Structure and Function of The Human Nervous System

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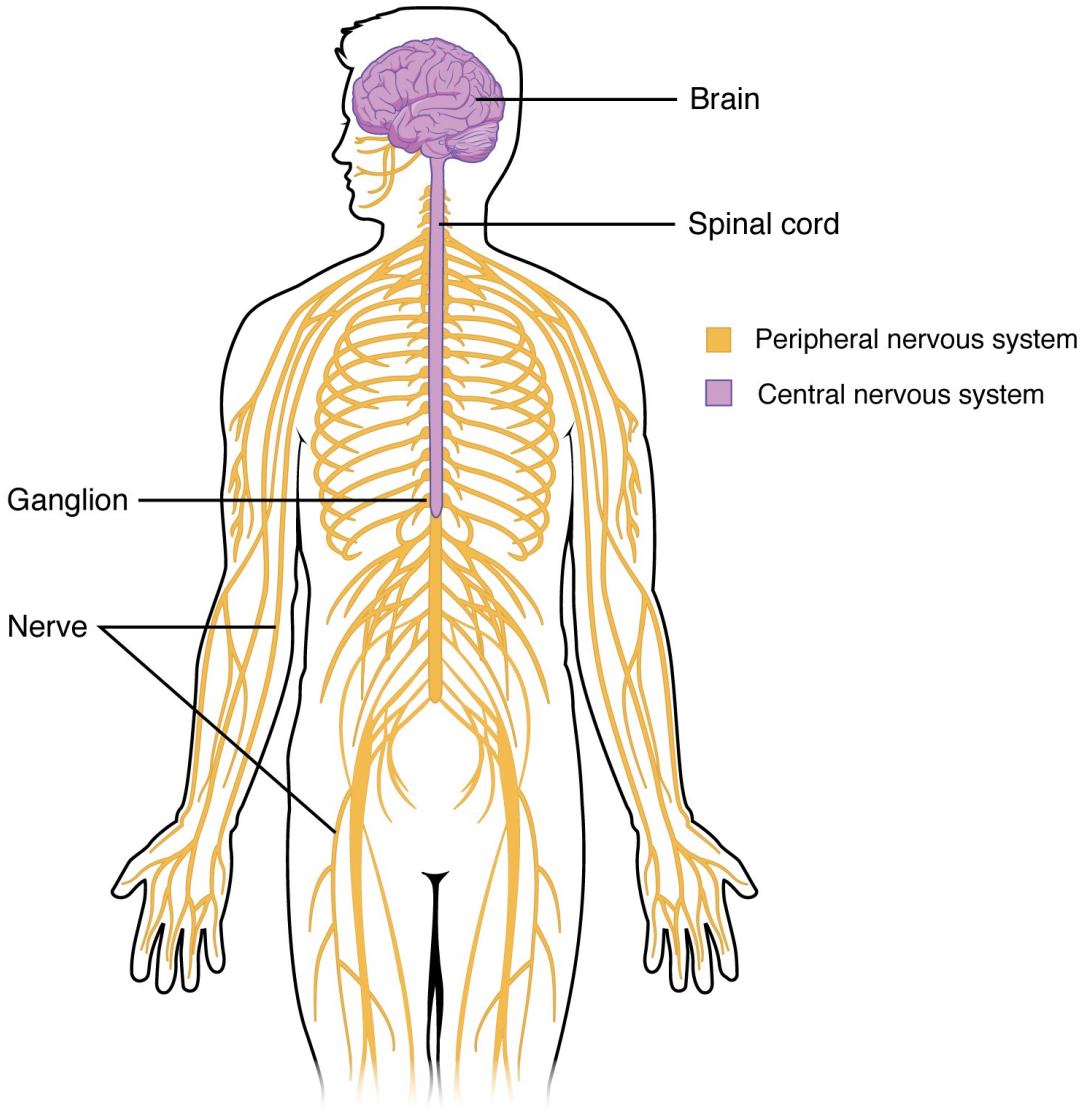
OVERVIEW:

Think of the body as a well-run business headed by a CEO. There must be some form of communication network, whether through emails or a chain of command, in order to work in an efficient manner. Similarly, the body uses its own special communication network called the nervous system to pass messages and instructions to and from the brain in response to internal and external stimuli. Simply put, the nervous system serves as a communication link between the brain and muscles, glands, and organs, allowing them to respond to the brain's response after receiving stimuli from them. The nervous system is split into two sections: the central nervous system (brain and spinal cord) and the peripheral nervous system.

