1

Ocular Anatomy

The Globe

The eye is a very elegant organ, and a wonderful example of the intimate relationship of structure to function. Each part of the eye is designed to achieve or contribute to the special sense of sight. The globe is composed of three basic layers or coats. The outer coat is the fibrous tunic composed of the cornea, the sclera, and the juncture of the two called the limbus. The fibrous tunic gives the eye a constant shape and form which is imperative for a functional visual system. In addition, the anterior portion of the fibrous tunic, the cornea, is transparent, enabling light to pass through, and shaped in a manner that makes it a powerful lens which refracts light rays centrally towards the visual axis of the eye.

The middle layer, or vascular tunic, is the uvea which consists of the iris, the ciliary body, and the choroid. The most anterior portion of the vascular tunic, the iris, extends from the ciliary body centrally just anterior to the surface of the lens. The iris is heavily pigmented and contains muscles which change the shape and size of the iris and the pupillary aperture to control the amount of light that enters the posterior segment to stimulate the retina. The ciliary body is involved in both the production and outflow of aqueous humor, a fluid which flows through the anterior segment. Aqueous humor is secreted from ciliary body processes, which are heavily pigmented central extensions of the ciliary body. Aqueous humor leaves the eye through the iridocorneal angle, a portion of which (the uveal meshwork sinus) is of ciliary body origin. The ciliary body and its processes provide a base on which lenticular zonules are attached. These zonules are fine fibrous bands which attach to the outer portions of the lens and hold it in place. Contractions of ciliary body muscle alter the tension of these zonules and are able to change the shape or position of the lens. This process, called accommodation, alters the degree to which light is refracted. Thus, the lens acts as a fine focusing mechanism, while the cornea serves as the most powerful fixed "lens" of the visual system. The choroid, located in the posterior half of the eye, is found between the outer sclera and the retina. It functions to provide nourishment to the highly metabolic retina and to modify internal light reflection and scatter, as it is either heavily pigmented or reflective. In some species, a special reflective structure, called the tapetum, is located within the choroid and acts to improve photoreceptor stimulation in dim illumination.

The third layer of the eye is the nervous coat which is made up of the retina and associated optic nerve. Briefly, the retina contains light sensitive cells (photoreceptors) which, after a series of intermediate modifying processes, transmit impulses to the brain via the optic nerve.

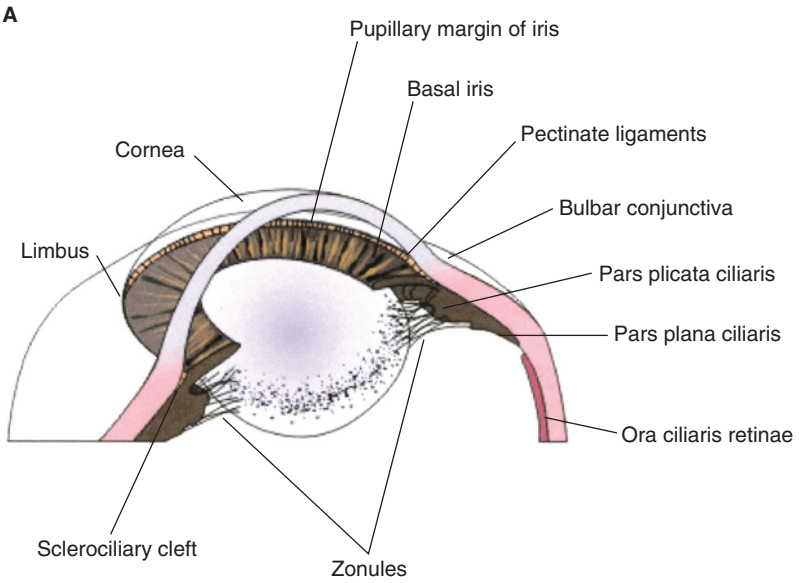
In addition to the three tunics, additional ocular components fill the interior of the globe: (i) the intraocular fluids (aqueous humor and vitreous humor) and (ii) the crystalline lens.

Aqueous humor is continuously produced by ciliary body processes at a slow rate and fills the anterior and posterior chambers of the eye (between the cornea anteriorly and the lens posteriorly), then drains out of the eye into the bloodstream through the iridocorneal angle to regulate the intraocular pressure of the normal eye. Aqueous humor provides vital nutrients to the avascular lens and cornea and also assists in removing metabolic waste products.

