, atropin, and hot applications. Should the ulcer show a tendency to spread it should be freely treated with undilute tincture of iodin. The eye is cocainized and tincture of iodin floated over the cornea for a few minutes or mopped on freely. There is usually a great deal of pain which reaches its height in an hour or so, but the next day the eye is considerably better. Cold applications and solution of holocain are to be used for the relief of the pain. Galvanism along the supraorbital nerve has been suggested. Quinin and arsenic should be given internally unless a specific history is obtainable.

Filamentous Keratitis.—Now and then after the rupture of a corneal vesicle there is seen attached to the surface of the ulcer a rope-like body, its free end being frayed. The cord consists of fibrin and epithelial scales, it has no special significance. The condition was first described by Leber and Nuel.

Phlyctenular Keratitis is essentially the same disease as phlyctenular conjunctivitis, varying only in the locality of efflorescence, so by some authorities the two diseases are called under the one head of phlyctenular conjunctivitis, inasmuch as it is the conjunctival epithelium which passes over the surface of the cornea. When the phlyctens are upon the cornea we have the usual corneal symptoms, namely: lachrymation, photophobia, ciliary injection, etc. The phlyctens disappear by resorption or degenerate into ulcers.

Treatment is that of simple ulcers of the cornea, together with the hygienic treatment described under the head of phlyctenular conjunctivitis.

Aspergillus Keratitis (*Keratomycosis*).—Aspergillus keratitis is a very rare disease of the cornea but not so rare as is generally supposed by ophthalmologists. The patient experiences intense pain in the eye with the formation of a brown, black or yellowish body in the cornea. There is intense photophobia, lachrymation and pain which does not entirely subside when the patient is in the dark. Failure to properly treat the case is followed by the development of a sloughing ulcer of the cornea with the destruction of the eye. The cicatrized cornea is more or less permanently stained by the coloring matter of the aspergillus. The commonest cause is the aspergillus niger and more rarely the aspergillus fumigatus and finally the aspergillus glaucus.

Treatment.—Removal of the pigmented mass in the cornea early is followed by a speedy cure. The mass should be removed by curetting and the area cauterized with carbolic acid or actual cautery. Atropin should of course be used and a protective bandage applied. If on subsequent examination more discoloration of the corneal infiltrate is manifest it should be removed.

Abscess of the Cornea.—An abscess of the cornea consists of an infiltrate situated deep in the substance of the cornea, limited in front and behind by intact lamellæ of the cornea.

Symptoms.—Abscess of the cornea appears as a whitish or yellowish-white infiltrate in the central portion of the cornea. The opacity is greater upon the edge of the infiltrate than in the center. Lines of infiltration frequently extend from the margins of the disc of infiltrate into the adjoining clear cornea. The surface of the cornea over the abscess is dotted and often raised above the surrounding cornea. The whole cornea looks clouded and soon the center of the abscess becomes depressed. There is always a hypopyon with violent inflammation of the iris present. The latter is discolored and the pupil tied down to the lens capsule behind by adhesions. There is some edema of the lids, and considerable pain in and about the eye. The abscess extends to a certain point, enlargement taking place in the direction in which the margin of the abscess is most deeply infiltrated, and then the cornea overlying it breaks down and the abscess is converted into an ulcer. Soon after the layers of the cornea posterior to the abscess may break down, thus producing an extensive perforation of the cornea with a consequent prolapse of the iris. The iritis is in the meantime increasing and the pupil becomes filled with exudate, and hypopyon fills the greater part of the anterior chamber of the eyeball. Panophthalmitis may result from the disease passing to deeper parts. After the perforation of the cornea the symptoms however usually abate, and the perforation heals with a dense cicatrix in which the iris is incarcerated. The iris is left adherent to the lens capsule behind (posteria synechia) and the pupil closed (occlusio pupillæ). If panophthalmitis ensues upon perforation of the cornea the eyeball gradually shrivels after discharging its purulent contents (phthisis bulbi).

Diagnosis of an abscess of the cornea from an ulcer is made in the following way: In abscess the opacity is central and disc-like, and there is no surface loss of substance (fluorescein does not stain the area of infiltrate unless there is present a small sinus leading to the

surface) only an indentation, and there is early and marked iritis and hypopyon.

Prognosis is always bad. In the most favorable cases the sight is destroyed by the formation of a dense central scar of the cornea, so that if the iris and other parts of the eye are normal it can only be restored by an iridectomy.

Etiology.—The cause of abscess is infection of the cornea with pus organisms which come from without or are carried to the eye through the circulation. Corneal abscesses are hence ectogenous or endogenous (metastatic) in origin. Infection of the cornea from without takes place through a lesion of the epithelium which under normal conditions protects the cornea against the entrance of micro-organisms. As a rule then abscess results from injury of the cornea, the body which inflicts the injury carrying the organisms or more frequently the injury by causing a loss of epithelium of the cornea simply affords opportunity for the entrance of organisms from the lachrymal passages. The injuries giving rise to corneal abscesses are, as a rule, very slight, consisting of a simple abrasion, such as scratching of the cornea with the finger-nail, a thing which children not uncommonly do to their mothers who are carrying them around in their arms. A twig of a tree, leaf or what not grazes, or pieces of stone or metal fly into the eye and produce a superficial injury. Some authors say that injury of the cornea associated with contusion of the latter especially gives rise to abscess formation. There is present in about one third of all cases of corneal abscess a chronic catarrh of the conjunctival cul-de-sac (muco-purulent or trachomatous) or dacryocystitis, which furnishes the infecting material. Abscesses of the cornea are more frequent in the adult and among the working class. They are also more frequent in the hot season than in winter as heat favors their development.

Metastatic infection of the cornea is seen in acute infectious diseases, hence occur associated with small-pox, typhoid and typhus fevers, scarlatina and measles. The abscess arising from variola is the commonest. It is not the result of efflorescence upon the cornea

because it occurs late in the disease, often after the patient has left his bed, during the stage of desquamation. They not infrequently affect both eyes and lead to total blindness.

Treatment is both medicinal and operative. The medicinal treatment consists in the application of a bandage, use of atropia, powdered iodoform and heat locally. Operative measures should be resorted to early if the abscess is at all extensive, or if there is considerable pus in the anterior chamber of the eye. It consists in cauterization of the abscess with the actual cautery. In cauterizing especial attention is paid to destroying the infiltrated margin of the abscess. Cauterization is appropriate in cases unassociated with much hypopyon. Incision of the abscess, after the method of Saemisch already described, is indicated if the abscess is large and threatens perforation of the cornea and associated with considerable hypopyon. By it the tension in the cornea is relieved. The anterior chamber is furthermore opened by the incision and the hypopyon liberated. It has the disadvantage of frequently giving rise to a prolapse of the iris. The medicinal treatment must not in the meantime be discontinued. The perforation of the cornea should be kept open by daily passing a blunt probe or sound between the lips of the incision, until the purulent infiltration disappears. The perforation of the cornea and the prolapse of the iris, if one occurred, are to be treated in the same manner as before outlined.

Ring Abscess of the Cornea.—This is a very rare form of corneal abscess associated with wounds of the cornea and characterized by sudden infiltration of the cornea in a zone concentric with the corneal margin. The cornea early sloughs and the eye is usually lost from panophthalmitis. Hanke isolated an organism from these cases which causes softening and sloughing of the cornea and panophthalmitis and shrinkage of the eyeball when introduced into the aqueous chamber of rabbits and claims that this bacillus, which is .8 to 1.6 microns long, staining with ordinary aniline dyes but not by Gram's method, and which grows on bouillon and other media and liquefies gelatin and blood serum, is the specific organism of ring abscess of

the cornea. Others have not yet identified the bacillus. The nature and position of the infiltrate in the disease shows however that a very virulent organism is at work. The cause of the peripherally situated infiltrate is perhaps due to the virulence of the toxin produced at the site of the injury and speedy death of the migrating leucocytes at a distance from the site of the lesion. In cases reported by Fuchs both cocci and bacilli were present but no particular organism. The zone of purulent infiltrate in the cornea seemed to be free from bacteria but from the interior of the eye great numbers were obtained.

Keratitis e Lagophthalmo.—If the cornea is continuously exposed its epithelium desiccates and exfoliates, thus exposing it to a liability of an infection. Keratitis e lagophthalmo is seen in cases of paralysis of the seventh nerve, in excessive exophthalmos, in destruction of and contraction of the lids, etc. The danger of desiccation taking place is during sleep, for during the daytime the reflex act of winking keeps the cornea moist sufficiently, but during the night when the reflex winking of the lids is absent the cornea becomes dry where it lies exposed, which in the majority of cases is its lower portion. The corneal lamellæ as they dry are cast off in a process of suppuration. The same thing is seen in those who with clouded consciousness from disease lie with the lids open or only partly closed.

The exposed part of the cornea becomes dull, dry looking and slightly depressed, the cloudiness becomes more and more decided until disintegration of the superficial layers of the cornea takes place with the formation of an ulcer. The ulcer extends above to the extent at which the cornea is uncovered, and below to the lower edge of the cornea. The upper edge of the ulcer is more or less horizontal. There soon follow hypopyon and iritis. The ulcer may heal without perforation or may perforate and give rise to prolapse of the iris or even panophthalmitis.

Treatment has primarily to do with the prevention of desiccation of the cornea, that is in taking care that it is covered by the lids, especially in sleep. In this way the development of the keratitis is prevented as it depends solely upon the desiccation of the cornea.

While the cure of the lagophthalmos is being wrought a bandage should be applied at night only in the milder forms, but if the lagophthalmos is considerable, or if keratitis has already begun, the eye must be kept bandaged all the time. To keep the lids properly closed beneath the bandage it is often necessary to fasten them together with strips of adhesive plaster, before applying the bandage. The keratitis should be treated in the manner already described for the treatment of keratitis in general.

Keratomalacia is a form of destructive corneal trouble which occurs in poorly nourished infants and children, and in a modified form in adults greatly reduced from want of proper food and disease. It accompanies variola, meningitis, measles, pneumonia, severe diarrhœa, dysentery, etc.

Symptoms. — The disease begins with night-blindness (hemeralopia). The patient, if he is old enough, notices that while his vision is good in bright daylight, it is very poor when the illumination is diminished so much so that he is unable to go about alone after twilight. In young children the first thing that attracts our attention is dryness of the conjunctiva associated with the formation of two triangular xerotic spots upon the conjunctiva adjacent to the cornea. The conjunctiva in these spots is covered with a white foam-like substance which consists of fatty material and epithelial cells. To these areas the lachrymal fluid does not adhere. The dryness extends rapidly over the remaining conjunctiva and over the cornea. The cornea becomes uniformly cloudy and insensitive. The clouding of the cornea increases and especially at its center where an area of dense infiltration occurs.

The area of infiltration spreads rapidly and assumes the color of pus and ends in the disintegration of the cornea, taking place in a few hours in extreme cases. The affected eye is remarkably free from injection in the beginning, but after the cornea becomes much involved it takes on a dusky venous injection. The lachrymal secretion is not increased as is usual in corneal disease but diminished. The other symptoms of irritation as photophobia and blepharospasm

are entirely wanting. The disease attacks both eyes. Children affected with the disease sooner or later succumb to a pneumonia as the usual thing. If the patient gets better before the cornea has disintegrated it may clear up once more according to Gouvea.

Etiology.—Keratomalacia depends upon an insufficient nourishment of the cornea, but this is only one of the symptom-complex of the disease. The hemeralopia is caused by a depressed nutrition of the retina. The retina continues to perform its function under strong light or stimulation but fails to respond to weak stimuli (torpor retinæ). Typical keratomalacia does not occur in adults. In them the cornea is little implicated, but the night-blindness and xerosis conjunctivæ are present. A number of organisms have been found in cases of keratomalacia but those most frequently found are the pseudo-diphtheritic bacillus and the xerosis bacillus of Kuschbert and Neisser. The latter are found chiefly in the altered epithelium of the conjunctiva and are probably the specific cause of the disease.

Treatment.—The patient's strength must be supported by proper nourishment and tonics. If the eyes remain open during sleep on account of apathy of the patient, the corneæ should be protected from desiccation by bandaging the eyes. In addition we attempt to stimulate the vitality of the corneæ by application of moist warm compresses and use of some stimulating antiseptic solution as bichlorid solution 1–4,000. The compresses should be kept on an hour and left off for the same length of time. Atropia should be instilled to prevent the occurrence of iritis.

Keratitis Neuroparalytica is a very characteristic affection of the cornea, caused by paralysis of the trigeminus or fifth nerve.

The causes of fifth nerve paralysis are: exposure to cold, tumors at the base of the brain, syphilitic or tubercular meningitis. The nerve may also be compressed by disease of the cavernous sinus, by aneurism, or by tumors or cellulitis of the orbit. The commonest cause of anæsthesia of the fifth nerve are focal lesions in the pons, such as hemorrhages, tumors, embolic softening and sclerosis. Primary neuritis of the fifth nerve is indeed a rare affection. The results

of fifth nerve paralysis are trophic lesions, first of which is herpes (herpes ophthalmicus), which has already been described; the other trophic lesion is the neuroparalytic ophthalmia about to be described. While the latter disease is always to be feared in anæsthesia of the fifth nerve, it is not an invariable result, and there are many cases in which sensation of the eyeball and adjacent parts has been wanting for years and yet the eye has remained unimpaired. When the ophthalmic or first branch of the fifth nerve is involved the eyeball, forehead, side of the nose and corresponding nostril are insensitive.

Symptoms. — The cornea becomes steamy, and its epithelium exfoliates first at the center, gradually extending until there is left only a narrow margin of epithelium several millimeters broad. This loss of epithelium imparts to the cornea quite a peculiar appearance which is characteristic of the disease. In the meantime cloudiness of the cornea has been increasing. This is most marked at the center of the cornea and fades off towards the periphery. The cloudiness is resolved into separate spots of infiltration by aid of a magnifying glass. The infiltrate soon assumes a purulent color, hypopyon sets in, and the cornea ultimately breaks down into pus at its center. A large ulcer forms, and cicatrizes with inclusion of the iris, with flattening of the entire cornea. This is the severest picture of the disease. Most cases do not go on to purulent disintegration of the cornea, but the latter remains permanently cloudy and often becomes altered in shape, becoming ectatic or flattened. There are practically no symptoms of irritation, the eye often being far advanced in the disease before much attention is given to it as it is free from pain. There is no pain nor lachrymation on account of the nerve paralysis, but there is ciliary injection.

Prognosis. — Treatment has practically no effect over the progress of the disease which leads to complete loss of sight.

Treatment. — Although treatment is unsatisfactory, the eye should be given the benefit of the doubt. Warm moist compresses and atropin are indicated locally, and an attempt to restore the function

of the nerve made. If the nerve partly regains its function even the cornea will clear up in a measure.

A diligent search should be made for the cause of the paralysis and it removed if possible. The most favorable cases are those due to exposure to cold, or to specific trouble. Nieden recommends that $\frac{1}{60}$ gr. of strychnin sulphate be injected under the skin of the temple every few days. The constant current should also be employed. *Keratitis e lagophthalmo* occupies the lowest part of the cornea. *Keratomalacia* begins in the center of the cornea, and is found almost solely in children who are much reduced in strength from some wasting disease. Finally *keratitis neuroparalytica* is characterized by a rapid exfoliation of epithelium over the whole extent of the cornea and does not occur except in connection with a fifth nerve paralysis which can be diagnosed at once.

NON-SUPPURATIVE FORMS OF KERATITIS.

Pannus is a vascular connective tissue growth that develops upon the surface of the cornea beneath its epithelium. It is a sequel of trachoma, trichiasis and entropion. The leash of vessels which develops upon the cornea in phlyctenular keratitis is classed by some as a pannus and called pannus lymphaticus in contradistinction to pannus trachomatosus (Fuchs). Pannus as usually observed is the result of trachoma. In such cases especially when it accompanies the first stage of the disease it is an expression of the trachomatous process itself in the cornea, and not a secondary effect as it is when occurring in the third stage or when associated with trichiasis or entropion. In the latter the vascularity is due to mechanical irritation of the cornea. The pannus due to trachomatous infection is much thicker than that due to mechanical irritation of the cornea by roughened lids, inturned lashes or what not. The thicker and denser forms of pannus are designated as pannus crassus; the thinner as pannus tenuis. In the latter the blood-vessels are confined to the superficial layers and there is very little thickening and infiltration of the epithelial layer, but in the more fleshy forms the infiltration extends

into the deeper layers of the cornea as well. Pannus always begins at the upper margin of the cornea, under the upper lid, from which the cornea gets its infection in cases of trachoma. The whole cornea may become covered and so opaque that the iris cannot be seen through it. As pannus runs its course it is very seldom without ulceration or loss of tissue. Occasionally the process is one of hypertrophy only, characterized by the formation of new blood-vessels and connective tissue. The process ends with complete resorption of the newly formed tissue, leaving the cornea nearly as transparent as ever if there was no destruction of the substantia propria.

Treatment.—As pannus depends upon some other pathological condition it improves *pari passu* with that condition. If vascularity and opacity persist in any degree after the cure of the cause of the pannus remedial measures are directed to the condition itself. These consist in limiting the blood-supply to the pannus. A narrow piece of conjunctiva 2 millimeters broad may be dissected from around the base of the cornea (peridectomy) (Fox) or the conjunctiva merely incised around the limbus (peritomy) or the tissue adjacent to the edge of the cornea may be cauterized deeply with the actual cautery. Curetting the surface of the cornea in the early stages of pannus is done with decided benefit. Absorption may also be hastened by placing a bit of yellow oxid salve upon the everted lid and then massaging the eye through the closed lids once or twice daily. Finely divided calomel insufflated into the eye is useful for the same purpose. Experience has shown that further resorption can be obtained in an old pannus, chiefly made up of connective tissue and very few vessels, by exciting a violent inflammation in it, thus producing a greater succulence and increased vascularity.

For this purpose we make use of the jequirity bean which was first recommended by DeWecker. A three to five per cent. infusion is made by steeping the ground beans in cold water for twenty-four hours. The solution should be prepared fresh every day. With this solution the conjunctiva of the everted lids is painted over several

times a day. The inflammation thus produced reaches a considerable height upon the second or third day when the applications are stopped. The lids become reddened, swollen and edematous, chemosis is often present and the conjunctiva covered with a croupous membrane (jequirity ophthalmia). The application must not be continued too long, otherwise there results a disintegration of the conjunctiva. The inflammation is now allowed to run its course, the eye simply being kept clean. When the inflammation subsides the cornea in a favorable case is seen to have gained much in transparency. Every night a little yellow oxid of mercury salve should be well rubbed in, by placing a small bit in the conjunctival sac. Formerly an eye was inoculated with gonorrhœal pus for the relief of pannus, but the inflammation thus produced could not be kept within bounds and many eyes were lost. This plan has now been abandoned. Merck has recently placed upon the market a substance known as jequiritol which is destined to replace the other preparations of jequirity on account of its greater safety and exactness of dosage. The dose is increased from day to day from 10 milligrams until sufficient reaction is produced. The lids become swollen but the cornea never becomes involved or the neighboring lymph-glands affected. Coppez says that acute exacerbations of trachoma may be abated by this treatment in 10 to 12 days. Operative treatment is generally needed to effect a permanent cure however. In nearly all cases of pannus there is more or less photophobia, lachrymation and ciliary injection, and very frequently the inflammation extends to the iris. The pupil should therefore be closely watched and atropin used if there is danger of iritis, so that the iris will not become tied fast to the lens capsule by inflammatory exudates. During the treatment of trachoma the pannus may be with advantage lightly touched with the copper or alum stick after its application has been made to the everted lids, if it is very dense and rich in vessels.

Keratitis with the Formation of Vesicles.—In cases where there is the formation of vesicles upon the cornea its sensitiveness as a rule is greatly diminished or entirely lost. There are three varieties of kera-

titis with the formation of vesicles, namely: Herpes febrilis corneæ, herpes zoster corneæ and keratitis vesiculosa. Corneal vesicles are usually small and filled with a clear limpid fluid. Their anterior wall is formed in most instances of the epithelium of the cornea which is lifted up from Bowman's membrane by the collection of fluid beneath it. When the vesicles are large their anterior wall is usually reinforced by a layer of new-formed connective tissue beneath the epithelium, and are therefore more resistant. Violent symptoms of irritation are usually present during the development of the vesicle, occasioned by the stretching and tearing apart of the fine nerve twigs which ramify in the deeper layers of the corneal epithelium. The vesicle is seldom seen as it soon ruptures, but in its stead a defect in the epithelium to the edges of which the epithelium which has been lifted up still adheres in loose threads. The larger blebs on account of the firmness of their walls are more persistent. They occur as partly filled, pendent, tremulous sacs.

Herpes Febrilis (*Simplex*) *Corneæ.*—In febrile diseases and those of the respiratory organs especially, such as influenza, bronchitis and pneumonia, small vesicles appear about the lips, alæ of the nose, etc. A few small vesicles may occur upon the cornea associated with marked irritation of the eye. The vesicles soon rupture and the disease is over in two weeks, without leaving a trace behind. In severe cases ulceration may occur after rupture of the vesicles. The vesicles upon the cornea are analogous to those which occur elsewhere upon the skin, and as the latter are usually present only on one side of the face the ocular disease is unilateral.

The Treatment is protective bandage and atropin. If there is much pain a solution of holocain may be used.

Herpes Zoster Corneæ.—This occurs associated with herpes zoster ophthalmicus. The cornea participates in the morbid process by the formation of vesicles which are arranged in groups. They rupture speedily, but unlike herpes febrilis, irritative symptoms continue after rupture of the vesicles, and by a marked opacity of the substance of the cornea at the spots where the vesicles were located. Herpes

zoster is a trophic disturbance due to paralysis of the fifth nerve and the cornea therefore is insensitive.

Treatment.—For the relief of pain which is extreme in the beginning we use dry heat (Japanese hot-box). After the efflorescence has occurred atropin solution (4 grains to the ounce) is instilled every four hours and a bandage applied.

Keratitis Vesiculosa (*Bullosa*).—This occurs in eyes whose corneæ are insensitive and more or less cloudy and poorly nourished, as in eyes with large corneal scars, or those blind from irido-cyclitis or glaucoma. Small or large vesicles occur upon the cornea with much irritation. The vesicles occur in crops so that the disease may extend over a long time and becomes very annoying to the patient. The cause of formation of vesicles seems to lie in disturbance of the lymph circulation of the cornea. By more or less stasis of lymph, edema of the cornea is brought about. The edematous fluid penetrates the substance of the cornea until it comes to lie beneath its epithelium, which it lifts up in places, forming vesicles or bullæ. Bullous keratitis also occurs in eyes which have met with injury, causing an abrasion of the cornea but which are otherwise normal apart from the condition under consideration. The bulla occurs sometimes after the regeneration of the corneal epithelium has taken place and is probably due, as suggested by Stood, to imperfect regeneration, so that during sleep it adheres to the lid and is detached from Bowman's membrane. Others believe that certain degenerative changes take place which lead to the separation of the corneal epithelium from Bowman's membrane.

Treatment.—The larger vesicles should be opened, by removing the anterior wall. Atropin is instilled and a bandage applied. The case is then treated after the manner of corneal ulcers.

In order to prevent a recurrence if the disease has shown a tendency to recur the raw spots upon the cornea may be touched with a solution of silver nitrate (10 gr. to 1 oz.). Others advise the removal of the superficial layers of the cornea in these spots. Frequently the disease will continue until the nutrition of the eyeball is

increased by an iridectomy. If this fails the only relief for the patient is an enucleation.

Before passing to the consideration of the deep forms of non-suppurative keratitis, there remains one other form of superficial keratitis to be described, namely: *Keratitis punctata superficialis* (Fuchs). This affection begins as an acute conjunctivitis, and at the same time or some days afterwards there appear a number of gray points upon the cornea, arranged in groups or rows at times. The spots occur chiefly in the central portion of the cornea. The cornea looks steamy and its surface finely granular because the epithelium over the spots is raised in the form of nodules. The irritative symptoms soon disappear but the changes in the cornea often persist for months and then slowly disappear. Ulceration but rarely occurs. Now and then we see a case in which the epithelium over the tiny papules has exfoliated so that the cornea is seen to be actually peppered with minute ulcers after the instillation of fluorescein. The disease is found principally in young folks, and associated frequently with affections of the respiratory apparatus. The treatment of the corneal complication is that for keratitis in general.

Deep Forms of Non-Suppurative Keratitis.—In these forms the infiltrate develops in the substantia propria of the cornea which shows no tendency towards purulent disintegration. There is therefore no loss of substance. The infiltrate disappears by resorption and in favorable cases the cornea reëstablishes its transparency. In certain cases opacity is left which at times is accompanied by flattening of the cornea.

Interstitial Keratitis (*Parenchymatous Keratitis, Keratitis Profunda, Keratitis Diffusa, Uveitis Anterior* (*Stellwag*)).—This as its name indicates is an inflammation of the substantia propria or interstitial substance of the cornea. It is a manifestation of a systemic derangement, usually acquired syphilis, and occurs most frequently during adolescence.

Etiology.—Hutchinson was the first to see the connection between interstitial keratitis and congenital syphilis. All cases are not how-

ever syphilitic. Von Hippel says it is very frequent among those of tubercular taint. It is occasionally seen after acquired syphilis in chronic rheumatism and gout, and in women with deranged menses. and in a few cases seems to accompany chronic malarial poisoning. Various authorities say from 14 to 96 per cent. are caused by congenital specific trouble.

In specific cases we find the following array of symptoms: A peculiar formation of the face and cranium, the upper jaws are markedly flat, and the bridge of the nose low and often sunken in. Not infrequently there exists an ozena or blenorrhœa of the lachrymal sac occasioned by the nasal disease. The frontal eminences are very prominent. The intelligence of these patients is often abnormal, being very precocious or backward in mental development. The incisor teeth are abnormally shaped, so that instead of a straight edge, they show a semilunar indentation, from side to side and from before backward (Hutchinson's teeth), and are club-shaped. This change exists only in the teeth of the second dentition. At the angles of the mouth fine linear scars are often seen, relics of former rhagades or fissures, so also cicatrices in the buccal or pharyngeal cavity point to former syphilitic ulcerations. Numerous enlarged glands may be made out in the neck. They are hard, painless and show no tendency to ulcerate, by which they are distinguished from tubercular glands which are large and soft and readily undergo caseation.

Swellings of the periosteum or so-called tophi occur along the long bones as small, painless, hard lumps. They are best made out along the tibia. At times a hydrops of the knee-joint is present. Hardness of hearing is common which at the outbreak of the keratitis sometimes increases to absolute deafness. Furthermore syphilitic mothers will give the history of frequent abortions, or of death of their children in early infancy.

Symptoms.—The disorder usually begins with irritative symptoms, such as pain on exposure to light, lachrymation, and blurred vision which lead the patient to the physician. Examination of the affected

eye reveals circumcorneal injection, and a grayish opacity somewhere in the substance of the cornea, and perhaps at more than one place. The surface of the cornea over the opacity is somewhat dulled, but not disturbed. The true position of the opacity is furthermore told by the area failing to stain with fluorescein, as it would do if it was a surface disease of the cornea associated with a loss of the epithelium.

It may be necessary to examine the cornea with a high magnifying lens to reveal the exudate if the case is seen early. This should always be done after the eye has been carefully examined for other causes of irritation, as presence of foreign bodies in the cornea or under the lids, corneal abrasions, etc., or the disease in its incipiency will frequently be overlooked. In typical cases the opacity extends until the whole cornea is the color of ground glass. At this time the surface of the cornea appears roughened, caused by a disturbance in the epithelial cells. Blood-vessels develop in the substance of the cornea from the scleral vessels after the opacity has reached a considerable degree. The sight at this time is reduced to light perception. Many cases run their course however without the formation of blood-vessels. At times there are several spots of infiltrate in the cornea which remain discrete (discrete or circumscribed interstitial keratitis) but in most instances the spots become confluent so that the whole cornea is more or less homogeneously cloudy. In the discrete form which is commonest in rheumatic and gouty diathesis and in women about the climacteric, there is nearly always a permanent opacity left after the disease subsides, especially so if the spots are near the scleral border. By some the stage of vascularization of the cornea is spoken of as the secondary stage. In this stage the irritative symptoms greatly increase. The vessels are harbingers of good and sent to carry off the exudate. The disease is now regressive. The vessels are fine and seen through the cloudy layers of the overlying cornea appear almost like extravasated blood between the layers of the cornea.

Vascularization usually begins above and progresses from above below until vessels have permeated the cornea in all directions. At

this stage there is great danger of an iritis, and the inflammation not infrequently spreads to the ciliary bodies and chorioid. Ulceration nor hypopyon ever occur. After a length of time varying from three months to a year or more under energetic treatment the cornea begins to regain its transparency, first around the periphery and lastly in the center. The vessels should disappear with the exudate, but not infrequently a few of the finer ones are left, which are seen by aid of the magnifying glass, and permanently interfere with good vision. The majority of cases, if properly treated, clear up so that the vision is as good as ever. The disease affects both eyes at once or in succession as it is systemic in origin.

Treatment.—Locally agents to stimulate vascularization and to prevent the spread of inflammation to the iris and ciliary bodies are indicated. Internally antisyphilitic treatment is indicated in most cases. But if syphilis can be eliminated with any degree of certainty tonic alteratives are indicated such as iron, gr. 1; bichlorid of mercury, gr. $\frac{1}{60}$; strychnin sulphate, $\frac{1}{60}$, t. i. d. Subconjunctival injections do good and tend to cut the progress of the disease short. The following solution is preferred, especially when there is a specific history: Iodin, 1 gr.; potassium iodid, 10 gr.; water, 1 oz. Four minims are injected beneath the conjunctiva above the cornea every other day if well borne, and good is seen to follow its use. Atropin should be instilled three times a day and oftener if iritis ensues. After the cornea has gotten very cloudy it is difficult to tell whether the iris is inflamed or not as it can not be seen, but if during the progress of the disease the eye becomes more painful, especially at night it is fair to assume that there is a spread of the inflammation to the uvea. Smoked or blue glasses (not green) should be worn to protect the eyes from the light. To favor vascularization and at the same time to ease the discomfort of the patient a one per cent. solution of holocain may be used as often as every two to four hours followed by bathing the eyes in hot water for fifteen minutes or so. Mercury should be administered in appropriate cases by inunction, or fumigation, and also by the mouth in form of biniodid, $\frac{1}{8}$ gr.,

three or four times a day, to the point of salivation. So that this will not happen the patient should report frequently, and stop the medicine at once if more than two or three movements of the bowels occur in a day, or if the mouth gets at all sore. Salivation will not so readily occur if the teeth are kept clean and any carious teeth pulled or filled. A close lookout must be kept for the red line upon the gums. Potassium iodid is also given internally in doses of 10 gr. and upward three times a day.

Keratitis Profunda (*Central Parenchymatous Infiltration of the Cornea, Circumscribed Parenchymatous Keratitis*). — In this disease the opacity is located in the middle and deeper layers of the cornea. Over the opacity the cornea is gray and punctate in appearance but not depressed. The opacity by aid of the magnifying glass is seen to be made up of separate points and maculæ, or of interlacing striæ of infiltration. The opacity persists for several weeks and then begins to clear up, without ulceration ever taking place. Vessels very rarely develop or do so in a very limited degree. The accompanying symptoms of irritation are at times slight and at times rather violent. There is seldom any spread of inflammation to the uvea. The duration of the disease upon the average is four to eight weeks.

Etiology. — Rheumatism, gout, malarial cachexia, injuries and especially contusions of the cornea.

Treatment. — Dark glasses, atropia, and after injection subsides irritating lotions or salves to hasten resorption. The general treatment depends upon the cause.

Sclerosing Keratitis. — This variety of keratitis accompanies an attack of scleritis. In the course of a scleritis adjacent to the edge of the cornea, there develops in the latter an opacity which is situated in its deeper layers. The opacity has a triangular shape with its base towards the edge of the cornea, while its rounded apex projects towards the center of the cornea. The opacity which is at first grayish increases in density until the cornea becomes perfectly opaque.

The surface of the cornea above the opacity is punctate but not depressed. Ulceration does not take place, but there is frequent

involvement of the iris and ciliary bodies. As the disease process comes to an end, the edges of the corneal opacity are resorbed, but the greatest part of the opacity is permanent, and becomes bluish-white without any line of demarcation between it and the sclera. Von Graefe gave the name of sclerosing keratitis to the disease on account of the appearance of the sclera being pushed into the region of the cornea. In successive attacks of scleritis new opacities form in the cornea, so that when the disease runs a pretty long course, peripheral opacities form one after the other until the entire periphery of the cornea is clouded in this way, and only a small central portion remains transparent.

Treatment.—The treatment is that of scleritis, which see.

Keratitis Springing from the Posterior Surface of the Cornea.—Whenever an exudate or tissue is brought in contact with the posterior surface of the cornea and remains there for some length of time an opacity develops in the cornea at the spot of contact. This does not occur in ordinary cases of hypopyon as the exudate is soon carried away, but is formed in the more solid exudates associated with tubercular and syphilitic irido-cyclitis. Cysts or other tumors of the iris which press against the cornea also give rise to opacity in the latter as does the iris tissue itself and crystalline lens when in contact with the cornea. The opacity is of slow growth but finally becomes very dense and permeated with fine vessels in the deeper layers of the cornea. The opacity in a great measure is permanent. It is supposed that contact of the cornea with foreign tissue causes a lesion of Descemet's endothelium, which allows the aqueous humor to come in contact with the corneal substance. According to the researches of Leber it is this endothelium that normally protects the cornea from invasion by the aqueous. Treatment consists in removal of the cause.

Keratitis Punctata, which is not a disease of the cornea at all, but a deposit of round cells, with interspersed pigment granules, upon Descemet's membrane, and seen associated with opacities of the vitreous in cases of anterior chorioiditis and cyclitis will now be described.

The affection has been called aquo-capsulitis, hydromeningitis or descemetitis by those who suppose the spots upon the posterior surface of the cornea to be of inflammatory origin. These deposits are very often overlooked because they are at times extremely minute. In all cases of suspected uveitis we should examine the cornea for them with a strong magnifying glass. These deposits of cells and pigment are at times also seen upon the anterior capsule of the crystalline lens and upon the iris. After persisting for a variable length of time, sometimes for months, the deposits undergo fatty degeneration and are absorbed. The deposits are set free in the aqueous and by the motions of the eyeball are flung upon the posterior surface of the cornea where they adhere. They usually arrange themselves in a triangular form, with the apex of the triangle towards the pupil, and the larger masses of exudate at the bottom. Occasionally they are scattered irregularly upon the cornea. The pupil is usually somewhat dilated, tension of the eye elevated, and iris tissue discolored. Keratitis punctata of authors is nothing but a symptom of a uveitis, and especially iridocyclitis (so-called serous iritis).

Treatment.—Atropin must in such cases of uveitis be used sparingly, and close watch kept for rise of intraocular tension. If it occurs, a paracentesis of the anterior chamber should be done, dry heat applied to the eye, and 20 grains of sodium salicylate given internally every two hours. If there are no marked symptoms of an iritis, eserin solution (2 gr. to 1 oz.) may be instilled frequently until the pupil is contracted. For the opacities themselves, mild doses of bichlorid or biniodid of mercury or potassium iodid in ten-grain doses seems to hasten their resorption.

Striped Keratitis (Striated Opacities of the Cornea).—After operative wounds of the cornea, and less frequently after injuries or inflammation of the cornea, there are seen a number of linear opacities focusing towards the seat of injury. They are seen running at right angles to the corneal section after cataract extraction. The strips of opacity are from ½ to 1 mm. in width. There may be two sets of lines running across each other making a sort of panelled

figure. The intervening corneal tissue is wholly or comparatively transparent. They were supposed by Becker to have been overfilled lymph channels and by Arlt infiltration of large nerve-channels. They are caused however by a wrinkling or folding of Descemet's membrane, due to shrinkage of the corneal stroma in healing of the wounds or its unequal swelling due to infiltration. The opacities require no treatment as they usually disappear, but at times remain to obscure the vision. Frequently after an iridectomy for glaucoma or visual purposes, the vision remains poor or becomes poorer than it was primarily on account of these opacities. It is said that the folding of Bowman's membrane gives the same picture.

Keratitis Bandelette (*Ribbon-shaped Keratitis, Primary Transverse Opacity of the Cornea*).—This like the two foregoing is not a true keratitis. It is a rare form of corneal disease associated with ocular malnutrition from irido-chorioiditis, glaucoma, detached retina, or gouty tendency. The lesion of the cornea is situated in the palpebral fissure, and consists of finely punctate opacities under the epithelium of the cornea. It begins on one or the other side, leaving a small area of transparent cornea at the periphery, and extends towards the center of the cornea, where the two bands meet in time. The affection is bilateral, both corneæ being liable to be affected in course of time. It is mostly observed in men. After removing the epithelium of the cornea the opacity can be flaked off of the cornea, leaving clear cornea beneath. The deposit consists of phosphate or carbonate of lime. Its removal in this manner is the only treatment. Such eyes have a tendency to glaucoma so atropin should not be instilled.

Injuries of the Cornea.—The commonest injuries to the cornea are from the inception of foreign bodies. Most frequently observed are small bits of iron or emery among mechanics. The particles of metal in the cornea do not look like metallic iron but vary from a dark brown to a black color, being more or less oxidized, as they frequently hit the eye in a state of red heat, chipping off from a piece of metal that is being hammered. If a piece of iron remains awhile

in the cornea it becomes surrounded by a brownish ring, because the portion of the cornea in the vicinity takes up the oxidized iron and is thus stained brown. Bits of coal are also found in the cornea in firemen and engineers. Foreign bodies in the cornea should be removed as soon as possible with a needle specially prepared for the purpose or with a spud or small gauge. The surrounding ring of discoloration should be scraped out. If the stain can not at once be removed in a few days it will separate in a slough. The eye should be anesthetized by the instillation of a four per cent. solution of cocain. The physician stands behind his patient, and supporting the head of the patient firmly against his chest, separates the lids with the thumb and middle finger of his left hand. The patient is then instructed to look in various directions until the body is well seen. The eyeball is then steadied by pressure made upon it with

Spud.

Gauge.

Sharp Pointed Gauge.

the forefinger of the left hand and the particle removed. It is often necessary to employ oblique illumination in removing foreign bodies from the cornea. Care should be taken not to abrade the cornea any more than necessary. A solution of bichlorid 1–4,000 is then given the patient to instill every four hours to combat infection and the eye bathed frequently in hot water to favor the regeneration of the corneal epithelium. The instruments shown in the cuts above are those usually employed for removal of foreign bodies in the cornea.

If the foreign body is not soon removed it is expelled by suppuration. An inflammatory infiltrate in the form of a gray ring surrounds

it. Then the tissues of the cornea in this place break down so that the foreign body becomes loose and ultimately falls out. The resulting ulcer rapidly becomes clean unless infection has taken place and heals with the formation of a small scar. This process of elimination takes place with a certain amount of irritation, especially with irritation or hyperemia of the iris. Grains of powder will remain a long time in the cornea without exciting inflammation, unless the cornea has been peppered by them. In such a case we are apt to have an iritis resulting. If the particle in the cornea is not readily seen a drop of fluorescein solution may be instilled. More serious are those foreign bodies that penetrate more deeply into the substance of the cornea. In this case we often have to incise the overlying cornea and seize the foreign body with forceps to remove it. If the foreign body has almost perforated the cornea and there is danger of pushing it into the anterior chamber of the eyeball, a small incision through the cornea near its periphery and nearest the foreign body, should be made through which we can pass a spud and press the body forward while it is grasped by the forceps.

Abrasions.—Superficial excoriations of the cornea, which simply produce a loss of the epithelial covering of the cornea, are not uncommon. They are spoken of as abrasions or erosions. Such injuries of the cornea arise from scratching the eye with the fingernail, or from the eye being brushed by a stiff leaf or twig or what not. Such an injury is usually marked by considerable irritation which manifests itself in watering and pain on exposure to light, and circumcorneal injection. Often the lesion of the cornea will be overlooked until a drop or two of fluorescein solution is instilled. The abraded area is then outlined in green. If ulceration does not follow the injury healing occurs in a few days by regeneration of the epithelium starting from the edges of the defect. Opacity does not remain. Corneal abrasions are especially dangerous in cases of conjunctival catarrh or blenorrhœa of the lachrymal sac, as the cornea is very apt to become infected and develop an ulcer or abscess. At times after the erosion is apparently healed symptoms of irritation

again return and the recently regenerated epithelium peels off or is raised in form of a bulla.

Treatment.—If the abrasion is small it suffices to give the patient a solution of holocain muriate (two per cent.) to instill every two hours to allay the pain ; to protect the eye from the light by a shade or bandage and to frequently apply hot water. If there is any evidence of irritation of the iris atropia should be instilled several times a day and the eye kept bandaged.

Wounds which extend deeper into the substance leave opacities behind, the more decided the deeper they have extended into the cornea. Such wounds of the cornea are dangerous on account of possibility of infection and because they frequently perforate the cornea, so that a corneal abscess or prolapse of the iris is apt to follow. The iris and the lens are not infrequently injured at the same time the cornea is wounded, giving rise to a traumatic cataract and inflammation of the uvea, which may go on to the total destruction of the eyeball.

Treatment.—The eye is well cleansed with a solution of boric acid and if the iris is prolapsed an attempt should be made to replace it within the anterior chamber of the eyeball after loosening it from the edges of the wound of the cornea with a slender probe. If reposition is impossible the iris is drawn out a little more and snipped off. The wound should then be covered with finely powdered iodoform and a protective bandage applied. The patient should remain in bed during the closure of the wound, so that there will be no spontaneous prolapse of the iris.

Burns of the Cornea occur together with those of the conjunctiva from acids, lime and hot metals. The eroded or burned cornea presents a dull and opaque appearance. If the burn is superficial the opaque area is grayish, while in deeper burns it presents a whitish appearance and may in the severer forms be as white and opaque as porcelain. The cornea is dry upon its surface and quite insensitive within the eroded area. Burns of the cornea at first give rise to very sharp pain which subsides in a great measure after several

hours. The cornea heals by the extrusion of the dead tissue. The treatment of burns of the cornea is like that given under the head of burns of the conjunctiva, save the frequent instillation of atropin solution to protect the iris against inflammatory invasion.

Opacities of the Cornea.—Opacities of the cornea develop as the result of inflammation in the cornea, caused by cellular infiltration of the corneal tissue. The infiltration opacity is of a changeable nature, increasing or diminishing according to the progress of the inflammatory disturbance. Reference is now made, however, to those more or less stationary opacities or scars of the cornea caused by a former attack of inflammation or developing without any antecedent inflammation.

Opacities cause little disturbance of vision unless they occupy the pupillary area of the cornea, save a certain amount of distortion of the surface which they give rise to in their formation.

The real cause of disturbance of vision produced by corneal opacities is not the cutting off of light but rather its diffusion or scattering, caused by an unequal refraction in different areas. The whole retina is thus flooded with light and the outlines of the image obscured.

We occasionally meet with pigmented opacities of the cornea. Instead of the whitish area we find a brownish-red, black or yellowish discoloration. The first or brown discoloration of the opacity has its origin in the absorption of blood by the cornea from the anterior chamber in cases of hyphæma. The hæmoglobin undergoes a change in the corneal stroma into hæmatoidin crystals which stain its lamellæ. If the greater part of the cornea is thus discolored we may mistake it for a discolored and prolapsed cataractous lens lying in the anterior chamber in contact with the posterior surface of the cornea. It can be told from this however by the fact that in front of a dislocated lens there can be seen the corneal tissue when the eye is viewed from the side. Black and yellowish discoloration of corneal opacities are found in cases following aspergillus keratitis—the black spots caused by the aspergillus niger and the yellow by the aspergillus fumigatus.

Opacities of Inflammatory Origin.—These form as a sequela of suppurative and of interstitial inflammation of the corneal tissue. In the first instance the loss of substance of the cornea is replaced by a true cicatrix. In the same class belong most opacities or scars which remain after injuries to the cornea. In interstitial keratitis opacity at times remains because the cornea has been so strongly infiltrated during the progress of the disease that its lamellæ are not able to reëstablish their transparency, or from the exudate itself becoming organized. As has been mentioned before the deeper the disease penetrates into the substance of the cornea the whiter and the more permanent is the resulting scar. Thus small scars resulting from penetrating operative wounds of the cornea persist, while very extensive opacities produced by superficial burns or ulcers leave little trace behind.

Slight opacities appear as bluish-white spots with hazy outlines. When small they are spoken of as nubeculæ corneæ and when more diffuse as nebulæ corneæ. Well-marked opacities are grayish-white or pure white and are sharply outlined. When newly formed they are apt to be covered by vessels which in time disappear in a measure or altogether. As a rule the surface of the opacity is on a level with that of the surrounding cornea. This is especially the case when the cicatrix is small.

Elevation or depression of the cornea at the site of the opacity is also observed. Elevation of the surface is commonly the result of a bulging or ectasis of the cicatrix. In rare instances this is due to an abnormal thickening or heaping up of the cicatrix. Depression occurs from insufficient filling in of the excavation of the corneal surface following ulcers, or from retraction of the cicatricial tissue as is seen in cases of severe purulent inflammation of the cornea. This is especially apt to occur if there existed simultaneously a plastic irido-cyclitis with the inflammation of the cornea, for in irido-cyclitis extensive exudates are deposited in the interior of the eyeball which diminish the intraocular tension by their contraction, and so favor the flattening of the cornea. Incarceration of the iris occurs with many

cicatrices. Such cicatrices are very thick as they originate in a perforation of the cornea. The name of leucoma is given to dense white opacities of the cornea and if the iris is adherent to them we speak of it as adherent leucoma. It is important to determine whether the iris is or is not adherent in any special case, as evil consequences at times follow incarceration of the iris. The presence of the anterior synechia is recognized by the displacement of the pupil towards the site of the opacity, and also by the unequal depth of the anterior chamber, which is shallower near the place where the iris is adherent. In certain cases the dark color of the cicatrix will evidence that the iris is included in it. The iris is hindered in its action to light and convergence by an anterior synechia and thus kept irritable, and the infiltration of the aqueous into the canal of Schlemm is interfered with by the encroachment of the iris upon the infiltration angle of the eyeball, so that the eye is in danger of an attack of glaucoma.

Opacities of the Cornea not of Inflammatory Origin.— We find three different forms of opacities forming in the cornea unassociated with inflammatory disturbances; they are: Arcus senilis, zonular opacity and pressure opacity of the cornea. The first occurs in healthy eyes of those over fifty years of age as a rule although it is seen occasionally in the eyes of those younger. It is a physiological opacity as it comes to all eyes sooner or later. Arcus senilis is also called gerontoxon corneæ. It manifests itself as a ring of grayish opacity running parallel to and a little distance from the periphery of the cornea. It begins as two arcs above and below which gradually unite end to end to form the circle or annulus senilis. The outer edge of the arcus senilis is sharply defined and separated from the edge of the cornea by an area of clear cornea, while its inner edge tapers off into transparent cornea. It simulates the opacity left by a ring ulcer of the cornea, but from which it is differentiated in the following manner; In ring ulcer the opacity has not the even outline that it has in arcus senilis, and the opacity following the ulcer is not separated from the edge of the cornea by a strip of transparent tissue, but extends up to the very edge of the cornea. Arcus senilis

is caused by a colloid degeneration of the superficial layers of the cornea at its site. It was formerly supposed to have to do with arterio-sclerosis, but if so why should not the center of the cornea which is furthest from its blood supply cloud first?

The principal pathological opacity of non-inflammatory origin is the zonular opacity of the cornea. This occurs in the form of a gray stripe running across the cornea a little below its center. It begins as two points at each side which after years coalesce in the center of the cornea. The two ends of the opacity remain separated from the edge of the cornea by strips of transparent tissue. The edges of the opacity are well defined and more opaque than the center of the band. Examined closely with a magnifying lens the opacity is seen to be formed of a number of small white points lying in or directly beneath the epithelium of the cornea. The surface of the cornea over the opacity is therefore roughened. Zonular opacity of the cornea develops as a rule in eyes which are more or less blind as the result of an attack of irido-cyclitis or glaucoma. Very rarely in elderly people we find it coming in otherwise healthy eyes. Finally we find an opacity developing in the cornea from the rise of intra-ocular tension or in glaucoma, to which we give the name of pressure opacity of the cornea. It consists of a diffuse smoky opacity, most marked in the center of the cornea and diminishing towards its margin. That it is of non-inflammatory origin is proven by the fact that it speedily disappears (that is in a few hours) after the disappearance of the rise of tension. As a matter of fact we have to deal with a simple edema of the corneal tissue, located chiefly in the epithelium.

Treatment of Corneal Opacities.—Corneal opacities of recent date and especially in the young can be made to clear up and the vision improved in proportion by the prolonged use of irritants and heat. As irritants we employ for home use bichlorid solution in 1–4,000 strength or the yellow oxid salve. The solution should be instilled three times a day and the salve placed upon the everted lower lid, the eye closed and massaged for a few minutes every evening.

Probably more efficacious but at the same time more severe is the employment of calomel powder. A little is flicked upon the cornea from a camel's hair pencil or blown into the eye with a powder blower and then the eye is closed and rubbed well. The patient may use this at home once a day. Heat like these irritants causes a quickened circulation and tissue metamorphosis with absorption of the newly-formed tissue. The most convenient way for the patient to employ local heat is to apply a Japanese hot-box to the eye for an hour or so a day. Bissell devised an apparatus for the use of steam in diseases of the cornea. It is used with good results in all sorts of inflammation of the cornea, ulcerations and opacities. It lessens the pain and cuts short the attack.

It stimulates healing in sluggish ulcers and hastens resorption of exudate. The steam is employed plain or incorporated with iodin vapor by putting tincture of iodin in the boiling water. The eye of the patient is brought as close to the end of the spout of the kettle as can be without causing discomfort and the steam allowed to blow directly upon the cornea. There is no danger of doing any harm with the heat as the skin of the lids and cheek will feel the heat to an uncomfortable degree before the eyeball suffers.

Corneal Ectasis.—Ectasis (ectasia) or bulging of the cornea takes place, due to a loss of resistance as result of inflammation or lowered nutrition. We have then inflammatory and non-inflammatory ectasis.

Ectasis of inflammatory origin	{ Staphyloma, Keratectasis.
Ectasis of non-inflammatory origin	{ Keratoconus, Keratoglobus.

Staphyloma of Cornea.—A staphyloma of the cornea is a bulging cicatrix of the cornea originating in a protrusion of the iris. The staphyloma may wholly or in part replace the cornea. Hence we distinguish between partial and total staphylomata. A partial staphyloma occupies only a part of the cornea. It appears as a rule in the form of a whitish conical prominence (staphyloma partiale coni-

cum); spherical protuberances in partial staphylomata are very rare (S. partiale sphæricum). The staphyloma usually extends on one side as far as the edge of the cornea, while to the other side of it there is clear cornea through which the iris can be seen. The iris is of course drawn forward to the staphyloma and adherent to it. The pupil is therefore displaced toward the ectasis and often concealed behind it. If after a prolapse of the iris cicatrization takes place which does not yield before the intraocular pressure, we have a flat cicatrix including the iris to which the name of adherent leucoma is given.

In total staphyloma there is found in place of the cornea a protuberant cicatrix. The base of the protrusion is encircled by the outermost rim of the cornea which may be preserved, or by the limbus. The bulging cicatricial cornea may have the form of a cone (staphyloma totale conicum), or as is the rule in total ectasis of the cornea the protuberance has the form of a hemisphere (s. t. sphæricum). Not infrequently in newly-formed spherical staphylomata we can recognize the black pigment upon its posterior surface shining through the thin cicatrix with bluish luster. Such bluish-black staphylomata from their fancied resemblance to a grape have given rise to the term staphyloma. The wall of the staphyloma afterwards becomes thicker. The thickening may take place irregularly so that the surface of the protrusion takes on an uneven or blackberry appearance, giving rise to the so-called staphyloma racemosum. Old staphylomata have as a rule a thick white wall in which one or more dark spots can be observed, as the result of pigmentation or localized thinning. As a rule we find several rather large vessels traversing the staphyloma coming from the conjunctiva. Nothing can be seen of the deeper parts of the eyeball on account of the opaqueness of the staphyloma. The iris is all included in the staphyloma and there is no longer any anterior chamber.

Etiology.—A staphyloma may result as a primary or secondary protrusion of the iris through an opening in the cornea following a corneal ulcer or from traumatism. In unfavorable cases of prolapse

the iris fails to become converted into a flat resisting cicatrix, so that it is readily stretched by straining at stool, physical exertion and in children by crying and squeezing the lids together. As the cicatrix is not elastic it remains bulging after the elevation of tension has disappeared. Besides the misbehavior of the patient a large perforation of the cornea predisposes to an ectasis. A secondary protrusion is one when a prolapse of the iris heals with the formation of a flat cicatrix which later becomes bulging.

The cause which operates to produce this result is too early resumption of work after the cicatrization of the cornea. The new cicatrix is still too soft to withstand the transitory elevations of intraocular tension oft repeated, so gradually becomes attenuated and distended.

Sequelæ of Staphylomata.—Of course the vision is always diminished and in total staphylomata abrogated. The amount of sight retained depends upon the extent, character and position of the part of the cornea remaining.

The sight is always considerably reduced by the irregular astigmatism produced through distortion of the corneal surface in cicatrization. Large staphylomata besides produce a marked disfigurement. The eye often becomes irritable from the mechanical irritation of the lid, as the closure of the lids is rendered difficult due to the bulging. A chronic irritation of the conjunctiva is set up and ulceration occurs at intervals at the apex of the protrusion (atheromatous ulcers).

If the ectasis is very pronounced it remains uncovered by the lids and suffers from drying. The most important consequence of a staphyloma is the elevation of intraocular tension which takes place sooner or later in most staphylomatous eyes. This occurs in partial as well as in total staphylomata. Conical staphylomata more frequently lead to elevation of intraocular tension than do spherical ones. The elevation of tension further reduces what sight may be retained and finally renders the eye completely blind, besides giving rise to considerable pain. After elevation of tension takes place the

protrusion begins to yield so that its walls become more attenuated and at last yield at the least resisting point. The aqueous humor is then discharged and the staphyloma collapses to remain so for some time. The eyeball slowly fills again however and the process is repeated.

This may occur a number of times, or a profuse intraocular hemorrhage occurs, or a destructive irido-cyclitis ensues, giving rise to an atrophy of the eyeball. In the young during the stage of elevated tension the sclera becomes distended, so that there is produced a partial or total ectasis of the sclera. In the former case the sclerotic in the neighborhood of the cornea becomes distended and of a bluish luster from the chorioidal pigment shining through it, while in the latter the entire sclerotic becomes bulging, the eyeball larger, and of a bluish discoloration due to the uveal pigment shining through the attenuated sclerotic. A partial ectasis may form upon a total ectasis of the cornea or sclera, causing the eye to assume enormous proportions.

Treatment.—The best treatment is prevention. Whenever prolapse of the iris takes place every endeavor should be made to get a flat cicatrix. (See section on prolapse of the iris, in corneal ulcers.) The patient must abstain a long time from all physical exertion after cicatrization has taken place. As Fuchs advises it is wise to perform an iridectomy before the patient is discharged, and especially if the cicatrix is an extensive one, so that subsequent development of an ectasis is counteracted. If the staphyloma has already occurred we operate.

Operative Treatment of Staphyloma.—A simple incision into the staphyloma may be made with a cataract knife and a pressure bandage applied for some time at least until healing has taken place. If the wall of the protrusion is too thick to allow it to collapse a piece must be excised and the edges of the wound united with sutures. The incision is best made along the juncture of the staphyloma with the cornea. If the staphyloma involves the greater portion of the cornea it should be excised. Beere's method of simple ablation is

dangerous because a very large wound is left in the anterior wall of the eyeball and one which heals so slowly as to invite the entrance of microörganisms. The operation is done as follows: The lower half of the protrusion is separated from its base by a curved incision made with a cataract knife. The flap thus made is taken with a pair of forceps and the upper half of the staphyloma severed from its base with a pair of scissors. The crystalline lens which presents is then removed by opening its capsule. The vitreous then comes into view held back by a tense hyaloid membrane, and if the latter ruptures as is generally the case the vitreous escapes. If the loss of the vitreous is great there is very apt to be a more or less profuse intraocular hemorrhage. Moreover the vitreous hanging out of the wound is apt to become infected by the conjunctiva and lead to panophthalmitis. Far better is it to close the opening in the eyeball with sutures. The threads are passed vertically through the base of the protrusion before it is ablated, so that they can be immediately tied to prevent extensive escape of the vitreous humor. The most effective method at our disposal to combat ectatic cicatrices is iridectomy. The colomba should be broad, made by pulling the iris well out of the wound in the limbus before it is cut off. An iridectomy in many cases however is impossible as the iris has been pushed out and lies in contact with the posterior surface of the cornea.

If the staphyloma is total the contents of the eye should be removed after amputating the cornea from the sclera and a glass or aluminium ball placed in the sclera and the latter sutured over it (see Mules' operation) or the eyeball should be enucleated.

Keratectasis.—By the term keratectasis we mean a protrusion of the cornea which occurs as the result of inflammation in the latter but without any perforation taking place, as is the case in staphyloma of the cornea. The protrusion consists of corneal tissue and does not include the tissue of the iris as does staphyloma. The ectasis of inflammatory origin is differentiated from that of non-inflammatory origin, *i. e.*, keratoconus and keratoglobus, by the fact that the former is opaque while the latter retains its transparency. Inflammation in

the cornea causes it to yield before the intraocular pressure because it is thinned or softened thereby. An ulcer may affect the superficial layers of the cornea and by destroying the superficial layers allow the posterior lamellæ to bulge (keratectasia ex ulcere).

If all the layers down to the membrane of Descemet have been destroyed a hernia of this membrane occurs through the opening in the superimposed layers (descemetocele). This protrusion of Descemet's membrane most frequently ruptures but may cicatrize. The hernia in the latter case persists as a transparent vesicle projecting above the level of the surrounding cornea and surrounded by a ring of opaque tissue. Pannus by softening the cornea is at times followed by ectasis. This develops when the pannus is thick and fleshy and penetrated deeply into the corneal stroma. Rarely an ectasis follows a parenchymatous keratitis. All ectasiæ of the cornea sooner or later become opaque, so that the prognosis of restoration of vision in corneal tissue should be guarded as soon as bulging of the cornea is noted. Infrequently keratectasis is followed by rise of intraocular tension.

If keratectasis is threatened the cornea should be frequently punctured and a pressure bandage applied, or better an iridectomy should be performed. Very small ectasiæ may be made to shrink and cicatrize by often perforating them with the point of a thermo-cautery and applying a pressure bandage until healing is established.

Keratoconus.—In this disease the central part of the cornea very slowly and without inflammatory signs begins to bulge forward in the form of a cone. At first the cornea is perfectly transparent and the peripheral parts maintain their proper curvature. In the very beginning the bulging part of the center of the cornea is only recognized by the diminution that the corneal reflex undergoes as it is made to fall upon that area. As the condition advances the whole cornea becomes conical which can be recognized by taking a profile view of it. Finally the apex of the cone may become wrinkled and more or less opaque. The patient early becomes aware that something is wrong by the distortion that the irregular astigmatism gives rise to

in objects. All objects have to be brought very near the eyes to be seen at all distinctly, by which means the patient gets larger retinal images at the expense of distinctness. Keratoconus as a rule affects both eyes and after increasing to a certain point becomes stationary. The apex of the cornea never ulcerates nor perforates nor does the ectasis ever subside. Rise of tension is not associated with it as it is so often in cases of ectasiæ of inflammatory origin. It is a very rare disease and occurs principally between the ages of twelve and twenty and in females. We find it in otherwise healthy and robust individuals so that the cause of the central thinning of the cornea is not always evident. It at times follows long-continued ill health.

Treatment.—It is evident that spherical glasses can do no great good because the cornea assumes a hyperboloid form and the accompanying irregular astigmatism can not be corrected by cylinders, but vision can often be somewhat improved by use of concave sphere and cylinder, or by crossed cylinders with axes oblique to one another.

If the patient has lost useful vision it may be restored by wearing pin-hole spectacles, *i. e.*, opaque discs with a central hole or several holes separated a distance greater than the diameter of the pupil. (See section on Irregular Astigmatism.) The hyperbolic glasses as proposed by Raehlman are of service in some cases but to see well with them the patient must look in a line with the optic axis of the glass. They cannot be used for indirect vision and are therefore useless for going about. Arlt has seen good effect from the long-continued use of eserin or pilocarpin. The marked contraction of the pupil thus produced lowers the intraocular tension and thus lessens the pressure upon the attenuated part of the cornea. Iridectomy has done good for the same reason. The internal administration of agents to improve nutrition are also in order. Mercury and potassium iodid at times do good. Inasmuch as convergence increases the intraocular pressure it is wise to give the patient prismatic lenses with bases in to wear for near work, thus relieving the eyes of the necessity of convergence. In very advanced cases one may attempt to alter the curve of the cornea by cauterizing the

apex of the cone or the apex of the cone excised. Cauterization is preferable. Care should be exercised not to enter the anterior chamber as prolapse of iris may follow. The cornea at that site of course becomes opaque but later an iridectomy is done to displace the pupil behind a transparent peripheral portion. A great deal of the irregular astigmatism left can be corrected in the manner laid down under the latter head.

Keratoglobus.—Keratoglobus is the enlargement of the cornea as a whole. It is but a symptom of the enlargement of the eyeball as seen in hydrophthalmos or rise of intraocular tension in childhood. A fuller description of the condition will be given under the head of hydrophthalmos. By some staphyloma corneæ is used to denote any bulging of the cornea. Transparent ectasiæ are designated staphylomata pellucida and the opaque protrusions as cicatriciæ staphylomata.

Morbid Growths of the Cornea.—Of the benign tumors fibroma is the most commonly found tumor affecting the cornea. It may be primary or it may result from scar formation following an ulcer. It tends to return after removal. Papillomata are exceptionally found upon the cornea. The malignant growths are almost always of the epithelial variety, and are most commonly secondary to similar growths of the conjunctiva or sclera. A few cases of primary sarcoma of the cornea have been reported.

Congenital Defects of the Cornea.—Commonest among congenital defects are dermoid tumors of various kinds. They are as a rule situated upon the limbus, and not infrequently associated with coloboma of the lids. Congenital opacities and staphylomata are uncommonly observed and are due to intrauterine inflammation, which has become arrested prior to birth.

Microphthalmos is an abnormally small eye from arrested development. The cornea is thus reduced in all its diameters.

Megalophthalmos is the opposite condition, that is an abnormally large eye due to stretching of the outer tunic of the eyeball from rise of intraocular tension.

Sclerophthalmia is that condition in which the sclera encroaches upon the transparent cornea from imperfect differentiation of the cornea and sclera. In most cases it is the upper part of the cornea that is alone affected.

CHAPTER XII

DISEASES OF THE SCLERA

THE diseases of the sclera form about 0.4 per cent. of all dieases of the eyeball. The sclera is subject to inflammation peculiar to itself and to pathological changes taking place in the adjacent structures, especially in the chorioid and ciliary bodies. The cornea on account of its close connection with the sclera and little anatomical difference frequently becomes involved in scleritis (sclero-keratitis). The iris likewise is very prone to become affected and the overlying conjunctiva is always involved. We recognize the following forms of scleral disease:

- Episcleritis (Superficial Scleritis),
- Scleritis
  - Diffuse,
  - Circumscribed (Deep Scleritis),
  - Annular,
- Sclero-kerato-iritis,
- Abscess,
- Ulcers,
- Tumors,
- Wounds,
- Ectasis.

Episcleritis.—Episcleritis is the commonest form of inflammation of the sclera. In this affection the subconjunctival tissue and the most superficial layers of the sclera are conjointly the seat of the inflammation. The disease manifests itself as an illy defined spot of infiltration which is slightly elevated and usually situated between the equator of the eyeball and the edge of the cornea and to its outer side. Its color is of a violaceous hue because the associated injection is seen through the superimposed layers of the conjunctiva. It

is not movable upon the sclera but the conjunctiva is freely movable over it. There is often considerable tenderness. Photophobia and lachrymation, like in corneal disease, are pronounced symptoms. The disease reaches its height in about three weeks and then begins to slowly subside. It is frequently recurrent.

Etiology.—The specific cause of the inflammation is not known. It is rather more common in adult life and in the male. It is associated with a rheumatic, gouty or scrofulous diathesis. In women it is frequently associated with deranged menstruation. It is common in those who are exposed to the weather. At times it is due to eye-strain from errors of refraction or muscle anomalies, and gets well when these are corrected.

The prognosis is always favorable as the deeper parts of the eyeball are never implicated.

Diagnosis.—It at times closely resembles a large and thickened phlycten from which it can be told by the fact that pressure does not completely blanch the tissues, but beneath the fading conjunctival injection there is left after pressure a violaceous hue. It is not movable with the conjunctiva as is a phlycten, but on the other hand the conjunctiva can be moved about over the swelling of episcleritis.

Treatment.—The best results are gotten from the internal administration of salicylates in some form. Locally the yellow oxid salve is in order. A small bit is placed upon the eyeball, the lids closed and the lump massaged by rubbing the upper lid over the eyeball in a circular fashion. Subconjunctival injections of normal salt solution; or better, solution of potassium iodid after the manner already described hastens resorption. Excision, scarification or scraping of the lump as recommended by Shöler & Adamück is seldom necessary. Eye strain should be relieved by the proper glasses.

Scleritis.—Inflammation of the entire sclera is very uncommon except in cases of panophthalmitis. Indeed the deeper layers of the sclera seldom become inflamed save in connection with an inflammation of the underlying parts of the uveal tract.

Fugaceous Episcleritis (Episcleritis partialis fugax, Fuchs; Hot-Eye, Hutchinson; Vaso-motor dilatation of Vessels, Burnett).—This is the name given to a rather sudden and more or less intense hyperemia of the sclera and the overlying conjunctiva, lasting for a few hours or a day or two. It is recurrent and may persist for years. It is not dangerous as the deeper parts never become involved. It is exceedingly painful and accompanied by considerable lachrymation and photophobia. It occurs but very rarely in children. Its cause is unknown.

Treatment.—Atropin and heat for their sedative effect and protective glasses. If the pain is severe the local use of holocain or cocain may be required.

Acute Diffuse Scleritis.—This disease affects all the anterior portion of the eyeball in its acute form. It is very rare and must not be confounded with conjunctivitis or iritis. It simulates very closely catarrho-rheumatic ophthalmia. There is a diffused bright pink injection, with lachrymation and intolerance of light.

Etiology.—It is eminently of a rheumatic or gouty origin.

Diagnosis.—From conjunctivitis by the absence of a catarrhal secretion, from iritis by the clearness of the aqueous humor and want of iridic adhesions.

