

# OPHTHALMOLOGY


Lecture Notes



Bruce James  
Anthony Bron

11th Edition



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*We dedicate this book to Chris Chew, co -contributor and our esteemed friend and colleague, who died in 2004. We valued his insightful contributions, and his company is missed*

# Ophthalmology

## Lecture Notes

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## ***Preface to eleventh edition***

Welcome to the 11th edition of *Ophthalmology Lecture Notes*! As in the past, our aim has been to make the diagnosis and management of eye disease a palatable process and once again we stress the value of a good history and careful clinical examination of the eye.

The eye is remarkably accessible. Optical and digital techniques give access to the structures of the eye at cellular level. Specular microscopy can image the corneal endothelial cells which regulate corneal hydration and transparency; digital fluorescein angiography allows the retinal capillary bed to be explored in ischaemic retinal disease; optical coherence tomography allows the layers of the retina to be dissected and confocal microscopy provides a three-dimensional view of the optic nerve head. The shape of the cornea can be plotted digitally and, outside the globe, orbital structures and the visual pathway can be viewed by neuroimaging.

Therapeutically, lasers are used to relieve acute, angle closure glaucoma, to lower ocular pressure in chronic glaucoma, to open up an opaque lens capsule following cataract surgery and to seal retinal holes. Sight-threatening diabetic retinopathy can be treated effectively by retinal photocoagulation, to remove the angiogenic stimulus to vasoproliferation. More recently it has become possible to inhibit new vessel formation in diabetic retinopathy, macular degeneration and other retinal vascular disorders by intravitreal injections of anti-angiogenic drugs.

These techniques are matched by technological innovations in microsurgery, responsible for dramatic advances in cataract and vitreoretinal surgery. Cataracts are now removed by phacoemulsification, using an oscillating ultrasonic probe, and optical function is restored by insertion of a lens which unfolds within the eye. Vitreoretinal

surgery employs inert gases to flatten the detached retina and endoscopic probes which allow manipulations in the vitreous space and the dissection of microscopic membranes from the retinal surface.

Despite these advances, most ophthalmic diagnoses can still be made from a good history and clinical examination of the eye. This book aims to teach skills which will be useful to anyone engaged in medical practice. Many systemic disorders have ocular features which are critical in diagnosis. This book covers the ophthalmic features of systemic hypertension, diabetes, sarcoidosis, endocarditis, demyelinating disease and space-occupying lesions of the brain. It also explains how to recognize iritis, distinguish various forms of retinopathy and understand the difference between papilloedema and papillitis.

As in the tenth edition, each chapter provides a set of learning objectives and a summary of key points, as well as bullet lists for emphasis. You can test your understanding with the multiple choice questions and picture quizzes at the end of each chapter. In this edition, we have updated all the chapters and added new extended matching questions (EMQs) to bring this small volume up to date.

Chapter 19 offers classical case histories, which will let you test your diagnostic skills. The final section of the book provides a list of further reading and the details of attractive websites which offer an expanded view of the speciality. Try some of these out.

We hope that you will have as much fun reading these Lecture Notes as we did putting them together.

Bruce James  
Anthony Bron



## ***Preface to first edition***

This little guide does not presume to tell the medical student all that he needs to know about ophthalmology, for there are many larger books that do. But the medical curriculum becomes yearly more congested, while ophthalmology, still the 'Cinderella' of medicine, is generally left until the last, and only too readily goes by default. So it is to these harassed final year students that the book is principally offered, in the sincere hope that they will find it useful; for nearly all eye diseases are recognized quite simply by their appearance, and a guide to ophthalmology need be little more than a gallery of pictures, linked by lecture notes.

My second excuse for publishing these lecture notes is a desire I have always had to escape from the traditional textbook presentation of ophthalmology as a string of small isolated diseases, with long unfamiliar names, and a host of eponyms. To the nineteenth century empiricist, it seemed proper to classify a long succession of ocular structures, all of which emerged as isolated brackets for yet another sub catalogue of small and equally isolated diseases. Surely it is time now to try and harness these miscellaneous ailments, not in terms of their diverse morphology, but in simpler clinical patterns; not as the microscopist lists them, but in the different ways that eye diseases present. For this, after all, is how the student will soon be meeting them.