Vitreous humor, a gelatinous fluid, occupies the large chamber in the back of the eye. The vitreous humor helps support and distend the globe and also provides an optically clear medium through which light can pass essentially unaltered.

The crystalline lens is a transparent, avascular, nonpigmented, flattened spheroidal structure lying behind the iris held in place by lenticular zonules. The lens is responsible for focusing light that has entered the eye onto the retina (Figure 1.1).

Color Atlas of Veterinary Ophthalmology, Second Edition. Kirk N. Gelatt and Caryn E. Plummer.



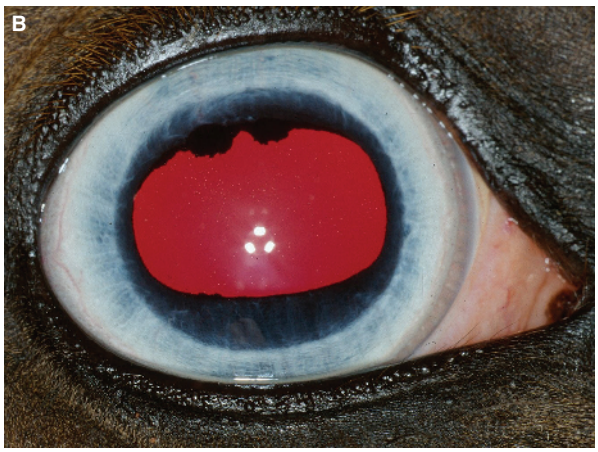
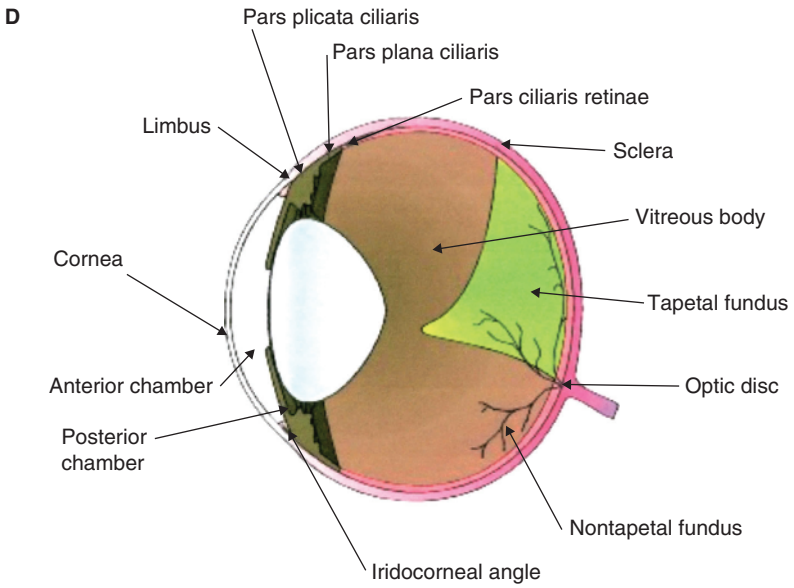
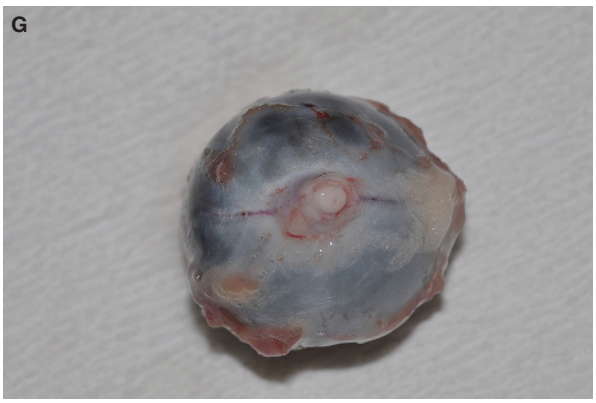


