6.1.2

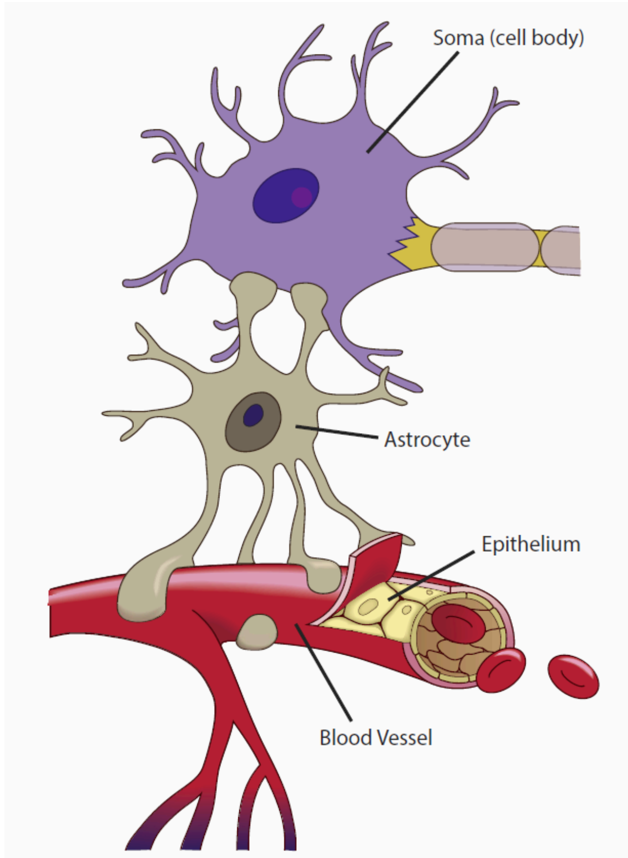
Glial Cells of the CNS

Unlike neurons, the glial cells can be replaced if they are damaged. Glial cells compose half of the volume of the brain and are more numerous than neurons. There are four major types of glial cells in the CNS: the astrocyte, the oligodendrocyte, the ependymal cell, and the microglial cell.

Astrocyte

Astrocytes have an enormous amount of processes that wrap around blood vessels and neurons. Because of this arrangement, astrocytes are ideally positioned to control and modify the extracellular environment around neurons. Most of the functions of the astrocytes are attributed to controlling this environment. One of the most important ways that astrocytes control this environment is by contributing to the blood-brain barrier formed by blood vessel endothelial cells in the CNS. The blood-brain barrier is a highly selective membrane that tightly controls what solutes, chemicals, pathgoens, etc. can enter the CNS.

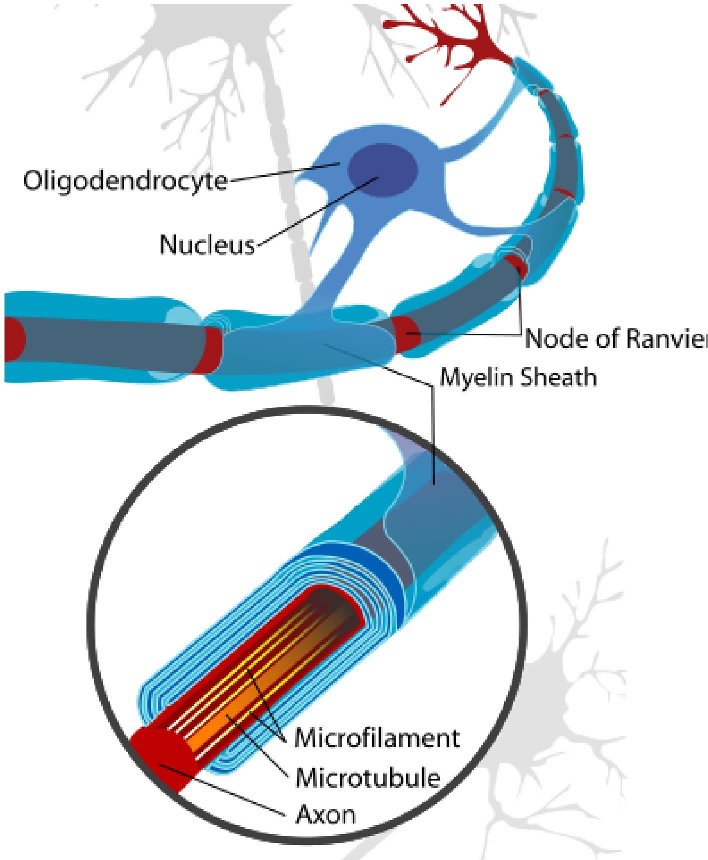
Astrocyte characteristic	Function
Glycogen storage	Astrocytes store all the glycogen present in the CNS. This glycogen is used to help meet the high metabolic needs of the CNS. The main source for these metabolic needs is blood glucose, but glycogen levels can sustain the needs of the CNS for 5–10 minutes.
K^+ permeability	Active neurons lose K^+ into the extracellular spaces, which would act as a positive feedback system for depolarization if the K^+ was not trapped by the astrocytes. They take up K^+ by a pump (Na^+/K^+ ATPase pump) and co-transporters ($Na^+/K^+/Cl^-$ and K^+/Cl^- exchangers).
Gap Junctions	Astrocytes are coupled to each other, as well as other glial cells and neurons, through gap junctions. This may serve to help modulate activity and sensitivity in the CNS.
Neurotransmitters	Astrocytes synthesize over 20 different neurotransmitters and take up excess neurotransmitters to help terminate signals at the synapse.
Growth factors	Astrocytes secrete a variety of growth factors, which are important for the establishment of fully functioning excitatory synapses.
Blood flow	Astrocytes can modulate blood flow in the brain by inducing localized vasodilation or vasoconstriction. This modulation can occur through gap junctions between the astrocytes and the endothelial cells of brain blood vessels.



