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**QUESTION 1**

Write briefly on the histological importance of the eye in relation to their cellular function.

**Answers**

The structure of the [mammalian](https://en.wikipedia.org/wiki/Mammal) eye has a [laminar organization](https://en.wikipedia.org/wiki/Laminar_organization) that can be divided into three main layers or *tunics* whose names reflect their basic functions: the [fibrous tunic](https://en.wikipedia.org/wiki/Fibrous_tunic), the [vascular tunic](https://en.wikipedia.org/wiki/Vascular_tunic), and the [nervous tunic](https://en.wikipedia.org/wiki/Nervous_tunic).

* The fibrous tunic, is also known as the *tunica fibrosa oculi*, is the outer layer of the eyeball consisting of the [cornea](https://en.wikipedia.org/wiki/Cornea) and [sclera](https://en.wikipedia.org/wiki/Sclera). The sclera gives the eye most of its white color. It consists of dense [connective tissue](https://en.wikipedia.org/wiki/Connective_tissue) filled with the protein [collagen](https://en.wikipedia.org/wiki/Collagen) to both protect the inner components of the eye and maintain its shape.
* The vascular tunic, also known as the *tunica vasculosa oculi* or the "uvea", is the middle vascularized layer which includes the [iris](https://en.wikipedia.org/wiki/Iris_(anatomy)), [ciliary body](https://en.wikipedia.org/wiki/Ciliary_body" \o "Ciliary body), and [choroid](https://en.wikipedia.org/wiki/Choroid). The choroid contains [blood vessels](https://en.wikipedia.org/wiki/Blood_vessel) that supply the retinal cells with necessary [oxygen](https://en.wikipedia.org/wiki/Oxygen) and remove the waste products of [respiration](https://en.wikipedia.org/wiki/Cellular_respiration). The choroid gives the inner eye a dark color, which prevents disruptive reflections within the eye. The iris is seen rather than the cornea when looking straight in one's eye due to the latter's transparency, the [pupil](https://en.wikipedia.org/wiki/Pupil) (central aperture of iris) is black because there is no light reflected out of the interior eye. If an ophthalmoscope is used, one can see the [fundus](https://en.wikipedia.org/wiki/Fundus_(eye)" \o "Fundus (eye)), as well as vessels (which supply additional blood flow to the retina) especially those crossing the optic disk—the point where the optic nerve fibers depart from the eyeball—among others
* The nervous tunic, also known as the *tunica nervosa oculi*, is the inner sensory layer which includes the [retina](https://en.wikipedia.org/wiki/Retina).
  + Contributing to vision, the retina contains the photosensitive [rod](https://en.wikipedia.org/wiki/Rod_cell) and [cone cells](https://en.wikipedia.org/wiki/Cone_cell) and associated neurons. To maximise vision and light absorption, the retina is a relatively smooth (but curved) layer. It has two points at which it is different; the [fovea](https://en.wikipedia.org/wiki/Fovea_centralis) and [optic disc](https://en.wikipedia.org/wiki/Optic_disc). The fovea is a dip in the retina directly opposite the lens, which is densely packed with cone cells. It is largely responsible for [color vision](https://en.wikipedia.org/wiki/Color_vision) in humans, and enables high acuity, such as is necessary in [reading](https://en.wikipedia.org/wiki/Reading_(activity)). The optic disc, sometimes referred to as the anatomical [blind spot](https://en.wikipedia.org/wiki/Blind_spot_(vision)), is a point on the [retina](https://en.wikipedia.org/wiki/Retina) where the [optic nerve](https://en.wikipedia.org/wiki/Optic_nerve) pierces the retina to connect to the nerve cells on its inside. No photosensitive cells exist at this point, it is thus "[blind](https://en.wikipedia.org/wiki/Blindness)". Continuous with the retina are the ciliary epithelium and the posterior epithelium of the iris.
  + In addition to the rods and cones, a small proportion (about 1-2% in humans) of the ganglion cells in the retina are themselves photosensitive through the pigment [melanopsin](https://en.wikipedia.org/wiki/Melanopsin" \o "Melanopsin).