I am well aware of the many inadequacies and omissions in this form of presentation, but if the belaboured student finds these lecture notes at least more readable, and therefore more memorable, than the prolix and time honoured pattern, perhaps I will be justified.

Patrick Trevor-Roper

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Numerous colleagues have provided valuable advice in their specialist areas, for which we are most grateful. The authors wish to thank Tom Meagher and Manoj Parulekar for providing additional pictures for the eleventh edition. We are particularly grateful to Professor Allen Foster at the London School of Hygiene and Tropical Medicine, who kindly provided the illustrations for the chapter on tropical ophthalmology. Asha Sharma kindly provided orthoptic advice. Thanks are due also to our editors and the staff at Wiley Blackwell for their encouragement, efficiency and patience during the production of this edition. We are also grateful to our copy editor, Joanna Brocklesby, for her meticulous reading of the text.

Bruce James

Anthony Bron

# ***Abbreviations***

AIDS	acquired immunodeficiency syndrome
AION	anterior ischaemic optic neuropathy
AMD	age -related macular degeneration
ARM	age -related maculopathy
CMV	cytomegalovirus
CNS	central nervous system
CRVO	central retinal vein occlusion
CSF	cerebrospinal fluid
CT	computed tomography
DCR	dacryocystorhinostomy
ENT	ear, nose and throat
ERG	electroretinogram
ESR	erythrocyte sedimentation rate
GCA	giant cell arteritis
GI	gastrointestinal
GPC	giant papillary conjunctivitis
HAART	highly active anti-retroviral therapy
HIV	human immunodeficiency virus
HLA	human leucocyte antigen
HSV	herpes simplex
ICG	indocyanine green angiography
INR	international normalized ratio
IOL	intraocular lens
KP	keratic precipitate
LASEK	laser assisted subepithelial keratomileusis
LASIK	laser assisted in situ keratomileusis
LGB	lateral geniculate body
MLF	medial longitudinal fasciculus
MRA	magnetic resonance angiogram
MRI	magnetic resonance imaging
NSAID	non steroidal anti-inflammatory drug
OCT	optical coherence tomogram
PAS	peripheral anterior synechiae
PEE	punctate epithelial erosions

PHMB polyhexamethylene biguanide  
PMN polymorphonuclear leucocyte  
PPRF parapontine reticular formation  
PRK photorefractive keratectomy  
PS posterior synechiae  
PVR proliferative vitreoretinopathy  
RAPD relative afferent pupil defect  
RPE retinal pigment epithelium  
TB tuberculosis  
TNF tumour necrosis factor  
UV ultraviolet  
VA visual acuity  
VEGF vascular endothelial growth factor  
VKH Vogt- Koyanagi- Harada disease

# 1

## ***Anatomy***

### **Learning objective**

✓ To learn the anatomy of the eye, the orbit and the third, fourth and sixth cranial nerves, to permit an understanding of medical conditions affecting these structures.

## **Introduction**

A knowledge of ocular anatomy and function is important to the understanding of eye diseases. A brief outline is given below.

