11.3: Neurons and Glial Cells

Life as Art

This colorful picture could be an abstract work of modern art. You might imagine it hanging in an art museum or art gallery. In fact, the picture illustrates real life rather than an artistic creation. It is a micrograph of human nervous tissue. The neon green structures in the picture are neurons. The neuron is one of two basic types of cells in the nervous system, the other type being the glial cell.

Figure (PageIndex{1}): (CC BY 2.5; By Wei-Chung Allen Lee, Hayden Huang, Guoping Feng, Joshua R. Sanes, Emery N. Brown, Peter T. So, Elly Nedivi via Wikimedia Commons)
Neurons, also called nerve cells, are electrically excitable cells that are the main functional units of the nervous system. Their function is to transmit nerve impulses. They are the only type of human cells that can carry out this function.

Neuron Structure

The figure below shows the structure of a typical neuron. The main parts of a neuron are labeled in the figure and described below.

**Structure of a Typical Neuron**

- **The cell body** is the part of a neuron that contains the cell nucleus and other cell organelles. It is usually quite compact, and may not be much wider than the nucleus.
- **Dendrites** are thin structures that are extensions of the cell body. Their function is to receive nerve impulses from other cells and carry them to the cell body. A neuron may have many dendrites, and each dendrite may branch repeatedly to form a dendrite “tree” with more than 1,000 “branches.” The end of each branch can receive nerve impulses from another cell, allowing a given neuron to communicate with tens of thousands of other cells.
- **The axon** is a long, thin extension of the cell body. It transmits nerve impulses away from the cell body and toward other cells. The axon branches at the end, forming multiple axon terminals. These are the points where nerve impulses are transmitted to other cells, often to dendrites of other neurons. An area called a synapse occurs at each axon terminal. Synapses are complex membrane junctions that transmit signals to other cells. An axon may branch hundreds of times, but there is never more than one axon per neuron.
- Spread out along axons, especially the long axons of nerves, are many sections of myelin sheath. These are lipid layers that cover sections of the axon. The myelin sheath is a very good electrical insulator, similar to the plastic or rubber that encases an electrical cord.
- Regularly spaced gaps between sections of myelin sheath occur along the axon. These gaps are called **nodes of Ranvier**, and they allow transmission of nerve impulses along the axon. Nerve impulses skip from node to node, allowing nerve impulses to travel along the axon very rapidly.
- A Schwann cell (also on an axon) is a type of glial cell. Its function is to produce the myelin sheath that insulates axons in the peripheral nervous system. In the central nervous system, a different type of glial cell, called an oligodendrocyte, produces the myelin sheath.

Neurogenesis

Fully differentiated neurons, with all their special structures, cannot divide and form new daughter neurons. Until
recently, scientists thought that new neurons could no longer be formed after the brain developed prenatally. In other words, they thought that people were born with all the brain neurons they would ever have, and as neurons died, they would not be replaced. However, new evidence shows that additional neurons can form in the brain, even in adults, from the division of undifferentiated neural stem cells that are found throughout the brain. The production of new neurons is called neurogenesis. The extent to which it can occur is not known, but it is not likely to be very great in humans.

### Neurons in Nervous Tissues

The nervous tissue in the brain and spinal cord consists of gray matter and white matter. Gray matter contains mainly the cell bodies of neurons. It is gray only in cadavers; living gray matter is actually more pink than gray (see image below). White matter consists mainly of axons covered with myelin sheath, which gives them their white color. White matter also makes up nerves of the peripheral nervous system. Nerves consist of long bundles of myelinated axons that extend to muscles, organs, or glands throughout the body. The axons in each nerve are bundled together like wires in a cable. Axons in nerves may be more than a meter long in an adult. The longest nerve runs from the base of the spine to the toes.

![Figure 3](https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_(Wakim_and_Grewal)/11%3A_Nervous_Sy...

**Figure \(\PageIndex{3}\):** You can see the layers of (pinkish) gray matter and white matter in this photo of a brain from a recently deceased human patient. (CC BY 4.0; OpenStax [via Wikimedia.org](https://creativecommons.org/licenses/by/4.0/)).

### Types of Neurons

There are hundreds of different types of neurons in the human nervous system. These types exhibit a variety of structures and functions. Nonetheless, many neurons can be classified functionally based on the direction in which they carry nerve impulses.
Sensory (also called afferent) neurons carry nerve impulses from sensory receptors in tissues and organs to the central nervous system. They change physical stimuli such as touch, light, and sound into nerve impulses.

Motor (also called efferent) neurons, like the one in the diagram below, carry nerve impulses from the central nervous system to muscles and glands. They change nerve signals into the activation of these structures.

Interneurons carry nerve impulses back and forth often between sensory and motor neurons within the spinal cord or brain.

Glial Cells

Besides neurons, nervous tissues also consist of glial cells (also called neuroglia). The word glial comes from a Greek word meaning “glue.” This reflects earlier ideas about the role of glial cells in nervous tissues. Glial cells were thought to be little more than “glue” holding together the all-important neurons. Glial cells are no longer thought to be just “glue.” They are now known to play many vital roles in the nervous system. There are several different types of glial cells, each

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with a different function. You can see six types in the figure below.