**Histology Of The Cornea**

The cornea is the clear front surface of the eye. It lies directly in front of the iris and pupil, and it allows light to enter the eye. Viewed from the front of the eye, the cornea appears slightly wider than it is tall. This is because the [sclera (the "white" of the eye)](https://allaboutvision.com/resources/sclera.htm) slightly overlaps the top and bottom of the anterior cornea. The horizontal diameter of the cornea typically measures about 12 millimeters (mm), and the vertical diameter is 11 mm, when viewed from the front. But if viewed from behind, the cornea appears circular, with a uniform diameter of approximately 11.7 mm. This makes the cornea about two-thirds the size of a dime. The center thickness of the average cornea is about 550 microns, or slightly more than half a millimeter.

The cornea has five layers. From front to back, these layers are:

1. **The corneal epithelium.** This outer layer of the cornea is five to seven cells thick and measures about 50 microns — making it slightly less than 10 percent of the thickness of the entire cornea. Epithelial cells are constantly being produced and sloughed off in the tear layer of the surface of the eye. The turnover time for the entire corneal epithelium is about one week.
2. **Bowman's layer.**This is a very thin (8 to 14 microns) and dense fibrous sheet of connective tissue that forms the transition between the corneal epithelium and the underlying stroma.
3. **The corneal stroma.** This middle layer of the cornea is approximately 500 microns thick, or about 90 percent of the thickness of the overall cornea. It is composed of strands of connective tissue called collagen fibrils. These fibrils are uniform in size and are arranged parallel to the cornea surface in 200 to 300 flat bundles called lamellae that extend across the entire cornea. The regular arrangement and uniform spacing of these lamellae is what enables the cornea to be perfectly clear.
4. **Descemet's membrane.** This very thin layer separates the stroma from the underlying endothelial layer of the cornea. Descemet's (pronounced "DESS-eh-mays") membrane gradually thickens throughout life — it's about 5 microns thick in children and 15 microns thick in older adults.
5. **The corneal endothelium.**This is the innermost layer of the cornea. The back of the endothelium is bathed in the clear aqueous humor that fills the space between the cornea and the [iris](https://www.allaboutvision.com/resources/uvea-iris-choroid.htm) and pupil. The corneal endothelium is only a single layer of cells thick and measures about 5 microns. Most of the endothelial cells are hexagonal (six-sided), but some may have five or seven sides. The regular arrangement of these cells is sometimes called the endothelial mosaic.

**Cornea Function**

As already mentioned, the clear cornea allows light to enter the eye for vision. But it has another very important function as well — the cornea provides approximately 65 to 75 percent of the focusing power of the eye.

The remainder of the focusing power of the eye is provided by the crystalline lens, located directly behind the pupil.

Most [refractive errors](https://allaboutvision.com/eye-exam/refraction.htm) — [nearsightedness](https://allaboutvision.com/conditions/myopia.htm), [farsightedness](https://allaboutvision.com/conditions/hyperopia.htm) and [astigmatism](https://allaboutvision.com/conditions/astigmatism.htm) — are due to a less-than-optimal curvature or symmetry of the cornea. [Presbyopia](https://allaboutvision.com/conditions/presbyopia.htm" \o "), on the other hand, is due to an aging change in the crystalline lens.

In addition to allowing light to enter the eye and providing most of the focusing power of the eye, individual parts of the cornea have specialized functions:

**Corneal epithelium.** The corneal epithelium provides an optimal surface for the tear film to spread across the surface of the eye to keep it moist and healthy and to maintain clear, stable vision.

**Bowman's layer.** The dense nature of Bowman's layer helps prevent corneal scratches from penetrating into the corneal stroma. [Corneal abrasions](https://allaboutvision.com/conditions/corneal-abrasion.htm) that are limited to the outer epithelial layer generally heal without scarring; but scratches that penetrate Bowman's layer and the corneal stroma typically leave permanent scars that can affect vision.

**Corneal endothelium.** The single layer of cells that forms the endothelium maintains the fluid content within the cornea. Damage to the corneal endothelium can cause swelling (edema) that can affect vision and corneal health.