Central and Peripheral Nervous System



Note. By Oregon State University. n.d., illustration found on Oregon State University.

The Central Nervous System

The central nervous system is divided into two parts: the brain and the spinal cord. The central nervous system's role is to enable the brain to interact with the rest of the body and

operate independently of other bodily components. Aside from the circulatory system, it is also responsible for maintaining the balance and safety of all bodily systems. The brain is the central nervous system's major functional unit and is critical to an organism's mental functions such as interpreting signals from the senses of touch, vision, and hearing, as well as speaking, thinking, emotions, learning, and fine motor control.According to Harrow-Mortelliti et al., 2022, the spinal cord connects the brain to the rest of the body by conveying nerve messages and coordinating reflexes from the brain's responses. To prevent damage from external sources, both the spinal cord and the brain are protected by three layers of membranes known as meninges, with the brain encased in the skull or the cranial cavity and the spinal cord protected in the spine with cerebrospinal fluid surrounding them to prevent grating or irritation of the soft flesh on the hard bone.

According to the Nedergaard group at the University of Rochester Medical Center, another function of cerebrospinal fluid is to eliminate waste products from the brain. As glia, the connective tissue found in the nervous system, provide cerebrospinal fluid access to the brain, it circulates through the brain, collecting proteins and other detritus then transporting them to lymphatic ducts, which then drains them into the blood vascular system. (Andreone, 2018).

The Peripheral Nervous System

The peripheral nervous system uses thousands of miles of nerve fibers to deliver and receive sensory messages for the central nervous system. It is made up of both the autonomic and somatic nervous systems. The autonomic nervous system governs involuntary bodily processes such as digestion, pulse, and eye reflexes, whereas the somatic nervous system controls voluntary muscle activities such as walking and also delivers sensory impulses to the central nervous system.

The primary role of the somatic nervous system is to connect the central nervous system to the organs, muscles, and skin. This allows for more complex motions and actions. It has afferent nerves that send information to the brain and spinal cord and are made up of sensory neurons that inform the central nervous system about our five senses, as well as efferent nerves that send information from the brain and are made up of motor neurons that are responsible for voluntary movements like walking or lifting an object. The somatic nervous system, in addition to managing voluntary movements, is in charge of involuntary muscle reactions known as reflexes, which are governed by a neuronal pathway known as the reflex arc.

The autonomic nervous system is further subdivided into the sympathetic and parasympathetic nervous systems. These systems collaborate to keep each other in check by counteracting one another's actions in order to preserve homeostasis. As a result, they frequently communicate with the same organs. The sympathetic nervous system connects the internal organs to the brain via spinal nerves. It also regulates the body's quick natural reaction to dangerous or stressful situations, known as the "Fight or Flight" response (McCorry, 2007). When sensory neurons are activated, the body prepares for stress by increasing heart rate, boosting blood supply to muscles, and decreasing blood flow to the skin. The parasympathetic nervous system does the opposite and calms the body down to

conserve energy through another physiological reaction called "Rest and Digest". Following the acts of the sympathetic nervous system, the parasympathetic nervous system causes decreased arousal in places such as the eyes, salivary glands, gastric nerves, blood vessels, and pelvic parasympathetic nerves, which are nerves that travel to the bladder (Tindle & Tadi, 2020).