## **Gross anatomy**

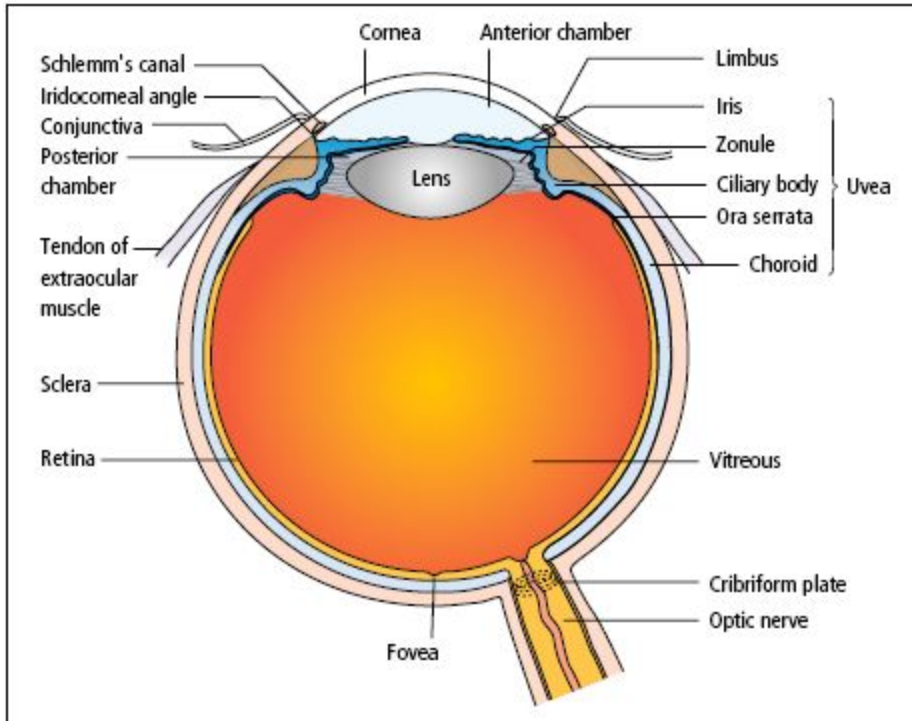
The eye ([Figure 1.1](#)) comprises:

- A tough outer coat which is transparent anteriorly (the *cornea*) and opaque posteriorly (the *sclera*). The junction between them is called the *limbus*. The extraocular muscles attach to the outer sclera while the optic nerve leaves the globe posteriorly.
- A rich vascular coat (the *uvea*) forms the *choroid* posteriorly and the *ciliary body* and *iris* anteriorly. The choroid lines the retina, to which it is firmly attached and nourishes its outer two-thirds.
- The ciliary body contains the smooth *ciliary muscle*, whose contraction allows the lens to take up a more curved shape which permits focusing for near objects. The ciliary epithelium secretes *aqueous humour* and

maintains the ocular pressure. The ciliary body provides attachment for the *iris*, which forms the pupillary diaphragm.

- The *lens* lies behind the iris, supported by the *zonular fibrils*, which run from the lens equator to the ciliary body. When the eye is focused for distance, tension in the zonule maintains a flattened profile of the lens.
- The cornea anteriorly and the iris and central lens posteriorly form the *anterior chamber*, whose periphery is the *iridocorneal angle* or *drainage angle*. The angle is lined by a meshwork of cells and collagen beams called the *trabecular meshwork*, through which aqueous drains into *Schlemm's canal* and thence into the venous system via the *aqueous veins*. This is the basis of aqueous drainage.
- Between the iris, lens and ciliary body lies the *posterior chamber*, a narrow space distinct from the *vitreous body*. Both the anterior and posterior chambers are filled with aqueous humour. Between the lens and the retina lies the vitreous body, occupying most of the posterior segment of the eye.

