

英中文版教学参考书

第 16 版

Vaughan & Asbury's  
General Ophthalmology

---

眼科学总论

原 著 Paul Riordan-Eva  
John P. Whitcher

主 译 赵桂秋

副主译 梁 涛 王 青

审 校 崔益群



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译者 (按姓氏笔画为序)

马玉娜 孔庆兰 白海青 孙学华 刘淑君

李倩 李慧 杨珊珊 杨先 罗文娟

姜涛 赵艳 赵善瑶 袁春燕 康菊

童卉琳 潘晓晶

审校 崔益群

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Paul Riordan-Eva, et al.

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# 译者序

改革开放以来,我国的国民经济有了飞速的发展,人们对改进生活质量的要求也日益增强。眼科疾病是影响生活质量的极为敏感的因素之一。近20年来我国眼科工作者与其他学科一样与国际交流逐渐增多,学习和引进了一些新理论、新知识、新技术和新方法,提高了国人眼科医师的专业理论知识和技术技能,使眼科疾病的诊治水平取得了较大进步和提高。但从我国眼科基础研究和临床专业工作的整体水平来看与国际先进水平还有相当差距。因此,学习先进理论、技术,尽早实现与国际接轨已是当务之急,直接学习国外教材不失为一种有效的学习方法。

本书第16版由美国多位著名眼科学家撰写,内容丰富,除了详尽介绍眼的解剖、生理和眼科常见病的诊治外,还较详细叙述了神经眼科学、防盲、眼与全身病、小儿眼科疾病、基因与遗传性眼病、眼科药物及临床常用药物对眼的影响等章节,并介绍了眼科近年发展起来的新技术,如吲哚青绿造影检查法及眼科激光的应用等,内容丰富,有重要的使用和参考价值,适合作为眼科医师、医学院教师、医学生、护师(士)、验光师学习之参考。

在本书出版之际,衷心感谢各位译者的不懈努力,感谢青岛大学医学院及附属医院各位领导和眼科同事们予以的大力支持。

由于编译者水平有限、编写经验不足,加之时间仓促,虽然竭尽全力以求体现原文之精华,书中贻误之处仍在所难免,望广大同道及读者不吝指正。

赵桂秋

青岛大学医学院附属医院

2006年4月

# 前 言

四十年以来，眼科学总论一直是医学生、眼科住院医师、眼科实习医师、护士、验光师、其他专业的医生和医学相关专业人士的最简明最前沿最权威的专著。为继续达到这一目标，第 16 版眼科学总论进行了修改和更新。相对于第 15 版做了如下修改：

主要对“玻璃体疾病”、“眼外伤”、和“激光在眼科学中的应用”三章做了修改。

“青光眼”、“神经眼科学”和“基因遗传学”三章也做了重要的修改。

和过去的版本一样，许多眼科学权威专家给了我们很多的建议。我们特别感谢 J. Brooks Crawford, Philip P. Ellis, Frederick T. Fraunfelder, Connor O'Malley, Michael D. Sanders, James J. Sanitato, 和 James B. Wise 对以前的版本做出的巨大贡献。衷心感谢新的作者 James J. Augsburger, Robert J. Campbell, Steven Charles, N. H. Victor Chong, William O. Edward, Allan J. Flach, Frederick W. Fraunfelder, Francisco J. Garcia-Ferrer, Thomas R. G. Poole 和 Debra J. Shetlar。

Paul Riordan-Eva, FRCS, FRCOphth

John P. Whitcher, MD

2003 年 9 月



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# Anatomy & Embryology of the Eye

1

Paul Riordan-Eva, FRCS, FRCOphth

A thorough understanding of the anatomy of the eye, orbit, visual pathways, upper cranial nerves, and central pathways for the control of eye movements is a prerequisite for proper interpretation of diseases having ocular manifestations. Furthermore, such anatomic knowledge is essential to the proper planning and safe execution of ocular and orbital surgery. Whereas most knowledge of these matters is based on anatomic dissections, either postmortem or during surgery, noninvasive techniques—particularly MRI and ultrasonography—are increasingly providing additional information. Investigating the embryology of the eye is clearly a more difficult area because of the relative scarcity of suitable human material, and thus there is still great reliance on animal studies, with the inherent difficulties in inferring parallels in human development. Nevertheless, a great deal is known about the embryology of the human eye, and—together with the recent expansion in molecular genetics—this has led to a much deeper understanding of developmental anomalies of the eye.

## I. NORMAL ANATOMY

### THE ORBIT (Figures 1–1 and 1–2)

The orbital cavity is schematically represented as a pyramid of four walls that converge posteriorly. The medial walls of the right and left orbit are parallel and are separated by the nose. In each orbit, the lateral and medial walls form an angle of 45 degrees, which results in a right angle between the two lateral walls. The orbit is compared to the shape of a pear, with the optic nerve representing its stem. The anterior circumference is somewhat smaller in diameter than the region just within the rim, which makes a sturdy protective margin.

The volume of the adult orbit is approximately 30 mL, and the eyeball occupies only about one-fifth of the space. Fat and muscle account for the bulk of the remainder.

The anterior limit of the orbital cavity is the **orbital septum**, which acts as a barrier between the eyelids and orbit (see below).

The orbits are related to the frontal sinus above, the maxillary sinus below, and the ethmoid and sphenoid sinuses medially. The thin orbital floor is easily damaged by direct trauma to the globe, resulting in a “blowout” fracture with herniation of orbital contents into the maxillary antrum. Infection within the sphenoid and ethmoid sinuses can erode the paper-thin medial wall (lamina papyracea) and involve the contents of the orbit. Defects in the roof (eg, neurofibromatosis) may result in visible pulsations of the globe transmitted from the brain.