Treatment.—Atropin solution several times daily for its anodyne effect and cold applications if well borne; if not dry heat. Internally salicylates, iodids or colchicum according to indications. The combination of conjunctivitis and scleritis in catarrho-rheumatic ophthalmia gives rise to very considerable pain, making it often necessary to administer one of the coal tar derivatives as an anodyne. Locally holocain in 2 per cent. solution with or without adrenalin 1–10,000 every two hours is grateful.

Deep Scleritis.—A very common example of deep scleritis is what is known as sclerotico-chorioiditis posterior or posterior staphyloma nearly always found in high grades of myopia. This will be considered under the head of chorioiditis. Anterior scleritis is less frequent. Swelling of the sclera under the form of more or less circum-

scribed elevations occurs. The whole sclera adjacent to the edge of the cornea may show violaceous injection and a more of less uniform swelling. Inflammation of the sclera does not disappear by disintegration of the inflammatory products but by resorption with the formation of dark-colored cicatrices. The sclera in the meanwhile undergoes considerable thinning at the site of the inflammation, so that it is no longer able to withstand the pressure of the intraocular tension, though this may be no greater than is normal. Bulging or ectasis of the diseased spot occurs. The disease nearly always begins in the uveal tract and most commonly from gummatous formation in the ciliary region. The overlying conjunctiva fades upon pressure, leaving a deeply situated violaceous tint. The swelling is not sharply circumscribed as in episcleritis, but the chief distinction between the two is the invariable tendency of the deep form to extend and involve the deeper structures of the eyeball. There is often considerable tenderness on pressure and always decided photophobia and lachrymation.

Etiology.—It occurs chiefly in the young and middle aged. It comes from exposure to cold, rheumatism, gout, scrofula, vaso-motor changes and disturbances of the sexual apparatus, especially disorders of menstruation. Syphilis is the commonest cause of the severer form in which the patches are yellowish-brown and translucent. Gonorrhœa, after it has given rise to synovitis, is at times a cause. Deep scleritis usually attacks both eyes and runs a chronic course. Its sequelæ are: iritis, often leading to the closure of the pupil, cyclitis, chorioiditis, corneal and vitreous opacities.

Annular Scleritis is the name that Parsons applies to those cases of anterior scleritis in which the swelling is more or less uniform and surrounds the entire cornea. He considers the disease a specific one. Annular scleritis differs from ordinary anterior scleritis in that the swelling extends quite up to the corneal edge. The swelling is succulent and of a brownish-red color. The disease is extremely chronic and occurs in those over sixty years of age and mostly in women. The cornea and uvea are very apt to become involved.

The scleritis and accompanying uveitis are regarded by some as independent, or separate manifestations of the same disease.

Sclero-kerato-iritis (Scrofulous Scleritis, Anterior Chorioiditis).— This name is applied to those cases of scleritis mentioned in the foregoing paragraphs in which the cornea and the uvea become involved. It is characterized by its chronicity and relapses. Beginning with a well-marked deep scleritis of the ciliary region the adjacent cornea becomes opaque but very seldom ulcerates or breaks down; the iris quickly becomes inflamed, posterior synechiæ form, and pain becomes severe. After a month or so the symptoms begin to abate. The discolored scleral area marks the site of the scleral disease, and haziness in the cornea and an irregular pupil indicate that the cornea and the iris have been involved. Sclerosing keratitis is the name applied to the form of corneal disease found associated with a scleritis.

Treatment of Scleritis.—Unfortunately treatment has little power over deep scleritis save that from gummatous formation. In the latter case very decided good is obtained from large doses of mercury and iodin. If there is a rheumatic history the salicylates are pushed and if disturbed menstruation seems to be the causative factor, the preparations of iron are employed. Locally the eye should be treated by instillation of atropin solution every two to four hours, by hot applications, and protective glasses. If pain is very severe, local blood-letting from the temple by means of the artificial or natural leech is indicated and usually followed by a subsidence of the pain. After the attack has run its course it is not infrequently necessary to perform an iridectomy either for optical purposes, that is to place the pupil behind clear cornea, or to prevent the rise of tension in the eye from seclusion or occlusion of the pupil or from the scleral ectasis.

Abscess of Sclera.—Abscess of the sclera is an exceedingly rare manifestation of scleritis. It is never idiopathic, but results from infected wounds, and has been seen in connection with certain specific and contagious diseases, as glanders. The uvea becomes violently inflamed and the eyeball is destroyed.

Ulcer.—The sclera seldom ulcerates as the products of its inflammation seldom undergo purulent disintegration. As an example a scleritic nodule never breaks down and ulcerates, and corneal ulcers never progress beyond the edge of the cornea. Ulcers of the conjunctiva are furthermore not likely to extend to the underlying sclera. When ulcers of the sclera do occur they result from the ulceration of new growths as gummata, tuberculous and leprous nodules, or malignant neoplasms.

Tumors of Sclera.—Primary tumors of the sclera are likewise very rare. The sclera is seldom affected by new growths, except gummata, save by tumors originating in other parts of the eyeball and passing to the sclera. Fibromata, sarcomata and osteomata have been observed as primary tumors in the sclera.

Wounds of the Sclera.—Wounds of the sclera are inflicted with all sorts of instruments, as knives, scissors, broken glass, wire, sticks, etc., or by flying bodies, as chips of iron or steel, shot or what not, or they may result from a blow giving rise to rupture of the sclera which usually takes place concentric with the margin of the cornea and about three millimeters from it according to Collins. If the injury has opened the eyeball there is danger from the loss of intraocular substance (vitreous and lens) and from the introduction of infected material within the eye, so that the eyeball atrophies and shrivels up into a small mass within the orbit or develops panophthalmitis, necessitating enucleation. The presence of a perforation may be diagnosed in the following manner: The eyeball will be softer than normal due to the leak. This sign is especially valuable in cases of small wounds in the sclera as they are often obscured by swollen and ecchymotic conjunctiva. The diminution of tension of course only lasts as long as the wound is open. If the perforation has occurred in the region of the anterior chamber the latter is shallow or altogether obliterated until after the wound closes.

If the wound is large there is a prolapse of the underlying structures. Most frequently it is the uvea which protrudes through the wound as a pigmented mass. According to the site of the wound the part

presenting will be the iris, the ciliary bodies or the chorioid. If the chorioid is likewise ruptured there will be some vitreous hanging out of the wound. There is always more or less extravasation of blood within the eyeball. (This occurs likewise from non-penetrating wounds.) If the blood is in the anterior chamber it sinks to the bottom of it, filling up the lowermost part of the chamber and is bound above by a horizontal line (hyphæma). When the vitreous chamber contains blood it occasionally gives a reddish reflex through the pupil (hæmophthalmos).

The scleral wound may heal without much inflammatory reaction if it is non-infected and if the uvea or vitreous is not incarcerated in the wound. But even when the latter is the case the eye may not suffer greatly. The tissue between the lips of the wound cicatrize. The incarcerated tissue of course remains adherent which may entail evil consequences later on. Scleral wounds lying near the margin of the cornea and in which the iris or lens capsule is lodged often heal very slowly if at all. The overlying conjunctiva unites but through the wound in the eyeball the aqueous humor continually percolates, rendering the conjunctiva edematous or raised in the form of a cyst. To this condition Von Graefe applied the name of "cystoid cicatrization." It is frequently observed after operation for cataract extraction and iridectomy. In consequence the tension of the eyeball remains soft and the eye irritable. More frequently the healing of the wound of the sclera is accompanied by considerable intraocular inflammation. In most instances this is due to infection entering the eye upon the instrument inflicting the injury or subsequently through the rent in the envelope of the eyeball from the conjunctival cul-de-sac. In the acutest form there is developed a purulent uveitis leading to the conversion of the eyeball and orbital tissues into an abscess (panophthalmitis). If the reaction is less violent we have a plastic irido-cyclitis. Most frequently this leads to a destruction of the eyeball through atrophy. From the iris and the ciliary bodies there is poured out a plastic lymph which soon becomes organized, and contracting gradually diminishes the size of the eye-

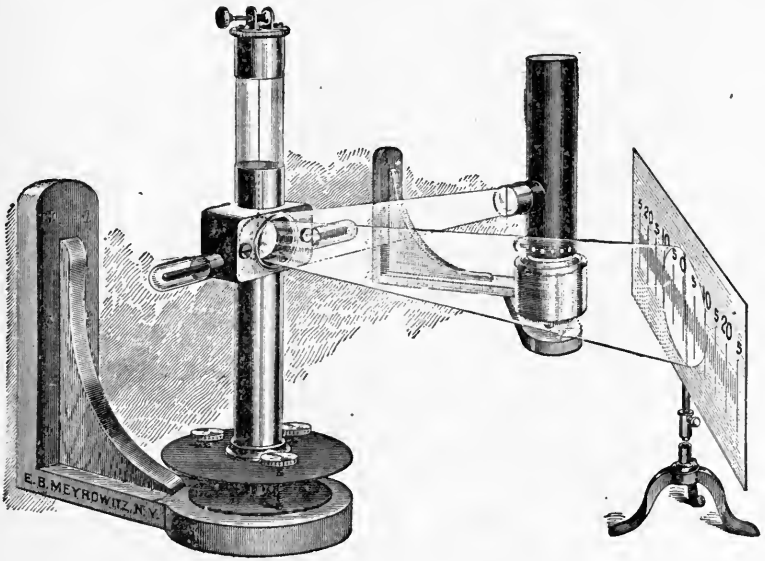
ball. This latter outcome is at times followed by sympathetic ophthalmia and is therefore more dangerous to the patient than that which results in panophthalmitis.

The main thing of importance after an injury to the eyeball is to ascertain whether it contains a foreign body or not, since the eye is nearly always lost if the body is allowed to remain. If the foreign body is small and accompanied by little reaction its presence in the background of the eye may be tolerated for a long while with the preservation of good vision, but as Knapp says it can never be trusted as it is liable sooner or later to cause degenerative inflammation.

Foreign bodies may be imbedded in any of the structures of the eyeball but are most frequently found in the vitreous. If loose they gravitate to the lowest part of the vitreous chamber and rest upon the posterior part of the ciliary body. If the substance has entered the eyeball with great force it may pass entirely through it and lodge in the tissues of the orbit. Perforating injuries of the eyeball with copper wire may result in purulent inflammation merely by the chemical action of the metal, as pointed out by Leber. If infection is proven to be absent by culture experiments made from the wound, the eye may be saved by the removal of the foreign body even if inflammation has begun. The presence of a foreign substance within the eyeball is especially suspected if the wounding body was small, *e. g.*, a chip of steel, a piece of glass or a bullet. The foreign body may be seen with the aid of the ophthalmoscope if the media are clear, but unfortunately bleeding into the vitreous or anterior chamber often obscures the media or the body is covered with hemorrhage or exudate and is invisible. We may attempt to locate the foreign body by taking into account the situation of the external wound and the probable course of the substance. This as a rule fails however. At times the eyeball is found more tender to pressure at the site of the foreign body than elsewhere when pressed with a probe. If the media are clear one may take the field of vision in search for a scotoma, but unfortunately blind spots are caused by hemorrhages

and many lesions of the fundus, and no information is obtained as to whether there is a foreign body present at that site of lesion or not.

If there is any doubt as to the presence of a foreign body a skiagraph should be made, by which the location as well as presence or absence of the foreign body is readily revealed. For this purpose the method devised by Sweet is the most useful and one generally employed. Sweet's method is as follows: The sensitive plate-holder is fastened to the side of the head on the side of the affected eye, projecting well forward beyond the eye. To the anterior end of the holder are fixed two metal indicators, one pointing to the center of the cornea and the other a known distance to the temporal side. Two exposures are made with the ray-tube in different positions to



Dr. Hirschberg's Simplified Sideroscope.

give two different relative positions of the shadows of the indicators and foreign body within the eyeball — one with the tube horizontal with the plane of the indicator and the other with the tube below or above this plane. The axis of the eyeball should be parallel with the

indicators and photographic plate. In making the exposure the tube is placed about one foot to the opposite side of and a little in front of the eye containing the foreign body. The patient should lie down as this encourages greater steadiness of the head. An exposure of one half to four minutes according to the apparatus is all that is needed to obtain a good radiograph. The best results are obtained when the tube is run at high vacuum.

In localizing magnetic foreign bodies, *e. g.*, iron and steel in the eye, the sideroscope has proved of great value and the instrument constructed after the design of Dr. Hirschberg is of a simple character and can be very readily operated.

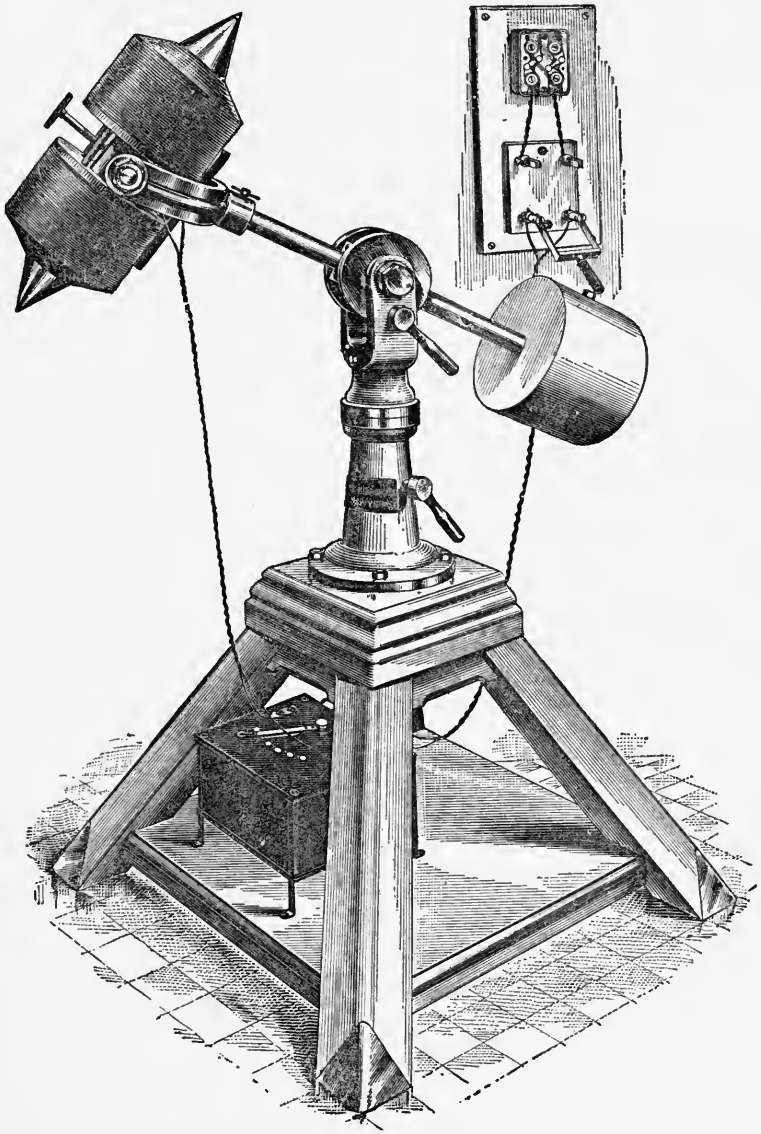
It consists of three parts, viz.: The sideroscope proper, consisting of an upright, attached to an adjustable table, carrying in the glass tube suspended by a silk thread a small mirror to which is attached a magnetic needle; second, an adjustable illuminating lamp provided with a condensing lens with cross-line connection; third, a scale mounted on an adjustable portable tripod.

In setting up the instrument, it is well to observe the following instructions:

The two wooden brackets should, if possible, be attached to a massive wall which should stand, preferably, north and south, and the instrument turned until the magnetic needle, when suspended, should swing free from the glass tube in which it is encased.

The end of the needle with a small groove is the north pole and should point towards the north; the lamp is adjusted in such a manner that the light on same is reflected by a small mirror suspended in the sideroscope against the graduated scale which is placed about two meters from the sideroscope. When the eye of the patient, who is seated near the instrument,is brought close to the end of the glass tube, the needle will be attracted by the metallic body and will deflect; such deflection will then be indicated by the bright disc reflected from the mirror, and can be easily read by the movement of the black central line of the illuminated field over the scale. If no deflection takes place it will indicate that there is no metallic foreign body there.

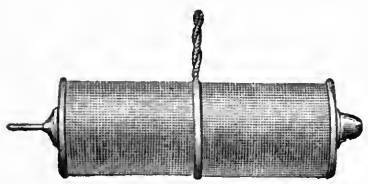
In using the sideroscope anything about the operator or patient that is liable to cause deflection of the needle should be removed;



Haab's Giant Magnet.

such are steel spectacles, pen knives, keys, etc. After the diagnosis of a foreign body within the eyeball has been made, the surgeon should attempt to remove it through the original wound with a pair of delicate forceps, or through an opening made in the eyeball at the most favorable site. If the foreign body is of iron or steel its presence can be diagnosed and it can be removed by means of a powerful electro-magnet. There are several good magnets upon the market but the most powerful and therefore most useful one is that devised by Dr. Haab, shown in the cut on page 345.

The magnet is operated by the street current and supplied with such mechanical devices that it can be easily moved in any direction and can be placed over the eye of the patient while he is reclining in bed or sitting in a chair. The magnet rotates upon a stand, can be raised and lowered by tilting the supporting bar, and can be rotated in any given direction by means of the gimble joint with which it is provided. Each movement is provided with a safety clutch so that when once placed in position the magnet can be firmly held there. The instrument is provided with a resistance box so that the current can be gradually admitted and thus increase the drawing power of the magnet. The objections to this magnet are its cost, which places it beyond the reach of many, and the fact that it is stationary. To meet the demands for a strong portable magnet Johnson has devised one of sufficient internal resistance so that it can be attached directly to the 110-volt current without interposing any additional resistance. The magnet has two tips, one one half inch long and ovoid in shape and the other one and one half inch long having a diameter of three thirty-seconds of an inch. Before describing the manner in which the magnet is used to remove foreign bodies from the eyeball, a few words will be said in regard to its use in diagnosing the presence of a foreign body.



Dr. Johnson's Magnet.

If the eyeball contains a fragment of iron or steel, pain will be felt by the patient when the magnet is brought in close proximity to the eyeball. The pain will be greatest when the end of the magnet is nearest the foreign body. The magnet should therefore be moved about in front of the eyeball—almost touching it—to try to locate the foreign body. If the foreign body is very small, pain will not be experienced on approach of the magnet. If the piece of metal is of large size a tugging at the eyeball will be felt when the magnet is approached. Perhaps the eyeball will be pulled this way or that by the attraction of the magnet for the foreign body.

In removing the piece of metal from the eyeball one preferably draws it through the wound of entrance, but if this is impossible it is better to draw it forward through the lens or its capsule, the latter being the path the body usually takes as it is the path of least resistance, into the anterior chamber where it can be extracted by making a small incision in the cornea. Some operators are in the habit of making an incision through the sclera overlying the foreign body after its location has been made out and applying the tip of the magnet to this opening. According to Knapp this is a questionable procedure, as detachment of the retina is very apt to supervene sooner or later from the contraction of the resulting cicatrix and interference with the chorioidal circulation. In this way fluid gathers beneath the retina and lifts it up.

Experiment has shown that the farther the magnet is from the splinter the more uniform is its action, and the nearer the more jerky its force. The stronger the magnet the more marked is this law. Therefore in practice one should bring the eye of the patient close to the end of the magnet before turning on the current and it should be increased gradually, or bring the eye from a distance gradually with the full current turned on. If there is any jerky force the foreign body is liable to be drawn deeply into the ciliary body, with such force that it is next to impossible or quite so to remove it, or it may be drawn into some other undesirable location. If such an accident happens Kipp says the current in the magnet should be reversed or

the other end of the magnet employed to repel the foreign body from its position, and then removed. When the splinter is caught in the iris Haab advises making an incision in the cornea directly over the site of the splinter, then enter with an iris forceps and grasp the iris just to the inner side of the foreign body, and then gently push it inward until a rent is made in the iris just over the splinter. The magnet is now applied to the opening in the iris and the foreign body removed. The tear soon heals and the iris retains its motility, and a nearly round pupil. This method is, therefore, preferable to an iridectomy. By comparing Haab's results with the small magnet and those with the giant magnet we see the advantage of the latter. Of 18 cases operated upon by the small magnet the foreign body was in the vitreous chamber; the splinter was not found in 5; was extracted in 13; vision of about one seventh was secured in one case; counting of fingers in 8; most had a detachment of the retina at the time or soon following, and seven eyes had to be enucleated. He reports 165 cases treated with the giant magnet. Of these 23 failed; 39 eyes were enucleated; 9 had lingering cyclitis; 19 were saved but were sightless. Of 71 cataracts extracted 51 had good vision.

Failure to extract the body lies in one of the following causes: A very firm fixation of the splinter in the posterior portion of the eyeball; firm fixation of the splinter in the ciliary body; splinter held by a firm fibrinous exudate, or healed over after the lapse of months.

After the foreign body has been removed the eyeball should be carefully disinfected with a solution of bichlorid of mercury 1–4,000 and the edges of the wound penciled with a stronger solution of the same drug (1–2,000). The conjunctiva over the wound is then brought together with several fine sutures if there is much gaping. The eye is then closed with an antiseptic bandage and the patient put to bed.

The eye should be inspected and the dressing changed every twenty-four hours. If the wound in the sclera is large it should be sutured with fine silk thread passed only through the superficial layers of the sclera. It is not advisable to introduce powdered iodo-

form or other antiseptic powder into the conjunctival sac before bandaging as it irritates the eye considerably without acting in any decided way as a germicide. Being insoluble in the tears it collects in masses at the inner canthus and along the edges of the lids. On the other hand iodoform introduced into the eyeball in the form of a pencil or plug has been followed by good results, especially in the hands of Goldziehr following the suggestion of Ostwald and Haab. After removal of the foreign body a small pencil of iodoform is passed into the vitreous chamber through the scleral wound. As yet this method has not been tried sufficiently to prove its value.

ECTASIS OF THE SCLERA.

Partial Ectasis. — Partial ectasis of the sclera occurs under the form of a dark-colored protrusion or prominence. The sclera at the site of the ectasis is thinned so that it can be readily indented with a sound; and in consequence of the thinning the chorioidal pigment appears through it and imparts to the ectasis its dark bluish-black color. According to the situation of the ectasis we have the following varieties: Anterior (ciliary), equatorial (chorioidal) and posterior ectasiæ or staphylomata. The anterior ectasiæ occupy the most anterior part of the sclera, that is the part adjoining the cornea. They appear at first under the form of small dark spots which after awhile become larger and bulging. If they lie close together they become confluent and may completely surround the edge of the cornea. The limbus in such cases is seen under the form of a depressed gray line separating the ectasis from the edge of the cornea. Very frequently the cornea is also ectactic when the line of demarcation between sclera and cornea is entirely lost. If the cornea is not involved in the ectasis and scleral ectasis occurs on one side only the cornea is pushed out on that side and made to face obliquely, giving rise to great disturbance of vision from high irregular astigmatism.

The equatorial ectasiæ occur about the equator of the eyeball. They are usually small and never surround the entire eyeball as do

the anterior ones. They can be seen only when the eyeball is turned strongly in the opposite direction.

Etiology.—Every ectasis of the sclera is the result of increased intraocular pressure or a diminished resistance of the sclera itself to the normal intraocular tension. The former is much more frequently the cause of the ectasis if the posterior ectasis in myopia is excepted. If the sclerotic tunic of the eyeball possessed the same resistance throughout it would stretch equally in all directions from hypertony, but it is essentially weaker in places than in others, for instance at the entrance of the optic nerve and in the region of the equator where the venæ vorticosæ perforate it, and in the region of perforation of the anterior ciliary vessels. The most frequent causes of heightened intraocular pressure are primary glaucoma, seclusio pupillæ, and ectatic cicatrices of the cornea. In glaucoma we more commonly have equatorial ectasiæ produced, while those diseases which affect the anterior portions of the eyeball induce anterior ectasis of the sclera. Diminished resistance of the sclera results from inflammation in the latter, and hence occurs in the deep forms of scleritis and when gumma, tubercular nodules or malignant growths develop in or beneath the sclera. Injuries of the sclera also diminish its resistance, and hence the cicatrices after ruptures of the sclera often become ectatic.

The posterior ectasiæ are distinct from the other varieties. They cannot be seen in the living eye as they occupy the posterior segment of the eyeball. There are two kinds of posterior scleral ectasiæ: The staphyloma posticum Scarpæ and the posterior scleral protuberance of Ammon. The first consists of a protrusion of the sclera at the posterior pole of the eyeball to the outer side of the optic nerve entrance. The optic nerve is at times also involved in the larger forms of ectasis. As Arlt first discovered this is a most frequent accompaniment of near-sightedness, and in many cases is the cause. It is always the cause of increase in the myopia, the eyeball undergoing an elongation of its antero-posterior axis due to a recession of the sclera from inherent weakness and the excessive convergence of

uncorrected myopia. The diagnosis of posterior ectasis in the living eyeball can only be made by the accompanying changes in the chorioid seen with the ophthalmoscope. (See section on diseases of the chorioid.) The posterior protrusion of Ammon does not lie exactly at the posterior pole of the eyeball but just below it. It is a congenital abnormality and is never acquired. It arises from incomplete closure of the fœtal ophthalmic cleft. It is most frequently found together with a coloboma or fissure of the chorioid and less commonly with coloboma of the iris.

Total Ectasis of the Sclera.—This consists in a uniform stretching of the entire sclera. The eyeball is therefore enlarged in toto. The sclera is everywhere thinned so that the pigment of the middle tunic shows through it with a bluish-black luster. As a rule there are a number of equatorial or anterior ectasiæ existing upon the total ectasis. Total ectasis of the sclera can only develop in youth when the sclera is thin and yielding. At times there is seen a pure total ectasia of the sclera in which the cornea participates so that the eye shows simply a uniform enlargement in all its parts (megalocornea). This condition is called hydrophthalmos or buphthalmos. It is either congenital or acquired soon after birth and is analogous to glaucoma of adults. Any disease which gives rise to increased intraocular tension acts as a predisposing factor in its production.

Sooner or later the rise of tension which occasions the ectasis destroys the sight. The eyeball continues to enlarge so that it becomes very unsightly, and may finally rupture, the sclera giving away at its thinnest portion. A great part of the fluid vitreous is then discharged and the eyeball shrivels. The posterior ectasis is not associated with the rise of ocular tension as are the anterior and equatorial varieties, but may lead to blindness by attenuation and inflammation of the chorioid and retina due to the stretching of the eyeball. Even if the proper treatment is instituted the ectasis at times goes on because the sclera has become so attenuated that it is unable to resist the normal intraocular pressure. The scleral protuberance of Ammon remains stationary and gives rise to no injurious consequences.

Treatment.—The treatment of the anterior and equatorial varieties is iridectomy, as they are caused by rise of tension. After the eyeball has reached a considerable size, it is painful and disfiguring, and iridectomy is no longer practicable; there is nothing else left to do but enucleation. To prevent the further development of posterior staphylomata the myopia should be fully corrected and the patient instructed in regard to the proper use of his eyes, *e. g.*, the avoidance of too prolonged near work, poor illumination, etc. (See section on Correction of Myopia in Vol. I.)

CHAPTER XIII

DISEASES OF THE IRIS AND CILIARY BODIES

Diseases of the iris and ciliary bodies will be considered together inasmuch as an uncomplicated inflammation of either is rare. Both structures are supplied by the same blood-vessels, and the iris springs directly from the anterior extremities of the ciliary bodies, so that inflammation readily spreads from the one structure to the other. Diseases of the iris and ciliary bodies form six per cent. of all eye diseases. We will first consider congenital anomalies of the iris.

Heterophthalmos is the name applied to a difference of color of the two irides. It has already been referred to. It has no special significance.

Corectopia, or Ectopia Pupillæ, is the term applied to an eccentric pupil. The grade of eccentricity may vary from the normal eccentric position of the pupil, a little to the inside and below the center of the iris to those cases in which the pupil is displaced to the border of the iris. The latter are rare but are apt to be confounded with cases of coloboma of the iris. Both eyes may be like affected, and several of the same family may present the defect.

Polycoria or numerous pupils is a very rare congenital anomaly. They may be scattered irregularly throughout the tissue of the iris, arranged about the normal pupil or peripherally situated. They may be separated by normal iris tissue or result from interlacing strands of persisting pupillary membrane. Several have described the occurrence of a linear opening situated at the ciliary margin of the iris, probably due to an iridodialysis occurring during birth.

Persistent Pupillary Membrane is the remains of the fœtal membrane which covers the anterior surface of the crystalline lens. It usually disappears at the end of the seventh month of intrauterine

life, but it may persist for a month after birth and then disappear. Now and then threads of tissue are seen stretching across the pupil, either singly or in groups from the anterior surface of the iris. This condition is erroneously also called persistent pupillary membrane. At times the fibers fuse and become adherent to the anterior capsule of the lens, forming what is called capsulo-pupillary membrane. Persistent pupillary membranes are more commonly unilateral in the proportion of 13 to 55 according to Stephenson. Capsulo-pupillary tags are not infrequently taken for posterior synechiæ or adhesions of the iris to the capsule of the lens, the sequel of iritis. They are differentiated by the fact that the normal action of the pupil is not interfered with by these anomalies. The vision is not often much interfered with and the membrane is detected only when examining the eye by oblique illumination or with the ophthalmoscope for some other trouble.

Coloboma of the Iris is a congenital fissure of the iris resembling the pupil made by iridectomy. It commonly affects both eyes, but may be unilateral, affecting more frequently the left side. This fissure almost always extends downward or downward and inward. Theobald has reported a rare case in which the coloboma was upward. The fissure may extend across the entire iris, from pupil to periphery or only part of the way (complete and incomplete coloboma). Pseudo-coloboma is a light-colored strip of iris, somewhat granular, and indicates the last remains of the ocular fissure. At times there extends across the coloboma a bridge of pigmented tissue or colorless band of fibers (bridge coloboma). Coloboma of the iris is not infrequently associated with a similar defect in the chorioid coat, and also with microphthalmos, congenital cataract, fissure of the eyelids, lips and palate. Its cause is arrest of closure of the ocular cleft. There is a hereditary tendency in this defect.

Anaridia or Irideremia means a congenital absence of the iris in part or complete. Total anaridia is always bilateral. The eye thus affected presents a peculiar appearance. The pigmented ciliary processes are presented to view in the periphery of the anterior

chamber, and the entire anterior surface of the lens is exposed. Accommodation may be perfect. Anaridia is frequently associated with other anomalies of the eyeglobe, as posterior polar cataract, nystagmus, high myopia, irregular astigmatism, dislocation of the crystalline lens, etc. It is strongly hereditary, occurring in many members of the same family at times.

Dyscoria (*Faulty Pupil*), or ectropion of the uvea, consists of excrescences of dark color which project from the pupillary margin of the pupil into the anterior chamber. This formation is common to the eye of the horse and frequently seen in the eye of the cow. It has been called by Von Ammon corestenoma congenitum and by others papilloma of the iris, but it is in no sense a neoplasm or new formation in the iris tissue.

IRITIS.

Inflammation of the iris may be purely a local affair or arise in consequence of some general disease or result from the spread of inflammation from other ocular structures, chief among which is the cornea. We have therefore primary and secondary iritis. Primary iritis is caused by the following disorders: Syphilis, tuberculosis, rheumatism, gout, gonorrhœa, diabetes, acute febrile diseases, irregular menstruation.

As a local affection it occurs from injury direct or indirect, that is from penetrating foreign bodies or from blows upon the eyeball. Occasionally it arises from injury to the fellow eye (sympathetic iritis) and not infrequently we can ascertain no cause for it when we speak of it as idiopathic. The more careful we are in searching for the probable cause of the iritis the fewer do the idiopathic cases become.

Primary Iritis.—Syphilis is by far the most frequent cause of iritis, at least one half of all cases are referable to it alone. As a rule it is the acquired syphilis, although it is at times seen as a secondary or tertiary manifestation of congenital syphilis. It is not always possible to differentiate an iritis caused by syphilis from other

varieties, but now and then we find the formation of papules or nodules in the tissue of the iris about the size of a pin's head, having a reddish-brown color and situated about the pupil or in the periphery of the iris. These nodules disappear by resorption without disintegration. At the sites of the papules broad and firm adhesions form between the iris and the capsule of the lens behind, and not infrequently a circumscribed atrophy of the iris is left. If no local marks are present we can only diagnose specific iritis by the history of syphilis. Syphilitic iritis usually is a secondary manifestation of the disease, making its appearance soon after or at the time of skin eruption. The papules in the iris may be compared to the papules or condylomata which form in the skin. It is at times called iritis papulosa. Iritis less frequently breaks out for the first time or recurs in the tertiary stage of the disease. Nodules now show themselves in the form of gummata (iritis gummosa). These occur in the iris and ciliary bodies, attain great size unless arrested by treatment, break down and bring about the destruction of the eyeball. Less frequently iritis occurs in consequence of hereditary syphilis. It occurs very often associated with the interstitial keratitis which is due to hereditary specific disease. The iritis due to hereditary syphilis is of course a disease of childhood while that from the acquired form of the disease occurs in the adult. It often happens that the chorioid or retina are simultaneously inflamed with the iris in cases of syphilitic iritis. Syphilitic iritis is prone to recur.

Tubercular Iritis.—Tubercular iritis usually occurs in children and is associated with tuberculosis of other organs of the body. The disease shows itself in the form of a solitary tubercle resembling a neoplasm or as grayish-red nodules in the tissue of the iris. Closely allied to this is what is at times called scrofulous iritis which bears much resemblance to the iritis of heriditary syphilis in its appearance and course. Lardaceous looking deposits or masses appear to grow from the sinus of the anterior chamber. Not only does it occur in scrofulous (tubercular) children but is at times seen in severe cases of anemia Cohnheim produced tubercular iritis experimentally by

introducing into the anterior chamber of the rabbit's eye small bits of tubercular material. After about the lapse of a month the characteristic gray nodules were seen to develop in the iris. The gray nodules increase in number until they fill up the anterior chamber if the animal lives long enough, and finally break through the tunics of the eyeball. A solitary tubercle of the iris may be present for some time without the usual signs of an iritis. The solitary form as a rule affects only one eye while the disseminated form affects both eyes. The prognosis is always grave as the eye is usually lost.

Rheumatic Iritis.—This form of iritis occurs in those affected with subacute and chronic rheumatism. It is seldom seen accompanying the acute form of the disease, and frequently recurs with the swelling of the joints. It is exceedingly painful, out of proportion to the apparent inflammatory reaction in the iris. Adhesions to the lens capsule are usually slender and readily yield to the use of atropia, while those occurring in specific iritis are usually broad and firm. *Arthritis deformans* and *gout* are also recognized causes of iritis.

Gonorrhœal Iritis occurs in those cases in which the gonorrhœa has given rise to a general infection. Such cases run a course not unlike articular rheumatism. The knee-joint is first attacked and then other joints without order and finally heart complications may occur. Iritis supervenes the joint implication and is usually bilateral, affecting both eyes at the same time or in succession as with the other varieties of iritis caused by a general infection unless treatment so modifies the case that the fellow eye is not affected. Clinically gonorrhœal iritis resembles very closely rheumatic iritis and cannot be differentiated from the latter except by the history of the case. It is frequently recurrent, the recurrences being associated with exacerbation of swelling in the affected joints, with the involvement of other joints or with the renewal of discharge from the urethra.

Diabetic Iritis.—Diabetes is a rare cause of iritis. Diabetic iritis does not differ from the usual type save that infrequently it is associated with an abundant exudation from the iris which sinks to

the bottom of the anterior chamber under the form of an hypopyon. It runs a favorable course as a rule.

Iritis in Acute Febrile Diseases. — The diseases that are occasionally accompanied by an iritis are: Relapsing fever, typhus, typhoid, small-pox, cerebro-spinal meningitis, pyemia, influenza and malaria.

Idiopathic Iritis. — Such are all those cases in which the iritis apparently develops without any cause, local (traumatism) or systemic. Idiopathic iritis is frequently ascribed to cold. It affects one eye only as a rule and that of the adult male. Iritis is very rare in children and never occurs as an idiopathic affection. Idiopathic iritis is at times chronic. The eyes are not much infected, and pain is present now and then. The thing that the patient notices the most is the steady decline in vision. Posterior synechiæ form and finally the pupil becomes entirely surrounded by them and a thin membrane forms in the pupil. The iris becomes atrophic, noted by its bleached appearance, and bulged if seclusion of the pupil is present. This affection is really a chronic irido-cyclitis or irido-chorioiditis. In the majority of cases there are seen (oftener than is generally supposed) a number of fine macular deposits upon the posterior surface of the cornea, as well as opacities in the vitreous body. If the diseased process passes unchecked the opacities in the vitreous increase and it is finally liquefied. The crystalline lens now becomes opaque and the chorioid and retina degenerate. If the eye is not already blind, tension soon sets in to render it so, inasmuch as the free circulation of the aqueous lymph is interfered with by the seclusion and occlusion of the pupil. This disease runs a protracted course, so that a year or more elapses before cure or blindness sets in. It more frequently occurs in the elderly, being the commonest cause of blindness in old people according to Fuchs. It occurs in young women from suppressed menses, and in both sexes from poor nutrition from some deep underlying cause. On the other hand it occurs in those whose health apart from their eye trouble is good.

Traumatic Iritis. — The causes of this are injuries of all kinds. Blows upon the eye, penetration of foreign bodies, operations upon

the iris or eyeball. Less frequently we have an iritis caused by the contusion of the iris by a dislocated crystalline lens or by the swelling of the lens substance after rupture or incision of its capsule, or from swelling of particles of soft lens substance left behind in the eyeball after removal of a cataract. Tumors within the eye or cysticercus in certain stages of development often set up a violent irido-cyclitis.

Sympathetic Irido-cyclitis.[1]—This is an inflammation occurring in one eye as the result of an injury to the fellow eye. The eye that is wounded is spoken of as the exciting eye and its inflamed fellow as the sympathizer. For the production of sympathetic ophthalmitis we must have the following triad: a traumatic irido-cyclitis of one eye, a certain lapse of time and a serous or plastic uveitis of the fellow eye.

Etiology.—The causes of sympathetic affections are as follows: Wounds and particularly lacerated wounds of the ciliary region or dangerous zone, as Nettleship calls the region of the limbus and part just posterior to it, and especially if the iris or ciliary body is incarcated in the wound. Next frequently we find the presence of foreign bodies within the eyeball a cause. Traumatisms of the eyeball are responsible for over 80 per cent. of all cases. Other causes are perforating wounds or ulcers of the cornea with prolapse of the iris or scars involving the ciliary body, badly performed operations upon the eyeball, as cataract extraction, iridectomy, iridodesis, discision, etc., dislocation and calcification of the lens.

Intraocular tumors according to Schirmer when they give rise to irido-cyclitis, ossification and calcification of the chorioid or ciliary bodies, pressure of an artificial eye upon a shrunken eyeball or incarceration of the stump of the optic nerve in cicatrix after enucleation. In fact it seems possible that any condition capable of causing an irido-cyclitis may give rise to sympathetic ophthalmia. The greatest danger of transmission of the inflammation from the injured eye to its fellow is when the inflammation of the injured eye is at its height. Later when the traumatic irido-cyclitis has subsided and the eyeball undergone atrophy there is no need for fear of sympathetic inflammation so long as the eye remains free from inflammation and

[1] Also called sympathetic ophthalmia or sympathetic ophthalmitis.

pain especially upon pressure. The most frequent cause of renewed inflammation in the injured eye is the presence of a foreign body within the eyeball or the continued ossification of inflammatory exudates. An eye which has been destroyed by injury is therefore a constant menace to the welfare of the fellow eye and should be removed. It is not necessary for the eye to be perfectly blind for it to give rise to sympathetic inflammation, so that at times the sympathizing eye may go on to blindness while the exciting one still retains useful vision.

Symptoms.—In the majority of cases sympathetic irido-cyclitis is preceded by a stage of incubation. The duration of this prodromal stage varies greatly. The common period is from three to six weeks although it may extend to twenty or thirty years. The patient notices that he is obliged to stop near work as it grows indistinct before his eyes, but after a period of rest he is able to resume his work. This interference with vision is due to a weakness of the ciliary or accommodating muscle. The eye is also sensitive to light, and watery but pain is usually absent. There is, however, often a tenderness on pressure which is very characteristic. This tenderness is sometimes more decided at one place around the cornea than at another as can be elicited by touching various points around the limbus with the blunt end of a probe. Pericorneal injection is more or less present. This stage of sympathetic irritation, as it is termed, may continue with interruptions for months or years without much change. The development of the irritative into the inflammatory type of sympathetic ophthalmia has been denied by many competent observers, among whom is Donders, but many, first among whom were Lawson and Rossander, have noticed eyes drift as it were from the stage of sympathetic irritation into that of sympathetic inflammation.

Sympathetic inflammation is fortunately a rare disease, occurring in less than one per cent. of severe injuries, but more than 80 per cent. of those affected go blind. It occurs more frequently in children not only because they meet with more accidents to their eyes but because the child's eye seems more susceptible to it.

Symptoms of Sympathetic Inflammation.—The symptoms vary according to the stage and severity of the disease. In the simpler and rather benign form of the disease we have a serous irido-cyclitis or serous uveitis, which may pass over into the malignant or plastic form of irido-cyclitis or subside after pursuing a rather chronic course. A sympathetic neuroretintis and retino-chorioiditis have been described. The latter, unlike the plastic irido-cyclitis, show no tendency to relapse. Sympathetic inflammation has never been observed to develop after enucleation of the injured eyeball except in those rare and doubtful cases in which the causative factor was supposed to be in the stump of the optic nerve. The symptoms of sympathetic inflammation do not differ from those of irido-cyclitis, so a detailed account of them will be deferred to the consideration of the latter subject.

Pathogenesis of Sympathetic Inflammation.—The manner in which irritation and inflammation spread from the injured eye to its fellow is not up to this time well understood. Mackenzie in 1858 first called the attention of physicians to the fact that the inflammation of the second eye depended upon that of the first and taught that the channel of communication was the optic nerve and chiasm, that is that the inflammation extends back along the optic nerve of the injured eye, crosses the chiasm and passes along the optic nerve to the second eye. This view prevailed pretty generally but was afterwards given up because inflammation in the exciting eye so seldom made its appearance under the guise of an optic neuritis but as an irido-cyclitis. Inasmuch as the uvea is supplied by the ciliary nerves Müller regarded them as the path of transmission. Many accepted this theory, among whom was Von Graefe. This ciliary-nerve theory assuming that the irritation started in the ciliary nerves of the inflamed eye causing an irritation in the nerve center, which is transmitted like a reflex to the other eye, held sway until the optic-nerve theory was revived in 1879 by Horner and Knies. Several years later Snellen, Berlin and Leber advanced the theory that the disease was of microbic origin and that the lymph spaces about the optic

nerves and chiasm were the channels of communication between the two eyes. Deutschmann's experiments along this line seemed to be conclusive, for he was able to produce sympathetic diseases in the eyes of rabbits by introducing a suspension of pus organisms in the vitreous chamber. He claimed that the organisms passed back along the channels around the optic nerve of the injured eye to the base of the brain, whence they were swept towards the fellow eye by the lymph current.

Many competent experimenters have failed to produce the disease in lower animals and especially with pus organisms. The prevailing opinion of to-day is that pus organisms probably play no part in the production of the disease in man. As a proof is often cited the fact that sympathetic inflammation rarely if ever occurs in panophthalmitis where pus organisms are present in abundance. This however is no proof as it is quite possible that in such cases the lymph channels are sealed by the violence of the inflammation. There are two factors necessary for the development of the disease, they are: A wound of the ciliary region and a certain amount of infection (whether purulent or not is uncertain) for sterile wounds of the ciliary region do not cause the disease.

The term secondary iritis or irido-cyclitis is applied to cases resulting from the spread of inflammation from adjacent structures to the iris and ciliary bodies. Corneal lesions and especially ulcers of the cornea most frequently give rise to secondary iritis and irido-cyclitis. Less frequently we have a more or less chronic form of irido-cyclitis secondary to a chorioiditis or detached retina.

General Symptoms of Iritis.—We may for convenience of study divide iritis into four groups, namely: Plastic, parenchymatous, spongy and serous. The suppurative iritis so-called of many authors is to be considered a symptom of purulent inflammation of the whole eyeball (panophthalmitis), beginning in the uvea following a penetrating injury to the eye with an infected instrument.

The same causes that give rise to inflammation of the iris operating to a less extent will produce hyperemia of the iris only. We

commonly see hyperemia of the iris in corneal disease and especially in foreign bodies in the cornea. Hyperemia may pass into iritis or subside without leaving a trace behind. Hyperemia may be expected in cases of keratitis whenever the eye becomes painful, not only when exposed to light but at other times. The symptoms of an iritis are due to hyperemia of the iris and to the formation of exudate. Hyperemia of the iris is evidenced by a small pupil and one which does not react normally to light and by discoloration of the iris. The contraction of the pupil is caused by the dilatation of the iris through fullness of its vessels, and also by a reflex spasm of the sphincter pupillæ. Atropin acts less thoroughly and less promptly upon such a pupil, although the dilatation is accomplished with an even round pupil. Discoloration of the iris causes a blue or gray one to appear greenish, and a dark-colored iris reddish. The hyperemia of the iris is accompanied by a circumcorneal injection, photophobia and lachrymation.

Exudation from an inflamed iris takes place into the anterior and posterior chambers and into the tissue of the iris itself. That which is set free in the anterior chamber causes the aqueous humor to become cloudy, causing the pupil to appear grayish instead of a pure black color. A muddy aqueous and a steamy cornea are at times difficult to differentiate. Both obscure a good view of the iris and pupil, and both interfere with vision. They can be told apart in the following way: In a muddy aqueous the natural luster of the cornea is preserved and seen in front of the cloudy aqueous, while in cases of steamy cornea, as so often, seen in cases of glaucoma, the cornea has lost its luster and appears as if it had been breathed upon. If the exudate into the aqueous is considerable the organized elements in it sooner or later sink to the bottom of the anterior chamber under the form of a hypopyon. At times the inflammation of the iris is so intense that blood escapes from its vessels by diapedesis and settles as a red mass at the bottom of the anterior chamber. To the latter condition the name of hyphæma is given. Exudation into the posterior chamber cannot be directly seen but manifests itself by ad-

hesions which it causes between the iris and the capsule of the lens. To such an adhesion the term posterior synechia is given. Posterior synechiæ chiefly develop at the place where the iris is normally in contact with the capsule of the lens, that is at the pupillary border. They form when the pupil is greatly contracted and the inflammation at its height. After the inflammation has passed and the pupil dilates it can do so only at the areas where the iris has remained unattached. The attached portions cannot dilate so the pupil becomes indented or irregular in outline.

The irregular shape is especially revealed if a mydriatic is instilled, for the iris then retracts strongly at its unattached portions. We therefore employ a mydriatic to diagnose the presence of posterior synechiæ.

It is the posterior pigmented epithelium of the iris that becomes adherent to the capsule of the lens in iritis, so that the tags seen in the pupil when the iris is retracted appear brown. By the continual use of atropia or perhaps after the disease has run its course the synechiæ give way and a brown spot remains upon the capsule of the lens. These spots never entirely disappear and are therefore lasting evidences of an attack of iritis. In very severe cases of iritis the iris becomes adherent to the lens capsule throughout its pupillary border which we speak of as an annular posterior synechia or seclusio pupillæ.

No projecting tags of iris are then apparent because the iris can not retract in any of its parts. There is however often a brown fringe from ectropion of the pigmented epithelium of the iris or a gray fringe caused by exudate investing the pupillary margin. An annular synechia is usually the result of a number of attacks of iritis, but does infrequently occur as the result of a long-continued attack. Very often the exudate in the pupil becomes organized, entirely closing up the pupil (occlusio pupillæ). These two sequelæ of iritis, shutting off of the pupil (seclusio pupillæ) and shutting up of the pupil (occlusio pupillæ) often occur together. Of the two the seclusio

pupillæ is the more dangerous to the welfare of the eyeball, inasmuch as the aqueous humor secreted behind the iris is unable to gain access to the anterior chamber through the pupil as it is everywhere tied fast to the capsule of the lens, and the eyeball therefore suffers rise of tension (secondary glaucoma).

The sight however is at first not interfered with if the pupil is free of exudate. On the other hand, exudate in the pupil interferes much with seeing but does not entail any further danger to the eyeball as the aqueous is able to percolate through it and thus find its escape by the infiltration angle of the anterior chamber. If the exudate is very great into the posterior chamber it leads to the adhesion of the entire posterior surface of the iris to the capsule of the lens, thus obliterating the posterior space entirely. Such a synechia is called total. A total synechia is a very rare sequel of uncomplicated iritis but occurs when there is an accompanying cyclitis, so it will be referred to again further on.

Symptoms of Cyclitis.—Exudation from the inflamed ciliary bodies gets into the anterior chamber, into the posterior chamber and into the vitreous. The exudate can get into the anterior chamber of the eyeball in two ways, first directly through the ligamentum pectinatum covering the anterior portions of the ciliary bodies, and secondly by the exudate being poured out into the posterior chamber and being carried by the aqueous through the pupil. The exudates that are most characteristic of cyclitis are deposits upon the posterior surface of the cornea (descemetitis). These occur as small dots varying in size but seldom larger than the head of a pin and of a light gray or brownish color. The smaller the deposits the more numerous they are and they then occupy as a rule the lower half of the cornea where they arrange themselves in a triangular form with the base of the triangle at the periphery and its apex towards the center of the cornea.

The deposits frequently diminish in size from the base to the apex of the triangle. If the deposits are large they are scattered without any regularity over the posterior surface of the cornea. These

deposits are conglomerations of cells held together by means of fibrin. They are at first set free in the aqueous humor and by motion of the eyeball are flung upon the posterior corneal surface and adhere. In doing so the larger and heavier bits settle below. The triangular shape of the arrangement of the deposits is due to the motion of the eyeball by which they are cast upon the cornea. The same thing happens when sand is thrown upon a wire sieve. The sand when it has settled down always forms a pointed figure with the point upwards and containing the finest particles.

These deposits were formerly thought to be located in the cornea itself, but some of the spots will disappear if the cornea is punctured and the aqueous allowed to escape, which is a proof that the deposits simply lie upon the posterior surface of the cornea. They are easily told from deposits in the substance of the cornea by their peculiar arrangement. They are also frequently brownish, containing few pigment cells from the uvea and are sharply circumscribed. Furthermore they are seen to lie in the same plane and not at different depths as deposits in the cornea. That the deposits originate in the ciliary bodies or chorioid and not in the iris itself is proven by cases of cyclitis or chorio-cyclitis in which the iris is not implicated. The exudate deposited by the ciliary bodies may also appear under the form of a hypopyon. Spongy masses of exudate that spring from the anterior ends of the ciliary bodies and appear to grow out from the sinus of the anterior chamber are often seen.

Adhesion of the entire surface of the iris to the lens capsule is apt to occur if the exudate into the posterior chamber is extensive. We diagnose its presence from the altered form of the iris and anterior chamber. The exudate in shrinking pulls the iris back to the surface of the lens, so that the posterior chamber is entirely obliterated. The anterior chamber is therefore deeper than normal, and especially at the periphery. Recession of the periphery of the iris is consequently a sign of cyclitis. Exudation into the chamber of the vitreous is seen with the ophthalmoscope if the media are clear enough. It interferes seriously with the vision, and evil consequences are en-

tailed by the shrinkage of the exudate. The intraocular tension which is unaltered in iritis is often elevated in the beginning of an attack of cyclitis from the increased amount of contents of the eyeball due to the deposit of inflammatory material, and blindness may be caused by the elevation of tension alone.

Later on in the disease the tension is minus, due to shrinkage in the exudate. Pain, circumcorneal injection, photophobia and lachrymation occur in varying degrees in all cases of iritis and cyclitis but are apt to be severer when the ciliary bodies are involved. The pain is often intolerable and reaches its height at night. It is not infrequently associated with nausea, vomiting and febrile movement. On the other hand certain chronic cases occur which are associated with scarcely any redness or pain. As said before it is seldom that the ciliary bodies do not in some measure participate in inflammation of the iris, but we make a diagnosis of irido-cyclitis only when in addition to the symptoms of an iritis there are positive evidences of involvement of the ciliary bodies.

Diagnosis Between Iritis and Cyclitis.—In cyclitis the inflammatory symptoms reach a higher pitch than they do in uncomplicated cases of iritis, and the eyeball becomes tender to pressure or palpation in the ciliary region. We diagnose cyclitis when there are deposits upon the cornea or when the periphery of the iris is retracted. When the interference with vision is greater than explained by exudation in the anterior chamber we infer the presence of vitreous opacities, and if the tension is altered — whether elevated or diminished — we know that the ciliary bodies participate in the inflammation. The association of inflammation of the ciliary bodies in cases of iritis makes the prognosis much more grave. Not only is inflammation more violent but it leads to changes which are more difficult to remedy. Severe iridocyclitis not infrequently leads to atrophy of the eyeball, a thing which never occurs in uncomplicated cases of iritis. We will now consider the other varieties of iritis.

Parenchymatous Iritis.—Plastic exudation is the rule in iritis, but now and then we see cases in which yellow nodules and masses de-

velop in the substance of the iris also, and project from its surface. These masses are called gummata or condylomata from their usual syphilitic origin. As a rule they occur singly, and occur most frequently in the periphery of the iris. At times they reach a considerable size, almost filling the anterior chamber and come in contact with the posterior surface of the cornea. When they occur below they may be confused with hypopyon, but from which they may be told by their golden yellow or reddish-yellow color and by their upper convex margin. When absorbed they leave a grayish-yellow spot where the iris is adherent to the lens capsule and atrophied. The same deposits occur in the ciliary bodies and chorioid. When they occur in the ciliary bodies the sclera not infrequently becomes softened from infiltration and bulges in a considerable manner (ectasis of sclera). Tuberculosis also gives rise to an interstitial iritis. Grayish-red nodules resembling neoplasms develop in the iris (see Tubercular Iritis).

Spongy Iritis.—This term was first applied by Knapp to cases of iritis associated with extreme turbidity of the aqueous due to a gelatinous exudate. The iris is pushed far back, the pupil semi-dilated and obscured by a very muddy aqueous humor. As the aqueous clears, the material is first exposed to view at the edge of the anterior chamber and appears to be semi-solid, and not unlike the edge of a dislocated lens. It appears to arise from the iris like a cyst. As a rule it is absorbed to a thin membrane covering the pupil and finally disappears without synechiæ. According to Arlt the material consists of a sero-fibrinous and hemorrhagic exudate rich in cell elements held in a meshwork of fine fibers.

The term *serous iritis* is applied to those cases of uveitis without iritis. True there is some discoloration of the iris due to hyperemia but no exudation. Fuchs speaks of the disease as simple cyclitis but we know that the same symptoms may be present in cases of posterior uveitis (chorioiditis). The disease is essentially chronic and the inflammatory symptoms are slight or absent altogether. The iris is normal in appearance or only slightly discolored and the

pupil moderately dilated. The diagnostic points are deposits upon the posterior surface of the cornea (descemetitis) and in the vitreous. The tension of the eyeball is often slightly elevated and the anterior chamber abnormally deep due to an excessive amount of fluid contents. It would be better to drop the term serous iritis entirely, as the iris is the least implicated, and to speak of such cases as serous uveitis.

Prognosis. — The average case of iritis takes four or more months to entirely subside. The first change for the better is manifested by decrease of pain and injection and by better dilatation of the pupil. Chronic iritis or irido-cyclitis may extend over several years, and relapses are not infrequent. The presence of posterior synechiæ is thought by some to predispose the eye to a relapse, inasmuch as the adhesions hamper the iris in its movements. It had been noticed however that all synechiæ are not associated with a relapse but only such as are left from an iritis due to a constitutional cause and not those left from an iritis secondary to a corneal ulcer for example. It is therefore most likely the constitutional taint which causes the recurrence. The second attack of iritis is usually less severe than the primary one, but every relapse puts the eye in more danger, as by their recurrence the pupil is often entirely closed by exudate and the iris completely tied down to the lens capsule. The outcome of the disease in the majority of cases is a perfect cure as far as the function of the eye is concerned. The adhesions of the iris break away leaving bits of pigment upon the anterior capsule of the lens which give rise to no symptoms. The hypopyon and deposits upon the posterior surface of the cornea together with slight vitreous opacities disappear in time by resorption. In many cases permanent sequelæ are left. Such are:

Atrophy of the Iris which is rare save after repeated attacks of iritis, but may be the result of a prolonged attack of chronic inflammation of the iris. It is characterized by a bleached-out and attenuated appearance of the iris tissue. The markings of the anterior surface of the iris disappear and new blood-vessels make their appearance. The pupil often appears ragged or frayed out as it

were and its reaction to light as well as drugs is lost or greatly impaired. The iris becomes very friable and tears readily during operative procedures.

Posterior Synechiæ are among the commonest of all sequelæ. They do no harm at all if few, but an annular adhesion of the iris to the capsule of the lens (seclusio pupillæ) entails especial injury to the eye. By it the communication between the anterior and the posterior chambers is obliterated, so the aqueous collects behind the iris and pushes it forward (iris bombé) and rise of intraocular tension follows with its baneful influence. The anterior ciliary veins are engorged, the cornea becomes steamy in appearance and insensitive and total blindness finally sets in.

Pupillary Membranes cause interference with the vision according to their thickness.

Exudates in the Posterior Chamber and in the Vitreous.—The former occur between the iris and the lens (total posterior synechia), the latter between the lens and the ciliary body and into the anterior portion of the vitreous, immediately behind the lens. A tough fibrous mass may be formed completely enveloping the lens to which the name of *cyclitic shell* is applied. The anterior chamber becomes deeper through shrinkage in the exudate in the posterior chamber.

By shrinkage in the vitreous exudate the volume of the vitreous becomes diminished and the eyeball in consequence softer than normal. Detachment of the retina from the chorioid is then apt to follow with total blindness. This condition, consisting of a soft eyeball with decrease in its size and complete blindness, is known as atrophy of the eyeball. The cornea is smaller than normal, opaque and flattened or transparent, bulging or wrinkled. The eyeball is often so soft that the tension of the extraocular muscles indent it, so that it becomes irregular in shape. The lens is opaque and the iris atrophic. The anterior chamber is frequently obliterated by the iris and the lens coming in contact with the posterior surface of the cornea. The eyeball is at times sensitive to touch and photophobic. In very old cases hard masses can be felt through the sclera due to

calcification or ossification of the exudate. Opacity of the crystalline lens develops in consequence of disturbed nutrition, and always occurs if the lens is surrounded by exudate. The cataractous lens is frequently shrunken and dislocated from degeneration of the zonula of Zinn.

The manner by which we differentiate iritis from irido-cyclitis has already been described, but even more important is it to properly diagnose iritis from conjunctivitis and glaucoma. We should be early to diagnose iritis because in the very beginning it is not difficult to break up adhesions if they have formed or prohibit them from forming altogether. Iritis is seldom taken for a case of conjunctivitis after conjunctival secretion has been established. The immobile or irregular pupil of iritis, the circumcorneal injection, cloudy aqueous with decided photophobia and lachrymation will serve to differentiate the two. The eye suffers the greatest possible amount of damage, however, when we fail to diagnose iritis from glaucoma, for in the former mydriatics are the sheet anchor in treatment while in the latter they act as poison to the eye, quickly destroying its sight. In iritis the pupil is small, in glaucoma larger than normal; tension is elevated in glaucoma, normal in iritis; cornea steamy and somewhat lusterless in glaucoma, unaltered in iritis, etc.

Treatment of Iritis and Irido-cyclitis.—There are three things to be accomplished in the treatment of an iritis, namely: The dilatation of the pupil, the relief of pain and removal of the cause. If the etiological factor is not apparent we treat the case symptomatically. The dilatation of the pupil is accomplished by the use of atropia (this drug is superior to all others in the treatment of iritis). Inasmuch as atropia contracts the tissue of the iris it drives the blood out of its blood-vessels in a measure and thus lessens the amount of engorgement and by paralyzing the sphincter it imparts rest to the inflamed organ. Finally it ruptures any adhesions between the iris and the capsule of the lens and counteracts the formation of new ones by keeping the pupil dilated.

By dilating the pupil the iris is removed somewhat from the sur-

face of the lens and thus adhesions are less likely to form. In the beginning it is difficult to get the pupil to dilate on account of spasm of the sphincter. Heat favors the relaxation of the spasm and aids the atropia in dilating the pupil. We begin the treatment by employing a 4 gr. to 1 oz. solution of atropia, or if adhesions already exist an 8 gr. to 1 oz. solution. Several drops of the solution are instilled and heat applied to the eye for five minutes, then several more drops instilled and heat applied for five minutes more when several drops are again put in the eye. If the pupil shows no dilatation in an hour more atropia is instilled and two ounces of blood or so taken from the temple by means of an artificial leach. A pilocarpin sweat will often cause a pupil which will not respond to atropia alone, to dilate on account of its relaxing effect upon the system. It is better in cases that do not yield to the atropia to use strong solutions instead of weaker ones more frequently repeated, for by the latter the conjunctiva is made more irritable, adding to the discomfort of the patient. If a very decided effect of atropia is desired one of Wyeth's ophthalmic discs (gr. $\frac{1}{100}$) may be placed in the lower fornix by means of a pair of small tweezers or moistened camels' hair pencil and the eye kept closed until the disc melts. These discs are made by incorporating the drug with gelatine. In this way the eye gets the whole amount of the drug and the dry throat caused in great measure by the atropia solution passing down the lachrymal passage does not so readily occur. If flushing of the face and dry throat occur to an annoying extent or if the patient is very susceptible to the action of atropia and alarming symptoms occur — morphia sulphate should be administered. Some are in the habit of combining cocain with the atropia for the first few instillations, but it is a question whether in inflammation of the iris the cocain increases the effect of the atropia to the same extent as it does upon the normal iris.

If the patient is very susceptible to atropia, the sulphate of duboisin, hyoscyamin, daturin or scapolamin hydrobromate may be used in its stead. Of these duboisin is most frequently employed as it is more certain in its action upon the pupil than the others but un-

fortunately it is apt to produce constitutional disturbances in the very cases which have an idiosyncrasy against atropin. Each of these drugs are used in gr. ii–iv to ℥i solution. In the aged the continued use of atropia or the other mydriatics at times causes tenesmus and retention of urine. The prolonged use of any of the mydriatics occasionally produces considerable irritation with great burning and itching of the conjunctiva and skin of the lids with the development of an erythema or papular eczema. In such cases it is best to stop the use of the alkaloid for awhile and to apply a solution of zinc sulphate to the conjunctiva and an ointment of zinc oxid to the skin until the irritation has subsided. Sometimes a strong, filtered watery extract of belladonna can be used when the alkaloids cannot. The irritation of the conjunctiva and skin of lids does not so readily occur if the solution used is kept sterile. Euphthalmin does not produce any irritation but its action is too feeble to be relied upon in iritis. It will not maintain dilatation of the pupil and in consequence the pupil becomes contracted and perhaps adherent. If in the course of an iritis the pupil is allowed to contract by not using atropia frequently enough it is seldom that it can again be dilated. So the eye should be seen frequently. After the pupil has dilated the atropia should be instilled often enough to maintain the dilatation.

In cases of irido-cyclitis in which the ciliary bodies are much implicated and in cases of pure cyclitis, atropia is often not well borne. Because, as the pupil becomes more and more dilated the vessels of the iris contain less blood and the vessels of the ciliary bodies become overdistended, inasmuch as they have to hold the blood which finds no lodgment in the iris. The use of atropia must, therefore, be stopped whenever it seems to increase the pain. So also in cases of irido-cyclitis in which there is a rise of tension the atropia must be stopped. It is seldom safe however in the latter variety of cases to use a miotic, as there is usually some amount of iritis and contraction of the pupil would lead to synechiæ and pupillary exudate which would still further increase the tension or otherwise damage the eye. It is far better in such cases to resort to paracentesis of the cornea

for the relief of tension. This operation may be repeated once a day for several days but if the tension remains up an iridectomy must be performed. It at times occurs in irido-cyclitis that atropia seems to increase the pain when the tension of the eyeball is normal — perhaps due to the increased congestion of the ciliary bodies it occasions, not by dilating the pupil and mechanically pushing the blood in the iris back into the ciliary vessels but from the relaxing action of the drug upon the vessels themselves. In such a case adrenalin chloride solution (1–1000) instilled every two hours or so will relieve the pain and benefit the eye. The constant local application of the Japanese hot-box will also prove beneficial.

The Relief of Pain. — Pain is usually relieved in a measure by protecting the eye from the light by a bandage or pair of dark glasses. Dry heat which is best applied by means of the Japanese hot box is grateful to the eye. This is often necessary in order to give the patient any rest at night, for it is then that the pain is apt to be worse. The hot box is tied over a small piece of cotton upon the eye and the patient allowed to go to sleep with it on. The top of the box is left uncovered to get the proper draft and the lighted end of the charcoal stick placed uttermost so that the ashes will not extinguish the fire. One of the sticks of fuel burns about two hours and should be renewed if pain returns. Salicylate of soda in doses of ten grains every two hours or so, or a pilocarpin sweat every day or every other day not only lessens the pain but the inflammation as well and favors the further dilatation of the pupil.

To produce profuse diaphoresis most men recommend the use of hypodermic injections of pilocarpin muriate, but when administered by this method it has no better effect than when given by the mouth. Two grains of the hydrochlorate of pilocarpin are dissolved in one ounce of water, and we begin with the administration of thirty drops (representing one eighth of a grain of the drug) and increase gradually if necessary until the desired effect is produced. The patient should strip, wrap himself in a blanket and then have the bed clothes piled on. If the iridic inflammation is severe the patient should re-

main in bed in a semi-darkened room until the pain and inflammation begin to subside.

The Removal of the Cause of the disease must be accomplished by the internal administration of mercury and iodids if due to syphilis or if due to rheumatism by administration of salicylate of soda. In the specific cases mercury is indicated unless there is gummatous formation in the iris or ciliary region, in which cases the iodids are of more service. The biniodid of mercury should be given in doses of one eighth of a grain to one quarter of a grain three or four times daily, and combined with inunctions until the patient is gotten well under the effect of the drug. The gums of course must be watched so that you do not salivate the patient. This will never occur if proper care is taken. The patient should keep his teeth and mouth as clean as possible and use tobacco sparingly or better not at all. Iodids are given in a saturated solution and in increasing doses. Beginning with a dose of ten drops of the saturated solution a drop more is taken every dose until the point of tolerance is reached. The best treatment perhaps for all other cases of iritis, whether rheumatic or not in origin, including sympathetic inflammation, is the internal administration of salicylate of soda and pilocarpin sweats.