Figure 1.1 (A) The anterior eye showing the cornea, limbus, iris, ciliary body (pars plicata and pars plana), and the zonules that suspend the lens from the ciliary processes. The anterior chamber is the space between the interior cornea and the anterior lens and iris which is filled with aqueous humor. The bulbar conjunctiva covers the sclera which is the posterior continuation of the fibrous tunic (the cornea is the anterior portion). The pupil is the aperture in the center of the iris. (B) A normal horse eye. The iris in this animal is blue in color. There is a pigmented extension of the posterior pigmented epithelium of the iris along the dorsal pupil margin which is called the corpora nigrum or granula iridica. (C) A freshly enucleated canine globe from the front. (D) The globe from the side showing the cornea, limbus, anterior chamber, iridocorneal angle, posterior chamber, ciliary body (pars plicata, pars plana, and the ciliaris retinae), vitreal chamber, sclera, and optic nerve. The fundus is divided into tapetal and nontapetal sections. The tapetum is located within the dorsal choroid. The choroid, or the posterior aspect of the vascular tunic, lies interior to the sclera (the anterior extension of the vascular tunic is the ciliary body and the iris) and the retina lies interior to the choroid and adjacent to the vitreous body. (E) A normal horse eye in profile. (F) A freshly enucleated canine globe in profile. The optic nerve is observed extending from the posterior aspect of the globe. (G) Posterior aspect of a freshly enucleated canine globe. Running along the sclera anteriorly at the 3 and 9 o'clock positions are the long posterior ciliary arteries. These are important landmarks for surgical approaches to the eye. The insertions of the extraocular muscles (the muscles themselves have been removed) which move the globe are appreciable. (H) In this prosection, the cornea and a sector of the iris have been removed to reveal the lens equator and the ciliary body behind. (I) In this prosection, the cornea, and the anterior uvea have been removed revealing the lens sitting within the patellar fossa of the vitreous. (J) The lens has been removed from the globe and placed upon a page of type. Note the clarity and the magnification. (K) In this prosection, the anterior segment and lens have been removed, revealing the retina (artifactually detached in areas), the retinal vasculature, the tapetum in the dorsal choroid, the pigmented nontapetal fundus, and the optic disc. (L) Prosection of the posterior globe. In this example, the globe has been cut in order to flatten it. Source: (A, D) Gelatt KN and Gelatt JP 2011. Reproduced with permission of Elsevier.





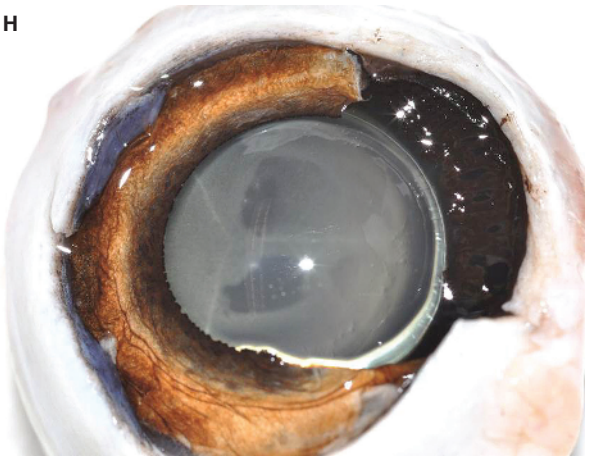
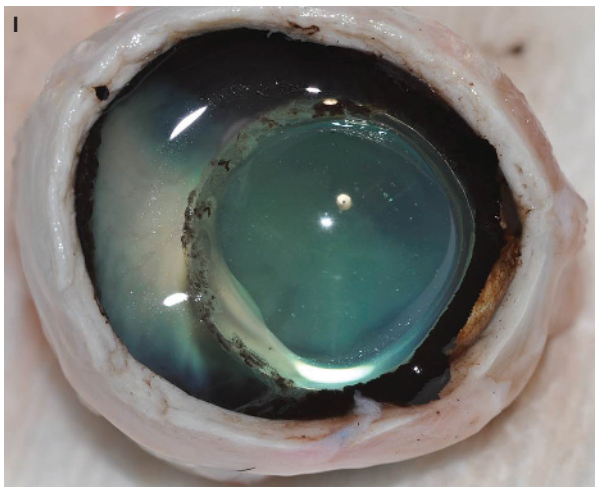


Figure 1.1 (*Continued*)



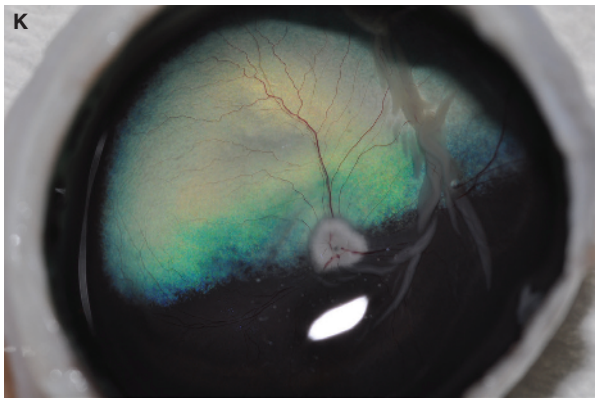


Figure 1.1 (*Continued*)