### Orbital Walls

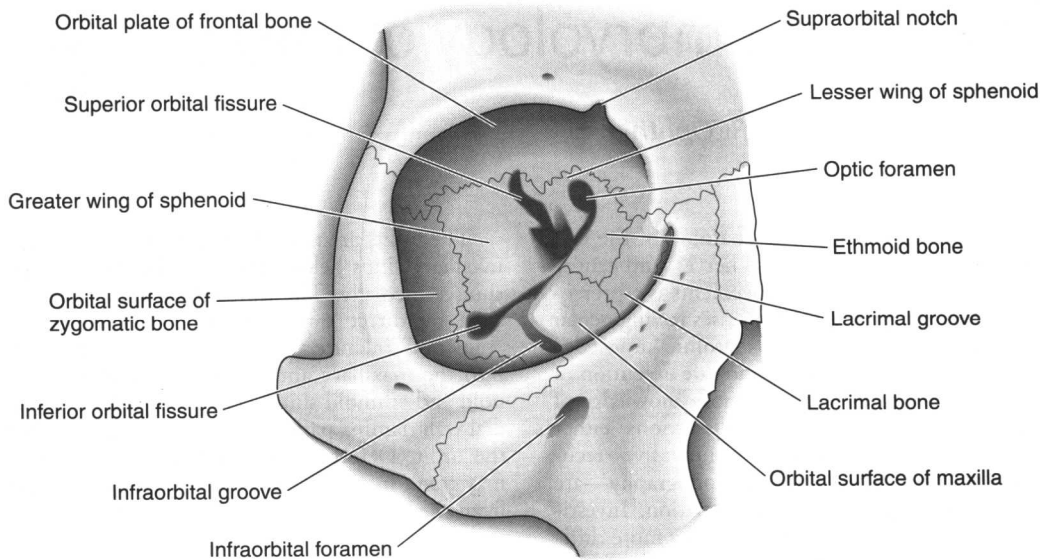
The roof of the orbit is composed principally of the orbital plate of the **frontal bone**. The lacrimal gland is located in the lacrimal fossa in the anterior lateral aspect of the roof. Posteriorly, the lesser wing of the **sphenoid bone** containing the optic canal completes the roof.

The lateral wall is separated from the roof by the superior orbital fissure, which divides the lesser from the greater wing of the **sphenoid bone**. The anterior portion of the lateral wall is formed by the orbital surface of the **zygomatic (malar) bone**. This is the strongest part of the bony orbit. Suspensory ligaments, the lateral palpebral tendon, and check ligaments have connective tissue attachments to the lateral orbital tubercle.

The orbital floor is separated from the lateral wall by the inferior orbital fissure. The orbital plate of the **maxilla** forms the large central area of the floor and is the region where blowout fractures most frequently occur. The frontal process of the maxilla medially and the **zygomatic bone** laterally complete the inferior orbital rim. The orbital process of the **palatine bone** forms a small triangular area in the posterior floor.

The boundaries of the medial wall are less distinct. The **ethmoid bone** is paper-thin but thickens anteriorly as it meets the **lacrimal bone**. The body of the **sphenoid** forms the most posterior aspect of the medial wall, and the angular process of the **frontal bone** forms the upper part of the posterior lacrimal crest. The lower portion of the posterior lacrimal crest is made up of the **lacrimal bone**. The anterior lacrimal crest is easily palpated through the lid and is composed of the frontal process of the **maxilla**. The lacrimal groove lies between the two crests and contains the lacrimal sac.





**Figure 1-1.** Anterior view of bones of right orbit.

### Orbital Apex (Figure 1-3)

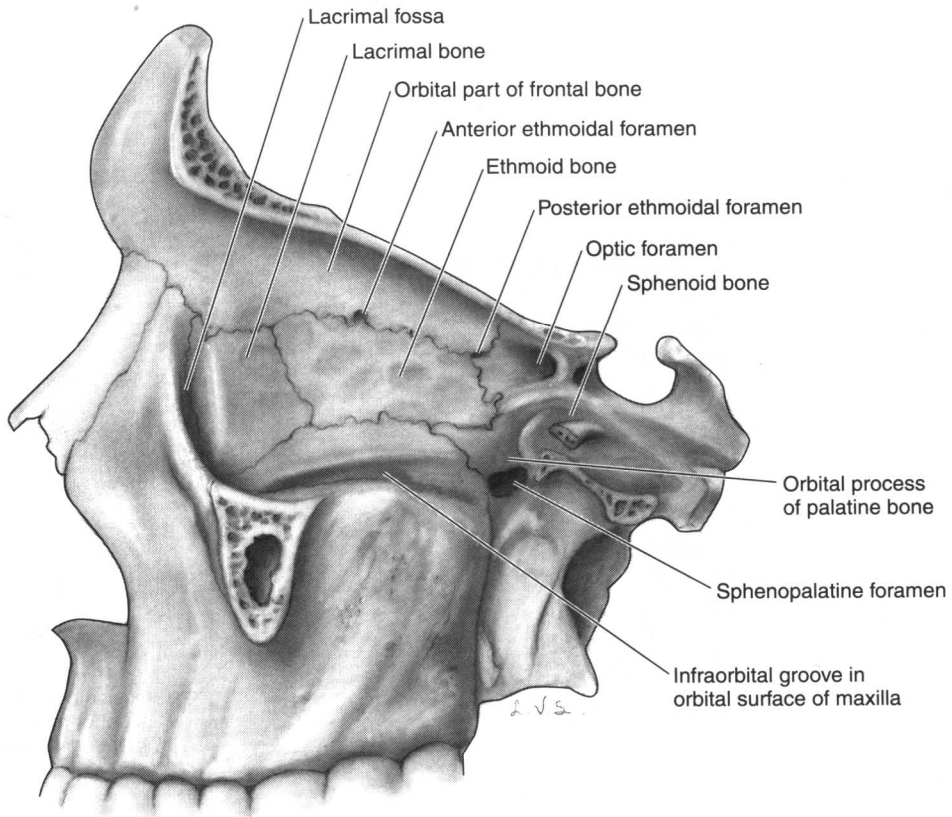
The apex of the orbit is the entry portal for all nerves and vessels to the eye and the site of origin of all extraocular muscles except the inferior oblique. The **superior orbital fissure** lies between the body and the greater and lesser wings of the sphenoid bone. The superior ophthalmic vein and the lacrimal, frontal, and trochlear nerves pass through the lateral portion of the fissure that lies outside the annulus of Zinn. The superior and inferior divisions of the oculomotor nerve and the abducens and nasociliary nerves pass through the medial portion of the fissure within the annulus of Zinn. The optic nerve and ophthalmic artery pass through the optic canal, which also lies within the annulus of Zinn. The inferior ophthalmic vein may pass through any part of the superior orbital fissure, including the portion adjacent to the body of the sphenoid that lies inferomedial to the annulus of Zinn. The inferior ophthalmic vein frequently joins the superior ophthalmic vein before exiting the orbit.