The only certain prophylactic treatment of sympathetic inflammation consists in removal of the injured eye just as soon as or before its fellow shows any irritation.

An eye that is injured beyond possible repair and is sightless or contains a foreign body that cannot be extracted should be removed as soon as possible. The only excuse for procrastinating is the retention of some useful vision in the injured eye. After sympathetic inflammation has set in the injured eye should not be enucleated because its removal does not benefit the fellow eye and it may retain the better vision of the two after the inflammation has subsided. Slender posterior synechiæ left after the inflammation of the iris has subsided can often be ruptured by the employment of atropin.

For this purpose we want a very energetic action of the drug, so

a bit of atropin in substance or an ophthalmic disc of atropin is introduced into the conjunctival cul-de-sac. Sometimes the alternate use of eserin is more effectual. This is especially the case in peripherally situated adhesions. Eserin should not be instilled however until all hyperemia of the iris has subsided, because by contracting the pupil the iris is made hyperemic, predisposing it to a relapse of inflammation. Posterior synechiæ that do not yield to this treatment are left alone. Formerly an attempt was made to sever them with a guarded hook-shaped knife which was introduced between the iris and the lens capsule, but so many traumatic cataracts resulted from this operation of corelysis as it was called that it has been almost entirely abandoned. If the adhesions seriously affect the action of the pupil to mydriatics they may be pulled loose with a blunt hook. Some prefer to use an iris forceps to pull them loose. In the majority of cases however some iritis follows this operation and the same or other synechiæ re-form.

When an annular synechia exists we perform an iridectomy to reëstablish communication between the anterior and the posterior chambers of the eye. In occlusion of the pupil the iridectomy is made inwards and downwards as it is to serve the purpose of vision, but in simple seclusion of the pupil the coloboma is made upward. Total posterior synechia also requires an iridectomy, but it is often impossible to excise a sufficiently large piece of iris as the iris has grown fast to the lens. In such a case the only thing to do is to remove the lens even if it is transparent after the method of Wenzel, that is by making a flap of the iris and capsule of the lens (see section on Cataract).

Motor Disturbances of the Iris.—The functional disturbances of the iris consisting in inequality, dilatation or contraction of the pupil have been considered in a former chapter. In addition to that however we will now consider the pupil in disease of the cervical sympathetic. Horner in 1873 drew attention to the following symptom-complex occurring in irritation of the cervical sympathetic, dilatation of the pupil, widening of the palpebral fissure, slight protrusion of the eyeball,

pallor of the side of the face and head with slight fall of local temperature, sometimes increased perspiration and quickened heart beat. Destructive disease of the sympathetic gives rise to just the opposite train of symptoms, that is, contraction of the pupil, which does not react to light but contracts somewhat to convergence and acts only partially to mydriatics. The upper lid drops and the lower lid is slightly elevated, due to paralysis of Müller's orbital muscle. Retraction of the eyeball is a late symptom but may not occur at all. The vessels of the face, nostril, ear and conjunctiva are dilated and the pulse is often slow. Atrophy of one side of the face may follow and glycosuria has been observed.

Disease of the cervical spinal cord between the fourth cervical and second dorsal may cause symptoms closely resembling those primary to the sympathetic. In the few cases examined post mortem there has been found parenchymatous inflammation of the cells of the ganglion with swelling, loss of nuclei and fatty and granular degeneration, together with degeneration of the fibers leading from the cells, scleroses of the connective tissue in and about the ganglia and engorgement of the vessels with ecchymoses.

The causes are numerous, namely, tumors pressing upon the sympathetic cord or ganglia such as enlarged glands, aneurism or abscess; cicatrices or old wounds; extension of inflammation from the apex of the pleura in phthisis or chronic pleurisy, injuries and wounds of the neck, and any lesion of the upper spinal cord or vertebræ between the fourth cervical and second dorsal may give rise to the symptoms. Prognosis upon the whole is unfavorable, unless the cause can be removed and the destructive process has not progressed far. Treatment consists in the removal of the cause if possible. Electricity and galvanism do no good.

Tumors of the Iris.—The iris is rarely the seat of a new growth. The following varieties are however met with: tubercular, sarcomatous and cystic. Tubercles are chiefly seen in children. They are grayish-red, irregular nodules growing in the periphery of the iris accompanied by a moderate amount of inflammatory reaction. They

grow and multiply and in a few months fill the anterior chamber, render the eye painful and end in perforation. Their progress may be more chronic and instead of ending in perforating the sclera the tumor may begin to shrink after reaching a certain size and leave the anterior portion of the eyeball atrophied. Treatment consists in the removal of the entire eyeball.

Sarcoma of the iris as a primary disease is rare indeed. It is almost always of the pigmented variety. It grows slowly at first, later it grows rapidly with much pain and bleeding into the anterior chamber and finally perforates the eyeglobe. It occurs more frequently in women between twenty and forty years of age, the average age being about forty years. The growth is usually located in the lower part of the iris.

Treatment in the early stage when the growth is small and circumscribed.—The diseased portion of the iris may be removed by iridectomy and the growth subjected to microscopical examination. If there is any recurrence the eyeball should be enucleated.

Cysts of the Iris.—Cysts having transparent delicate walls lined with squamous epithelium, and filled with a serous fluid at times develop in the iris as the result of an injury. The cyst may be situated in the substance of the iris or have a superficial position. The implantation of a lash in the anterior chamber may be the starting point of an epithelial pearl-like tumor (cholesteatoma) of a cystic nature. The lining of the cyst consists of laminated epithelium and contents of degenerated epithelial cells and fat globules. The cyst may be small or entirely fill the anterior chamber. Treatment of cyst of the iris is excision by iridectomy. Nevi, leprosy nodules and lymphomata have been observed in the iris.

Differential diagnosis of tumors of the iris is not always easy. A non-pigmented nodular tumor for instance may be either a papule or gumma, a solitary tubercle, or non-pigmented sarcoma. We distinguish them in the following manner: The sarcomata contain the most vessels, the syphilitic growths fewer and tubercular nodules practically none. Papules of the iris are only situated at the pupil-

lary and ciliary borders, while other tumors spring from other portions of the iris as well. Iritis appears very early in syphilitic and tuberculous tumors and late in sarcomata. Tubercle is found oftener in young people, those under twenty, while both the other kinds occur in those over that age. We should carefully examine the patient to find other evidences of tuberculosis or syphilis. In all doubtful cases an energetic mercurial treatment should be given.

Injuries to the Iris.—An incised wound of the iris caused by penetration of the cornea with a tack or sharp instrument is not of itself dangerous unless the lens capsule is at the same time wounded or infection carried into the eyeball. The rent may be seen in the iris and there will be more or less blood in the anterior chamber which will be absorbed after a few days. Atropin should be instilled to give the iris rest and to prohibit the formation of an iritis and a bandage applied. The danger of wounds which penetrate the ciliary region of the eyeball has been pointed out in a former section. In such accidents the wound of the iris itself is of comparatively little consequence. Foreign bodies which penetrate the cornea and lodge in the iris are removed by including the piece of the iris containing the foreign body in an iridectomy. The most frequent wounds of the iris come from blows upon the eyeball and will now be considered.

Irido-dialysis means the separation of the iris from its ciliary attachment or rupture of the ligamentum pectinatum. By this means an opening is produced through which the red glare of the fundus and the edge of the lens can be seen with the ophthalmoscope. It is semilunar in shape and if of any size the iris sags, causing the pupil to appear flattened next to the tear. The lesion is permanent unless the edges can be brought in contact by the vigorous use of atropin when reattachment may take place. If the lesion is small and under the upper lid it occasions no trouble, otherwise it gives rise to double seeing with that eye. The patient has some pain and photophobia after the accident and there may be slight bleeding into the anterior chamber. Complete irido-dialysis, or anaridia as it is sometimes called, is an entire separation of the iris from its attach-

ment. An injury severe enough to produce this condition is usually accompanied by serious lesions to other structures of the eye.

Rupture of the Sphincter of the Pupil gives rise to a semi-dilated pupil with notched border and hyphæma. The pupil should be dilated to prevent formation of iritis. At times the iris is itself ruptured by a blow.

Displacement of the Iris. — Retroflexion of the iris or folding back of a portion of the iris upon the ciliary processes is accompanied by a dislocation of the crystalline lens. Anteversion consists in the iris turning upon itself so that the posterior surface of the detached portion is exposed to view.

Anomalies of the Anterior Chamber. — The depth of the anterior chamber varies in different individuals within physiological limits. It is shallow in infancy, becoming deeper in adult life and again shallower in old age. In myopia as a rule the depth of the anterior chamber is greater than in hyperopia.

Pathologically it shows variations in depth. It is made shallow by adhesions of the iris to the cornea, by increase of intraocular tension, by swelling of the lens during cataract formation or by collection of exudate behind the iris in cases of total posterior synechiæ. The periphery of the anterior chamber is often deeper than the center after an attack of irido-cyclitis due to the contraction of the exudate pulling the root of the iris backward. The chamber is increased in depth in ectasis of the cornea in dislocation of the crystalline lens, after the removal of the lens (aphakia) and in hydrophthalmos.

The presence of blood in the anterior chamber is called hyphæma; of pus, hypopyon. Blood and pus in the anterior chamber as a rule disappear under a pressure bandage, but if they persist after several days and seem to be doing harm paracentesis of the anterior chamber at its lowest point should be performed. Large doses of sodium salicylate and rotatory massage of the eyeball will hasten the resorption of blood or pus. After wounds of the eye rupturing the suspensory ligament of the lens or after the needling operation masses of soft lens substance frequently get free into the aqueous.

If great in amount paracentesis should be performed. The internal administration of potassium iodid will hasten the disappearance of small bits of lens substance. Foreign bodies, as pieces of metal and glass, may penetrate the cornea and lodge in the anterior chamber.

Cysticerci and filaria sanguinis hominis have been observed in the aqueous.

Operations Upon the Anterior Chamber. — Paracentesis or puncture of the cornea is done to evacuate pus, blood, soft lens substance or foreign bodies from the anterior chamber. It is also done for the relief of tension and to hasten absorption of soft cataracts. It is at times performed to prevent prolapse of the iris in threatened perforation of a corneal ulcer. It may be performed with a lance knife (keratome) or with Von Graefe's linear cataract knife. In using the lance-knife it is made to enter the cornea perpendicularly close to its outer inferior margin. As soon as the point has entered the anterior chamber the handle of the knife is depressed until the blade is parallel to the plane of the iris. The knife is then pushed on a little further until the wound gets to be two to three millimeters long, then it is withdrawn very slowly. To make the aqueous flow out we depress the peripheral edge of the wound intermittently. The operation may be repeated one or more times. Paracentesis with Graefe's cataract knife is only done in corneal abscess after the method of Saemisch. That is the knife is made to enter the anterior chamber with its cutting edge directed forward, to the outer side of the external border of the abscess. It is then pushed through the anterior chamber until its point can be brought out to the inner side of the abscess. The tissue overlying the knife is then divided.

OPERATIONS UPON THE IRIS.

Iridectomy, Iridotomy, Iridorhexis, Corelysis, Iridodesis. — Iridectomy or the removal of a piece of the iris is the most frequently performed operation upon the iris, so it will be first described. It is performed for the following purposes: To lower intraocular tension in glaucoma or ectasis of the cornea, to enlarge the pupil preliminary

to cataract extraction, to exercise a beneficial influence over the nutrition of the eyeball in obstinate cases of keratitis and iritis especially, to reëstablish a communication between the anterior and posterior chambers in seclusio and occlusio pupillæ, and for optical purposes in central opacity of the cornea or stationary central opacity of the lens and for the removal of foreign bodies and growths in the iris. Before performing the operation for visual purposes we first ascertain whether such an operation will benefit the patient. Of course the eye must have good light perception and projection, and in most cases the vision will be improved by dilating the pupil, so for several days the eye is kept under the influence of a mydriatic to

Hall's Angular Shank Keratome.

Jaeger's Angular Keratome.

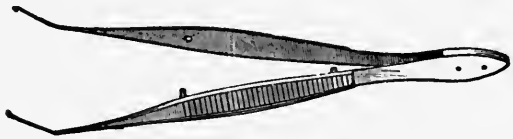
Jaeger's Straight Keratome.

ascertain what improvement may be expected from the operation. The choice of place for the operation is determined by the region that offers the greatest amount of clear cornea. If the opacity is central the new pupil is made down and in for visual purposes. If the pupil is made for enlarging the field of vision it should be made down and out. If both eyes are operated upon the colobomas should be symmetrical, *i. e.*, both inward, both outward or both downward. If one is compelled to select the upper part of the cornea for the operation, the opening in the iris can be made more useful for seeing if the superior rectus muscle is cut, provided the patient has but one eye. Whenever possible the iridectomy is made upward for thera-

peutic purposes, so that it may be covered by the upper lid. The incision through the cornea will be made closer or more distant from the edge of the cornea according to the case. For optical purposes it should be kept as near the center of the cornea as possible, as the cornea is often very irregular upon its edge and a very peripherally situated pupil will not therefore afford as good vision as one nearer the center. For therapeutic purposes it should be made through the anterior edge of the sclera even several millimeters from the edge of the cornea. The pupil for visual purposes should be small while

Lebreich's Iris Forceps.

Curved Iris Forceps.



Graefe's Angular Forceps.

that for other purposes large. The inner orifice of the wound through the cornea is what regulates the size of the iridectomy as it is always smaller than the external opening. The instruments needed for this operation are speculum, fixation forceps, keratome, iris forceps, iris scissors and iris repositor.

There are several forms of keratomes shown in the cuts. There is one made not shown in the cut with a curved instead of angular shank which makes it rather more easily managed. The blade is selected wide or narrow according to the size iridectomy you wish. No. 1 is useful when the patient has very prominent brow and deep-

set eyes. The accompanying cuts show a few of the many kinds of iris forceps and scissors.

By use of the Theobald scissors it is claimed a wider coloboma is obtained. It will be noticed that the curve of the blades conforms to that of the sclera when using them. The concave side is applied to the eyeball.

The iris repositor is nothing but a small curved probe with which the iris is placed back into the eyeball so that none of it remains incarcerated in the scleral wound.

Iris Scissors.

The instillation of a four per cent. cocain hydrochlorate solution will, in the great majority of cases, be all that is necessary unless the eyeball is very painful and injected, in which case the cocain is hardly absorbed in sufficient amount to render the operation painless. If the patient is very nervous or if cocain fails to properly anesthetize a general anesthetic is administered (preferably chloroform). The lids are separated and speculum introduced and the eyeball held quiet with a pair of fixation forceps applied below the cornea. The lance-knife should be held perpendicular to the cornea until its point enters the anterior chamber, then the handle depressed until the blade becomes parallel to the plane of the iris; it is then pressed steadily forward, care being taken not to prick the anterior capsule of the lens as the knife enters the eyeball, for by so doing a cataract is produced. The lance-knife penetrates with difficulty, so a to-and-fro motion of the handle will enable the point to enter more readily.

A lance-knife must be made very thin so that the point may even bend on light pressure upon the thumb nail and be exceedingly sharp. For very large and very peripherally situated incisions a Graefe cataract knife is preferable, also when we do not wish to exert much pressure upon the eyeball as in cases of soft eyes. If a

Graefe's knife is used it should be narrow. The objection to the use of the linear knife by many is that with it the inner opening through the eyeball is apt to be much shorter than the outer. This may be obviated, as Noyes points out, by entering nearly perpendicularly, and after the point of the knife is seen in the anterior chamber bring it up to the point of counter-puncture and instead of advancing draw it back for a millimeter, then push forward and complete the incision. There is however more danger of incarceration of the iris in the section when it is made with a cataract knife, as the edges of the wound do not coapt as well as when the section is made with a spade knife. Incarceration of the pillars of the coloboma retards healing and keeps the eye irritable for weeks.

The great objection to the use of a linear knife is that it is almost impossible to avoid wounding the iris in making the scleral section if the anterior chamber is shallow. As the aqueous flows out the iris is apt to wrap itself about the edge of the knife. Blood then fills the anterior chamber, obscuring the field of operation, or the iridectomy wound is left with ragged edges. Attempt should be made to allow the aqueous to escape slowly, for the sudden reduction of intraocular tension favors a detachment of the retina or intraocular hemorrhage. The forceps are next introduced closed and the iris seized close to its pupillary margin and withdrawn from the wound. When it is upon the stretch it is excised with one snip of the scissors, or if a very large iridectomy is desired the iris is pulled to one side (away from the scissors) and then to the other (towards the scissors) and cut with two snips of the scissors. The iris is now nicely replaced with the repositor, care being taken that none remains incarcerated in the wound. If the iris has properly receded into the anterior chamber the pupil will have a central position and the coloboma will have the proper inverted key-hole appearance.

Tyrell's Hook.

Tyrell's hook shown in the cut is at times used to advantage when a very small pupil for optical purposes is desired. Through

the opening in the cornea the hook is introduced, caught in the iris and the latter drawn out to the required extent and excised. There is danger, however, of producing a traumatic cataract with the hook and so great care should be exercised in its use. It is especially adapted for eyes which are devoid of a lens. With it the operation is rather more easily performed.

Hemorrhage does not readily occur save in cases in which tension has lasted for some time, causing engorgement of the iridic blood-vessels. If bleeding does occur its escape from the wound is favored by keeping up a little pressure upon the eyeball with the fixation forceps and at the same time gently pressing upon the posterior lip of the wound with a spatula or the cornea is stroked gently from below. If the bleeding is copious so that the blood fills the anterior chamber the latter should be irrigated with sterile salt solution. A few drops of adrenalin, 1–4,000, will stanch the bleeding. After the wound in the sclera has been freed of bits of clot a bandage is applied and the patient put to bed. He should remain quiet in bed in a partially darkened room for several days. The bandage may be removed as a rule upon the third or fourth day and a pair of dark glasses substituted. The bandage should be worn however until healing is complete.

The presence of a very shallow anterior chamber renders the performance of an iridectomy difficult. If the chamber is shallow from rise of intraocular tension and consequent advance of the iris and lens the following plan may be pursued: The tension is first lowered and the anterior chamber allowed to reëstablish itself by making a posterior sclerotomy, *i. e.*, the sclera is divided from before backward in its posterior portion. The section is made from before backward as this is the direction of most of the scleral fibers and such a wound gaps. The incision should be made between the extraocular muscles and not extend further forward than six millimeters from the edge of the cornea so as not to wound the ciliary bodies. Some vitreous is evacuated and the tension of the eyeball lessened. The iridectomy is performed the next day. If the iris is adherent to the cornea or

the lens swollen, pushing the iris forward, we operate after the method of Darrier which is: An opening is made at the point of entrance and at the point of counter-puncture with a small keratome. A curved probe-pointed cataract knife is then made to transfix the anterior chamber through these openings and the section completed in the usual way.

Iridotomy.—This consists in dividing or incising the iris without removing a piece. This operation is only adapted to an eye without a lens, because the incision in the iris would also affect the lens lying behind it and thus produce a traumatic cataract. This operation furnishes a new pupil by gaping of the iris tissue. As a rule the operation is reserved for eyes which have been operated upon for cataract and have suffered a subsequent irido-cyclitis with the formation of pupillary membranes and with after-cataracts. To restore the sight a new pupil must be made. Iridotomy can be

De Wecker's Scissor-Forceps.

accomplished by a simple incision made through the part of greatest tension so that the wound gaps. With the Graefe's cataract knife the operation is as follows: The knife is passed through the cornea and the diaphragm and the latter is divided in a direction at right angles to that of greatest tension. This method is only applicable when the membrane is thin, as there is danger of producing undue traction upon the ciliary processes in attempting to cut a tough thick membrane.

De Wecker's method is as follows: An incision is made through the margin of the cornea and through this a pair of scissors-forceps is introduced closed. The blades are then opened and the posterior sharp one is passed through the membrane while the other blade remains in the anterior chamber. By closing the scissors the diaphragm is then divided perpendicular to the direction of greatest

tension. There is usually some vitreous lost during this operation. The new pupil thus made seldom remains open any great length of time. It soon fills in with exudate from the renewal of inflammation or is closed by the gradual contraction of the already formed exudate.

Iridorhexis or iridodialysis is an operation seldom performed. It happens at times when too much tension is exerted upon the iris in the operation of iridectomy. The operation consists in tearing the iris away from its periphery when only the very extreme margin of the cornea is available for vision. In performing the operation a sharp hook is employed (Tyrell's). The hook is inserted near the periphery of the iris opposite the wound of entrance and traction made upon it. There is some danger of wounding the lens so an iridectomy is usually done in its stead. *Iridovulsion* is the term applied to total separation of the iris from the ciliary bodies. It is done in hydrophthalmos at times to open up closed lymph channels at the periphery of the anterior chamber.

Corelysis is at the present time seldom done. It consists in rupturing posterior synechiæ. Streatfield's hook (blunt hook) or a pair of toothless forceps may be employed.

Iridodesis was formerly employed to make a peripheral pupil in cases of conical cornea or for central opacity of the lens or cornea. It consists of making an incision through the limbus and drawing the pupillary portion of the iris into it where it is allowed to remain during the healing of the wound. After the iris is drawn into the wound it is tied in a loop of silk to retain it. The pupil by this means was dislocated behind the best portion of the cornea. The objection to the operation is that a few cases are followed by cyclitis and sympathetic ophthalmia. The operation has been superseded by iridectomy and tattooing the center of the cornea, or by operations upon the cornea designed to improve its curve.

Critchett, who devised the operation of iridodesis, made his incision through clear cornea and caught the iris up in its breadth. He met with no bad after effects.

CHAPTER XIV

DISEASES OF THE CHORIOID

Congenital Anomalies.—Albinism is the congenital absence of pigment in the tissues of the body, chiefly in the hair and eyes. The eye of the true albino has a pale watery blue or pinkish iris due to lack of pigment in its stroma and the reflection of light from its own blood-vessels as well as from the chorioid, and the pupil has a bright pink color when viewed from a favorable position. The lack of pigment is conspicuous in the entire uvea. The ophthalmoscopic picture of the fundus is therefore very brilliant. The vessels of the chorioid are especially well seen upon the white background formed by the sclera. If there is any pigment in the chorioid at all it is usually found near the middle of the fundus. Such eyes are over-sensitive to the light. Frequently there is nystagmus with amblyopia and a high refraction error. The lens of the eye is often illy developed, giving rise to a high grade of irregular astigmatism. Albinism runs in families. The subjects are neurotic and often feeble-minded. Refraction errors should be corrected and smoked lenses worn.

Coloboma of the Chorioid is a defect caused by a more or less imperfect closure of the ocular or chorioidal fissure. It may or may not be associated with a similar defect of the iris. With the aid of the ophthalmoscope the deficient area appears as a brilliant white or pearl-colored patch extending from the neighborhood of the optic papilla to behind the iris. Its surface is depressed, due to a bulging of the sclera at its site (a thing which differentiates it from area of chorioidal atrophy) and uneven. Over its surface course the posterior ciliary vessels, and its border is fringed with an irregular pigment. The retinal vessels either pass over the cleft uninterrupted or cease abruptly at its edge. The coloboma may include the nerve head, be

separated from it by an area of normal chorioid or be confined entirely to the neighborhood of the nerve.

The cleft of the chorioid is seldom continuous with that of the iris when associated with a coloboma of the iris but separated from it by a strip of healthy chorioid. A defect very similar in appearance appears in the region of the macula and in the nasal half of the eye ground, not involving the optic disc. These are spoken of as extra-papillar colobomata. They have no connection with closure of the ocular fissure but result from intrauterine chorioiditis, or as Johnston thinks from atrophied nevoid growths of the chorioid. When the coloboma occurs in the optic nerve there is a deep depression formed in the lower part of the papilla or the entire disc is enlarged and deeply excavated and its vessels forced apart to its edge.

(*Gibbons*)
Coloboma of Chorioid.

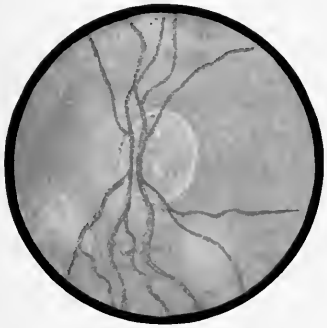
Not infrequently eyes with colobomata are smaller than normal and nearly always the vision is below par, due to arrested development. The coloboma furthermore gives rise to a large scotoma but one which does not annoy much because it lies in the upper field. The smallest colobomata are larger than the disc and the large ones so extensive that their anterior border cannot be seen as it lies too far forward behind the iris.

Hyperemia of the Chorioid cannot be diagnosed except when very pronounced, as it is difficult to say whether the altered appearance of the fundus in such cases is within physiological limits or not. Nevertheless the following appearance is usually attributed to hyperemia of the chorioid: Distinct redness of the nerve head which is scarcely differentiated from the unduly flannel-red appearance of the surrounding chorioid, more or less retinal striation surrounding the disc discernible by direct ophthalmoscopic examination. The

chorioid furthermore may lose its homogeneous red color and present slight blurring of details in spots with more or less heaping up of pigment in the periphery, a condition spoken of as "woolly chorioid." We see this picture in many cases of eye-strain, and from exposure to bright light and heat, hence in glass-blowers, stokers and puddlers, and it is not infrequently a precursor of chorioiditis.

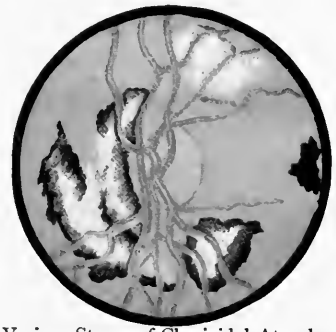
There is more or less aching of the eyes with intolerance of light and pronounced asthenopia. Such eyes should be put under the full effect of atropia and a total correction of the error of refraction made. The atropin should be continued and dark glasses worn until the irritable condition of the fundus has subsided.

Inflammation of the Chorioid.—Chorioiditis occurs either as an



Exudative Chorioiditis.

(Gibbons)



Various Stages of Chorioidal Atrophy.

exudative inflammation which undergoes resolution or passes into pus formation; hence we have exudative or plastic chorioiditis and suppurative chorioiditis.

Exudative Chorioiditis affects only the chorioid, while suppurative chorioiditis is never limited to the chorioid, but leads to a destruction of the eyeball through purulent inflammation of all its parts (panophthalmitis).

Exudative Chorioiditis (*Chorioiditis Exudativa, C. non-suppurativa*) occurs as isolated foci of inflammation confined to one or more areas or scattered irregularly over the fundus oculi. When recent they appear with the aid of the ophthalmoscope as yellowish-white indis-

tinctly outlined, irregular, circular patches over which the retinal vessels pass unobscured. The yellow material consists of exudate which hides the normal red color of the chorioid. As the exudate disappears by resorption the chorioid is again presented to view but in an altered condition. It is atrophic, more or less deprived of its pigment and converted in part into connective tissue. After the disappearance of the exudate we see at the site of the exudate a lighter colored area varying in appearance according to the depth to which the exudate had penetrated. If the chorioid is altogether atrophic there exists a white spot because the area is filled in with a white cicatrix and the white sclera is seen through it. The pigment of the chorioid soon begins to proliferate and the spot becomes bordered with pigment and more or less covered by it. Perhaps the white spot is entirely covered with black pigment. In other cases just the superficial portions of the chorioid become affected, so that there is formed a lighter area in the fundus in which the deep layer of large vessels of the chorioid is exposed to view.

The distinction between recent exudates and old atrophic spots is made as follows: Recent exudates are of a yellowish color with illy defined non-pigmented borders, while atrophic spots are sharply circumscribed by the normal chorioid and fringed more or less by pigment or totally converted into pigment patches.

The retina overlying the spots of diseased chorioid suffers from want of nutrition, so that we find blind spots at the sites of chorioidal disease if the media are clear enough to take the field of vision. The various disturbances that are met with in chorioiditis are due to implication of the retina and cloudiness of the vitreous.

The vision is always poor as a whole from cloudiness of the vitreous and in a measure from hyperemia of the retina. Owing to the fact that there is some localized swelling in the chorioid at the spots of exudate, which however can not be made out with the ophthalmoscope except very rarely, the retina is pushed forward and its elements distorted so that objects whose images fall upon this distorted area appear likewise distorted (metamorphopsia), that is

straight lines appear curved or bent in various directions. As long as the inflammation is recent symptoms of retinal irritation manifest themselves; flashes of light before the eyes (photopsia). The influence which chorioiditis exerts upon the vision depends upon the part of the fundus affected. Peripherally situated scotomata do little or no harm, but if the macular region is affected the eye is rendered totally unfit for fine work. In many cases of chorioiditis, especially those affecting the most anterior portions of the fundus, we have deposits upon the posterior surface of the cornea (descemetitis). The dots of fibrinous exudate are formed in the chorioid, set free into the vitreous, and, following the nutrient currents of the eyeball, are deposited upon the posterior surface of the cornea. This symptom occurs more frequently in uncomplicated exudative chorioiditis than was formerly supposed, as it is invisible ofttimes unless looked for with a magnifying glass. When found however it will always make a diagnosis of uveitis in doubtful cases. It occurs most frequently in those cases in which there is much exudation into the vitreous, causing it to become very muddy and the eye to be slightly harder than normal (serous uveitis). The exudate in these cases is only slightly organized, being more serous than plastic in nature. The pupil is usually dilated and the iris somewhat discolored, but may be entirely normal in appearance. The outside of the eyeball except in anterior sclero-chorioiditis is entirely normal in appearance.

Chorioiditis is an essentially chronic disease. Many months—often a year or more—elapse before the spots of exudation are converted into atrophic spots and the vitreous opacities persist even longer, often in fact permanently. Chorioiditis is especially dangerous to the sight from its tendency to recur. New foci of inflammation may develop from time to time until the whole chorioid becomes covered with atrophic spots. Finally atrophy of the retina and optic nerve ensues so that the case terminates in total blindness. After the disease is well advanced the lens becomes cloudy from disturbed nutrition. Vitreous opacities may be absent during the entire course of the disease. Their presence depends more upon coincident impli-

cation of the retina than upon the disease of the chorioid itself. They are found in great numbers only when the inner layers of the retina are involved, as shown by blurring of the retinal vessels. The implication of the retina is due to extension from the chorioid and also occurs as an independent process brought about by the same cause as the chorioiditis. Shreads or films of exudate or lymph are now and then seen attached to the edge of a chorioidal plaque and floating in the vitreous. The vitreous opacities for the most part occur from free exudation into the vitreous, but occasionally there is a migration of the chorioido-retinal pigment into the vitreous, giving rise to large black masses which interfere much with vision. In old cases of chorioiditis the vitreous becomes liquefied from degeneration of its trabeculæ. The eyeball is then softer than normal.

We recognize the following varieties of plastic chorioiditis according to the situation of the focus of inflammation or according to its shape: Congenital irido-chorioiditis, disseminated chorioiditis, areolar chorioiditis (Förster), chorio-retinitis, central chorioiditis, anterior chorioiditis, anterior sclero-chorioiditis, posterior sclero-chorioiditis.

Congenital Irido-Chorioiditis of one or both eyes from intra-uterine inflammation is occasionally met with in illy developed and poorly nourished infants of tubercular or syphilitic diathesis. The disease may run its course and leave the eye more or less blind during the first year. The iris is seen to be tied down to the lens capsule and if the media permit very extensive chorioidal atrophy, usually involving the macular region, is discoverable with the ophthalmoscope. Such cases are hopeless and even if seen during the stage of active inflammation little can be done to save the sight.

Disseminated Chorioiditis is characterized by numerous round or irregular-shaped spots scattered over the fundus. This form of chorioiditis is especially chronic and new spots are forming all the time, until the whole eye-ground becomes covered with them. In many places they become confluent so that a very large part of the fundus may be whitish with accumulation of more or less pigment in masses. The sight however may remain good if the macular region

is spared. Later on in the disease both the retina and optic nerve are apt to become atrophic. The nerve-head assumes a dirty gray color and its vessels in great part disappear and those which are left are greatly contracted (chorioiditic atrophy of optic nerve).

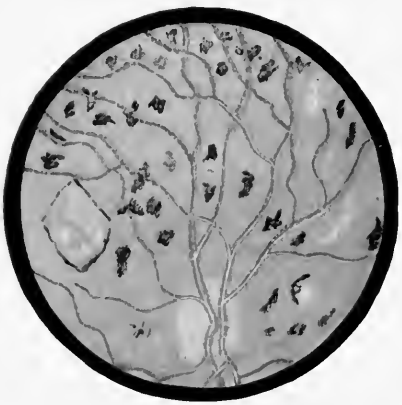
Causes.—Syphilis and tuberculosis are far the most frequent causes of this variety of chorioiditis. Rheumatism, gout and gonorrhœa after the joints have become involved, malnutrition or poorness of the blood from anæmia, chlorosis, malaria or what not, disturbances of menstruation, typhus and typhoid fevers are other less frequent causes.

The disease makes its appearance in syphilis about six to eighteen months after the initial sore; in congenital syphilis sometimes after birth, but more often between the third and sixth year. It not infrequently is combined with interstitial keratitis.

Areolar Chorioiditis which was first described by Förster is really a form of disseminated chorioiditis. The first foci develop in the region of the macula and the newer ones make their appearance at a constantly increasing distance from the latter. The more recent the spots are the more pigment accumulation they have. They gradually become larger and the pigment is absorbed, leaving them almost entirely white.

Chorio-retinitis (*Syphilitic*) is at first characterized by increased redness of the disc and by fine dust-like opacities of the vitreous. Many regard this affection as syphilitic retinitis, but it is really a superficial form of chorioiditis. It is always caused by syphilis, coming on from six to eighteen months after infection. It affects both eyes as a rule and is very chronic in its course. At times it is accompanied by iritis. With the ophthalmoscope no individual patches in the fundus can be discerned as a rule but the whole fundus is scarcely seen through the foggy vitreous. In other cases there may be one or two patches of exudation found here or there in the fundus. Perfect recovery usually takes place after a number of months. If the disease advances the vitreous becomes very fluid and larger opacities form in it. The retinal veins are overfull and

the arteries diminished with paleness of the papilla. Especially in old people and when treatment has been neglected irregular and well-defined areas are seen in the periphery of the fundus in which the pigment has disappeared, exposing the chorioidal vessels to view with irregular bits of pigment infiltrating the overlying retina and coating its vessels in places. The central region may be occupied by a large bluish-gray opacity with a number of cicatricial bands intersecting its surface. Vision is by this time very poor from degeneration of the retina. The retinal pigment may be absorbed over the entire fundus, exposing to view the deeper layer of chorioidal vessels.



(*Gibbons*)

Chorio-Retinitis.

This appearance is told from the psychological condition of tessellated fundus by the fact that there is thickening of or other changes in the chorioidal vessels, and by the occurrence of bits of coal-black pigment in the retina and about its vessels. At times the pigment deposits are so numerous that the condition may be taken for a case of retinitis pigmentosa. In the latter disease there is no exposure of the chorioidal vessels, however, and the pigment is of a more delicate and lace-like character, the field of vision is much contracted and central vision very good.

Central Chorioiditis.—When the chorioiditis is confined to the central region of the fundus it is spoken of as central chorioiditis. It occurs very frequently as a senile change or from the other causes of chorioiditis in general in the young and not infrequently from blows upon the eye, and is common in high myopia. The senile form of the disease nearly always affects both eyes. It comes on after the sixtieth year. The prognosis is very bad. As a rule no improvement in vision takes place at all. It is rather common and

often occurs together with senile cataract. In all cases in old people of gradual loss of reading-ability with transparent media and normal fields it should be thought of. In a well-developed case we have the following picture: Occupying the region of macula there is an oval or circular area about the size of the papilla which lacks the luster of the surrounding fundus, due to an infiltration of the tissues, and its surface shows pigmentary disturbances and sometimes punctate hemorrhages and cholesterin crystals. In course of time the atrophy of the chorioid becomes more marked. In the young some improvement is to be expected from proper treatment.

Anterior Chorioiditis gives rise to the formation of foci of exudation in the extreme periphery of the chorioid. The patches are easily overlooked. It is quite frequent and is at times combined with peripapillar inflammation of the chorioid. Its commonest cause is syphilis, hereditary or acquired. In an old case the periphery of the fundus is seen studded with well-defined round ink-black spots.

Sclero-Chorioiditis.—There are two forms of sclero-chorioiditis, namely, anterior and posterior. The latter is the commoner of the two forms, so will be described first.

Posterior Sclero-Chorioiditis (*Staphyloma Posticum*). This condition results from the elongation of the eyeball in cases of myopia. It really denotes a protrusion of the sclera backward (ectasis scleræ) but has to do as well with the resulting inflammation and change in the chorioid. There first appears at the external margin of the optic papilla a narrow crescentic shaped area of chorioiditis which becomes atrophic. This may spread out to assume the form of a triangle or cone. The atrophic process finally passes entirely around the nerve-head (annular posterior staphyloma). The appearance of the atrophic area is either entirely white or remains of the chorioidal tissue, vessels and pigment are still present. Not infrequently there exists several crescents, the one to the outside of the other. Next to the nerve will be an area of complete atrophy, while next to that an area of partial atrophy and outermost an area of active chorioiditis. Pigment may become increased and heaped up in the locality of the

nerve, giving rise to a black crescent. If the edge of the crescent is sharply cut from the surrounding chorioid we know that the progress of the myopia is at that time at a stand still, but if the edge is blurred the eyeball is still undergoing elongation. After the myopia has reached a rather high degree changes in the chorioid make their appearance in the region of the macula lutea also ; light-colored and pigmented areas are found. Not infrequently a number of branching and interlacing white lines of atrophy are seen surrounding the macula.

Sight is very much better in such cases than would be expected from the ophthalmoscopic appearance, but on the other hand all useful vision may be lost by the coalescence of several small atrophic areas, giving rise to large patches which may become connected with the atrophic area surrounding the papilla. Hemorrhages not infrequently occur in the region of the macula in the myopic eyeball. Vitreous opacities may form adjacent to the areas of chorioiditis and by contracting separate the vitreous and retina from the underlying tissue, or the vitreous, no longer able to accommodate itself to the elongating eyeball, becomes separated from the fundus and the space between it and the bottom of the staphyloma (ectasis) filled by a thin fluid exudate from the chorioid. The greatest danger to the myopic eye is from detachment of the retina, which in most cases ends in complete blindness. Quite high degrees of myopia may exist and progress without the formation of any considerable staphyloma ; on the other hand very large atrophic areas are observed in myopic eyes of low degree. It not infrequently happens that in chorioiditis we see areas of exudate or atrophy surrounding the optic nerve more or less while the rest of the fundus is spared. To these cases the term peripapillar chorioiditis is given.

Peripapillar Chorioiditis may occur from any of the causes of chorioiditis in general. It is seen most frequently in non-myopic eyes as a senile change. Thaden says 72 per cent. of persons over the age of eighty show this condition. The ring of atrophy is usually incomplete. In glaucoma there frequently forms a ring of atrophy

around and adjacent to the papilla to which the term glaucomatous halo is applied.

Anterior Sclero-Chorioiditis means an anterior chorioiditis with a localized more or less diffuse bulging of the overlying sclera. The patient will complain of a sensitiveness about the eye and on inspection the superficial and deep blood-vessels of the conjunctiva will be found injected. The redness fades upon pressure but not entirely. This occurs as a rule to the outer side of the cornea. The cornea and iris and episcleral tissue are apparently normal. At this stage the disease looks more like a diffuse scleritis or a rheumatic catarrhal ophthalmia than anything else. If the fundus is examined however in the region of the external injection there will be found a patch of chorioiditis with a rather clear vitreous but unduly red papilla. In a day or so, there develops a descemetitis and the sclera over the chorioiditic patch becomes weakened by infiltration and slightly distended.

Treatment of Exudative Chorioiditis.—The treatment of the cause is of course most essential. Those with a distinct history of syphilis afford the best prognosis. It is not altogether certain which gives the best result in syphilitic chorioiditis in general, but in rapidly progressing cases mercury seems to exercise more control than the iodids. The quickest way to bring the patient under the effect of mercury is by inunction. A drachm of the blue ointment should be rubbed into the skin twice daily and continued until tolerance is reached. Salivation will occur less frequently if the patient's teeth are put in good condition and kept clean and free from collections of tartar. In syphilitic cases inunction should be combined with the internal administration of iodid of potash in increasing doses. Rheumatic cases demand the use of salicylates. Good service is done by several pilocarpin sweats in the beginning of chorioiditis of whatever cause. If there is marked hyperemia of the fundus some blood may be drawn from behind the mastoid process. Six to ten leeches may be applied or two to four ounces of blood withdrawn by means of the artificial leech. This does good because there passes

through the mastoid the vein of Santorini leading from the lateral sinus which in turn communicates with the cavernous sinus into which empties the ophthalmic vein.

Atropin should be instilled often enough to keep the ciliary muscle in abeyance so that the patient will not attempt to use the eye and so that the inflamed chorioid may get complete rest. Dark glasses should be worn to protect the eyes. In children of tubercular or syphilitic diathesis in addition to mercury tonics should be given, cod-liver oil, hypophosphites, etc. The chorioiditis of myopia is to be relieved by properly correcting the error of refraction and enjoining rest under atropia (see section on Myopia).

Suppurative or Purulent Chorioiditis.—Suppurative chorioditis is caused by invasion of the chorioid with pyogenic matter. The infection may be metastatic but usually originates from the outside (ectogenous chorioiditis). Infection occurs most frequently from penetrating injuries among which are included unsuccessful operations upon the eyeball. From the passage inward of infection from ulcers or abscess of the cornea and from hernias of the iris that are covered with pus as in cases of purulent ophthalmia. Less frequently we have purulent chorioiditis occurring in eyes with incarceration of the iris when the cicatrix including the iris is especially thin. The organisms of suppuration presumably penetrate the thin cicatrix into the interior of the eyeball.

Metastatic or endogenous infection takes place most frequently in the septic fevers and especially in puerperal fever. In rare cases it also occurs in acute infectious diseases as typhus, typhoid, scarlatina, influenza, anthrax and in ulcerative endocarditis. It also occurs in meningitis, especially cerebro-spinal meningitis, through transfer of inflammation from the meninges. Such cases occur in children and are distinguished by their comparatively mild course, so that a considerable degree of sight is often preserved. It is also observed in thrombosis of orbital veins associated with orbital abscess.

The prognosis is very bad as the sight and in most cases the shape of the eyeball as well are lost. In meningitis and septicemia puru-

lent chorioiditis coming on late in the course of the disease is a grave prognostic sign for the life of the patient.

Symptoms. — The first thing noted in the development of suppurative chorioiditis is distension of the subcutaneous veins of the eyelids with more or less edema. The edema increases and spreads to the ocular conjunctiva, giving rise to considerable amount of chemosis. The cornea becomes hazy and the iris and ciliary bodies inflamed, which in many cases occasions an hypopyon. If the cornea is transparent enough a purulent collection may be seen in the vitreous chamber which gives a yellowish reflex to the pupil especially by transmitted light. The tension of the eyeball is elevated, the pupil partially dilated unless tied down by inflammatory adhesions and the anterior chamber shallow. There is very severe pain in the eyeball and corresponding side of the face and head.

The eyeball is tender to touch and blind. There is always some fever which in severe cases may be ushered in by a chill and accompanied by nausea and vomiting. The disease may remain confined to the uvea, in which case the symptoms gradually abate and the eyeball undergoes a slow atrophy. In most cases, however, especially in adults, the inflammation spreads and involves all the ocular and orbital tissues, giving rise to what is called *panophthalmitis.* The eyeball becomes popped and more or less fixed from involvement of Tenon's capsule. The lids are now enormously swollen and cannot be opened and the chemotic conjunctiva presents as a fleshy mass between them. Finally the cornea sloughs or the sclera ruptures and the purulent contents of the eyeball escape. The pain now subsides and the eyeball undergoes shrinkage, becoming in about six weeks a misshapen painless mass within the orbit. This condition is spoken of as *phthisis bulbi.*

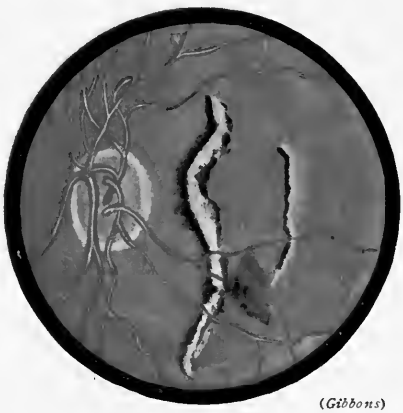
Pathological Anatomy. — There is a dense infiltration of the chorioid and overlying retina with pus cells. The retina finally becomes detached from the chorioid by a collection of pus and the vitreous becomes degenerate and converted into a homogeneous mass of purulent matter. Metastases can often be seen under the micro-

scope filling the chorioidal vessels. These septic emboli may first lodge in the retinal vessels, in which case we would have a suppurative or purulent retinitis with the same clinical picture however as in purulent chorioiditis. The term *metastatic suppurative ophthalmia* has been suggested for these metastatic affections.

Treatment.—From the experiments of Goldziehr and others it would seem that the introduction of iodoform into the vitreous chamber of injured eyes acted as a prophylaxis against panophthalmitis. Many injured eyes, however, never develop panophthalmitis, so that in a few cases it is very difficult to decide upon the value of a certain line of treatment. After the disease has developed we are powerless to arrest its course. Atropia should be instilled and heat applied to the eye for relief of pain. Most cases need in addition some anodyne internally for the relief of the pain. As soon as the diagnosis of panophthalmitis can be made the eye should be enucleated. Many surgeons, especially those abroad, advise against enucleation in cases of panophthalmitis through the fear of setting up a purulent meningitis, as the lymph spaces about the optic nerve, they say, are freely opened by removal of the eyeball. True it is that cases of meningitis have occurred after enucleation of eyes affected with panophthalmitis, but it has likewise occurred from panophthalmitis without enucleation. There is no apparent danger in enucleation if the conjunctival sac is left unsutured so that there is good drainage. One should try to remove the eyeball without rupturing it so that no pus is spilt in the orbit, but even if this occurs there is little cause for alarm because the lymph spaces passing brainward are pretty well sealed by swelling of the tissues and exudation before operation is undertaken. Those who oppose enucleation practice incising the eyeball through the sclera below the cornea and thus give vent to the pus with subsidence of the pain. After the eyeball has shriveled up, if it is at all painful, enucleation is done. Others prefer evisceration of the eyeball.

At times suppurative chorioiditis runs such a sluggish course that all external signs of inflammation are wanting, so that one may con-

found it with a neoplasm in the eyeball. The iris is not discolored and the cornea and lens are clear. The anterior chamber is shallower than normal from pressing forward of the iris by the exudate in the vitreous and the pupil is dilated. Deep down in the vitreous is the exudate of a yellowish color sometimes seen at a distance from the eye. The same appearance is presented by a glioma of the retina. Such cases of suppurative chorioiditis are, hence, at times designated as pseudo-gliomata. The principal diagnostic point is the tension of the eyeball which is normal in the early stages of glioma retinæ and later becomes elevated, while it is elevated at first in pseudo-glioma and soon becomes diminished. The subsequent course of the two is different also. Pseudo-glioma causes a continued shrinkage in the eyeball while in true glioma the growth penetrates the sclera and keeps on growing. It is not proper to wait until this occurs however as it is right to remove the eyeball affected with glioma just as soon as possible, so in any doubtful case the eyeball should be removed so that the life of the patient is not put in jeopardy. Even if we should make a mistake in diagnosis it makes very little difference as the eye is already blind. Meningitis in children is the commonest cause of pseudo-glioma, also the exanthemata and the presence of foreign bodies in the eyeball. A few cases of tuberculosis of the chorioid presenting the appearance seen in pseudo-glioma have been reported.



(*Gibbons*)
Rupture of Chorioid.

Rupture of the Chorioid.—This is a rather common occurrence and is produced by sudden compression of the eyeball by a blow. There is usually some extravasation of blood into the vitreous so that the rent in the chorioid is not seen immediately after the injury. After a few days when the blood has been absorbed the rupture of

the chorioid is discovered. It usually lies in the neighborhood of the optic papilla, between it and the macula and is often crescentic in shape with its concavity towards the papilla. Becker says the cause of such crescentic ruptures is that the optic nerve is thrust into the eyeball by the blow which throws the chorioid into a fold concentric with its margin, and it is at this point that it gives away. The lacerations are nearly always vertically placed and may be situated centrally or peripherally and there may be several. They form long irregular whitish streaks with more or less pigment around their edges. The retinal vessels run unbroken over the spot and in the bottom of the streak may be seen a posterior ciliary artery if the situation of the laceration is favorable. Exudation may take place about the rupture and completely conceal it and at times the exudation extends into the vitreous as a fluffy mass.

Hemorrhage of the Chorioid.—Hemorrhages of the chorioid are as a rule secondary to inflammatory change in that structure and not as in the retina the sole lesion. When hemorrhages occur in the nerve fiber layer of the retina it is easy to tell them from chorioidal hemorrhage by their striated and feathery appearance, but when they are situated in the deeper layers it is impossible to tell with certainty whether they are in the retina or in the chorioid. Usually when a retinal vessel runs over a hemorrhagic area unobscured we say the hemorrhage is in the chorioid. Chorioidal hemorrhages form sharply defined more or less round rose red spots in the fundus and are replaced by pigmentation.

Detachment of the Chorioid.—This is a very rare clinical condition but not infrequently seen in excised eyes. Von Graefe was the first to draw attention to the condition in 1854. It occurs commonly from a blow upon the eye but may come on spontaneously. It may occur after extraction of cataract with much loss of the vitreous humor. Impairment of vision in the field corresponding to the detached portion comes on immediately. The eye is normal in outward appearance at first but atrophy of the globe eventually takes place. In the very beginning it is not very difficult to make a proper diagnosis.

At some part of the fundus there is seen projecting into the vitreous a more or less uniform hemispherical translucent elevation of an orange-red color with masses of pigment upon its surface, and behind the pigment are made out the flat anastomosing vessels of the chorioid. Unlike simple detachment of the retina there is no fluctuation in the elevation when the eyeball is moved and in tumors of the chorioid the underlying chorioidal vessels are not visible. There are a few rare cases, however, in which the retina and the chorioid have become separated while each is elevated from the plane of the fundus. There soon takes place a layer of lymph between the two which obscures the chorioidal vessels causing the detachment to simulate closely the appearance of a sarcoma of the chorioid. A case is reported by Elschnig in which the detachment of the chorioid took place at the site of an old chorioido-retinitis, and he suggests that possibly in these cases there is an agglutination of the retina and the chorioid and that detachment results from shrinking of the vitreous.

Degenerative Changes in the Chorioid usually occur as the result of inflammation, as has been seen, but at times are unassociated with any inflammatory reaction. In old age, and especially in senile cataract, obliteration of vessels in the anterior part of the chorioid is common. The most conspicuous senile change is what is called "Drüsen" or colloid degeneration of the basal membrane. It consists of translucent bead-like bodies of various shapes, sessile or pedunculated and more or less aggregated, which push into the retinal epithelium and are seen as minute yellowish-white dots. They are most frequent about the equator of the eyeball, but occur in any region. They do not impair vision. They occur at times in young individuals. Similar bodies occur as the result of inflammation both in the chorioid and optic nerve.

Tuberculosis of the Chorioid.—Tubercular disease of the chorioid occurs as a symptom of miliary tuberculosis or as large masses or infiltrations in chronic tuberculosis. Miliary tubercles nearly always occur in both eyes.

They occur by preference in the neighborhood of the nerve and

macula but when numerous are pretty generally scattered over the fundus. They occur as round rose-colored spots, shading off gradually at their margins into the normal fundus without the formation of any pigment ring as is so common in lesions of the chorioid. They are from one to two thirds the diameter of the optic disc. The larger ones are decidedly prominent, slightly grayish and sometimes slightly pigmented at their margins. Together with the tubercles may occur some atrophic spots as seen in disseminated chorioiditis as the latter trouble is often due to tuberculosis, that is to the malnutrition it produces. The tubercles grow mostly from the adventitia of the larger vessels while the changes in disseminated chorioiditis start in the most superficial layers. Examination of the eye after excision reveals many more tubercles in the chorioid than were visible with the ophthalmoscope, as they are when recent, quite transparent and minute. They give rise to no deterioration of vision so repeated examination is necessary to exclude their presence. The overlying retina remains intact save for its pigment layer which is broken through over the larger areas. Tubercle bacilli cannot always be demonstrated in the lesions. Chorioidal tubercles are common in general miliary tuberculosis; on the other hand they appear to have no relation with tubercular meningitis. Indeed as Horner remarks they are less frequently found in cases of miliary tuberculosis with meningitis than those cases without meningitis.

Tumors of the Chorioid occur once in from 1,000 to 2,000 eye cases, but are important on account of their serious effects if neglected. There are only two sorts of tumors that affect the chorioid of any practical importance; they are the tubercular and sarcomatous. Carcinoma (always metastatic), cavernous angioma, fibroma and fibrochondroma are exceptionally met with.

Aggregated Tubercle of the Chorioid.—Aggregation of tubercles of the chorioid, or as it is also called conglomerate tubercle of the chorioid, is met with in individuals who are subjected to chronic tuberculosis, but it is often difficult to prove the existence of the latter, so that a diagnosis is chiefly made by exclusion and especially of syphi-

lis. One eye only is usually affected. There may be an early destruction of the eyeball with perforation of its tunics or it may occur without any external signs of inflammation or a glaucomatous condition may supervene. The sclera seems to soften and melt away before tubercular growths so that staphyloma takes place very soon with the rise of intraocular tension or only to a very slight degree, while in glioma retinæ and sarcoma chorioideæ the capsule of the eyeball is very resistant and only gives way after a period of a year or more and then more from the mechanical effect of increased tension than from softening.

When the disease takes the form of a general destructive inflammation it must be differentiated from panophthalmitis and from a syphilitic manifestation. The first is excluded by the absence of trauma or any of the conditions causative of purulent chorioiditis and by the entire absence of pain, while the latter always follows a gummatous iritis or irido-cyclitis and is accompanied by other signs of syphilis. The disease appears ophthalmoscopically as a solitary white or grayish-white nodular distinctly elevated area under the retina accompanied by one or more satellite patches. It usually occurs about the central region but may spring from the margin of, or surface of, the disc.

It is told from a leuco-sarcoma of the chorioid and retinal glioma by the absence of vessels and by the irregularity and lack of definition of its borders. It differs from a subretinal cysticercus by its immobility and lack of translucency. Sooner or later the sclera becomes ectatic, breaks down and the growth appears upon the outside of the eyeball as a nonvascular irregular grayish mass breaking down in the center and apparently continuous with the sclerotic. If the media are opaque from glaucomatous symptoms or destructive inflammation when the eye is first seen all that can be inferred is that there is an intraocular growth of some kind.

Treatment.—The case should be treated with creosote and cod-liver oil internally together with plenty of fresh air, that is the patient should practically lead an outdoor life. As far as the eye is con-

cerned it should be watched and treated pro re nata. As the eye disease is usually secondary there is little hope of staying the progress of the general disease by enucleation so the eyeball should only be removed when lost or when the disease is developing very rapidly.

Sarcoma of the Chorioid.—Eighty-five per cent. of chorioidal tumors are sarcomata and of these the melano-sarcoma is of much more frequent occurrence than the leuco-sarcoma. Sarcoma of the chorioid is of especial importance not only because it destroys the eye but the life of the patient as well unless recognized early and the eye removed before metastases occur in the internal organs. Sarcoma is the chief intraocular growth occurring in adult life. It usually occurs between the ages of forty and fifty although it may appear at any age after the twentieth year.

This is in contrast to glioma of the retina, the other most important intraocular growth which is found only in infancy before the second year. Sarcoma of the chorioid is frequently mistaken for some other condition because its possibility is not borne in mind and because it has practically no age limit. It is always primary, always single and only affects the one eye. It springs from the chorioid by a broad base at any part of the fundus and assumes the form of a rounded tumor which grows toward the center of the eyeball. Many of the growths have a more or less distinct neck which separates them from their base. Microscopically the free surface of the tumor throughout most of its extent will be found invested by the lamina vitrea and chorio-capillaries, or the neck of the tumor may correspond to where the lamina vitrea has been broken through. The melanotic variety of growth is almost entirely composed of pigment cells held together by a limited amount of intercellular substance. The blood-vessels are very thin walled, and extravasations into the growth are frequent. The pigment is not evenly distributed throughout but is often heaped up here and there in different parts of the growth. It is often more abundant near the sclera. The cells are mostly of the long or short spindle variety. Round cells are also met with, and in rare cases compose the entire growth.

Etiology.—Nothing is known as to the cause. The history of an injury is often obtained but has nothing to do with the case. The growth does not seem to be of a hereditary nature, and those affected appear in the best of health.

Symptoms.—Usually the case does not come under our notice until the tumor has reached a considerable size and the eye is almost if not entirely blind. The patient is not aware of this until some day the fellow eye is closed for some reason or other.

If the tumor arises from the region of the macular as in a case reported by Knapp the loss of direct vision will bring the patient to the physician early while the growth is very small. The symptoms vary according to the development of the growth. Knapp divided the progress of intraocular tumors into four stages: (1) The period of early growth in which no irritation is occasioned; (2) the period when the eyeball becomes inflamed and glaucomatous from the growth of the tumor; (3) where the tumor perforates the envelopes of the eyeball and appears upon the outside; (4) the stage in which metastases form in other parts of the body. Michel says that the first evidence of sarcoma of the chorioid is the formation of a mesh of convoluted vessels at some spot in the fundus, with a bluish-gray opacity of the overlying retina If the tumor is visible at all with the ophthalmoscope we may recognize the elevation it produces in the fundus but it is often the case that the retina is lifted up by an effusion of serous fluid and the tumor beneath may be obscured. Unless the retina is too opaque we can discern the black surface of the growth beneath the retina because the retinal pigment layer always adheres to it. The detached portion of the retina will be smooth and will not undulate when the eyeball is moved. If the media are cloudy an intense light will be needed to see the growth. Examination by direct sunlight, as has been described, enables one at times to make a diagnosis that would otherwise not be made. If the patient gives the history that there has been a slow deterioration succeeded by a sudden loss of vision without any pain we suspect an intraocular growth. The outward appearance of the eye is entirely normal unless the

tumor grows from the ciliary region, in which case the anterior ciliary veins nearest the origin of the growth will be engorged.

According to Fuchs the duration of the first stage is from six months to four years, the average being about twenty-one months. There is rise of tension at the onset of the second stage due to the interference of the tumor with the vortex veins and canal of Schlemm as well as by the increase it makes in the ocular contents. If the vision has not already been lost from total detachment of the retina it now speedily goes out from rise of tension. A greenish reflex is now visible from the pupil and no details can be made out in the interior of the eye. The lens is often pushed forward out of place, the iris in contact with the posterior surface of the cornea obliterating the anterior chamber, in other words, an acute or chronic secondary glaucoma. The eye may yield to the pressure by bulging of the sclera. In a very small number of cases the eyeball undergoes shrinkage from an irido-cyclitis which is set up. After a year or so the growth appears upon the outside of the eyeball and then grows much more rapidly. The growth may extend along the optic nerve or make its way out of the eyeball by the ciliary vessels or nerves. Separate tumors may arise in the orbit and they may invade the adjacent bone and cavities. During the fourth stage we have the sarcoma cachexia with local indication of metastases in the stomach, liver, brain or kidney. The commonest seat of secondary growth is in the liver, to which the patient succumbs within a year or two.

Differential Diagnosis of Sarcoma of the Chorioid.—From carcinoma of the chorioid it is diagnosed by the flat discoid shape of carcinoma and that carcinoma is secondary to a growth elsewhere in the body and leads to early blindness and seldom gives rise to intra-ocular tension. From simple detachment of the retina it is told by the fact that the detached portion of the retina fails to undulate when the eyeball is moved and that the retina does not appear to be thrown into folds and kinks as it does in simple detachment, but is more or less rotund and free from folds as it passes over the tumor. If there is coexisting tension of the eyeball as at times occurs in

detachment with deposit of bone the diagnosis is quite difficult. From detachment of the chorioid and retina it is told by being unable to see the vessels of the chorioid in the protrusion of the fundus. The patient is often first seen during the stage of pain and tension so that the diagnosis of acute glaucoma might be made, especially if the media are so cloudy that a view of the interior of the eyeball cannot be gotten. In case the eye contains a growth the history will be that the sight has been lost for some time past before the onset of inflammation. Estimation of the field of vision by aid of a candle will at times aid in diagnosis. Thus, in glaucoma we will find the nasal field the most curtailed, while in case of a growth there will be no light perception in part of the field corresponding to the growth. If the case is complicated with a cataract the latter should be removed, and then if after a few days a growth is found present the eyeball may be enucleated. An intraocular hemorrhage at times closely simulates a growth, especially when followed by acute glaucoma. The blood clot in the vitreous may easily be mistaken for a growth through the cloudy media. The history of good vision before the very sudden onset of blindness followed by pain may serve to differentiate. Rise of tension may not be present when the patient is first seen and still the growth far advanced. This is explained by the fact that the growth has already penetrated the tunics of the eyeball or started degenerative changes in the latter.

Prognosis of sarcoma of the chorioid is unfavorable for the life of the patient unless the eyeball is removed early in the progress of the growth. Even if the eye is removed when the growth is yet small the prognosis is not perfectly favorable. Metastases may develop in the orbit or remote portions of the body before the growth has attained much size. Sarcoma of the chorioid is then to be regarded as one of the most malignant of all diseases and one which often terminates in death.

Treatment consists in enucleation of the eyeball as early as possible. In removing the eyeball the optic nerve should be cut as far back as possible in case cancer cells have already begun to invade

it. If the growth has already grown out of the eyeball the orbit should be exenterated, that is, the entire contents of the orbit with the periosteum should be removed.

For the removal of the eyeball a lid speculum, pair of scissors with dull points curved on the flat, fixation forceps, pair of clamp forceps or artery forceps and a strabismus hook are needed.

A general anæsthetic is necessary. The physician stands behind the patient, be it the right or the left eye that is to be removed, and begins by grasping the conjunctiva with the fixation forceps on the left side of the cornea near the limbus and incises it. The conjunctiva is then divided all around the cornea from this starting point working from right to left and then loosened from its connections further back. One blade of the scissors is then passed under the external rectus muscle (if it is the left eye) and later severed from the eyeball so as to leave a stump of tendon attached by which the eyeball may be held during the rest of the operation. If we are operating upon the right eye we first divide the internal rectus. The clamp forceps are now attached to the stump of tendon. The superior and inferior rectus are next divided close to the eyeball. The scissors are then passed into the orbit on its outer side with their blades closed, the optic nerve felt for and cut through as it is put upon a stretch by pulling the eyeball forward. The eyeball can now be drawn out of the orbit in front of the eyelids. Then the remaining structures, the internal rectus muscle with the two obliques, are divided close to the ball and the enucleation is complete.

The method of enucleation just described is that of Arlt. As is seen it simply consists in shelling out the eyeball from the capsule of Tenon. Bonnet was the first to introduce this operation, being led to it by his studies upon the capsule of Tenon which is also called Bonnet's capsule. Up to this time the eyeball was removed somewhat after the manner a butcher is accustomed to do it by scooping the eyeball and orbital contents out with a knife which is made to enter the orbit to the outer side of the eyeball. After the removal of the eye a pressure bandage is put on over considerable cotton

which is forced down into the orbit to control bleeding as well as to bring the conjunctiva in contact with Tenon's capsule so that it will become united with it. Gauze should never be placed in the orbit because it becomes so tightly adherent to the wound cavity that it is almost impossible to remove it without tearing the wound open or without considerable pain. A wad of sterile cotton is as good as anything to pack the orbit with. Some use a piece of sponge wrapped in a bit of linen, but there is more or less danger from infection from the sponge. Many operators pick up the several muscles upon a strabismus hook and then sever them from the sclera. This is the better plan. They also sever all the recti muscles before cutting the nerve. If the eyeball is ruptured it can be better controlled by a strong suture passed through the anterior portion of sclera than by the stump of one of the muscles as described. Again some suture the conjunctiva after the globe has been removed. Healing is thus promoted and a better socket obtained for an artificial eye. The opening in the conjunctiva is closed by a tobacco-pouch suture or by ordinary interrupted sutures applied vertically.

If for any reason one cannot do a clean operation as in panophthalmitis where there is danger of spilling pus in the orbit from rupture of the eyeball, the conjunctiva should not be sewed but free drainage left from the bottom of the orbit. If pus does get into the orbit during the operation it should be washed out with 1–4,000 bichlorid without any pressure being used for fear of driving some infection backward through the open spaces into the brain.

Indications for Enucleation. — 1. Malignant tumors of the eyeball. In such cases as has been said the optic nerve should be divided as far back as is possible. A cross-section of the nerve should be examined microscopically and if it is found involved, the portion of nerve left in the orbit should be exsected.

2. *Injuries.* — Enucleation should be performed at once when the eyeball is certainly lost. This is the case in extensive lacerations of the anterior portions of the eyeball with the evacuation of its contents. By early operation in such cases we save the patient the pain

which develops from panophthalmitis or the tedious process of shrinking of the eye. If the eye is not at first removed it should be removed later if by the subsequent inflammation that develops the sight is absolutely destroyed. This is done to prevent any possible sympathetic inflammation of the fellow eye.

3. Lost eyes, whether from disease (irido-cyclitis) or injury that threatens sympathetic inflammation. Even if some vision is retained the eye should be parted with if there is irritation of the fellow eye. It should not be removed, however, if sympathetic inflammation has already set in.

4. *Continued Pain*, as occurs in eyes lost from absolute glaucoma, when other less radical measures have failed, is an indication for enucleation, also painful lost eyes from any other cause.

5. Lastly all eyes which are blind and disfiguring should be removed so that an artificial eye can be worn, as there is some danger of sympathetic inflammation if the artificial eye is worn over a shrunken eyeball.

The Operation of Exenteration is Done as Follows: The external canthus is split to a point over the external margin of the orbit. One lid is then turned up and the other one down to allow easy access to the orbit. The soft parts along the orbital ridges are now divided down to the bone with a knife. The periosteum is then detached from the bone all around down to the apex of the orbit. The only remaining attachment of the contents of the orbit is now at the optic foramen by means of the optic nerve and ophthalmic artery. This pedicle should be squeezed for a short while with an artery forceps and then divided with some blunt instrument to avoid hemorrhage. If bleeding should occur the pedicle must be cauterized with a thermocautery. All remaining shreds attached to the bone should be removed so that the latter is completely denuded. The orbit should be irrigated with an antiseptic solution and packed with gauze over which a pressure bandage is applied.

The artificial eye or prothesis should not be inserted before the expiration of at least two weeks after enucleation. The artificial eye

consists of a shell of glass made like the anterior portion of the eyeball, and is retained in position by the pressure of the lids upon it.