The Adnexa

The orbit is a bony fossa that separates the eye from the cranial cavity, surrounds and protects it, and provides several pathways through foramina for the various blood vessels and nerves involved in the function of the eye. The orbit in the dog and cat is an incomplete bony orbit composed of five, sometimes six bones, the supraorbital ligament, and the periosteum. The ruminant large animals usually have enclosed orbits. Closure of the temporal side of the orbit is accomplished by the union of the zygomatic bone and the frontal bone. The enclosed orbit is essential for protective purposes.

The eyelids are dorsal and ventral folds of thin skin continuous with the facial skin. The free edges of the dorsal and ventral lids meet to form the lateral and medial canthi. The opening formed by the free edges is the palpebral fissure. The fissure is prevented from assuming a circular shape by medial (nasal) and lateral (temporal) palpebral ligaments which attach the canthi to the orbital wall. The medial ligament inserts into periosteum of the nasal bones whereas laterally it inserts into temporal fascia. The lateral ligament is absent or rudimentary in the dog and is replaced by the retractory anguli oculi muscle. Closure of the eyelids is achieved by the contraction of the orbicularis oculi muscle located deep in the lids around the palpebral fissure. Opening or parting of the lids is by relaxation of the orbicularis oculi and contraction of the levator palpebrae superioris which inserts on the orbicularis oculi muscle.

The free margin of the eyelid can contain a row of cilia or lashes. These lashes are directed away from the anterior surface of the cornea. The inner surface of the lids is lined with a mucous membrane, the (palpebral) conjunctiva. The conjunctiva is reflected onto the globe (bulbar conjunctiva). The junction between the palpebral and