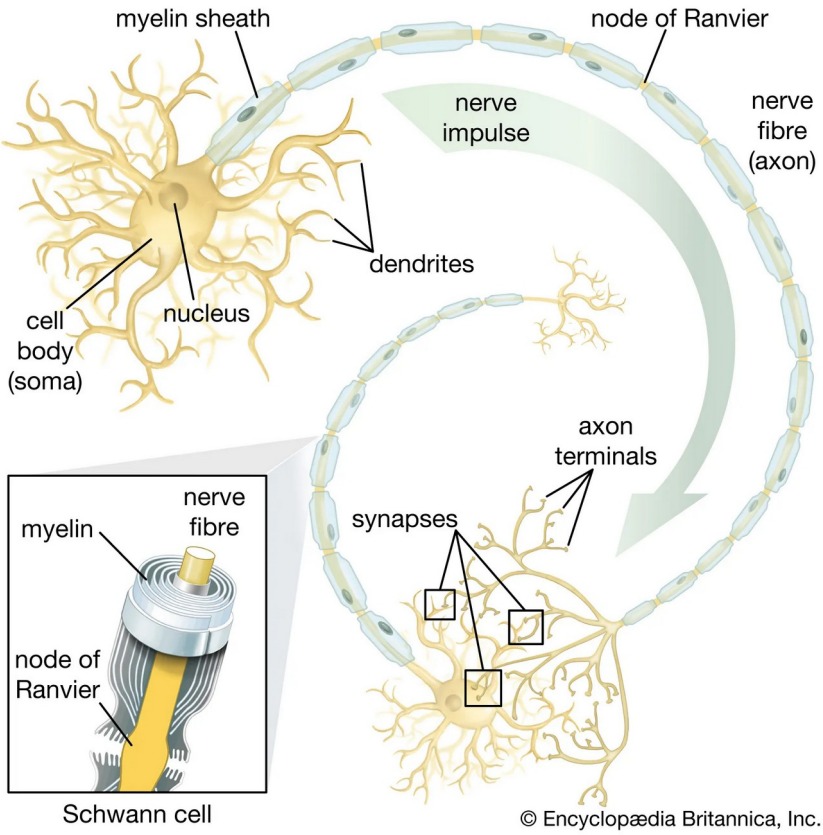
Neurons

To start from the beginning, the essential building blocks of the nervous system are neurons.There are three types of neurons: motor neurons, sensory neurons and relay neurons.

Contrary to popular belief, the human brain has 86 billion neurons rather than 100 billion, according to a recent study by Herculano-Houzel (2012). What's more unexpected is that, while accounting for only 2% of body mass, these cells utilize 20% of total body energy due to their increased metabolic demand required to transmit messages as swiftly and effectively as possible.

Motor Neurons

motor neuron



Note. By Encyclopædia Britannica. n.d., image found on Encyclopædia Britannica.

A motor neuron or efferent neuron is a three-part electrically conducting nerve cell that has a cell body, dendrites, and an axon. This is the movement of an impulse through the motor neuron:

1. First, the impulse moves down the dendrites. Dendrites are specialized extensions of the cell body that protrude in a tree-like form. They receive impulses through synapses between neighboring neurons (Kapalka, 2010).

2. Then it heads to the cell body. The cell body or soma, which governs neuron activity, is made up of cytoplasm, cytoplasmic structures, and a nucleus. Its function in the neuron is to convey the impulse from the cell body to the axon.

3. The stimulus then travels up the axon, which is the part of the neuron that transmits electrical impulses from the cell body to the axon terminal. The following are some interesting points regarding the axon:

    a. The myelin sheath, which is made up of mostly fat and a small portion protein, surrounds the axon and helps electrical impulses travel swiftly and effectively between nerve cells by acting as insulation from electrical loss.

    b. Both the Schwann cells and the Node of Ranvier make up the axon.

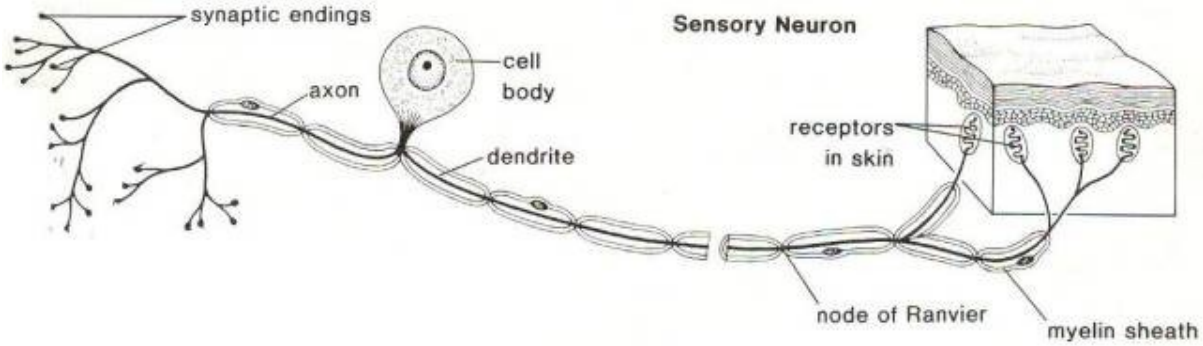
    c. The Node of Ranvier is a periodic break in the myelin sheath on the axon of some neurons that serves to enhance the fast conduction of nerve impulses.

    d. Schwann cells play an important role in the formation, maintenance, function, and regeneration of peripheral nerves (Ludwig et al., 2021).