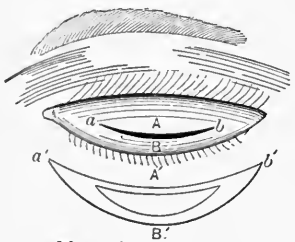
The shell of enameled glass is formed in the flame of a blow-pipe. In the middle of the convexity of the shell which is made the color of the normal sclera, the iris and the pupil are represented by fusing together colored glass. A transparent curved bit of glass is then fused on to represent the cornea and the anterior chamber. Some have advised that artificial eyes be made of celluloid which has the advantage of being practically unbreakable but it is rather irritating to the eye. Dr. Snellen, who was the first to devise the artificial eye over thirty years ago, has recently modified it so that the concavity of the shell is closed by a disc-shaped plate of glass. This gives a broad bearing surface to the shell. This eye is known as the reform eye and is more or less free from the objectionable features of allowing mucus and tears to collect between the shell and the bottom of the orbit, and of causing irritation at the edges after being worn awhile. It is also more mobile and more prominent and thus simulates more closely the natural eyeball.

At first the artificial eye should be worn only an hour or two a day, and the time lengthened by degrees as the orbit becomes tolerant until at last it is possible to wear it with comfort all day long. It is better to remove the eye at night and clean it, but many patients —especially women because of pride—wear the artificial eye day and night for years without the least inconvenience, removing it only for a few minutes to wash out the socket and to cleanse the shell. Artificial eyes become much roughened in about a year's time. The surface loses its polish and becomes dull in appearance and irritating to the eye. Most of those who handle artificial eyes repolish them. For the first few times it is advisable to instill a few drops of cocain into the orbit before inserting the shell, and the latter should be moistened before being introduced. For the right eye the shell is taken between the thumb and index finger of the right hand and the patient's upper lid raised with the other thumb. The wide extremity of the shell is inserted beneath the upper lid, raising it against the

cheek. It is pushed upwards and outwards as the shell is gradually raised to a horizontal position, when the upper lid is let fall. The lower lid is then everted and the shell pressed into the lower cul-de-sac which holds it. When the lower lid is released it covers and retains the artificial eye in place. To remove an artificial eye the lower lid is everted and the patient looks up. The eye then falls out upon the palm of the hand which is held to receive it.

A right artificial eye is told from a left by the fact that the notch in the edge of the eye goes below in each case. Some eyes are made to wear on either side. In adjusting an eye it should be as large as possible, but allow the lids to be closed readily over it when in place.

If the conjunctiva and orbital structures are very much torn by the injury which destroys an eye or if much lacerated by the operator in performing an enucleation cicatrices form which contract and constrict the orbit so that it becomes painful or impossible for the patient to wear an artificial eye. Again if after a properly performed enucleation an artificial eye is not worn the orbit gradually shrinks and after some years it is impossible to wear an eye. Each of these conditions demand operative interference if the patient cares for appearances. The best operation for enlarging the orbit is that devised by Maxwell, of Dublin. It is performed as follows: An incision is made in the floor of the orbit and is carried down behind the lower lid. A semilunar flap about 8 mm. in width at its widest part is marked out on the skin, its upper concave border being about 5 mm. below the edge of the lower lid. The incision along the upper border of the flap is made to communicate with the bottom of the wound in the socket. The flap is now dissected up from the subcutaneous tissue except at the area denoted in the figure by the dotted line. The two ends of the flaps are now passed through the opening into the orbit and sutured to each end of the socket incision. The



Maxwell's Operation.
(*Gibbons*)

upper edge of the flap is sutured to the upper edge of the incision (A' to A) in the socket and the lower edge to the lower edge of the incision (B to B'). The space on the cheek is closed and a glass eye inserted. This should be the size and shape of the one to be permanently worn. This eye prevents the new sulcus from contracting and gives it the proper shape. The eye should be left in for about a week, or otherwise the skin incision may be opened in removing it. If the glass eye has a hole drilled in the front it allows free drainage and opportunity to wash out the socket during the healing process. Make the incision in the socket as long as the space will permit and see that this length is maintained throughout its entire depth. Make the skin flap considerably longer than the incision in the floor of the orbit. The portion of skin flap left attached must be of the same length as the incision in the socket. This portion ultimately forms the fornix. If the attached portion is too short the fornix becomes a V-shape which would require a special formed artificial eye. In closing the opening on the cheek great care is needed to properly distribute the excess of tissue so that there will be no puckering. If the orbit is contracted laterally as well, the palpebral slit must first be lengthened by an internal canthoplasty.

Inasmuch as an artificial eye looks so much better and has better movement when worn over a shrunken eyeball, various operations have been devised to retain the eyeball as a stump and at the same time do away with the possibility of any irritation to the fellow eye by the wearing of the eye-shell. The operation usually performed is that of exenteration of the eyeball or evisceration. The v. Graefe method of performing the operation is as follows: The cornea and the adjacent sclera is amputated by first incising the sclera near the limbus with a knife and detaching it by a circular cut with the scissors. The entire contents of the eyeball are then removed with a sharp spoon so that the inner surface of the sclera lies exposed. The eyeball is then closed by sutures passed through the sclera. Mules modified this operation by inserting a hollow glass sphere in the sclera to retain its form. The sclera is sewed over the glass sphere

and the latter remains permanently enclosed in the stump. Other operators use paraffine instead of a glass bead. The sutures are first introduced and tightened around the nozel of a syringe containing melted soft paraffine and the latter injected. The syringe is then withdrawn and the sutures tied tightly.

The best operation is a modification of Mules. The cornea is amputated, the contents of the eyeball removed and then with a pair of forceps the posterior portion of the sclera drawn up and excised. Through this opening in the posterior part of the eyeball a pair of scissors is introduced and the optic and ciliary nerves divided. The eyeball is then turned wrong side out and the nerves trimmed close to the sclera so that they will not reunite. The bead is then introduced and the anterior opening closed. In the endeavor to be as conservative as possible Boucheron and Schöler devised the operation known as optico-ciliary neurotomy. The conjunctiva over the internal rectus muscle is divided and then the muscle itself. A pair of blunt-pointed scissors is then passed through the wound back to the optic nerve which is divided far back. The eyeball can now be rotated outwards so that the stump of the optic nerve appears in the wound. The portion of the nerve attached to the sclera is then removed. The posterior section of the eyeball as far forward as the equator is then freed from its connection, in doing which the ciliary nerves are divided. The eyeball is now replaced in its proper position and the rectus muscles sutured, lastly the conjunctival wound is closed with sutures and a pressure bandage applied. Of course none of these operations are applicable in cases of malignant neoplasms.

Carcinoma of the Chorioid.— Carcinoma of the chorioid is much rarer than sarcoma, and when it occurs it is usually secondary to carcinoma of the breast. It therefore is met with more frequently in women. There are about thirty authenticated cases now on record. According to Oatman the theory that the left eye is more frequently involved is not borne out. According to him both eyes are involved in one third of all cases. The deposits always occur posteriorly where the short ciliary arteries enter the eyeball and

when the other eye is subsequently affected the corresponding region is attacked, showing that the metastasis does not occur by route of the lymph channels about the optic nerve and chiasm. The typical shape of the growth is a flat discoid thickening of the chorioid with a central elevation sloping off to the periphery. There is early and rapid retinal detachment and total blindness in about two to eight weeks. The tension of the eyeball is elevated in not more than one third of all cases and diminished or normal in the others. The duration of life is about six months after the appearance of the growth within the eyeball. The condition is hopeless and operative interference is contraindicated as it only hastens death.

CHAPTER XV

DISEASES OF THE VITREOUS HUMOR

DISEASES of the vitreous occur in 0.7 per cent. of all eye diseases. The vitreous becomes involved in two types of inflammation — the one connected with the formation of pus and the other with the formation of opacities. Inflammation of the vitreous, or hyalitis as it is called, is almost always the result of a disease of the uvea, retina or optic nerve. Some believe that there may arise a spontaneous inflammation of the vitreous with the formation of opacity or go on to suppuration, in exhaustion and debility caused by low fevers or infectious blood disorders, but this is doubtful. When primary it occurs most frequently from injury.

Suppurative Inflammation of the Vitreous or Purulent Hyalitis occurs as the result of a penetrating injury, or the presence of a foreign body and is associated with purulent chorioiditis from whatever cause.

Symptoms. — If the case is seen early when the cornea is clear a yellowish reflex is seen shining from the pupil. The iris is drawn back at its periphery from adhesions to the ciliary bodies and bulged at its pupillary border. As a rule there is present some iritis with synechiæ and the tension is diminished from fluidity of the vitreous (synchisis). In addition there may be an active irido-cyclitis with all its symptoms. If the collection of pus in the vitreous is circumscribed the appearance is not unlike that presented by glioma of the retina. The manner of differentiating the conditions has been described.

Treatment is of no avail. The eyeball should be removed if it becomes painful, otherwise it undergoes a slow shrinking.

Opacities in the Vitreous. — Opacities of the vitreous are fixed or floating and vary in shape, size, number and somewhat in color. They appear in the form of membranes, bands, dots, threads, strings

or what not, or the entire vitreous body may lose its transparency from a diffuse dust-like opacity. The fixed membranous opacities are attached as a rule at one or more points to the retina, optic disc, ciliary processes or posterior capsule of the lens.

Method of Detection.—The method of detecting opacities in the vitreous has been described in the chapter on objective examination of the eye. In regard to their motion as the eye is moved about, the more fluid the vitreous naturally the more rapid the opacity floats about. An opacity of the vitreous moves in a direction opposite to that which the eye takes while one in the cornea or in the lens moves with the eye and immediately ceases its movement as soon as the eye stops, while one in the vitreous slowly settles to the bottom after the eye has come to rest. Oblique illumination will also serve to differentiate.

Different portions of the vitreous may be examined by gradually withdrawing the objective lens from the eye or by the direct method by employing stronger and stronger convex lenses back of the sight hole of the mirror. In this way successive layers of the vitreous are brought into focus. The extent to which the opacity interferes with the vision depends upon its locality. There may be little or no interference with central vision or it may be entirely obliterated. As a rule the patient complains of spots floating before his eyes. When first noticed the patient often supposes that a fly has crossed the field and makes an attempt to brush it aside. The spots assume all sorts of shapes. If the opacity is a fixed one it gives rise to a positive scotoma somewhere in the visual field, in which case the patient is often able to outline it with a pencil upon a piece of paper. By the contraction of the exudate the retina to which it is attached not infrequently becomes drawn up from the chorioid, or by the vitreous body becoming smaller by shrinkage in the exudate the retina becomes detached.

The causes of vitreous opacities are the following:

1. Refraction errors and especially high myopia with the formation of posterior ectasis and the consequent changes in the chorioid.

2. Cyclitis, irido-cyclitis, chorioiditis, retinitis and chorio-retinitis. The nature of the opacity varies with the disease that gives rise to it; thus in cyclitis and irido-cyclitis we find inflammatory deposits in the form of shreds or flakes, especially in elderly folks, some of which are due to hemorrhages into the vitreous. In syphilitic chorio-retinitis the vitreous is cloudy from a dust-like deposit which may be diffuse or localized in patches (hyalitis punctata).

3. Injuries of the eyeball which give rise to a hemorrhage from the chorioid or ciliary bodies. The extravasated blood becomes more or less organized. In cases of traumatic cyclitis the vitreous is apt to break down into pus.

4. Certain general and local diseases as infectious blood diseases, low fevers, endarteritis, gout, syphilis, malaria, liver troubles and disturbed menstruation. The prolonged use of arsenic is said to give rise to vitreous opacities.

5. Idiopathic cases. At times the vitreous becomes cloudy in old people without any ascertainable disease of the uvea or retina or other cause. Sometimes it is studded with minute light-colored spheroids. This is a congenital condition to which the name of asteroid hyalitis was given by Benson. White glistening spots are described as evidences of fatty degeneration of the vitreous.

Vitreous opacities never entirely disappear if dependent upon a disease of the fundus of the eyeball but may be absorbed to a considerable degree. The dust-like deposits entirely disappear.

Treatment. — In uncomplicated mist or dust-like opacities the error of refraction should be corrected and the eye kept under the effect of atropin. In each case the cause should be treated and pilocarpin sweats given every day or every other day for a week or so. Pilocarpin in small doses, not sufficient to produce sweating, also does good by its alterative effect. A dense membranous opacity more or less fixed and general may be needled. Bull performs the operation with an ordinary discision needle. The pupil should be kept well illumined with an ophthalmoscopic mirror held in place by a steel band about the head. The needle is introduced into the eyeball

the retinal elements as they force their way through its tissue. They occasionally become detached from the chorioid and wander into the tissue of the retina, forming globules which project considerably above the level of the retina. Such lesions only occur at the ora serrata. With the ophthalmoscope they appear as numerous round yellowish-white dots surrounded by pigment and projecting above the surrounding retina. Between the white dots are numerous black ones to be seen caused by the retinal epithelium being pushed ahead of the advancing excrescences. Central vision is unaffected and perimetry may fail to show any alteration in the periphery of the visual field. Clinically this condition is important because it must be differentiated from a disseminated chorioiditis by the fact that the spots are small, elevated and symmetrically arranged. They are moreover found only in the periphery and do not coalesce. Again we find as evidence of degenerative changes in the retinæ of elderly folks deposits of crystals of carbonate of lime or cholesterin. This variety of senile change may accompany the form just described. These crystals do not alter the vision, so that when falling off of vision does occur we refer it to retinal degeneration. Lime and cholesterin crystals are infrequently found in normal eyes. The ophthalmoscopic picture presented by this third variety of senescentia retinæ may be confounded with albuminuric retinitis as the lesions are principally grouped about the posterior pole of the eye although they occur also in the periphery. The central vision is much lowered while the peripheral vision may remain intact. Arranged around the macula may be seen numerous whitish-yellow spots sometimes merging into larger spots or plaques. They often finally assume a pale rose color. There remains yet another variety caused by the coalescence of the spots just described about the papilla, forming a yellowish-white ring bordered with pigment. This form may be mistaken by the beginner for a posterior staphyloma. Vision remains normal, although the perimeter detects an enlargement of the blind spot of Mariotte. Treatment is of no avail in any of these conditions just described.

Congenital Anomalies of the Retinal Vessels.—Sometimes a small

branch or two of the posterior ciliary arteries pierce the optic nerve behind the eyeball, branch out in the nerve sheaths and anastomose with the branches of the central retinal artery, establishing a collateral circulation between the ciliary and retinal vessels. The anastomosis may be established by the circulus arteriosus nervi (Zinn's circle) according to Leber or by the circle of Haller in the chorioid according to Donders. Less frequently a large ciliary vessel enters the eye through the margin of the chorioid. A branch may be given off from the ciliary bodies, run posteriorly and then enter the eyeball around the edge of the chorioid. With the ophthalmoscope these aberrant retinal vessels, whether vein or artery, appear to arise at the edge of the optic disc. If the aberrant vessel runs towards the macula it may be of great value in preserving central vision in case of obliteration of the central artery of the retina.

Persistent hyaloid artery has been discussed in connection with diseases of the vitreous. There is a condition in which the hyaloid artery does not take its origin from the physiological pit but from one of the chief branches of the central artery of the retina. This eccentric hyaloid artery sometimes persists. The occurrence of post-embryonic formations not related in any wise to a persistent hyaloid artery, such as string-like connective-tissue formations the result of hemorrhages or chronic hyperplastic processes, especially when they start from the nerve or posterior lens capsule, may be misleading in certain rare cases. To this condition the term of persistent pseudo-hyaloid artery is applied.

Opaque Nerve Fibers.—The fibers of the optic nerve normally drop their medullary sheaths and are continued into the retina as naked axis-cylinders. Now and then we see a case in which the nerve fibers have carried their white medullary sheath with them into the interior of the eyeball. The highly refractive material of the medullary sheath (sheath of Schwan) gives rise to shining white, more or less striated areas running from the papilla varying distances into the retina. Most frequently there is only a patch or several radiating patches from the edge of the papilla. At times the whole

edge of the nerve as well as some of its vessels are obscured by the white sheaths of the nerve. Vision is not at all disturbed, although the blind spot may be found enlarged in some cases. This condition is apt to be confounded with exudate but can be differentiated by its streaked and shining appearance, well-defined borders and otherwise normal eye-ground.

Hyperemia of the Retina independent of a true inflammation is possibly not demonstrable with the ophthalmoscope any more than hyperemia of the chorioid is, yet about the same picture is described in each case. Although under certain conditions the invisible network of retinal capillaries become visible the presence of any hyperemia is inferred not from any alteration in the appearance of the retina itself but from changes that occur in the papilla. The papilla is redder than normal, and associated with an increase in the amount of retinal striation about it, so that its edges are slightly veiled. Such an appearance is common in asthenopic eyes and those exposed to the glare of light or artificial heat. Gowers divides hyperemia into an active type in which an increased amount of blood is sent to the retina because the systemic circulation is unduly filled and a passive type where there is a failure of the blood to return from the eye. In the latter the veins are overfull, tortuous and of dark color while the arteries are unaffected. In the first instance both arteries and veins seem overfull. Rapid action of the heart with fever, pneumonia, etc., are causative factors, while among the causes of stasis hyperemia may be mentioned mitral valvular disease, emphysema, violent cough, convulsive attacks or anything that is liable to give rise to engorgement of the veins of the head and neck. The commonest change that takes place in the arteries is a diminution of their size while the veins even more readily become engorged.

Treatment.—In hyperæmia dependent upon refraction error, the eyes should be kept under the effect of atropin and the proper correcting glasses worn until the fundus assumes its normal appearance. If severe some blood may be abstracted from over the mastoid process.

Anæmia of the Retina is a symptom of localized pressure or stop-

page in the retinal circulation or from some general cause. The greatest degree of anemia or ischemia is seen in cases of embolism of the central artery of the retina. Quinin and salicylic acid poisoning cause an extreme anemia of the retina from spasmodic constriction of its vessels. The retina in such a case appears yellowish-red and the vessels of the disc extremely attenuated and filiform. Spasmodic contraction of the retinal vessels occurs in cases of migraine with alterations in the field of vision, to which the term retinal epilepsy is given. This condition will be described in another section.

Retinitis.—Inflammation of the retina is made evident by a diffuse cloudiness of the organ. The cloudiness varies greatly in degree. Usually it is most decided about the optic papilla because here the retina is thickest. Consequently the outlines of the papilla become indistinct and the retinal vessels hazy. Furthermore circumscribed exudates occur in the retina, usually in the form of yellowish-white sharply defined spots. The vessels of the retina are distended and tortuous and hemorrhages into the retina, chiefly from the veins, are not infrequent. The vitreous becomes hazy and more or less filled with exudate by the passage of the products of inflammation from the retina into it. The sight is impaired more or less according to extent of inflammation and portion of the retina affected. In the mildest cases the vision may be normal when tested with the test letters, the patient only complaining of a light cloud before the eyes, but in the majority of cases the vision is greatly impaired both from the inflammatory disturbance in the retina and from the vitreous opacities. The course of the disease is sluggish; it is only in the lightest cases that the inflammation abates within a few weeks so that the vision completely returns. Most frequently it takes several months before the disease is arrested while the sight remains permanently altered. Severe and especially recurrent attacks of retinitis lead to atrophy of the retina. Frequently pigmentation occurs from migration of the pigment in the pigment epithelium. The sight is then either completely abolished or all save a small remnant and its restoration is no longer possible. In the circumscribed variety there

is demonstrable with the perimeter a scotoma corresponding to the site of lesion.

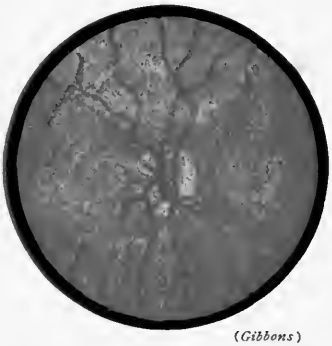
Distortion of objects frequently occurs from the altered condition of the retina. The exudation into the retina changes its position more or less and distorts the rods and cones which gives rise to distorted images. Objects therefore at times appear larger than normal (megalopsia) or they may be smaller (micropsia) or they may be twisted and distorted in various ways (metamorphopsia). Occasionally the patient can see much better by imperfect illumination, that is the light sense is reduced. This condition was denominated by Arlt nyctalopic retinitis, but it occurs in all forms at times, so is nothing but a symptom. As there are no nerves of sensation in the retina save those that propagate light impulses there is no pain connected with cases of retinitis, but it is common to have the patient complain of flashes of light before the eyes. Photophobia is also frequently present.

Serous Retinitis.—This is synonymously spoken of as edema retinæ, or peripapillar retinitis. Any retinal inflammation of very slight degree marked only by hyperemia and exudation is spoken of as serous or simple retinitis. When there is in addition an alteration of the deeper tissues the term parenchymatous is used. The two forms may merge into one another, or beginning as a simple retinitis the case may develop into a parenchymatous inflammation. The simple retinitis however frequently enough occurs as such that it may be classed as a distinct disease. The diffuse variety of the disease is most common. The edema extends over the entire retina veiling to a greater or less extent the details of the fundus. Now and then the edema is confined to the portion of the retina immediately around the optic nerve entrance, in which case it is spoken of as peripapillar retinitis.

Etiology.—The causes are numerous. In many cases it is due to syphilis or may be the initial form of the parenchymatous type of the disease. Other causes are refraction errors, using the eyes under unfavorable conditions, exposure to bright light, cold, chill, etc.

The changes observed with the ophthalmoscope are slight. They are: Edema of the retina which causes the details of the retina to be seen as through a mist. The vitreous is also more or less cloudy so that the fundus details are further obscured. The vessels and especially the veins of the retina are altered. They are overfull, more tortuous and appear to have a greater number of branches than normal, due to the overfilling of small tributaries. They now and then disappear from view under the swollen retina. Sometimes the arteries appear smaller than normal from compression.

Diagnosis is easily made, especially if the case is well established. Beginners frequently confuse this variety of retinitis with the shifting reflections which are so often seen along the blood-vessels in eyes with dark-colored fundi. They can be differentiated by the fact that these reflections are seen to change their positions as the objective lens is moved or tilted.



(*Gibbons*)

Simple Retinitis.

The Prognosis is somewhat uncertain and depends upon the cause. One can never tell with certainty whether the case will continue a serous one or pass into the parenchymatous variety. When the inflammation is slight or when it has existed for a comparatively short time absorption is apt to take place. If the serous inflammation is due to syphilis the prognosis is more encouraging as such cases yield readily to treatment.

Treatment.—The pupil should be dilated with atropin to afford the eye complete rest and dark glasses worn to protect it from the light. If the cause can be ascertained it is necessary to combat that first. Unfortunately in many cases no cause can be ascertained. In such cases the local abstraction of blood from the mastoid by means of the artificial leech, and sweats either from use of pilocarpin or Turkish bath every other day or so, together with an alterative tonic, do the most good.

Syphilitic Retinitis.—It is a mooted point whether syphilis ever produces a primary retinitis. Many observers believe that when the retina is affected it is secondary to a syphilitic affection of the chorioid, the disease being really a syphilitic chorio-retinitis. However this may be there certainly occurs a serous inflammation of the retina due to syphilis. There is nothing pathognomonic about the disease to distinguish it from serous retinitis from other causes. There is one peculiarity however and that is for the inflammation to be circumscribed instead of general. Galezowski speaks of it therefore as retinitis with exudative spots. These spots may exist at the same time with considerable edema of the entire retina.

Symptoms.—The ophthalmoscopic picture is the same as has already been described under serous retinitis varied only by the occurrence of localized edemas in addition to the general edema of the retina. The general exudation obscures the edges of the disc and the details of the whole fundus. The arteries and veins are frequently hidden more or less by lines of grayish opacity. The papilla often presents a yellowish-red appearance as it is seen through the foggy vitreous. This form of retinitis may result from congenital or acquired syphilis. In the latter it appears one or two years after the initial sore, sometimes as early as the sixth month. It occurs in about eight per cent. of all cases. Both eyes are as a rule affected, not at the same time but one after the other. The prognosis is very much more favorable than in retinitis from other causes because syphilitics as a rule respond well to treatment. The cases in which the macular region is involved are prone to recur and finally lead to destruction of central vision. To such the term *central relapsing retinitis* is applied. There may be a diffuse opacity of the macula or numerous yellowish-white spots with pigment dots interspersed. The cause is syphilis, being a late secondary manifestation.

Treatment is antisyphilitic. Mercury does the greatest amount of good in the form of the biniodid and inunctions. An eighth of a grain of mercury is taken three times daily and increased to the point of tolerance. If the patient is very debilitated this should be

combined with a tonic. The pupil should be dilated and dark glasses worn.

Sympathetic Retinitis. — This variety of retinitis is rare. It is caused by a traumatic irido-cyclitis of the fellow eye (see Sympathetic Ophthalmia). The ophthalmoscopic picture in this is about the same as in serous retinitis from other causes and is treated by sweats, atropin and removal of the injured eyeball if the latter is blind and if not the irido-cyclitis present should receive careful attention.

Concussion of the Retina (*Concussion Retinitis*) is also called commotio retinæ or simple edema of the retina. It may follow injuries of almost any sort, but is usually seen after blows upon the eye from balls, corks or similar substances. There is more or less loss of vision which is often greater than the amount of retinal change would indicate. At times blindness results when the ophthalmoscope shows little or no change at all in the retina. The pathology of the condition is obscure. After the blow there appear small points or streaks of edematous exudation in the retina and these may later coalesce, giving rise to the ordinary picture of serous retinitis. Corresponding to the infiltrated area there is a scotoma which at times extends beyond the area. The exudation begins to disappear in a day or so but the blindness may persist. Long-continued use of atropin locally and small doses of pilocarpin, not enough to produce sweating, say $\frac{1}{50}$ gr. t. i. d., gives as good results as any other form of treatment. Cases like these are at times confounded with malingering and *vice versa* and naturally. For after the removal of the retinal infiltration the fundus of the eye may look perfectly normal and yet the eye not see. Usually, however, such cases have a semidilated and stationary pupil when light is thrown into the eye while that of the malingerer will react normally to light.

We will now consider a more serious form of retinitis, namely *parenchymatous retinitis*, otherwise called plastic, interstitial or perivascular retinitis. In addition to hyperemia and edema of the fundus there are changes in the deeper portions of the retina such as hyperplasias, fatty and colloid degeneration which lead to structural change

in the retina with more or less loss of vision. Parenchymatous and serous retinitis are frequently found together in the same eye so that it is difficult to properly classify the diseased condition.

Etiology.—The cause of parenchymatous retinitis is at times obscure. In most instances however it will be found dependent upon chronic nephritis, intracranial diseases or certain general diseases already enumerated.

Pathological Anatomy.—The same changes occur in many cases as in the serous variety with the addition of cell infiltration and transformation of the retina into connective tissue. According to Arlt this infiltration takes place oftenest in the inner-granular or intergranular layer of the retina. Alterations are noted at the same time in the walls of the capillaries. The latter is so often the case that some authors have called the disease retinitis perivascularis. Opinion is still divided which is the cause and which is the effect, whether the alterations in the vessels are primary or secondary to the other changes in the retina. There may result an entire absorption of inflammatory products, or there may result partial or total atrophy of the retina from various changes taking place in the nerve tissue.

Symptoms.—The subjective symptoms are similar to those described under serous retinitis. There is always a falling off of vision but to a more decided degree than observed in the serous type of retinitis. There may be total blindness if the interstitial inflammation is general or if circumscribed well-marked scotomata are observed in the visual field. Metamorphopsia, photopsia and scintillations are common. There is no pain nor external redness.

With the ophthalmoscope the vitreous is found to be free of exudation so that the fundus details can be readily seen. The papilla is redder than normal and the arteries and veins appear overfull and their terminal branches extended, and not infrequently, as evidence of their distention, ecchymoses occur in the adjacent tissue. Hemorrhages are especially frequent in retinitis of nephritic origin. If exudation takes place in the neighborhood of a vessel the latter

will be hidden from view as it passes through the exudate to reappear again beyond it.

The Prognosis is very grave. It is very rare for any degree of absorption to take place with restoration of perfect vision save in the retinitis of pregnancy. In the majority of cases the cell infiltration is followed by formation of connective tissue with slowly increasing atrophy and gradual obliteration of the retinal vessels.

Treatment locally is the same as outlined for serous retinitis and in addition the treatment of the underlying cause.

Renal or Albuminuric Retinitis (Retinitis Gravidarum) is as a rule the result of a chronic interstitial nephritis but also occurs with the large white kidney and lardaceous disease. A very frequent and important cause is the albuminuria of pregnancy. A considerable proportion of pregnant women, and especially multipara, who have albuminuria suffer with this form of retinitis. With each gestation there is apt to be a recurrence of the eye-trouble with further decrease in vision until finally the patient is left entirely blind. In many cases it becomes a serious question whether or not the pregnancy should be interrupted as the partial or total loss of vision may be permanent from the first attack even though the cause be removed.

The disease is not infrequently overlooked until it is well established, inasmuch as central vision is not always at first impaired and as there is no pain or external signs of inflammation accompanying the disease. Lecorche says that as many as one fifth of all patients with albuminuria are affected with this variety of retinitis whether complaining of imperfect vision or not. It not infrequently happens that Bright's disease is diagnosed by the appearance of the eye ground before the urine shows anything particularly abnormal. Albuminuric retinitis is also frequently caused by post-scarlatinal nephritis.

Symptoms.—The only symptom of which the patient complains is imperfect vision. This varies from slight implication of the sight to total blindness. Not infrequently the history will be sudden loss of vision (uremic amblyopia) with partial or total restoration followed

by a gradual falling off due to the retinal disease. Usually both eyes are affected but the disease occurring in one eye is not very infrequent. Commonly however a monolateral case is converted into a bilateral one before death. The ophthalmoscopic picture varies somewhat in different cases. Thus there may be an exudative neuro-retinitis with tendency to numerous retinal hemorrhages; very little alteration in the retina itself but considerable optic neuritis or numerous hemorrhages scattered throughout the retina. The typical picture however is as follows: (1) Areas of fatty degeneration more or less numerous — appearing as glistening whitish patches with well-defined edges though shading off gradually into the normal color of the retina, in the posterior portion of the retina. These patches may be limited to the region of the macula lutea about which they are arranged in radiating lines or star-figure, or they may cover the entire posterior portion of the retina. The dots vary much in size, being very minute in some cases, but in nearly every case they are more or less grouped about the macula. Not infrequently there is a white dot in the macula and radiating from that glistening striations. The striated appearance is due to the arrangement of the retinal fibers.

The spots about the macula may persist long after every other trace of the disease has subsided. We see this especially in cases caused by the albuminuria of pregnancy. (2) Retinal hemorrhages occur and are more or less flame-shaped or streaked, extending along the arteries which appear obliterated in parts by exudation or hemorrhage. (3) Changes in the optic nerve are nearly always present. The edges of the disc become indistinct and the disc appears swollen and streaked by exudate diverging in different directions from its center. In other words we have a papillitis. It is now believed that no particular form of neuro-retinitis corresponds to intracranial disease and another to kidney and other general diseases, but that we may have atypical forms from albuminuria which in appearance may be supposed to be caused by a brain tumor and *vice versa*. The vitreous is clear as a rule in this disease, so that the alteration in the fundus can be well studied. The process is essentially a parenchymatous

inflammation, and edema is slight. There is hyperplasia in the deeper layers of the retina with fatty degeneration of cells and fibers and at times sclerosis of the nerve fibers in spots. The diagnosis is not difficult in typical cases, but unfortunately atypical are too often the rule. In all cases of retinitis the urine should be examined for albumin and casts. The latter elements are often present in cases of interstitial nephritis when albumin is absent or present only at times, so that the true cause of the retinitis may be overlooked unless casts are looked for. The amount of urea excreted should also be determined, especially in pregnancy, as the prognosis depends much upon the proper function of the kidneys and not so much upon the amount of abnormal constituents in the urine. It might be mentioned in this connection that there are cases of chronic nephritis which never show albumin nor casts in the urine, but the latter is found filled with kidney tubule cells. It was pointed out some time ago that the colon bacillus had a digestive power and if present in the urine containing casts they would be broken up and destroyed. And not infrequently in females do we have a few colon bacilli present in the bladder.

(*Gibbons*)
Nephritic Retinitis.

Prognosis. — In regard to the vision it is only rarely that it returns to normal save in the cases of albuminuric retinitis of pregnancy. In regard to the life of the patient there are few who survive more than two or three years after the onset of retinitis, cases occurring with pregnancy excepted. The presence of the retinal lesion indicates a serious kidney lesion or marked arterio-sclerosis which is always associated with the kidney lesion. According to Bull's statistics 50 per cent. died within the first year after the onset of retinitis. Others give the following: 65 per cent. die within one year, 85 per cent. within two years and 14 per cent. live longer than two years. Cases in hospital practice have even a higher mortality

as they are not blest with as good hygienic surroundings as those well to do. Thus there are only 6 per cent. among the poorer classes that survive longer than two years.

Treatment.—If albuminuric retinitis occurs in the early months of pregnancy an abortion should be produced, but if occurring late in term and of slight degree the pregnancy should be allowed to continue unless histories of former pregnancies show a tendency to severe attacks of retinitis.

Locally atropin should be employed and dark glasses worn to protect the eyes from light. The treatment appropriate to chronic Bright's disease is indicated. Steam baths or pilocarpin sweats are among the best means of hastening absorption of the retinal exudate besides ridding the system of deleterious effete matter. The Turkish bath is better than pilocarpin in cases with debilitation. If the patient is unable to get out he may employ a Robinson's hot air bath cabinet in his room for the sweat. This cabinet consists of a canvas compartment in which the patient sits, the head alone being out. A gas or oil stove with a pail of water upon it is placed beneath the patient's chair. The sweat should be continued an hour or two daily or every other day, according to the way the patient stands it. After the sweat he should be well rubbed down and put to bed. Infusion of digitalis and tincture of iron may be employed between the sweats. It is well to administer a saline cathartic every other day or so.

Diabetic Retinitis.—This occurs only in diabetes mellitus. It is also known as glycosuric retinitis. Bowman and Hansell report cases of atypical diabetic retinitis from diabetes insipidus. As a rule the disease occurs late in the progress of diabetes when other grave lesions are present, such as gangrene.

Pathology.—This does not differ much from that of albuminuric retinitis. There seems to be primarily a perivasculitis of the retinal vessels leading to the changes observed in the retina in all the cases of parenchymatous retinitis. There are deposits of fatty degeneration situated about the macula and between it and the papilla but

smaller than those observed in albuminuric retinitis, and scattered with more irregularity over the fundus. Hemorrhages are few or absent altogether, and there are few or none of the white radiating lines from the macula.

Diagnosis. — The urine should be examined for sugar, albumen and casts in all cases of interstitial (parenchymatous) retinitis.

The Prognosis is very grave, the patient only surviving several months or at most a year. The sight is permanently altered.

Treatment. — The treatment is the same as that of nephritic retinitis save the treatment of the cause.

Leukemic Retinitis is seen in splenic leukocythemia. Both eyes are as a rule affected. The retina has a pale pink or yellowish-red color. The arteries are small and the veins engorged. There is usually considerable optic neuritis present and there develop in the retina between the macula and the papilla and extending towards the equator opaque deposits fringed with red borders which Leber says are nothing but collections of leucocytes. In fact the whole retina becomes invaded with leucocytes. The diagnosis is usually easy, if not a count of the blood corpuscles will determine the cause. The treatment is to protect the eyes and to improve the general condition if possible.

Syphilitic Chorio-retinitis. — This may begin as such or the inflammation may originate in the chorioid and affect the retina secondarily. The disease may begin as a serous retinitis or the two may coexist in the same eye. It occurs from a half to two years after the primary sore.

Symptoms. — In typical cases there are spots of exudation of various sizes scattered over the fundus which at first appear like areas of edema, whitish and more or less elevated. Later atrophy of the retina sets in and there results a dark spot or a light area showing the underlying chorioid. The pigment spots, when they are small, resemble those seen in retinitis pigmentosa. If the chorioid has likewise undergone atrophy white spots fringed with more or less pigment deposits from the chorioid are visible. If a vessel crosses

such a spot its outlines will be plainly seen at first, but later it becomes cut off from the subsequent atrophy of the retina. In other varieties of syphilitic chorio-retinitis there is a punctate opacity of the vitreous with edema of the retina immediately surrounding the optic papilla. The iris not infrequently is affected likewise and there are deposits of exudate upon the posterior surface of the cornea (descemetitis). The subjective symptoms are the same as outlined for retinitis in general.

Treatment consists in the use of mercury and iodids.

In some cases of retinitis hemorrhages into the retina are an important feature on account of their number. To such cases the term *Hemorrhagic Retinitis* is applied.

The causes of hemorrhagic retinitis are valvular diseases of the heart and diseases of the kidneys, blood, liver and spleen. Amenorrhea and the climacteric are less frequent causes. The hemorrhages may be situated anywhere in the fundus but are commoner about the papilla from which they appear to "steam off" as it were, and about the macular region. Retinal hemorrhages are always more or less linear in form if in the internal layers of the retina in contradistinction to the rounded clots which form in the chorioid and external layers of the retina. These cases of retinal hemorrhage unaccompanied by signs of retinitis are often spoken of as retinal apoplexy and are the result of senile degeneration of the blood-vessel walls unless caused by trauma. The extravasations are large, irregular, and appear darker in color than the ecchymoses accompanying retinitis. The area of the macula seems to be a favorite spot for them. When they occur at the macula they produce an irregularly oval blotch with its long axis vertical. If the hemorrhage is large and of drop-like form it is as a rule situated between the internal limiting membrane of the retina and the hyaloid membrane of the vitreous. Retinal hemorrhages of spontaneous origin are important, as they are an index of the general condition of the arteries and not infrequently precede an attack of cerebral apoplexy.

Prognosis as far as return of vision is concerned is not good, for in the majority of cases more or less atrophy of the retina ensues at the sight of bleeding. Either the spot of ecchymosis is changed into a pale atrophic patch or becomes during absorption deeply pigmented.

Treatment consists in pilocarpin sweats and later the internal administration of potassium iodid.

Macular Retinitis.—Under this head are included several varieties of retinal inflammation occurring in and about the macula lutea. The pathology of these cases is not yet known, and the ophthalmoscopic appearances are not characteristic enough to properly differentiate them.

Central Punctate Retinitis (*Retinitis Punctata Albescens*).—In this disease there is a number of fine shining dots in the region of the macula and not infrequently extending partly or entirely to the optic papilla. The dots may be present in great numbers and then vitreous hemorrhages are at times present. Unlike Gunn's dots there exists a central scotoma and night-blindness. The peripheral field is normal as a rule but may be contracted. Fuchs was the first to call attention to the similarity of this disorder to retinitis pigmentosa in that it may occur in children, affecting several members of the same family and especially in children of blood-relations.

Treatment.—It is doubtful whether any treatment is of avail, although Neiden and Ladensberg believe that the dots may be made to undergo absorption by the internal use of potassium iodid and mercury.

Retinitis Circinata is the name Fuchs applied to the following ophthalmoscopic picture: A yellowish-gray opacity in the macular region which is surrounded at some distance by a zone of white dots or white atrophic looking patches. Some authors regard this disease as simply a manifestation of interstitial nephritis but Hartridge reports typical cases in which the urine was found normal. Many believe that this affection is not of inflammatory origin but that the appearance is caused by hemorrhages in the region of the macula.

Solar Retinitis. — Whenever intense light enters the eye for any length of time the visual purple is decomposed so thoroughly that it takes some time for its regeneration and at times it is never completely restored. Such a condition is manifested by a falling off of central vision with a contraction of the field of vision. The ophthalmoscope however fails to reveal any lesion of the fundus. If it so happens that the patient's eye has been exposed for a considerable length of time to the action of great heat or light which has been concentrated upon the retina by the crystalline lens of the eyeball (a thing which seldom occurs save in those using astronomical instruments in studying the sun) the changes produced in the retina are evident with the ophthalmoscope. In such cases, by direct method of ophthalmoscopy especially, a number of small spots of retinochorioiditis can be made out. Absorption may take place but central vision remain permanently altered.

Treatment. — Small doses of pilocarpin with a tonic alterative such as iron bichlorid and strychnin.

Symmetrical Changes in the Maculæ. — Tay was the first to call attention to this rare condition which clinically is very similar to the appearance presented by embolism of the central artery of the retina. The most marked feature of the ophthalmoscopic picture is a cherry-red spot at the site of the macula in the center of a grayish-white area. The mental condition of such patients is usually below par. The intraocular change is probably caused by alterations in the deeper layers of the retina. The cases examined after death show degeneration of the spinal cord and of the pyramidal cells of the cortex. The disease is fatal, death occurring within two years. All the cases reported were of Hebrew parents.

Punctate Conditions of the Fundus Oculi. — There are a number of punctate conditions of the fundus, some of which are of no pathological importance but are easily confounded with atrophic spots and exudations occurring in chorio-retinitis. The following is a résumé of these punctate conditions :

1. *Gunn's Small Dots.* — These are pale or yellowish-white dots

occurring in groups in the macular region and especially in young eyes. They are difficult to see and do not disturb vision. Their meaning is not understood.

2. *Metallic-like Spots.*—Minute isolated areas occurring in any part of the eye-ground and conspicuous for their brightness. They are found at all ages.

3. *Neurotic Dots.*—Irregular-shaped dots of chalky whiteness occurring in the region of the yellow spot and between this and the optic nerve and are associated always with evidences of a neuro-retinitis.

4. *Hyaline Excrescences from the Lamina Vitrea* occur as isolated small slightly elevated dots usually found in the eyes of old persons.

5. *Nettleship's Dots* consist of numerous dead-white small round dots uniformly scattered between the macula and the periphery. Associated with pigment changes at the periphery and night blindness. They occur in several members of the same family and are stationary or slowly progressive.

6. *Tay's Chorioiditis* or central guttate chorioiditis occurs after middle life. It manifests itself by pale or yellowish-white areas in the chorioid in the region of the macula.

7. *Colloid Changes in the Pigment Layer of the Retina* manifests itself by the occurrence of numerous pale dots almost confluent over the entire fundus but most numerous in the yellow spot region. It is met with in young adults and does not affect the vision.

Septic or Embolic Retinitis (Purulent Retinitis).—In the vast majority of cases this is secondary to a like process in the chorioid arising from sepsis, especially puerperal sepsis, but in rare instances the process originates in the retina, and can be diagnosed before the vitreous has become cloudy. Etiology is the same as for purulent chorioiditis, namely, injuries and especially foreign bodies in the eyeball, cerebro-spinal meningitis, septic conditions and especially puerperal sepsis. Some believe a gouty or rheumatic diathesis responsible in rare instances. The immediate cause is the presence of pus-producing organisms in the retinal vessels carried there from some remote part of the body by the circulation, or introduced from without.

Symptoms. — If the case is one in which the process has begun in the retina the imperfect vision first attracts attention, but, as said, the chorioid and the iris have already become involved so that we have ciliary injection, pain, etc. In the beginning exudates and hemorrhages are seen in the retina extending into the vitreous, but the vitreous soon becomes so muddy that all details of the fundus are lost.

A cure is impossible. If the eye is not utterly destroyed by panophthalmitis the retina is left thickened and detached and finally shrinks into a band of connective tissue.

Treatment. — Cold applications to retard the further development of microbes within the eye, atropin to keep the pupil dilated, and improvement of the general condition constitute the routine treatment. As pointed out in a former section upon foreign bodies in the eye good seems to have resulted from the introduction of bits of iodoform into the vitreous chamber, but this method needs further trial to prove its efficacy. The subconjunctival injection of bichlorid solution can do no harm and may be of value. Besides the various types of retinal inflammation thus far described there are a number of cases of pathological alterations in the retina without any of the usual signs of retinitis yet to be considered. These cases are classed according to their pathology under the general head of retinal scleroses. The types of this group of cases are *retinitis pigmentosa and retinitis proliferans.*

Retinitis Pigmentosa, also called *pigmented sclerosis of the retina*, or *pigmentary degeneration of the retina*, is applied to a condition in which there is a gradual increasing blindness from atrophy of the retina and optic nerve with deposits of peculiar-shaped pigment-masses in the retina. Atrophy of the retina is usually the result of protracted or oft-repeated inflammation or is the outcome of a retinal thrombosis or embolism. It is characterized by narrowing of the retinal vessels which may amount to actual obliteration so that the vessels are either transformed into white threads or are entirely invisible with the ophthalmoscope. Otherwise the retina

may appear unchanged and transparent, or there may be evidences of antecedent inflammation. In all cases there is secondary atrophy of the optic papilla evidenced by its pale dirty-gray appearance and fewness of its vessels.

The person affected with pigmentary degeneration of the retina when still quite young complains that he sees much worse whenever the illumination is reduced, that is, after night; he has hemeralopia in other words. This night-blindness increases with increase in years so that finally the patient is no longer able to go about alone after nightfall, while in the daytime he sees well enough. In the beginning of the complaint the field of vision is found quite normal if taken with good illumination, but much contracted if the illumination is reduced. This shows that the peripheral portions of the retina are less sensitive than normal, only called into function by strong light. Finally the field of vision shows itself curtailed even under the strongest illumination. Direct vision remains unaffected for a long time after the field has become curtailed so that the patient can read the finest print, but is often unable to get about alone. At last central vision becomes lost and the case progresses to absolute blindness. This is not the case as a rule until after the sixtieth year.

(*Gibbons*)

Retinitis Pigmentosa.

Ophthalmoscopic Appearance.—The most prominent feature of the disease is the presence of small black spots, more or less branch-shaped, resembling bone corpuscles in the retina. The pigmented areas are frequently connected by their branched processes, and are found especially in the periphery of the retina and along the blood-vessels. As the case progresses new spots form further and further back until finally they reach the macula lutea and the optic papilla. There is *pari passu* a gradual contraction of the visual field and atrophy of the optic nerve. Both eyes are affected.

Pathology.—There is a proliferation of the connective-tissue cells of the retina; a sclerosis in the walls of the retinal vessels, and a consequent narrowing of their lumina; atrophy of the nerve tissue with a destruction of the rods and cones with a migration of pigment from the pigment epithelium and pigment proliferation taking on the characteristic shapes referred to.

Etiology.—The disease develops in childhood and is apparently congenital but not discoverable until some time after birth. Retinitis pigmentosa runs in families and affects mostly the boys but seems to be transmitted through the mother. Not infrequently it is found associated with other congenital anomalies such as mental weakness, deaf-mutism, hare-lip, supernumerary fingers and toes, persistent hyaloid artery, posterior polar cataract or what not. Consanguinity is supposed by many to be an indirect cause in its production. After the disease has lasted quite a long time posterior cortical cataract develops.

Treatment.—It is very doubtful whether treatment is able to control the disease although it is difficult to say. As it runs such a protracted course the case is apt to be neglected until the vision has become very considerably reduced. Increasing doses of strychnia with iodid of potash and mercury kept up for months at a time seem to do good inasmuch as the field of vision becomes broader under their use, but whether these remedies are able to postpone the fatal issue is uncertain.

Retinitis Pigmentosa Atypica (*Non-pigmented Sclerosis of the Retina*).—This disease differs from the foregoing in that there is an entire absence of pigmentation of the retina or present in only scanty amount, massed in the macular region or irregularly distributed over the fundus. All the subjective and other symptoms of true retinitis pigmentosa are present. The etiology, course and prognosis are likewise the same. Gould believes that this disease is much more frequent than supposed. *Retinitis pigmentosa* is at times difficult to differentiate from an old case of chorio-retinitis with its distribution of irregular masses of pigment over the fundus. In retinitis pigmen-

tosa the pigment masses are always confined to the periphery of the fundus except in very advanced cases and are spider or bone-corpuscle shaped. In chorio-retinitis the pigment deposits are not so regularly distributed and there are white and pigmented areas scattered over the fundus which are seen to lie in the chorioid by the vessels of the retina passing unobscured over them. There is also a history of syphilis. There are atypical cases of each which are very difficult to classify.

Retinitis Proliferans consists in a proliferation of the sustentacular fibers of the retina together with the formation of connective tissue among them (Manz). It appears as a bluish-white growth of tissue which frequently extends free into the vitreous humor. This hyperplasia may take place at any point in the fundus, but most frequently the change takes place in the neighborhood of the optic nerve and the mass of tissue is bent more or less around the nerve according to Denig. There is as a rule new formation of blood-vessels in and upon the mass. The disease is insidious in onset and chronic in its course and interferes very materially with vision. The cause of the affection is not known, but the formation of these masses may be due, as suggested by Leber, to repeated hemorrhages into the vitreous or retina. Syphilis and traumatism seem to be the causative factors in some cases. In many cases there is a complicating detachment of the retina.

Treatment seems to be of little avail. It consists in the use of mercurials and iodids.

Angeoid Retinal Streaks (Retinal Pigment Striæ).—This consists in the presence of dark-colored vessel-looking streaks often branching in the deeper layers of the retina and running more or less parallel to the retinal vessels. They are due to pigment changes following retinal hemorrhages in most cases. Casper believes that they may also originate from spontaneously cured detachments of the retina.

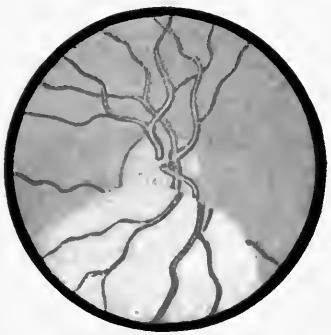
Retinitis Striata.—Jaeger was the first to describe this condition. It is characterized by the presence of yellowish-white streaks, more

or less branching, lying beneath the retinal vessels. The stripes extend from the periphery towards the disc. These streaks, like the angeoid streaks, originate in the metamorphosis originating in retinal hemorrhage or detachment of the retina.

Detachment of the Retina, also spoken of as Ablatio or Amotio Retinæ, consists in an elevation or separation of the retina from the chorioid. The normal retina is simply applied to the chorioid except at the papilla and ora serrata and held in place by the tension of the vitreous body. A detachment of the retina only occurs when the pressure of the vitreous ceases to act or when the retina is pushed from the chorioid by a growth from the latter. The former variety of detachment results from loss of or disease of the vitreous. Loss of a considerable amount of vitreous humor during an operation or following trauma usually results in a detachment of the retina. The most frequent causes of detachment from vitreous disease are irido-cyclitis and irido-chorioiditis. The exudates that form in the vitreous become organized and draw the retina up as they shrink. This kind of detachment has to be inferred in the vast number of cases from the soft eyeball and curtailed field of vision as the vitreous is too muddy and organized to allow of vision through it. Detachment of the retina may occur without any antecedent inflammation, in which case it is usually associated with high myopia or occurs as the result of a sudden jar or jolt, in which case the retina is rent and vitreous gets behind it, that is, between it and the chorioid. In myopia it is a fibrillary degeneration and contraction of the vitreous which is regarded as the cause of the detachment. A similar change may be the cause of retinal detachment seen at times in elderly persons. More frequently the retina is actively propulsed from the chorioid. The causes of such propulsion are: An acute process of exudation from the chorioid as occurs often in exudative and purulent chorioiditis and phlegmons of the orbit; hemorrhage from the chorioid due to trauma or spontaneous in origin; tumors of the chorioid or retina and cysticercus developing beneath the retina. The patient usually comes with the history that he is unable to see objects below or to one side

or the other, according to the site of detachment, unless he looks directly at them. If the field be taken there will be found an absolute negative scotoma corresponding to the lesion.

Symptoms. — Externally the eye may look perfectly normal although in many cases the anterior chamber appears abnormally deep. The tension of the eyeball if altered at all will be found diminished. With the ophthalmoscope the detached portion of the retina appears as a delicate gray veil projecting above the level of the surrounding fundus and into the vitreous, it having lost its transparency after being separated from the chorioid. This gray membrane can be recognized as the retina by the fact that the vessels of the retina can be traced from the optic papilla up over the prominence. The vessels show sharp bends at the spots corresponding to folds in the detached retina, and may even be entirely concealed from view. If there is fluid beneath the retina, it is thrown into numerous folds and undulates with every movement of the eyeball. But if the retina is lifted up by a growth the folds and tremulousness are absent; the detachment then forms a more or less rounded prominence rising steeply from the fundus. If the detachment is considerable so that the vision is much reduced in consequence the pupil of the eye will be semidilated. The detachment of the retina is at first partial. It may develop at any spot of the fundus whatever but usually changes its place gradually as the subretinal fluid gravitates to the lowest part of the eyeball so that detachments are most frequently found below although they may have originally been above. Every detachment has a tendency to enlarge and become total. In the latter case the retina as a whole is pushed forward, remaining attached only at the papilla and ora serrata. As the retina becomes detached its pigment epithelium remains adherent to the chorioid so the retina appears as a trans-



Detached Retina. (*Gibbons*)

lucent gray veil of a dull luster but if there is some blood mixed with the subretinal serum the color of the detachment acquires a greenish tinge. After the retina has been detached for a long time, that is a number of months, it becomes entirely atrophic and more transparent.

Diagnosis. — The diagnosis of a detachment is frequently made difficult or impossible by cloudiness of the refracting media, usually of the vitreous and lens. The diagnosis in such a case is based upon two factors, upon the character of the field of vision and upon the intraocular tension. If the field is found contracted at the same time the tension is diminished there is usually present a detachment of the retina as occurs in long standing cases of irido-cyclitis and irido-chorioiditis.

The diminished tension and abnormal depth of the anterior chamber seen in eyes which are undergoing shrinkage from contraction of the vitreous are absent in eyes with detachment of the retina due to a growth in the chorioid and also in those cases in which the detachment occurs suddenly. In case of an intraocular growth the tension will usually be elevated but at times is found less than normal as the growth has perforated the envelopes of the eyeball at some point allowing the escape of the intraocular fluids. In very rare instances also, as has been pointed out, we meet with neoplasms within shrunken eyeballs.

Prognosis. — The retina retains for a few days its sensitiveness over the detached area and if it then becomes reattached it may resume its perfect function. In most instances, however, the detachment resists treatment and sooner or later becomes total. The most that can be hoped for in the majority of cases is reattachment without regaining function. By causing the retina to become reapplied the eye is saved from total detachment and total and irreparable blindness.

Treatment. — The treatment has from time to time varied considerably. There is no certain method of success in detachment of the retina. The cases that recover are greatly in the minority. Those cases associated with a rent in the detached retina are hopeless as

the vitreous gets behind the retina and interferes with its reposition. In those forms caused by an exudation between the chorioid and the retina we seek to cause resorption of the subretinal fluid. We accomplish this by the internal use of pilocarpin, by saline purges and by internal administration of potassium iodid. The patient should be kept quiet in bed and a pressure bandage applied to the eye. This line of treatment is kept up for several weeks. If these remedies fail we evacuate the subretinal fluid by a puncture through the sclera over the point where the detachment is most pronounced. A cataract knife is made to enter the sclera and then turned cross-wise and as much fluid as will flow out spontaneously allowed to escape. The patient is then put to bed and kept there for several weeks, with a light pressure bandage upon the eye. Scleral puncture is advantageously combined with the subconjunctival injections of salt solution. About 25 m. are to be injected every other day for several weeks. Even in cases in which we have succeeded in getting the retina to reapply itself the detachment recurs sooner or later as no treatment is able to do away with the primary cause in many cases.

Wray, Clavier and others have made attempts with some degree of success to cause absorption or coagulation of the subretinal fluid by electrolysis. Five milliampères is the strength of current used and it is allowed to pass about one minute. Before any definite opinion can be passed upon this method of treatment more testimony is needed. Finally an attempt may be made to evacuate the fluid by an operation. Some draw the fluid away with a syringe, others puncture the sclera as already mentioned, but the results are for the most part entirely unsatisfactory. Inasmuch as fibrillary contraction of the vitreous is at times the cause of the detachment Deutschman advocates extension of the scleral puncture to cutting of the fibrillæ in the vitreous. This he frequently repeats and reports good results. Wecker suggested the passage of a gold wire through the sclerotic to maintain drainage. The plan advocated by Graefe is said to give as good results as any operative measure and is done as follows: Two needles are passed through

the sclerotic and the retina transfixed. An opening is thus made in the retina which allows the subretinal fluid to escape into the vitreous. If the vitreous passes through the rent and gets behind the retina, however, the case is rendered absolutely hopeless. Schoeler advocates the injection of a solution of iodin beneath the retina, but this is particularly dangerous as destructive inflammation is apt to be set up. According to the best opinion there is no better way to deal with a detachment of the retina than by rest in bed upon the back, dry diet, atropin locally, bandage and the internal administration of some drug which may induce absorption of the subretinal exudate, and if this line of treatment fails to cause a reattachment the sclera over the detached retina is to be punctured and subconjunctival tissue injected with salt solution or Dor's plan tried, that is punctate cauterization of the sclera with the electric cautery over the point of detachment combined with salt injections and rest in bed. More than 50 per cent. of cures are reported by Dor, and according to Dallus a cure may be expected in every case in which the cause is subretinal exudate.

Glioma Retinæ. — Glioma is the only neoplasm that occurs in the retina, and is only found in children. At some stage of its growth there emanates from the pupil a golden yellow reflex. Beer for this reason called the disease amaurotic cat's-eye; amaurotic because the eye is blind and cat's-eye because it shone like the eye of a cat in the dark. If a case be examined by oblique illumination we can see the degenerated retina as a nodular mass behind the lens, covered with minute vessels. Glioma of the retina shows the same courses that are seen in chorioidal tumors, namely: a stage in which inflammatory symptoms are absent, then one in which there is rise of intraocular tension and then a stage in which the tumor makes its way out of the eyeball and lastly the stage of metastases and death. Through continuity of tissue the tumor cells spread along the optic nerve to the brain so that the child usually dies from involvement of the brain if not from exhaustion. The course of the disease usually extends over several years. Bilateral glioma is rare, the disease in

vast majority of cases affecting only one eye. Children over five years of age are seldom affected. It is often found present a short while after birth, in which case it must have had its beginning in intra-uterine life. The cause is obscure, but it seems to be some congenital defect or faulty development of the retina, as it runs in families.

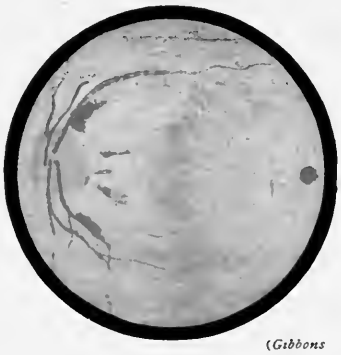
Prognosis is bad unless the eye is removed very early.

Treatment, therefore, consists in the earliest possible enucleation. If the growth has extended beyond the eyeball, exenteration of the orbit should be performed, but in such a case recurrences in the neighboring lymph glands are common; nevertheless, the child is saved much suffering by removal of the eyeball, which sooner or later would break down into an ulcerating bleeding mass.

Pathological Anatomy. — Glioma is composed of numerous small cells and a soft delicate basement membrane. The cells have very large nuclei and scanty cell substance which in some places possesses cell processes, which communicating form a reticulated structure. The cells are imbedded in a half fluid substance so that the whole growth is soft. Glioma is a variety of round-celled sarcoma and grows from the neuroglia. It is not encapsulated, but seldom forms metastases in the neighboring lymph glands or internal organs. Glioma retinæ is never pigmented in distinction to other intraocular growths. It develops mainly from the inner but also from the outer granular layer of the retina. The overgrowth of the retina leads to a wrinkling and frequently a detachment. Secondary foci are often found in the chorioid and in the vitreous from migration of cells.

Embolism of the Central Artery of the Retina. — An embolus sometimes lodges in the central artery of the retina or in one of its branches and gives rise to the following symptoms: The retinal arteries become very much attenuated and can be traced only a short distance from the disc. Many of their branches have disappeared from view as they contain no blood. The veins likewise are contracted or present a beaded appearance from unequal distension. Pressure upon the eyeball with the finger causes an interrupted current of blood to pass through the vessels. This consists of

cylinders of blood separated by clear spaces as if the vessel contained air moving slowly along. Directly after the lodgment of the embolus an interrupted blood stream is visible in the veins without any pressure being exerted. A few hemorrhagic areas are seen principally along the veins. The disc becomes grayish-white, due to its ischæmic condition. In the region of the macula and of the papilla, and extending more or less towards the periphery, there develops a fogged or veiled appearance of the retina due to a decided edema. This is so opaque at times that it appears milk-like. This opacity of the retina may come on almost immediately or be delayed for a day or so. The characteristic symptom of stoppage in the circulation of the retina is the formation at the site of the fovea of a cherry-red spot looking not unlike a circular hemorrhagic area in the midst of the area of fog-like edema. This red spot is caused by the red chorioid showing through the much attenuated retina and to changes in the pigment epithelium. In dark-skinned people the cherry spot is frequently replaced by a deeply pigmented one. This cherry spot only forms when the main stem of the retinal artery is occluded. After several weeks or months the edema of the retina subsides and the papilla becomes atrophic, of a dirty red color with very few if any vessels left emanating from it.



(*Gibbons*

Embolism of Central Artery of Retina.

If only a branch of the central artery becomes stopped the changes in the retina are limited to the area supplied by that vessel. Sometimes the plug in the vessel can be seen as a yellowish-red substance but more frequently we assume the embolus to be present from a swelling upon the vessel, while beyond the vessel is obliterated or very much reduced in size. In embolus of the central artery of the retina the sight is lost very suddenly in a manner that is almost characteristic. If only a branch is involved central vision may be

preserved, especially if the eye is fortunate enough to possess a cilio-retinal artery. The field of vision of course suffers according to the area of retina affected. The tension of the eyeball suffers no alteration.

Cause. — The commonest cause is valvular heart disease and especially during an attack of renewed endocarditis. It occurs likewise in arterio-sclerosis, aneurism of the aorta or carotid, in Bright's disease and in pregnancy. It occurs at any age and is nearly always unilateral.

Treatment is of little avail. Most good seems to have followed the employment of vigorous massage of the eyeball. Thus, the eyeball is massaged while considerable pressure is exerted upon it and then the pressure suddenly relaxed. Efforts to dislodge the embolus by lowering the intraocular pressure by frequently repeated paracentesis of the anterior chamber by sclerotomies or iridectomy have been futile. Gifford recommends the inhalation of nitrite of amyl during the massage or kneading of the eyeball with the hope that the dilatation of the vessels caused thereby will more readily allow the escape of the embolus. Iodids and mercury should be administered for their absorbent effect.

Thrombosis of the Central Artery of the Retina gives rise to a picture not unlike that already described. In many cases it is impossible from the ophthalmoscopic examination to tell whether we are dealing with a case of thrombosis or embolism. We are more apt, according to Priestley Smith, to have the following train of symptoms in cases of thrombosis: Previous attacks of temporary blindness in the affected eye, a simultaneous attack of temporary blindness in the fellow eye, with giddiness, faintness and headaches.

Causes are diseases of the heart or of the blood-vessels or alterations in the composition of the blood, very violent cases of retrobulbar neuritis or papillitis such as are caused by phlegmonous inflammation in the orbit, or by fractures extending through the optic canal and involving the nerve primarily or secondarily. Treatment consists in careful investigation of the blood and circulatory ap-

paratus in all cases of transient blindness, so that an extensive thrombosis may be prevented by proper treatment of the cause. Otherwise it is the same as that for embolism already described.

Thrombosis of the Central Vein of the Retina occurs from the causes as the foregoing and presents about the same symptom-complex. The two are differentiated in the following manner:

Thrombosis of Central Vein.	*Thrombosis of Central Artery.*
Caliber of arteries normal or slightly smaller.	Arteries filiform.
Veins tortuous, and turgid and appear interrupted from being buried in the retina.	Course of veins normal, veins decrease towards disc and blood current often broken into segments.
Venous pulsation upon pressure.	No pulsation of vessels.
Extensive retinal hemorrhages.	None or very few hemorrhages.

CHAPTER XVII

DISEASES OF THE OPTIC NERVE

Hyperemia of the Optic Nerve.—There are such wide variations in the color of the optic disc within physiological limits that it is extremely difficult if not impossible to diagnose a hyperemia. A deepening of the rosy tint of the papilla would indicate a hyperemia. If this is limited to one eye or if the disc had been previously examined in its normal condition a diagnosis of hyperemia is warranted. If the hyperemia is very decided the veins of the disc may show some engorgement. The optic disc becomes hyperemic in inflammation of the nerve further back and in chorioiditis and retinitis. It may be a premonition of approaching papillitis. If in addition to the darker color the nerve head becomes indistinct from the effusion of exudate we have an optic neuritis.

Optic Neuritis.—Whenever we can see the inflammation of the nerve with the ophthalmoscope it is commonly spoken of as papillitis, although in most cases the portion of the nerve posterior to the eyeball is involved as well. If there is little alteration apparent in the nerve head itself and the disturbance of vision considerable the condition is called retro-bulbar neuritis.

The common causes of optic neuritis and neuro-retinitis are:

Local Causes.—Cellulitis, wounds and tumors of the orbit; thrombosis of the orbital veins and their tributaries and especially of the central vein of the retina; hemorrhage into the nerve sheath; wounds or tumors of the optic nerve; wounds of the eyeball.

Intra-cranial Causes.—Meningitis whether traumatic, tubercular, syphilitic, pyemic (from middle ear disease as a rule) or epidemic cerebro-spinal meningitis; tumors of the brain wherever located although chiefly in the cerebellum or at the base of the brain; abscess and aneurism especially in the cavernous sinus.

General Causes.—Acute febrile diseases, albuminuria, influenza, anemia in all its forms, scurvy, diabetes, malarial poisoning, syphilis, poisoning from lead and probably other agents, leucocythemia, pyemenia and heredity.

Papillitis or Intraocular Optic Neuritis.—V. Graefe divided inflammations of the optic disc into two classes, papillitis from a stasis in the circulation, which is commonly spoken of as choked disc, supposedly due to a congestion and edema of the disc from increased intracranial pressure; and descending neuritis sometimes spoken of as simple neuritis, which means that the inflammation has spread down along the nerve from an intracranial lesion. The separation between these two forms of neuritis can not be sharply drawn either from a pathological or etiological standpoint. The amount of swelling of the papilla depends upon the severity of the inflammation — a simple neuritis if severe gives rise to more or less stasis in the circulation of the nerve and hence choked disc. There is no one form of papillitis belonging to cranial lesions and another to kidney trouble and so on as experience has shown. For practical purposes however this division is useful and will be used here.