### Blood Supply (Figures 1-4, 1-5, and 1-6)

The principal arterial supply of the orbit and its structures derives from the ophthalmic artery, the first major branch of the intracranial portion of the internal carotid artery. This branch passes beneath the optic nerve and accompanies it through the optic

canal into the orbit. The first intraorbital branch is the central retinal artery, which enters the optic nerve about 8–15 mm behind the globe. Other branches of the ophthalmic artery include the lacrimal artery, supplying the lacrimal gland and upper eyelid; muscular branches to the various muscles of the orbit; long and short posterior ciliary arteries; medial palpebral arteries to both eyelids; and the supraorbital and supratrochlear arteries. The short posterior ciliary arteries supply the choroid and parts of the optic nerve. The two long posterior ciliary arteries supply the ciliary body and anastomose with each other and with the anterior ciliary arteries to form the major arterial circle of the iris. The anterior ciliary arteries are derived from the muscular branches to the rectus muscles. They supply the anterior sclera, episclera, limbus, and conjunctiva as well as contributing to the major arterial circle of the iris. The most anterior branches of the ophthalmic artery contribute to the formation of the arterial arcades of the eyelids, which make an anastomosis with the external carotid circulation via the facial artery.

The venous drainage of the orbit is primarily through the superior and inferior ophthalmic veins, into which drain the vortex veins, the anterior ciliary veins, and the central retinal vein. The ophthalmic veins communicate with the cavernous sinus via the superior orbital fissure and the pterygoid venous plexus via the inferior orbital fissure. The superior ophthalmic vein is initially formed from the supraorbital and supratrochlear veins and from a branch of the angular vein,



**Figure 1–2.** Medial view of bony wall of left orbit.

all of which drain the skin of the periorbital region. This provides a direct communication between the skin of the face and the cavernous sinus, thus forming the basis of the potentially lethal cavernous sinus thrombosis secondary to superficial infection of the periorbital skin.

## THE EYEBALL

The normal adult globe is approximately spherical, with an anteroposterior diameter averaging 24.2 mm.

## THE CONJUNCTIVA

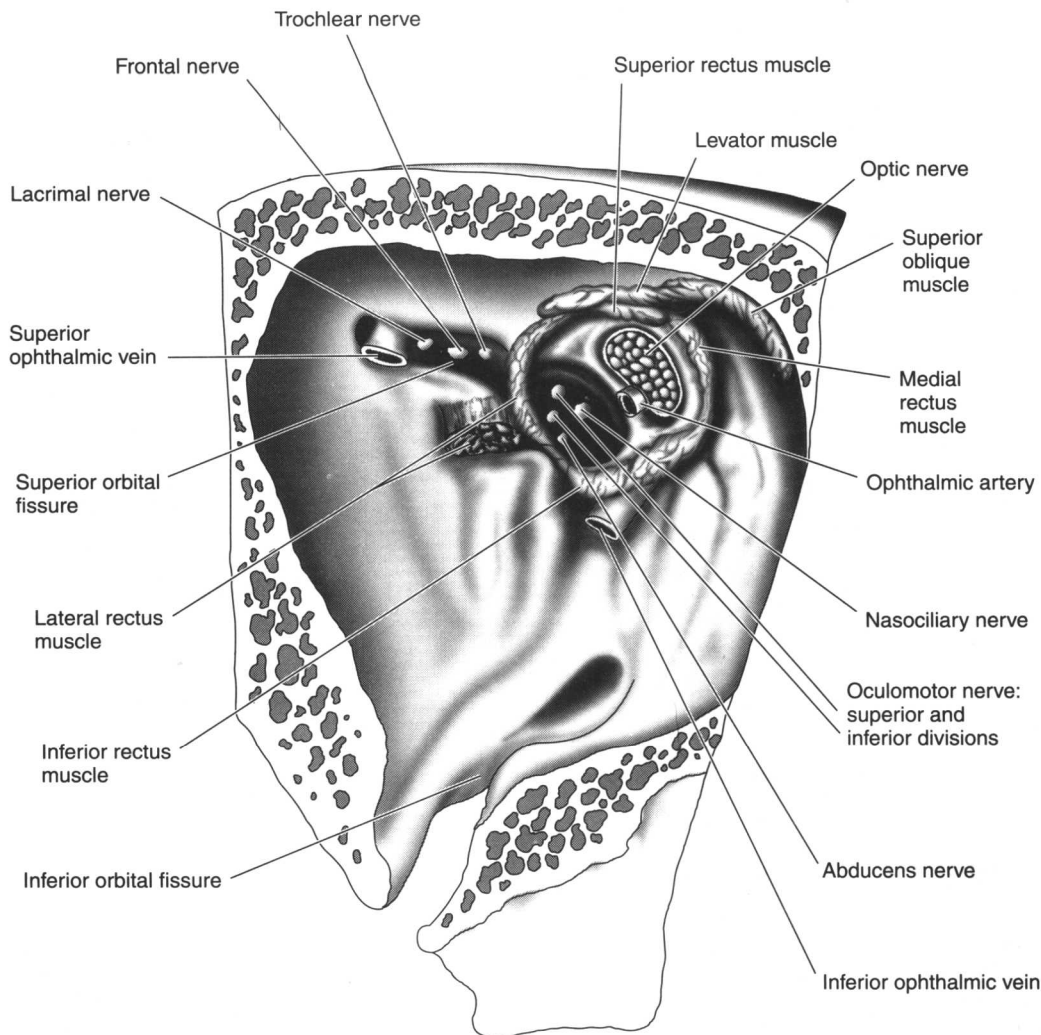
The conjunctiva is the thin, transparent mucous membrane that covers the posterior surface of the lids (the palpebral conjunctiva) and the anterior surface of the sclera (the bulbar conjunctiva). It is continuous with the skin at the lid margin (a mucocutaneous junction) and with the corneal epithelium at the limbus.

