**Nervous System Notes Guide**

The nervous system: rapid communication, 1

Rapid communication between cells is fundamental to the function of the animal nervous system.

Neurons and neuroglia, 1

The nervous system consists mainly of nervous tissue, which has two types of cells: neurons and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

Neurons and neuroglia, 2

Neurons are interconnected cells that communicate via electrical impulses.

Neuroglia support neurons.

Neurons work together

Many neurons work together as an animal senses and reacts to its surroundings, makes decisions, and maintains \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

The evolutionary history of the nervous system

Nervous system complexity reflects evolutionary history.

Cnidaria

Cnidaria have nerve \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, in which nervous impulses spread over the entire body surface.

Flatworms

Flatworms and most other animals have ganglia—clusters of neurons.

Flatworms have a nerve ladder

The nerve \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of flatworms connects to paired muscles on each side of the body, allowing the worm to move rhythmically.

Segmented worms

Segmented worms have a larger brain and a ventral nerve cord that helps the animal coordinate movements.

Arthropods

Arthropods have a brain, a ventral nerve cord, and organs that detect light, sound, chemicals, and balance.

Vertebrates

Vertebrate nervous systems are divided into the central and peripheral nervous systems.

Even seemingly simple tasks, like this lynx seeing and chasing a hare, require interactions among many neurons in both divisions.

The peripheral nervous system: sensory input

Sensory input (ears, eyes, and nose detect prey)

Neurons in the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ nervous system carry information to or from the central nervous system.

For example, neurons in sense organs respond to sensory input.

The nervous system: rapid communication, 2

The central nervous system interprets signals it receives from the peripheral nervous system.

Peripheral nervous system: motor response

In a fraction of a second, the central nervous system signals the peripheral nervous system to stimulate a motor response.

Neuron structure and arrangement

All neurons have the same basic parts:

Cell body

Dendrites

Axon

Cell body

The cell body contains the nucleus, mitochondria, and other \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

Dendrites

Dendrites are short, branched extensions that transmit information toward the cell body.

Axon

The axon, or nerve fiber, conducts nerve impulses away from the cell body.

Synapses, 1

The end of the axon meets another cell, forming one or more synapses.

Myelin sheath

Some neurons also have a myelin sheath made of fatty neuroglia cells. The myelin sheath coats sections of the axon and speeds neural impulses.

Nodes of Ranvier

The myelin sheath is made of either \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ cells or oligodendrocytes. The spaces between myelin sheath cells are called Nodes of Ranvier.

Three classes of neurons

Biologists divide neurons into three classes:

Sensory neurons

Interneurons

Motor neurons

Figure 26.5

These neurons work together to coordinate reactions to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ such as pain.

Sensory neurons

Sensory neurons bring information from the body’s organs (such as heat, pain, taste, etc.) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the central nervous system.

Interneurons

Interneurons in the central nervous system receive signals from sensory neurons. The message is processed, and a signal is sent to a motor neuron.

Motor neurons

A motor neuron conducts a message from the central nervous system to a muscle or gland, stimulating contraction or secretion.

Action potentials convey information

Each neuron in this network sends a message to the next cell. How is information carried through a neuron to its connection with another cell?

Action potentials

The message is an electrical impulse called an \_\_\_\_\_\_\_\_\_\_\_\_ potential, which travels along a neuron’s axon.

Action potentials and ions

Action potentials result from the movement of charged particles (ions) across the cell membrane.

Triggering an action potential

Action potentials are triggered by changes in other parts of the neuron.

Dendrites receive and transmit information

A change in pH, a touch, or a signal from another neuron may cause some sodium channel gates in a neuron’s membrane to open, usually at the dendrites or cell

body.

Membrane potential

The resting membrane potential of a neuron is usually \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

A small amount of Na^+ leaks into the cell through the open channels. These movements regulate the membrane potential, or charge difference across the membrane.

Sodium ions change the membrane potential

Na^+ is a positive ion, so as it enters the cell, the interior becomes less negative.

Graded potential

The electrical current caused by moving Na^+ ions shown here is called a graded potential: it weakens with \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ from the source of the stimulus and its magnitude depends on the signal’s strength.

Initiating an action potential

If the graded potential that reaches the axon is strong enough (green arrow), then an action potential will initiate.

Action potentials: a closer look

Zooming in on a small patch of an axon’s cell membrane reveals the events of an action potential.

Action potentials require changes in membrane potential

As an action potential passes this patch of axon, ions move in and then out, causing the charge in the axon to change.

Establishing action potentials: resting potential

Notice that sodium (Na^+) and potassium (K^+) ions are distributed near the \_\_\_\_\_\_\_\_\_\_\_\_ membrane.   
Also, the inside of the axon has negatively charged proteins.

Membrane potential is regulated by the movement of ions

Na^+ and K^+ move in and out through channels in the axon membrane.

Resting potential: -70mv

When not conducting a neural impulse, an axon maintains its resting potential. The axon’s interior is negatively charged relative to the outside.

Sodium-potassium pumps

This charge difference results from the action of many sodium-potassium pumps, which use ATP to send three Na^+ ions out of the cell for every \_\_\_\_\_\_\_\_\_\_\_\_\_ K^+ ions they let in.

An action potential begins

When a graded potential reaches an axon, a few sodium channels open, allowing sodium ions to trickle into the axon.

Threshold: -50mv

These positively charged ions make the interior of the axon less negative near the membrane, a process called depolarization.

At threshold, more sodium channels open

If the membrane reaches threshold potential, more sodium channels open. Na^+ pours into the cell, driving the membrane potential higher.