The most frequent cause of typical cases of choked disc is the development of an intracranial tumor. It has been said that this form of papillitis occurs in 95 per cent. of all brain tumors, but this is evidently an error. It is true, however, that more than half of brain tumors give rise to some form of optic neuritis, but not invariably to choked disc. The nature and position of the tumor makes little difference, thus it may be of the brain substance, of the meninges, or of the skull, malignant, gummatous, tubercular or cystic in nature. Tumors of the cerebellum are especially prone to give rise to optic neuritis. The way in which a brain tumor gives rise to inflammation of the optic nerve is still a mooted point. Von Graefe originated the theory that owing to the increase of intracranial pressure an abnormal amount of lymph was forced into the intervaginal space which produced a stasis in the optic papilla, which became more decided from the unyielding nature of the walls of the lamina

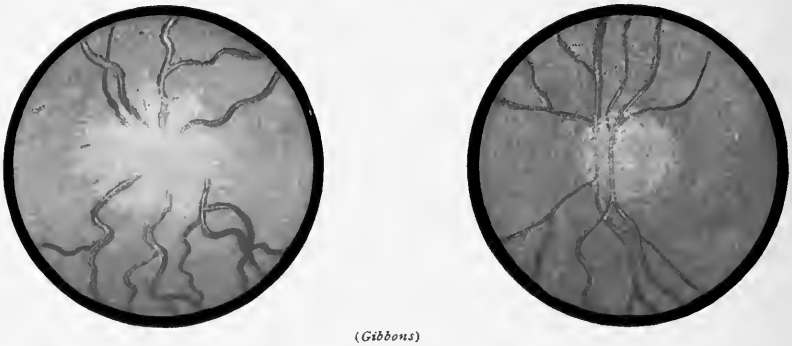
cribrosa. These acted, as was supposed, like the abdominal rings in a case of strangulated hernia, having a greater effect upon the thin-walled veins than upon the arteries with their thicker coats. This theory received support from Manz and others who noticed at necropsy that there actually did exist at times a distension of the intervaginal space with fluid in many cases of brain tumors. The theory of Leber and Deutschmann holds that the optic neuritis in these cases is not merely a stasis in the nerve head, but an active inflammation which has passed down along the optic nerve to the eyeball from the brain and produced by irritating substances caused directly or indirectly by the growth of the tumor. In support of this view it can be said that a certain amount of meningeal irritation can most always be demonstrated in the neighborhood of a brain tumor and that in many cases no distension of the intervaginal space can be found. It is true that in animals the appearance of choked disc can be produced by injecting fluids into the cranial cavity or intervaginal space, but this is no evidence that the pressure theory is the correct one, as in the experiments a greater intracranial pressure may be used than ever pertains in the human being. The adherents of the Graefe-Manz theory say that choked disc is seldom seen in cases of acute meningitis, but this may be due to the fact that the patient does not live long enough for the slight amount of neuritis present in such cases to develop into choked disc. There seems no doubt that production of choked disc depends upon active inflammation in the nerve, although it may be enhanced by increased intracranial or intervaginal pressure. Finally we have the theory of Perinaud, who holds that choked disc occurs from an extension of edema of the brain substance, which is so common in intracranial troubles. Ulrich believes that while this is true the edema of the disc itself is caused by pressure upon the central vein of the retina.

Optic neuritis is at times the first symptom in a case of brain tumor and the progress of the tumor may be so slow that the optic neuritis may pass into atrophy some time before death occurs. The presence of a bilateral choked disc without apparent cause is very suspicious

of brain tumor. One-sided choked disc rarely occurs, and when it occurs it may be on the same side or on the opposite side from the growth. Cases have been seen in which there has been a second attack of choked disc from a brain tumor, that is a second attack after the first has subsided. It is often the case that a neuritis very similar to that found with kidney disease is caused by an intracranial growth. With the causes of optic neuritis mentioned above amenorrhœa and premature menopause should be included. It is also observed in marked deformities of the skull, especially in the high and narrow or steeple-shaped skulls, as such frequently show pachymeningitis. Lead poisoning, scarlet fever and acute febrile diseases as a rule give rise to optic neuritis indirectly, the immediate cause being a nephritis. When we considered the effect of kidney lesions upon the eyes, stress was especially laid upon the retinitis, but as far as loss of vision is concerned the inflammation of the optic nerve is probably of greater importance, because the retinitis is much more apt to get well if the kidney trouble is curable than is the neuritis. Nephritis may give rise to typical choked disc and to retro-bulbar neuritis as well. Sunstroke and violent physical exertion are not infrequently followed by effusion or hemorrhage within the cranium and a secondary meningitis with optic neuritis. Cauterization of the nose, carious teeth, or the reaction following their extraction, has given rise to optic neuritis. A few one-sided cases of optic neuritis are seen for which no cause can be ascertained. Such offer a good prognosis and run a comparatively mild course. Disease of the accessory nasal sinuses at times give rise to a localized optic neuritis with descending atrophy or to choked disc.

Objective Symptoms of Optic Neuritis.—In its characteristic form choked disc gives rise to an ophthalmoscopic picture quite unlike simple neuritis. There is an entire obliteration of the outlines of the papilla which is elevated to a considerable extent above the surrounding fundus and marked on its surface by striæ radiating from its center and fading off gradually in the surrounding retina. Near the center of the swollen papilla are seen the larger retinal vessels,

the veins engorged and tortuous and the arteries smaller than normal. On the border of the papilla and in the retina immediately surrounding it there are to be seen patches of exudate and hemorrhagic areas of more or less flame shape. Occasionally a pulsation of the retinal



(*Gibbons*)

Choked Disc Simple Optic Neuritis.

arteries is seen. When the patches of exudate extend well into the retina beyond the border of the papilla the case is termed neuro-retinitis. In the latter class of cases opacities usually form in the vitreous and now and then become vascular. If one measures the elevation of the disc by the amount of hyperopia produced it will be found that it varies from one to six diopters. Arbitrarily if the elevation of the papilla is less than one diopter the case is termed one of simple neuritis. In simple neuritis there is less exudate upon the nerve head and hence less obscuration of its vessels and border and less strongly marked radiations. The appearance of choked disc frequently remains unchanged for months, but sooner or later the elevation recedes, the exudate is carried off or transformed into connective tissue and the nerve head is once more clearly seen but whiter than normal. From the long continued inflammation the smaller capillary vessels have disappeared and the nerve head appears distorted, its physiological pit filled in with cicatrix and its border irregular. To this condition the term neuritic atrophy of the optic nerve is given. There is always left some degree of atrophy

of the nerve if the inflammation is long standing, but in mild cases and those running a short course not more than several months the nerve may assume a normal aspect and a normal function. In the acute cases there is chiefly an infiltration of the tissues with leucocytes which undergo resorption, but in chronic inflammation, as is always the case, there is chiefly an increase of the fixed cells of the part which leads to a hyperplasia with subsequent shrinkage and atrophy.

Subjective Symptoms. — The vision does not bear any definite relation to the ophthalmoscopic appearance in optic neuritis. In light cases the patient complains of seeing objects as through a fog. In some central vision remains so good that the case runs its course and the patient does not discover anything the matter with the eyes until long after when the sight begins to fail from the subsequent atrophy. In other cases the lesion seems slight, but the eye may be almost or quite blind. The sight is furthermore subject to sudden changes, the patient seeing much better some days than others, and that without any alteration in the appearance of the eyeground. These facts suggest that a great deal of the visual disturbance is due to an accompanying retro-bulbar neuritis or intracranial lesion. A few cases of perfect vision occur with marked choked discs but usually it is much affected. Leber says such may be explained by the insidious course of the inflammation which allows the nerve fibers to accommodate themselves to new positions and a certain amount of pressure. In the majority of cases the field of vision will show a concentric contraction with a decided enlargement of the blind spot. Now and then there is in addition a central scotoma present. It all depends upon the portion of the nerve most involved. The color sense falls off as a rule according to the degree of inflammation, but if the reduction of vision is not extreme it may remain unimpaired. The patient complains of spectra and flashes of light, often lightning-like (photopsia) before the eyes, but suffers no pain. As the objective signs disappear the vision improves provided atrophy has not been going on at the same time, in which case the exudate clears away but the vision is not improved.

Diagnosis. — The diagnosis of optic neuritis offers no difficulty. The edge of the disc is blurred, its vessels somewhat obscured and the surface of the disc is redder than normal. If the vitreous is hazy it is often difficult to say whether the nerve is implicated or not, as the normal pink color of the nerve appears deeper and the whole nerve hazy when seen through the fog. In doubtful cases the field of vision should be taken. The beginner may mistake hyaline bodies on the nerve head and opaque nerve fibers for a neuritis. The former condition will be described later and the latter was considered in the previous chapter.

Prognosis. — A guarded opinion should always be given in cases of optic neuritis. There is absolutely no way of telling when the patient is seen for the first time whether a case will end in restoration of good vision or in blindness. As a rule the greater the ophthalmoscopic change the greater the permanent alteration in the sight through the destruction of nerve fibers by atrophy. The prognosis likewise depends upon the course taken by the disease which has given rise to it. Those cases in which central vision is left little impaired offer the best prognosis. Cases which are totally blind and in which the pupillary light reaction is lost, whether there is much alteration of the ophthalmoscopic appearance or not, are hopeless, as they are usually dependent upon advanced intracranial lesions.

Treatment. — The first indication in the treatment of optic neuritis is the removal of the cause if that is possible. If there is an intracranial growth suspected one should watch for localizing symptoms such as loss of coördination, paralyses or areas of altered sensation and the tumor removed as soon as possible. Even if all the growth can not be removed the diminution of intracranial pressure will benefit the neuritis. In quite a few cases reported the lessening of intracranial pressure obtained by trephining, with or without puncture of the lateral ventricle, where the neuritis was due to a hydrocephalus internus caused by a tumor or what not, has been followed by marked improvement of the vision. If there is a history of syphilis

mercurialization and iodids should be tried. In many non-syphilitic cases these remedies are to be relied upon. The sweat treatment by means of Turkish bath or pilocarpin, taken twice a week or so, aids materially in hastening resorption. If there is a rheumatic diathesis present administer salicylates. In disturbances of menstruation remedies to promote the proper flow are employed and finally orbital causes must receive the proper surgical measures.

Hemorrhagic or Apoplectic Neuritis.—This variety of neuritis is somewhat identical with the like affection of the retina. The papilla becomes splotched with spots of ecchymosis or entirely blood red with hemorrhages. The arteries are reduced in size and the veins very large and tortuous. The diameter of the disc is enlarged and its border sharply defined, unless the surrounding retina participates in the inflammation, in which case the red color of the disc, mixed with streaks of exudate, fades off gradually into the surrounding retina. The cause of this form of optic neuritis is supposed to be due to an inflammation with thrombosis of a vein in the nerve near the eyeball and the papilla shows the effects of the obstructed circulation and edema.

Diseases of the Optic Nerve from Affections of the Accessory Nasal Sinuses. — In all obscure cases of optic neuritis, especially if unilateral, one should bear in mind the possibility of involvement of the nerve by a disease of one of the accessory nasal sinuses or ethmoid cells. On account of their relations to the orbit and brain cavity, and in case of the sphenoidal cells to the optic tract itself, a distension of their walls from a collection of pus or growth within the sinus may exert enough pressure directly or indirectly through the orbital tissues upon the optic nerve to cause inflammation or atrophy. The purulent matter within the sinus may furthermore gain access to the orbit or cranial cavity through a necrosed wall and give rise to an optic neuritis. A few cases of neuritis have been reported associated with a dropping of a clear fluid from the nose which was supposed to be cerebro-spinal fluid. Most of these cases are said to have had nasal polyps and undoubtedly were suffering with accessory sinus disease.

None of these cases had normal noses and no doubt they were cases of rhinorrhea, and not the dropping of cerebro-spinal fluid from the nose, due to imperfect development of the tegmen nasi. Inflammation of the optic nerve posterior to the eyeball, that is between the eyeball and the chiasm with little or no appreciable change in the appearance of the optic papilla, is called *retro-bulbar neuritis* (orbital neuritis, central amblyopia). Retro-bulbar neuritis is essentially chronic but may be acute. The latter is also spoken of as fulminating retro-bulbar neuritis.

Acute or Fulminating Retro-bulbar Neuritis.

Etiology. — Many cases result from the severe exposure to cold. Exposure to the heat of the sun resulting in sunstroke is also a rather common cause. Other causes are the circulation of some poisonous agent in the blood from rheumatism, gout, syphilis, influenza, diabetes, scarlet fever and less frequently the other exanthems; infection from the accessory nasal sinuses; cellulitis of the orbit; fracture of the optical canal; gummatous deposits or periostitis. The sudden suppression of menstruation at times gives rise to it. The disease is also attributed to the ingestion of certain drugs in large quantities, chief among which are alcohol, especially wood alcohol, lead and quinin. Acute retro-bulbar neuritis may be a symptom of insular sclerosis or of acute myelitis. The disease affects both eyes unless there is a local cause, but one eye is usually affected in advance of or more decidedly than the other.

Symptoms. — There is either a sudden loss of vision or the sight fails progressively in from one to eight days to complete or nearly complete blindness. The fundus in some cases shows no alteration whatever but the majority of them, especially after a few days, present a hyperemic papilla with slight blurring of its border, with or without haziness of the surrounding retina. In rare cases punctate retinal hemorrhages occur with minute yellowish dots in the macular region.

The sight may improve slowly until very good vision is obtained, but there usually remains a certain amount of amblyopia with a con-

tracted field or central scotoma or both. The color sense is greatly affected throughout the course of this affection. After the improvement, the vision in most cases slowly declines from a progressing atrophy of the optic nerve so that the patient is finally left irreparably and totally blind. Observers have found an interstitial neuritis throughout the entire nerve in acute retro-bulbar neuritis, and extending from the eyeball more or less to the chiasm. Some cases arise from the spread of a pachymeningitis into the optic canals

Treatment. — Any cause must be removed if it is possible and if the neuritis has developed during an attack of some infectious disease the latter must receive its proper treatment. In other cases the best results are obtained by sweating with pilocarpin or hot air baths, large doses of salicylate of soda, free use of mercury and iodids and infusion of normal salt solution (lymphatic flushing) to dilute and hasten the excretion of the poison in the system.

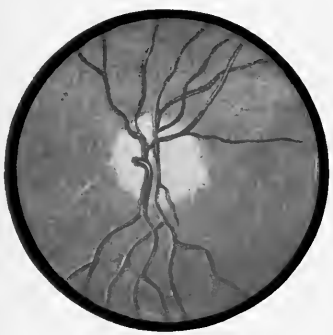
Chronic Retro-bulbar Neuritis pursues a much slower course than the preceding, progressing several months or so in the form of a central scotoma, more or less elliptical in shape and extending from the optic papilla to the macula lutea. The scotoma is at first relative, white appearing as gray and the various colors being confused within its area. Later the central blindness becomes more or less complete and is accompanied by a contraction of the field of vision. The ophthalmoscope in the incipiency of the affection fails to reveal anything abnormal or only a very slight haziness of the disc and the retina immediately around it. Atrophy at the outer quadrant or half of the nerve head sooner or later causes it to appear paler than the rest of the papilla and occasionally the whole disc becomes atrophic even in cases in which the central scotoma is the only evidence of the diseased condition of the nerve.

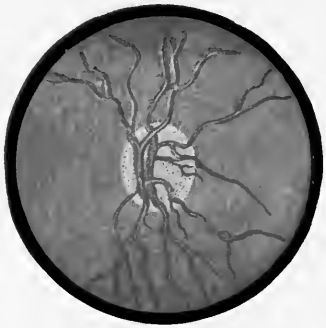
Etiology. — Some cases may be attributed to rheumatism or exposure to cold, others to a tubercular or other chronic meningitis or periostitis in the optic canal. There is a form of chronic retro-bulbar neuritis which seems hereditary, that is, it affects several members of the same family and without any apparent cause. It occurs as a

rule in the male offspring between the ages of eighteen and twenty-two and certain observers have noticed that it occurred more frequently in the children of the brunette type. In many cases no cause for chronic retro-bulbar neuritis can be ascertained. The very great majority of all cases are caused by systemic poisoning by some agent or drug, chief among which are the following: Tobacco and alcohol (chiefly wood alcohol), singly or combined, tea, coffee, chocolate, quinin, cocain, stramonium, cannabis indica, male fern, chloroform, chloral, opium, bisulphid of carbon, nitrobenzol, arsenic, lead, iodoform, aconite, santonin, mydriatic alkaloids, picric acid, osmic acid, digitalis, ergot, coal-tar products, potassium bromid, amyl nitrite, silver salts—curare, carbon monoxid gas, and the toxins of diabetes and nephritis. Of these drugs tobacco and alcohol together are mostly responsible. It is rare to find a user of tobacco develop the disease, however, unless he is a user of alcohol as well. The disease is usually bilateral, though unilateral cases have been seen in which the symmetrical development of the disease has been delayed. To those cases caused by some toxic agent the term toxic amblyopias is applied. Toxic amblyopia is never seen before the thirty-fifth year. The pathological lesion that gives rise to this disease is an interstitial neuritis involving the papillo-macular bundle of fibers. These fibers traced by means of their degeneration consist of a more or less triangular bundle in the papilla with its base in the lower outer quadrant. It gradually passes towards the axis of the nerve and then into the optic tracts. Nuel believes with others that the central scotoma in this affection is due to a degeneration of the ganglion cells in the macula, which in turn gives rise to a degeneration in the optic nerve.

Prognosis.—The outcome is good in tobacco and alcohol cases provided the patient presents himself early for treatment before atrophy of the nerve has ensued and is willing to totally abstain from the use of those agents. The treatment of the chronic retro-bulbar neuritis is the same as that of acute form. The toxic amblyopias with the other forms of amblyopia will be considered in a separate section.

Optic-nerve Atrophy.—Under the head of atrophy of the optic nerve are included several varieties of degeneration. We speak of the atrophy as primary or simple when it has not been preceded by inflammation of the chorioid, of the retina, or of the nerve itself and as secondary when it follows a neuritis (post-neuritic atrophy), a chorioiditis (post-chorioiditic atrophy) or retinitis (post-retinitic atrophy) or when caused by an increase in the intraocular tension (glaucomatous atrophy) or occlusion of the central artery of the retina by embolism or thrombosis (embolic atrophy). There are certain symptoms more or less common to all the types of optic





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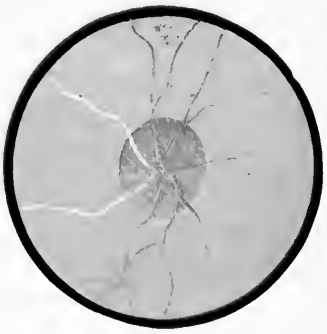
Post-neuritic Atrophy of Optic Nerve. Simple Atrophy of Optic Nerve.

atrophy but vary according to the type. Thus, there is always a pallor or alteration in the color of the papilla. The capillary circulation in the medulla of the nerve is interfered with so that the papilla assumes a reddish-gray, a dirty red or greenish-red appearance. In advanced cases the disc becomes chalky white or bluish-white with or without a diminution in the caliber of the retinal vessels. In the beginning it is often very difficult to make a diagnosis of atrophy from the appearance of the disc alone so that in such cases the field of vision should be taken. More or less sinking or pitting of the surface of the papilla is also present unless there is organization of exudate upon the surface of the papilla. The depth of this pitting (atrophic excavation of the disc) depends upon the degree of degen-

eration of the nerve fibers and its form depends much upon the shape and position of the physiological cup if one is present. At the bottom of the excavation the lamina cribrosa is exposed to view imparting to it a mottled or stippled appearance. At the edge of the disc the retinal vessels are seen to make a bend as they mount up to the level of the surrounding retina. The bending of the vessels at the edge of the disc is very decided in cases associated with rise of intraocular tension, as in such the depth of the pit is increased by the bulging of the lamina cribrosa. The margin of the optic papilla shows alteration with the ophthalmoscope. In simple-primary or non-inflammatory atrophy it becomes very much more distinct than normal from the disappearance of the nerve fibers which cross its edge, while in post-neuritic atrophy the margin of the papilla is distorted by the hyperplasia in the nerve and its edge obscured in places by bands of cicatricial tissue. The larger vessels become diminished in size, the smaller ones disappear altogether and are accompanied in places by white lines, in cases of post-neuritic atrophy. In simple atrophy the vessels remain unaltered. In post-retinitic and in embolic atrophy especially, the vessels of the disc, may almost or entirely disappear, their former course being marked only by white lines which are the empty atrophied vessels. The presence of alterations in the surrounding eyeground depend upon the cause of the atrophy. In simple atrophy there is no change in the surrounding fundus; but in post-neuritic and post-retinitic atrophy spots of degeneration marking the places of former hemorrhages and patches of pigment deposits are very frequently seen.



Post-retinitic Atrophy of Optic Nerve.

In addition to the ophthalmoscopic changes mentioned we find alterations in the vision. Central vision falls off gradually until absolute blindness is reached. In the beginning there is only a slight

depreciation of the sight. One eye usually sees poorer than its fellow. The effect of an existing refraction error upon the vision can be done away with by taking the patient's vision through a small perforation in an opaque disc.

Change in the Field of Vision.—There is concentric contraction; contracted field with large reëntering angles due to peripheral scotomata; quadrant-shaped defects; loss of one half of the field (hemianopsia) and the presence of a central scotoma. Concentric contraction is the commonest form of curtailment. In atrophy due to spinal disease the limitation more frequently begins at the outer side, in glaucoma, at the inner side and in chronic retro-bulbar neuritis with a central defect in the field. In optic atrophy there is always more or less defect in the color-perception. There is at first a contraction of the green and red field and then for the blue and yellow. The loss of central color-vision finally ensues. The contraction of the color-field usually precedes the contraction of the white field. In all cases the reaction of the pupil to light is changed. The pupil acts tardily or not at all when light enters the eye because the optic nerve fails to convey the afferent impulse in the pupillary reflex arc, so the pupil remains partially dilated. Consensual reaction may be preserved showing that the pupil is not dilated from involvement of the sphincter. In spinal atrophy we very frequently find that the pupil remains fixed to light but is mobile in accommodation and convergence.

VARIETIES OF OPTIC-NERVE ATROPHY.

Simple Atrophy (primary, genuine or non-inflammatory atrophy) is distinguished by the fact that the papilla becomes progressively paler until it is entirely white or bluish-white, and at the same time more sharply defined from the surrounding fundus and at the same time somewhat excavated. The vessels are not altered. The sight is gradually reduced until there is complete and irreparable blindness. The causes of simple atrophy of the optic nerve are: Spinal affections, chiefly tabes dorsalis, which is by far the most frequent cause of simple atrophy of the optic nerve. The atrophy

furthermore, usually develops at a time when the ataxic symptoms are very slight or absent and a diagnosis of tabes not yet certainly made. There is at the same time present contracted pupils which react poorly, or not at all, to light stimulus (spinal miosis) or normal-sized pupils which fail to react to light, but react normally to convergence and accommodation. These three eye symptoms with a loss of reflexes, especially the patellar reflex (Westphal's symptom), and loss of coördination (Romberge's symptom), will usually make a correct diagnosis of tabes dorsalis. Spinal atrophy of the optic nerves affects both eyes, but not necessarily at the same time nor to the same degree. It advances very slowly, but just as surely, until complete blindness is the result. Spinal atrophy is therefore at times spoken of as progressive atrophy. Disseminated sclerosis and progressive paralysis of the insane are at times complicated by simple atrophy. Tumors and other intracranial lesions may induce atrophy of the optic nerve by exerting pressure directly or indirectly upon it or upon its continuation within the skull. In the latter case the atrophy gradually passes towards the intraocular extremity from the site of the break, hence it is sometimes spoken of as descending atrophy. Orbital diseases and tumors are also causative of optic atrophy, but more frequently set up a neuritis, which in turn gives rise to atrophy. There are many cases in which the cause is not ascertainable. Simple atrophy is found most frequently in middle life and in males as they are more prone to spinal affections. Optic-nerve atrophy occurring in childhood is, as a rule, post-neuritic.

Secondary Atrophy or that occurring after a neuritis, retinitis or what not is distinct from the simple variety of atrophy because the papilla becomes more or less covered with cicatricial tissue from the organization of exudate. In post-neuritic atrophy the papilla is at first of grayish-white color and its margins slightly hazy; the veins are distended and tortuous. Afterwards the papilla becomes pure white or bluish-white, but the lamina cribrosa is not exposed to view as in the simple form of atrophy. The papilla is now sharply defined, more or less distorted and sometimes smaller than formerly, as

though it had shrunken ; both the arteries and veins are contracted and often inclosed within white streaks. In the post-retinitic and post-chorioiditic atrophy the papilla appears very cloudy and of a dirty reddish-gray color. Its margin is poorly marked and its vessels greatly thinned or entirely absent.

Glaucomatous Atrophy. — The papilla appears bluish-white and deeply pitted. The depth of the pit is recognized by the fact that the vessels in the bottom of the pit, and after they pass into the retina, cannot be brought into focus at the same time, and that they undergo parallactic displacement when the objective lens is moved from side to side. Again, the vessels make sharp bends on leaving the disc and some few seem to disappear as they pass up the wall of the pit, being seen end on. All of the vessels in the majority of cases are pushed well to the nasal side of the papilla.

Embolic Atrophy causes the nerve to appear dead white or dirty reddish-gray ; its margins poorly defined and vessels entirely absent, or very few in number, running in one direction.

	Post-neuritic Atrophy.	Simple Atrophy.
Color of Disc.	Uniform, dead white.	Stippled, bluish or grayish-white.
Surface of Disc.	Flat, physiological pit usually filled in.	More or less concave. Physiological cup not filled in.
Margin of Disc.	Not more distinct than normal. May be blurred in places. Often irregular.	Much more distinct than normal. Not irregular.
Larger Vessels of Disc.	Diminished in size. Accompanied in places by white lines.	Not altered.

Prognosis. — The prognosis of atrophy of the optic nerve is unfavorable at the best, and especially so in cases following embolism and glaucoma. Inflammatory atrophy affords a somewhat better prognosis, inasmuch as the amount of sight which the neuritis or retinitis has left is in many cases retained.

Treatment. — Unfortunately treatment is of little avail. It depends somewhat upon the cause, which should have proper attention. Many different remedies have been advocated in the treatment of optic-nerve atrophy, but have not proven efficacious. None afford more satisfactory results than the following: mercury and iodids in suitable cases, the alteratives, strychnia and nitroglycerin.

Amaurotic Family Idiocy. — This is a disease which manifests itself in early life. It has usually run its course within two years and ends in death. The clinical picture of it is about as follows: The child is born normal apparently and develops for some months or perhaps a year in a perfectly normal manner. It fails to show the dawning of intelligence that children of this age do, however, and signs of degeneracy begin to manifest themselves, such as violent fits of temper, apathy, failure to ask for food or drink, inability to stand or walk, and extreme backwardness in beginning to talk. The child's strength begins to wane rapidly, the back and lower extremities suffering especially and paralyses appear which may be flaccid or spastic. The reflexes are unaltered. Usually before the disease has reached this stage the child has become quite blind. Ophthalmoscopic examination reveals atrophied optic nerves with a white area occupying the region of the macula with a characteristic red center at the site of the fovea. This appearance is due to a fog-like edema of the retina and is very similar in appearance to that seen in embolism of the central artery of the retina. The infant finally dies at about the end of the second year. As a rule several members of the same family are attacked.

Etiology. — The cause of the disease is obscure, but is said to occur more frequently among Jews.

Pathology. — There is a great destruction of nerve fibers both in the brain and cord, particularly in the pyramidal tracts. At some points there is fatty degeneration and hypertrophy of the neuroglia. In the eye there is an increase in the ganglion cell layer of the retina, with edema and atrophy of the optic nerve.

Injuries of the Optic Nerve. — This may occur from the entrance of a foreign body into the orbit or from a fracture through the optic canal involving the nerve directly or secondarily through callous formation. The result is sudden loss of vision followed by complete atrophy of the optic nerve.

Hyaline Bodies in the Papilla or Drusen. — This affection is characterized by the formation, in the papilla, of more or less numerous globular colloid-like excrescences. They are of yellowish-white or bluish-gray color, and form a mulberry-like mass, projecting from the surface of the disc. They occur at all ages and in eyes free of pathological alterations as well as in eyes with chorio-retinitis, optic neuritis or optic atrophy. The origin and nature of these bodies is still a mooted point. There are two theories in regard to them. First, that they are hyaline excrescences of the lamina vitrea of the chorioid which becomes imbedded in the optic papilla, and secondly, that they have nothing in common with the chorioidal excrescences, but are a special pathological process confined to the optic nerve. Hirschberg says the bodies are amorphous and organic, and resemble elastin in their composition. They at times undergo calcification.

Tumors of the Optic Nerve. — Tumors of the optic nerve are very rare, but include fibromata, sarcomata, gliomata, endotheliomata, gummata, myxomata. The symptoms are exophthalmos, the eyeball being pushed downward and forward, while its motions are unaffected. Defective vision sets in very early. There is no pain and the tumor is usually of slow growth. With the ophthalmoscope the retinal veins are found distended with edema and inflammation of the optic nerve. Sooner or later white atrophy of the nerve ensues.

Treatment consists in enucleation of the eyeball, cutting the nerve as far back as possible, and if the growth is found to be malignant, subsequent exenteration of the orbit.

CHAPTER XVIII

AMBLYOPIA AND AMAUROSIS

AMBLYOPIA, as we employ the term to-day, means poor vision without any discernible lesion or cause apparent within the eye. Some are functional, while others have their origin in deficient development of the visual pathways or in chronic inflammation posterior to the eyeball itself leading to more or less blindness without any or only slight change in the optic papilla. Amaurosis means blindness without apparent cause. In the broader sense the term amblyopia is used by many to indicate a poor seeing eye and amaurosis a blind eye from whatever cause. Before the invention of the ophthalmoscope this was the manner in which the two terms were employed, but since many such cases have resolved themselves into diseases of the lens or those affecting the fundus of the eyeball. Amblyopia may be therefore congenital or acquired, temporary or permanent, symmetrical or non-symmetrical. The various causes of acquired amblyopia will be seen in the following table:

Acquired Amblyopia.

- Reflex (usually through the fifth nerve from the teeth),
- Traumatic,
- Uremic (nearly always during scarlatina or puerperium),
- Malarial,
- Glycosuric (gives rise to scotomata, like tobacco and alcohol),
- From loss of blood (especially from hemorrhage from the stomach),
- Toxic from:

Alcohol,	Iodoform,
Tobacco,	Chloral,
Quinin,	Bromids,
Lead,	Tea,
Silver nitrate,	Coffee,
Salicylic acid,	Chocolate,
Cannabis indica,	Picric acid,

Bisulphid of carbon,	Opium,
Nitro-benzol,	Osmic acid,
Stramonium,	Ptomains,
Male-fern,	Mydriatic alkaloids,

Fœnigreek and any other substance containing Pyridin or other derivative of Nicotinic acid.

Congenital Amblyopia. — Unilateral congenital amblyopia is not very rare. We see it in nearly all cases of early squint, in congenital cataracts and corneal scars. The poor vision in such cases is not infrequently due to non-use, and are therefore spoken of as cases of amblyopia exanopsia, or, according to Gould, as argamblyopia. In most of the squinting cases the vision can be materially improved by straightening the eye and correcting its error of refraction objectively. It is hardly less than criminal to place a plane glass before the amblyopic eye in cases associated with errors of refraction, and to allow the vision to continue to deteriorate. If the vision is $\frac{20}{100}$, or better, there is always hope of improvement, but if the vision is less than this little improvement is expected from glasses. There are not many cases that develop binocular vision unless taken in hand very early and bar-reading and stereoscopic exercises persisted in for months. If the vision is primarily worse than $\frac{20}{100}$ there is reason to believe that the eye sees so poorly from deficient development of its visual pathway or center. From the latter cause we very often see bilateral blindness in idiotic infants. The majority of amblyopic eyes show no alteration in the fundus details with the ophthalmoscope or only some slight change as attenuation of the chorioid, irregular shaped papilla or one that is somewhat dimmed in its outline. The perimeter reveals as a rule a concentric contraction of the field for colors and for white, and less frequently central scotomata. Congenital amblyopia for colors or color-blindness has been dealt with in another chapter so will only be mentioned here. We will now consider the acquired forms of amblyopia.

Reflex Amblyopia. — Both poor vision and complete loss of vision may result from a reflex irritation from remote parts, but such are

comparatively rare. Loss of vision more or less suddenly has been attributed to diseases of the reproductive organs of the female or of the digestive apparatus. Well authenticated cases have been reported caused by carious teeth or by extraction of them, by nasal cauterization, by diseases of the naso-pharynx and accessory nasal cavities and from the presence of impacted cerumen in the ear. There can be no doubt, however, that some of these cases have been cases of hysterical amblyopia. The etiology of reflex amblyopia is still obscure. Just what occasions the loss of function in the retina or central ganglia is unknown, but the disturbance may be due to an alteration of the local vaso-motor system.

Traumatic Amblyopia may occur after severe injuries to the back of the head, bruises along the spinal column from railroad accidents or what not and from blows upon the brow in the region of the supra-orbital nerve. In some of these cases there is a fractured skull, the line of fracture involving the optic canal or giving rise to intracranial hemorrhage or some contusion of the brain followed by secondary atrophy in the optic nerve which does not become apparent at the ocular end for some time subsequent to the accident. In other cases there are to be discovered no alterations within the eyeball at any time and the deficient vision is only temporary or there may be an effusion or hemorrhage into the inner sheath of the optic nerve. We must always look out for malingering after railroad accidents as the patients frequently exaggerate their blindness in hope of recovering damages. It is very difficult to differentiate these cases from those of concussion retinitis so the fundus should be very carefully examined to exclude the presence of edema, hemorrhages and likewise detachment of the retina. The treatment is rest in bed and the internal administration of strychnia with nitroglycerin and in case of reflex amblyopia examination of the teeth should be made and any diseased condition receive proper attention, or other apparent cause removed. Amblyopia and amaurosis may occur under the influence of the toxins of certain diseases circulating in the blood of which the three following are examples.

Uremic Amblyopia or Amaurosis. — This is almost always seen in the post-scarlatinal nephritis or during the puerperium. In scarlet fever it usually appears with the nephritis during the stage of desquamation and is associated with the other symptoms of uremia, so also in pregnancy. The disease is bilateral and in spite of the total blindness often present the pupils retain their reaction to light. The ophthalmoscopic picture is negative or there may be evidence of an incipient neuro-retinitis, in which case we made a diagnosis of uremic amblyopia by the blindness being out of proportion to the apparent structural change within the eyeball.

The prognosis as far as recovery of sight is concerned is good, but one cannot answer for the final outcome of the vision for there may follow an intense neuro-retinitis with its damaging effect upon the sight. The treatment is the treatment of the cause.

Glycosuric Amblyopia. — It will be recalled that diabetes likewise gives rise to cataract, retinitis and retinal hemorrhages. The dimness of vision associated with sugar in the urine is very similar to that from alcohol and tobacco. There is no alteration in the fundus. There is a central scotoma first for red and green but afterwards becoming absolute with more or less contraction of the field. If the diabetic is a smoker or user of alcohol it is difficult to decide whether the diabetes or the drugs have given rise to the amblyopia, but in such instances the color-defect often extends to the blue and yellow. Horner believes the cause to be malnutrition of the macular fibers brought about by the glucose in the blood. Or, according to more recent views due to irritation and loss of conductivity of the ganglion cells of the macular region of the retina primarily and gradually extending peripherally.

The prognosis, unlike the tobacco-alcohol amblyopia which it resembles, is very grave as the patient usually goes blind from progressive atrophy of the optic nerves in spite of all treatment.

Malarial Amblyopia. — Malaria presumably at times gives rise to amblyopia. During the course of an intermittent or remittent fever dimness of vision has been observed. The attacks are usually of

short duration, but may persist for a week or so. The dimness of vision is attributed to the irritating action of the malarial poison upon the optic nerve and retina but in such a case one must not forget that quinin is itself capable of causing poor vision. The diagnosis of malarial amblyopia can however be made if the plasmodium is found in the patient's blood or before much quinin has been taken. Malarial amblyopia gets well rapidly under the action of quinin.

Amblyopia from the Loss of Blood. — Quite commonly we see excessive hemorrhage from any part, but especially from the stomach or intestines, cause a temporary loss of vision. Severe post-partum hemorrhages are always associated with a disturbance in vision. The sight usually entirely returns but may gradually fail from an optic neuritis and subsequent atrophy of the optic nerve. Treatment consists in transfusion of blood and in saline injections. The bowels should be kept full of warm saline solution and the same solution injected into the muscles especially in the gluteal region. The head should be lowered and limbs bandaged to retain the blood in the trunk and head. Later the treatment is pro re nata.

Toxic Amblyopia is caused by the abuse of many drugs which have already been enumerated. The most important of these are as follows: Tobacco, alcohol, carbon disulphid, iodoform, lead salts, quinin, mydriatics, male-fern, ptomains.

The clinical picture of the effect of a few of these agents upon the eye will serve as types of toxic amblyopia. The commonest examples of toxic amblyopia occur from the abuse of tobacco and alcohol singly or together. Either alone may give rise to a partial blindness, but as alcoholics as a rule smoke we have to do in most cases with a mixed intoxication. Many believe that alcohol predisposes to tobacco poisoning by giving rise to a dyspepsia which interferes with the general nutrition. Horner thinks that neither of these agents produce the pathological alterations found in the visual pathway, but that together they produce a chronic gastric catarrh which brings on an anemia of the optic nerves, terminating in a retro-bulbar neuritis characteristic of tobacco and alcoholic amblyopia. Cigarette smokers

seem to suffer most frequently from the poisonous effects of tobacco, as they consume as a rule more tobacco than those who smoke pipes or cigars on account of the mildness of the cigarette, and usually form the habit of inhaling the smoke.

According to recent authorities the injurious element in tobacco smoke is not nicotin, but exactly the same as that which exists in the fumes of burning charcoal, namely, carbon monoxid, the result of incomplete combustion. It seems probable that very little if any nicotin reaches the system through tobacco smoke, as it does not occur in a free state in tobacco, but as an organic salt which is not volatile and breaks up under the influence of heat. If two or three mouthfuls of tobacco smoke be shaken up with a few drops of blood diluted with water in a bottle the mixture will assume the pink color characteristic of blood containing carbon monoxid; furthermore, the spectroscope confirms the presence of the gas. It is different with tobacco chewers, however, as in those nicotin, pyridin and other injurious substances are directly absorbed into the system, but they less frequently suffer with toxic amblyopia than smokers. Pipe smoking (if the pipe is kept clean) seems to be the least injurious and cigar smoking the most injurious, taking it for granted that the same amount of tobacco is consumed. A few cases have been reported occurring in girls who were employed in tobacco factories, probably from the inhalation of the dust.

Pathology. — All are not agreed as to the essential lesion in toxic amblyopia. Some hold that it is essentially a disease of papillo-macular bundle of fibers in the optic nerve, while others believe it originates in the macula lutea. Samelsohn, Uhthoff and De Schweinitz among others are adherents of the first theory and they say in toxic amblyopia there is an increase of nuclei and hypertrophy of the connective tissue of the nerve, beginning in the papillo-macular bundle somewhere between the eyeball and brain, and extending thence towards the center and periphery, and involving about one third of the fibers of the macular tract. In fact that there exists an interstitial neuritis comparable to the pathological process seen in

the liver from the inordinate use of alcohol, that is an interstitial hepatitis.

On the other hand, Nuel, Langley and Fisher among others believe that tobacco amblyopia is caused by the loss of transmission of impulses through ganglion cells upon which the drug acts. This fact explains why direct vision suffers out of all proportion to indirect vision. All the impulses of the macula are passed through ganglion cells, which are more numerous at the macula than in any other portion of the retina, there being a ganglion cell for every cone and each connected with a separate nerve fiber. About one fourth of the total number of fibers in the optic nerve compose the macular bundle. Inasmuch as the macular region is more complex its vulnerability is greater, and as there is a decided vaso-constriction in all cases of toxic amblyopia it is no wonder that the macula so sparsely supplied with blood should suffer first. There then follows an ascending atrophy of the papillo-macular bundle of fibers. That atrophy of this tract follows destruction of the macula is proven by experiments upon animals. The experiments of Holden and Friedenwald have shown there is a degeneration of the ganglion cells and macular layers of the retinæ caused by nutritive disturbance, which in the case of methyl alcohol is due to a vaso-constrictor effect upon the retinal vessels.

Symptoms.—In the first place tobacco-alcoholic amblyopia is rare before the thirty-fifth year of age, although several cases have been observed as early as the fifteenth year. Diminution of the sight, associated with a fogginess in the center of the field of vision, occurs. The patient's sight may vary from $\frac{20}{30}$ to ability to count fingers at close range. It rarely falls below $\frac{6}{200}$, and is usually about $\frac{20}{100}$. It is often noticed that vision is better in reduced light (nyctalopia) and the patient will say that he has less trouble to get about after sunset. This fact is explained by the already irritated retina being tired out and ceasing to function in strong light, and also perhaps by the fact that the pupil is larger in diminished light. The ophthalmoscope fails to reveal any alteration in the papilla or there is slight haziness

with a paleness of the temporal half or quadrant-shaped portion of the papilla. The diagnostic symptoms are found in the field of vision. At first there is a normal field for white and colors in the periphery, but in an elliptical area embraced by the optic nerve and macula the colors are not recognized in their true hue. Thus white is grayish in appearance within this scotoma, green and red look dirty brown or are not seen as colors at all, but appear grayish. At this stage there may be defective light sense. The scotoma represents then a red-green blind area, and usually the extent of green blindness is greater than that of red. In the very beginning the scotoma may be central and very small and be overlooked unless looked for diligently. When the typical egg-shaped scotoma is developed the process may cease or the stage may progress. The color defect increases in size, especially above, until it meets the limits of the field for red, that is, the scotoma breaks through, as we speak of it. In the severer cases there may be a scotoma for blue and yellow as well as for red and green. Finally the central scotoma becomes absolute, nothing at all being seen within its area. The field for white now shows considerable shrinkage and the man ultimately goes completely blind from complete atrophy of the entire optic nerve. Prognosis is favorable even though the case is of long standing. If the patient will totally abstain from the use of tobacco and alcohol sight should be recovered in from six to twelve weeks if there is no other optic nerve disease present.

Diagnosis. — The diagnosis of tobacco-alcohol amblyopia is not always easy, for men who drink much are very apt to be exposed to the weather and to venereal diseases and other influences which may give rise to a retro-bulbar neuritis. Furthermore, the disease may be mistaken for non-toxic orbital axial neuritis, disseminated sclerosis, locomotor ataxia, and scotomatous atrophy of the optic disc. The following is the manner in which we differentiate toxic amblyopias from retro-bulbar neuritis caused by syphilis, cold, rheumatism, disorders of menstruation, diabetes, and so forth.

Toxic Amblyopia.	Non-toxic Retro-bulbar Optic Neuritis.
History of the abuse of alcohol and tobacco; much more frequent in men and after the thirty-fifth year.	History of chilling of the body or excessive exertion, suppression of menses or an infectious disease, rheumatism, etc. There is also no especial relation to age or sex.
Vision varies from $\frac{5}{200}$ to $\frac{5}{30}$.	Vision is usually greatly disturbed at times, even loss of light perception.
Central scotoma of oval shape, extending from the papilla to the fixation point, but rarely extending beyond the latter. The scotoma is, as a rule, for red and green only, or if for the other colors it has the general shape described.	Absolute and often positive scotoma, except in the beginning, and shows tendency to pass to the nasal side of the point of fixation and is not especially horizontally oval in shape.
Peripheral visual field intact until late in the progress of the disease.	Peripheral contraction of the form and color fields.
Ophthalmoscopic appearances are negative or there is a quadrant-shaped area of atrophy in the lower temporal portion of the papilla.	Generally some woolliness of the margins of the disc. At times the veins are distended, but there is seldom any ischemia of the papilla.
No pain.	Often considerable pain upon extreme rotation of the eyeball.
Slow in onset and quickly amenable to treatment.	Often rapid in onset and very slow in responding to treatment.

Disseminated Sclerosis.	Locomotor Ataxia.	Scotomatous Atrophy of the Disc.
History of exposure, mental distress, overwork, acute disease, specific febrile disease, injury to central nervous system; no relation to sex, appears usually between 20 and 25, sometimes in childhood.	History of *syphilis*. Common. Uncommon in women. More than half of all cases occur between 30 and 40 years.	Hereditary tendency. Usually appears in males before the thirty-fourth year.

Disseminated Sclerosis.	Locomotor Ataxia.	Scotomatous Atrophy of the Disc.
Vision varies with stage of disorder. Pupils unequal.	Varies with condition of optic nerves. Argyll-Robertson's pupil.	Marked loss of central vision.
Central scotoma like toxic variety.	Scotoma perhaps at first like toxic variety but progressive.	Scotoma in form like toxic variety but absolute.
Usually concentric contraction of visual field.	Reëntering angles in field and often restriction of temporal half of field.	Very marked contraction of field.
A general atrophy of disc or incomplete pallor, temporal atrophy, or slight neuritis.	Gray degeneration of the nerve. In the early stages grayness of the deeper portions of the nerve and broadening of the scleral ring.	White atrophy of the papilla, at times accompanied by evidences of a low grade neuritis.
Characteristic tremor. Staccato speech. Nystagmus very common.	Ataxia. Knee-jerk absent. Pains in extremities. Pupils inactive to light. Diplopia common.	No general symptoms.
Very little result from treatment.	Optic nerve atrophy progressive.	Stationary scotoma unaffected by treatment.

Wood Alcohol Amblyopia (Wood Spirits, Columbian Spirits, Naphtha, Wood Naphtha).—Wood alcohol is more poisonous and gives rise to greater disturbances in vision than does grain alcohol. When ingested in considerable quantities it gives rise to an acute retro-bulbar neuritis with falling off of the vision to almost complete blindness. The disc shows as a rule as it does in poisoning from quinin and after exhausting hemorrhages great diminution in the size of its vessels with some haziness of its margins. Some sight returns but is scarcely ever restored to normal and what is regained too

often is lost through a subsequent atrophy of the nerve. There is usually a central scotoma with a peripherally contracted field found after the vision has become good enough to take the field. The pupils are dilated and respond poorly or not at all to light. A few cases of amblyopia and one case of death have been reported from the inhalation of the fumes of methyl alcohol, in workmen who were engaged in renovating vats in which the substance was kept or from shellacing in a closed space for several days. The smallest amount of methyl alcohol known to have given rise to poor vision is four ounces. Usually a pint or more must be ingested to give rise to any serious disturbance in vision. The purified product known commercially as Columbian spirits is not nearly so dangerous as the impure product. It is said that the toxicity of wood alcohol depends upon the acetone it contains. Since by purification the odor of wood alcohol has in great measure been done away with it has been used by many firms in the preparation of essences, especially essences of Jamaica ginger, peppermint and lemon, as it is only one fifth as costly as grain alcohol. Harlan and Main demonstrated as much as 75 per cent. of wood alcohol in many preparations of essences and flavoring extracts. In localities in which there are local option laws these preparations are used largely as beverages with the deleterious effect upon the eyes spoken of. The ophthalmoscopic picture in wood alcohol is then that of acute retro-bulbar neuritis, so a differential diagnosis is, therefore, rather difficult. In the absence of exposure to heat and cold, of infectious diseases, injury and so forth and if the patient is known to have used wood alcohol and no other drugs which are capable of giving rise to a retro-bulbar neuritis can we make the diagnosis of wood alcohol amblyopia. The very decided ischemia of the retina may in some cases serve to differentiate it from acute retro-bulbar neuritis from other causes. In a few hours after the appearance of the blindness degeneration begins in the ganglion cells of the macular region and their fibers and then gradually extends brainward. The vision becomes implicated in 12 to 24 hours after the ingestion of the drug.

In the last eight years there have been reported about fifty-five cases of death following the ingestion of varying amounts of wood alcohol. In most of these cases the victims had been on a spree and finished up with several bottles of essence of jamaica ginger or essence of peppermint. Death is said to have followed the ingestion of as little as two ounces of wood alcohol. Eighty-six cases of amblyopia from wood alcohol have been reported. If there are constitutional disturbances present, as great muscular weakness with defective heart action followed by intense gastro-intestinal disturbances with severe nausea and vomiting, headache, coma and delirium and finally the eye symptoms described, a differential diagnosis of wood alcohol amblyopia can be made. If death results it usually occurs within twenty-four hours after the ingestion of the drug. The exact mode of production of death is not known, but Pohl and Hunt have shown that methyl alcohol is excreted from the body very slowly, that it is only partially oxidized in the body, giving rise to a highly poisonous acid namely formic acid and probably also to formaldehyde. The alcohol is excreted into the stomach and then reabsorbed several times so there is kept up a circulation of wood alcohol in the system. The result of this is that the irritating effect of the drug is exerted several times upon the digestive tract.

Treatment of Tobacco-alcohol Amblyopia and Toxic Amblyopia in General.—Of course the first thing for the patient to do is to totally abstain from the use of the agent or agents that have given rise to his poor vision. It is often simply a matter between alcohol or tobacco and the eyesight. Even in very advanced cases the prognosis is good as far as recovery of vision is concerned if the patient will give up the use of the alcohol and tobacco. Much good is at the same time accomplished by the internal administration of strychnin and nitroglycerin. Some believe that potassium iodid hastens a cure, but this is used by few. A Turkish bath or a pilocarpin sweat twice or three times a week favors the elimination of the poison. The marvelous results following the use of large quantities of salt solution injected into the veins or introduced subcutaneously

in uremia, pyemia and septicemia has led to its adoption in toxic amblyopia, in which there is likewise a poison circulating in the system which acts specifically upon the optic nerves. The correctness of this line of treatment is proven by the rapid manner in which the cases improve under it. Cheron, in order to make the serum as antitoxic as possible, uses the following mixture: 1 part of white phenic acid, 2 of chlorid of soda, 8 of sulphate of soda, 4 of phosphate of soda and water to 100 parts. In using the liquid of Cheron we ought to exceed 100 c.c. a day. The solution should be sterilized before using and before injecting it should be warmed and the elevation of the skin produced by the injection should be covered by warm cloths. Three or four injections will sometimes bring the vision up from $\frac{20}{200}$ to $\frac{20}{60}$ or better. This treatment has its disadvantages, inasmuch as the patients often relapse into the use of alcohol and tobacco when they find they are so readily cured. In hemorrhagic amblyopia the serum ought also to be used as the coagulability of the blood is increased thereby. Subcutaneous injections of gelatin, described under the head of recurrent hemorrhages into the vitreous, may also be employed.

Lead Amblyopia is found in painters and those who are employed in paint-shops or factories or in persons poisoned from eating canned food or drinking water conveyed in lead pipes. The commonest ophthalmoscopic picture found is atrophy of the optic nerve with woolly disc margin and smallness of vessels. The center and peripheral vision are likewise affected to a great extent. On the other hand we may find an optic neuritis or the typical quadrant-shaped area of degeneration from retro-bulbar neuritis. There are so many changes in the nervous system and kidneys as well as other organs in cases of lead poisoning that it is difficult to say whether the eye-lesions are primary or secondary to some of these other changes. The ocular changes begin in all events in a fatty change in the terminal vessels of the retina followed by an obliterating endarteritis and degeneration of the areas supplied by these vessels. Lead, like uremia, at times gives rise to temporary obscuration of vision with-

out any ophthalmoscopic change. The diagnosis of lead amblyopia is made by examination of the excreta for the presence of lead or its salts. The prognosis is good in the transient forms but bad if inflammation has set in. The treatment is the same as that given above for alcohol and tobacco save the internal use of magnesium sulphate or other purge is indicated as it is from the intestinal tract the posion is absorbed.

Quinin Amblyopia and Amaurosis. — Quinin gives rise to temporary amblyopias and complete blindness with very characteristic fundus change and alteration in the field. The amaurosis sets in suddenly and lasts for several days, the eyes being blind to light with widely dilated pupils. With the ophthalmoscope there is an extreme ischemia of the retina, so much so that the vessels of the retina can scarcely be found if at all in the pale yellowish-red fundus. The nerve likewise is very white. Associated with this condition we have tinnitus aurium and more or less mental hebetude. Quinin produces an edema of the optic nerve as far as the chiasm and through the vaso-motor system causes the excessive contraction of the retinal vessels. De Bono says that quinin intoxicates the protoplasmic elements of the retina, acting as a depressing poison upon the rods and cones, and Holden believes that the primary action of the drug is upon the ganglion cells of the retina. If the latter theory is correct we should expect to have central vision suffer to the greatest amount as the ganglion cells in the region of the macula are more plentiful than elsewhere in the retina, but this is not the case, for as vision returns in a few days the central vision is found to be very considerably better in proportion than the peripheral. Indeed the central vision may become almost if not quite normal, but the field as a rule remains concentrically contracted.

Treatment. — Besides the use of sweats and serum the inhalation of nitrite of amyl is especially indicated on account of the decided ischemic condition of the retina. A nitrite of amyl pearl containing five drops of the drug may be crushed and its contents inhaled every two hours.

Ptomain-poisoning, Botulismus, Allantiasis.—This occurs from eating decomposed meat, from intestinal absorption, as well as from the bites of poisonous reptiles, snakes, and from the leukomains of poisonous fungi. Breiger says ethylendiamin is the poisonous agent in decomposed flesh. The symptoms closely resemble those of belladonna poisoning. The dim vision is temporary and is due to a paresis of accommodation and iridoplegia. Ptosis at times occurs. Indeed there may be a paralysis of any of the extrinsic or intrinsic muscles of the eyes. There are no alterations to be made out in the fundus. Sometimes the paralyses persist from a basilar meningitis or nuclear hemorrhage. Treatment should be eliminative in character.

Toxic Asthenopia.—Pain on use of the eyes, as well as the other symptoms of eye-strain, are at times caused by the various drugs mentioned in connection with toxic amblyopias, even when used in moderate amounts as pointed out by Dr. Casey Wood some time since. The commonest symptoms are decrease in the amplitude of convergence and accommodation. The asthenopic symptoms occasionally observed in some forms of dyspepsia are undoubtedly mild cases of allantiasis. In not a few cases the patient fails to experience entire relief after the proper glasses have been adjusted because they are habituated to the use of tobacco, alcohol, tea, coffee, etc., even in moderate amounts at times.

Hysterical Amblyopia.—This particular form of amblyopia is most commonly seen in young girls and women, although it does occur in men. The commonest form of trouble is blindness to a more or less degree of one or both eyes without any changes being apparent in the tissue of the eyeball. The pupil of the affected eye usually reacts to light, but may be dilated and stationary. It is rather the rule in hysteria to find both eyes affected, but to different degrees. There is often associated with the eye-symptoms a hemiæsthesia of the affected side with loss of reflexes, especially of the pharynx and cornea, with clonic spasms of the eyelids and face muscles. Distorted vision, seeing objects smaller or larger with one eye than with the other, monocular diplopia, etc., also occur. The diagnosis is very

difficult, especially from pretended blindness. (See page 177, Vol. I.) The field of vision in hysteria, however, will serve to make a diagnosis, as in most cases there is either a reversal of the order of the color fields; that is, red is seen furthest from the center and blue over only a small area, or the red and green fields will be found to reach out to, or even extend beyond, the field for white.

Treatment.—The most effective treatment is a forceful suggestion from the physician that the trouble will get well. Electricity to the side of the face and the administration of tonics aid in the cure.

Pretended Amblyopia.—This has been dealt with fully under the head of simulated blindness in Vol. I, page 177.

Erythropsia, or red-vision, is not uncommonly seen after cataract extraction. It occurs likewise from poisoning from santonin. The latter drug also gives rise at times to xanthopsia or yellow vision. Kyanopsia, or blue seeing, has been described and is said to occur chiefly in patients with more or less amber-colored cataractous lenses, the blue vision depending upon long-continued exposure of the retina to yellow light with its consequent fatigue. This colored vision usually passes off in a few days and if it does not potassium bromid will afford a cure.

CHAPTER XIX

GLAUCOMA

THE term glaucoma is applied to a train of symptoms in which increased intraocular tension usually due to a disturbance in the secretion and excretion of the aqueous humor is the most prominent. Glaucoma may be congenital or acquired and, when the latter, primary or secondary. Primary glaucoma is further divided into acute (inflammatory), subacute and chronic (non-inflammatory).

Congenital Glaucoma (*Buphthalmos or Hydrophthalmos*).—This form of glaucoma is especially manifested by the increase in the size of the entire eyeball. The increased intraocular tension causes the non-resisting tunics of the eyeball of the new born to stretch and the eyeball to assume an enormous size. The cornea is very much attenuated and at times more or less opaque and its diameter much increased, the anterior chamber is deeper than usual, the pupil dilated and the iris tremulous (iridodonesis) from stretching or rupture of the suspensory ligament, and from lack of support by the lens as it remains small. The cause of the trouble is not known but supposed to be due to a disease of the uveal tract in intrauterine life which causes an obstruction to excretion, or to some malformation in the region of the canal of Schlemm. It is present at birth or manifests itself in the first years of life. Heredity plays an important part in its production. Treatment is followed by little result. Iridectomy does no good. Pilocarpin and eserin may be tried. Repeated sclerotomies or frequent punctures of the anterior chamber have been followed by good results in the hands of such men as Snellen and Stölting. Recently sympathectomy (to be described later) has been advocated. The prognosis is very unfavorable. The eyeball usually continues to increase in size until it becomes blind and very

ugly or interferes with the movements of the eyelids. It should then be removed. The disease is usually bilateral.

Primary Glaucoma is very rare in the young, occurring most frequently after the age of 50 or 60 years. The extremes of age noted are 13 and 96 years. There are more women than men who suffer with the acute or inflammatory type of the disease, while on the other hand there are more men affected with the chronic or non-inflammatory form. The Jews and Egyptians are said to be peculiarly liable to the disease. Heredity seems to play an important rôle in the causation of glaucoma. De Wecker says when this is the case the attacks occur earlier in each succeeding generation. In many cases there is a gouty diathesis and those with chronic bronchitis and heart disease are more prone to the disease. Some see a relationship between influenza and non-inflammatory glaucoma. Small hyperopic eyes are especially apt to be affected with glaucoma. This is explained by the fact that the circumlental space is much encroached upon by the large, well-developed ciliary muscle found in such eyes from the constant use of the accommodation. Priestley Smith says the constant increase in the diameter of the crystalline lens throughout life is also an important factor in the etiology. Eyes with small cornea and otherwise normal are more prone to glaucoma, thus the normal diameter of the cornea is about 11.6 mm., while that of many glaucomatous eyes is as little as 11.1.

Ayres has reported a case of glaucoma which seemed dependent upon the presence of a nasal polyp, at least all symptoms disappeared and the patient was well three years after the polyp was removed.

Exciting Causes.—Many indefinite causes are mentioned by various authors as factors in the production of glaucoma, but the cause that precipitates the attack is unknown. Ciliary congestion brought about by a decided impression of an emotional nature, such as great joy, grief, anxiety or what not, exposure to cold, a very hearty meal, loss of sleep, worry, etc., have been mentioned among other causes. Glaucoma may be a symptom of eye-strain from uncorrected errors

of refraction, that is due to an over-use of the accommodation with its consequent ciliary congestion. Mydriatics by dilating the pupil and crowding the iris up into the infiltration angle of the anterior chamber may bring on an attack of glaucoma in those predisposed. Inasmuch as increased intraocular tension is the most prominent symptom in the glaucomatous eye many theories have been advanced to account for it, but what its true cause is, however, has not been definitely determined. Upon it, nevertheless, all the other symptoms seem to depend. Von Graefe taught that glaucoma arose from an over-secretion produced by a serous chorioiditis and Donders that there was an increased supply of aqueous due to nervous irritation. These theories are now discarded and certain retention theories which explain the increased hardness of the eyeball by an obstruction to the escape of the intraocular fluids have been advanced to take their place. The Kneis-Weber theory considers the obstruction to be situated in the infiltration angle of the anterior chamber of the eyeball and consists in the blocking of this angle by the apposition of or adhesion of the periphery of the iris to the sclero-corneal junction, the iris having been pushed forward by a swollen or congested condition of the ciliary bodies. Kneis believed that tension resulted from the iris becoming adherent to the corneo-sclera, while Weber thought the adhesions were secondary to the pressure. That adhesion of the iris to the corneo-sclera does not account for all cases is shown by the fact that glaucoma has not infrequently been observed in congenital anaridia, in coloboma and in aphakia. Recently Kneis has drawn a distinction between simple or non-inflammatory glaucoma and inflammatory glaucoma. He conceives the former to be an optic nerve atrophy with excavation of the nerve and the latter as an irido-cyclitis anterior. Many concur in this view that the pitting of the optic nerve is due in simple glaucoma to a pushing back of the lamina cribrosa by the normal intraocular tension of the eyeball which is rendered possible by some inherent weakness in the lamina or by the presence of an unusually large physiological pit.

Jaeger and Bitzos, as do others, think that the pitting of the optic papilla is always preceded by a papillitis. The aqueous humor is secreted by the ciliary processes, passes forward through the zonula of Zinn into the posterior chamber. It then passes through the pupil, filters through the mesh work of the ligamentum pectinatum and leaves the eyeball by way of the canal of Schlemm. Priestley Smith says the filtration of the aqueous through the pectinate ligament may be retarded by a serosity of the fluid. Troncosco also believes the character of the intraocular fluid has much to do with preventing drainage of the eyeball. He showed that the aqueous of all glaucomatous eyes contained albuminous substances in excess. He concluded that hypertension is produced in two ways, first by the greater difficulty in the excretion of an aqueous loaded with albuminoid material, and secondly that there was also a mechanical interference caused by the advance of the iris. He thinks the albuminoid substances may result from a low grade inflammation in the anterior segment of the eyeball or from a vascular infirmity in the ciliary processes which allows the escape of albumin. In the normal condition the vessels of the ciliary bodies do not allow the passage of albumin into the aqueous, but in the event of arterio-sclerosis, described by several observers as the most constant lesion in glaucoma, this may occur. Neisnamoff says in some cases the meshwork of the infiltration angle becomes choked with exfoliated pigment cells from the posterior surface of the iris and from the ciliary bodies. Many believe that in some cases the crystalline lens being relatively too large becomes dislocated in front of the ciliary bodies and thus pushes the iris forward, occluding the canal of Schlemm. Stilling says tissue change within the eyeball may hinder the exit of fluid from it by the way of the posterior lymphatic channels around the optic nerve.

Rheindorf claims that the obstacle to excretion is a sclerosis of the zonula of Zinn. Laquer believes that the hypertension of the eyeball is the result of the obstruction of the lymphatics which pass out of the eyeball around the venæ vorticosæ. Abadie says the fila-

ments of the sympathetic play the chief rôle in all nutritive troubles of the eye, among which he places glaucoma. In the acute there is a transient and in the chronic form a permanent excitation of the vaso-dilator fibers of the ocular vessels; all other symptoms he believes proceed from this beginning. As a proof of the correctness of his theory he cites the action of mydriatics and myotics upon the eye, which dilate or constrict the vessels as they do the pupil. In a few cases the cause of tension seems to have been faulty metabolism due to a degeneration of the vessels of the chorioid with aneurismal dilatations occurring in places like beads upon a string. Wahlfors thinks the real origin of glaucoma is atrophy of the chorioidal elements. This destroys the nerve sensory apparatus and leads to an increase in the intraocular tension by paralysis of the muscular network of the chorioid, slowing the course of the currents of liquids with the eyeball. The channels of exit thus become blocked and cause tension. He believes that in simple glaucoma there is a primary atrophy of the lamina cribrosa and a secondary pitting of the optic disc. Zimmerman considers glaucoma due to a decrease in the general blood pressure, brought about by heart disease, shock or what not, in consequence of which blood is not properly forced into the eye. Stasis, then edema, results, raising the tension. Treatment by general measures has been most satisfactory, strophanthus and adonis vernalis giving the best results. It will be seen from the foregoing account that no one cause can be assigned to all cases to explain the hypertension in the glaucomatous eye.

Acute Glaucoma, also called inflammatory or congestive glaucoma, may come on very suddenly (glaucoma fulminans), the patient retiring at night for instance with good sight to wake irreparably blind. Usually, however, there are certain prodromata. This prodromal or intermittent stage is characterized by mild attacks in which the vision is more or less disturbed, the cornea slightly steamy and anesthetic, pupil moderately dilated and reacting sluggishly. The anterior chamber is shallower than normal and there is a venous circumcorneal injection of a violaceous hue and palpation shows the pres-

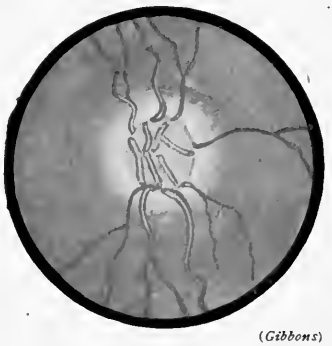
ence of hypertension of the eyeball. During this stage artificial lights seem surrounded with a rainbow of colors due to the edema of the corneal epithelium. If the media are clear enough the ophthalmoscope reveals a turgid condition of the retinal vessels, but there is as yet no pitting of the optic papilla. The attack passes off and the eye returns to its normal condition save there remains an appreciable decrease in the accommodative power. The patient discovers he is unable to read as well as formerly and applies for a change in his glasses. With stronger reading glasses the vision is once more brought to normal. These prodromata recur once or twice a month or so, and may continue months or years until they finally terminate in an acute attack.

The attack itself, whether preceded by a prodromal stage or not, is ushered in with violent and excruciating pain extending to the side of the head and face, and not infrequently extending to the shoulder, and associated with nausea and vomiting. The lids and ocular conjunctiva are more or less edematous. The cornea is decidedly hazy, owing to an edema of its uppermost layers, so much so that the pupil is seen with difficulty. The haziness of the cornea may be more dense in spots, imparting to the cornea a mottled appearance. If the cornea is touched with a wisk of cotton it will be found to be almost, if not quite, insensible. The pupil is dilated and immobile and emits a greenish reflex from the lens from which the disease gets its name (γλαυκός, green).

The pupil is seldom uniform in its dilatation and the tissue of the iris is discolored and its marking effaced (irititis); the aqueous and vitreous humors are also turbid, so that as a rule no view of the fundus can be obtained. If the dioptric media are clear enough the papilla will be found very hyperemic and the retinal arteries pulsating. According to most authorities the dilated pupil in glaucoma is the direct result of the intraocular tension interfering with the nerve innervation to the iris, as all the nerves and vessels passing through the tunics of the eyeball are pressed upon. Franck believes that the pupil is expanded, however, by the overaction of the sympathetic, as

he found the vaso-dilators of the eye arising in the medulla with the dilator of the pupil and following the same course, and he remarks that both are thrown into action at the same time.

The sight at this time, partly from the turbidity of the humors and cornea and partly from the pressure upon the retinal vessels and optic nerve fibers as they pass into the eye, rapidly falls off until only large objects or fingers held close to the eyes can be seen. Palpation of the eyeball reveals a stony hardness. After a few days or weeks the intensity of the case subsides. The corneal haze and edema of the lids and conjunctiva disappear. The pupil, however, usually remains semidilated and sluggish, the circumcorneal injection does not entirely fade, tension remains up and the anterior chamber somewhat shallower than normal. The vision is now found to have suffered considerably.