4. Finally, the impulse reaches the axon terminal, also known as the synaptic bouton or terminal bouton, which are little bumps at the axon's terminus. Neurotransmitters, which are molecules having an internal origin, primarily inside the neuron, that let neurons interact with each other throughout the body, exit the neuron and are released into the synapse to relay signals to the next cell surface, are vital in cell-to-cell communication (Sheffler et al., 2022).

Sensory Neurons

Sensory Neurone



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The sensory neuron or afferent neuron is similar to the motor neuron in that its dendrites are attached to receptor cells, which are signal-receiving proteins found within or on the cell surface, but the motor neuron's dendrites are connected to a preceding cell's axon terminal (Miller et al., 2022). Sensory input from the environment activates their role in the nervous

system, causing them to send signals to the rest of the nervous system regarding the data they have obtained from this stimulus.

Relay Neurons

A diagram of the relay neuron with all its key components labeled

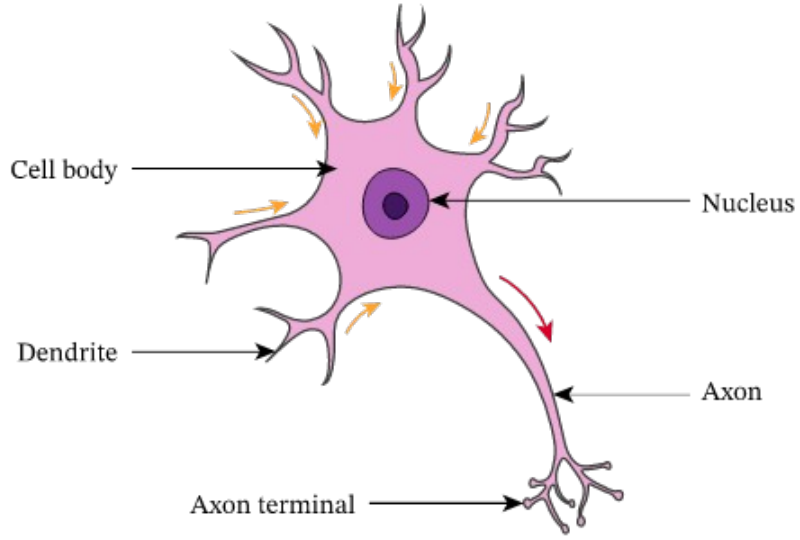


Figure 3: A relay neuron, with the key components labeled

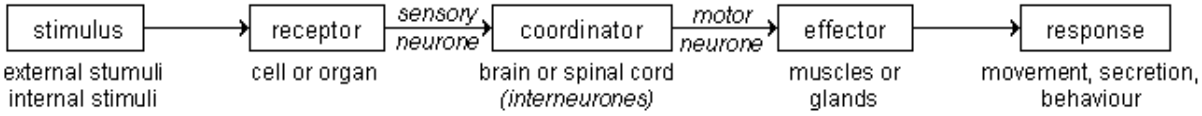
Note. By Nagwa Limited.n.d., image found on Nagwa.

The interneuron, also known as the relay neuron, is a kind of neuron found solely in the spinal cord and plays a role in the central nervous system. The relay neuron's purpose is to function as a link between sensory and motor neurons, transmitting impulses from one to the other. Even while the interneuron's structure is similar to that of a motor neuron, especially since it is multipolar (Guy-Evans, 2021), meaning it has one axon and several dendrites, it differs in that it lacks a myelin sheath around its axon, making it unmyelinated. Since their axons are actually smaller than those of sensory and motor neurons, an electrical impulse is unlikely to be lost as it travels along (Moini & Md, 2020; Physiopedia contributors, n.d.; Zavvarian et al., 2020).