The **palpebral conjunctiva** lines the posterior surface of the lids and is firmly adherent to the tarsus. At

the superior and inferior margins of the tarsus, the conjunctiva is reflected posteriorly (at the superior and inferior fornices) and covers the episcleral tissue to become the bulbar conjunctiva.

The **bulbar conjunctiva** is loosely attached to the orbital septum in the fornices and is folded many times. This allows the eye to move and enlarges the secretory conjunctival surface. (The ducts of the lacrimal gland open into the superior temporal fornix.) Except at the limbus (where Tenon's capsule and the conjunctiva are fused for about 3 mm), the bulbar conjunctiva is loosely attached to Tenon's capsule and the underlying sclera.

A soft, movable, thickened fold of bulbar conjunctiva (the **semilunar fold**) is located at the inner canthus and corresponds to the nictitating membrane of some lower animals. A small, fleshy, epidermoid structure (the caruncle) is attached superficially to the inner portion of the semilunar fold and is a transition zone containing both cutaneous and mucous membrane elements.



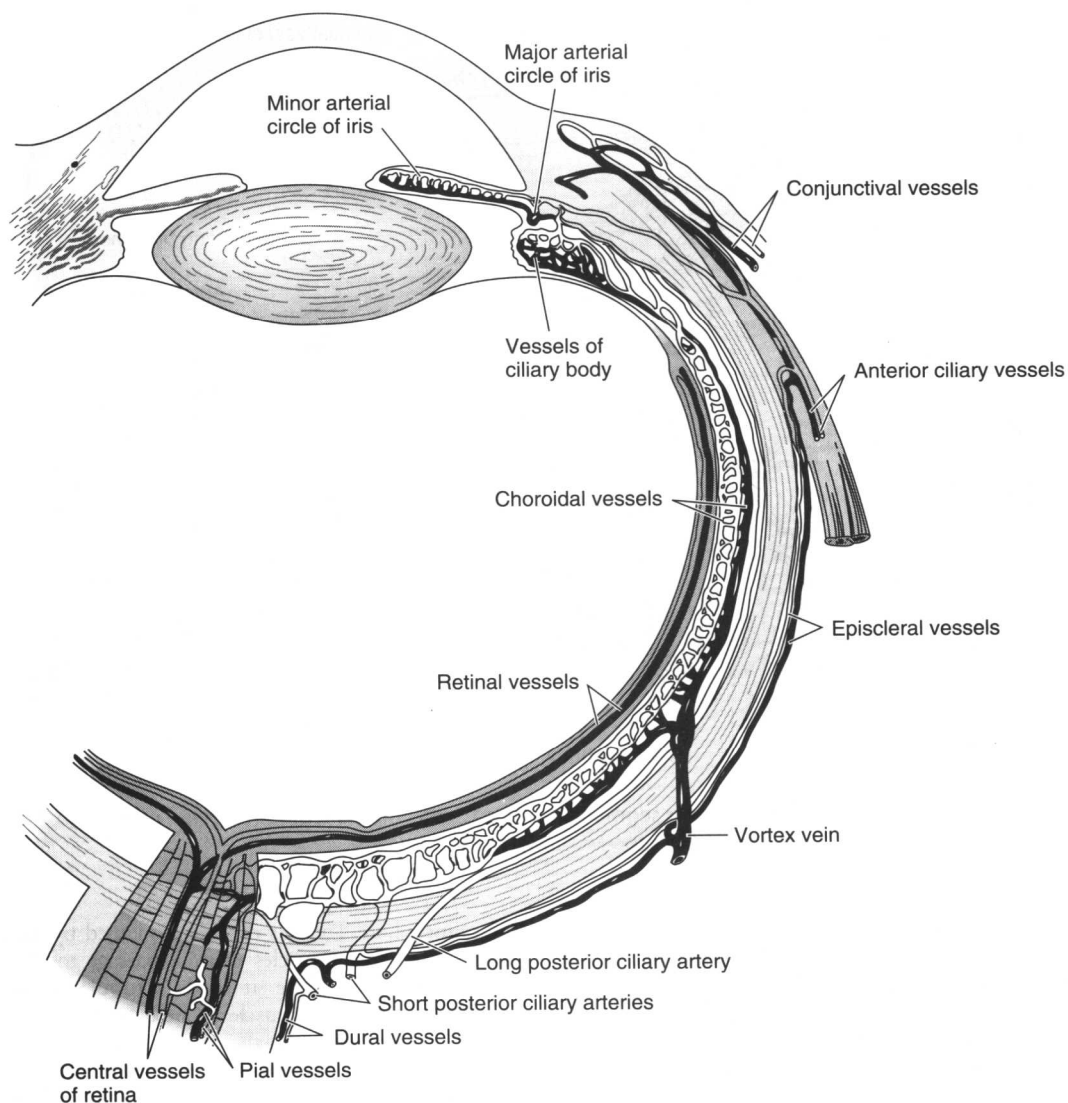
**Figure 1-3.** Anterior view of apex of right orbit.

## Histology

The **conjunctival epithelium** consists of two to five layers of stratified columnar epithelial cells, superficial and basal. Conjunctival epithelium near the limbus, over the caruncle, and near the mucocutaneous junctions at the lid margins consists of stratified squamous epithelial cells. The **superficial epithelial cells** contain round or oval mucus-secreting goblet cells. The mucus, as it forms, pushes aside the goblet cell nucleus and is necessary for proper dispersion of the precorneal tear

film. The **basal epithelial cells** stain more deeply than the superficial cells and near the limbus may contain pigment.

