Eye Anatomy and Function in Animals

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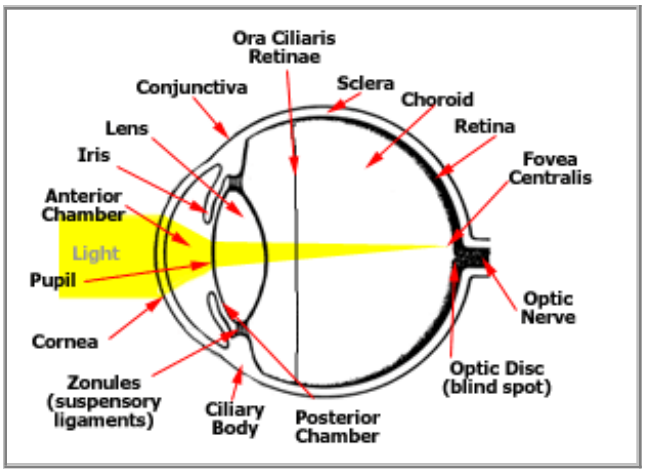
The eye is a complex and delicate organ. It has many functional parts that all work together to make sight possible. Though many of the parts are the same in different species, animals have developed certain adaptations that best suit their needs.

Eye anatomy

The eye has three main layers: the outer fibrous tunic, middle vascular tunic, and inner nervous tunic. The names are clues as to their basic structures and functions, but a closer look at the components of each layer will make understanding the mechanism of sight much easier.

Fibrous tunic: The fibrous tunic is the outermost layer of the eye. An opaque (not transparent) network of collagen (fibrous protein) and elastic fibers, called the "sclera," covers the posterior (back) three fourths of the eye. The sclera is tough and somewhat stretchy, like a thick balloon filled with the gelatinous contents of the eye. The rest of the fibrous tunic, the anterior (front) quarter of the eye, is a clear structure called the "cornea." It is made up of extremely thin layers of cells arranged in a unique fashion so the cornea is transparent. A normal cornea allows light to enter the eye.

Vascular tunic: The vascular tunic, as the name implies, is a network of blood vessels that supply oxygen and nutrients to the tissues of the eye. The actual area where this network is located is beneath the portion covered by the sclera and is called the "choroid." Anterior to the choroid is a circular structure called the "ciliary body." The ciliary body has muscles that act on suspensory ligaments called "zonules," which suspend the lens in the correct position. The ligaments are either taut or relaxed based on the action of the ciliary muscles. The tension on the ligaments changes the shape of the lens, depending on the distance of the object being viewed. This process is called "accommodation" and will be discussed in more detail in the following section. The iris is the colored portion of the eye. At its position in front of the ciliary body, it is the most anterior portion of the vascular tunic, and it divides the front portion of the eye into two chambers – the anterior and posterior chambers. The opening in the middle of the iris is called the "pupil," which appears as the dark center of the eye. The iris either dilates or constricts the pupil to regulate the amount of light entering the eye. In bright light the pupil will be small, but in dim light the pupil will be very large to let in as much light as possible.



Nervous tunic: The nervous tunic is a layer of photoreceptor cells called the "retina." These cells are able to change light into electrochemical signals, which are transmitted to the nervous system. There is a roughly circular opening where the optic nerve and blood vessels exit, called the "optic disc." Often the optic disc is called the "blind spot," because there are no photoreceptor cells there, so no images can actually be perceived at that position. There are two types of photoreceptor cells which perform different functions and are named for the shape of the cell. These are the rods and cones. The rods are very light sensitive, so they are most abundant in nocturnal species. The cones need bright light, and they are for sharp image formation and perception of color. Domestic mammals have mostly rods, and are unable to distinguish colors well. Some reptiles and most birds can see color, though, since they have many cones. There is a centrally located indentation at the back of the retina. It is called the "fovea centralis," and it is much more pronounced in larger animals. Surrounding the fovea is a slightly raised ring of cells called the "macula lutea." Because most of the light is focused on this region, the concentration of photoreceptor cells is increased greatly. The anterior edge of the retina is non-visual and does not contain any photoreceptors, as light does not come into contact with that surface. A line called the "ora serrata" demarcates the division between the visual and non-visual retina. This name was given because the line appears jagged, or serrated, in humans. In domestic animals, however, the division is not serrated, and it is sometimes referred to as the "ora ciliaris retinae." Most often the term "ora serrata" is still used to describe the structure in animals as well as humans.

The mechanism of sight

The component of the eye most responsible for clear vision is the lens. The lens is not really a part of one of the layers of the eye, but it is most closely associated with the components of the vascular tunic. The suspensory ligaments of the ciliary body suspend it in a position just posterior to the iris. It is a soft, transparent, spherical structure and its convex shape brings images into critical focus on the retina. When the ciliary muscles are relaxed, the ligaments are taut, and the lens is elongated. This allows the animal to see things far away. The contraction of the ciliary muscles loosens the ligaments, thus making the lens more round, and the animal can focus on things that are close up. The process of changing the shape of the lens to see things as they become closer is called "accommodation." If the lens were not able to accommodate, the animal would only be able to see things that were at a certain distance away. Accommodation is, therefore, a very important and useful function of the lens. Human eyes have a high degree of accommodation, cats and dogs much less, and cattle have hardly any. The lens also divides

the eye into two different compartments. The area behind the lens, and is filled with a gelatinous fluid called "vitreous humor." The anterior portion, which is subsequently divided into the anterior and posterior chambers, is the entire space in front of the lens. It is filled with a watery fluid called the "aqueous humor." These mediums help focus the light on the back of the retina, but more importantly, they circulate nutrients and remove wastes from tissues not in direct contact with blood vessels. The pressure of the vitreous humor is also what maintains the shape of the eyeball.