Reflex Arc

After going through the different types of neurons, it's time to talk about how they behave in the nervous system, which would be performed in a reflex arc. The reflex arc in the peripheral nervous system had been mentioned previously. A reflex arc, according to Blanchard and Bronzino (2012), is a neurological loop that begins with a sensory neuron at a receptor that receives inputs and converts them into a stimulus and ends with a motor neuron at an effector that performs the brain's required response. When it comes to the peripheral nervous system, the reflex arc plays an important role in properly transferring sensory impulses to the brain.

Reflex arc represented as a flow diagram



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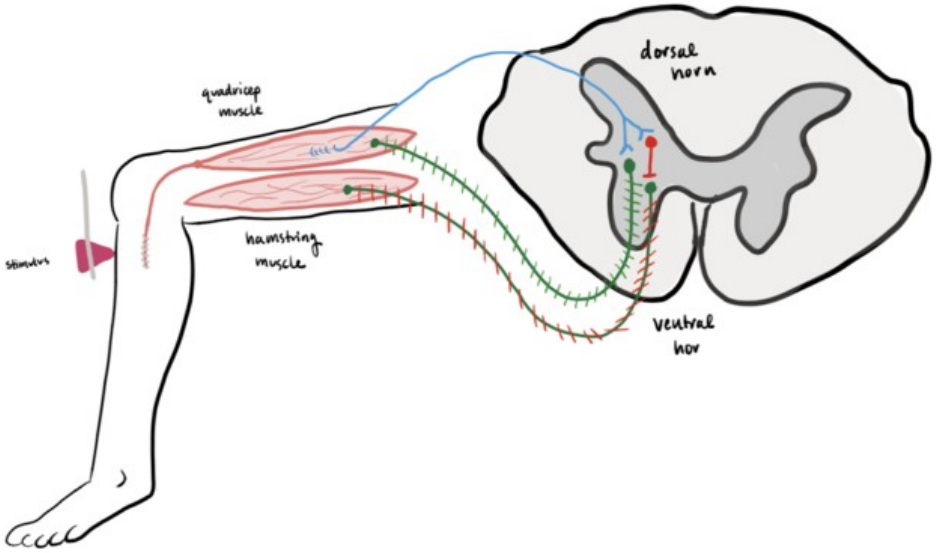
The reflex arc is performed as follows:

Consider the basic knee jerk reflex test, which is used by doctors to measure the sharpness of the body's reflexes.

Simple spinal reflex: The knee jerk reflex



Note. By Nascari and Sved. 2019, September 10, image found on Wikimedia Commons.

1. The stimulus from a tap on the knee is first recognized by muscle receptor cells.
2. These cells then generate a pattern of nerve impulses, which are transported to the central nervous system by a sensory neuron to be passed to a relay neuron.
3. The relay neuron's axon terminal then releases neurotransmitters, which include the response to the signal from the central nervous system, by the motor neuron's dendrites and converted to an electrical signal by the cell body, allowing it to travel down the axon.
4. Finally, the motor neuron sends the signal response to an effector to have it complete an action, which in this example was the knee muscle contracting.

ACTIVITY 1:

Name: Class: Date:

word search clues

The Central Nervous System

Using the clues provided, find the scientific terminology connected to the Central Nervous System in the word search below. The words can be found by traveling horizontally, vertically, or diagonally in one of eight various directions. There might be an unused word or a message hidden in another solution to the problem.

h v a l t r r t j t p t g t e q e g q i
t e n h n o u a e s o s u r n z r e n z
l s t r r f o d l b e d r a n o s d r u
c n t q a p h o a n o f n l l g e o l y
y s m b o j e s m d l n e e h p c b t y
e o p o l s e l o c r n w g e o r t m e
p n u i g r z r u a y i e n d a a d w k
h o e a n s f t r r d h d i i o n r h r
a u m d i a d i s h h e e n g c i d e a
l x w a i e l h s e n u t e n i a p i i
e a s t c u d c i t a h p m y l l e e c
m e t s y s y r o t a l u c r i c s i i
m n d a b o i p a r a e i s o o a i a t
e c s p i n e n t w d i y t s i v o t f
c e r e b r o s p i n a l f l u i d u a
w f g h a t u s f k y u i g a n t i t o
e t r t e k e e t h t x e n o m y t c x
c t i g n i h c e p a h i i v d n o t e
d o i y i p o d b f s c h t o o r s u e
n n c i y s s r i l a m m p r a c e g l