The **conjunctival stroma** is divided into an adenoid (superficial) layer and a fibrous (deep) layer. The **adenoid layer** contains lymphoid tissue and in some areas may contain "follicle-like" structures without germinal centers. The adenoid layer does not develop until after the first 2 or 3 months of life. This explains why inclusion conjunctivitis of the newborn is papillary in nature rather than follicular and why it later becomes follicu-



**Figure 1-4.** Vascular supply to the eye. All arterial branches originate with the ophthalmic artery. Venous drainage is through the cavernous sinus and the pterygoid plexus.

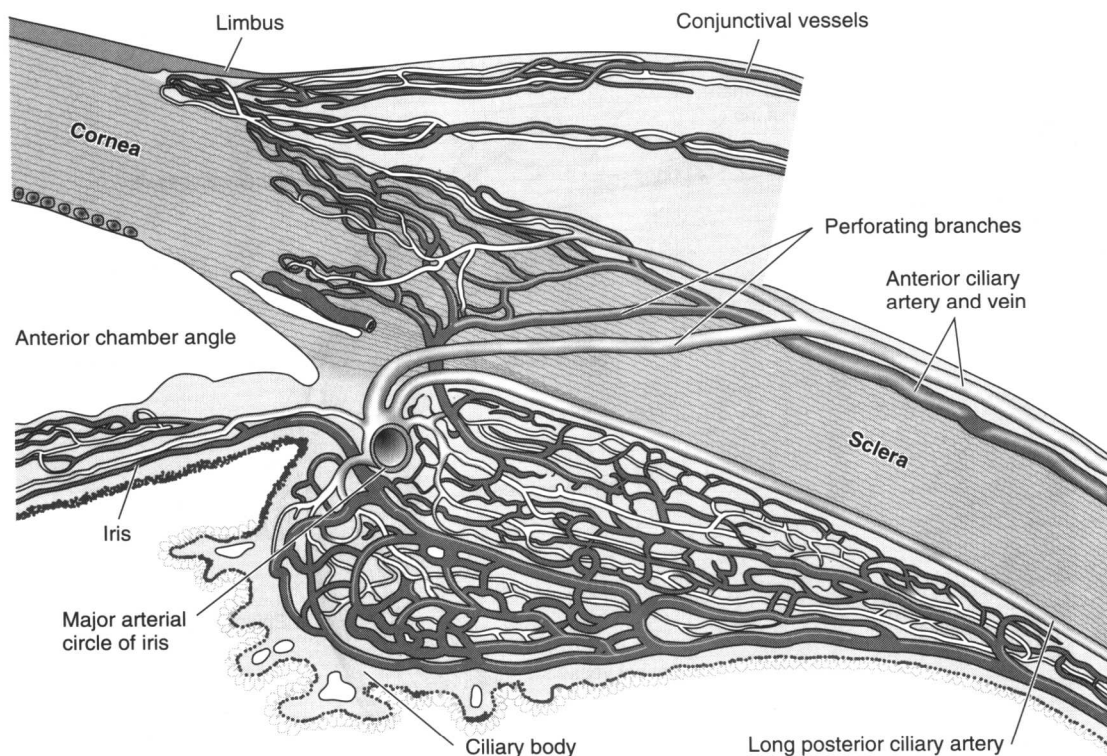
lar. The **fibrous layer** is composed of connective tissue that attaches to the tarsal plate. This explains the appearance of the papillary reaction in inflammations of the conjunctiva. The fibrous layer is loosely arranged over the globe.

The **accessory lacrimal glands** (glands of Krause and Wolfring), which resemble the lacrimal gland in structure and function, are located in the stroma. Most

of the glands of Krause are in the upper fornix, the remaining few in the lower fornix. The glands of Wolfring lie at the superior margin of the upper tarsus.

### Blood Supply, Lymphatics, & Nerve Supply

The conjunctival arteries are derived from the anterior ciliary and palpebral arteries. The two arteries anasto-



**Figure 1-5.** Vascular supply of the anterior segment. (Modified, redrawn, and reproduced, with permission, from Wolff E: *Anatomy of the Eye and Orbit*, 4th ed. Blakiston-McGraw, 1954.)

mose freely and—along with the numerous conjunctival veins that generally follow the arterial pattern—form a considerable conjunctival vascular network. The conjunctival lymphatics are arranged in superficial and deep layers and join with the lymphatics of the eyelids to form a rich lymphatic plexus. The conjunctiva receives its nerve supply from the first (ophthalmic) division of the fifth nerve. It possesses a relatively small number of pain fibers.

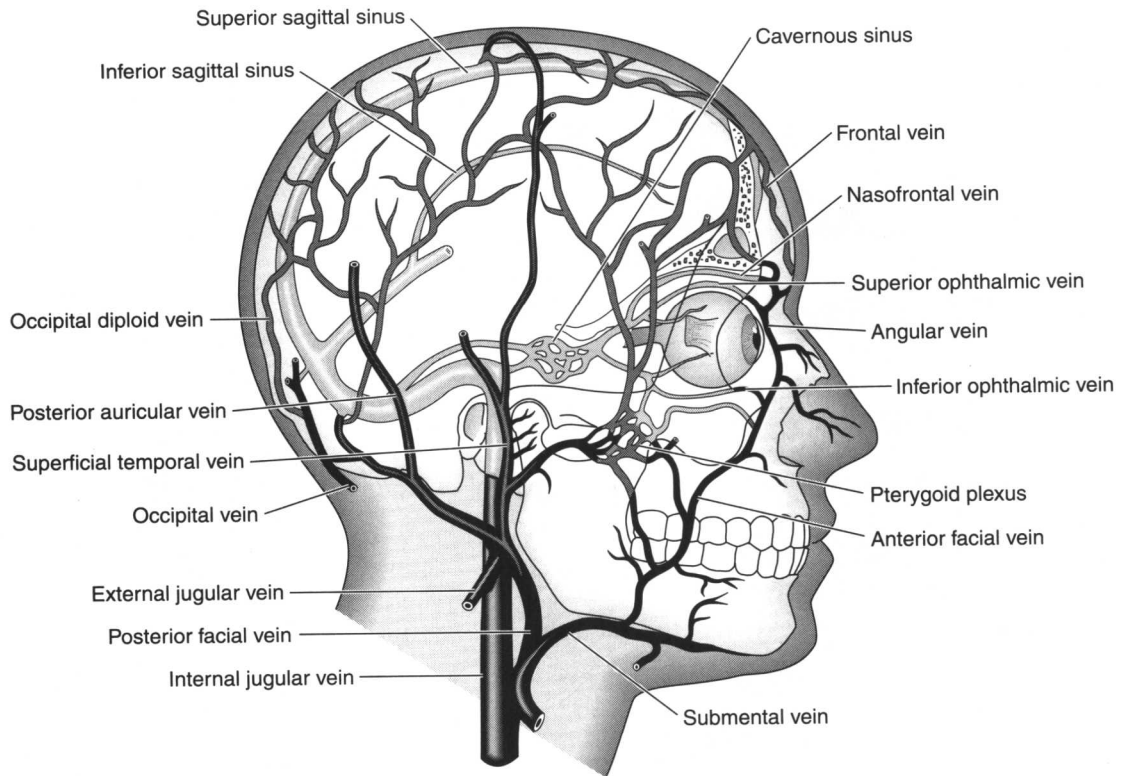
### TENON'S CAPSULE (Fascia Bulbi)

