BMD 415
Eye supplement - clinically relevant structures

Glaucoma: interference with drainage of aqueous humor at the trabecular meshwork will cause a gradual increase in intraocular pressure (IOP) because of the continuous secretion by the ciliary epithelium. The increased IOP will be transmitted to all parts of the globe but will affect the optic papilla in particular because the lamina cribosa provides less structural support due to the optic axons traveling through the sclera at this point. Increased IOP will lead to cupping of the optic disk (papilla) which can be observed with an ophthalmoscope. If the cupping becomes severe the distorted optic axons will cease to function, resulting in blind spots in the patient's visual field. Treatment is carried out with drugs (e.g., beta blockers) which will help relax drainage structures, or by surgically opening the drainage pathways.

Presbyopia: A normal lens is elastic, tending to assume a spherical shape. In distance vision, the shape of the eye causes the zonule fibers of the ciliary body to pull on the equator of the lens, flattening it. In close vision (accommodation) parasympathetic nerves excite the ciliary muscle fibers, which are arranged like a sphincter and so decrease the tension on the zonule fibers, allowing the elastic lens to assume a more spherical shape. This results in a thickening of the lens in the anterior-posterior axis which increases its refractive index which bends light rays more, allowing a focused image to be projected onto the retina. In the fourth decade of life, it is common for the lens to lose its elasticity, possibly by hydration, so that it is incapable of responding when the ciliary muscle contracts. This results in a decreased ability to focus on close objects and can be remedied by convex lenses, or reading glasses.

Retinitis pigmentosa: The rod and cone photoreceptor outer segments are closely associated with the retinal pigment epithelium, which separates the outer segments from their blood supply, the choriocapillaris. This means that the retinal pigment epithelial cells must transport oxygen and nutrients from the choriocapillaris to the photoreceptors. The outer segments contain visual pigment that undergoes a conformational change on exposure to light and begins a chain reaction that changes the ionic permeability of the photoreceptor cell and causes synaptic transmission with the bipolar cells. According to an animal model of retinitis pigmentosa, in rod outer segments, there is a constant turnover with new visual pigment synthesized by the cell body, and old visual pigment shed or sloughed off at the distal tip next to the pigment epithelium. One role of the pigment epithelium is to phagocytize the sloughed visual pigment membrane. If the phagocytosis does not occur, a zone of cellular debris builds up between the outer segments and the pigment epithelium, driving the photoreceptor cells away from their source of oxygen and nutrition. As the process progresses, the photoreceptors slowly starve to death. Rods seem most susceptible, so an initial symptom is loss of night vision, followed by complete blindness.

Detached retina: There are no intercellular junctions between the pigment epithelium and the photoreceptor cells so they can be physically separated. This is what occurs in retinal detachment. Normal IOP will prevent detachment.

Papilledema: The central retinal artery supplies the inner layers of the retina. It reaches its target by traveling through the optic nerve and papilla and emerging at the optic papilla onto the inner surface of the retina and branching into quadrant arteries. Similarly, venous drainage flows toward the optic papilla and coalesces into a central retinal vein that leaves the eye by traveling through the optic papilla. The retina and optic nerve develop embryologically as an outgrowth from the diencephalon and so are parts of the central nervous system. Thus, the optic nerve is covered by all three meningeal layers, including a subarachnoid space. If there is an abnormal increase in cerebral spinal fluid pressure anywhere in the CNS, the increased pressure is transmitted throughout the CSF. At the optic nerve, one consequence is squeezing of the thin walled central retinal vein, obstructing the outflow of blood from the retina. As venous blood accumulates, the vein becomes leaky, resulting in papilledema. This cloudy appearance can be seen with an ophthalmoscope and is an indication of increased CSF pressure.

Convergence: As signals are sent from photoreceptors to retinal ganglion cells they follow pathways that vary in different regions of the retina. At the peripheral retina, which senses peripheral vision, there is convergence of the signal so that hundreds of rod photoreceptors synapse onto one bipolar cell, and many bipolar cells synapse onto one retinal ganglion cell. Thus, the action potential conveyed by a retinal ganglion cell from the peripheral retina might be a summation from thousands of rod photoreceptors. The signal is therefore very sensitive and can be triggered by stimulation of any one of the rod photoreceptors. On the other hand, the signal cannot be localized to a specific photoreceptor.

In the area of the fovea, there is very little convergence, with a single cone photoreceptor synapsing on a single bipolar cell, which synapses onto a single retinal ganglion cell. Consequently, the signal reaching the brain from the retinal ganglion cell can be localized to a tiny region of the visual field, and the composite signal from many ganglion cells presents a detailed image.

Accommodation: The process of focusing on close objects (~<1m) involves three steps. The lens thickens due to decreased tension on zonule fibers because of contraction of the ciliary muscle (parasympathetic innervation). The pupil constricts increasing the depth of focus (recall how hard it is to focus if you have your eyes dilated for an eye exam). Pupillary constriction is due to parasympathetic stimulation of the sphincter muscle of the iris. The medial rectus muscles contract bilaterally, causing both eyes to be directed toward close objects. These muscles are controlled by the oculomotor nerve, CN III.