1 Protects the brain and spinal cord from rubbing against the bone
2 The connective tissue that makes up the nervous system
3 The brain is enclosed there
4 Membrane that protects the brain and spinal cord
5 The bodily system that is not monitored by the central nervous system
6 Drains waste from the brain into the blood vascular system
7 It transmits nerve impulses and organizes responses
8 The central nervous system enables the brain to do this separate from other bodily systems
9 The line of bones down the centre of the back that provides support for the body and protects the spinal cord from external damage

Name: Class: Date:

More Clues

10 The organ of the body in the head that controls functions, movements, sensations, and thoughts.

ACTIVITY 2:

The Peripheral Nervous System

Name: _____

Date: _____

Match the word on the right side to its definition on the left side. The words may be used once or none at all.

1. _____ Coordinates voluntary muscular movements
2. _____ Sends information to the central nervous system from the organs, muscles, and skin.
3. _____ Regulating involuntary biological functions
4. _____ Uses the spinal nerves connect the internal organs to the brain.
5. _____ Initiate the body's inherent "Fight or Flight" response.
6. _____ In charge of motor neurons
7. _____ Preserves homeostasis
8. _____ Reduced reactivity in gastric nerves
9. _____ The process of conserving physiological energy following the "Fight or Flight" response.
10. _____ Nerves leading to the bladder

A. sympathetic nervous system

B. somatic nervous system

C. afferent nerves

D. efferent nerves

E. parasympathetic nervous system

F. sympathetic nervous system

G. Rest and Digest

H. automatic nervous system

I. autonomic nervous system

J. efforent nerves

K. autonomic nervous system

L. Conservation of bodily energy

M. pelvic parasympathetic nerves

ACTIVITY 3:

Neurons

Name: _____

Date: _____

Section I

Circle the correct answer for each question below.

1. **What is the basic unit of the nervous system?**

   A. Neuron
   B. Glia
   C. Cerebrospinal fluid
   D. Meninge

2. **What are the three types of neurons present in the nervous system?**

   A. interneuron, efforent and afferent
   B. motor,affluent and interneuron
   C. motor, relay and sensory
   D. motor, synaptic and relay

3. **How many neurons does the human brain have?**

   A. 100 billion
   B. 86 billion
   C. 80 billion
   D. 14 billion

4. **What is the name of the chemical secreted at axon terminals in order to spread a nerve impulse?**

   A. sodium-potassium mixture
   B. neuroreceptor fluid
   C. glia
   D. neurotransmitter

5. **Another name for the cell body is**

A. glia
B. soma
C. neve fibre
D. myelin

6. **How much of total body energy do the neurons in the brain use?**

A. 80%
B. 22%
C. 20%
D. 40%

7. **Which of the following is correct about the axons and dendrites?**

A. Dendrites transmit information, whereas axons receive it
B. The functions of axons and dendrites can switch depending on the type of nerve impulse sent
C. Axons convey signals, and dendrites receive them
D. Axons and dendrites both send and receive information.

8. **Which of the following roles does the myelin sheath perform?**

A. Protects the neuron from pathogenic bacteria
B. Insulates the axon to prevent electrical losses
C. Nourishes the cell by acting as nutrient storage
D. Organizes cell-to-cell communication

9. **What is the signal-receiving protein found within or on the cell surface?**

A. Galgia Cells
B. Signal Cells
C. Glial Cells
D. Receptor Cells

10. **Where are interneurons found solely?**

A. Muscle

B. Spine

C. Spinal Cord

D. Cranial Cavity

Section II

Answer each question in the space provided.

11. **Give two examples of how a sensory or afferent neuron differs from a motor neuron.**