Tenon's capsule is a fibrous membrane that envelops the globe from the limbus to the optic nerve. Adjacent to the limbus, the conjunctiva, Tenon's capsule, and the episclera are fused together. More posteriorly, the inner surface of Tenon's capsule lies against the sclera, and its outer aspect is in contact with orbital fat and other structures within the extraocular muscle cone. At

the point where Tenon's capsule is pierced by tendons of the extraocular muscles in their passage to their attachments to the globe, it sends a tubular reflection around each of these muscles. These fascial reflections become continuous with the fascia of the muscles, the fused fasciae sending expansions to the surrounding structures and to the orbital bones. The fascial expansions are quite tough and limit the action of the extraocular muscles and are therefore known as **check ligaments**. They regulate the direction of action of the extraocular muscles and act as their functional mechanical origins. The lower segment of Tenon's capsule is thick and fuses with the fascia of the inferior rectus and the inferior oblique muscles to form the suspensory ligament of the eyeball (Lockwood's ligament), upon which the globe rests.

### THE SCLERA & EPISCLERA

The **sclera** is the fibrous outer protective coating of the eye consisting almost entirely of collagen (Figure 1-7).



**Figure 1-6.** Venous drainage system of the eye. (Redrawn and reproduced, with permission, from Wolff E: *Anatomy of the Eye and Orbit*, 4th ed. Blakiston-McGraw, 1954.)

It is dense and white and continuous with the cornea anteriorly and the dural sheath of the optic nerve posteriorly. Across the posterior scleral foramen are bands of collagen and elastic tissue, forming the **lamina cribrosa**, between which pass the axon bundles of the optic nerve. The outer surface of the anterior sclera is covered by a thin layer of fine elastic tissue, the **episclera**, which contains numerous blood vessels that nourish the sclera. The brown pigment layer on the inner surface of the sclera is the lamina fusca, which forms the outer layer of the suprachoroidal space.

At the insertion of the rectus muscles, the sclera is about 0.3 mm thick; elsewhere it is about 0.6 mm thick. Around the optic nerve, the sclera is penetrated by the long and short posterior ciliary arteries and the long and short ciliary nerves (Figure 1-8). The long posterior ciliary arteries and long ciliary nerves pass from the optic nerve to the ciliary body in a shallow groove on the inner surface of the sclera at the 3 and 9 o'clock meridians. Slightly posterior to the equator, the

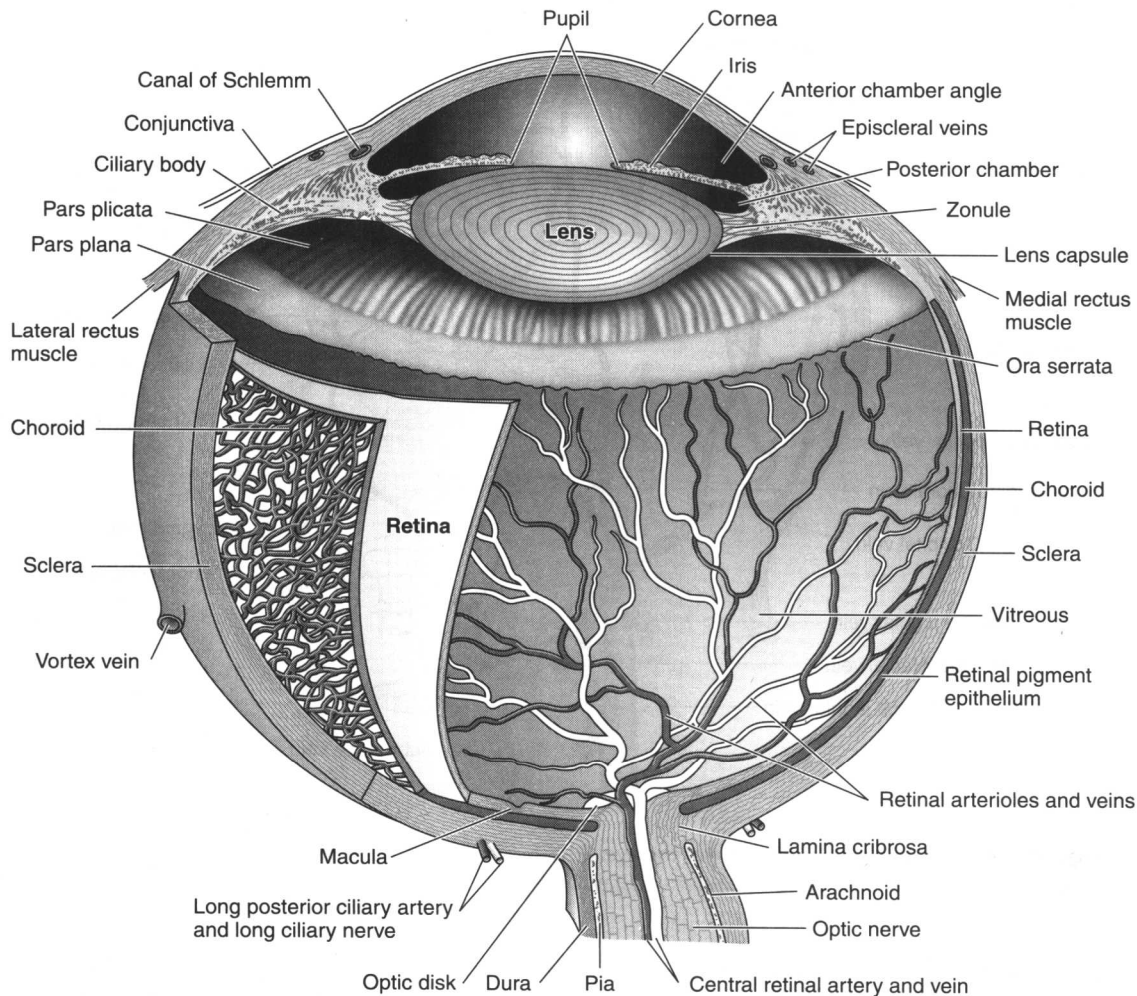
four vortex veins draining the choroid exit through the sclera, usually one in each quadrant. About 4 mm posterior to the limbus, slightly anterior to the insertion of the respective rectus muscle, the four anterior ciliary arteries and veins penetrate the sclera. The nerve supply to the sclera is from the ciliary nerves.

