The axons of the ganglion cells bend to become parallel to the inner surface of the retina, where they form the nerve fiber layer and later the axons of the optic nerve. Each optic nerve has more than 1 million nerve fibers. The nerve fibers from the temporal retina follow an arcuate course around the macula to enter the superior and inferior poles of the optic nerve head. The papillomacular fibers travel straight to the optic nerve from the fovea. The nasal axons also pursue a radial course. The visibility of the nerve fibers is enhanced when they are viewed ophthalmoscopically using green (red-free) illumination.

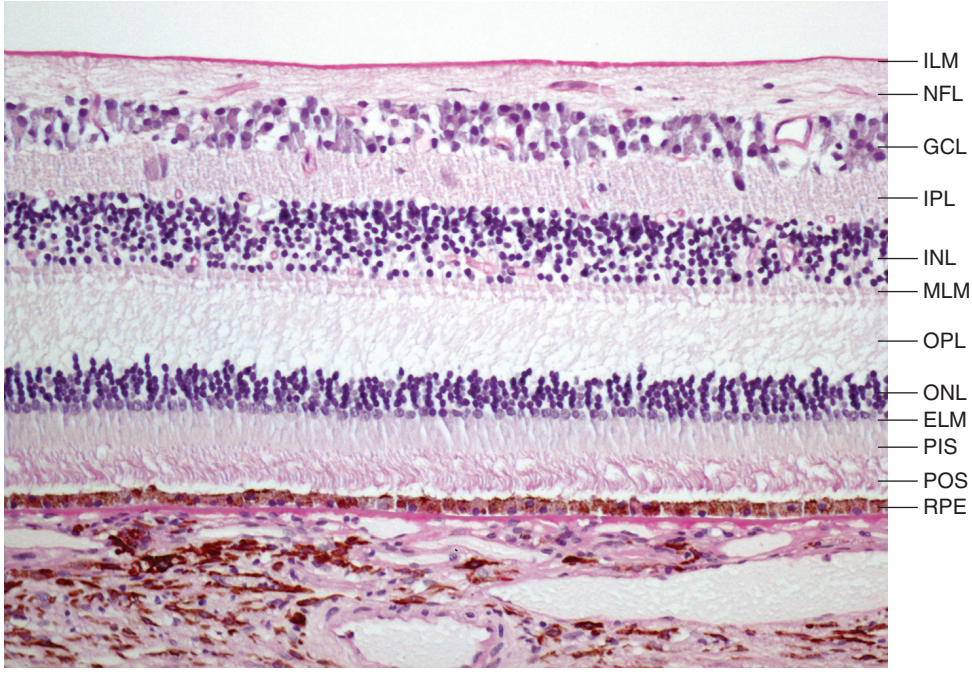
The neuronal elements and their connections in the retina are highly complex (Fig 2-42). Many types of bipolar, amacrine, and ganglion cells exist. The neuronal elements of the rods and cones are interconnected, and signal processing within the neurosensory retina is significant.

Glial elements

Müller cells are glial cells that extend vertically from the external limiting membrane inward to the internal limiting membrane (see Fig 2-42). Their nuclei are located in the inner nuclear layer. Müller cells, along with the other glial elements (the fibrous and protoplasmic astrocytes and microglia), provide structural support and nutrition to the retina and are crucial to normal physiology. In addition, they contribute to the inner blood–retina barrier.

Vascular elements

The retina is a highly metabolic structure, with the highest rate of oxygen consumption per unit weight in the body. The retinal blood vessels are analogous to the cerebral blood vessels and maintain the inner blood–retina barrier. This physiologic barrier is formed by a single layer of nonfenestrated endothelial cells, whose intercellular junctions, under physiologic