Peak depolarization: +35mv

Peak depolarization is achieved at +35mv. A split second after sodium ions flow into the axon, potassium ions exit. Sodium ion channels are now \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

Repolarization

K^+ ions leaving the cell cause the membrane potential to drop; this process is called repolarization.

Hyperpolarization

During hyperpolarization, the membrane temporarily dips below resting potential, until the sodium-potassium pumps reestablish it.

One action potential triggers the next

The wave of ion movements progresses to the next patch

of membrane and continues to the end of the axon.

Action potentials are fast

The entire process, from the initial influx of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ to the restoration of resting potential, takes only a few milliseconds.

Myelinated vs. unmyelinated axons

Myelinated axons conduct impulses more quickly than unmyelinated axons.

There are gaps between myelin

Ion channels are concentrated in the gaps between myelin.

Action potentials move from gap to gap

Some of the sodium ions flooding in at one gap diffuse to the next gap, cueing additional ion channels to open. The action potential therefore seems to jump from one gap to the next.

Messages move from cell to cell

We’ve seen how impulses travel along one axon. How do these impulses translate into messages conveyed to other cells?

Synapses, 2

This communication occurs at a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, a junction between a neuron and another cell.

Neurotransmitters cross the synapse, 1

Molecules called neurotransmitters travel across synapses.

The parts of a synapse

The synapse includes a presynaptic cell, a synaptic cleft, and a postsynaptic cell (which could be a neuron, muscle cell, or gland cell).

The synaptic terminal

The end of the presynaptic neuron’s axon is the synaptic \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

This figure shows how an action potential reaching the synaptic terminal initiates communication with the receiving cell.

The synaptic terminal has calcium channels

Action potentials cause calcium channels in the synaptic terminal to open.

Neurotransmitters are released

An influx of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ stimulates vesicles loaded with neurotransmitters to fuse with the presynaptic neuron’s membrane.

Neurotransmitters cross the synapse, 2

Neurotransmitters bind to receptor proteins in the membrane of the postsynaptic cell.

Ion channels on the postsynaptic membrane open

Ion channels open in the postsynaptic cell membrane, changing the likelihood of an action potential in the receiving cell.

Neurotransmitters can be inhibitory or excitatory

Neurotransmitters might have excitatory, inhibitory, or no effect on the postsynaptic cell.

Excitatory = increased chance of action potential

Inhibitory = decreased chance of action potential

Some may have no effect on the post synaptic neuron

Synaptic integration

The postsynaptic cell may receive many stimuli (both excitatory and inhibitory) at once. Synaptic integration determines the cell’s response: if the majority of stimuli are excitatory, then the postsynaptic cell will likely initiate an action potential.

How antidepressants work

Some antidepressants work by affecting neurotransmitter concentrations in synaptic clefts. The drugs \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the sending neuron from re-uptaking the neurotransmitter serotonin, allowing serotonin to remain abundant in synapses.

Subdivisions of the nervous system

The nervous system has several subdivisions.

The function of the central nervous system

The central nervous system (tan) integrates sensory information and coordinates the body’s responses.

The function of the peripheral nervous system

The peripheral nervous system (pink) carries information between the central nervous system and the rest of the body.

The peripheral nervous system: sensory pathways

In the peripheral nervous system, sensory pathways lead to the brain and spinal cord; motor pathways lead to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and glands.

The peripheral nervous system: motor pathways

The neurons controlling motor pathways are classified according to function.

The peripheral nervous system: somatic motor neurons

Somatic motor neurons carry signals to voluntary muscles.

The peripheral nervous system: autonomic motor neurons

Autonomic motor neurons carry signals to involuntary muscles and glands.

Sympathetic and parasympathetic pathways

The autonomic nervous system is further divided into sympathetic and parasympathetic pathways.

Sympathetic nervous system

The sympathetic nervous system dominates under \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and emergencies. The neurons:

increase heart rate and breathing rate

dilate arteries

The parasympathetic nervous system

The parasympathetic nervous system returns body systems to normal. The neurons:

decrease heart rate and breathing rate

constrict arteries

Contrasting roles of the autonomic nervous system

The central nervous system

The central nervous system consists of the brain and spinal cord.

Two types of tissue in the CNS

Two types of nervous tissue occur in the central nervous system:

Gray matter: cell bodies and dendrites

White matter: myelinated \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

The spinal cord

The spinal cord transmits information between the body and the brain.

The spinal cord controls reflexes

The spinal cord also controls \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ without interacting with the brain.

The brain

The brain is divided into several regions.

The brain is divided into several regions

The cerebrum

The cerebrum, part of the forebrain, controls the qualities of what we consider the “\_\_\_\_\_\_\_\_\_\_\_\_\_\_.”

The association areas of the cerebrum

Association functions occur in all four cerebral lobes.

The motor areas of the cerebrum

Motor functions are controlled only by the frontal lobe.

The sensory integration areas of the cerebrum

Sensory integration occurs in the parietal, temporal, and occipital lobes.

The limbic system

The limbic system is also contained within the cerebrum. This “emotional center” of the brain is actually scattered through different brain areas.

The hippocampus

The hippocampus is part of the limbic system responsible for forming long-term memories.

The amygdala

The amygdala is another part of the limbic system. It is responsible for forming emotions such as \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and pleasure.

The central nervous system is protected

Because of its many functions, protecting the central nervous system is vital.

The meninges and cerebrospinal fluid

The CNS is surrounded by meninges, layered membranes that help protect it. Cerebrospinal fluid bathes and cushions the brain and spinal cord.

The blood-brain barrier

The blood-brain barrier protects the brain from extreme chemical fluctuations.

Damage to the CNS can be devastating

Although these protections require energy to produce and maintain, their benefit exceeds their cost. Damage to the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ can be devastating.