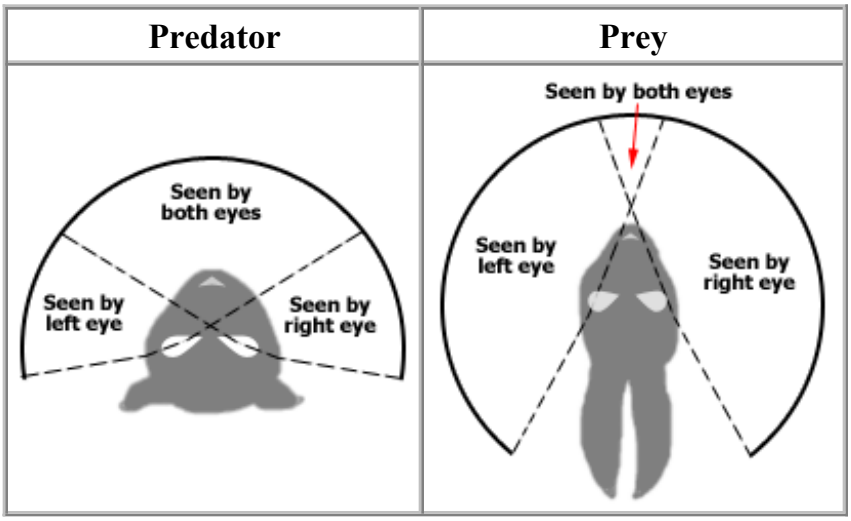
When light enters the eye, it first passes through the transparent cornea. Its spherical shape focuses the light through the pupil to the lens. The lens and vitreous then focus the light to converge and cross at a point on the retina. This crossing causes the image produced on the retina to be an inverted (upside down) version of the image actually being viewed. The signal is sent through the optic nerve to the visual cortex of the brain where the image is then flipped again and perceived in the upright position. If either the cornea or the lens are misshapen or damaged, the image will be focused in front of or behind the retina, and vision will be blurred.

All animals have binocular vision, meaning that they see with two eyes, but the brain combines the signals from both eyes into one image. Binocular vision helps make up for the "blind spot" caused by the optic disc. The overlap of the visual fields fills in the gaps. The other benefit of binocular vision is depth perception. If only one eye is functional, it is difficult to judge distances between objects, and therefore is very hard to hunt moving prey or do most other activities.

Adaptations

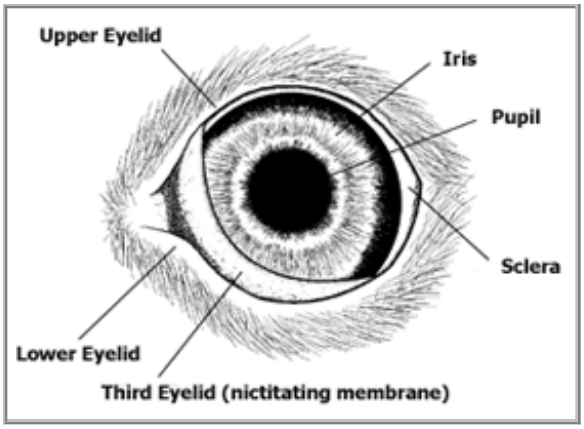
Because sight is such a vital sense when hunting or being hunted, animals' eyes have adapted to best suit their situations. For example, nocturnal animals will have highly dilated pupils to let in the most light, and they will also have larger corneas, proportionally.

Predators and prey have differences in their visual fields. Predators have large, forward-facing eyes that allow them to see best in the downward and forward direction. As they are often looking down and forward on their intended prey, this visual field is best suited for their hunting lifestyle. Prey, on the other hand, generally have eyes situated more to the sides and top of the head. This position allows them excellent peripheral and upward vision. Because prey animals are often attacked from above, behind, or the side, it is advantageous for them to have this wide visual field, even if they cannot see well in front of their faces.



Accessory structures

The eye has many accessory structures present to ensure that it is protected and clean. These structures include the eyelids, eyelashes, lacrimal (tear) glands, and nictitating membrane. Most animals have three eyelids: the upper lid, lower lid, and nictitating membrane (third eyelid). The three eyelids and the surrounding conjunctiva lubricate, nourish, and protect the eyeball. The conjunctiva is the delicate membrane that lines the inside of the upper and lower lids and some outer portions of the eyeball. The nictitating membrane affords the eye extra protection. Large eyelashes are attached to the upper eyelids in most animals and help to keep dust particles from getting in the eye. The eyelids serve much the same purpose, but they also have a blinking reflex to help spread tears and other lubricating oils over the cornea, plus cleanse it of dust and microscopic debris. Tears are produced by the lacrimal glands, and also contain lysozyme, an antibacterial enzyme. Tears exit the eye and its



related structures through a small duct or opening at the inside corner of the eye, called the lacrimal or tear duct.
Interesting facts

- Humans, primates, insects, fish, some reptiles, and most birds can see color well.
- The eyes of albino animals appear pink or red because light reflects off the blood vessels in the back of the eye.
- An animal may have irises of two different colors. This condition is called heterochromia.
- A cataract is a condition in which the components of the lens break down and it becomes cloudy.
- Most animals have a reflective layer in the choroid called the "tapetum lucidum." This is what causes their eyes to shine in the dark.