12. **Why are interneurons unmyelinated?**

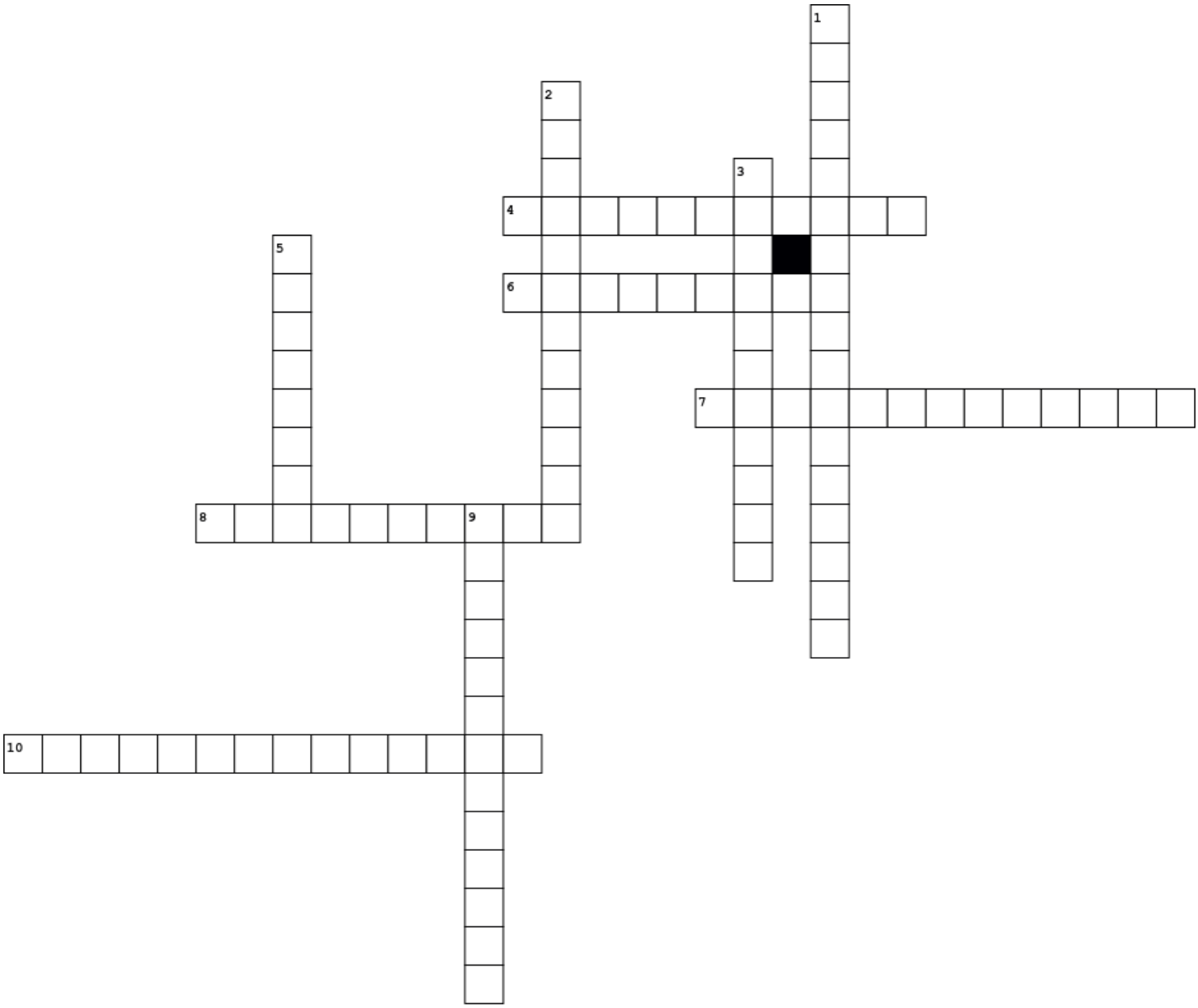
13. **If multipolar indicates the neuron has one axon and several dendrites, and bipolar means the neuron has one axon and one dendrite, what does unipolar mean?**

14. **What is the name given to a break in the myelin sheath on the axon of certain neurons that serves to improve rapid conduction?**

15. **What are the three structures present in the cell body?**

ACTIVITY 4:

The Reflex Arc



Across

4. The sensory neuron passes the impulse to this neuron

Down

1. The form that nerve impulses take to travel down a motor neuron axon

6. The loop or action cycle in the body that governs reflexes

7. The neuron present at the start of the reflex loop

8. The subdivision of the nervous system that relies on reflex arcs

10. Creates a pattern of nerve signals for transmission to the brain

2. This portion of the neuron releases neurotransmitters to be caught by the motor neuron's dendrites

3. Acts as an intermediate between a sensory neuron and motor neuron

5. Completes the action using the response sent from the brain

9. Detects external or internal stimuli on the skin or muscle

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