**Histology Of The Sclera**

The sclera forms the posterior five-sixths of the [connective tissue](https://en.wikipedia.org/wiki/Connective_tissue) coat of the [globe](https://en.wikipedia.org/wiki/Globe_(human_eye)). It is continuous with the [dura mater](https://en.wikipedia.org/wiki/Dura_mater" \o "Dura mater) and the [cornea](https://en.wikipedia.org/wiki/Cornea), and maintains the shape of the globe, offering resistance to internal and external forces, and provides an attachment for the [extraocular muscle](https://en.wikipedia.org/wiki/Extraocular_muscle" \o "Extraocular muscle) insertions. The sclera is perforated by many nerves and vessels passing through the posterior scleral foramen, the hole that is formed by the [optic nerve](https://en.wikipedia.org/wiki/Optic_nerve). At the [optic disc](https://en.wikipedia.org/wiki/Optic_disc) the outer two-thirds of the sclera continues with the dura mater (outer coat of the brain) via the dural sheath of the optic nerve. The inner third joins with some [choroidal](https://en.wikipedia.org/wiki/Choroid" \o "Choroid) tissue to form a plate ([lamina cribrosa](https://en.wikipedia.org/wiki/Lamina_cribrosa_sclerae)) across the optic nerve with perforations through which the optic fibers ([fasciculi](https://en.wikipedia.org/wiki/Nerve_fascicle" \o "Nerve fascicle)) pass. The thickness of the sclera varies from 1mm at the posterior pole to 0.3 mm just behind the rectus muscle insertions. The sclera's blood vessels are mainly on the surface. Along with the vessels of the [conjunctiva](https://en.wikipedia.org/wiki/Conjunctiva) (which is a thin layer covering the sclera), those in the [episclera](https://en.wikipedia.org/wiki/Episclera" \o "Episclera) render the inflamed eye bright red.[[4]](https://en.wikipedia.org/wiki/Sclera#cite_note-eb-5)

The eyes of all non-human [primates](https://en.wikipedia.org/wiki/Primate) are dark with small, barely visible sclera.

### Histology

The [collagen](https://en.wikipedia.org/wiki/Collagen) of the sclera is continuous with the [cornea](https://en.wikipedia.org/wiki/Cornea). From outer to innermost, the four layers of the sclera are:

* [episclera](https://en.wikipedia.org/wiki/Episclera)
* stroma
* [lamina fusca](https://en.wikipedia.org/wiki/Suprachoroid_lamina)
* [endothelium](https://en.wikipedia.org/wiki/Corneal_endothelium)

The sclera is opaque due to the irregularity of the Type I collagen fibers, as opposed to the near-uniform thickness and parallel arrangement of the corneal collagen.

## Sclera Function

The sclera, along with the intraocular pressure (IOP) of the eye, maintains the shape of the eyeball.

The tough, fibrous nature of the sclera also protects the eye from serious damage — such as laceration or rupture — from external trauma.

The sclera also provides a sturdy attachment for the extraocular muscles that control the movement of the eyes.

**Histology Of the Limbus**

Encircling the cornea is the limbus, a transitional area where the transparent cornea merges with the opaque sclera. Here Bowman’s membrane ends and the surface epithelium becomes more stratified as the conjunctiva that covers the anterior part of the sclera (and lines the eyelids). Epithelial stem cells located at the limbus surface give rise to rapidly dividing progenitor cells that move centripetally into the corneal epithelium. The stroma becomes vascular and less well-organized at the limbus, as the collagen bundles merge with those of the sclera. Also at the limbus Descemet᾿s membrane and its simple endothelium are replaced with a system of irregular endothelium-lined channels called the trabecular meshwork. These penetrate the stroma at the corneoscleral junction and allow slow, continuous drainage of aqueous humor from the anterior chamber. This fluid moves from these channels into the adjacent larger space of the scleral venous sinus, or canal of Schlemm, which encircles the eye. From this sinus aqueous humor drains into small blood vessels (veins) of the sclera.