**Figure 1.1** The basic anatomy of the eye.

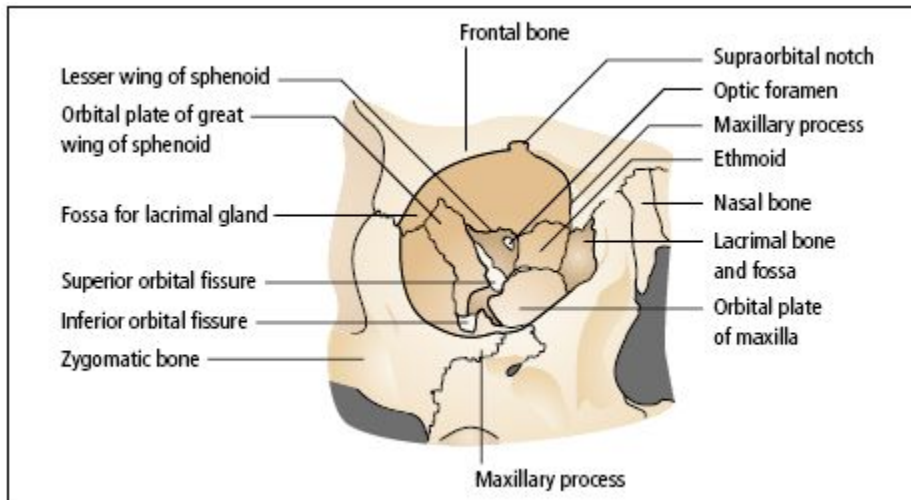


Anteriorly, the *bulbar conjunctiva* of the globe is reflected from the sclera into the fornices and thence onto the posterior surface of the lids where it forms the *tarsal conjunctiva*. A connective tissue layer (*Tenon's capsule*) separates the conjunctiva from the sclera and is prolonged backwards as a sheath around the rectus muscles.

## The orbit

The eye lies within the bony orbit, which has the shape of a four-sided pyramid ([Figure 1.2](#)). At its posterior apex is the *optic canal*, which transmits the optic nerve to the chiasm, tract and lateral geniculate body. The *superior and inferior orbital fissures* allow the passage of blood vessels and cranial nerves which supply orbital structures. The *lacrimal gland* lies anteriorly in the superolateral aspect of the orbit. On the anterior medial wall lies the fossa for the *lacrimal sac*.

**Figure 1.2** The anatomy of the orbit.



## The eyelids (tarsal plates)

The eyelids ([Figure 1.3](#)):

- offer mechanical protection to the anterior globe;
- spread the tear film over the conjunctiva and cornea with each blink;
- contain the *meibomian oil glands*, which provide the lipid component of the tear film;
- through closure and blinking prevent drying of the eyes;
- contain the puncta through which the tears flow into the lacrimal drainage system.

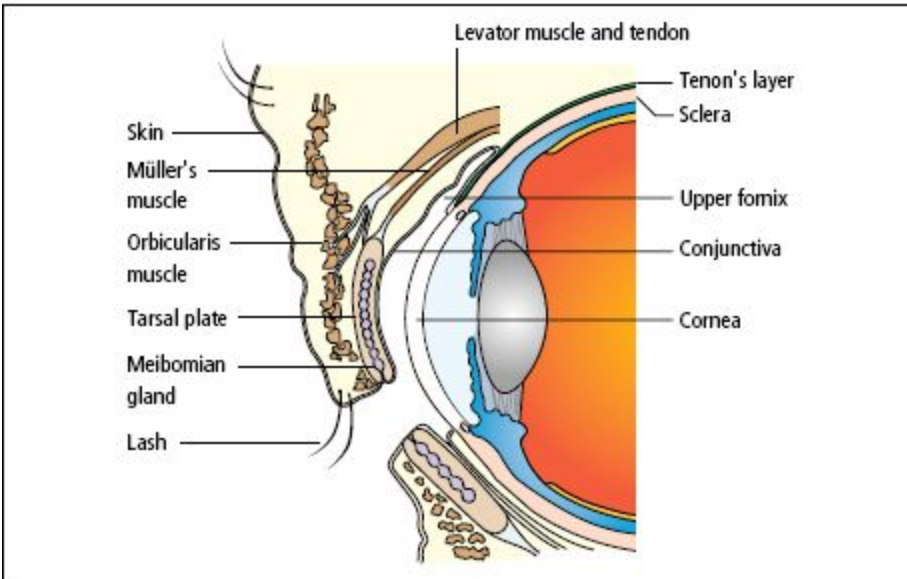
They comprise:

- an anterior layer of skin;
- the *orbicularis muscle*, innervated by the seventh nerve;
- a tough collagenous layer (the *tarsal plate*) which houses the oil glands;
- an epithelial lining, the tarsal conjunctiva, which is reflected onto the globe via the *forrices*.

Contraction of the peripheral fibres of the orbicularis muscle results in a protective, forced eye closure, while that of the inner, palpebral muscle results in the blink.