![Types of Neuroglia](https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_(Wakim_and_Grewal)/11%3A_Nervous_System/11.04_Neuroglia/figure-6.png)

**Figure \(\PageIndex{6}\):** Different types of glial cells (neuroglia) are found in the central nervous system and peripheral nervous system. Ependymal cells, oligodendrocytes, astrocytes, and microglia are found in the CNS. Satellite cells and Schwann cells are found in the PNS. (CC BY-NC 3.0; BruceBlaus; 2014 via Wikimedia.org)

In general, glial cells provide support for neurons and help them carry out the basic function of nervous tissues, which is to transmit nerve impulses. For example, oligodendrocytes in the central nervous system and Schwann cells in the peripheral nervous system generate the lipids that make up myelin sheaths, which increase the speed of transmission of nerve impulses. Functions of other glial cells include holding neurons in place, supplying neurons with nutrients, regulating the repair of neurons, destroying pathogens, removing dead neurons, and directing axons to their targets. Glial cells may also play a role in the transmission of nerve impulses, but this is still under study. Unlike mature neurons, mature glial cells retain the ability to divide by undergoing mitosis.

In the human brain, there are generally about equal numbers of neurons and glial cells. If you think intelligence depends on how many neurons you have, think again. Having a relatively large number of glial cells is actually associated with higher intelligence. When Einstein’s brain was analyzed, researchers discovered a significantly higher-than-normal ratio of glial cells to neurons in areas of the brain associated with mathematical processing and language. On an evolutionary scale as well, an increase in the ratio of glial cells to neurons is associated with greater intelligence in species.

**Feature: My Human Body**

Would you like your brain to make new neurons that could help you become a better learner? What college student wouldn’t want a little more brain power when it comes to learning new things? If research on rats applies to humans, then sustained aerobic exercise such as running can increase neurogenesis in the adult brain, and specifically in the hippocampus, a brain structure important for learning temporally and/or spatially complex tasks as well as memory. Although the research is still at the beginning stages, it suggests that exercise may actually lead to a “smarter” brain. However, even if the research results are not confirmed in the future for humans, it can’t hurt to get more aerobic exercise, because it is certainly beneficial for your body if not for your brain.
Summary

- Neurons are one of two major types of nervous system cells. They are electrically excitable cells that transmit nerve impulses.
- Glial cells are the other major type of nervous system cells. There are many types of glial cells, and they have many specific functions. In general, glial cells function to support, protect, and nourish neurons.
- The main parts of a neuron include the cell body, dendrites, and axon. The cell body contains the nucleus. Dendrites receive nerve impulses from other cells, and the axon transmits nerve impulses to other cells at axon terminals. A synapse is a complex membrane junction at the end of an axon terminal that transmits signals to another cell.
- Axons are often wrapped in an electrically-insulating myelin sheath, which is produced by glial cells. Electrical signals occur at gaps in the myelin sheath, called nodes of Ranvier, which speeds the conduction of nerve impulses down the axon.
- Neurogenesis, or the formation of new neurons by cell division, may occur in a mature human brain but only to a limited extent.
- The nervous tissue in the brain and spinal cord consists of gray matter, which contains mainly the cell bodies of neurons; and white matter, which contains mainly myelinated axons of neurons. Nerves of the peripheral nervous system consist of long bundles of myelinated axons that extend throughout the body.
- There are hundreds of types of neurons in the human nervous system, but many can be classified on the basis of the direction in which they carry nerve impulses. Sensory neurons carry nerve impulses away from the body and toward the central nervous system, motor neurons carry them away from the central nervous system and toward the body, and interneurons often carry them between sensory and motor neurons.

Review

1. Identify the three main parts of a neuron and their functions.
2. Describe the myelin sheath and nodes of Ranvier. How does their arrangement allow nerve impulses to travel very rapidly along axons?
3. What is a synapse?
4. Define neurogenesis. What is the potential for neurogenesis in the human brain?
5. Relate neurons to different types of nervous tissues.
6. Compare and contrast sensory and motor neurons.
7. Identify the role of interneurons.
8. Identify four specific functions of glial cells.
9. What is the relationship between the proportion of glial cells to neurons and intelligence?
10. For each type of neuron below, identify whether it is a sensory neuron, motor neuron, or interneuron.
   a. A neuron in the spinal cord that receives touch information and then transmits that information to another spinal cord neuron that controls movement of an arm muscle.
   b. A neuron that takes taste information from your tongue and sends it to your brain.
   c. A spinal cord neuron that stimulates a muscle to contract.
11. The myelin sheath is made by:

   A. Sensory neurons
   B. White neurons
   C. Peripheral nervous system neurons
   D. Glial cells

12. True or False. Synapses often exist where a dendrite and an axon terminal meet.

13. True or False. There is only one axon terminal per neuron.

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**Explore More**

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Multiple sclerosis (MS) is a progressive degenerative disease that is caused by demyelination of axons in the central nervous system. When myelin degrades, conduction of nerve impulses along the nerve can be impaired or lost, and the nerve eventually withers. Watch this inspirational TED talk in which the speaker shares how being diagnosed with MS changed her life and led her to become an MS nurse.
After his death in 1955, Albert Einstein's brain was studied by scientists worldwide—all wanting to gain insight into the anatomy of a genius. But it wasn't until the 1980s when Marian Diamond noticed that Einstein had more glial cells than average. Glia, stemming from Greek for "glue", was previously thought to have performed a strictly support role for the neurons. Now it is clear that glia may play a more active, non-electrical role in brain activity.

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