**Histology Of the Iris**

The posterior surface of the iris is covered by the retina. The inner layer of the retina, i.e. the layer facing the posterior chamber, is called the posterior epithelium of the iris. Both layers of the retina are pigmented, but pigmentation is heavier in the inner layer. In the region of the central opening of the iris, the pupil, the retina extends for a very short distance onto the anterior surface of the iris. The iridial stroma consists of a vascularized loose connective tissue rich in melanocytes in addition to macrophages and fibrocytes, which are all surrounded by a loose meshwork of fine collagen fibers. The anterior surface of the iris is not covered by an epithelium - instead of we find a condensation of fibrocytes and melanocytes, the anterior border layer of the iris.

The iris forms the aperture of the eye. Myoepithelial cells in the outer (or anterior) layer of the retina, i.e. the layer adjacent to the stroma of the iris, have radially oriented muscular extensions. These extensions form a flat sheet immediately beneath the anterior layer of the retina, the dilator pupillae muscle. Embedded in the central portion of the iridial stroma are smooth muscle cells which form the annular sphincter pupillae muscle. In humans, this muscle surrounds the pupil as a less than 1 mm wide and only 0.2 mm thick band. The two muscles regulate the size of the pupil.

**Histology Of The Choroid**

The choroid consists of loose connective tissue, which houses a dense network of blood vessels. Connective tissue cells and melanocytes are numerous. The latter give the choroid its dark colour. Small blood vessels are especially frequent in the innermost part of the choroid, which is called the choriocapillary layer. This layer supplies the retina with nutrients. Bruch's membrane is located between the choroid and the retina. It consists of two layers of collagen fibres and a network of elastic fibres between them.

**Histology Of the Ciliary Body**

The ciliary body is an inward extension of the choroidea at the level of the lens. *Ciliary processes* are short extensions of the ciliary body towards the lens. A small amount of loose connective tissue similar to that of the choroid is located between smooth muscle cells which form the bulk of the ciliary body. They form three bundles, the *ciliary muscle*.

The inner surface of the ciliary body and its processes are lined by two layers of columnar cells which belong to the retina - the *ciliary epithelium* formed by the pars ciliaris of the retina. The outer cell layer is pigmented, whereas the inner cell layer, i.e. the layer that faces the posterior chamber of the eye, is nonpigmented.

The *ciliary processes* contain a dense network of capillaries. The cells of the inner layer of the ciliary epithelium generate the *aqueous humor* of the eye. , i.e. they transport the plasma filtrate generated by the capillaries in the ciliary processes into the posterior chamber of the eye. Thight junctions between the cells form the blood - aqueous humor barrier.

Fibers, which consist of fibrillin, extend from the ciliary processes towards the lens and form the *suspensory ligament of the lens*. These fibres are also called *zonule fibres*. Two of the bundles of the ciliary muscles attach to the sclera and strech the ciliary body when they contract, thereby regulating the tension of the zonule fibres. The reduced tension will result in a thickening of the lens which focusses the lens on close objects - a process called *accomodation*.

**Histology Of The Lens**

The lens is a transparent biconvex structure suspended immediately behind the iris, which focuses light on the retina. Derived from an invagination of the embryonic surface ectoderm, the lens is a unique avascular tissue and is highly elastic, a property that normally decreases with age. The lens has three principal components:

■ A thick (10-20 μm), homogeneous lens capsule composed of proteoglycans and type IV collagen surrounds the lens and provides the place of attachment for the fibers of the ciliary zonule. This layer originates as the basement membrane of the embryonic lens vesicle.

■ A subcapsular lens epithelium consists of a single layer of cuboidal cells present only on the anterior surface of the lens. The epithelial cells attach basally to the surrounding lens capsule and their apical surfaces bind to the internal lens fibers. At the posterior edge of this epithelium, near the equator of the lens, the epithelial cells divide to provide new cells that differentiate as lens fibers. This process allows for growth of the lens and continues at a slow, decreasing rate near the equator of the lens throughout adult life.