Astrocyte Processes Associated with Capillaries and Neurons.
Image by BYU-Idaho student, Jared Cardinet, 2013.

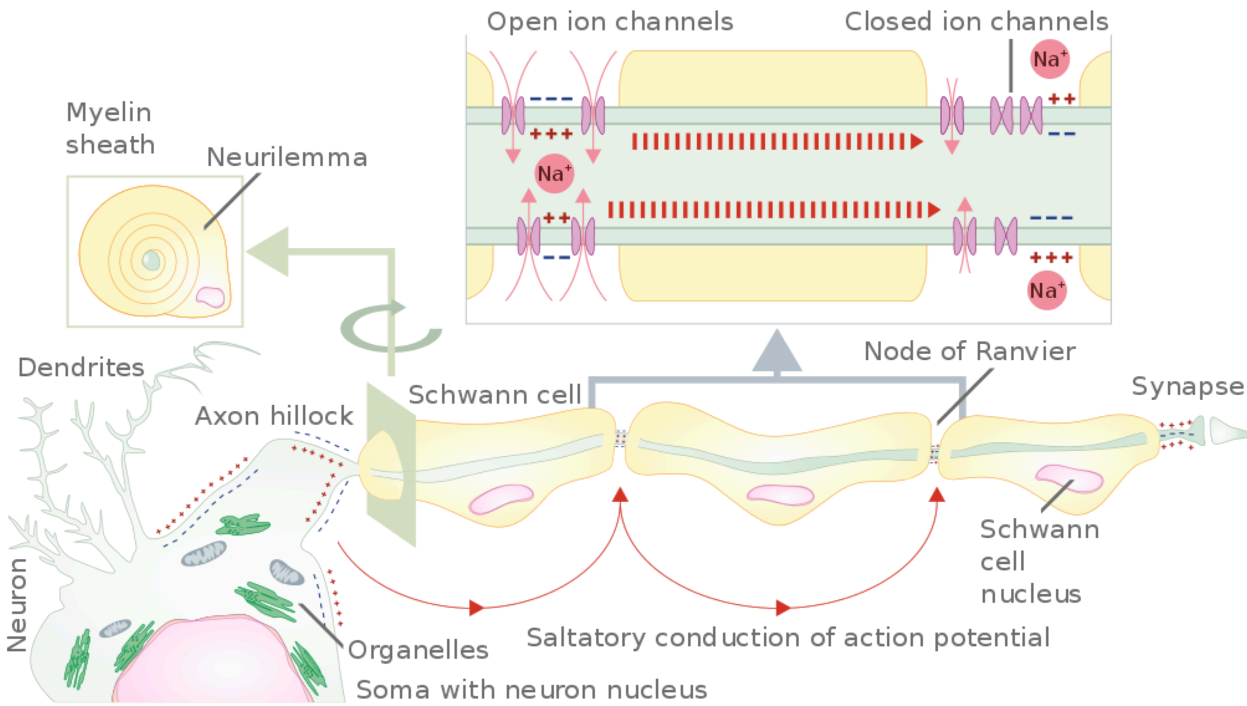
Oligodendrocyte

The primary function of the oligodendrocyte is to provide and maintain the myelin sheaths around axons in the CNS. Myelin is the insulating component of the nervous system. It allows for electrical signals to be propagated along one axon without being spread to other axons. Oligodendrocytes send out 15–30 long processes, which wrap many times around a section of an axon. Between each "wrapping," there is a small area of exposed axon called the **node of Ranvier.**



Oligodendorcyte. *File: Neuron_with_oligodendrocyte_and_myelin_sheath.svg: *Complete_neuron_cell_diagram_en.svg: Author: LadyofHats derivative work: Andrew c; Liscence: [Public domain], via Wikimedia Commons*

The wrapping creates many layers of tightly compressed membranes that is called **myelin**. Myelination speeds up the conduction of action potentials down the axon by allowing the action potentials to occur only at the nodes, a process called *saltatory conduction*. Myelination also induces the clustering of voltage-gated Na^+ channels at the nodes. In addition to myelination, oligodendrocytes also play key roles in pH regulation of the CNS.