**[Figure 1.3](#)** The anatomy of the eyelids.





The *levator muscle* passes forwards to the upper lid and inserts by an aponeurosis into the tarsal plate. It is innervated by the third nerve. Damage to the nerve or weakening of the aponeurosis in old age results in drooping of the eyelid (*ptosis*). A flat, *smooth muscle*, innervated by the sympathetic nervous system, arises from the deep surface of the levator and inserts into the tarsal plate. If the sympathetic supply is damaged, a slight ptosis results (*Horner's syndrome*).

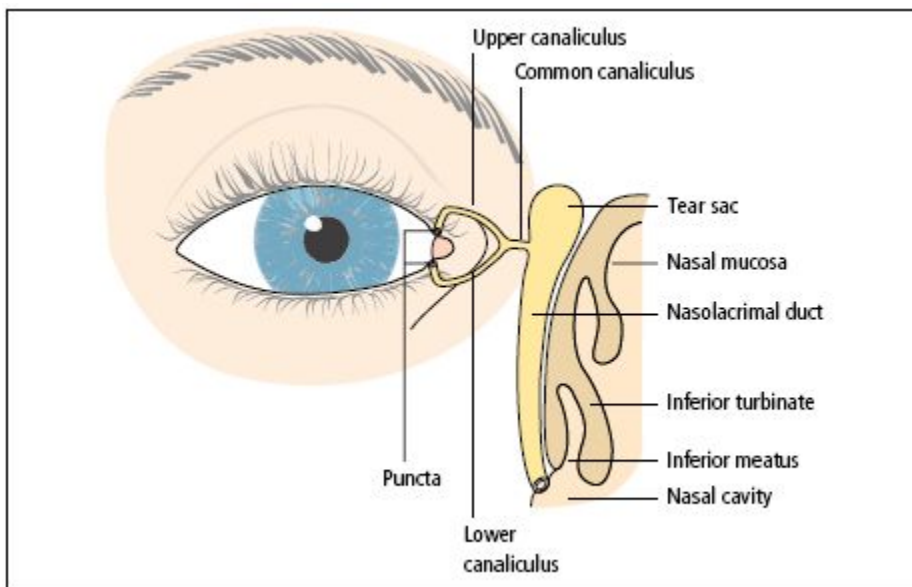
The meibomian oil glands deliver their oil to the skin of the lid margin, just anterior to the *mucocutaneous junction*. This oil spreads onto the anterior surface of the tear film with each blink, to form a lipid layer which retards evaporation. Far medially on the lid margins, two puncta form the initial part of the lacrimal drainage system.

## The lacrimal drainage system

Tears drain into the upper and lower *puncta* and then into the *lacrimal sac* via the upper and lower *canaliculi* ([Figure 1.4](#)). They form a common canaliculus before entering the lacrimal sac. The *nasolacrimal duct* passes from the sac to

the nose. Failure of the distal part of the nasolacrimal duct to fully canalize at birth is the usual cause of a watering, sticky eye in an infant. Tear drainage is an active process. Each blink helps to pump tears through the system.

**Figure 1.4** The major components of the lacrimal drainage system.



## Detailed functional anatomy

### The tear film

The ocular surface is bathed constantly by the tears, secreted mainly by the lacrimal gland but supplemented by conjunctival secretions. They drain away via the nasolacrimal system.

The epithelial cells of the ocular surface express a *mucin glyocalyx* which renders the surface wettable. When the eyes are open, the exposed ocular surface (the cornea and exposed wedges of bulbar conjunctiva) are covered by a tear film, 3  $\mu\text{m}$  thick. This comprises three layers:

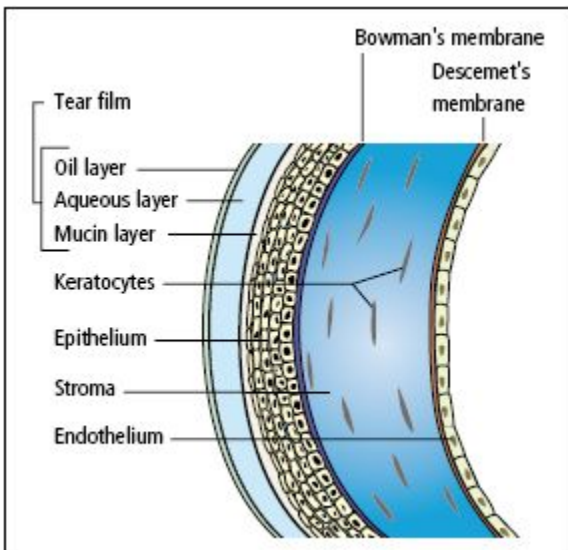
- 1 a *mucin gel layer* produced by the conjunctival goblet cells, in contact with the ocular surface;
- 2 an *aqueous layer* produced by the lacrimal gland;
- 3 a surface *oil layer* produced by the meibomian glands and delivered to the lid margins.

## ***Functions of the tear film***

- It provides a smooth air/tear interface for distortion-free refraction of light at the cornea.
- It transmits oxygen to the avascular cornea.
- It removes debris and foreign particles from the ocular surface through the flow of tears.
- It has antibacterial properties through the action of lysozyme, lactoferrin, defensins and the immunoglobulins, particularly secretory IgA.

The tear film is replenished with each blink.

**Figure 1.5** The structure of the cornea and precorneal tear film (schematic, not to scale – the stroma accounts for 95% of the corneal thickness).



## **The cornea**

The cornea ([Figure 1.5](#)) is 0.5 mm thick and comprises:

- The *epithelium*, an anterior non-keratinized squamous layer, thickened peripherally at the *limbus* where it is continuous with the conjunctiva. The limbus houses the germinative *stem cells* of the corneal epithelium.
- An underlying *stroma* of collagen fibrils, ground substance and fibroblasts. The regular packing, small diameter and narrow separation of the collagen fibrils account for corneal transparency. This orderly architecture is maintained by regulating stromal hydration.
- The *endothelium*, a monolayer of non-regenerating cells which actively pump ions and water from the stroma, controlling corneal hydration and hence transparency.

The difference between the regenerative capacity of the epithelium and endothelium is important. Damage to the epithelial layer, by an abrasion for example, is rapidly repaired by cell spreading and proliferation. Endothelial damage, by disease or surgery, is repaired by cell spreading alone, with a loss of cell density. A point is reached when loss of its barrier and pumping functions leads to over-hydration (oedema), disruption of the regular packing of its stromal collagen and corneal clouding.<sup>7</sup>

The nutrition of the cornea is supplied almost entirely by the aqueous humour, which circulates through the anterior chamber and bathes the posterior surface of the cornea. The aqueous also supplies oxygen to the posterior stroma, while the anterior stroma receives its oxygen from the ambient air. The oxygen supply to the anterior cornea is reduced but still sufficient during lid closure, but a too-tightly fitting contact lens may deprive the anterior cornea of oxygen and cause corneal, especially epithelial, oedema.

## ***Functions of the cornea***

- It protects the internal ocular structures.

- Together with the lens, it refracts and focuses light onto the retina. The junction between the ambient air and the curved surface of the cornea, covered by its optically smooth tear film, forms a powerful refractive interface.

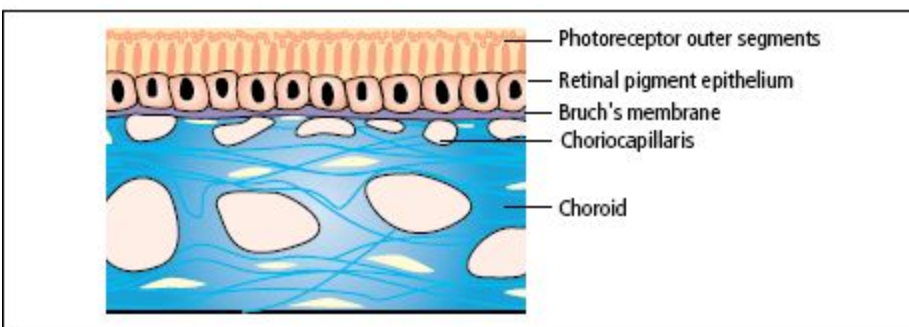
## The sclera

- The sclera is formed from interwoven collagen fibrils of different widths lying within a ground substance and maintained by fibroblasts.
- It is of variable thickness, 1 mm around the optic nerve head and 0.3 mm just posterior to the muscle insertions.