■ Lens fibers are highly elongated, terminally differentiated cells that appear as thin, flattened structures. Developing from cells in the lens epithelium, lens fibers typically become 7-10-mm long, with cross-section dimensions of only 2 by 8 μm. The cytoplasm becomes filled with a group of proteins called crystallins, and the organelles and nuclei undergo autophagy. Lens fibers are packed tightly together and form a perfectly transparent tissue highly specialized for light refraction. The lens is held in place by fibers of the ciliary zonule, which extend from the lens capsule to the ciliary body. Together with the ciliary muscles, this structure allows the process of visual accommodation, which permits focusing on near and far objects by changing the curvature of the lens. When the eye is at rest or gazing at distant objects, ciliary muscles relax and the resulting shape of the ciliary body puts tension on the zonule fibers, which pulls the lens into a flatter shape. To focus on a close object the ciliary muscles contract, causing forward displacement of the ciliary body, which relieves some of the tension on the zonule and allows the lens to return to a more rounded shape and keep the object in focus. In the fourth decade of life presbyopia (Gr. presbyter, elder + L. opticus, relating to eyes) normally causes the lenses to lose elasticity and their ability to undergo accommodation.

**Histology Of The Vitreous Body**

The vitreous body occupies the large vitreous chamber behind the lens. It consists of transparent, gellike connective tissue that is 99% water (vitreous humor), with collagen fibrils and hyaluronate, contained within an external lamina called the vitreous membrane. The only cells in the vitreous body are a small mesenchymal population near the membrane called hyalocytes, which synthesize the hyaluronate and collagen, and a few macrophages.

**Histology Of the Retina**

Similar to the retinal lining of the iris and ciliary body, the outer layer of the light sensitive retina forms a single layer of cuboidal cells ***- the pigment epithelium***: The outer pigmented layer is a simple cuboidal epithelium attached to Bruch’s membrane and the choroido-capillary lamina of the choroid. This heavily pigmented layer forms the other part of the dual epithelium covering the ciliary body and posterior iris.

■ The pigmented layer absorbs scattered light that passes through the neural layer, supplementing the choroid in this regard.

■ With many tight junctions, cells of the pigmented epithelium form an important part of the protective bloodretina barrier isolating retina photoreceptors from the highly vascular choroid and regulating ion transport between these compartments.

■ The cells play key roles in the visual cycle of retinal regeneration, having enzyme systems that isomerize all-trans-retinal released from photoreceptors and produce 11-cis-retinal that is then transferred back to the photoreceptors.

■ Phagocytosis of shed components from the adjacent photoreceptors and degradation of this material occurs in these epithelial cells.

■ Cells of pigmented epithelium remove free radicals by various protective antioxidant activities and support the neural retina by secretion of ATP, various polypeptide growth factors, and immunomodulatory factors.

The inner layer of the retina- **Neural Layer** contains the photoreceptors, the first neurones which process the sensory information, and the neurones which convey the pre-processed sensory information to the central nervous system. Receptors, neurones, supporting cells and their processes are segregated into nine layers:

1. The ***layer of rods and cones*** contains the outer, rod- or cone-shaped light sensitive segements of the photoreceptive cells. The lights sensitive part and the perikayon of the rods and cones are connected by a narrowed bridge of cytoplasm. At the level of this connection the rods and cones are surrounded by the processes of a specialised type of glial cells, *Müller cells*, which form the
2. ***outer limiting membrane***.
3. The ***outer nuclear layer*** contains the nuclei and perikarya of the rods and cones. Their processes form part of the
4. ***outer plexiform layer***, where they form synapses with the processes of neurones whose cell bodies are located in the
5. ***inner nuclear layer***. The cells of the inner nuclear layer are concerned with the initial processing of the sensory input. The three major neurone types are *horizontal, bipolar* and *amacrine cells*. The inner nuclear layer also houses the perikarya of the Müller cells.
6. The ***inner plexiform layer*** contains the processes of the inner nuclear layer neurones which convey the sensory input to the
7. ***ganglion cell layer***. Ganglion cells are not evenly distributed. There are few of them towards the periphery of the retina. Close to the fovea, ganglion cells form a densely packed layer. Both ganglion cells and the cell bodies located in the inner nuclear layer which contact the rods and cones of the fovea are displaced towards the margins of the fovea.
8. ***Layer of optic nerve fibres***. The axons of the ganglion cells travel in this layer towards the optic disc. Towards the optic disc, the thickness of this layer increases as more and more axons are added to it.
9. ***The inner limiting membrane*** corresponds to a basal lamina formed by the Müller cells.