Propagation of Action Potential Along Myelinated Nerve Fiber. *Author: Helixitta; Licence: [CC BY-SA 4.0 (http://creativecommons.org/licenses/by-sa/4.0)], via Wikimedia Commons*

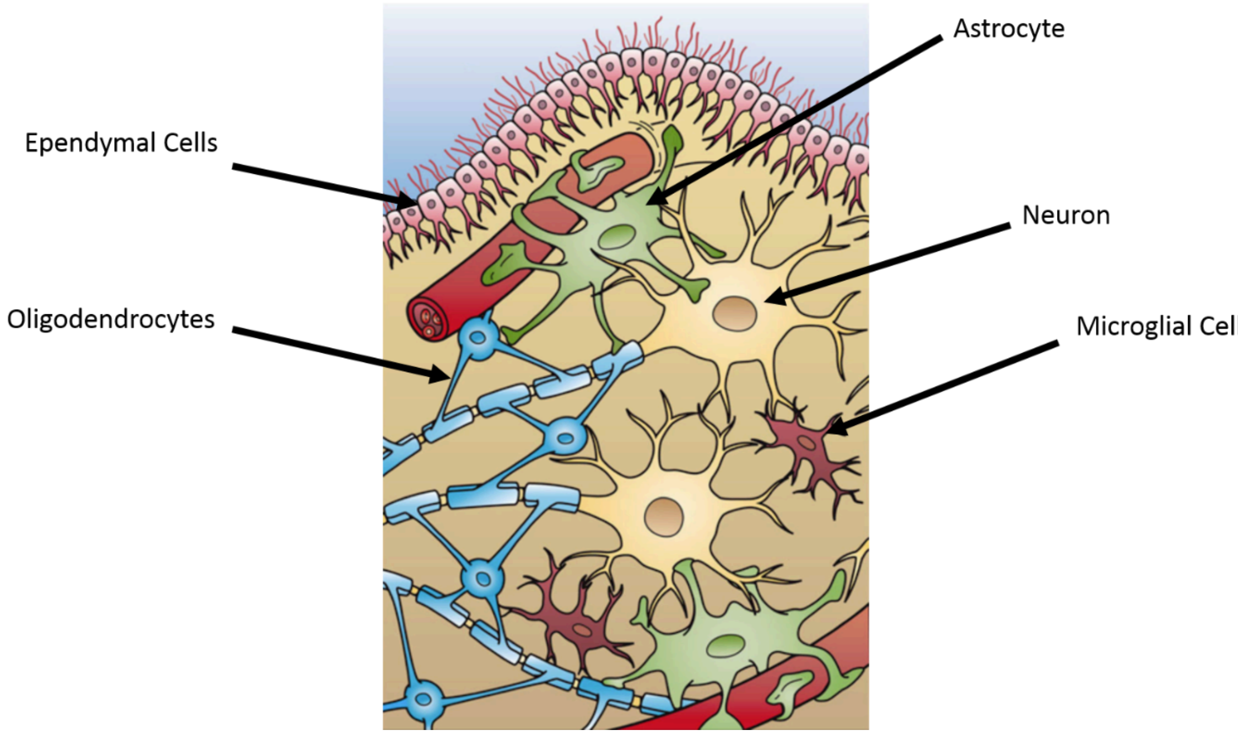
There are many diseases that selectively damage or destroy myelin; the most common demyelinating disease of the CNS is **multiple sclerosis**. Multiple sclerosis (MS) is an autoimmune disease that results in the selective destruction of oligodendrocytes, resulting in a reduction of myelin. The reduction in myelin severely decreases the conduction velocity and duration of action potentials in the affected neuron. Depending of where in the CNS the affected nurons are found, this can result in loss of sensory perception and motor control. The cause of MS is currently unknown, but the disease is twice as common in women as in men.

Ependymal Cell

Ependymal cells line the cavities (ventricles) of the CNS. Ependymal cells are responsible for the production of Cerebral Spinal Fluid (CSF) and are important barriers between the cerebral spinal fluid and the brain extracellular space. These cells beat their cilia to help circulate the cerebral spinal fluid. Ependymal cells selectively utilized different components of blood to create the CSF.

The Microglial Cell

Microglial cells are immune cells that are rapidly activated in the CNS in response to injury or infection. . Injury causes these cells to proliferate, change shape, and become phagocytic. These cells are also very important in presenting antigens to lymphocytes in response to infection. Although these cells are an important component of the CNS, it is believed that their chronic activity is also toxic to neurons and can result in long-term damage. For this reason, medical intervention in response to brain injury often involves factors that inhibit microglial activity.



Glial Cells of the CNS.
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