Histologically, the sclera consists of many dense bands of parallel and interlacing collagen bundles, each of which is 10–16  $\mu\text{m}$  thick and 100–140  $\mu\text{m}$  wide. The histologic structure of the sclera is remarkably similar to that of the cornea. The reason for the transparency of the cornea and the opacity of the sclera is the relative deturgescence of the cornea.

## THE CORNEA

The cornea is a transparent tissue comparable in size and structure to the crystal of a small wristwatch (Figure 1-9). It is inserted into the sclera at the limbus, the circumferential depression at this junction being

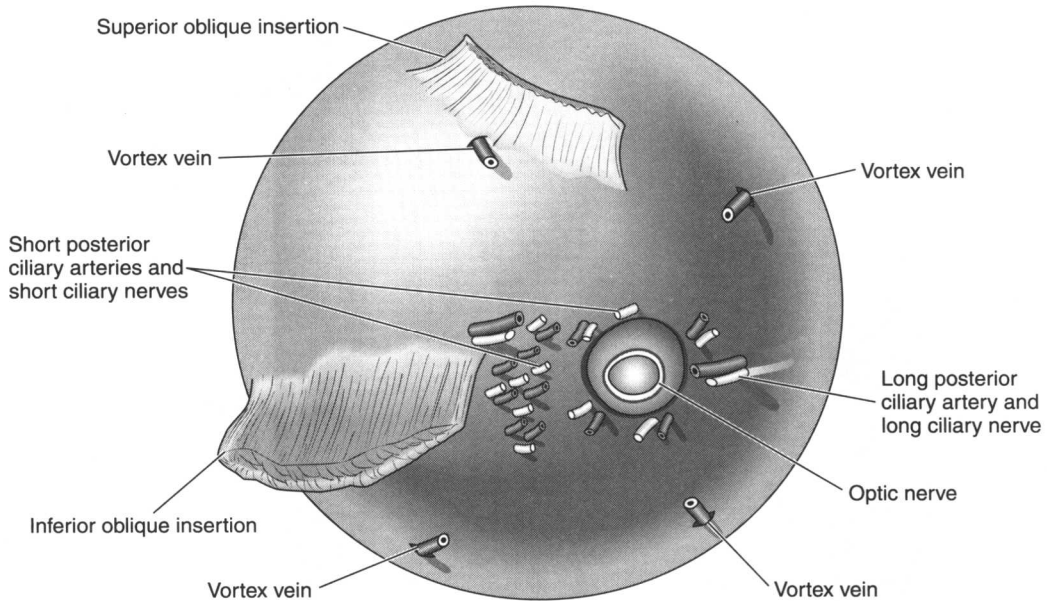




**Figure 1-7.** Internal structures of the human eye. (Redrawn from an original drawing by Paul Peck and reproduced with permission, from: *The Anatomy of the Eye*. Courtesy of Lederle Laboratories.)

known as the scleral sulcus. The average adult cornea is 0.52 mm thick in the center, about 0.65 mm thick at the periphery, and about 11.75 mm in diameter horizontally and 10.6 mm vertically. From anterior to posterior, it has five distinct layers (Figure 1-10): the epithelium (which is continuous with the epithelium of the bulbar conjunctiva), Bowman's layer, the stroma, Descemet's membrane, and the endothelium. The epithelium has five or six layers of cells. Bowman's layer is a clear acellular layer, a modified portion of the stroma. The corneal stroma accounts for about 90% of the corneal thickness. It is composed of intertwining lamellae of collagen fibrils 10–250  $\mu\text{m}$  in width and 1–2  $\mu\text{m}$  in height that run almost the full diameter of the

cornea. They run parallel to the surface of the cornea and by virtue of their size and proximity are optically clear. The lamellae lie within a ground substance of hydrated proteoglycans in association with the keratocytes that produce the collagen and ground substance. Descemet's membrane, constituting the basal lamina of the corneal endothelium, has a homogeneous appearance on light microscopy but a laminated appearance on electron microscopy due to structural differences between its pre- and postnatal portions. It is about 3 mm thick at birth but increases in thickness throughout life, reaching 10–12  $\mu\text{m}$  in adulthood. The endothelium has only one layer of cells, but this is responsible for maintaining the essential deturgescence of the corneal



**Figure 1-8.** Posterior view of left eye. (Redrawn and reproduced, with permission, from Wolff E: *Anatomy of the Eye and Orbit*, 4th ed. Blakiston-McGraw, 1954.)

stroma. The endothelium is quite susceptible to injury as well as undergoing loss of cells with age. Endothelial repair is limited to enlargement and sliding of existing cells, with little capacity for cell division. Failure of endothelial function leads to corneal edema.

