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Eye Anatomy and Physiology

Editor's Note: The equine eye is very sensitive, and even the slightest injury can result in blindness. While vision in only one eye does not mean the horse must be euthanized, it does somewhat limit the athletic and working potential of that animal. This article discusses the anatomy and physiology of the eye, complete with drawings and photographs.

Anatomy and Physiology
Orbit--Orbit refers to the bony socket of the skull that contains the eyeball or globe, and the surrounding nerves, blood vessels, fat, connective tissue, and muscle. The equine orbit is a large, conical cavity protected by a complete bony rim. Respiratory sinuses border the horse orbit on the midline (center of the head).

Animals with laterally positioned orbits (one on each side of the head), such as horses, have tremendous peripheral vision but reduced binocular vision and depth perception.

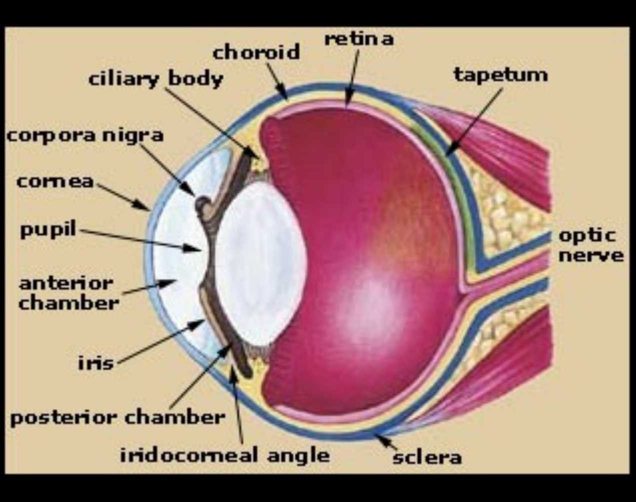

Diagram of the equine eye.

Eyelids--Anatomically, the eyelids are divided into the skin, a fast-acting and powerful muscle (for rapid blinking), and an inner lining of palpebral conjunctiva. The eyelids are thin and contain many blood vessels. Eyelids protect the eye, produce and distribute the tears, aid tear drainage, and help control the amount of light entering the eye. Eyelid swelling can be an early sign of corneal ulceration (more about corneas in a moment). Meibomian glands, which secrete the fatty component of the tear film that lubricates the eye, are found at the eyelid margins. Horses have large eyelashes or cilia on their upper eyelid margin and none on the lower lid. Long sensory hairs or vibrissae provide sensation to the skin surrounding the eyes of horses.

Nictitans--The nictitans or third eyelid (TE) of the horse is located medially (toward the midline of the body; the medial edge of the eye is the one toward the nose) and contains the third eyelid gland that produces tears. It has supportive cartilage and a covering of conjunctiva (the same delicate membrane that lines the eyelids). It displays rapid, almost horizontal movement as it protects the cornea and distributes the tear film (it moves from the inside corner of the eye across the eye). The TE conjunctiva of horses might be darkly pigmented or might be pink.

Conjunctiva--The conjunctiva is important to the immune system of the eye. It covers the inner eyelids, TE, and sclera (more on this later). Components of the immune system that protect the eye and tear-producing cells are present in the conjunctiva, which is pigmented near the limbus (more on this later) in some horses.

Anterior Anatomy
The tear film layer, cornea, iridocorneal angle, iris, lens, and ciliary body comprise the anterior (forward) segment of the eye.

Precorneal tear film--The precorneal tear film is produced by the meibomian glands (outer fat layer), the lacrimal and nictitans glands (watery layer), and the conjunctiva (inner fat layer). The tear film provides an optically smooth surface to the cornea, helps deliver nutrition to the cornea, and contains vitamins, enzymes, and other substances that affect corneal health. Tears enter the tear drainage system at the medial canthus (pocket formed at the inside of the eye), pass through the bony nasolacrimal duct in the skull, and drain in the horse's nose.

Cornea, limbus, and sclera--The cornea is a very prominent, transparent, and physically strong tissue that supplies a large part of the eye's light-bending power. Light rays pass through the cornea to begin the visual process and are focused on the retina.