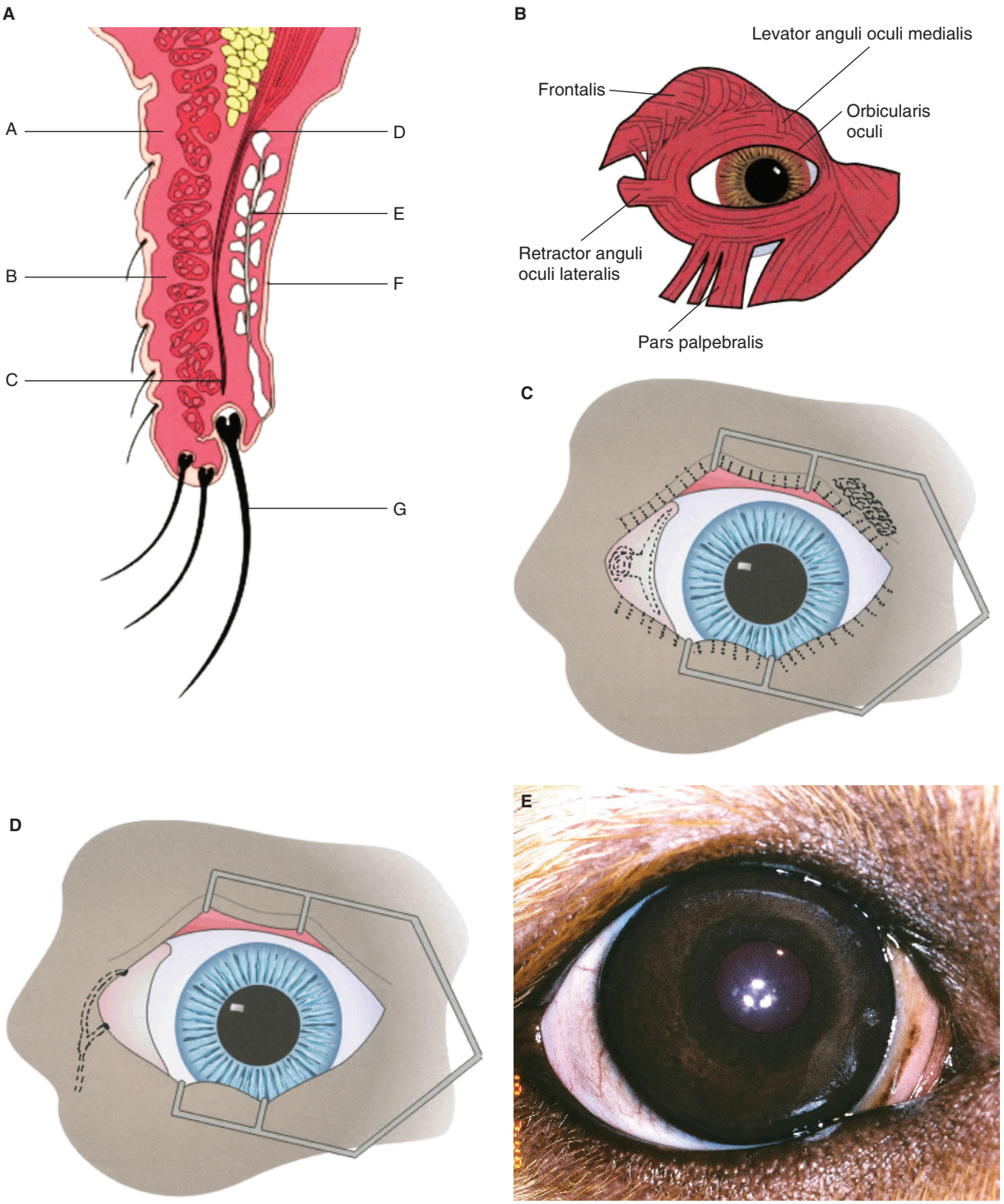


Figure 1.2 (A) The eyelids. A. Haired skin. B. Orbicularis oculi (eyelid musculature responsible for closure of the palpebral fissure). C. Tarsal plate. D. Insertion of the levator palpebrae superioris (responsible for elevation of the upper eyelid). E. Meibomian glands. F. Palpebral conjunctiva. G. Cilia (eyelash). (B) The eyelid musculature showing the muscles of facial expression and eyelid movement. The levator palpebrae superioris and the Müller's muscles, responsible for eyelid opening, are not shown. (C) The location of the lacrimal glands (orbital and gland of the third eyelid) and the meibomian glands lining the upper and lower eyelids along their margins. (D) The location of the lacrimal puncta of the nasolacrimal apparatus in the medial canthus and the subcutaneous pathway into the nasolacrimal duct. (E) A normal dog eye. Note the apposition of the eyelids to the globe, the smooth, regular margins of the lids and the third eyelid, and the normal appearance of the conjunctiva and the nictitans. Source: (A-D) Gelatt KN and Gelatt JP 2011. Reproduced with permission of Elsevier.

bulbar conjunctiva is the fornix. The conjunctiva is the most exposed of all mucous membranes. Its primary functions are preventing dessication of the cornea, increasing mobility of the eyelids and globe, and providing a barrier against microorganisms and foreign bodies. Ventrally, an additional fold is formed by the reflection of the conjunctiva over the nictitans. The nictitans (third eyelid) is a large, semilunar fold of conjunctiva that protrudes from the medial canthus over the anterior surface of the globe (from the dorsomedial orbit in birds). It contains a cartilaginous plate which is T-shaped, the horizontal part of it being parallel with the free edge of the membrane. The nictitans gland surrounds the caudal end of the shaft of the cartilaginous plate with the majority of the gland on the bulbar surface. It produces approximately 30% of the tears. The largest lacrimal gland, which is responsible for producing the majority of the aqueous tears, is located in the dorsal orbit.

Visible through the conjunctiva on the posterior surface of the eyelid margin are the meibomian glands. These form parallel rows of lobules which have their ducts opening close to the lid margins. The glands in the distal eyelid stroma are sebaceous in nature and contribute to the oily component of tear film. Each gland is made of a number of holocrine acini which are arranged in vertical columns and open into a central duct.

The tear film is considered an anatomic structure as well. This fluid covering the partially exposed anterior segment of the globe is necessary for maintaining an optically uniform corneal surface, removing foreign material and debris from the cornea and conjunctival sac, providing oxygen and other nutritional requirements to the cornea, and preventing the development of ocular surface infections. It normally consists of an aqueous component, a lipid component, and a mucous component. Aqueous tear fluid, once it has fulfilled its duties, drains through lacrimal puncta in the upper and/or lower eyelids at the medial canthus into the nasolacrimal sac and duct which subsequently drain into the nasal passages or the oropharynx (Figure 1.2).