(*Gibbons*)

Glaucomatous Excavation of the Papilla.

This condition just described following the acute attack is called the Status glaucomatosus. After a varying interval there is another outburst of the disease, then another, until the sight is completely abolished. We have then a condition spoken of as absolute glaucoma. The eye now presents a dull expressionless look, the cornea is surrounded with a zone of purplish hue, the anterior ciliary vessels are engorged, the pupil is dilated and displays a border of black pigment (ectropion pupillæ). The lens and narrow rim of atrophied iris are in contact with the posterior surface of the cornea, thus obliterating the anterior chamber. The tension of the ball is high unless degenerative changes have begun. The ophthalmoscope now reveals the characteristic cupping of the papilla. The nerve is white or bluish-white, the vessels crowded well to the nasal side of the disc and are seen to make sharp bends as they pass over the edge of the pit into the surrounding retina.

The patient may continue to suffer great pain even after the eye has been rendered sightless. Decided tissue changes occur in the eyeball after the glaucoma becomes absolute. The atrophied sclerotic coat yields to the pressure from within and bluish-black swellings appear between the limbus and the equator (ectasis of sclera). The cornea and lens become opaque, the retina detached and the eyeball soft from fluidity of the vitreous. We have now a condition of total atrophy. Sloughing of the cornea or panophthalmitis may occur.

Subacute Glaucoma.—This is not as intense as the acute, but consists rather in the prodromal stage of the latter. It may be intermittent or continuous from the outset, but usually passes slowly into the chronic congestive form. In the latter the sclera appears as a dusky or livid hue from deep injection and turgidity of the anterior ciliary vessels, especially the anterior ciliary veins. The cornea has a smoky appearance and is insensitive. The pupil is irregular, being tied down in places by adhesions to the lens capsule, the iris attenuated and faded in appearance, due to atrophic changes, and the anterior chamber shallow. The pain is not so intense in the subacute as in acute glaucoma. Central vision gradually fades and the field gradually contracts. Like the acute form, if treatment is not instituted or fails to benefit, it passes into the absolute stage.

Simple, Chronic or Non-inflammatory Glaucoma.—Simple glaucoma is a very insidious disease and is seldom discovered until far advanced. It has little or no tendency to exacerbation or remission. Unless arrested by treatment it leads in the course of months or years to total blindness. The patient usually consults the physician for failing vision. He may have had his presbyopic correction changed frequently within a few months. On examination the range of accommodation will be found much curtailed, the patient being more presbyopic than his age would indicate. Often one eye is alone affected or to a greater extent than its fellow. The disease is as a rule, however, bilateral. We sometimes obtain a history of periods of obscuration of vision with the rainbow effect about artifi-

cial lights. There is also frequently a history of nervous exhaustion from some cause.

The anterior ciliary veins are found slightly engorged, the anterior chamber too shallow. One or both pupils may be partially dilated and act poorly, but this does not occur regularly in all cases. The lens often appears opalescent when with the ophthalmoscope it will be found perfectly transparent.

The tension of the eyeball is increased in the majority of cases, although at the time of examination this may not be so. As the tension fluctuates it should be examined several times during the day, especially after a full meal or in the evening after the worry and toil of the day. There are cases which never show an appreciable elevation of tension. Such may be examples of progressing optic atrophy with excavation of the disc. The refraction of the eye will be found to be hyperopic, with or without astigmatism, which is against the rule in most cases. If the patient was previously emmetropic, forward dislocation of the lens through the intraocular hypertension produces myopia, while the eye becomes more hyperopic if the tension is exerted chiefly upon the zonula of Zinn. In most cases the refraction is increased, being a diopter or so higher during an attack of tension (due to forward dislocation of lens).

Both peripheral and direct vision suffer in simple glaucoma, especially peripheral vision. In many cases a good degree of central vision is retained for a long time after the field is so contracted that the patient is unable to get about alone. In such cases not infrequently complete blindness comes on suddenly. In all cases the field of vision will be found constricted and most on the nasal side but there is in many cases concentric contraction. In some cases sector-like defects are seen, in others dumb-bell shaped fields and many bizarre forms. The color fields do not as a rule show any disproportionate shrinkage as in optic atrophy from other causes. There are cases, however, in which the color fields show a greater proportionate contraction than the form field, making the differential diagnosis between optic atrophy and glaucoma difficult from the field

alone. The excavation of the optic nerve is the most marked objective symptom in cases well advanced, being rarely absent when the patient is first seen.

The excavation of the nerve in glaucoma involves the entire or almost the entire surface of the disc and attains a considerable depth. The sides of the pit are steep and at times overhanging so that the vessels disappear from view as they pass up the side of the pit. The vessels are all crowded to the nasal side of the pit and are seen to make sharp bends as they pass from the pit into the retina. It is impossible if the pit is deep to get the vessels in its bottom and upon its edge in focus at one time so that they appear lighter in color and blurred either in the retina or in the pit. With the direct method a stronger concave or weaker convex lens is needed to see the vessels in the pit than in the surrounding retina; thus we can measure the depth of the excavation, every three diopters corresponding to about one millimeter of pitting. The vessels also undergo parallactic displacement upon the bottom of the pit as the objective lens is shifted. The disc often shows a greenish pallor and is surrounded by a more or less complete yellowish-white ring of chorioidal atrophy which is called the glaucomatous halo. Not uncommonly a low grade neuritis is manifest.

Arterial pulsation is often present or can be produced by gentle pressure upon the eyeball. The cause of this is that the blood is unable to enter the eyeball on account of the tension except during the systole of the heart. Venous pulsation is less commonly seen though often present. The pitting of the optic papilla in glaucoma is brought about by the intraocular tension causing the lamina cribrosa to recede, it being the weakest point in the tunic of the eyeball. In some cases the process is no doubt favored by an inflammation and softening and later cicatricial contraction, explaining those cases of deep pits without appreciable tension.

Glaucoma simplex nearly always attacks both eyes as has been said. In contra-distinction to inflammatory glaucoma it at times occurs in young people and attacks men more frequently than women.

It is also occasionally found in myopic eyes, which never develop inflammatory glaucoma.

Secondary Glaucoma is applied to increased intraocular tension with its train of symptoms occurring as the result of some antecedent disease or injury of the eye. It is most commonly seen in the following conditions.

1. *Occlusio and Seclusio Pupillæ from a Plastic Iritis or Iridocyclitis.*— In this condition the aqueous is pent up behind the iris, which it bulges forward against the posterior surface of the cornea and to which it finally becomes adherent at its periphery, closing the spaces of Fontana.

2. *All Intraocular Tumors* at some time in their progress give rise to intraocular tension, especially if of rapid growth, by interfering with the vortex veins or drainage system of the eye.

3. *Corneal Ectasis*, and especially those associated with an inclusion of the iris universally lead to secondary glaucoma. It is only occasionally that a keratectasis resulting from a disease of the cornea is followed by a rise of tension. Scleral ectasis resulting from injury or disease may likewise be followed by glaucoma.

4. *Fistula of the Cornea* if it closes after remaining open a long while.

5. *The Crystalline Lens* may give rise to secondary glaucoma in two ways: (*a*) After a discission or traumatic rupture of the capsule of the lens the latter may swell rapidly and press the iris forward, besides filling the aqueous with an albuminous material difficult to excrete. (*b*) Luxations of the lens and especially those in which the lens is wedged into the pupil or passes through the latter into the anterior chamber nearly always cause tension.

6. *Intraocular Hemorrhage* due to an atheromatous or hyaline condition of the vessels of the retina. Secondary glaucoma from this cause not uncommonly occurs in albuminuric retinitis, and is known as hemorrhagic glaucoma.

7. *Serous Irido-chorioiditis* often gives rise to increased tension, so that the use of atropin in this affection must be guarded.

Diagnosis. — A rapid increase in presbyopia with history of periods of poor vision should arouse the suspicion of the physician. The acute form of glaucoma is most frequently taken for iritis, but in the latter the pupil is smaller than normal, while in the former it is dilated, unless tied down by adhesions. The eyeball will be found hard, however, in glaucoma, the cornea insensitive and the anterior chamber shallow. In the non-inflammatory forms the diagnosis is often difficult, but can usually be made upon the character of the excavation of the disc. Physiological pitting involves only a portion of the papilla while the rest presents a normal pink appearance. Physiological excavation is furthermore always bilateral. The pit in atrophy of the optic nerve is shallow and slopes gradually to the depth of the physiological excavation if one is present, and the nerve head is paler than it would be in glaucoma with an equal amount of pitting. In glaucoma the pit is deep, its sides steep and often overhanging and extends to the limits of the disc. The vessels are also all pushed well to the nasal side. Again good central vision is much more apt to be present in glaucoma than in optic nerve atrophy and the color sense is not altered until very late in the progress of glaucoma, while it suffers out of proportion to the form field in atrophy of the nerve. The shape of the form field may give us some information as well as to the nature of the trouble.

Treatment. — Iridectomy, which was first advocated by Von Graefe in the year 1856, is still the best means we possess for combating the rise of intraocular tension. All are not agreed as to the manner in which it operates in lowering the tension. The more acute the attack and the more decided the tension the more brilliant is the result following an iridectomy. The majority of observers believe that an iridectomy does good simply by affording better drainage through the infiltration angle of the eyeball, which had become occluded by the advance of the root of the iris. The iridectomy for glaucoma is therefore made broad, including about one fifth of the circumference of the iris and should include likewise the root of the iris. The primal incision should be made a little posterior to the

limbus and better with the spade knife. The latter should be withdrawn gradually, so that the eye does not suffer a too sudden diminution in tension, as that is at times followed by an intraocular hemorrhage or rupture of the zonula of Zinn with loss of vitreous humor. The iris repositor should be used after the iridectomy so that the angles of the scleral wound are left perfectly free of iris-tissue. General anesthesia is more satisfactory than cocain in acute forms of glaucoma because very little of the drug can be absorbed on account of the tension. It is furthermore essential for the patient to be perfectly quiet so that one does not wound the capsule of the lens in performing the iridectomy. A certain amount of bleeding nearly always occurs in the anterior chamber from the iris, because the tension has caused the vessels to lose their elasticity and they therefore do not retract when divided. Adrenalin solution (1–1,000) instilled several times before and after the operation lessens the liability to hemorrhage. It at times happens that the edges of the wound do not coapt well, but turn out or remain separated so that the wound fills in with cicatrix or perhaps there is left a fistulous opening. Either condition rather adds to the success of the operation by allowing a continuous escape of the aqueous. Abadie explains the curative effect of an iridectomy in the following manner: Under normal conditions the nerves which control vaso-dilatation and constriction traverse a nerve-plexus in the central part of the iris in the cells of which terminate a certain number of ciliary fibers. When vaso-dilator impulses take place it comes without hindrance to this plexus where probably nervous force is stored up and dilatation of the ocular vessels is the result. If this circular nervous plexus is interrupted by an iridectomy the invigorant action of the dilator impulses ceases. In iridectomy it is then not merely the excision of the iris, but the cutting of a portion of the nervous net-work it encloses. If the periphery of the iris is alone removed the operation is not followed by curative action, but on the other hand, if the middle portion of the iris containing the nerve elements is excised, leaving the other portions intact, cure is effected as

though the excision had been made complete. Even a simple incision will suffice according to Abadie.

In acute glaucoma the pain, tension and corneal steaminess promptly disappear after an iridectomy and the vision is rapidly improved and not infrequently restored to normal if the operation is done without delay. In the more chronic forms of glaucoma on account of the degeneration and pitting of the optic nerve iridectomy does not accomplish so much. In chronic inflammatory glaucoma, according to Gruening, the morbid process is usually checked however by the operation.

In simple glaucoma iridectomy benefits in about one half of cases, retaining what vision the patient had prior to the operation. In the remaining number some are not benefited at all, tension remaining up and the eye going on to blindness, while others are made worse. In about 2 per cent. of cases of the non-congestive type iridectomy is followed by circumcorneal injection, steaminess of the cornea and great increase in the tension. The anterior chamber remains empty and the vision is destroyed. To this condition the term malignant glaucoma has been applied. It seems predisposed to affect both eyes so that Schweigger advocates to operate upon the worse eye first even if it is blind. If this heals well the fellow may be expected to follow a similar course, but Freidenwald has shown that the second eye may develop malignant glaucoma even when the first eye showed no such disposition. Absence of perceptible increase in tension and a much contracted field of vision lessen very much the chances of iridectomy doing good. Next to iridectomy sclerotomy is most often practiced, but it should never be done as a primary operation as it is vastly inferior in its curative power to iridectomy. It is often done after an iridectomy if the latter fails to benefit or when the iris tissue is so atrophied that an iridectomy is impossible. Smith and Gifford perform sclerotomy in cases with very shallow anterior chambers prior to an iridectomy. Terrien reports cases in which no effect followed an anterior sclerotomy, but tension was lowered by posterior sclerotomies. In one case reported posterior sclerotomy failed

to relieve the tension on account of an edema of the vitreous as he thought and says edema of the vitreous may be the secret of non-success following posterior sclerotomies in some cases. Now and then operation upon one eye is followed by a fulminating glaucoma in the other one so that it is a wise plan to instill several drops of a solution of eserin in the fellow eye before doing an iridectomy. Painful and sightless eyes should be enucleated.

Chibret advocates puncture of the sclero-cyclo-iridal angle in the treatment of glaucoma. Gould, Pratt and Dornec report cases in which direct massage to the eyeball was used in the treatment of the more chronic forms with flattering results. The massage may be applied through the upper lid with the ball of the thumb in a circular manner over the sclero-cornea, or as Dornec prefers by rapid and often repeated pressure upon the globe at the upper corneal border. This method of treatment is applied once or twice daily, but it needs further trial for one to form proper conclusions as to its value.

In 1897 Abadie said that section of the cervical sympathetic ought to be followed by a decided improvement in the glaucomatous eye and predicted a great rôle for sympathectomy in ophthalmic surgery. Shortly afterwards Jonnesco, of Bucharest, performed the operation of cervical sympathectomy for the relief of glaucoma. Long before the time of Abadie the relation of the cervical sympathetic to the tension of the eyeball was appreciated.

In 1867 Adamük and Wegner discussed the relationship between intraocular tension and disorders of the cervical sympathetic and the influence of the latter in the development of glaucoma. These observers and others noted that stimulation or irritation of the superior ganglion of the sympathetic in the neck of rabbits was followed by a dilated pupil and increased intraocular tension, while excision of it produced the reversed phenomena. Not only is simple glaucoma benefited by the operation of Jonnesco, but exophthalmic goitre and optic nerve atrophy in a certain number of selected cases. Before describing the technique of the operation a few words will be

said concerning the anatomy of the cervical sympathetic and its distribution to the eye.

The sympathetic nerve is composed of a collection of ganglia, cords and plexuses or rather of two great gangliated cords lying partly in front and partly to the side of the spinal column and running from the skull to the coccyx. The number of ganglia correspond to the vertebræ against which they are placed except in the neck, where there are only three in number. There is a connection between these ganglionated cords and the central nervous system by means of short communicating rami of two kinds, the one of medullated fibers and the other of gray fibers. The medullated fibers proceed from both roots of the spinal nerves but to a greater extent from the anterior roots and pass to the sympathetic. In man these communicating rami are found from the first dorsal to the second or third lumbar nerves. The fibers arise in the nerve cells of the ganglia of the sympathetic and enter the primary anterior division of the spinal nerves. The majority of the fibers of the superior cervical ganglion are medullated and pass to the fifth cranial nerve and are distributed with its sensory fibers, for example the pupillodilator fibers and other fibers destined for the eye pass into the ophthalmic division of the fifth nerve and long ciliary nerves.

Vasoconstrictor fibers to the iris run in the internal carotid plexus. A few fibers from the superior cervical ganglion proceed to the third and to the sixth cranial nerves which are supposed to convey vasomotor fibers to the vessels of the ocular muscles. This system of the sympathetic includes also aberrant motor cells such as are found in the course of the spinal accessory, in the ganglion trunci vagi and in the course of the third nerve in the ciliary ganglion.

Four sets of fibers pass to the eye, according to Thane's classification from the sympathetic of the neck, they are:

1. *The Pupillodilator Fibers.*—These arise from the second and third dorsal nerves and are connected to the superior cervical ganglion of the sympathetic by means of slender gray cords. They pass upward in the carotid branch of the ganglion and arrive at the

plexus around the internal carotid artery and the Gasserian ganglion. They pass to the eyeball through the first division of the fifth nerve by means of the long ciliary nerves, which pierce the sclerotic coat and are distributed to the ciliary muscle, iris and cornea. Some believe pupillodilator fibers are also found in the seventh and eighth cervical nerves. A small filament passes into the eye with the central retinal artery.

2. *Motor Fibers to the Involuntary Muscles of the Orbit and Eyelids.* — These, according to Langley, come from the fourth and fifth dorsal nerves and their communicating rami. The involuntary muscle of the orbit receiving this sympathetic nerve supply was first described by Müller in 1858 and is called after him. It is a more or less rudimentary mass of fibers that bridges over the spheno-maxillary fissure and infraorbital groove. In certain animals the muscle is well developed and is found in the extensive aponeurosis of the orbital wall. The contraction of this spheno-maxillary muscle causes the eyeball to start from the orbit. Müller also described the involuntary part of the levator palpebræ superioris and a mass of involuntary fibers found in the neighborhood of the inferior oblique muscle of the eyeball. Each of these latter is attached to the upper edge of the tarsus of the corresponding lid and aid in opening the eye. According to Dwight the function of the fibers of Müller in the upper lids is to draw the skin to the fold above when the lids are open.

3. *Secretory Fibers.* — These are derived from the third, fourth and fifth dorsal nerves and pass to the eye through the lachrymal branch of the fifth cranial nerve. Their sympathetic fibers are derived from the superior ganglion of the cervical sympathetic.

4. *Vaso-constrictor and Vaso-dilator Fibers.* — These probably arise from the second, third and fourth dorsal nerves. Their course to the eye has not been definitely made out.

Jannesco's Operation is performed as follows: An incision about four inches long is made, beginning at the tip of the mastoid and extending down along the posterior border of the sterno-cleido-mastoid muscle. After this the operator proceeds with a blunt

instrument and separates the muscles until the rectus capitis anticus major is reached; for directly beneath its sheath is the ganglion.

On top of it lies the internal carotic artery, the internal jugular vein and the pneumo-gastric nerve enveloped in their sheath. The superior ganglion is now sought for and its branches divided as high up as possible and at least one inch below the ganglion. The ganglion is readily recognized by its peculiar color, shape and relations to the transverse processes of the second, third, fourth or fifth cervical vertebræ, rectus capitis anticus major muscle and internal carotid artery. It is not necessary to cut or ligate the external jugular vein or cut the spinal accessory nerve, as Ball says, provided the dissection is done with a blunt director, or what not, after having made the initial skin incision. The operation is neither lengthy nor bloody and the wound heals promptly if the operation is clean. The mortality is practically nil. According to Nicati we may expect to find any or all of the following conditions after resection of the cervical sympathetic: Contraction of the pupil, narrowing of the palpebral fissure from a partial ptosis, decrease in intraocular tension, lachrymation, injection of the ocular conjunctiva and often slight exophthalmos, congestion of the same side of the face, anidrosis or hyperidrosis and in a few cases acceleration of the heart beat.

The ptosis is permanent, the myosis persists for several months, and the tension of the eyeball becomes normal after some weeks or months, gradually becoming less pronounced. The vaso-motor disturbances disappear in a comparatively short time. In a few cases atrophy of the same side of the face ensues.

Positive conclusion as to the advisability of sympathectomy can not be reached. The statistics up to date indicate that the simple non-inflammatory form of glaucoma is the one most suited to the operation next to the hemorrhagic form if that can be determined. As a safe guide one may follow Abadie when he says: "In acute forms of glaucoma and in subacute with intermissions, practice first iridectomy and if it fails do sympathectomy. In simple glaucoma

use myotics twice a day and if they suffice continue them. If the vision continues to fail do sympathectomy."

The Medicinal Treatment of Glaucoma.—Many feel that the best results are gotten in the simple non-inflammatory forms of glaucoma by the employment of myotics and careful attention to hygiene, diet, avoidance of excitement of all kinds and so forth. Eserin or pilocarpin are the myotics employed and are used in solution of one eighth to one half grain to ounce instilled twice daily. If the pupil is kept small and tension less by their use they should be continued. Unfortunately they do not always continue to benefit over any length of time, the eye growing worse despite their use. After a certain length of time they not only produce considerable external irritation, but ciliary congestion. Freidenwald and Stupen first recommended large doses of salicylate of sodium in glaucoma and undoubtedly it exercises a very beneficial influence over the disease. If for some reason operation is denied or has to be postponed, in a case of acute glaucoma a myotic should be instilled and the eyeball massaged twice a day. A hot box should be worn constantly and 15 to 20 grains of salicylate of soda taken every two hours until decided systemic disturbance is produced thereby.

CHAPTER XX

CATARACTS AND DISLOCATION OF THE LENS

A CATARACT is an opacity of the crystalline lens or of its capsule. We have therefore lenticular, capsular and lenticulo-capsular cataracts. Cataracts may be congenital, acquired, partial, stationary or progressive. They are furthermore primary or secondary. The following scheme includes the commonest forms of cataract:

- **Partial Stationary Cataracts.**
  - Anterior polar cataract, Posterior polar cataract } Capsular,
  - Circumscribed opacities in lens itself (lenticular),
    - (*a*) Small nuclear opacity,
    - (*b*) Spindle-shaped or fusiform opacity,
    - (*c*) Punctate cataracts,
    - (*d*) Perinuclear, zonular or laminar cataracts.
- **Progressive Cataracts.**
  - Nuclear or cortical,
  - Incipient,
  - Intumescent,
  - Mature,
  - Hypermature
    - Liquefied or Morgagnian,
    - Liquefied with thickened capsule called cystic,
    - Shriveled with thickened capsule (Cataracta arida siliquata),
  - Cataracts adherent to iris or ciliary bodies (Cataracta accreta),
  - Traumatic cataract.

A cataract may be soft or hard and this can be told as a rule by the color of the opaque lens; thus, all light-colored cataracts are soft and all dark-colored ones are hard.

Cataracts were so called by the ancients because they believed them to be something which flowed down from above (like a waterfall) behind the pupil. They were well known to the Greek and

Roman physicians. On account of the greenish-gray appearance cataract was at times called glaucoma. They located the opacity of the pupil in front of the lens instead of in that body itself. The lens was considered to be the true seat of vision, that is the percipient organ, as it was the most obvious thing when the eyeball was opened; so accordingly the loss of the crystalline lens would mean total blindness, but since they were aware that after operation for cataract the pupil was rendered clear and still the sight was not lost but restored, they were forced to believe that the pupillary opacity was situated in front of the lens itself. Our knowledge of the true nature of cataract dates from the beginning of the eighteenth century. Even before this Mariotte and Boerhaave recognized the true locality of the opacity, but their theory was not generally accepted. About the year 1705 one Brisseau, a Frenchman, was able to perform a depression of a cataract in the eye of a cadaver and then open the eye. He found that the opaque body he had depressed into the vitreous humor was indeed the crystalline lens. He laid his observations before the French Academy, but his theory was confuted. Three years later others brought new proofs of the true nature of the disease and the Academy finally recognized the doctrine and it then soon gained general acceptance. Jacque Daviel was the inventor of the modern operation for cataract; Samuel Sharp, an Englishman, was the first to perform a simple extraction and Thomas Young, a Scotchman, was the first to give the profession a suitable knife with which to operate.

Etiology.—Cataracts may be congenital, due to senility or general diseases, caused by trauma or secondary to other diseases of the eyeball. The latter are also called complicated cataracts.

Congenital Cataracts.—The cause of this variety of cataract is either a disturbance in the development or an intrauterine inflammation of the eye. Both the stationary and partial cataracts which are the anterior and posterior polar cataracts and the progressive forms of cataract may be congenital. They are as a rule bilateral and run in families and are often associated with other lesions as

amblyopia, chorioidal disease or malformation of the optic discs or tracts.

Senile Cataract is by far the commonest form of cataract. It occurs very frequently in old people, or those over fifty years of age as a rule. It is exceptionally observed in younger individuals. We must not fall into the error of calling all cataracts occurring in the elderly senile, as an old person may have a cataract from trauma, diabetes or what not. Senile cataract affects both eyes always, but one eye is usually in advance of the other.

Cataracts due to General Diseases.—The commonest general disease giving rise to opacity of the crystalline lens is diabetes. This develops when the amount of sugar in the urine is high and it matures rapidly. Diabetic cataract is due to a disturbed nutrition that affects the entire system, and not to the abstraction of water from the lens as was once believed. If a transparent lens is placed in a solution of sugar or salt it very soon becomes opaque from the loss of water which the solution takes by osmosis. If the lens is now placed in plain water it will regain its transparency. The same experiments can be done upon a frog. If the blood in the vessels of a frog is replaced by a solution of sugar or salt his lenses become opaque, to clear up again after he is put back into plain water. These experiments seemed to confirm the fact that diabetic cataract only occurred when the amount of sugar in the blood is great and was directly due to it. There is a form of cataract, however, that is due to the direct abstraction of water from the lens, and that is the opacity of the lens that occurs in the last stages of Asiatic cholera. As a rule an eye affected with a diabetic cataract recovers as well as any other from the operation, so there is no particular danger in operating upon them as formerly believed. Coma and death, however, now and then follow operation for cataract in diabetics, due to the confinement or shock of the operation. Nephritis also gives rise to cataracts in adults, and rickets to a form of congenital cataracts (perinuclear). Syphilis, according to Michel, is a causative factor.

Traumatic Cataract.—A blow upon the eyeball may rupture the capsule of the lens, and allowing access of the aqueous cause a cataract. More commonly a piece of wire, wood, tack, or what not penetrates the cornea and inflicts a wound directly in the capsule of the lens. Through imbibition the lens swells, becomes opaque and finally breaks up through a process of cleavage. Precisely the same thing takes place if a transparent lens is placed in clear water. If the traumatism affects the posterior portion of the capsule of the lens the vitreous acts in the same way. A cataract may be caused by contusion of the lens without the imbibition of the aqueous, and such at times clear up spontaneously. The history of a traumatic cataract is somewhat like the following: In a few hours after the injury to the eye the part of lens in the neighborhood of the capsular wound is found to be opaque. After a day or so, depending upon the size of the rent in the capsule, the swollen lens fibers protrude through the wound of the capsule into the anterior chamber as flocculent masses. A certain amount of the disintegrating lens substance settles to the bottom of the anterior chamber. The opacity continues to spread further and further through the lens and new masses protrude through the pupil as the former ones become absorbed. If the swelling of the lens is not too rapid, so that the tension of the eyeball is not interfered with, or if the iris is not too forcibly pressed upon, the eye remains free of inflammation and pain and the lens becomes gradually absorbed within a month or two. The absorption may come to a standstill at some period of the disease, due to closure of the lens capsule, and opaque portions of the lens still remain within the shrunken capsular sac, demanding an operation for the restoration of the sight.

As a direct result of the injury to the eye or the result of infection the membranes of the eye, and especially the uvea, may become inflamed during the course of a traumatic cataract. Then the clouding of the lens and the inflammation usually in the form of an iridocyclitis go on at the same time. In a few cases the inflammation is the direct result of the growth and progress of the cataract, the

swelling lens pressing upon the iris and irritating it, or by filling the anterior chamber with soft lens substance and albuminoid material renders excretion of the aqueous difficult and thus gives rise to increased intraocular tension. The irido-cyclitis often leads to the adhesion of the lens capsule to the iris and ciliary bodies, giving rise to what is termed adherent cataract (cataracta accreta). By such adhesions the operation for cataract is rendered very difficult. The plastic irido-cyclitis may be severe enough to totally destroy the sight or panophthalmitis may develop if the infection has been violent enough.

Secondary Cataracts (*Complicated Cataracts*).—The affections most frequently giving rise to cataracts by disturbing the nutrition of the crystalline lens are: Violent inflammations of the cornea, as an extensive suppuration; irido-cyclitis; chorioiditis; myopia of high degree; retinitis pigmentosa; detached retina; glaucoma in the absolute stage. The diagnosis that a cataract is due to some other morbid change in the eyeball can be made by inspection in case the disease affected the more anterior portions of the globe. Morbid changes in the cornea or in the iris, or adhesions between these organs and the cataract may be made out. In deeper affections the resulting cataract often presents peculiarities which make a diagnosis of secondary cataract, although other evidence of the disease is not apparent. Thus in chorioiditis and retinitis pigmentosa stellate anterior and posterior cortical cataracts are found and total cataracts are often found liquefied, calcified, with thickened capsules, of a yellow or greenish color associated with tremulousness of the iris. Again in uncomplicated cataracts the light perception is always good, no matter how dense the opacity of the lens, while in secondary cataracts the light perception is found very poor or perhaps wanting all together. Again in secondary cataracts the tension of the eyeball may be found too soft, showing the presence of chorioidal lesions or too hard, showing a glaucomatous state. The prognosis in secondary or complicated cataracts is less favorable than in other varieties, both because the operation is rendered more difficult and

because the sight is apt to be poor from the accompanying disease even if the removal of the cataract is successful.

Symptoms. — Loss of or distortion of vision is the only symptom of cataract and it varies according to the stage of the latter and upon the situation of the opacity. Small, sharply circumscribed patches of cloudiness as polar cataracts do not disturb the vision as the more diffused clouds. Opacities in the posterior portion of the lens near the nodal point disturb the vision to a greater extent than the same amount of opacity in the anterior portion of the lens.

Besides simple failure of vision cataract patients often complain of specks before the eyes and of polyopia. The opacities in the lens become recognized as they cast shadows upon the retina, and on account of the refraction of the lens being different in different portions the patient, when he looks at an object, sees it two or more times. Seeing specks before the eyes and distorted vision often brings the patient to the physician before any decided opacity is apparent in the lens, but only a high degree of irregular astigmatism discoverable by retinoscopy due to the altered refraction of the lens in sections. If the opacity is nuclear the vision will be better when the pupil is dilated, that is in poor illumination (nyctalopia), while the reverse is the case, but to a less degree, in the cortical forms of cataract (hemeralopia). Folks with central opacities can often be given vision enough to carry on their vocation by keeping the pupils partially dilated with a weak solution of atropin.

Later on as the opacity increases the sight becomes worse and worse, the specks before the eyes and polyopia disappear and the patient becomes blind save to light. The examination of the perception of light is of great importance in regard to the prognosis of the case. If it is deficient or entirely wanting there is present a complication on the part of the retina or optic nerve. Myopia frequently develops in the beginning of cataracts, due to swelling and increase in refraction of the lens, so that reading glasses can be dispensed with, but at the same time the individual cannot see so well in the

distance as formerly. This condition is spoken of as second sight by the laity.

Objective Symptoms.—In the very beginning the irregular refraction of the lens is made apparent by the plane mirror. On rotating the mirror the light in the pupil moves irregularly, that is there is present a high degree of irregular astigmatism. The plane mirror is especially adapted to diagnosing cataracts in the beginning, for often with the concave mirror, as well as by daylight, there seems to be an opacity, when with the plane mirror there is no opacity found. This is because the lens reflects more light as it undergoes a process of sclerosis, and instead of the pupil looking black it has an opalescent appearance, a condition often taken by the beginner to be a cataract. If the opacities of the lens lie far in the periphery it may be necessary to dilate the pupil to bring them into view, although they can be frequently seen by having the patient look far to one side or the other or up or down. The opacities will then be seen as dark spicules or radii extending towards the center of the lens. By reflected light the opacities present themselves in their true color, as gray or whitish spots or striæ. Often they are of the form of sectors or radii. With the ophthalmoscopic mirror the opacities appear dark upon the red background of the pupil unless very dense, when they are seen in their true color. By lateral illumination the depth of the opacities within the lens can be approximated. Opacities of the anterior capsule are seen to be superficial and of a brilliant white hue; at times they form a distinct conical projection upon the capsule. Far advanced opacities of the lens can be recognized by the unaided eye by the change in the color of the pupil which becomes white or gray of varying degrees of brightness.

Pathology of Cataracts.—The pathology of cataracts has been almost entirely studied in the senile form. Most of our knowledge of the formation of cataract is due to the study and research of Becker. As the nucleus becomes harder and harder through a process of desiccation or sclerosis and less elastic it is less and less able to respond to accommodation, so that nutritive changes ensue,

inasmuch as accommodation is necessary for the welfare and nourishment of the lens. There is then a separation of the lens fibers from each other at certain spots, especially between the cortex and the nucleus, brought about also in part by a shrinkage of the nucleus. These fissures become filled with liquid. This liquid collects in globules, forming the so-called spheres of Morgagni. The fibers bordering the fissures and the fluid as well are at first both transparent. Later the lens fibers become cloudy from the presence of numerous small areas of fatty degeneration. The fibers at the same time become swollen in spots, so that their outline becomes uneven, and large and frequently nucleated vesicular bodies, the so-called vesicular cells, are formed. Finally the lens entirely breaks down into a pultaceous mass, consisting of drops of fat, Morgagnian spheres, remains of lens fibers and an albuminoid liquid. As the lens breaks down fluid collects in separate vacuoles between the lens substance and the capsule of the lens, finally separating the capsule entirely from the cortex so that the lens can be shelled out of its capsule in cataract extraction. The nucleus of the lens is as a rule so dense, due to a sclerosis of its fibers, that it remains unchanged in the disintegrating lens. The nucleus of the cataractous lens is, according to Becker, not unlike that of healthy lens of an individual of the same age. There now begins a gradual absorption of the pultaceous lens-mass, so that some opacity clears up again, not to be sure by the fibers becoming transparent or regenerating, but by disappearance of the opaque parts. The hardened nucleus remains intact, however. Cholesterin and lime salts are at times deposited in the cataractous lens. Capsular opacities are not situated in the capsule itself, but deposited upon the capsule. Atheroma of the vessels of the ciliary zone, in the opinion of many, is a frequent cause of cataract from malnutrition of the lens, and as syphilis is often the cause of such change in the vessel walls, it may be said that syphilis is at times the etiological factor in cataract. Anterior capsular cataract consists of an opaque tissue found on the inner surface of the anterior capsule caused by a proliferation of its epithelium. The

cells normally in a single layer increase in number until a laminated mass is formed, and by it the capsule is lifted up in a distinct conical shape. The opacities of the posterior capsule, however, lie upon its posterior surface. Inflammation of the lens or phakitis, as it would be called, does not exist. Inflammatory cells or leucocytes found in the lens do not originate in it, but enter the lens from the outside through its capsule.

We will now consider briefly the clinical forms of cataract. Every lenticular opacity begins at some special point in the lens (partial cataract). It may remain limited to this locality (partial stationary cataract) or it may gradually progress over the entire lens, giving rise to a total opacity (progressive cataract).

Partial Stationary Cataracts. — *Anterior Polar Cataract* occurs as a white dot at the anterior pole of the lens. As has been already said it is caused by a proliferation of the cells of the capsule of the lens. It is therefore a capsular cataract. Sometimes this form of opacity is spoken of as anterior central capsular cataract. At times the collection of cells is thick enough to produce a distinct conical projection, so the term pyramidal cataract is frequently applied to anterior polar cataract. Anterior polar cataract is most frequently congenital but may be acquired. The former form has to do with a faulty development of the lens or of its capsule, the nature of which is not understood.

The acquired form develops in childhood from perforating corneal ulcers which are as a rule secondary to gonorrheal ophthalmia. When the cornea becomes perforated by the ulcer the aqueous escapes, the lens pushes forward so that its surface is brought in contact with the opening in the cornea. Inflammation being present about the corneal opening lymph is poured out, which with the mechanical blocking of the opening of the lens seals the hole in the cornea. The anterior chamber is then gradually restored and the lens and cornea separated. We have then a central scar of the cornea and an anterior capsular cataract. While the lens capsule was in contact with the cornea enough irritation was produced to

give rise to a proliferation in the epithelium of the capsule and this increase in the number of cells continues for some time after the cornea and lens have been separated by the reëstablishment of the anterior chamber of the eye. At times one sees an anterior polar cataract joined to the corneal scar by a slender band of connective tissue. This filament of tissue may end by rupturing or persist through life. Corneal opacities acquired in early childhood often clear up in a marvelous way, so that in some cases of anterior polar cataract nothing but a thin haze is seen in the cornea or no scar at all. In the new-born we sometimes see anterior polar cataract with the scar of the cornea opposite, showing there has been intrauterine ulceration of the cornea. In other cases of anterior polar cataract there is no evidence of corneal scar, so that the etiology of the latter cases is distinctly different. It is not necessary that the cornea be perforated at its center to have an anterior polar cataract, a peripheral perforation by allowing the escape of aqueous and advance of the lens suffice; simple contact of the lens with the cornea only being sufficient to give rise to irritation and proliferation of the capsular epithelium.

Posterior Polar Cataract consists of a small white dot at the posterior pole of the crystalline lens which can only be seen with the ophthalmoscopic mirror or by oblique light. It consists of a deposit upon the posterior surface of the posterior capsule of the lens, and is therefore also called posterior central capsular cataract. This form of opacity is congenital and is caused by the remains of the hyaloid artery, so that we at times find posterior polar cataract with a persistent hyaloid artery. The interference with the vision depends upon the size of the opacity. It interferes more with the sight than one of the same size at the anterior pole of the lens, as rays that would pass into the eye through the nodal point are intercepted by the opacity.

Circumscribed Opacities in the Lens (Lenticular Cataracts).—In this group we place the small central opacity of the lens, the spindle-shaped cataract consisting of a fusiform opacity running between the

poles of the lens and thicker at the center of the lens; punctate cataract in which extremely small white dots are found distributed throughout the lens or united in groups in the anterior cortical layer. All of these are congenital and usually bilateral and run in families. Eyes presenting this variety of cataract often possess other congenital abnormalities and the patients not uncommonly are below par both mentally and physically. The opacities themselves cause little disturbance of the sight but the latter is often poor from other causes.

Perinuclear Cataract (*Zonular or Lamellar* (*Laminar*) *Cataract*). —Perinuclear is the most frequent form of cataract seen in children. Through a dilated pupil a gray ring opacity of the lens is seen surrounded by a perfectly transparent portion. The center of the lens is likewise free of opacity. The diameter of the opaque disc varies as well as the extent of the transparent zone. The size of the opaque disc depends upon the age of the child when it developed, being smaller the younger the child. With the ophthalmoscopic mirror the cataract appears as a dark disc surrounded by the illuminated periphery of the pupil. The disc is denser nearer the edge by which zonular cataract is distinguished from a solid opacity which is denser in the center if it affects the nucleus too. Along the periphery of the opaque disc are a number of radiating striæ which extend into the transparent portion of the lens. These are called riders. This form of cataract always affects both eyes. It originates in the first years of life and according to Arlt is commonest in children who have suffered from convulsions. Such convulsions are mostly caused by rickets and especially when the cranium is affected by it. The teeth are at the same time irregularly formed, being represented by irregular stumps deficient in enamel in places or deeply serrated upon their edges. Horner says lamellar cataract stands in etiological connection with rachitis. After the disappearance of rachitis and nutrition becomes improved normal transparent lens fibers are deposited upon the opaque disc. Lamellar cataracts are not infrequently inherited. As a rule the opacity is stationary, although in some cases it gradually increases into a total opacity of the lens. The

opacity is more apt to progress if riders are present upon it. This form of cataract affects the vision in varying degrees according to the diameter of the opaque ring and according to the freedom of the center of the lens from opacity. Deutschman, Lawford and Schirmer demonstrated within the opaque layer of lamellar cataracts numerous small gaps filled with fluid and fissures which surround the nucleus like a shell.

Anterior and Posterior Cortical Lenticular Cataracts.—This form of cataract manifests itself in the form of a stellate opacity in the anterior or posterior cortical portions of the lens, its center corresponding to the center of the lens while its rays reach towards the equator of the lens. Both anterior and posterior forms are found together, but the posterior cortical cataract is much commoner than the anterior. These two forms of cataracts occur commonly in eyes which have a disease of the deeper portions, such as retinitis pigmentosa, chorioiditis, fluidity of the vitreous, detached retina and so forth, the opacity being the direct result of disturbed nutrition in the lens. The vision is usually very poor, since not only the opacity in the lens operates to make it poor but the fundal lesion as well. For many years these forms of lens opacities are stationary, but usually at last become total. They are, therefore, to be considered as transition forms between the stationary and progressive forms of cataract. Anterior and posterior cortical cataracts are at times observed after injuries that do not open the capsule of the lens, that is from simple contusion. The stellate form develops in a day or so after the injury. It may rapidly become total, remain stationary or, as occurs in exceptional cases, entirely disappear. The fact that they develop so rapidly and entirely disappear at times proves the opacity is not in the lens fibers themselves. Schlösser says what occurs is a distention of the lymph spaces of the lens.

PROGRESSIVE CATARACTS.

Progressive cataracts begin as partial opacities of the lens, which gradually extend and involve the whole lens in young persons; in

older persons the nucleus, which is sclerosed, generally remains transparent. The time taken for an opacity to involve the whole lens or for the cataract to get ripe, as we say, varies very much in different cases Some ripen in a few weeks, while others take years to mature. There is no way to tell how long a cataract will be in maturing save approximately by taking notice how long it has been in reaching the stage in which we find it at the time of examination, and remembering that light-colored cataracts with broad opaque radii and in young individuals mature more rapidly than others. Sudden ripening of cataract has been reported by several observers. In one case a cataract became ripe in a few hours following a violent emotion Another case is reported by Delbes, in which the cataract became ripe over night. The latter case was operated upon and received good sight. Following Fuchs we will divide the progress of progressive cataracts into four stages.

The First Stage or incipient stage (cataracta incipiens) exists when there are opacities in the lens between which there are areas that are still transparent. The shape of the opacity is most often in the form of sectors or spokes which extend from the periphery towards the center of the lens. Less frequently we have the nuclear more or less homogeneous opacity either alone or associated with the spoke-like form.

Second Stage (*Cataracta Intumescens*).—As the lens becomes more and more opaque it contains more and more water and hence swells up. This increase in the size of the lens causes the anterior chamber to become shallower than normal. If a light is held to one side of the eye the iris will be seen to throw a shadow upon the opacity of the lens until the opacity reaches the anterior capsule or the plane of the iris; the iris then no longer throws a shadow upon the cataractous lens. The swollen lens presents a bluish silky luster and shows plainly its lines of cleavage or sectors. As soon as the opacity of the lens becomes total the lens begins to lose water and to return to its former volume. The cataract has then reached the third stage.

Third Stage (*Stage of Maturity, Cataracta Matura*).—Beginning with this stage the anterior chamber is once more of normal depth and the iris no longer casts any shadow upon the lens as the opacity has reached the plane of the iris. The lens has lost its peculiar bluish-white iridescent appearance and assumes a dull gray or even brownish color. The sectors of the lens are still visible. A mature cataract has the property of separating readily from its capsule and is therefore ready for operation, or ripe. The easy separation of the lens from the capsule in this stage is due to the fact that the disintegration of the lens fibers has proceeded quite to the capsule and partly to the fact that the lens has diminished again in volume and thus its connection with the capsule loosened. In this stage the vision is reduced to light perception. Light perception should always be present for a good prognosis after operation as its absence indicates a disease of the retina or optic tract.

Fourth Stage (*Hypermature Cataract, Cataracta Hypermatura*).—Further changes take place in the opaque lens in time, that is a complete disintegration of the cataract. All markings now disappear, the appearance of sectors and so on. Nothing but irregular spots of opacity are seen. The consistency of the hypermature cataract varies according to the amount of water it has parted with since the intumescent stage. The lens with its nucleus may continue to dry up into a flat cake-like mass. In consequence the anterior chamber becomes deeper and deeper. This change is most commonly observed in the hypermature senile cataract. If the loss of water ceases after the lens has become entirely opaque further disintegration renders it more fluid, so that in young persons, especially in whom there is no hard nucleus to the lens, the entire lens may become fluid (cataracta fluida sive lactea). If this change occurs in an older lens in which there is a hard nucleus the latter sinks to the bottom of the liquefied mass.

The cataract has then a homogeneous milky appearance above and below a brownish portion bounded above by the convex line of the upper edge of the nucleus which may alter its position with the

inclination of the patient's head (cataracta Morgagni). Inspissation of the liquefied lens mass now constantly takes place from the loss of water, the disintegrated lens fibers being in part resorbed until the cataract is transformed into a thin transparent membrane (if no nucleus is present) called a membranous cataract (cataracta membranacea). In children and younger persons in whom the resorption is carried especially far clear spaces form by the apposition of the layers of the capsule and vision is in a measure restored. These clear spaces emit a red reflex with the ophthalmoscope, appearing as black areas in the white pupil by reflected light. Cholesterin crystals or lime salts are at times deposited in the degenerating cataract. The former appear as shining spots in the lens even to the unaided eye. Calcification of the lens (cataracta calcarea sive gypsea) occurs almost entirely in cataracts due to other diseases of the eyeball (cataracta secunda or complicata). It is characterized by a peculiar color varying from a yellow to a chalk-white, by thickening of the anterior capsule due to a proliferation of its cells so that a lenticulo-capsular cataract is the result. The opacity of the capsule presents itself under the form of a very dense irregular area upon the gray or brownish surface of the lens situated as a rule at the anterior pole and extending over an area about the size of the pupil. The lens may become tremulous, due to an atrophy of the zonula of Zinn. By the shrinkage of the lens which the cataract undergoes the zonula is put upon the stretch and this finally leads to atrophy. A spontaneous luxation of the lens may occur from rupture of the zonula. On account of these changes the operation for hypermature cataract is often difficult and the operation is followed as a rule by less favorable results than when the lens is removed during the stage of maturity.

Sclerosis of the lens may advance so far that the whole lens will be transformed into a hard dark-colored mass, the consistency of the nucleus. The pupil looks black and it is only on careful inspection with the oblique light that it appears a dark brown. This condition is spoken of as cataracta nigra. Truly speaking it is not a cataract at all, but a far-advanced senile alteration of the lens, that is a total

sclerosis of it. Such lenses are very hard and large, so that a large opening must be made in the eyeball to deliver them. We find the following forms of opacity in the development of senile cataract.

Opaque sectors or radii which appear dark by reflected light and gray by transmitted light. They grow from the edge of the lens and converge towards the center. They are at times broad and triangular and at other times narrow and sparsely scattered around the border of the pupil or occur more or less massed together in one place. It is said that the sectors are especially slender in cataracts of myopic eyes. To see the opaque radii in the lens in the beginning of cataract it is necessary to dilate the pupil with a mydriatic. This form of cataract is called cortical. On the other hand we may have a diffuse clouding of the central portion of the lens called nuclear cataract. This clouding is found in the layers of the lens immediately surrounding the nucleus. Vision in this variety of cataract suffers more than in the cortical because the opacity occupies the center of the pupil and is diffuse, while in case the lens is opaque in sectors clear spaces are left between them. Ammon described a peculiar condition of the lens resembling the arcus senilis of the cornea and was called by him the arcus senilis lentis. It consists of an opaque ring around the lens near its edge or equator. It does not interfere with the vision as it lies wholly behind the iris. It is also stationary. We may meet with a combination of the above forms in senile cataract or one form may alone be present. If naphthalin is administered to rabbits an opacity of the crystalline lens develops, due to an altered condition of the nutrient fluids. According to Bouchard retinitis develops first, then vitreous opacities and cataract. Michel produced cataracts experimentally by lowering the temperature of the eye by the local application of ice. Stein produced cataracts in rabbits by subjecting them to the vibrations of a tuning fork for a certain length of time. In the latter case the opacities were probably caused by the frequent concussions of the lens by the vibrations of the tuning fork. We find cataracts developed from concussions of the lens during certain convulsions such as

epileptic, hysterical or eclamptic convulsions. Lamellar cataract, which as we have seen, develops in children after convulsions is, according to Arlt, directly due to concussions of the lens. Perhaps the cataracts which develop in ergotism and raphania as suggested by Fuchs belong to the same category. Now and then after a stroke of lightning cataract develops which is either due to concussion, to the heat or to the electrolytic action of the electric spark. Hess found that electric shocks in animals caused death of the capsular epithelium and subsequent opacity of the lens.

Treatment of Cataract.—There is no remedy that will cause an opaque lens to again become transparent. The juice of the cineraria maritima was highly extolled as a cure for cataract not long since but in the author's hands it has proven useless. Its use may be followed by return of some sight, but this is to be expected in hypermature cataracts and those fog-like opacities of the lens due to concussion of the eye from blows. Indeed it may happen that complete cataract may clear up if we credit the report of such cases as that of Chevallereau and others. Massage and electricity seem to be of no avail in improving the nutrition of the lens. The use of irritating collyria and moist heat seem to delay opacification of the lens. The improvement of the general health may arrest the development of cataract in its very incipiency.

If the cataract is especially nuclear the use of atropin by dilating the pupil and exposing clear lens substance in the pupil will improve the vision and often to a considerable degree. Many of the remedies of quacks contain atropin or other mydriatics and act favorably in the way just mentioned. The vision, however, again fails just as soon as the peripheral portions of the lens are involved. A cure for cataract can only be obtained by operation. An indispensable prerequisite for this is that the retina and optic nerve should be in good condition. To test the light-perceiving parts we stand at a distance of eighteen to twenty inches and reflect the light from an ophthalmoscopic mirror into the eye. The patient is asked to tell whenever the light enters the eye which he should be able to do with accuracy

no matter how dense the opacity of the lens or capsule if the deeper portions of the eyeball are in good condition.

Furthermore, besides seeing the light as it enters the eye the patient should be able to tell from which direction the light comes as it is reflected into the eye from different points. His field of vision and direct vision for light then should be good. There are two operations for cataract practiced to-day, namely, the operation of discission or solution and that of extraction, or the removal of the lens in toto from the eyeball. Discission is performed on young individuals before the formation of a hard nucleus in the lens, that is in those under the age of thirty. Discission is also performed in the early stages of cataract and in partial stationary opacities to ripen the cataract or cause it to become total. Discission is moreover indicated in membranous cataracts and after-cataracts or thickened capsule after the extraction of the lens, in which case we speak of the operation as dilaceration. Extraction of cataract can only properly be performed in the stage of maturity with few exceptions, for as has been noticed in that stage the lens strips easily out of its capsule or rind and in the mature stage there is less tendency than in the hypermature to prolapse of the vitreous during the operation, due to a defective condition of the suspensory ligament of the lens, and less likelihood of a thickened capsule being present, necessitating a second operation for the restoration of sight, and less possibility of lime salts or cholesterin crystals being present to come in contact with the iris and irritate it so that an iritis develops. In immature cataracts soft cortical lens substance is apt to remain behind in the eye and becoming opaque give rise to an after-cataract. Cataracts which are congenital or occur at an early period of life should be operated upon as early as possible. A baby of a few weeks old stands the operation of discission well. If the operation is not done early amblyopia develops from non-use, and if the cataract is removed later the vision is very poor and remains so or improves but slowly. In traumatic cataract we try to combat the inflammation which often follows the injury by the application of iced

compresses. These also retard the swelling of the lens to a considerable degree.

If the lens is much disintegrated and filling the anterior chamber or through swelling is giving rise to iritis or increased tension it should be removed at once. Otherwise the operation is postponed and atropin used to keep the pupil dilated. If the process of absorption goes on properly the lens will be entirely absorbed in two months, so that nothing more is needed save perhaps a dilaceration of a thickened capsule which is left behind. If the process of solution comes to a standstill we perform discission and thus allow the aqueous a fresh attack upon the lens. In complicated cataracts it is deemed unwise to operate while there is any inflammation about the eyeball unless the presence of the lens is the sole cause of such inflammation.

An eye which has been operated upon for cataract is aphakic and hyperopic to a marked degree. (See the chapter on Aphakia in Vol. I.) Shall we operate upon an eye with a mature cataract while its fellow sees, ask many? Some say only when the development of a cataract is apparent in the fellow eye. They argue that if the lens is removed from one eye the anisometropia is so high that the two eyes can never be used in unison even if the proper refraction correction is adjusted. This is true, but what the patient gains by the operation is a broadening of the field of vision. While the eye, without a proper glass, may not have vision enough with which to read, the amount of sight present will enable the patient to see large objects on that side and thus be better able to avoid approaching objects while in the streets or where not. Again to leave a cataract alone until the other eye develops one is dangerous because if an accident happens to the good eye and destroys its sight we may have to operate upon a very hypermature cataract with all its risks. The vision after operation is scarcely ever as good in eyes which have had cataracts for a very long time as in those operated upon early in the mature stage.

History of Operation for Cataracts.—From what has been said it will be gathered that we may by discission subject the lens to

resorption, by dilaceration tear a hole in it or by extraction remove it altogether from the eye. Each of these is a modern method of dealing with cataracts. For a thousand years or so preceding the year 1745, in which Daviel performed the first extraction of cataract the method of couching, displacement or depression of the cataract was practised, but is now almost entirely abandoned. The manner in which it was done is as follows: A needle was passed through the lower part of the cornea and was pushed forward until its point rested upon the surface of the lens. The point of the needle was then made to sweep quickly backward and downward, and thus the lens was depressed into the lower part of the vitreous chamber. Immediately the sight was restored. Various modifications were made in the manner of operating from time to time until the operation of reclination had its day. This consisted in turning the lens over instead of simply depressing it. The needle was passed through the sclera four millimeters from the edge of the cornea into the posterior chamber and with it pressure was made upon the upper part of the anterior surface of the lens. This latter operation was also called cataract pricking. All the modifications of the couching operation were followed in most cases in time, by severe inflammation in the eyeball terminating in irreparable blindness. This was due to the nature of the operation itself. The lens after being depressed into the vitreous chamber came in direct contact with the ciliary processes, where acting as a foreign body it set up inflammation. If the capsule of the lens was ruptured in couching it underwent absorption in the vitreous save its nucleus, which was found at the spot to which it had been carried encysted and tied down by adhesions. Now and then it happened that the lens would not remain down but in time would float up in the vitreous and again block the pupil. This occurred especially if the vitreous was fluid. The lens at times even passed through the pupil into the anterior chamber and caused the sight to go out from increased tension.

Bourgeois recognizes the following conditions for couching cataract: Fear of expulsive hemorrhage; threatened infection; unruly

patient (insane or alcoholics, etc.); chronic bronchitis, as the coughing would either cause prolapse of the iris, vitreous detachment of the retina or intraocular hemorrhage; fear of loss of vitreous from presence of tremulous iris or subluxated lens. One of the great dangers of the operation is the occurrence of acute glaucoma. The surgeon avoids this by an iridectomy done fifteen days previous to the couching. He performs couching with the patient sitting and maintains this position for some time to keep the lens from rising.

Cases of prolapsed lens into the anterior chamber occasioned the first performance of cataract extraction. According to some this method of operating was practised even in ancient times, but Fuchs remarks that if it was it had long fallen into oblivion before the middle ages. The operation of cataract extraction underwent various modifications from time to time until there now seems little room for further improvement. Daviel used a small knife somewhat the shape of a bistoury to make his section in the eyeball, for which it was poorly adapted. On account of the difficulty in making a smooth incision in the eyeball Beer invented a knife which is triangular in shape, increasing in width from the point to the heel as shown in the cut, the long side of the triangle being the cutting edge. The section in the eyeball is completed with this knife by simply pushing it through the anterior chamber and the cut made is therefore extremely regular.

Beer's Knife.

The incision was made just inside of the limbus and separated the lower half of the cornea from the sclera. The capsule of the lens was then opened and the cataract delivered by pressure upon the eyeball. This method of operating was in vogue until Von Graefe introduced his process. Many eyes were lost after the operation by the Beer method, and not knowing anything about the infections of wounds in those days it was supposed to be due to the manner in which the section in the eye was made and to its size which involved quite half of the cornea. Von Graefe thought linear section preferable as it allowed of much less gaping of the wound, so he and others

began to practise it, using a lance-shaped knife. The wound was made as large as possible by placing it in the upper part of the cornea and was combined with an iridectomy to allow freer exit for the cataract. Some even tried to diminish the size of the cataract by crushing the lens so that it could more readily be delivered. All the various methods were followed by little success, as the section was too small for the lens to pass. Jacobson then conceived the idea of placing the section in the sclera and obtained much better results. He made a flap by skirting the lower margin of the cornea. This section was followed by less suppuration than customary, which was attributed to the fact that the sclera being more vascular was less liable than the cornea to suppurate.

Graefe's Knife.

Von Graefe now combined both of these methods in one, that is the linear character of the section which allowed a better coaptation of the edges of the wound and the position of the section in the sclera which affords a more rapid healing and as he thought a protection against suppuration. Finding the lance-knife unsuitable for making the section of proper length he devised the linear cataract knife shown in the cut which is in use to-day as our best knife for making the section. With his new knife he made the section in such a way that its summit was in contact with the edge of the cornea but its edges some distance removed therefrom. The point of puncture and that of counterpuncture or point at which the knife was brought out were determined by tangents dropped to the lateral margins of the cornea. Owing to the peripheral position of the section an iridectomy was a necessity or otherwise the iris would have become incarcerated in the wound. The cataract operation when combined with an iridectomy was now called the modified operation, as by the older methods an iridectomy was only done when the occasion arose, that when the pupil seemed too small to properly deliver the lens. Von Graefe called his method the modified linear extraction in contradis-

tinction to the simple linear extraction as previously performed with the lance-knife.

Stress now began to be laid upon the iridectomy as the essential part of the new operation. It was said to prevent hernia and inflammation of the iris, to enable one to more thoroughly open the capsule of the lens and to better free the anterior chamber of soft lens substance. The weak point in the operation of Von Graefe was the fact that it was very difficult to perform, and the wound being linear gaped poorly and the peripheral portions of the section were dangerously close to the ciliary bodies. Prolapse of the vitreous was very frequently met with as well as inclusion of the pillars of the coloboma in the angles of the wound. Suppuration following the operation became less frequent, but irido-cyclitis became much more common, so that all in all about as many eyes were lost as by the older methods. Operators then began to blame the peripheral situation of the section for these untoward results and were led to place the extremities of the section nearer the cornea. The modified sections were less linear than that of Von Graefe's, being curved sections of small altitude. Scleral section soon became the popular method; that is, the section was made to lie wholly in the sclera and concentric with the margin of the cornea. Since the methods of antisepsis we make the incision in the limbus or in the transparent cornea itself at will. More recent improvements have been in regard to the excision of the iris. By careful reposition in the anterior chambers it was discovered that the incarceration of the edges of the coloboma would not occur and again that it was unnecessary to make the extensive iridectomy that Von Graefe advocated. Indeed some worthy authorities, among whom is Fuchs, make the iridectomy as small as possible.

A small iridectomy or even a "button-hole" in the iris averts a hernia just as certainly as a larger opening. Finally surgeons reverted to the methods of Daviel and Beer in that they operated without an iridectomy, the so-called simple extraction. Von Graefe opened the capsule of the lens with a cystotome, that is, a triangular

cutting instrument, Other operators made the opening with a discission needle or with a sharp hook. More recently forceps for opening the capsule have been devised and in the judgment of many this was an important improvement in the operative technique. Not only is the anterior capsule of the lens readily opened with the forceps, but a portion is removed, which reduces the frequency of a subsequent opacity occurring in the capsule. Not long since MacKeown, and more recently Wicherkiewicz and Reik, have advocated the irrigation of the anterior chamber of the eye after the removal of the lens. Chibret syringes the posterior chamber after the extraction of cataract. He employs for this purpose an instrument provided with a double canula, which is introduced into the eye in such a manner that the fluid is injected posterior to the pupil. He uses a solution composed of a gram of cyanid of mercury to 2,000 grams of boric acid solution.

MacKeown's conclusions in regard to lavage of the anterior chamber are as follows: That the introduction into the eye of the sterilized solution is harmless. That the removal of the cortex is a mechanical process and regulated by physical laws. That from the anatomical structure of the eye and the conditions existing after the operation, irrigation is more efficient in removing cortex than any other method. That just as irrigation removes soft lens substance so it removes blood and bubbles of air. It also shows the condition of the capsule, gives tone to and replaces the iris and is effectual in making the toilette of the wound. That very free irrigation may be practised without fear. That irrigation does not tend to cause the vitreous to prolapse. That the necessity of a secondary operation is rendered less frequent.

MacKeown and Reik use an irrigation jar and specially formed nozzles in their work. Dr. Fuchs and many other excellent authorities have failed to see any benefit to be derived in this method. Many feel that the fewer instruments introduced into the eye during a cataract operation the better, and that every unnecessary procedure increases the risk of the operation. After fair trial the author agrees

with MacKeown in his conclusions. Many however that formerly practised the method of irrigation have now abandoned it. The form and the position of the section for cataract extraction varies with nearly every operator. The amount of iris excised also varies; thus some make a "button-hole" only, while others excise a large bit of iris. Lebrun and Liebrich make the incision well into the cornea, and Kuchler even places it at its center. There is no question that prolapse of the iris less frequently occurs in the simple extraction when the section is made well into the cornea. As the wound lies nearer the pupil the aqueous finds a freer exit. Weber advocated the use of a concave lance-knife, and Jaeger the use of a concave linear-knife.

DeWecker, Mooren and many other good authorities advocate doing the combined extraction (extraction with iridectomy) in two separate steps, that is, the iridectomy at one sitting and the cataract extraction at a subsequent period. It is advisable to perform the operation in two separate steps under the following conditions: When it is undesirable to keep the patient for any length of time in bed; as a ripening operation for immature cataract; in very advanced cataracts which should admit of extraction but would likely leave considerable soft cortical substance behind and in those cases where failure has followed operation upon the fellow eye from suppuration, irido-cyclitis or glaucoma.

With this short historical sketch of the operation for cataract we will pass to the consideration of the

Technique of Cataract Operations as Performed To-Day.

Discission of Soft Cataracts.—By this operation the capsule of the lens is opened so that the aqueous humor can effect the solution and resorption of the cataract. Discission is performed with a discission needle passed through the cornea in its lower outer quadrant. At first the instrument is held perpendicular to the surface of the cornea, but as soon as its point enters the anterior chamber the handle of the instrument is depressed somewhat so that the iris is not wounded.

It is then pushed straight forward as far as the capsule of the lens. The latter is then incised. The pupil must previously be dilated with atropin. The needle is held very lightly, no pressure being made, but simply sweeping movements. The incision in the capsule of the lens should not penetrate deep into the substance of the latter. The needle is quickly withdrawn from the eyeball so that as little aqueous escapes as possible. Discission is nothing but an imitation of what traumatism does when the capsule of the lens is lacerated and the progress of the case after the aqueous gains access is exactly the same. This operation is adapted for all soft cataracts, that is, those that have as yet no hard nucleus. The chief advantage of discission consists in its freedom from danger and the simplicity of after-treatment. The small wound made in the cornea almost immediately closes, the patient is able to get up immediately and go without a bandage. In favorable cases those in which not too large an incision has been made in the capsule of the lens, the after-treatment consists simply in keeping the pupil dilated with atropin solution. Discission is therefore the only cataract operation that can be done upon small children who do not keep quiet after the operation.

The possibility of iritis occurring from a too rapid swelling of the lens as well as from irritation of the iris by the altered condition of the aqueous humor, and of increased tension have already been spoken of. In either of these events the anterior chamber should be opened at the limbus and the soft and disintegrated lens substance allowed to drain off. If there is considerable swelling of the lens without much breaking up of its substance it may be extracted in toto. Excessive swelling of the lens is, as already said, successfully combated by iced compresses. On the other hand, there are cases that undergo resorption very slowly or come to a standstill a few weeks after the discission. Such need a second operation. The cause of the failure of the first operation lies in the fact that the wound in the capsule of the lens has become closed. If a very free discission was made the first time it is rather unsafe to repeat it, but

instead a paracentesis of the anterior chamber is done. This starts again the process of solution by drawing off the aqueous humor which is surcharged with albuminoid material from the lens, and allowing fresh aqueous to collect.

Discission is Contraindicated in the Following Conditions: (1) In elderly persons whose lenses have a hard nucleus which would not undergo absorption save as a ripening operation preparatory to a cataract extraction. (2) In subluxation of the lens, a condition which is recognized by the tremulousness of the latter, since the lens not being sufficiently held in place would likely be pushed back into the vitreous by the discission needle. (3) When there is a considerable thickening of the capsule, in which cases there would be danger of dislocating the lens before the capsule was cut through. (4) In the presence of posterior synechiæ which render the dilatation of the pupil impossible. In the latter case an iridectomy would be done first.

Discission of Membranous Cataracts or Dilaceration. — By this operation the membranous cataract is torn apart or preferably cut through, the discission needle being replaced by a knife-needle or an instrument with a very fine and extremely sharp point.

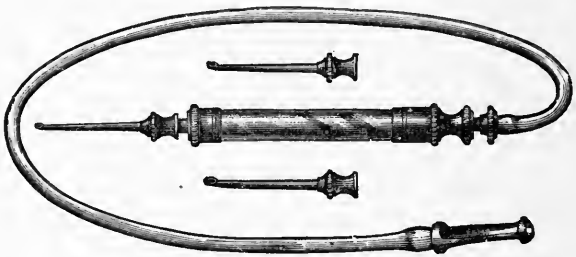
The operation may be performed either through the cornea or through the sclera. In case the operator chooses the corneal route the puncture is made in the outer and lower part of the cornea just as for discission of soft cataract. The needle is then pushed through the center of the cataract and the membrane torn in all directions by sweeping movements.

This operation of tearing the capsule is at times followed by cyclitis, especially if the membrane is thick and resisting. It is much better to follow the axiom of Knapp to cut and not tear. We examine the eye before the operation to ascertain the direction of the fibers in the membrane and then the latter are cut across at right angles

to their length with an instrument formed like the one shown in the cut. In the operation through the sclera the knife-needle is plunged in through the sclera about six millimeters behind the limbus and

somewhat below the horizontal meridian and then pushed forward so that its point passes through the cataract into the anterior chamber close to the margin of the pupil.

The cataract is then either cut or torn as before. The scleral method is preferred by some because a greater force can be exerted upon the cataract than by the corneal method. Dilaceration through the sclera is rarely done in this country. Here we prefer to cut through the cataract and get a clear pupil by pulling its fibers apart. Dilaceration is most frequently done to remove a capsular cataract following the operation of extraction. After discission has caused disintegration of the lens fibers we may remove them by making a section in the limbus and allow the aqueous to escape. Any remnants that may be left are gotten out by stroking the cornea gently



Teale's Instrument for Removing Soft Lens Substance.

from below upwards with a horn spatula, or the anterior chamber may be irrigated or we may draw out the particles with a suction apparatus after the fashion of the one shown in the cut. The canula of the instrument is introduced into the anterior chamber, the rubber tube inserted in the mouth and gentle suction made as the canula is moved over one particle, then another.

In case the membranous cataract is very thick and adherent to the iris Bowman recommends the introduction of two needles passed through the cornea at the same time, one near its inner and the other close to its outer edge.