The horse cornea has four layers. The outermost epithelium is a barrier to microbes and to the tears. The epithelium is attached to the stroma. The stroma constitutes approximately 90% of the corneal thickness and is mostly collagen (a fibrous protein). The next layer is Descemet's membrane, the basement membrane that's secreted by the inner corneal endothelium and produced throughout life. It is only about three red blood cells in thickness! (The significance of this will become apparent in the upcoming article on corneal disease.) The innermost endothelium consists of only one cell layer, but it contains a little pump that drains water out of the cornea so it stays clear. Endothelial disease results in pump failure and corneal swelling.

The cornea is one of the most sensitive tissues in the body. Corneal nerves are concentrated in the superficial (outer) cornea, with no nerves present in the Descemet's membrane. The average thickness of the middle of the cornea is approximately 1.0-1.5 millimeters. The peripheral horse cornea (the edge) is slightly thinner at 0.8 mm.

The limbus is located at the peripheral edge of the cornea and forms the transition zone between the clear cornea and the white sclera. In most horses, there is an obvious gray line at the limbus where ligaments bridging the iris and cornea are visible.

The sclera is connected to the cornea and constitutes the major portion of the outer layer of the eyeball.

Anterior chamber--The anterior chamber (AC) is the large aqueous humor-filled chamber located between the cornea and iris. Aqueous humor is a clear fluid derived from blood that aids corneal health.

Iridocorneal angle--The drainage of aqueous humor from the eye to the blood occurs at the junction or angle formed by the cornea, iris, and ciliary body.

Iris--The iris is the front of the uveal tract, and it has lots of blood vessels. Iris muscles located near the pupil (more on the pupil next) cause pupillary contraction or miosis. Dilator muscles in the mid-iris cause the pupil to enlarge.

In general, the iris color of the horse is brown, varying from dark brown to golden brown to yellow. Blue or white iris color might be seen in some horses. Horses have cystic granula iridica or corpora nigra that appear to hang from the top of the pupillary rim; they are believed to shield the retina from overhead sunlight.

Pupil--The pupil (hole in the iris) changes in size depending upon environmental light intensity--it constricts in bright light and dilates in dim light to control the amount of light entering the lens. It is round in foals and horizontally oval in adults.

Ciliary body--The middle portion of the uveal tract is the ciliary body, which produces aqueous humor.

Choroid--The choroid is the rear portion of the uveal tissue. It lies between the retina and the sclera and contains many capillaries and larger blood vessels. The choroid is the primary blood supply to the equine retina. The triangular tapetum is also found in the dorsal (top) choroid of the horse; it's function is to amplify light in low light conditions.

Uvea--Composed of the iris, ciliary body, and the choroid, the vascular uveal tract is involved in the production of aqueous humor, the exit of aqueous humor from the eye, nutrition of the eye, and the immune response of the eye to numerous diseases.

Inflammation of the uvea is called uveitis, and this is a serious problem in horses. The uveal tissue of the horse eye is fragile and easily damaged. During uveitis, the iris sphincter muscle contracts to cause profound closing of the pupil. The ciliary body muscles spasm, resulting in severe ocular pain and squinting. The capillaries (small blood vessels) in the uveal tissue become leaky and release proteins and cells during attacks of uveitis.

Focusing Light
The lens is a transparent structure located behind the iris and held in place by ligaments. The horse uses the lens to focus on nearby objects.

Posterior Segment or Fundus
Vitreous chamber--This is the large space between the lens and retina that contains the very thick vitreous.

Retina--The retina is the most complex structure of the eye and is the most metabolically active tissue in the body. It converts light energy into chemical energy to generate the electrical signal that is conducted to the brain in order for the horse to see.

The retina is classically described as a layered structure. Rod photoreceptors dominate in number over cones in the horse. The rods are responsible for the very good night vision of horses, and the cones are responsible for daytime vision and the limited color vision (horses see blue colors best). The retina also contains a high number of very large ganglion cells that conduct the visual impulses quickly, which explains the superb ability of horses to detect movement in their field of vision. The nerve endings of retinal ganglion cells form the optic nerve, which carries visual information from each eye to the brain for processing.

Optic disk--The horse's optic disk (which is also called the optic papilla or optic nerve head) contains ganglion cell nerve fibers and can be seen with the ophthalmoscope.

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