Sources of nutrition for the cornea are the vessels of the limbus, the aqueous, and the tears. The superficial cornea also gets most of its oxygen from the atmosphere. The sensory nerves of the cornea are supplied by the first (ophthalmic) division of the fifth (trigeminal) cranial nerve.

The transparency of the cornea is due to its uniform structure, avascularity, and deturgescence.

## THE UVEAL TRACT

The uveal tract is composed of the iris, the ciliary body, and the choroid (Figure 1-7). It is the middle vascular layer of the eye and is protected by the cornea and sclera. It contributes blood supply to the retina.

### Iris

The **iris** is the anterior extension of the ciliary body. It presents as a flat surface with a centrally situated round aperture, the pupil. The iris lies in contiguity with the anterior surface of the lens, dividing the anterior cham-

ber from the posterior chamber, each of which contains aqueous humor. Within the stroma of the iris are the sphincter and dilator muscles. The two heavily pigmented layers on the posterior surface of the iris represent anterior extensions of the neuroretina and retinal pigment epithelium.

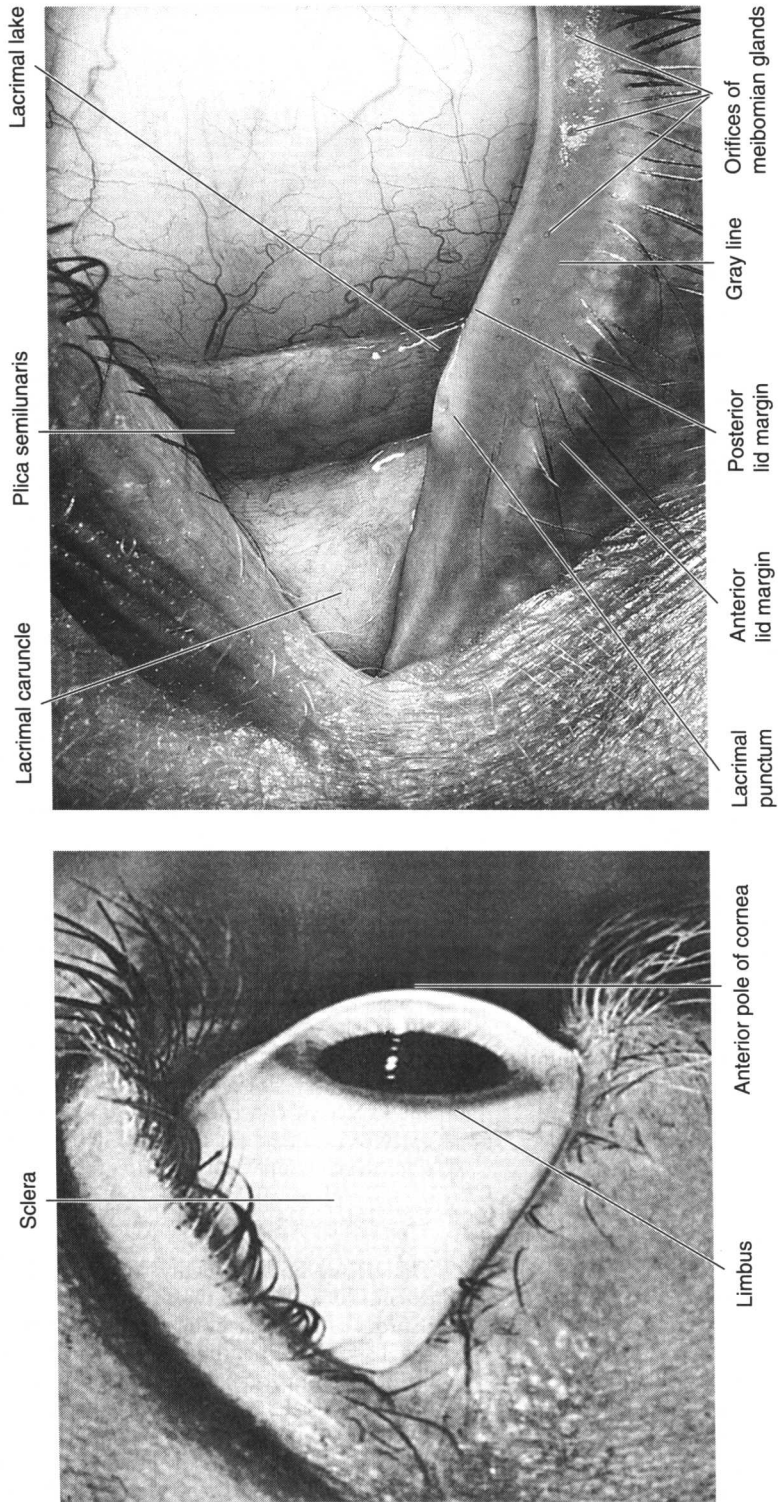
The blood supply to the iris is from the major circle of the iris (Figure 1-4). Iris capillaries have a nonfenestrated endothelium and hence do not normally leak intravenously injected fluorescein. Sensory nerve supply to the iris is via fibers in the ciliary nerves.

The iris controls the amount of light entering the eye. Pupillary size is principally determined by a balance between constriction due to parasympathetic activity transmitted via the third cranial nerve and dilation due to sympathetic activity. (See Chapter 14.)

### The Ciliary Body

The **ciliary body**, roughly triangular in cross-section, extends forward from the anterior end of the choroid to the root of the iris (about 6 mm). It consists of a corrugated anterior zone, the pars plicata (2 mm), and a flattened posterior zone, the pars plana (4 mm). The ciliary processes arise from the pars plicata (Figure 1-11). They are composed mainly of capillaries and veins that drain through the vortex veins. The capillaries are large and fenestrated and hence leak intravenously injected





**Figure 1-9.** External landmarks of the eye. The sclera is covered by transparent conjunctiva. (Photo by HL Gibson, from: *Medical Radiography and Photography*. Labeling modified slightly.)