QUESTION 2

## What is coronavirus?

Coronaviruses are a broad family of viruses that normally affect only animals, although some of them can spread from animals to humans. They can produce anything from a common cold to more serious diseases.The most recent type of coronavirus, called “SARS-CoV-2” was first detected in December 2019 in the Chinese city of Wuhan and causes a disease known as «COVID-19», which can lead to severe respiratory infections, among which pneumonia. **Those affected experience symptoms such as fever, cough or shortness of breath**, which can appear between 2 and 14 days after being exposed to the virus. In addition, according to a paper published in [The Lancet](https://www.thelancet.com/coronavirus), patients can transmit the virus even before experiencing symptoms.

Although it seems that this new coronavirus is not as severe as SARS-CoV (which began in China in November 2002) or as lethal as MERS-CoV (detected in 2012 in Saudi Arabia), it has spread rapidly to other countries and there have already been a significant number of fatalities.

## How can it be transmitted?

According to the American Academy of Ophthalmology, **the virus spreads through small respiratory droplets produced when an infected person coughs or sneezes**, although it could also spread if people touch an object contaminated with the virus and then touch their mouth, nose or eyes. Some reports suggest that **the virus can cause**[**conjunctivitis**](https://icrcat.com/en/eye-conditions/conjunctivitis/) and be transmitted by aerosol contact with the conjunctiva. Therefore, patients who go to the ophthalmologist for conjunctivitis and have respiratory symptoms, in addition to having traveled to areas with known outbreaks, could be suspect of having the virus.

**The layers of the Retina that corona virus penetrates are:**

The pigment epithelium

The rod and cone layer

The outer limiting membrane

The outer nuclear layer

The outer plexiform layer

The inner nuclear layer

The inner plexiform layer

The ganglion cell layer

The nerve fiber layer

The inner limiting membrane

**The pigment epithelium** is the most external layer of the retina. It abuts on the choroidal layer of the eye. It contains a single layer of cuboidal-supporting cells for the neural portion of the retina. These cells contain melanin, which absorbs light and decreases light scatter within the eye.

**The outer limiting membrane (external limiting membrane)** is the layer that separates the inner segment portions of the photoreceptors from their cell nuclei. The rod and cone layer (bacillary layer) contains the inner and outer segments of the rod and cone photoreceptors cells.

**The outer nuclear layer** consists of the cell bodies of the retinal rods and cones. In the peripheral retina, the rod cell bodies outnumber the cone cell bodies, whereas the reverse is true for the central retina.

**The outer plexiform layer** contains the rod and cone axons (projections of rods and cones ending in the rod spherule and cone pedicle), horizontal cell dendrites, and bipolar cells dendrites. Synapses among these structures occur within this layer. In the macular region, this layer is termed the fiber layer of Henle. The outer plexiform layer is also known as the outer synaptic layer.

**The inner plexiform layer** contains the synapses between dendrites of ganglion cells and amacrine cells and the axons of bipolar cells. The inner nuclear layer contains the nuclei of horizontal, bipolar and amacrine cells. The inner nuclear layer is thicker in the central area of the retina compared with peripheral retina because of a greater density of cone-connecting second-order neurons (cone bipolar cells) and smaller and more closely spaced horizontal cells and amacrine cells concerned with the cone pathways. There are also nuclei of the supporting Muller cells.

**The inner limiting membrane** is the boundary between the retina and the vitreous body. It is formed by astrocytes and the footplates of Muller cells together with a basal lamina. The nerve fiber layer is the layer of optic nerve fibers consisting of ganglion cell axon fibers, which course towards the optic nerve head. The ganglion cells layer contains the nuclei of ganglion cells, the axons of which become the optic nerve fibers for messages. There are also some displaced amacrine cells within this layer. Additionally, this layer also contains the non-rod and non-cone photoreceptors, the photosensitive ganglion cells, which are important for reflexive responses to bright daylight.