The points of the needles are then plunged into the center of the cataract and drawn apart by sweeping movements, — so the iris is not

pulled upon. If adhesions to the iris are very numerous an iridotomy or iridectomy is done.

Discission through the sclera is never performed upon a lens to cause resorption, as in that case to split the anterior capsule the needle would need to be passed quite through the lens, which would give rise to a dangerous degree of swelling besides the possibility of luxating the lens.

Cataract Extraction.—By extraction of cataract we mean the removal of the entire lens from the eye. The operation consists of three steps as follows: Making the section, opening the anterior capsule of the lens, and the expulsion or delivery of the lens by pressure exerted upon the eyeball. There may be a fourth step to the operation if the iris does not return well into the anterior chamber, namely the excision of the portion of the iris adjacent to the section. Some perform an iridectomy regularly after the section in the eyeball is made. The common and best methods of cataract extraction are the following.

Linear Extraction.—Simple linear extraction is done both in soft lenticular and in capsular cataracts and is therefore done in two different ways.

1. In operating upon soft cataracts a lance knife is passed into the center of the lower and outer quadrant of the cornea at the limbus. It is first passed through the cornea at right angles to its surface and then the handle is depressed until the blade is parallel to the plane of the iris. The knife is then pushed forward until the wound has a length of about four or five millimeters. This wound must run parallel to the border of the cornea. Then a discission needle or a small sharp hook or capsule forceps is introduced into the eyeball and the anterior layer of the lens capsule thoroughly torn up in the center of the pupil. After the capsule has been opened the instrument is withdrawn from the eyeball and pressure made upon the peripheral lip of the wound to evacuate the lens. By the pressure the contents of the eyeball are pressed upon and the wound made to gape. This procedure is continued intermittently until all portions of the lens have been removed from the eye.

2. When a membranous or capsular cataract is to be operated upon the section is made in the same way, then a sharp hook or forceps is introduced into the eye, the membrane grasped and drawn out of the wound. The great advantages of this method of linear extraction consist in the fact that the wound passes obliquely through the limbus, which causes the edges of the section to coapt well and the wound being short does not necessitate an iridectomy to prevent a hernia of the iris. On the other hand by this method we can only remove soft cataracts, those which will break up, or membranous cataracts, as a lens with a hard nucleus could not pass through such a small wound.

Flap-Extraction.—By this we mean the making of a curved incision the length necessary to deliver the cataractous lens in toto. According to the operator the section is made either in the cornea or in the sclera.

We will first consider the *scleral flap-extraction.* The primary section is made with a Grafe's cataract knife. The eye is held with fixation forceps applied at the inner side of the horizontal diameter of the cornea where it will serve as a guide for the size of the section which should include more than one third and less than one half the circumference of the cornea. The knife is entered at the outer border of the cornea a little above the horizontal diameter of the latter and brought out at a point diametrically opposite. The points of entrance and exit are situated in the sclera about half a millimeter from the margin of the cornea. The knife is introduced so that its cutting edge looks upwards and the point is directed towards the center of the cornea. As soon as the point has passed into the anterior chamber it is raised and cautiously pushed across the anterior chamber, care being taken that it does not enter the iris before the point of counter-puncture is reached.

As soon as the knife has transfixed the anterior chamber the cut is completed by sawing movements so that through its whole extent it divides the sclera just behind the limbus. Care is needed to prevent the iris from floating over the knife as the aqueous escapes.

To prevent this we slant the cutting edge of the knife slightly forward, and as we complete the section press the knife as a whole forward, away from the iris. If we do cut into the iris we nevertheless continue to complete the section. If the coloboma produced is ragged we pick up the tags with the iris forceps, draw them out of the wound and snip them off with scissors. Soon as the knife has severed the sclera it is carried rapidly upward after its edge is turned somewhat backward so that the conjunctiva is divided at a distance behind the section through the sclera. This last step forms a conjunctival flap several millimeters broad.

After the conjunctival flap has been turned down upon the cornea so that the section is exposed to view, a pair of iris forceps is introduced, the iris grasped at its pupillary border, drawn out of the eye and excised. The capsule is now opened with a cystotome or sharp hook or forceps, each of which is shown in the cuts below.

Graefe's Cystotome.

Knapp's Cystotome.

Tyrell's Sharp Hook.

Knapp's Capsule Forceps.

Pansier, instead of finishing the conjunctival flap extraction in the usual manner, carries the knife under the conjunctiva for several millimeters and then withdraws it without cutting through the bridge of conjunctiva. He claims for this method that the lips of the wound

are better coapted, that union is quicker, that hernia of the iris is less apt to occur, and that the bandage may be removed from the eye sooner than in the usual manner of operating. The objection to this method of operating is that it takes considerably more pressure upon the eyeball to deliver the lens than when the incision is allowed to gap widely by severing the flap of conjunctiva.

One incision or more is made in the capsule, or if the forceps are used the capsule is grasped and a piece torn away. A horn spatula is now placed upon the lower part of the cornea and gentle pressure made upward and backward until the greatest diameter of the lens

has been delivered. An iris repositor shown in the cut is now introduced and the pillars of the coloboma smoothed back into the anterior chamber so that no iris is left incarcerated, otherwise the pupil will be drawn up, perhaps entirely under the upper lid in the healing process. If there are any portions of the cataract left in the eye, stroking movements of the spud from below upwards upon the cornea will remove them. The conjunctival flap is now smoothed out and a bandage applied.

Corneal Flap-Extraction (*Stellwag and De Wecker*).—In this operation the section is made throughout in the limbus so that the upper third of the cornea is severed from the sclera. A conjunctival flap is not formed and the iridectomy is often omitted, especially if the iris shows no disposition to push through the wound. Some advise the use of eserin to prevent a prolapse of the iris if an iridectomy is not done. The eserin by contracting the pupil and drawing the iris taut renders it less liable to hernia. After the edges of the wound have become agglutinated atropin should be instilled to prevent iritis and possible sealing up of the pupil. Flap-extraction is performed upon all hard cataracts.

The difference of the two methods depends upon the following point: In the scleral section a conjunctival flap is made which becomes agglutinated very soon after the operation and closes the

wound externally even before the section itself has healed. In this manner the wound is protected from infection. The great disadvantage of conjunctival flap is that there is more or less bleeding from the conjunctiva always when it is cut and some of the blood gets into the interior chamber despite you, where it acts as a nidus for the development of infection but especially favors the formation of an after-cataract through a hyperplastic process in the cells of the capsule, or by becoming organized gives rise to bands of tissue stretching across the pupil. These disadvantages outweigh the advantages to be gained from the conjunctival flap extraction. The corneal flap method is called the simple extraction, as it is possible to perform the operation without an iridectomy. The advantages of the operation without an iridectomy are, first the appearance of the eye is better when the pupil is small and round and dazzling is not so annoying, vision is therefore better and this according to the size of the pupil. The best vision therefore is obtained if the pupil is left clear, small and round. The disadvantages of simple extraction are these: The delivery of the lens is more difficult without an iridectomy as it has to pass through a narrow pupil and to accomplish its delivery therefore a pretty strong pressure is required. Hence in those cases in which there is a tremulous lens or a soft eye to be operated upon, in which cases any undue pressure is liable to be followed by a rupture of the suspensory ligament of the lens and the hyaloid membrane with loss of vitreous simple extraction is not adapted. Again simple extraction is not adapted to complicated cataracts or those in which the lens is adherent to the iris. Finally in spite of the use of eserin after the operation a hernia of the iris may occur.

The plan to be followed is to perform simple extraction if the cataract is uncomplicated and in the mature stage (not hypermature) and if atropia causes a wide dilatation of the pupil and then if the iris shows any tendency to prolapse do an iridectomy. We can tell if there is a tendency for the iris to prolapse by removing the speculum from the eye and then have the patient close and

open the eye several times and to turn the eye in different directions; if the pupil remains round and centrally placed during all this, there is little danger of a subsequent prolapse. Two other classical methods of extraction will now be described.

Extraction of the Lens by Wentzel's Method.—This operation is designed for those cases in which there is an adhesion of the iris to the lens capsule over a considerable extent and especially for cases of total posterior synechiæ. A curved incision is made downward (or upward at the will of the operator) either in the limbus or in the transparent cornea. After the knife is entered it is carried on behind the iris, through the lens to the opposite side where the point of counter-puncture is made. There is then formed at the same time with the flap of the cornea a flap of the iris and anterior capsule of the lens. The lens is then delivered. This operation is also performed upon eyes with transparent lenses but total synechiæ in which there is no other way to get an open pupil.

Darrier not long since devised a new operation of keratotomy for iridectomy, or cataract extraction in cases of very shallow or absent anterior chambers. It is as follows: Two spade-shaped knives are used, making two punctures opposite each other, and at appropriate distances on the corneal periphery. Then a blunt-pointed curved cataract knife is entered at the external of these openings and treaded through the anterior chamber to the counter-puncture. The intervening bridge of cornea is then cut through. Another method is, make a small incision with a cataract knife and enlarge it with blunt-pointed scissors.

Extraction of the Lens in the Capsule: Pagenstecher's Method.—This operation is only adapted to those cataracts with thickened capsules, hence hypermature and complicated (secondary) cataracts. It is performed as follows: After the section is made, an iridectony is done and then instead of opening the capsule a scoop like the one in the cut is passed behind the lens and, at the same time maintain-

Levis' Lens Scoop.

ing pressure upon the cornea, the lens is lifted out of the eye. This is not possible with a capsule of normal thickness as it would rupture every time when the attempt was made to remove it with the lens in toto. This operation has the advantage that the entire lens is certain to be removed and consequently there is left behind no material for an after-cataract or thickening of the capsule. Its great disadvantage is that in passing the scoop behind the lens the hyaloid membrane is ruptured and there is great danger of losing considerable vitreous humor.

Gradeningo and Saggoni use a specially constructed instrument which they call a zonulotome for freeing the suspensory ligament of the lens from its attachments, with the ciliary bodies. Great care is needed not to rupture the zonula nor injure the ciliary bodies during the operation. This procedure is too delicate for the average operator, so will never be adopted to any extent.

There are a few modifications of cataract extraction of comparatively recent date, which will now be considered. Haddams advocates the extraction of the cataract through the posterior chamber by making an incision in the eyeball about one millimeter behind the edge of the cornea. The lens is either removed with or without its capsule. He claims the following advantages: Prevention of a secondary cataract; a better degree of vision; no deformity through iridectomy. This incision to be safe lies too close to the ciliary bodies, which are very apt to be injured during the operation and give rise to irido-cyclitis.

Angelucci has given up the use of a blepharostat or speculum in cataract operations and instead controls the upper lid with the thumb of the right hand, while the globe is grasped with forceps held in the left hand. The lid is now relaxed and is held in place by the forceps affixed to the eyeball. An ordinary linear incision is then made and the capsule of the lens opened with the point of the knife as it crosses the anterior chamber. The lens is delivered by pressing the lower lid against the lower part of the cornea or a horn spatula is used for this purpose.

Artificial Ripening of Cataract.—A time comes when the individual with cataract can not use his eyes in pursuit of his avocation and when from the nature of the case there is reason to believe the cataract will be some time in maturing. Thus there may be a slight central haze or opacity which has been more or less stationary for months or years, but interfering much with vision or well marked but narrow radiating opacities which show little tendency to progress, and have been long in developing. It is an accepted doctrine in ophthalmology not to operate upon an unripe cataract. If the cataract is unripe and stationary we do not hesitate to ripen it by an operation, especially if bilateral. There are a few good surgeons who deprecate this practice, however.

The various operations for ripening immature cataract are as follows: (1) Simple discission of anterior capsule. (2) Discission combined with an iridectomy. Mooren's Operation, the oldest of the various operations, advocated by Mooren in the year 1858. (3) Discission and external massage. Forster's operation (1881). (4) Iridectomy with internal massage directly upon anterior capsule, or Bettman's operation advocated in 1887. (5) Simple paracentesis and external massage or White's operation. (6) Paracentesis with direct massage.

Before doing any of these operations the surgeon should know that the zonula is intact, the tension not below normal and the pupil dilatable. Bettman's operation, either with or without iridectomy, is to be preferred. Trituration is made directly upon the capsule of the lens with the spatula used in repositing the iris. A half dozen strokes over the center of the lens is all that is necessary. By external massage we mean massage of the lens through the cornea, but this method subjects the cornea to too great a trauma, sometimes being completely denuded of epithelium. In old people, those of seventy years of age or over, it is possible to remove the lens before complete opacification occurs. Indeed, in many complete opacification never does occur, because sclerosis of the lens has advanced so far that the lens is almost entirely

nucleus and, as will be remembered, the nucleus of the lens remains transparent in all forms of cataracts in those above middle life. If a patient of 70 years of age or upwards with immature or incipient cataract has been under observation for some time, that is for several months, and no change is noted in the growth of the cataract or vision, it is perfectly justifiable to operate and a good result may be expected. If any soft lens substance is left behind it can readily be removed by irrigation of the anterior chamber. With the knowledge that cataract frequently develops in the eyes of workers exposed to intense heat Wolfberg recently advocated the employment of a hot air douche to the eye for the maturation of cataract. The temperature of the air used is 70° C. and seance continued about five minutes twice daily. In the cases reported opacification was complete in eight days.

After a cataract operation, the best way to protect the eye is to apply a metallic shield over a piece of cotton which is thinned out over the eye and the whole held in place by several strips of adhesive plaster. Several forms of these shields are shown in a subsequent chapter. Some apply a double bandage, that is one covering both eyes for the first days after the operation. This is only necessary in case we have to deal with unruly patients who will not remain quiet if one eye is left open. The eye should be looked at the day after the operation if a simple extraction has been done to ascertain whether there has occurred a hernia of the iris or not. If there is a hernia the protruding portion of the iris should be excised.

If an iridectomy has been done the eye is not usually inspected until the third day following unless there is pain. The lids are gently washed with boric acid solution and the lashes freed of secretion under as careful asepsis as the operation itself, and a drop of atropin solution instilled. If the eye had done well the anterior chamber is restored and there is very little injection of the ocular conjunctiva and practically no redness of the skin of the eyelids nor engorgements of the veins. If there is there is either an infection or an irido-cyclitis present. There is nothing more disappointing to the

ophthalmic surgeon than to find the eye has been infected when he first looks at it after the operation. There are one to two per cent. of cases resulting in infection and panophthalmitis after operation for cataract, but this percentage is entirely too high. In all cases the conjunctival sac should be examined for streptococci and staphylococci and especially pneumococci, as the latter organism is especially virulent towards the eyeball and most surely destroys it. There are two forms of infectious results, those beginning in the cornea twenty-four hours after the operation and which are the more grave and those originating in the uveal tract from the fourth to the eighth day, which are less serious but which go on to destroy the eye in the majority of cases even under appropriate treatment. The most reliable treatment according to Bourgeois is the subconjunctival injection of the bichlorid or better solutions of the mercury cyanid. The cyanid solution should be freshly prepared in strength of 1 to 1.000 parts of distilled water. Cocain is first instilled and the needle of the syringe then carried under the conjunctiva about a centimeter and a half. Bourgeois injects a centigram of the solution and repeats it in twelve hours if the case is a grave one. Large injections are much more beneficial than small ones. Atropin is instilled and mercurial inunctions employed. If the infection begins in the corneal wound it should be treated with the galvanic cautery or curetted. The use of antistreptococcic serum seems to be without effect in these cases. Bourgeois reported six cases treated in this manner and three of them afterwards obtained fair vision while the process was arrested in all. The so-called open method of treating cataract cases after operation is gaining favor with certain ophthalmologists, especially those abroad, notable among whom is Dr. Fuchs. This method consists in protecting the eye from any possible injury during the healing process without keeping the lids closed or exerting any pressure upon the eyeball. Several layers of gauze are placed over the eye to prevent contamination and a wire net or shield over that so that the eye is free to move beneath. Those that have adopted this plan of after-treatment are convinced that the wound in the eyeball heals more readily and

more smoothly, that hernia of the iris is less frequent as there is no pressure exerted upon the eyeball and that on the whole it is a great improvement over the old method of bandaging. The author has had no experience with this method.

Before an operation for cataract is undertaken both light perception and light projection should be tested. The tension of the eye should also be ascertained as a diminished tension means chorioidal disease and hypertension glaucoma, each of which would render the prognosis proportionately poor. The pupil should also be active and not adherent to the lens capsule, and finally the conjunctiva and lachrymal passages in a normal condition. If each of these things are found normal we can promise a good outcome and restoration of the sight. Some bandage the eye over night to see if the conjunctival sac contains infection. In case it does the eye is found mattery the next morning. There is needed no preparation of the eye before operation save the flushing of the conjunctival sac with warm salt solution or plain water and washing the brows and lashes with some soap and water and then rinsing the whole with sterile water.

In the majority of cases the corneal wound closes with the reëstablishment of the anterior chamber in two or three days, the bandage can be removed from the eye in about five to seven days, and dark glasses substituted for another week, when the eye is examined and its refraction corrected unless a secondary operation is needed upon the capsule. In a few cases union of the section in the eyeball is delayed. As Querenghi points out, this is due sometimes to rise of tension and gaping of the wound induced by the use of atropia. Even in cases in which the combined extraction (with iridectomy) is done the iridectomy does not reach to the periphery of the iris and does not therefore afford better drainage to the eyeball, so that atropin can just as readily give rise to glaucomatous symptoms as in the unoperated eye. If we accept the theory of Abadie in regard to the nature of iridectomy in glaucoma this theory becomes erroneous. If the wound remains open longer than two or three days there is danger of infection, or glaucoma when it closes in an eye predisposed.

According to Jarnatowski the cause of failure of the wound to unite in the usual time is due to the manner in which the section is made, the delayed healing being more apparent in the linear incision than in the flap variety. Treatment consists in rest in bed, with a well-applied bandage; instillation of atropia; iridectomy; according to Valude and Terson smoothing the inner edges of the wound with a spatula, as advised by Terrein, and finally touching the edges of the wound with tincture of iodin (Vacher).

Accidents that may Occur in Cataract Operations.—If the operator makes the section too short the lens may be unable to pass. No unnecessary pressure must be exerted upon the eyeball in an attempt to deliver the lens if it hangs in the wound but the latter must be enlarged with a pair of strong scissors (Stevens tenotomy scissors answer well) or if the capsule of the lens is insufficiently opened the delivery of the lens is made impossible, so the opening in the capsule should be made freely. If the capsule is thick or the cystotome dull by dragging upon the capsule it may rupture it and vitreous escape. If too firm pressure is exerted upon the eyeball or capsule of the lens vitreous may gush out. Each of these accidents lies somewhat in the power of the operator to prevent, but the following are accidents in the proper sense of the word that are beyond the control of the operator. The most frequent of these is prolapse of the vitreous. This occurs when the zonula of Zinn ruptures.

Such ruptures happen at times from the patient squeezing the lids together and exerting pressure upon the eyeball, and is especially liable to occur in cases in which the zonula was defective prior to the operation as in hypermature cataracts. The significance of prolapse of the vitreous varies according to whether it takes place before or after the delivery of the lens. In the former case the lens can not be delivered in the usual manner by pressure upon the eyeball but must be drawn out of the eye with a Weber's Hook or Reisinger's Double Hook. When it follows the extraction of the lens it is much less to be dreaded. If only a small amount prolapses it should be snipped off with scissors and the eye bandaged.

The prolapsed vitreous does harm by preventing an accurate replacement of the iris and the coaptation of the lips of the wound in the eyeball and may cause the cornea to slough from lack of blood supply if the eye does not become infected. If there is a sudden gush of vitreous from the eye the retina may become detached and the sight utterly ruined. Knapp & Andrews advocate in cases of considerable loss of vitreous and collapsed eyes the injection of sterile salt solution to take the place of the vitreous and report some eyes saved by this method which would otherwise have been irreparably lost. By the injection the eyeball is restored to its shape and the retina is reapplied to the chorioid if it had become detached as the vitreous escaped. A rare but very troublesome accident is a dislocation of the lens back into the vitreous as pressure is exerted upon it in an effort to open its capsule, and from which it can not be extracted.

In elderly folks and in those whose tissues are lax and non-resisting the cornea now and again sinks back or dimples after the incision has been completed. As a rule this does no particular harm but at times delays healing and favors hernia or incarceration of the iris. Andrews recommends the injection of salt solution into the anterior chamber if the cornea wrinkles or collapses. In such cases the author employs free irrigation of anterior chamber with salt solution.

Results of Cataract Extraction.—The eye is left aphakic and devoid of accommodation to any degree save in those rare cases in which the indices of refraction of the aqueous and the vitreous differ considerably or in which the pupil is left extremely minute but clear from an attack of iritis. In the latter case it may happen that the patient will be able to see at a distance and read with the same refraction correction.

The eye that has been operated upon for cataract presents the following appearance: The iris shelves backward, is tremulous from loss of support of the lens unless adherent to the posterior capsule, the anterior chamber is deeper than is normal and tension minus.

If an iridectomy has been done, it is seen above together with the white line of cicatrix lying in the limbus or as a gray line in the cornea, according to the position of the original section. The pupil appears pure black, but often on oblique illumination reveals a thin membrane of silky luster which may be thrown into folds giving rise to a certain amount of irregular astigmatism, especially if it separates two media of considerably different densities, the aqueous and the vitreous. Behind the iris, where the capsule of the lens is still intact, the anterior and the posterior layers apply themselves together and enclose any soft lens substance that remains. As the two layers of the capsule become agglutinated, the aqueous cannot gain access to the lens substance to absorb it, in fact as Fuchs, Randolph and Gonin say, it acts as an irritant to cause increase in the cells of the capsule with a sort of regeneration of the lens fibers. This abortive attempt at regeneration of the lens enters largely into the causation of after-cataracts. An after-cataract is operated upon about four weeks after the extraction, by dilaceration or by simple extraction (drawing the capsule).

In all cases of cataract extraction there is to be expected a variable amount of iritis appearing upon the third or fourth day following. This is usually readily controlled by a few instillations of atropin solution and completely disappears in a few days. If the iris has been much bruised in the delivery of the lens or if the operation has been dirty, irido-cyclitis develops and the eye is lost by the formation of a dense membrane adherent to the capsule of the lens and the iris, unless a pupil can be successfully made by an iridectomy or iridotomy.

Panophthalmitis infrequently occurs after cataract extraction, the infection entering at the time of operation or gaining access to the eye through the lachrymal passages, so the latter should be perfectly normal.

Change in Position of the Crystalline Lens.—The lens may be found in an abnormal position from faulty development of the zonula of Zinn, or from stretching or rupture of the latter. When the lens

is dislocated to a slight extent only we speak of it as a subluxation and as a luxation when it has entirely left its fossa in the vitreous.

Congenital Dislocation of the Lens.—This consists in a lateral displacement of the lens and is called ectopia lentis. It is caused by the fact that the zonula is developed to an unequal degree in different directions. The lens is as a rule found to be dislocated upwards and it is also usually smaller than is normal. Very frequently in later years the ectopia increases and may pass entirely into luxation of the lens. The defect is present in both eyes and usually symmetrical in both. It is commonly hereditary in origin.

The Acquired Dislocations develop as the result of trauma or spontaneously. Traumatic dislocations are principally caused by contusions of the eyeball. The eyeball is squeezed back into the orbit by the trauma increasing its vertical or horizontal diameter. This puts the zonula upon a stretch which it cannot withstand, so it gives way at its ciliary attachment. The lens is dislocated to varying degrees according to whether its suspensory ligament is simply torn into or entirely torn through. If the trauma is a severe one the eyeball may be ruptured and the lens expelled from it. In this connection may be mentioned the dislocation of the lens into the anterior chamber from a sudden perforation of a corneal ulcer. Spontaneous dislocation of the lens occurs from a progressive fatty degeneration and softening of the zonula, due to liquefaction of the vitreous from chorioiditis or myopia of high degree or the shrinkage of a hypermature cataract may give rise to atrophy of the zonula from stretching. The lens through its own weight then subsides. After the zonula has become atrophied a subluxation may become total at any time from an insignificant traumatism or from coughing or sneezing. Hydrophthalmos and ectasis of the cornea and anterior portions of sclera occasionally cause the zonula to atrophy by being overstretched and luxation of lens follows.

Symptoms of Subluxation of the Lens.—There is an unequal depth of the anterior chamber and the curved edge of the lens, which is pigmented from contact with the ciliary processes when it was in its

normal position, can be seen to occupy the pupil. If the lens is depressed the anterior chamber will be found deeper above. The lens and iris are tremulous and the part of the pupil situated above the edge of the lens is of a deep black color, while through the lens it appears a delicate gray, its normal appearance.

There is produced a high degree of irregular astigmatism by luxation of the lens by which the sight is rendered very poor. Above the edge of the lens the eye is aphakic and below through the lens the refraction is very irregular because the edge of the lens acts as a strong prism. Double vision or monocular polyopia is often observed. The subluxated lens sooner or later becomes opaque and the vision is thereby rendered more distinct as we then have to do only with the aphakic portion of the pupil which can be corrected by a convex lens.

In luxation of the lens it has left the fossa patellaris altogether and is found in the anterior chamber or in the chamber of the vitreous. A lens luxated into the anterior chamber can be readily recognized by its shape. Dislocation backward into the chamber of the vitreous occurs more frequently than dislocation into the chamber of the aqueous. The anterior chamber is abnormally deep and the iris is tremulous from lack of support.

The pupil is pure black and the crystalline images of Purkinje are wanting. If the lens is opaque it may be recognized deep down behind the iris by oblique light. In most cases the ophthalmoscope is needed, however, to detect it. At times it floats about in a fluid vitreous giving rise to what is called cataracta natans, but is usually attached to some spot by exudate.

Dislocations of the lens usually give rise to secondary disturbances which lead to the destruction of the eye in not a few cases. The uvea is so irritated by the lens pushing and striking against it that an irido-cyclitis is the result and this may give rise to a sympathetic affection of the fellow eye. Increase of tension or glaucoma also at times arises from luxations of the lens especially if dislocated into the anterior chamber. The cornea becomes opaque wherever the

lens remains in contact with it and the eye undergoes rapid destruction either from rise of tension of from irido-cyclitis.

Treatment.—In cases in which the disturbance of vision is the only symptom of the dislocation we prescribe suitable glasses. The best thing to do under these conditions is to cover the portion of the pupil with a half ground glass so that vision is only performed with the aphakic portion which can be corrected by means of a convex spherical lens. If the patient's other eye is good, it is better to exclude the injured one from the visual act by means of a ground glass in his spectacles, that is, if annoyed by polyopia. If the symptoms of irido-cyclitis or glaucoma are caused by the dislocated lens it should be removed if possible, but unfortunately this is not always an easy task. If the lens lies in the anterior chamber it can readily be extracted and this is especially necessary as otherwise the eyeball would certainly be lost. If the lens is free in the vitreous it can not be removed by any means at our command. In subluxation the removal of the lens is difficult because the vitreous is most apt to prolapse on account of the defective nature of the zonula of Zinn. If the tension is elevated and the lens can not be removed we may try the effect of an iridectomy. If the eye is already blind from a dislocated lens it should be removed so that we avert the danger of a sympathetic inflammation and relieve the patient of pain.

Lenticonus is a very rare congenital anomaly of the lens consisting in a conical like projection upon its anterior surface at or near its center. Posterior lenticonus is still rarer and consists of a similar projection upon the posterior surface of the lens.

CHAPTER XXI

OPHTHALMIC MIGRAINE

THE term migraine as usually employed is indiscriminately applied to various forms of headaches, from a neuralgic affection of the ophthalmic division of the fifth nerve or hemicrania to the gravest sensory neurosis. Any headache accompanied by more or less nausea is erroneously called by many migraine. Strictly speaking, migraine is more than an affection of the fifth nerve, although the most important symptom is situated in that nerve. It is characterized by various visual disturbances, neuralgic and gastric symptoms. The attack of pain in the head is ushered in by an aura which is usually in the form of scintillations, ocular spectra or phantoms. This sensory aura may be situated in some other nerve than the optic, for instance there may be a tingling of the hand or arm or numbness of some part. After the aura has subsided the patient suffers with violent pain, which is usually situated in the head. The attack terminates with nausea and vomiting. Sometimes it is followed by a period of somnolence or drowsiness. On account of its periodicity, explosive nature and occurrence of an aura and followed by a period of drowsiness or somnolence many consider ophthalmic migraine a partial sensorial epilepsy. Sensorial epilepsy, as you are aware, manifests itself by crises of painful numbness or by sensations of heat or cold and may be distributed more or less widely over half of the body. It may or may not be associated with motor impulses. It is very common in general epileptics and paralytics. Whenever the eye symptoms are especially prominent in an attack of migraine we speak of it as ophthalmic migraine. Occasionally we have motor disturbances associated with it, constituting one of its most important characteristics and showing its close relationship to

epilepsy. Mental disturbances are also at times seen and enhance the similarity.

In most cases the visual disturbances in migraine manifest themselves first, and consist of a slight impairment of vision, of considerable loss of sight or of a hemianopsia, the patient being much surprised that she can see only the half of objects. In rare cases absolute blindness occurs, but this more frequently in hysterical subjects. There may also occur alone, or with the other disturbances named, scintillating scotomata. These scotomata always occupy the periphery of the field of vision and usually the external or temporal portion. They present themselves in the form of balls or rings of fire or in the shape of a rapidly vibrating or rotating wheel of red or white color. Occasionally the scotoma consists of zigzag or lightning-like streaks.

In the beginning of the attack the pupils are contracted, and that of the affected eye rather more so than that of its fellow. Dilatation of the pupils may occur with amaurosis. The disturbances of vision are accompanied by more or less tenderness of the eye and feeling of tension in the organ, so that in cases with dilated pupils the presence of glaucoma may be suspected. The pain in the head may not come on for several hours after the appearance of the aura, but usually follows the eye symptoms at the end of a few minutes. The pain is compared by the patient to a nail being driven into the cranium, is often intolerable and is relieved somewhat by pressure. The pain begins in the temporal region and soon radiates to the entire side of the head. The head is hot, pulse strong and full, and the pain aggravated by the least movement of the head. Not infrequently there is added a feeling of vertigo. Vertigo, with more or less nausea in consequence, is not infrequent in errors of refraction or anomalies of the extraocular muscles, so that some care is needed to properly discern whether the wearing of glasses will afford relief, for the correction of errors of refraction does not benefit migraine.

Abortive forms of ophthalmic migraine are not uncommon. Ocular disturbances occurring periodically may constitute the only symptom,

while some complain of a sudden and complete loss of vision of one or the other eye. To this latter condition the term retinal epilepsy is applied. In other cases the eye symptoms may be very slight or entirely absent. The nausea and vomiting at the end of the crisis are also inconstant. The various symptoms may likewise be disconnected; thus the ocular disturbances and the migraine may manifest themselves at different times. At times we find ophthalmic migraine associated with partial or general epilepsy, and it not infrequently leaves behind true paralyses. The visual disturbances, hemianopsia, or what not, may persist for quite a while after the subsidence of the attack. Another common sequella is dullness of hearing. Attacks of migraine may occur day after day, constituting what Fèrè has chosen to call the status of migraine. Ophthalmic migraine occurs principally in young adult females. In young individuals it is of little gravity save the suffering it entails, but when it occurs at an age when arterio-sclerosis is common, any temporary disturbance may become permanent, the paralyses persisting as monoplegias or hemiplegia.

Permanent aphonia is not a rare sequence of these migraines. In many cases there is during the attack of migraine more or less spasm of the orbicularis palpebrarum on the affected side, together with stiffness of the facial muscles and perhaps drawing of the head away from the affected side by the contraction of the sterno-cleido-mastoid muscle. In a few cases there is also asphyxia of the extremities, showing a condition of spasm of the peripheral vessels.

Etiology. — Many are inclined to look upon ophthalmic migraine as a distinct neurosis in which the crises are precipitated by the absorption of a leucomaine poison from the intestinal tract. Rachford in 1894 made some very important observations on the action of paraxanthin as a factor in migraine. Paraxanthin is one of the leucomaines belonging to the uric acid group found in normal urine to the extent of one milligram to a liter. The tests for it are as follows: (1) Add a few drops of a concentrated solution of potassium hydroxid to a small amount of concentrated urine

and if paraxanthin is present a white glistening precipitate will be thrown down. If only a trace is present the solution simply becomes turbid. (2) A little chlorin water containing a trace of nitric acid may be added to the urine and the mixture evaporated to dryness. The residue is then exposed to the fumes of ammonia and if paraxanthin is present a rose-red color is produced. The result of Rachford's observations confirm those of Haig regarding the increase of uric acid compounds in connection with the paroxysms of headache or the epileptiform convulsions that sometimes replace the migraine. If a solution containing paraxanthin be injected into the peritoneal cavity of a mouse or rat there follows great exaggeration of the reflex excitability which is followed in a few minutes by tetanic convulsions and finally death. Haig has made clear the gouty affinities of hemicrania and found an increase in the amount of uric acid derivatives in the urine after an attack.

Hysterical subjects not infrequently suffer with ophthalmic migraine and in them the ocular disturbances are predominant and greatly exalted. It is in such cases desirable to know just which symptoms belong to the migraine and which to the hysteria. In the first place hemianopsia does not figure in hysteria, having never been seen due to hysteria, but hemianopsia is among the commonest visual disturbances in ophthalmic migraine.

In hysteria the visual disturbances are bilateral ninety-nine times in one hundred but limited to the affected side in migraine. In cases of unilateral hysterical amaurosis the eye that does not see when its fellow is screened may see in stereoscopic vision, that is the individual will be able to properly discern the shape and depth of an object or properly interpret the pictures of the stereoscope. This reëstablishment of sight has only to do with direct vision for the field which remains contracted. (This experiment shows the bilateral innervation of the two maculas.) A hysterical patient is often blind to a certain simple color, but can readily recognize a compound color containing it.

Treatment.—Bromid of soda is the drug that gives us the best results in relieving and preventing the crises. If there is a distinct aura in the case ten to fifteen grains of the drug should be administered with the hope of aborting the attack. If the pain in the head is very severe we rely upon morphia or one of the coal-tar derivatives. In the interim bromid should be taken in sufficient quantities to ward off the attacks. At the same time the treatment appropriate to the uric acid diathesis is indicated.

CHAPTER XXII

ASSOCIATED DISEASES OF THE EYE AND EAR

EDMUND SPEAR was the first to point out the relationship between the eye and the internal ear in 1889. Many since him have also noted the connection and verified his statements. There is little doubt left in the minds of physiologists of to-day that the function of the semicircular canals is to apprise one of a sense of location in space, which operating through the cerebellum and with the aid of the muscular sense of the extraocular muscles enables the individnal to maintain his equilibrium. It is possible and probable that the labyrinth has indirectly a regulating function over the eye-muscles. Politzer and Lucae do not believe that the foregoing is a fact, for they were unable to observe any loss of equilibrium or coördination in cases in which the canals of the internal ear were entirely wanting or entirely destroyed by disease. They apparently forgot, as Spear says, that these canals form only a peripheral organ, and that when destroyed the individual possessed no means of telling the position in which he might place his head, while he still retains a center within the brain capable of education through sight and touch. Many patients who suffer with dizziness have disturbances in the balance of the extraocular muscles. The commonest errors of the eye-muscles, causing a reflex disturbance of the labyrinth, are exophoria and cyclophoria. So far there has been located no space-center in the brain which would act as a reflex medium between the eye and the ear. The cause of the reflex irritation to the labyrinth in heterophorias lies probably in the anatomical relationship of the vestibular nerve and the one supplying the particular muscle involved although not demonstrable. The vertigo is often associated with tinnitus and is worse in some one position of the head. Thus in one case of the author's the individual became dizzy whenever he lay upon his back

or tilted his head backward, another whenever he inclined his head to one side.

Both cases had oblique astigmatism of a diopter or so with associated cyclophoria. The proper glasses completely relieved them after several weeks' wear. Many cases are equally dizzy all the time when the eyes are open and not more so in one position of the head than in another. Such cases are no doubt due to a confusion arising from the attempt to properly orientate with a faulty muscular apparatus of the eyes, or by the annoyance of diplopia as occurs in the earliest periods of squints. Inasmuch as the specialties of ophthalmology and otology are usually linked together we will consider some associated symptoms of the eye and ear so that the diagnosis of a neighboring disorder may be more readily made or the causative factor discovered in the diseased condition. Oliver and Cleveland divide the subject matter into three heads which we will follow, namely: (1) Ocular lesions depending upon disturbances originating in the aural apparatus, (2) auditory lesions depending upon a primal cause in the eyes, (3) coincident ophthalmic and aural lesion from other causes.

Ocular Lesions Depending upon Disturbances Originating in the Auditory Apparatus.—The most important and the most frequent eye lesion found associated with aural disease is optic neuritis. It is to be looked for in all cases of suppuration of the internal ear, and is positive evidence that the diseased process has invaded the cranial cavity

The presence of optic neuritis during the progress of a middle ear disease means the occurrence of cerebral abscess, sinus phlebitis or meningitis. Meningitis is the commonest cause of death in suppurative ear diseases, then cerebral abscess, cerebellar abscess, sinus phlebitis and exceptionally pyemia. The absence of optic neuritis will not, however, negative the diagnosis of intracranial disease. The optic neuritis may be unilateral or bilateral, usually it is bilateral, one eye, that on the affected side, becoming involved somewhat sooner than the other.

According to statistics about 88 per cent. of sinus thrombosis cases develop optic neuritis, and 31 per cent. show the same condition in brain abscess. The presence of optic neuritis then favors the diagnosis of sinus thrombosis, then of meningitis and finally of abscess. Neuritis is very rarely associated with an extradural abscess. The study of the visual fields will enable one to place a lesion with some degree of accuracy; thus if there is homonymous hemianopsia present the disease will be found to involve the opposite optic tract. Again, if both of the blind halves of the two retinas are situated temporally, the brunt of the disturbance will have fallen upon the optic chiasm. It is rather common to find a paralysis of the seventh cranial or facial nerve with the resulting lagophthalmos in suppurative diseases of the tympanum. This may occur from necrosis of the facial canal as it passes through the middle ear or from an extension of inflammation from the mucous membrane of the middle ear to the bony wall of the facial canal and thence to the sheath of the nerve itself. The presence of foreign bodies in the external auditory canal, non-perforative catarrh of the tympanic cavity, necroses of the labyrinth and malignant tumors of the middle ear have all been observed in connection with facial paralysis. Lesions of other nerves connected with the visual apparatus have occasionally been seen coincident with diseases of the ear.

Paralysis of the external rectus (abducens paralysis) has been reported several times from intracranial involvement due to ear disease. Diplopia, internal and external squints and various anomalous pupillary action have also been noted. There are reported a few cases of purulent irido-chorioiditis in conjunction with purulent otitis media. There are two explanations given for the cause of this latter phenomenon. First the carrying of a septic embolus from the ear to the vessels of the chorioid, and second a direct extension of the inflammation to the membranes of the brain and thence to the eye by way of the sheaths of the optic nerve. The first explanation is the more probable. Nystagmus sometimes occurs as the result of primary ear disease.

There are instances recorded in which syringing the ear with plain warm water, pressure upon the tragus, and the presence of a plug of cerumen or polyp were associated with spasmodic oscillations of the eyeballs. In most of these cases there was present a purulent otitis media. In each of the cases there was supposed to have been a pressure exerted upon the semicircular canals and from these a propagation of reflex through the central nervous system, the cerebrum or cerebellum or both. Experiments upon animals have confirmed the theory that irritation of the semicircular canals will produce a nystagmus. Another variety of clonicism, that is blepharospasm, has likewise been observed from the presence of impacted cerumen, foreign bodies or polyps in the ear. This spasm is identical to that associated with carious teeth or irritation to the conjunctiva or cornea and is caused by a spread of irritation from the branches of the fifth nerve to the seventh in some way not yet made out.

Auditory Lesions Occurring as the Result of Primary Eye Diseases. — The instances of this kind are rare but there are five cases of glaucoma reported which existed simultaneously with deafness, and in two cases the hearing improved in a marked manner after the performance of iridectomy. It is a common experience of many to have a blowing tinnitus occur when they get a foreign body in the eye and certain corneal diseases have been associated with deafness. One case noted by the author had a snapping noise in the ear of the corresponding side from the presence of a foreign body in the cornea. This was possibly due to a clonic spasm of the tensor tympani or stapedius muscle.

Coincident Eye and Ear Diseases Arising from Other Causes. — Thrombosis of the cerebral sinuses may be associated with simultaneous ophthalmic and aural symptoms which is as a rule the result of purulent middle ear disease. Apoplectic hemorrhages are frequently the cause of optic neuritis and infrequently cause a disturbance of hearing as well. In leukæmia we have both eye and ear symptoms, deafness due to inflammatory changes and hemorrhages into the middle and internal ears. In the eye we have retinitis as

already described. In pseudo-leukæmia we find deafness from the presence of growths in the naso-pharynx while the optic discs appear of a dirty red-grayish tint.

Meningitis frequently causes unilateral or bilateral deafness due to involvement of the corresponding nerves within the cranium or to an extension of the inflammation to the labyrinth, and as already mentioned, meningitis is a common cause of optic neuritis. About one fifth of all intracranial growths cause a simultaneous disturbance of vision and of hearing. In migraine we have both aural and ophthalmic symptoms as we have seen. Posterior sclerosis of the spinal cord frequently gives rise to gray atrophy of the optic nerves and not uncommonly causes deafness from degeneration of the acoustic nerves as well. Hysteria causes various degrees of dullness of hearing and tinnitus with various anomalies of the visual fields.

General Diseases. — In nephritis the eye is very commonly involved but only one case of ear trouble has been reported due to Bright's disease and that was of the nature of Meniere's disease.

In diabetes again, eye symptoms are common but aural symptoms rare. On the other hand, furuncles of the auditory canal are not infrequent and purulent otitis media sometimes develops. Subjective auditory sensations and impairment of hearing may also be present.

Hutchinson was the first to draw attention to the fact that both eye and ear affections are found in hereditary syphilis. He says deafness associated with a dryness and opacity of the drum heads is very often associated with interstitial keratitis, iritis, irido-chorioiditis and appears at about the same time as the ocular lesion. Hinton says that in every case of hereditary aural syphilis the patient has previously suffered with impaired vision. The deafness is usually due to an involvement of the auditory nerve, center or labyrinth. Typhoid, relapsing fever, scarlatina, small-pox, diphtheria, rubeola, gout, etc., often give rise to coexisting ear and eye diseases.

CHAPTER XXIII

EYE LESIONS IN GENERAL DISEASES

In many diseases there are important symptoms referable to the eyes, which not infrequently develop early in the progress of the disease, thus aiding materially in the diagnosis, or occurring later influence the prognosis. Every general practitioner of medicine should therefore have an understanding of the ophthalmoscope and ophthalmology to the extent of being able to recognize eye symptoms when they occur in his practice. Eye lesions are found in the following diseases:

Acromegaly,
Arthritis deformans,
Cerebral arteritis,
Cerebro-spinal meningitis,
Chlorosis,
Chronic nephritis,
Diabetes,
Endocarditis,
Erysipelas,
Exophthalmic goitre,
General paralysis of the insane,
Gonorrhœa,
Gout,
Rheumatism,
Hysteria,
Idiocy,
Leprosy,
Grippe,
Leptomeningitis,
Leukemia,
Malaria,
Measles,
Mountain sickness,
Multiple neuritis,
Mumps,
Myelitis,
Neurasthenia,
Pernicious anemia,
Relapsing fever,
Scurvy,
Smallpox,
Syphilis,
Syphilitic meningitis,
Syringomyelia,
Tabes dorsalis,
Tobacco and alcohol poisoning,
Brain tumors,
Typhoid,
Valvular heart disease,
Aortic aneurism,

Diphtheria,	Epilepsy,
Cancer,	Tuberculosis (scrofula),
Multiple sclerosis,	Insanity.

Let us now consider the symptoms as presented by each in turn.

Acromegaly. — Diminution of vision is not infrequently present, especially bitemporal hemianopsia, although the curtailment of the visual field may take various forms. In advanced cases absolute blindness is apt to set in. The pupils are normal or sluggish in reaction to light. There may be at an early stage the signs of an optic neuritis, or optic atrophy more or less marked.

Arthritis Deformans. — Irititis and scleritis are occasionally met with although some believe that such cases are complicated with gonorrhœal rheumatism which is very frequently accompanied by iritis or scleritis.

Cerebral Arteritis. — As first described by Rahlman and Bull ophthalmoscopic examination of the retinal vessels will reveal atheroma of the cerebral vessels. The vessels of the retina show a strangulation or constriction at some point with a diminution of their lumen beyond. These constrictions occur where one vessel crosses another. The vessel beneath is likewise obscured from view at the point of crossing by the thickened and opaque walls of the overlying one. Above and below the constriction the vessel at times presents a fusiform thickening. Such retinal vessels are called Bull's vessels, for it was Bull who first described them. The veins less frequently show the same changes to a minor degree. The retina above and below these constrictions presents a streaked appearance with small hemorrhages without any inflammatory reaction.

Cerebro-spinal Meningitis. — In cerebro-spinal meningitis the pupils are normal in size, dilated or contracted, often unequal in size and sluggish in their reaction to light. Photophobia is very common, and at times patients complain of double seeing. Keratitis, uveitis and retinitis may also occur, resulting in more or less blindness. Amblyopia and amaurosis are infrequently observed, but are often transitory.

Chlorosis.—The eye ground is pale and optic neuritis or neuro-retinitis often present. Dimness of vision or complete blindness without ophthalmoscopic changes has been observed. Optic neuritis is more common than in pernicious anemia, while retinal hemorrhages are rare. Not infrequently the retinal picture is one of albuminuric retinitis, that is, yellowish-white areas of fatty degeneration radiating from the macula lutea, with numerous hemorrhages and optic neuritis.

Chronic Nephritis.—(Chronic granular and large white kidney.) The retinitis seen in pregnancy and scarlatinal nephritis are due to the same causes as that associated with other forms of albuminuria. Functional albuminuria is said to cause retinitis at times. In typical cases, beginning in the macula or immediate neighborhood, and continuing to be most numerous in this region, a variable number of irregular white spots occur. They arrange themselves about the macula in the form of a star-figure. Around the nerve head these spots (which are distributed more or less irregularly throughout the fundus) coalesce and form a snowy white ring around the papilla, which has given rise to the name "snow-bank appearance of the retina." The white spots are due to a fatty degeneration of the inner ends of the supporting fibers of the retina, or of the fiber and granular layers of the retina. Besides the spots numerous hemorrhages occur scattered throughout the retina. They may be linear, flame-shaped or round, and of variable size. The blood-vessels may be hidden in the swollen tissues of the retina to appear again on the other side of the spot or may run over the spot unobscured. Finally, the nerve head and the part immediately around it becomes hyperemic and edematous. The edge of the papilla is obscured, but not necessarily swollen, and the surrounding retina traversed with numerous radiating lines, as is so often seen in brain tumors. It is well known that Bright's disease is often discovered by an ophthalmoscopic examination, the patient being ignorant that anything is the matter with him save some diminution of vision. The changes in the fundus may be from the beginning

that of a neuroretinitis, or to that may be added the degenerative changes, or formation of whitish spots in the retina. The prognosis as far as vision is concerned is most unfavorable, and as far as the life of the patient is concerned nephritic retinitis is most unfavorable —few patients living over two years after its onset. Local treatment is of little avail. Cataract occurs in about six per cent. of cases of Bright's disease, due to malnutrition and partly to the arterio-sclerosis with which it is associated.

Diabetes.—The ophthalmoscopic picture afforded by diabetes is not unlike that just described. The opacities are less apt to be arranged so regularly, and opacities and hemorrhages occur in the vitreous humor more frequently. Cataract is also of more frequent occurrence. Diabetic retinitis is a late manifestation of the disease and patients with it do not survive long, gangrene, carbuncle or hemiplegia carrying them off. There is no local treatment.

Endocarditis.—Embolism of the retina is not infrequent and is marked by the occurrence of sudden blindness. If the embolism is septic there develops panophthalmitis with the destruction of the eyeball. The trouble is bilateral, one eye being affected before the other. The picture of embolism of the retina can not be told from that of thrombosis with any degree of certainty. The main branches of the artery are thin and can be traced only a short distance over the edge of the papilla, and there is a diminution in the number of ramifications, if the central artery is stopped. The veins are contracted and often present a beaded appearance from unequal distension.

In the veins immediately after the accident the flow is intermittent, the blood appearing to be broken up into cylinders separated by clear spaces which move sluggishly along. This same appearance can often be produced in the arteries by pressure upon the eyeball. Hemorrhages are apt to occur along the course of the veins especially. The papilla assumes a pallid, grayish-white appearance, caused by a lack of blood in its capillaries, and an opacity develops in the retina in the form of a grayish-white, fog-like edema, sometimes per

mitting the reddish color of the eye-ground to shine through it, at other times being very opaque. This opacity occurs especially in the macular region and in the neighborhood of the papilla, the space between the two being at times entirely free from clouding. This clouding may set in in a few hours after the accident or be delayed as much as several days. This characteristic sign of sudden obstruction of the retinal circulation is the formation of a red spot in the fovea. It is known as the cherry-red spot of the macula lutea. It is occasioned by the red chorioid showing through the retina, which is not clouded at this spot, and by changes in the pigment epithelium. In dark skin races the red spot is often replaced by a black one. This spot occurs at the same time as the opacity in the macula. After several weeks the retina and nerve become atrophic, the former establishing its transparency once more. Pigment markings and cholesterin crystals are then seen scattered here and there in the retina. If only a branch of the artery is obstructed the retina supplied by it becomes edematous and opaque, and the point of stoppage may be seen as a yellowish body or more frequently assumed to be present because at one point the vessel is dilated and beyond completely obliterated.

Erysipelas. — Facial erysipelas, besides affecting the eyelids, very frequently gives rise to the severest forms of orbital abscess, which are often bilateral. The symptoms of an orbital phlegmon are: Protrusion of the eyeball, which may be straight forward or not, according to the focus of suppuration; pain on moving the eye, tenderness on pressure and limitation of movement; inflammatory edema of the lids and ocular conjunctiva. Fluctuation finally appears and pointing takes place usually below the inner portion of the supraorbital ridge. There is danger of the inflammation passing to the eyeball, which may be destroyed by suppurative chorioiditis. The sight may be permanently affected by the occurrence of an optic neuritis, thrombosis of the central artery of the retina or ulcer of the cornea. Late in the progress of erysipelas there may occur what is called ischemia of the retina, with complete blindness. There is extreme pallor of

the optic papillæ with narrowing of the blood vessels, the same as is seen after toxic doses of quinin and salicylic acid. Finally erysipelas is not an infrequent cause of purulent inflammation of the vitreous. When the cornea is clear there is seen a yellowish reflex through the pupil, there is retraction of the periphery of the iris and bulging of its pupillary border. The pupil is small and inactive to light (signs of iritis) and there is a certain amount of tenderness upon pressure (cyclitis). When the pus is circumscribed the appearance with the ophthalmoscope is not unlike that of glioma retinæ, as seen in children, and is, therefore, called pseudo-glioma. It is to be distinguished from true glioma by the absence of inflammatory signs in the latter, and by the fact that in pseudo-glioma the tension of the eyeball is diminished.

Exophthalmic Goitre.—So constant is the protrusion of the eyeballs in this disease that it forms one of the classical triad of primary symptoms, the other two being a quick heart and enlargement of the thyroid gland. It is only in rare cases that the exophthalmos is absent. It is not the first symptom to appear, but develops subsequently to the tachycardia, which latter is never wanting. The exophthalmos may affect only one eye, or both to unequal degrees. The following signs serve to differentiate exophthalmic goitre from other varieties of exophthalmos:

Graefe's Sign consists of a defective descent of the upper eyelids when the gaze is directed downwards. In health, when the eyes are directed downwards, none of the white sclerotic above the cornea comes into view, but in a fair number of exophthalmic goitre cases the upper eyelids remain more or less in their elevated position as the eyes are directed downward, thus exposing a certain amount of sclera above the cornea. This sign is found in about one third of all cases. It is supposed to be due to a contracture of the involuntary fibers, or Müller's muscle, found along with the levator palpebræ superioris.

Dalrymple's Sign.—Owing to a persistent retraction of the upper lid, the palpebral fissure is widened, the eye having the appearance of one under cocain.

Stellwag's Sign consists in the imperfect winking movements of the lids. The fundus of the eyeball is usually normal, although pulsation may be noticed in the retinal veins, with a slight edema of the margins of the optic papilla.

General Paralysis of the Insane.—As a rule in this condition information can be obtained from the examination of the eyes. Early in the progress of the disease the pupils are in many instances very minute, spoken of as the pin-hole pupils, or they are of unequal size or may be oval or irregular in shape. These alterations in the pupils are intermittent. One pupil may be semidilated and inactive to light and to sympathetic irritation, that is, fails to dilate as does the normal pupil on irritating the skin. At times the partially dilated pupil will contract when light is made to enter the eye, but immediately dilates and remains so throughout the illumination of the retina. The pupils react to convergence and accommodation in about 63 per cent. of all cases, so the Argyll-Robertson pupillary phenomenon is fairly frequent, that is, the pupils react to convergence and accommodation, but not to light.

Gonorrhœa.—There are two forms of ocular complications in gonorrhœa, one due to local infection with the pus and the other due to the same dyscrasia that gives rise to the joint complications. The first usually results in the loss of the affected eye, while the latter is not so serious. Purulent ophthalmia in the adult is not very different from that of a new-born child save in its severity. In the adult the lids and conjunctiva become edematous and infiltrated and by pressure upon the cornea and its circumcorneal vessels interfere with its nutrition, and it is therefore liable to ulceration, which is apt to leave the sight more or less permanently affected. Gonorrhœa as an etiological factor in scleritis, iritis, and neuritis in not generally known. In scleritis there is a diffuse bluish-red injection of the entire sclera, very painful, unattended by secretion save some increase of lachrymation. It is often mistaken for iritis or conjunctivitis. It also occurs in circumscribed patches of violaceous tint, situated in the ciliary region, slightly elevated, and fading gradually into the normal surrounding tissue.

Gonorrhœal iritis simulates closely that caused by rheumatism. It occurs subsequent to joint involvement, and is due to the influence of the gonococci or their toxines upon the iris tissue. It is attended with severe pain, besides the usual symptoms of iritis. Neuritis of the optic nerve is infrequently caused by gonorrhœa. It does not differ from that caused by other agents. The nerve head appears with the ophthalmoscope abnormally red, its vessels blurred in spots and the margin of the nerve obscured by inflammatory exudate.

Gout. — The disorders of the eye encountered in gout are similar to those seen in rheumatism. Gouty inflammations of the eyeball are apt to be fugacious or take sudden exacerbations and are frequently recurrent. Fugacious periodic episcleritis, or that disease in which there forms one or more patches of scleral injection or edema or violaceous hue, lasting seven or eight days and recurring at intervals of several weeks or months. Gouty iritis resembles rheumatic iritis in its tendency ro relapse and to attack one eye at a time. In eyes predisposed to glaucoma, an exacerbation of gout will precipitate an attack of glaucoma. The eye becomes very painful and the sight much interfered with. On examination the cornea is found steamy, partially anæsthetic, and pupil dilated. The anterior ciliary veins and circumcorneal vessels are congested and eyeball is hard.

Gout also infrequently gives rise to cataracts, and to opacities in the vitreous. Subconjunctival and retinal hemorrhages and hemorrhage into the vitreous less frequently, are at times associated with a gouty diathesis, but are more apt to be caused by an accompanying nephritis.

It has been estimated that about one fourth of all cases of uveitis and optic neuritis are due to gout and rheumatism. Gouty iridochorioiditis is prone to recur, and finally leads to complete glaucoma in many instances. It is also very intractable to the usual methods of treatment. In some cases of gouty manifestations of the eye true tophi have been discovered in the tunics of the eyeball.

Rheumatism. — What has been said in regard to the ocular manifestations of gout applies equally well to rheumatism.

Hysteria.—As Fèrè says, it is the eye that best shows the relations which exist between troubles of sensibility and those of motility. The general sensibility of the eye as well as its special sense is affected, thus the skin of the lids, the conjunctiva and the cornea are more or less devoid of sensation, and blindness without ophthalmoscopic signs is often present. Hysterical blindness is shown to us by its miraculous cure. Pupillary actions remain normal in hysterical blindness. At times we have color-blindness with retention of good light sense. There seems to exist some connection between the visual power and loss of sensibility of the eyeball in hysteria, for those who show no narrowing of the visual field seldom have anæsthesia of the conjunctiva and cornea, while others who develop achromatopsia or present constricted visual fields have also anæsthesia of the conjunctiva. The lachrymal reflex is not ordinarily lost and is excited by irritation to the conjunctiva. One of the most important signs of visual anæsthesia is narrowing of the visual field. The contraction is, as a rule, concentric. Hysterical amblyopia is often accompanied by diplopia or monocular polyopia. Hysterical subjects at times suffer from ophthalmic migraine. Hemianopsia does not seem to figure among the visual disturbances of hysteria.

The loss of muscular sense may be as complete for the muscles of the eye as for those of the extremities. This loss can not be without influence upon the function of the ciliary muscle. The ciliary muscle is very frequently affected in hysteria, its contracture is always found when that of the orbicularis exists, but it may occur alone. The contracture of the muscle of accommodation produces a pseudo-myopia, that is the eye is adjusted for a near point. Among the contractures of the external ocular muscles, blepharospasm is the most frequent. It may arise spontaneously or originate in some irritation to the conjunctiva or cornea. The spasm may be tonic or clonic. Tonic blepharospasm may be painful or not, the former is usually bilateral while the latter is unilateral. The spasm of the lids is at times associated with spasm of the motor muscles of the eye but the latter, though rarely, may alone be affected. It is not easy to dis-

tinguish between paralysis and spasms, and indeed both may exist at the same time, as spasm of the lids in a patient with hysterical hemiplegia. Paralyses of the ocular muscles are very rare in hysteria. Iridoplegia is the commonest form of ocular palsy, and it occurs without dilatation of the pupil.

Idiocy. — Vision is the only sense by which we can in cases of idiocy determine whether there is a change in the sensorial apparatus or alteration of perception itself — in case of the other senses we must rely upon the statements of the patient. It must not be forgotten that idiots may pass as deaf, dumb and blind through want of attention. In regard to sight it is easy to determine whether the apparent blindness is due to a lesion of the visual apparatus or to inattention. In the majority of cases we have to do with central changes, the activity of the pupils showing that there is no gross lesion present. Inequality of the pupils and abnormalities of the iris are common. There may be a congenital cataract and floating bodies in the vitreous. Pigmentary retinitis, or the occurrence of pigment deposits in the periphery of the retina with retinal anæsthesia, is at times present. Blindness, either congenital or acquired, is encountered in about 8 per cent. of cases. The perception of colors and perspective, etc., seem to bear a relation to the intellectual development in general.

Grippe. — The ocular affections of la grippe vary from the slightest conjunctivitis to the severest form of inflammation of the eyeball, and scarcely a tissue of the eyeball or its adnexa is exempt. The eye complications may be classified under one of three heads, namely: Inflammatory symptoms, symptoms referable to the nervous system and those relating to the circulatory apparatus.

Among the inflammatory symptoms, those involving the palpebral conjunctiva, cornea, uveal tract, retina and Tenon's capsule are the most frequent. Abscesses of the lids are occasionally seen during convalescence. The commonest affection occurring is a conjunctivitis, which comes as a simple catarrh, save that it develops more quickly, and recedes rapidly.

On the other hand it may run a protracted course, varying from a simple to a fibrinous inflammation. The tear passages often suffer, ending in a dacryocystitis. Two rare forms of keratitis are met with, namely: Keratitis punctata superficialis, and dendritic keratitis. Keratitis punctata superficialis preferably attacks the young and involves both eyes. It is accompanied by a catarrhal condition of the respiratory organs and is ushered in by a violent catarrhal conjunctivitis, and marked ciliary injection. Soon the cornea becomes covered with numerous papules giving it a roughened appearance, which often break down into ulcers. Keratitis dendritica ulcerans is a very superficial ulceration presenting an arborescent form, which gradually extends over the entire surface of the cornea. There is frequently an absence of pain and irritation in these disorders due to a diminished sensitiveness of the cornea. Several have reported the occurrence of a parenchymatous keratitis after influenza. Inflammation of Tenon's capsule is at times the cause of the severe pain felt on moving the eyes in cases of influenza. The inflammation may become sero-fibrinous or purulent.

Ocular Neuroses. — Various neuralgic pains in and about the eyes are frequent. The commonest form of ocular paralysis due to the grippe is that of accommodation. The third to the extraocular muscles and sixth nerves are also though infrequently involved. The retina presents a very small number of affections which are referred to influenza. Among such affections may be mentioned hyperemia, hemorrhage, detachment and atrophy. Functional disturbances embrace amblyopia and amaurosis. The optic nerve is frequently the seat of a retro-bulbar inflammation or of a papillitis.

Circulatory Disturbances. — Subconjunctival and retinal hemorrhages and hemorrhages into the vitreous.

Leprosy. — The eye is affected in about 75 per cent. of cases of tubercular leprosy. The leprous process almost always begins in the oculopalpebral mucous membrane. At an early stage the white of the eye assumes a muddy appearance and there is a periodical circumcorneal injection. The change of color in the sclera increases

and produces a grayish-yellow thickening, beginning at the external border of the cornea and gradually extending quite around it, forming a wall of thickened tissue about the cornea. The whole conjunctiva finally by degrees becomes the seat of the specific inflammation. The lids become swollen and erythematous, the eyelashes fall, and permanent thickenings remain in the tarsal plates, or the lids may be involved by leprous tubercles. The disease eventually extends upon the cornea. The original infiltration has ere this acquired a brownish color, is firm to the touch, and has extended through the thickness of the cornea. After penetrating the cornea, the tubercle reaches the iris and gradually passes into its substance. The pupil becomes irregular and the anterior chamber is filled with tubercular matter. The disease continues until the anterior chamber and the entire cornea are occupied by the yellowish-white mass. The eyeball is now a shapeless mass. A staphylomatous tumor forms and increases in size, so that at times the eyelids cannot cover it. According to a few authorities the iris may be primarily involved. The almost invariable result of leprous iritis, either primary or secondary, is loss of sight.

Leptomeningitis (*Meningitis*). — During the stage of depression or paralysis the pupils are widely dilated, and one often larger than the other, and they do not respond to any form of retinal stimulation. If the fundi are examined, profound optic neuritis, or choked discs, are found. Ocular paralyses are rare, but ptosis of one side is at times present.

Leukemia. — The eyes show changes in about one third of all cases of leukemia. There is a certain amount of exophthalmos or bulging of the eyeballs due to lymphomatous growths within the orbits, and large lymphatic masses are at times found in the eyelids and about the orbits. The lachrymal gland may be similarly involved. The most constant symptom is the change that takes place in the retina. The eye-ground presents a marked pallor, appearing orange colored. The discs are remarkably pale, and the veins enlarged and perhaps tortuous, and their color is light red in comparison to that of the normal veins of the retina. In some cases a border

of light color is seen outside the venous walls. Hemorrhages are frequent, especially in the periphery and between the macula and the disc. The central portion of the hemorrhagic area is yellowish in color, from a fatty metamorphosis, while the edge is red. There is also less frequently hemorrhage into the vitreous, lymphomatous nodules in the chorioid and iris and cataract. The vision is often not all affected, although the ophthalmoscope reveals such marked changes in the fundus, but marked alteration in the vision may occur.

Malaria.—Diseases of the eye are not very common in malaria. It is especially within the tropics that such complications of malaria are observed, and most frequently in the æstivo-autumnal variety. The retina and the optic nerve are the parts of the eye most prone to malarial lesions. Both the acute and the chronic form of the disease give rise to ocular complications. In acute pernicious fevers amblyopia or amaurosis is of rather frequent occurrence. The amaurosis is usually bilateral and lasts from thirty minutes to as much as twelve hours or so. It usually comes on with the initial chill and passes away with the sweat. There may be only one attack or it may become intermittent in character. The type of the attack is for the most part tertian and rarely quotidian. When the attacks are daily and coming on during the hours of the evening it resembles very closely hemeralopia, and so some have described hemeralopia as caused by intermittent fever. The pupils are dilated and immobile during an attack and the fundi usually show no change, though there may be evidences of optic neuritis, as blurring of the disc margins and congestions of the veins. The amaurosis has not always a temporary character, but may end in permanent blindness due to atrophy of the optic nerve. When optic neuritis is manifest the continued use of quinin for four weeks will effect a cure. There at times occurs a retino-chorioiditis, revealed by a venous congestion of the fundus accompanied by a peripapillar retinal edema, and by a slight prominence of the optic disc, which takes a characteristic pinkish-gray appearance in its central portion. Retinal hemorrhage with or without amaurosis is at times seen in acute malaria. In cer-

tain cases there is doubt whether the amblyopia is due to malarial or quinin poisoning.

The ophthalmoscope will decide such cases, as the fundus picture is characteristic of quinin amblyopia. In quinin poisoning there is a decided ischemia of the retina and nerve. The arteries and veins are extremely contracted, and all traces of them may be lost a short distance from the papilla. The optic nerve is from the first of pearly whiteness and its margin unusually distinct, as in simple atrophy. There are no evidences of retinal hemorrhages which are more or less frequent in cases of malarial amblyopia. In malarial amblyopia the fundus is seen to be hyperemic, papillary edema, optic neuritis with hemorrhages into the retina. The course of the two maladies is also different—malarial amblyopia or amaurosis being of comparatively short duration. Another point of difference is that in quinin poisoning the patient often retains almost perfect central vision, while the field is concentrically contracted almost to the fixation point. Chorioiditis, iritis and cataract are infrequently caused by malaria. White atrophy of the optic nerves in rare cases has been ascribed to a malarial cachexia, and the fundus changes supposed to be characteristic of Bright's disease have been caused by malaria.

Finally, there is a special change that takes place in the vitreous in chronic malaria poisoning. This consists of a whitish infiltration occurring at intervals and causing an almost complete loss of sight. On ophthalmoscopic examination nothing is seen but the white reflex characteristic of this affection. After an oscillating course of several months the affection ends in recovery.

Measles.—The conjunctival catarrh, that so constantly accompanies measles during the prodromal and eruptive stages, may become very intense, causing great swelling of the lids, and copious mucopurulent discharge. This severe form occurs in strumous children, and is frequently followed by corneal ulceration and opacities, or even by perforation and destruction of the eyeball by panophthalmitis. At a later stage, as the eruption is fading, phlyctenular conjunctivitis or keratitis is not uncommon.