A

Figure 2-42 *(Continued)*

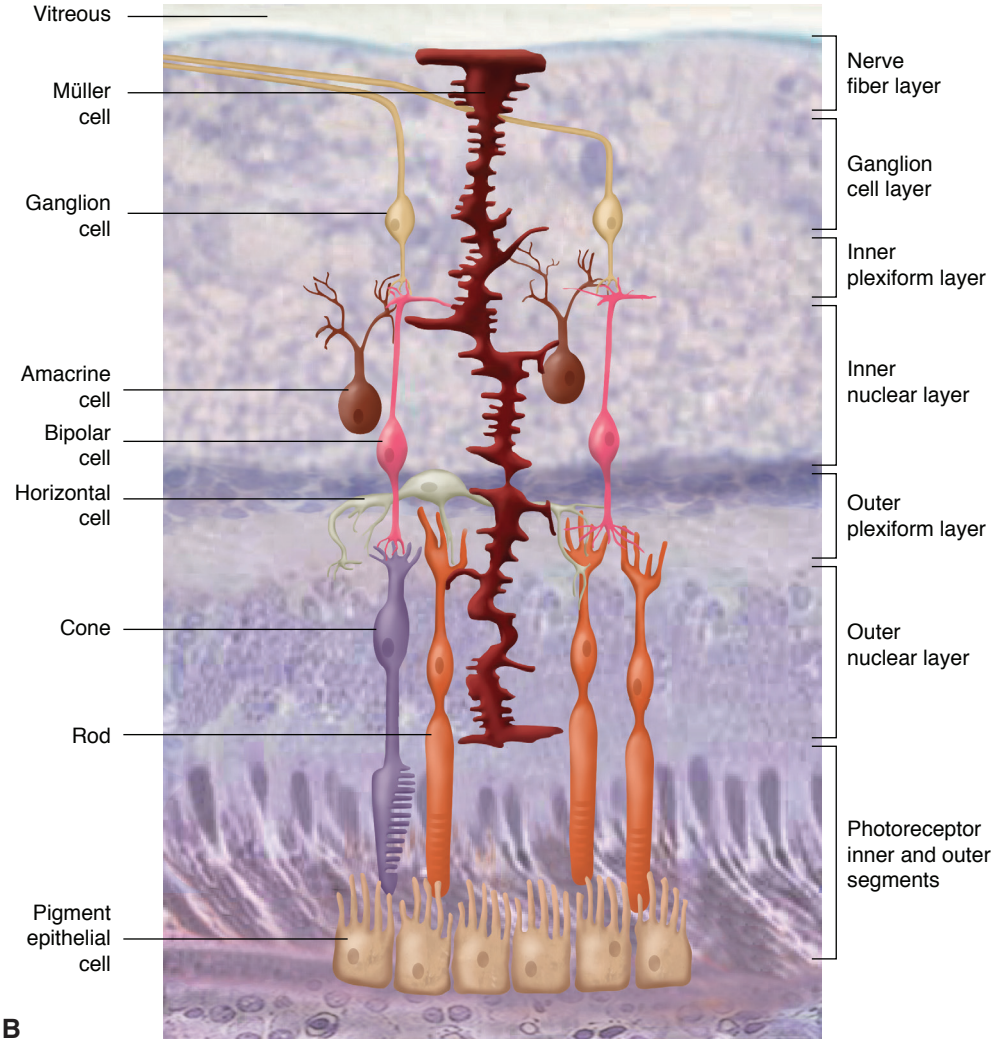


Figure 2-42 *(continued)* Normal retinal layers. **A,** Histology (periodic acid–Schiff [PAS] stain). From vitreous to choroid: ILM = internal limiting membrane; NFL = nerve fiber layer; GCL = ganglion cell layer; IPL = inner plexiform layer; INL = inner nuclear layer; MLM = middle limiting membrane; OPL = outer plexiform layer; ONL = outer nuclear layer; ELM = external limiting membrane; PIS = photoreceptor inner segment; POS = photoreceptor outer segment; RPE = retinal pigment epithelium. **B,** Diagram including cell types of the retina. *(Part A courtesy of Robert H. Rosa, Jr, MD. Part B illustration by Paul Schiffmacher; revised by Cyndie C.H. Wooley.)*

conditions, are impervious to tracer substances such as fluorescein and horseradish peroxidase (Fig 2-43). A basal lamina covers the outer surface of the endothelium and is surrounded by pericytes, or mural cells, which suppress endothelial proliferation and, along with glial cells, contribute to the inner blood–retina barrier (Fig 2-44).

Müller cells and other glial elements are generally attached to the basal lamina of retinal blood vessels. Retinal blood vessels lack an internal elastic lamina and the continuous layer of smooth muscle cells found in other vessels in the body. In the absence of the latter, there is no autonomic regulation of the retinal vessels.