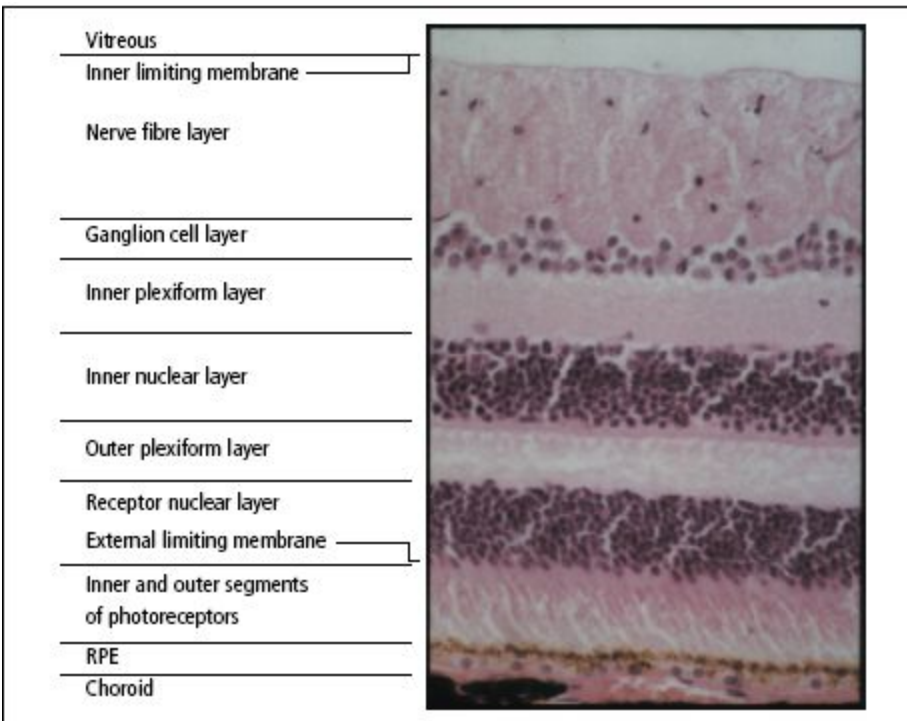
## The choroid

- The choroid ([Figure 1.6](#)) is formed of arterioles, venules and a dense, fenestrated capillary network.
- It is loosely attached to the sclera.
- It has a remarkably high blood flow.
- It nourishes the deep, outer layers of the retina and may have a role in its temperature homeostasis.
- Its basement membrane, together with that of the retinal pigment epithelium (RPE), forms the acellular Bruch's membrane, which acts as a diffusion barrier between the choroid and the retina.

**Figure 1.6** The relationship between the choroid, RPE and retina.



**Figure 1.7** The structure of the retina.



## The retina

The retina ([Figure 1.7](#)) is a highly complex structure derived embryologically from the primitive optic cup. Its outermost layer is the retinal pigment epithelium (RPE) while its innermost layer forms the neuroretina, consisting of the photoreceptors (*rods* and *cones*), the bipolar nerve layer (and horizontal nerve cells) and the *ganglion cell* layer, whose axons give rise to the innermost, nerve fibre layer. These nerve fibres converge to the optic nerve head, where they form the *optic nerve*.

### ***The retinal pigment epithelium (RPE):***

- is formed from a single layer of cells;
- is loosely attached to the neuroretina except at the periphery (*ora serrata*) and around the optic disc;
- forms microvilli which project between and embrace the outer segment discs of the rods and cones;