Mountain Sickness.—Among the symptoms presented by those who have recently taken up their abode in high altitudes must be mentioned certain ocular changes, which are due to the glare of the sun upon the snow-covered mountains, to the irritating particles of snow carried by the wind and finally to the effect of the ultra-violet rays of light, which are so numerous in such regions, upon the eye. Snow blindness is characterized by an irritable condition of the eye, manifested by great photophobia, lachrymation, conjunctival and circumcorneal injection. While the majority suffer from undue sensibility some exhibit amblyopia or anæsthesia of the retina.

Multiple Neuritis.—The optic nerve and ocular muscles are frequently profoundly affected in cases of multiple neuritis, whether from alcohol, lead, diphtheria or other infectious disease. The commonest form of ocular paralysis following diphtheria is that of the external rectus muscle of one eye, and next paralysis of convergence and accommodation, with or without involvement of the pupils. Ptosis, which is often bilateral, occurs late in the disease in a fair number of cases. In regard to the optic nerve, it may become inflamed or undergo simple atrophy from the systemic intoxication, though it is rarely involved in diphtheria. In a limited number of cases we have the Argyll-Robertson pupillary reaction. The pupils are often of unequal size.

Mumps.—The sight is quite frequently affected in mumps. There is a diminution of vision with photophobia, lachrymation and redness of the optic papillæ. Edema of the lids is not uncommon. Amblyopia may occur. Dachryoadenitis occasionally develops at the time of involvement of the salivary glands or subsequently. This condition is not difficult to diagnose. The enlarged gland pushes itself forward and downward between the eyelid and the eyeball. The upper lid is edematous and hangs down.

Myelitis.—The eye is implicated when the lesion involves the first dorsal and adjacent segments. There is narrowing of the palpebral fissure, and frequently optic neuritis. Optic neuritis does not occur in a transverse myelitis, but only when there is coincident disease of

the optic nerves, that is, when there is more or less disseminated inflammation.

Neurasthenia. — Errors of refraction are often observed for the first time when the patient becomes run down from overwork and errors in the muscular apparatus of the eyes are also discovered. These readily lead to eye-strain with its train of symptoms, chief among which is headache. Neurasthenics complain much of muscæ volitantes or floating specks before the eyes and of intolerance of light.

Pernicious Anemia. — In impoverished states of the blood, and especially in pernicious anemia, retinal hemorrhages are not uncommon. If on the periphery, they give rise to little or no disturbance of vision, but if central almost complete blindness may result. The hemorrhages are most numerous about the optic papilla. They vary in size from mere points to large effusions. They vary in color from a bright red when fresh to a dark yellowish-red as they increase in age and finally leave atrophic, more or less pigmented, areas behind. Infrequently reduction of vision without ophthalmoscopic signs is present.

Relapsing Fever. — The eye is very commonly affected in this disease and almost any portion of it may become involved. Thus we may find subconjunctival ecchymoses, phlyctenular conjunctivitis, abscess or ulcer of the cornea, serous uveitis, iritis, irido-cyclitis, uveitis (exudative) and opacity of the crystalline lens. A few cases are reported in which the cloud in the lens has cleared up after the fever has subsided. More serious affections, as retinal hemorrhages, optic neuritis, amaurosis and retinitis, have been noted. Embolism may give rise to paralyses affecting the accommodation, pupil or various ocular muscles.

Scurvy. — The eyes are deeply sunken and surrounded by dark circles. Subconjunctival hemorrhages are not rare in the hemorrhagic form of the disease. Hemorrhages may also occur in the anterior chamber, retina and chorioid. Hemeralopia is occasionally a symptom of the disease.

Smallpox. — Pustules not infrequently develop upon the eyelids giving rise to enormous edema and perhaps sloughing. The lids may be the seat of abscess formation. The eyeball may be affected in a number of ways as follows: There may be a catarrhal conjunctivitis caused by retained secretion from edema of the lids or from pustulation. The pustules not infrequently develop upon the lid conjunctiva, but are extremely rare upon the cornea. According to Horner, the most frequent and serious mode of attack is a grayish-yellow infiltration in the conjunctiva close to the lower margin of the cornea and extending not quite to the fornix. This infiltration occurs in the eruptive stage and is to be regarded as a variola pustule. The infiltration leads to formation of an ulcer or abscess of the cornea with perforation and prolapse of the iris, purulent irido-cyclitis or panophthalmitis. The frequency with which the eyes become affected varies in the different epidemics. Hebra found that pustulation occurred upon the eyeball in only one per cent. of cases and that the eye was lost through metastases. Keratitis as a rule occurs from malnutrition and seldom from pustulation, so that the term atrophic keratitis is applied to such cases. Abscess of the cornea makes its appearance during the stage of desiccation and at times in those who have left their beds. The infection is caused by germs which are circulating in the blood. Among post-variolous affections we find also iritis and irido-cyclitis, opacities in the vitreous humor and glaucoma (secondary). Panophthalmitis not infrequently results. In the hemorrhagic form of the disease bleeding takes place beneath the conjunctiva into or behind the retina, detaching it and leading to blindness. Septic infection of the retina or chorioid may take place after pyemia comes on.

Syphilis. — The eye is more frequently affected in lues than any other organ of special sense and is one of the favorite localizations of the disease. The initial lesion may affect the brows or eyelids, but on account of its unusual situation is rarely recognized early, although the course of the lesion is like that anywhere else. For description of chancre of lid the reader is referred to the chapter on

diseases of the eyelids. Any of the cutaneous manifestations of syphilis may be found upon the skin of the lids. Gummata of the lids sometimes occur in the form of hordeola or tarsal cysts, or as flat superficial infiltrations or grow to tumors the size of almonds. The gummatous infiltration soon attacks the tarsus, giving rise to great distortion and swelling of the lids—tarsitis syphilitica. There is always more or less destruction of the lid due to ulceration and cicatrization. The differential diagnosis between lupus Willani, gummatous ulceration and cancerous ulceration does not offer any great difficulty. Lupus but very rarely indeed affects the eyelids primarily but extends to the latter from adjoining parts. It more frequently happens that cancerous ulceration is mistaken for syphilitic ulcer than *vice versa*. To avoid repetition the reader is referred to the chapter upon the diseases of the eyelids for further consideration of this subject.

More commonly do we find the various syphilitic affections upon the conjunctiva than upon the lids. The initial scleroses are as a rule met with in the transition fold of the lower lid, more rarely on the conjunctiva of the lids and eyeball. There are several cases on record where physicians treating patients for syphilis have developed chancre of the conjunctiva. A very common method of infection among firemen and engineers is the practice of removing cinders from each other's eyes with the tongue. A stubborn conjunctival catarrh must occasionally be regarded as evidence of constitutional lues. Gummata usually extend and involve the sclera, cornea and cicatrizing lead to a pterygium-like thickening of the conjunctiva. The tear passages are affected in syphilis by disease of the neighboring parts, especially by ostitis or periostitis of the bony lachrymal canal. Affections of the cornea are the commonest eye manifestations of syphilis. Since the work of Hutchinson we regard the presence of interstitial keratitis with a certain amount of deafness and peg-shaped incisor teeth as pathognomonic of inherited syphilis. Horner says that interstitial keratitis also occurs in the acquired form of the disease, but we must remember that tuberculosis and chronic malaria

and rheumatism may likewise give rise to an interstitial keratitis (keratitis profunda).

Syphilitic iritis is met with in all stages of lues, and is often the first constitutional symptom to appear. At least one half of all cases of iritis are syphilitic. In most cases there is no difference between syphilitic and other forms of iritis, although in the former the synechiæ are broader and firmer and there is a greater amount of exudate poured out which may occlude the pupil or obliterate the post-chamber. Now and again we have the formation of papules upon the iris. There is great tendency to relapses in the same eye or the occurrence of the same affection of the fellow eye.

The ciliary body is usually affected secondarily to an iritis—irido-cyclitis. Gummatous infiltration occurs in the iris and ciliary bodies and leads to softening of the sclera with the production of a bluish-white swelling adjacent to the limbus. One half or more of all cases of chorioiditis are of syphilitic origin. The same may be said of affections of the retina. Optic neuritis independent of other changes occurs frequently or secondarily to intracranial manifestations as gummatous meningitis. Mechel believes the crystalline lens may become cataractous from syphilis, but this is usually secondary to a chorioiditis or irido-cyclitis. Gummata at times occur in the orbits and periostitis of the orbit is usually syphilitic in origin.

Almost any portion of the eye may be affected by lues both in the secondary and tertiary stages of the disease. All the more serious affections of the visual apparatus have, in the majority of cases, to do with *specific* disease.

Syphilitic Meningitis, like meningitis from other causes, very frequently gives rise to palsies of the ocular muscles and to inflammation and atrophy of the optic nerves. The third nerve, as we have seen, is most frequently affected, and the fourth least often involved. Some disturbance of vision is usually not long delayed unless the luetic process at the base of the brain is very limited or far removed from the visual pathway. There is amblyopia, amaurosis or hemianopsia, according to the nature and extent of the lesion. Choked

disc, which is, as a rule, bilateral, suggests a very extensive lesion, while optic neuritis, which is often unilateral, bespeaks involvement of the sheath of the intercranial portion of the optic nerve. When there is a hemianopsia or hemichromopsia in the same portion of the visual field or amaurosis of one eye and hemianopsia of the other exists without ophthalmoscopic changes in the eye grounds, the luetic process is causing damage behind the eyeball in the optic tract, or possibly the chiasm and the discs will show the signs of optic atrophy sooner or later, although the change may be long delayed. Like all the symptoms of syphilitic basilar meningitis, the optic neuritis may clear up to recur again, or by the aid of treatment it may disappear altogether. As a rule, however, there is a variable amount of atrophy of the nerve left according to the amount and severity of the inflammation.

Squires has found a new sign in basilar meningitis, occurring as early as the third or fourth day of the disease, that is, alternate dilatation and contraction of the pupils during forced extension and flexion of the head upon the spinal column.

The child's head is taken between the knees of the physician and the body is supported upon the lap of the nurse. The head is then grasped upon the sides and forcible extension is made upon the spinal column. As extension begins the pupils will be seen to dilate and then contract as the head is bent forward upon the chest. This can be done several times a minute and each time the pupillary phenomena will be manifested. The extreme retraction of the head and dilated pupils as a late symptom of the disease may be due to increased pressure from effusion about the nerve roots.

Syringomyelia.—Paralyses of the eye muscles occur and especially paralysis of the abducens. More rarely single branches of the third nerve are involved. Frequently the fibers of the sympathetic are affected; then we find a narrowing of the pupil and palpebral fissure, the so-called oculo-pupillary symptom on the side involved. Nystagmus is occasionally observed. Alteration of the field of vision is sometimes present. Aside from those cases in which syringomyelia

is combined with hysteria, we find concentric contraction of the field, and especially for the colors red and green.

Tabes Dorsalis.—The most important symptom in tabes dorsalis is reflex iridoplegia, as it occurs in three fourths of all cases and is the first symptom to appear. This symptom was first pointed out by Argyll Robertson, and is therefore called after him. It consists in the fact that the pupil fails to respond when light enters the eye, although it contracts perfectly during convergence and accommodation. It is, therefore, to be distinguished from an iridoplegia or paralysis of the iris. In the latter all motility of the iris is lost while in the former only direct and consensual reactions are in abeyance. To prove the presence of reflex iridoplegia, or Argyll Robertson's pupil, it is not only necessary to prove that the pupil is stationary to light, but that the pupil reacts well to accommodation and to convergence.

Reflex iridoplegia is almost solely found in tabes dorsalis and in progressive paralyses of the insane. A few focal diseases of the brain, especially lesions about the corpora quadrigemina, have been known to give rise to it. This sign of tabes may precede other symptoms by years. In a few cases the sign is absent throughout the disease. It is said if it appears at all it will be present from the first. By it alone a probable diagnosis of tabes can be made. To test the action of the pupil to light the patient is seated facing the light from a window (artificial light will not answer, as being more intense the pupil may respond and lead the observer to believe nothing is wrong). The eyes are then covered for a few minutes by the hands of the observer and then uncovered and the pupils watched to see if there is any action at all as the light enters the eyes. In testing care must always be taken that the patient is looking in the distance with a relaxed accommodation or the associated action of the pupils will be manifest. If the pupils are found stationary to light the test for action during accommodation and convergence is made as follows: The patient is told to look at the end of his own nose or at the point of a pencil held close to the eyes and the pupils watched in the meanwhile. If the patient is unable to

converge the eyes on account of paralysis of the internal recti the test can be made by holding the pencil directly in front of one or the other eye. If the irides are immobile both to light and accommodation there is a complete paralysis of the sphincters of the pupils. In any case the complete immobility of the pupils is less a sign than the Argyll-Robertson pupillary reaction.

Reflex iridoplegia is almost always bilateral. What is called the paradoxical pupillary reaction has been described, that is an apparent dilatation of the pupils when light is made to enter them. This is explained in this manner: While the eyes were covered the patient was accommodating and when they are uncovered relaxes the accommodation with subsequent dilatation of the pupils. Slow and imperfect light reaction is to be differentiated from reflex iridoplegia. Careful observance is needed here, for it may happen that a weak action of the pupils may be taken for an abnormal one when it may not be so.

To constitute abnormality there must exist a considerable difference between the light and the associated actions of the pupils. Together with loss of light reaction there is generally a loss of dilatation of the pupils to painful stimulation of the skin. In the healthy individual when the skin is pinched or a sudden noise is heard the pupils dilate, not so in the tabetic.

Even during the violent lancinating pains that the tabetic suffers the pupils remain contracted. Very frequently besides failure to act to light stimulus the pupils are contracted in tabes (spinal myosis).

Myosis is, as a rule, followed in time by reflex iridoplegia or the two may coexist. Myosis without iridoplegia is also met with in tabes, but not often. Much rarer is a dilatation of the pupils, but it does occur and with or without iridoplegia. Difference in the size of the pupils formerly played an important part in the diagnosis of tabes, but this is often present without any special meaning. If the anisocoria is very decided, it may be a danger signal. Another very important eye symptom in tabes is atrophy of the optic nerves. This occurs in about ten per cent. of all cases. It develops almost

always in the first stages of the disease, although exceptions occur as in several cases that recently came under the notice of the writer, in which the disease was far advanced before any lesion of the nerve could be diagnosed. Leimbach says optic atrophy is the first sign of tabes in only 1.5 per cent. of all cases. The atrophy is bilateral. The nerves lose their normal pink appearance, become bluish-gray. The vessels are not altered save that they show a bending as they pass out upon the surrounding fundus. There is then a shallow excavation of the nerve head which reaches quite to the periphery in every direction. The edge of the nerve becomes unduly prominent and the disc stippled from the disappearance of nerve fibers. For further description of optic atrophy consult the chapter upon diseases of the optic nerve.

Paralyses of the eye muscles likewise occur. The majority of paralyses of eye muscles in adults are tabetic, syphilis excluded. The paralyses are very often transient, and among the first symptoms and not infrequently overlooked. Multiple sclerosis may cause paralysis of some eye muscle or muscles, but is a very much rarer disease. If a paralysis of an eye muscle comes on in an adult without pain, tabes may be diagnosed. Those from syphilis, rheumatism, grippe or what not are usually associated with more or less pain. The sooner the paralysis of the muscle develops, the more transient it is. The paralysis lasts from one to two weeks to as much as three months. It usually attacks the rectus externus, the levator of the lid or the superior oblique. Progressive ophthalmoplegia externa first pointed out in tabes by Hutchinson is the most important form of permanent paralysis occurring in tabes. Rarely are the internal eye muscles attacked. H. Müller, however, drew attention some time ago to the occasional unilateral failure of accommodation in tabes.

Tobacco and Alcohol Poisoning. — The effect of tobacco and alcohol upon the eyes consists in amblyopia and amaurosis and in dryness and redness of the eyes the so-called smoker's red eyes. The subject of toxic amblyopia has been fully discussed in a former section so will not be considered again here.

Brain Tumors.—The most valuable symptom of an intracranial growth is neuro-retinitis, descending or interstitial optic neuritis, choked discs, or optic atrophy. It should be remembered though that the optic nerve is involved from other causes and that it does not suffer in all cases of tumor of the brain. The diagnosis between optic neuritis and choked disc is an arbitrary one in many instances and the transition from the one to the other is a very gradual one. Unthoff has suggested that a diagnosis of choked disc should be restricted to a prominence due to swelling of the nerve of a millimeter or more. If the disease progresses the swelling of the discs subside and they gradually pass into an atrophic state, but some of the signs of the preceding inflammation remain. It is no longer considered possible to differentiate various causes for the inflammation in the nerve according to the kind of neuritis present. Choked disc was first described by Von Graefe and denotes that condition of engorgement, swelling and mechanical obstruction which was then supposed to depend upon lesions of the brain which interfere with the retinal circulation through the retinal veins. Descending neuritis on the other hand means an active inflammatory process extending along the optic tract and the optic nerve from a centrally located lesion. In practice we cannot always distinguish between the two conditions. Choked disc is evidently soon followed by inflammation and degeneration of the axis cylinders as they emerge from the eyeball, while on the other hand the descending neuritis is accompanied by swelling and engorgement of the papilla which practically constitutes choked disc. Hughlings Jacksons promulgated the view that there is only one kind of optic neuritis and that the amount of swelling depends upon the severity of the exciting cause. Ophthalmologists are now of this opinion almost generally. There are various theories of the cause of the optic neuritis in diseases of the brain. V. Graefe's theory is that it results from increased intracranial pressure. This is true in gross lesions as brain tumors, etc., but is not adequate to explain it in many instances. The same may be said of the theory that ascribed the neuritis to an occlusion

of the lymph spaces. Jacksons' theory that the neuritis may be due to the intermediation of the vasomotor nerves is visionary and unsatisfactory. The most probable theory is that the neurons of the optic nerve suffer irritation from some substance in the circulation. This is the manner in which a neuritis is set up in any part of the body. This latter view is curiously supported by the teaching of embryology. The optic nerve is to be regarded not as an ordinary peripheral nerve but comparable to the posterior column of the spinal cord, hence it is subject to the same diseases from the same causes that occur in the central nervous system. It is not so easy perhaps to understand why neuritis so frequently accompanies brain tumors. The theory of intoxication in these cases is not warranted. In such cases the theory of obstruction of the vascular and lymph spaces may be the correct one, as such blocking may dam up deleterious products, and that these undergoing retrograde changes may act by directly poisoning the sensitive neurons or interfere with their nutrition. It must also be remembered that foci of infection may occur in cases even of tumor of the brain. As a rule optic neuritis affects both eyes at once or the one soon after the other. In those cases in which the inflammation is severer on the one side one can not infer that the brain tumor is situated on the same side, as a number of cases are on record in which the eye on the opposite side from the tumor was the more involved. There is a great diversity of opinion among writers as to the frequency of optic neuritis in brain tumors. The percentage given by the writer in the chapter upon optic nerve diseases is the proper one as far as his review of statistics goes. Gowers claims that it occurs in four fifths of all cases, Knapp in two thirds, Starr in eighty per cent., and Oppenheim in eighty-two per cent. Optic neuritis is more common in tumors of the cerebellum and other basal structures, for the effect of intracranial pressure is most readily felt if the tumor is there situated. It may be absent in tumors of the cortex, especially of the occipital lobe of the meninges and even if the growth is situated in the pons. It is less likely to develop in slow-growing tumors like

gliomata. Again, tumors of the parietal, and especially of the occipital lobes, impinging as they may upon the optic pathway and centers in the brain, are still more liable to cause optic neuritis than are tumors of the frontal lobes. Transitory amblyopia may occur and periods of complete blindness in cases in which there is already an inflammation of the optic nerves. Bruns claims that this great fluctuation in vision is more apt to be present in tumors of the occipital lobe. Both central and peripheral hemianopsia in their various forms occur in brain tumors.

Tumors of the brain also cause paralyses of the various eye muscles either by direct pressure or through inflammation extending to the nerves supplying them. In tumors of the corpora quadrigemina we find loss of pupillary action, nystagmus, vertigo and a condition resembling cerebellar ataxia with vomiting and optic neuritis. Lesions at the base often involve the third and fourth branches of the fifth and sixth nerves, while the deeper nerves, the seventh and auditory, are less frequently affected. It is said that tumors of the pineal gland are associated with nystagmus and a peculiar rolling of the eyes upwards. In case of the primary optical ganglia we can never be assured before autopsy which one is involved. The near vicinity of the internal capsule is apt to excite motor symptoms, spasmodic or paralytic. Lesions of the optic radiation, or those fibers which pass backward from the primary optical ganglia to the cortex and of the cortex give rise to half seeing and in the latter case perhaps hemianopsia for colors only. In cortical hemianopsia we often have aphasia and mind blindness when the lesion is on the left side. These symptoms suggest lesions along the middle cerebral artery running through the fissure of Sylvius. The aphasia is amnesic because words recall no memories and therefore correct speech is impossible. There may also be alexia (inability to read) and agraphia (inability to write).

Tumors of the Pons and of the Medulla. — Tumors of the pons an medulla give rise to a multiplicity of symptoms due to the number of tracts which pass through them and to the number of

nuclei of cranial nerves situated there. While motor paralysis may be unilateral it is often bilateral as a result of a tumor of the pons or medulla. In addition to hemiplegia and double hemiplegia we may have other symptoms pointing to involvement of the various cranial nerves. A growth in the upper half of the pons may give rise to hemiplegia on one side of the body with involvement of the third and fifth nerves on the other side. Its proximity to the crus cerebri will account for the implication of the third nerve; if the tumor is in the lower half of the pons the fifth, sixth, seventh or eighth nerves will be more or less involved, and the resulting symptoms will be paralysis of the rectus internus, paralysis of all the branches of the seventh in the face on one side and loss of hearing in one ear. The nerve symptoms will be on the side opposite to the hemiplegia.

If the nucleus of the sixth nerve is involved there will be paralysis of one external rectus muscle with inability to turn the eyes towards the side of the lesion, for this nucleus is connected with the third of the opposite side and governs the outward movement of each eyeball.

Each internal rectus may be normal in convergence in spite of this conjugate paralysis. If the lesion is near the surface and away from the nucleus it will involve the external rectus but will not disturb the associated movements of the eyeballs. The differentiation between an isolated paralysis of the rectus externus and paralysis of conjugate movements is the most valuable differential point between a tumor near the surface and one within the substance of the pons.

The following is a good epitome of the symptoms: (1) Lateral hemianopsia always indicates an intracranial lesion on the opposite side from the dark fields. (2) Lateral hemianopsia with pupillary immobility, optic neuritis or atrophy, especially if associated with symptoms of basal disease, is due to a lesion of one optic tract or of the primary optical centers on one side. (3) Homonymous sector-like defects, that is those in the same field of each eye with hemianesthesia and choreiform or ataxic movements of one side of the body

without marked hemiplegia, are probably due to a lesion of the caudal lateral part of the thalamus or of the post. portion of the internal capsule. (4) Lateral hemianopsia with complete hemiplegia and hemianesthesia is probably caused by an extensive lesion at the knee and pulvinar of the internal capsule. (5) Lateral hemianopsia with typical hemiplegia; aphasia if the right side is paralyzed and with little or no alteration in sensation is quite certainly due to occlusion of the middle cerebral and adjacent arteries with an extensive superficial lesion, softening of the motor zone and gyri lying at the extremity of the fissure of Sylvius, namely, the inferior parietal lobe, the supramarginal gyrus and the gyrus angularis. There may also be alexia. (6) Lateral hemianopsia with moderate loss of power on one half of the body, especially if associated with the impairment of the muscular sense, would probably be due to a lesion of the inferior parietal lobe and angular gyrus with the subjacent white substance penetrating deeply enough to sever the optic fasciculus on its way to the visual center in the cuneus. If mental blindness the lesion would lie in the more anterior central portions of the occipital lobe. (7) Lateral hemianopsia without motor or common sensory or any accompanying symptoms is due to a lesion of the cuneus only or of it and the gray matter immediately around it, on the mesial side of occipital lobe on the side opposite to the dark fields.

Typhoid.—There is nothing to be found in the eye during typhoid fever that is characteristic of the disease, except that the pupils are usually dilated, thus contrasting with the contracted pupils of typhus. The dilatation of the pupils is due to a partial paralysis of the sphincters induced by the weak condition of the patient generally. There may be irregularity of the pupils and strabismus develop. Louis reports a few cases in which the eyelids were tightly closed as if from intolerance of light and remarks that this is an especially bad omen as far as the life of the patient is concerned. The ocular sequelæ of typhoid fever are many. The following are the most important of them: Catarrhal conjunctivitis, phlyctenular conjunctivitis, suppurative keratitis, iritis and chorioiditis, cataract, retinal hemorrhage, optic

neuritis and paralysis of the extraocular muscles, due to a neuritis from the toxine of typhoid.

Valvular Heart Disease gives rise to a hyperemia of the retina. The ophthalmoscope shows the veins distended and the disc redder than normal. Deidrich calls this condition cyanotic retinitis and says it is often accompanied by a slight serous exudation into the retina. Galezowski was the first to point out the frequency of hemorrhagic retinitis in heart disease. Embolism of the central artery of the retina also occurs in this affection. The disc is seen to be very ischemic and the arteries filiform with the cherry red spot at the macula.

Aneurism of the Aorta.—In suspected aneurism of the thoracic aorta the eyes should be carefully examined as the pupils may vary much in size, the left one being usually contracted. This anisocoria is due to the destruction of the nerve fibers of the cilio-spinal branches of the sympathetic in the aneurismal sac. There is then a paralysis of the dilator fibers of the iris with a consequent contraction of the pupil on that side.

Diphtheria.—The palpebral conjunctiva, and especially that of the upper lid, becomes diphtheritic either primarily or secondarily when the nose or lachrymal passages are primarily affected. Diphtheritic conjunctivitis is not as common as formerly, which is due to a difference in the virulency of the disease and also to the use of antitoxin, which cuts the disease short before it has become very extensive. When the membrane once appears upon either eyelid it spreads rapidly to the other. The palpebral conjunctiva is smooth, dry and pale, while that of the fornix is edematous. The whole lid becomes infiltrated and the membrane is first apparent as small flakes, but soon coalesces into solid masses. Chemosis of the conjunctiva soon follows and the cornea speedily becomes hazy and ulcerates. Perforation of the cornea nearly always takes place, the iris protrudes and sometimes the eye is lost in a single day. The diagnosis of the case is made in the usual way by film preparations and cultivation. There is only one organism with which the diphtheritic bacillus can

be confused and that is the xerosis bacillus. The main points of differentiation are these: (1) Both stain by Gram's method, but in alcohol the diphtheritic bacilli lose their stain much more thoroughly than the xerosis organism. (2) The Klebs-Loeffler bacilli give rise to an acid reaction in neutral media, while the xerosis bacilli do not. (3) The xerosis organism when injected into guinea-pigs causes nothing more than a local reaction at the site of inoculation. Ammann says the cornea is more apt to be invaded by the diphtheritic bacillus when associated with the strepto- or staphylococci. The treatment of diphtheritic conjunctivitis is considered in the section upon the diseases of the conjunctiva.

Epilepsy. — Fèrè and other distinguished authorities say that epilepsy may be provoked if not caused by a drain from or irritation to some distant organ. Errors of refraction by causing excessive accommodation or muscular anomalies may be the exciting cause of an attack. By way of parenthesis it is well known that irritation of the auditory nerve is very prone to provoke epileptic fits. Retinal and subhyaloid hemorrhages are frequently caused by epilepsy.

Cancer. — Legrange, Adelsdorf and others have reported cases of metastatic growths in the iris and chorioid secondary to mammary cancer, but they are very rare. If the visual organ is affected it is as a rule by a primary growth.

Tuberculosis. — One of the most important and characteristic symptoms of miliary tuberculosis is the occurrence of miliary tubercles in the chorioid of the eye. With the ophthalmoscope these bodies appear as slightly yellowish irregular circular spots, having a bright center and rather dark outline, and about the size of the optic disc. There may be one or two only, or present in great numbers. They should be sought for in every suspected case of miliary tuberculosis.

Multiple Sclerosis. — Nystagmus is the most significant symptom in leading to a diagnosis of multiple sclerosis. Only in a minority of cases do we have however a true nystagmus, that is pendulum-like oscillations of the eyeballs. The movements of the eyes are nearly always horizontal and present all the time, but exaggerated

when the gaze is directed far to one side or the other. The nystagmus is due to an interruption of conduction between the oculo-motor centers and the nuclei of the ocular muscles. Other motor defects occur as follows according to Unthoff: Paralyses of abduction in six per cent., which was unilateral in four per cent.; third nerve paralysis in three per cent., in three per cent. of which paralysis of convergence occurs, and two per cent. of ophthalmoplegia externa totalis, making seventeen per cent. in all. Furthermore we find various pupillary anomalies which according to Parinaud occur in about fifteen per cent. of cases. The commonest changes in the pupils are myosis, reflex iridoplegia (rarely) and increased excitability of the pupils.

Insanity. — The greatest changes in the eyes occur in general paralysis and in syphilitics. In early stages of the majority of cases of general paralysis there is no constant change in the optic disc nor eye-ground. There is no hyperemia, no gray degeneration of the nerves, no alterations in the fundi. Changes begin to show themselves as a rule at the end of the second stage. Rarely there is present well-marked optic neuritis; more commonly do we find dimness of the outlines of the discs with a fulness of the vessels and especially the veins. In mania we find the discs abnormally red or congested, in melancholia an anemic condition. In epileptic insanity or in syphilitics the appearance of the eye-grounds depends upon the intracranial lesion, and those affected by chronic alcoholism and other poisons, as tobacco or what not, exhibit the same atrophic changes whether there is an additional insanity or not.

In this chapter there is much repetition of what has been said in the description of the various eye lesions found in the several diseases considered, but to properly treat the subject with which this chapter deals this was necessary, and many points omitted from the sections upon the various diseases considered are here mentioned.

CHAPTER XXIV

GENERAL REMARKS

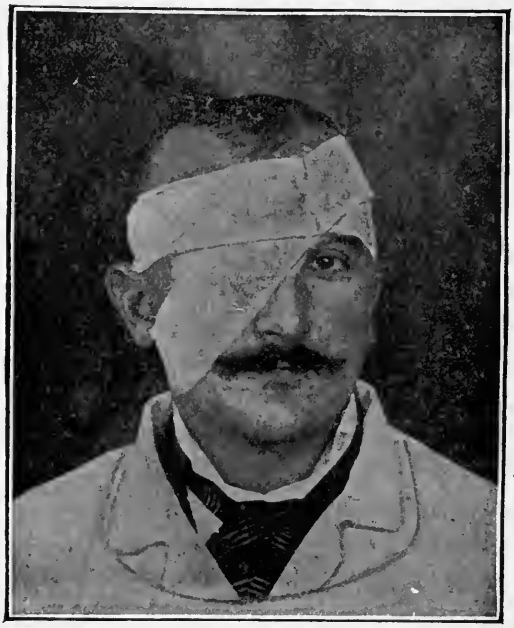
Bandages. — Roller bandages for use in eye surgery are preferably made of gauze, as it is soft and pliable and free from loose fibers or threads. The roller bandage may be applied to one or both eyes. If the bandage is to be removed often for change of dressing the *single-tour roller* is used. It is applied in the following manner: The assistant stands in front of the patient holding the bandage in the right hand. He then places the end of the bandage upon the center of the forehead with its external surface next to the skin, and secures the free end with his left thumb. The roller is then carried toward the patient's left above the left ear to the base of the skull, around which it passes, coming forward above the right ear to the forehead, securing the free end. A second circular tour is commenced and continued like the first until the back of the head is reached. It is then carried below the right ear and brought up over the right eye to the forehead, where it is pinned to the layers of the circular tour. The foregoing description, as is seen, is for the right eye. If the left eye is to be bandaged the roller is at first carried to the right around the head. The advantage of this method is that the eye is covered by a single layer of bandage, which can be loosened and laid back to change the dressing without raising the patient's head from the pillow.

Single-tour Roller for Both Eyes. — This is applied by simply modifying the foregoing bandage. After the bandage has been applied to cover over one eye and has been pinned on the forehead the roller is reversed and is carried downward over the opposite eye, passing below the ear to the occiput and thence to the forehead.

The third turn is circular around the head and is a repetition of the first. The fourth turn follows the diagonal of the second tour,

overlapping it so as to cover its lower two thirds. Each diagonal turn is therefore somewhat steeper than the preceding. The bandage is more readily applied and more comfortable if the ear on the affected side is included in the diagonal turns.

Figure of Eight Bandage for Both Eyes.—The first tours are identical with those of the preceding bandage. After fixing the bandage by the circular tours above the ears it is brought up from

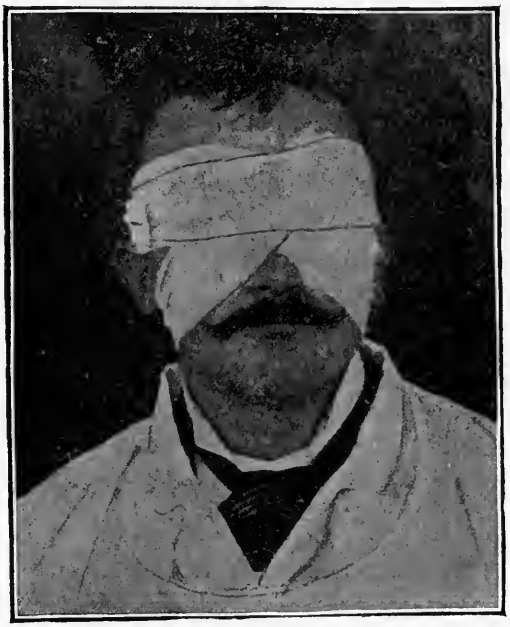


Single-tour Roller for One Eye.

behind diagonally over one eye, crosses the forehead and passes back over the ear to the opposite side. It then passes around the back of the head, forming a circular tour and is brought forward over the ear to the forehead. Here it descends across the opposite side and covers the second eye, passing back across the cheek and under the ear to the back of the head. A circular turn now follows which brings the roller to the back of the head, after which it is brought for-

ward below the ear as in the first diagonal tour, coming up over the jaw and covering the eye and so on. Pins are placed at the intersections of the bandage on the brow and at the sides of the head to hold it in place.

Moorfield's Single Eye Bandage.—This consists of a square made of a double fold of linen and just large enough to cover the eye well. To each corner of the pad or square is attached a piece of tape. The tapes attached to the upper corners are brought around the



Single-tour Roller for Both Eyes.

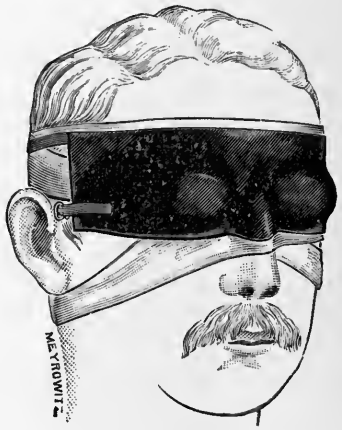
head above the ears and tied and those from the lower corners pass below the ears and are tied. The tapes should be long enough so that they can be tied at the side of the head.

The double Moorfield bandage is made from a double piece of linen three inches wide and seven or eight inches long, and consists of two squares joined together by a narrow strip which fits over the

bridge of the nose. At the corners are attached tapes which are tied above and below the ears around the back of the head.

For children and those who are apt to meddle with their dressing and from the point of comfort to the patient eye shields are to be preferred in cases in which the dressing is to remain several days. There are a number of such shields on the market. The one shown

Andrew's Eye Shield.



Ring's Ocular Mask.

in the cut is Andrew's and is designed to protect the eye from injury and is made of thin sheet aluminum, very light and easily bent to the required shape. The gauze bandage is applied and then the shield applied over this and held in place by tapes which pass through the apertures in its upper part.

McCoy's aseptic eye shield consists of two circular frames made of strong wire curved so as to present a concave surface next to the eye. It is applied over a roller bandage and fastened with tapes. Ring's ocular mask is one as seen by the cut which covers both eyes and secures a greater safety to the operated one than those already described. It is decidedly the best of the protective appliances yet devised. The shield is made of papier machè lined outside with silk

and inside with linen and is made to fit the contour of the average face. If one eye is to be left open a circular piece is cut out of the mask directly in front of it. A bandage can be dispensed with by filling in the oval depression in the mask with cotton.

The mask can be held on with the tapes attached to it or better still by several strips of adhesive plaster passed diagonally over it from the forehead to the opposite cheek. In applying a protective bandage one thins out the cotton to be placed directly upon the lids and heaps it up around the eye so that no pressure is exerted directly upon the eyeball itself.

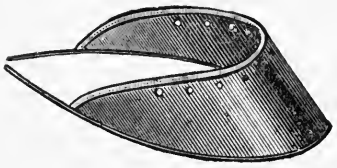
Pressure and Contentive Bandages.—The pressure bandage is used to check bleeding after removal of the eyeball, to prevent ecchymosis and swelling after squint operations (such are, however, better treated by the open method); to give protection to the eye in threatened perforation of the cornea from ulceration and to give support to the eye when negative tension has occurred from the loss of aqueous or vitreous and has produced the so-called nest-like collapse of the cornea. In applying a protective bandage the cotton is heaped up over the eye so that pressure is exerted directly upon it. Contentive bandages are made of some material which is impregnated with starch or water glass which stiffens and prevents the derangement of the dressing. They are especially useful in children and after certain plastic operations upon the lids. Water glass is an aqueous solution of thirty to sixty per cent. strength of the silicate of soda or potash. It is a clear yellowish fluid of the consistency of syrup. For use the bandage is soaked for ten minutes in a bowl of water glass, squeezed to expel the superfluous fluid and applied quickly. The hardening of the bandage can be hastened by adding a little magnesia, dextrin or chalk to the water glass.

Starch Bandage.—Starch powder is rubbed up with cold water to a stiff paste, boiling water is then added and the solution constantly stirred until a transparent jelly is obtained in which the roller bandage is soaked.

Dark Glasses and Eye Shades.—Dark glasses are used for a few

days after the bandage is removed following a cataract extraction, after iridectomies and in any diseased condition of the eyes in which exposure to light is painful. The protective glasses can be obtained either in London smoked or blue tints, and of different shades. The very dark shades are not as good as the medium ones as the vision is so interfered with that the eye strains to see. The smoked coquilles, as the glasses are called, being shaped like a watch crystal, are better than the blue tinted ones. The cheap coquilles on the market are very injurious to the eyes as they have a very irregular refraction due to irregularities in moulding which leads to eye strain.

The most practical and useful eye shade is that seen in the cut below. All are familiar with it. It may be used to protect the eyes from the light above while reading or pulled down lower to protect inflamed eyes from the light. The small monocular shade is useful in one-sided inflammation when the patient must be about and use the fellow eye.



Preparation of the Field of Operation and Instruments.—There is no special preparation of the eye necessary for an operation. If the eyeball is to be operated upon the surgeon sees that the conjunctival sac is free of secretion, that the lachrymal passages are normal, and that the patient has no symptoms of nasal sinus disease, for in not a few cases reported eyes have been lost following cataract extraction presumably from infection from the accessory nasal sinuses. The patient should not have recently recovered from an infectious disease, especially pneumonia, as there is then great danger of the wound becoming infected by the pneumococcus by way of the lachrymal passages from the nose. Diabetics do well as a rule, but if there is much sugar in the urine operation should be deferred, as the operation, especially in the aged, may hasten coma and death. Old people do not stand confinement in bed for any length of time so that they should be allowed to get up on the evening of the day after the operation. In such, as has been said in a former section, cataract ex

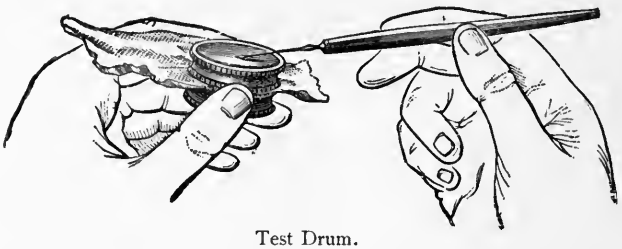
traction should be done by the combined method and preferably in two steps, *i. e.*, the iridectomy one time and the lens extraction a few weeks afterwards. Just before beginning the operation upon the eyeball the conjunctival sac is flushed thoroughly with sterile water and the brows and lashes washed with some bland soap, rinsed with bichlorid solution and dried with sterile cotton.

The hands of the operator and assistants should receive the proper attention consistent with aseptic surgery. In regard to the instruments they may be sterilized by boiling, by immersing in alcohol or by formaldehyde gas.

Boiling is perhaps the surest method of sterilization, but by repeated boiling the fine cutting instruments used in ophthalmology are dulled. The knives are therefore laid in 98 per cent. alcohol for some minutes and then rinsed in sterile water before using. The other instruments are boiled. Soda should not be added to the water to prevent rusting as it is apt to form a coating upon the knives if they are boiled and interfere with their cutting. The formalin sterilizer shown in the cut is that devised by Reik. It is efficient, neat and can be taken with one to the home of the patient. Formaldehyde gas does not spoil the most delicate cutting instrument nor does the amount of gas that clings to the instruments irritate the eye or retard the healing process. On the whole this method of sterilization is the best.

In selecting the instruments for an operation upon the eye the surgeon should see that the points of the knives and their cutting edges are in good condition, as it is very annoying to find that your

cataract knife or keratome has a blunt point when you are ready to make the section. To test the cutting edges of knives the test drum shown in the cut is very useful. It consists of tightly stretched gold



Test Drum.

beaters skin, that is, tanned peritoneal membrane over a small cylinder. If the knives are in perfect condition they will pierce the drum by their own weight.

Sterilization of Eye Drops.—The solutions used before or after an operation upon the eye during the healing process should be sterile. They may be sterilized by placing the bottle containing the solution in a kettle or boiler and exposing it to the steam for one half to one hour. For private practice it is better and quicker to sterilize the drops by boiling. This can be done in a test-tube and the tube plugged with a piece of aseptic cotton The dropper can be sterilized by boiling in any sort of vessel after detaching the rubber portion. It can then be kept for use in the test-tube containing the medicine.

In this way the solution can be sterilized in a very few minutes and cooled by holding the test-tube under the cold water tap. More convenient than the test-tubes for sterilization of solutions are the Stronschein flasks shown in the cuts. They are made of thin glass blown of equal caliber throughout, so as to bear heat without breaking and have the shape of a small carafe about an inch in its greatest diameter. In the neck of the flask fits a ground-glass pipette with an oval end for a rubber nipple. In order to sterilize the contents of the flask and the dropper, the rubber portion of the pipette is removed and the pipette inverted and inserted into the flask. The whole apparatus is then boiled over an alcohol flame for

three minutes During the boiling the flask is supported upon a piece of wire gauze upon a small tripod. Violent boiling is unnecessary. When the boiling point is reached, hot air and steam ascend through the pipette and sterilize it. Thirty seconds after the removal of the flask from the flame, the pipette may be taken with sterile forceps and placed in its proper position in the flask and the rubber tip adjusted. Should one be in a hurry the flask can be cooled by holding it in cold water. The nipple may be disinfected by soaking in alcohol or bichlorid solution or by boiling for a few seconds, but this is unnecessary, as the solution is never drawn up into the rubber. The boiling is repeated before each operation. Of course the solu-

tion becomes more and more concentrated by the boiling. This difficulty is met by adding ten to fifteen drops of sterile water before each boiling. The name of the contained solution is blown into the side of the flask. To aid assistance and to prevent mistake, it is a good plan to have the various solutions in use colored differently with some inert substance. Thus the cocain may be left plain, the atropin colored with a few drops of methyl blue and the eserin red with a little carmin, etc. Any solution intended for irrigation of the conjunctival sac may be kept warm by immersing the flask in hot water.

Collyria are almost universally made in aqueous solutions. A few prefer them prepared with an oily menstruum, but the writer fails to see the advantages of oily solutions over watery ones. If liquid vaselin or other oily base is used the alkaloid of the drug itself must be employed as the salts of the alkaloid are insoluble in oil, and very frequently the drug must be first dissolved in alcohol. If the drops are rendered neutral or slightly alkaline with bicarbonate of soda, they irritate the eye less than if acid in reaction. Eye drops are usually instilled with a pipette or eye-dropper. A separate dropper must be kept for each solution. It is well to have the droppers fit in the necks of the bottles for the solutions like a stopper, so that the stopper will always be in place and clean when needed. If the patient has no one to instill the drops for him, or if large quantities of fluid are needed especially in abscess of the eyelid or what not an eye-bath glass is employed.

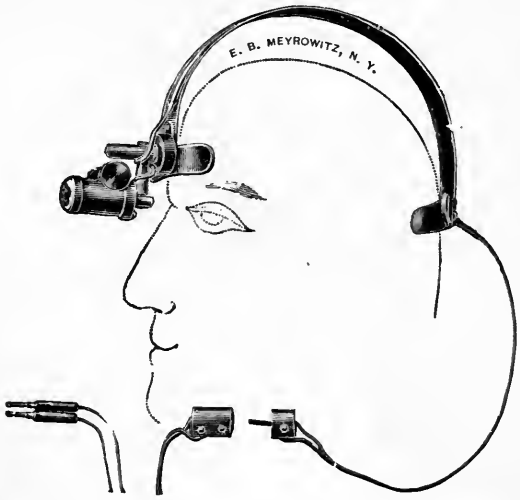
Atomizer for Spraying Solution upon the Eyeball.

In corneal disease the solution may be advantageously sprayed into the eye and this method is preferred by some as a routine method. In using the eye-bath glass it is half filled with the solution and then applied to the eye as the patient bends his head forward. The head is then thrown backward, allowing the medicine to come in contact with the eye, and remain there for a few moments. If the edge of the glass is pressed firmly against the eye the lids are kept open and the solution comes in direct contact with the eyeball itself.

Good illumination is an essential in operations upon the eyeball especially in cataract extraction, dilaceration and so forth. If it is impossible to utilize daylight by a properly arranged skylight or window we depend upon electric light. An electric bulb attached to a head band, is most convenient. The light is operated by attaching the cords to any incandescent light circuit. For examination of the eye

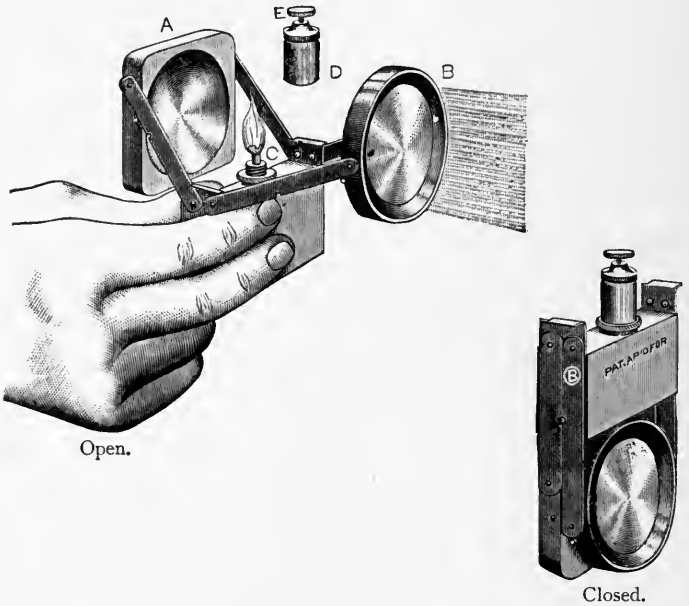
at the patient's home where an argand burner or electric current is available, the small lamp shown in the cut below is all that is needed.

Anæsthetics. — Since the introduction of cocain by Dr. Carl Koller in the year 1884, it has been the most widely employed local anæsthetic in eye surgery. Many other local anæsthetics have been brought out since that time, chief among which may be mentioned



eucain and holocain, but none of them up to this time has taken the place of cocain in ophthalmology. We employ cocain in a four per cent. solution, as a rule, in operative work. A solution of this strength is instilled twice or three times prior to an operation. For an iridectomy a drop may be injected into the anterior chamber after the section through the limbus is made. Pain can be completely abolished if we wait long enough for the drug to dilate the pupil, which implies its thorough absorption and anæsthetic effect. Tension of the eyeball is at the same time usually reduced, but there are a few cases on record in which there was an increase in the tension and tendency to glaucoma after use of cocain, so that in glaucomatous patients it is risky to use it. Cocain reduces the intraocular tension in most cases by its influence through the sympathetic and con-

stricting effect upon the vessels. It also constricts the lymphatics and hence dries the cornea to a marked degree, so that it is sometimes raised in a bleb or exfoliated in flakes. It is therefore unwise to employ cocain for the relief of pain in eye diseases, and especially in ulceration of the cornea, in which one wishes the epithelium of the cornea to regenerate as quickly as possible. The toxic effect of cocain is seldom produced by the local action of the drug upon the eye. The symptoms of poisoning are quick, weak pulse, sighing



Open. Closed.

Portable Illuminator.

respiration and syncope. The antidote is morphia used hypodermically.

In tedious operations, and in very nervous individuals and for iridectomy in glaucoma, a general anæsthetic is required. Chloroform is preferable to ether, because the cone can be held away from the field of operation. Eye operations should be done upon a table or narrow bed. The operator should stand behind the head of his patient, except when operating upon the left eye, in which case he

stands with his back towards the patient's feet, unless he is ambidextrous. The skill needed in the major operations upon the eye is largely a matter of practice in the handling of instruments in the minor operations and upon animals' eyes, or those of the cadaver. There must also be an original endowment of facility of hand, gentleness of touch and a mechanical bent of mind.

STATISTICS OF EYE DISEASES.

Search of the literature has failed to find any better article on this subject than that of Cohen, which is based upon the returns of about 67 institutions between the years 1869 and 1875, and embracing about 300,000 patients.

The relative frequency of the various eye diseases is shown in the following table:

	Per cent.
Conjunctiva	30
Cornea	21
Sclera	.4
Iris	6
Chorioid.	1
Glaucoma	1
Retina, optic nerve / Amblyopia	5
Amaurosis	6
Lens	.7
Vitreous	2
Globe	12
Refraction.	
Accommodation.	
Muscles	3
Fifth nerve	.2
Lachrymal apparatus	2
Orbit	.2
Lids	9
Various	1.5
	100

The following schemes give, according to Magnus, the cause of congenital and acquired blindness from disease and injury:

Congenital Blindness.	Total.	Males.	Females.
Anophthalmos	.50%	0.30%	0.84%
Microphthalmos	2.53	2.14	3.18
Buphthalmos	1.19	1.29	1.00
Atrophied optic nerves	3.53	3.09	4.27
Retinitis pigmentosa	2.28	1.99	2.76
Atrophy of retina	.33	.59	.42
Chorioiditis and chorio-retinitis	.66	.60	.80
Coloboma of chorioid	.09	.15	.00
Irido-chorioiditis	.44	.55	.25
Kerato-conus	.09	.15	.00
Keratitis	.03	.05	.00
Albinism	.12	.10	.17
Gliom of retina	.03	.05	.00
Cataracts	3.68	3.88	3.36
Undetermined conditions	1.34	1.24	1.50
Adhesions of lids to eyeball	.03	0.00	.08
Myopia	.12	0.10	.17
	17.19% 551 cases.	16.32% 327 males.	18.75% 224 females.

Blindness from Idiopathic Eye Diseases.

	Total 1060 Cases 33.08%.	Males 626 = 31.16%.	Females 434 = 36.32%.
Blenorrhœa neonatorum	23.50	20.66	28.28
Gonorrhœal ophthalmia	.47	.70	.08
Trachoma	1.31	1.34	1.26
Diphtheritic conjunctivitis	.44	.25	.67
Other conjunctival diseases	.81	1.00	.50
Keratitis	.47	.55	.33
Iritis	.19	.10	.33
Irido-chorioiditis	1.90	2.04	1.67
Chorioiditis	.44	.40	.50
Detached retina	.84	.90	.75
Myopia	.12	.19	.00
Glioma or retina	.03	.05	.00
Hemorrhagic neuroretinitis	.03	.05	.00
Atrophy of the optic nerves	2.31	2.69	1.67
Glaucoma	.19	.19	.17
Phthisis bulbi	.03	.00	.08

Blindness from Injuries.

	261 = 8.15%.	202 = 10.06%.	59 = 4.94%.
Injuries of the eye	2.37	3.13	1.09
Injuries of the head	1.03	1.24	.67
Operations	.16	0.19	.08
Sympathetic ophthalmia	4.58	5.47	3.10

BLINDNESS FROM CONSTITUTIONAL DISEASES.

	1063 = 33.17%.	686 = 34.15%.	377 = 31.54%.
Scrofula	7.58	7.07	8.45
Syphilis	1.00	1.14	.75
Brain and its membranes	8.18	9.96	5.19
Atrophy of nerves after hemorrhage	.06	.00	.17
Rubeola	3.56	3.63	3.43
Scarlatina	3.03	2.98	3.10
Variola	7.49	7.02	8.28
Other exanthemata	.44	.45	.42
Typhus	1.00	1.00	1.00
Purpura hemorrhagica	.03	.05	.00
Abscess of orbit	.03	.05	.00
Pertussis	.12	.05	.25
Cholera	.03	.05	.00
Intermittent fever	.03	.05	.00
Lead poisoning	.06	.05	.08
Tobacco-alcohol poisoning	.03	.05	.00
Unknown causes	.50	.55	.42

BLINDNESS FROM UNKNOWN CAUSES.

269 cases = 8.40%, Males 8.36%, Females 8.45.

As will be seen in the foregoing tables cataract is the chief factor in causing congenital blindness occurring in 20.51 per cent. of this class. In all it is not possible to secure good vision by an operation upon the cataract, as many eyes with congenital cataract are otherwise abnormal, especially in the percipient structures.

Gonorrhœal ophthalmia furnishes a very large number of cases of blindness both in children and adults but not as many as the table indicates, as since the time it was compiled Crede's method has been universally adopted both in private and hospital practice and in a few states it is criminal negligence for a midwife to fail to report a case of mattering eyes in the new born, thus bringing them sooner under the care of the physician than formerly, when such cases were treated by instillation of breast milk, chamomile tea or other foolish and ineffectual method until the cornea would be irreparably involved.

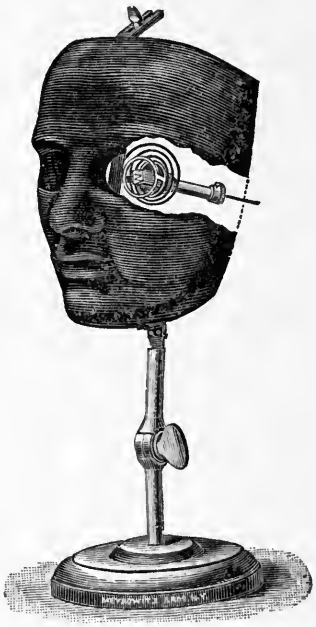
The percentage of blindness from tobacco-alcohol poisoning is much too low, especially since the introduction of wood alcohol into commerce in various purified states and its large use for essences, cologne, etc.

Glaucoma is another common cause of blindness among those more advanced in years. It contributes almost two per cent. of all cases of blindness. Sympathetic ophthalmia occurs at all ages, 4.5 per cent. among the young and about the same among the older. This is too high a percentage to-day as the injured eye is removed more frequently when wounded beyond repair or watched more carefully and removed the moment any irritation is manifest in the fellow eye. Those of the table that were rendered blind through unsuccessful operations were almost all from cataract extractions.

CHAPTER XXV

OPERATIONS UPON ANIMALS' EYES AND METHODS OF PRESERVING EYE SPECIMENS. PHOTOGRAPHY OF GROSS SPECIMENS

THE student will derive much from operations upon the animal's eye. He will learn how to handle the various instruments used in eye work, will become acquainted with the resistance of the tissues which have to be cut and lose much of the timidity which is always present with beginners in operations upon the human eye. Instruments should be purchased and kept for this alone. One needs an eye speculum, fixation forceps, angular keratome, Graefe's cataract knife, iris forceps and scissors, strabismus hook and scissors, a caniculus knife and a few needles. Pigs' eyes are the best for practice, as they more nearly conform to the form of the human eye than those of other animals, and in the density of their tissues they afford a good example of the resistance to the knife offered by the tissues of the human eye. Sheep's eyes are rather large and the conditions altered by the elliptical shape of the cornea and pupil. Pigs' eyes must be obtained before the animal is put in the hot-water vat, otherwise the corneæ are so cloudy that the eyes are useless for operative purposes. If one wishes to practice operations upon the lids or eye-muscles or lachrymal apparatus, a young pig's head is obtained; one that is about six weeks old is preferable. It is not necessary to practice upon the eyes of living animals, as no



additional knowledge is gained thereby. If possible all the operation should be done upon the fresh cadaver in the dissecting room. As the eyes undergo various changes shortly after death, they should be removed immediately after the animal is killed. Fresh eyes are far the best for practice, but it may be necessary to preserve them for a short while. All preservative solutions cloud the cornea and alter the densities of the various tissues. Eyes can easily be kept a week in a .1 per cent. solution of formalin. A stronger solution than this hardens them too much for operative work. If it is desired to keep them longer than this they may be transferred to a solution of thymol of 1 to 5,000 strength, in which they will keep for many weeks. No matter whether the eyes are fresh or preserved, the corneæ will be found rather dry and should be moistened well with water before beginning to operate.

When practicing upon an animal's eyes the best idea of the technique of the similar operation upon the human eye is obtained by placing the eye in a mask especially constructed for the purpose, which conforms to the shape and size of the human face. Such a mask known as the Vienna mask is shown in the cut. The sockets in this mask are movable in all directions and by means of a screw in the apex of the socket the tension of the eyeball can be lowered or elevated at will. The face is also attached to a base so that it can be placed at different angles. There are cheaper but inferior masks upon the market known as phantom faces, made of papier mache. If the student does not possess a phantom face or mask an assistant can hold the eyeball in a towel, leaving the cornea free, or he can construct a mask from a small box and a piece of cork. The cork is hollowed out in the center and glued to the middle of the lid of the box. The cork should be thick enough so that when the eye is placed upon it the hand will not come in contact with the lid of the box. The eye is held upon the piece of cork by pins passed through the shreds of tissue left attached to it, and the lid of the box can be placed at any desired angle. Most all the operations done upon the human eye can be practised upon the eye of the

animal, but attention should be paid especially to the operation for cataract and iridectomy.

Methods of Preserving Eyes for Specimens.— There are many methods in vogue for mounting gross eye preparations but only the more recent and useful ones will here be mentioned. First of all the *Priestley Smith Gelatin Method*, not because it is to-day the best method, but because it was the first good method of preserving and mounting eye specimens described. The eyeball is preserved in Müller's fluid. It is then wrapped in a piece of oiled silk and frozen by placing it in a vessel containing a mixture of salt and ice. The eye is allowed to remain in this freezing mixture for at least two hours, and is then divided with a sharp narrow knife. A razor will not answer for this purpose as the thick blade spoils the specimen and it cleaves through the eye. A thin bread knife is suitable, but it must be very sharp. If the eye has been soaked in Müller's fluid the stain must be removed by immersing in a 2 per cent. chloral hydrate solution. This solution is repeated every day or two until all the stain is removed. To prevent shrinkage the divided eye is next given a bath in a 50 per cent. glycerin solution for 24 hours. The jelly in which the eye is permanently placed is made in the following manner: Gelatin (Coignet et Cie), one part; glycerin and water each 8 parts by weight. Slowly dissolve the gelatin in water by gentle heat; add the white of one egg, boil thoroughly and filter through a piece of flannel. Finally stir in the glycerin, to which has been added 1 per cent. of carbolic acid. The best form of jar in which to mount the specimen is that made by Osler, of Broad street, Birmingham, Eng., or by Wall & Ochs, of Philadelphia.

These jars possess flat, even bottoms through which the specimen can be readily seen. Collins suggests that a plano-convex lens be cemented on the bottom of the jar to magnify the specimen. This adds to the cost of preparation without enhancing it to any extent. One of the jars is half filled with the melted jelly prepared as described and the half eye immersed with the concave surface up. When the eye has filled with the jelly it is turned over very carefully

so that no air bubbles are confined with its plane or cut surface next to the bottom of the jar. When the jelly has hardened the jar is filled with the melted jelly and the cover attached with Canada balsam. The objection to this method is that the jelly so frequently discolors, cracks or becomes fluid in very hot weather. This last objection can be removed by adding a few drops of formalin to the preparation of melted jelly, or better by subjecting the mounted specimen to the fumes of formaldehyde gas under a bell jar, which raises its melting point considerably.

The Dixon Method.—As soon as possible after enucleation the eye is punctured near the equator and immersed in a 10 per cent. solution of formalin. The eye is allowed to remain in this solution for 24 hours and then transferred to a 25 per cent. alcohol solution, which is increased 10 per cent. a day. The specimen is allowed to remain in the alcohol solution after it reaches 80 per cent. for 4 days or indefinitely if so desired. The alcohol hardens the vitreous so that it can be sectioned without loss. The next step is to remove the alcohol from the specimen in order that it may be frozen. This is done by placing it in a great bulk of water for about 24 hours. When the eyeball has settled to the bottom of the vessel sufficient alcohol has been removed to allow of freezing. After freezing and dividing the globe place it in water to thaw.

After ten or fifteen minutes place the half intended for microscopic section and examination in 25 per cent. alcohol and run it up to 80 per cent., in which it can be indefinitely kept. The other half of the eye intended for mounting is placed in a 5 per cent. aqueous solution of chloral hydrate for 24 hours; glycerin and one third water for 24 hours, and then equal parts of glycerin and water for 24 hours, when it is ready to mount in the glycerin jelly. The formula for glycerin jelly is as follows, if you wish it free from an amber tinge: The best Gold Label French jelly is used. Take gelatin, 1 part; water, 8 parts; glycerin, 8 parts. It is better to add a trifle more gelatin than this, say about 5 per cent. Cut the gelatin into small pieces and place in a fruit jar, cover with water and allow to stand for an hour.

Then place the whole in an Arnold sterilizer or water-bath and apply only sufficient heat to dissolve the gelatin. Stir in the white of one egg with the shell, if pure white, for each half a pint. Put again in sterilizer and boil until complete separation has occurred. Filter through absorbent cotton, add the glycerin and a drachm of 10 per cent. carbolic solution to every six ounces to preserve the jelly. Jelly made this way is free from color and of the same index of refraction as glass vessel in which it is to be mounted. If there is any intention of redissolving the jelly to reset the specimen, formalin should not be added. If too much formalin is added, or the specimen after it is mounted exposed to the fumes of formaldehyde, as is sometimes done, the jelly becomes opalescent, losing its sparkling appearance. In order to preserve the original colors of the specimen, Greenwood recommends that the eye be hardened by the Kaiserling method as follows: A solution is made of formalin, 200; water, 1,000; nitrate of potash, 15; acetate of potash, 30 parts. In this solution the eye is placed for several days (one to four). It is then drained and placed in 80 per cent. alcohol for about six hours, then in 95 per cent. for one to two hours to restore the color. The specimen is preserved in acetate of potash, 200; glycerin, 400; water, 2,000 parts. Fixation should be done in the dark and the specimen kept in a dark place. The jelly is made according to the following formula given by Verhoef: best French gelatin, 30 grams; cold saturated boric acid solution, 240 c.c. Add 80 c.c. of glycerin and the white and shell of one egg; heat in a water-bath, add 1 c.c. of glacial acetic acid to throw down the albumin, boil thoroughly for some time and then thoroughly filter. A hot-water filter should be used or the filter placed in a steam sterilizer to prevent hardening of the jelly. These methods of mounting in jelly make pretty specimens. The specimen is supported by the hard jelly, so that the anatomical relation of the different parts of the specimen is preserved and the specimen can be easily photographed. Several methods of making permanent preparations in fluid preservatives will now be described. All in all they are to be preferred, as they are much less troublesome

to make. When the eye section is preserved in a suitable fluid it can be removed therefrom at any time desired and microscopical sections made. This cannot be done with the gelatin mounts. The best known method of preserving specimens in a liquid is that of Greeff, and there are a number of modifications of his methods, some of which are improvements. Thompson recommends that the specimen be thoroughly washed and then hardened for twenty-four hours in a 4 per cent. formalin solution. The eyeball is then bisected and the piece intended for mounting is wrapped in absorbent cotton to prevent shrinkage and immersed in the following solution for three days:

Acetate of soda,	3 parts.
Potassium chloride,	5 "
Formalin,	10 "
Water,	100 "

The specimen is then wrapped in a fresh piece of cotton and then immersed in 80 per cent. alcohol and changed to 95 per cent. solution, in which it is allowed to remain for twenty-four hours. It is then soaked in the following solution:

Acetate of potash,	90 parts.
Glycerin,	100 "
Water,	300 "

After this the specimen is mounted in a fresh solution of the last formula. The jars in which the specimens are kept can be obtained from E. B. Meyrowitz, of New York, and are shown in the cut below.

It is not necessary to seal the jars. This method preserves the color of the specimen, gives the proper transparency to the cornea and to the lens, and can at any time be removed to make microscopical sections. There are many other methods of preserving eye specimens, but the author thinks for all practical purposes those that have been explained are sufficient.

Manner of Photographing Gross Eye Specimens.—To obtain a good photo of the specimen in the mount is not easy, as the reflections of light from the glass receptacle blur the picture. A very good picture of the glass bottle is obtained but a very poor one of the specimen itself. To obviate these reflections Dixon advocates fitting over the mount an ordinary three and one half inch focusing glass mounted in a metal tube. The specimen is then sufficiently illumined through the side of the glass bottle, while all direct light from the bottom of the bottle is excluded. Dr. Dixon also devised a camera which gives fair results.

It consists of a pair of bellows, the anterior a single one being smaller than the posterior one, which carries the lens and the plate-holder. The posterior bellows is securely attached to a base-board long enough to project considerably in front of the anterior bellows. The base-board of the anterior bellows is fastened to a couple of cleats sufficiently high to bring the diaphragm at the back and the object in the front in line with the axis of the lens of the camera. The anterior bellows is provided with a sliding front, in the center of which is a sliding diaphragm sufficiently large to hold all specimens. A spring is employed to hold the jar containing the specimens in position. As the front slides the whole can be removed and the specimen adjusted and returned back into position, so that the specimen is in the optic axis of the lens. The posterior bellows is provided with a three and one half inch wide angle lens, intended to cover a lantern slide and capable of enlarging the eye two diameters with satisfactory detail. An "F" 32 stop is employed for the exposure. Ordinary daylight is unsuitable for the exposure save in very thin specimens or very light substance in the interior of the hemisphere.

To render the illumination uniform and obtain detail in the negative, a truncated cone made of card-board is placed around the specimen and sunlight reflected through this upon the specimen by aid of a mirror. Even with this method the cornea and sclerotic coat are apt to appear overtimed, while the dark middle tunic and pig-

mented growths within the eyeball undertimed and without detail. To obviate the reflections from the bottom of the bottle containing the specimen, an annular prism may be cemented upon the bottom of the bottle. Even with all the precautions the pictures taken of mounted specimens are not pieces of art, but are at the best poor imitations and do not compare at all with well made drawings of same.

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