Nervous Tissue
Comprised of
- brain
- cranial nerves
- spinal cord
- spinal nerves
- ganglia
- enteric plexus
- sensory receptors
Functions

• sense changes in internal and external environment via sensory receptors

• analyze sensory information, store information and decision making processes

• respond to stimuli via muscles, glands or other nerves
Organization

Central nervous System (CNS)
- brain
- spinal cord

Peripheral nervous System (PNS)
- cranial nerves
- spinal nerves
- sensory and motor components
- ganglia
- receptors

Peripheral Nervous System Subdivisions
- somatic nervous system - voluntary
- autonomic nervous system (ANS) - involuntary
  - sympathetic division
  - parasympathetic division
- enteric nervous system - enteric plexi throughout GI tract
Organization

SNS
- Somatic and special sensory receptors and neurons

ANS
- Autonomic sensory receptors and neurons

ENS
- Sensory receptors and neurons in GI tract and enteric plexuses

CNS: brain and spinal cord

Somatic motor neurons (voluntary)
- Skeletal muscle

Autonomic motor neurons (involuntary): sympathetic and parasympathetic divisions
- Smooth muscle, cardiac muscle and glands

Enteric motor neurons (involuntary) in enteric plexuses
- Smooth muscle, glands, and endocrine cells of GI tract
neuron structure
Multipolar neuron

- Multiple dendrites; one axon;
- Found in brain and spinal cord.
Multipolar
- multiple dendrites; one axon;
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Bipolar
- one dendrite; one axon;
- found in retina of eye, inner ear, and olfactory area of the brain
Multipolar:
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Unipolar:
- Begin as bipolar in fetus.
NEUROGLIA

- oligodendrocyte
- microglia
- astrocytes
- ependyma
Neuroglia
Neuroglia

Oligodendrocytes
• responsible for forming and maintaining the myelin sheath around CNS axons

Microglia
• Phagocytic and act to remove cellular debris formed during the development of the nervous system---also removes damaged nervous tissue

Astrocytes
• are comprised of microfilaments and thereby support neurons
• processes wrap around blood vessels and protect neurons from harmful substances in the blood; responsible for forming the blood-brain barrier

Ependyma
• line the ventricles of the brain and central canal of the spinal cord
• possibly aid in CSF circulation
Ion Channels
Ion channels control the movement of ions through the neuronal cell membrane. Ion channels are

- selective
- passive or active
- regionally located
- functionally unique
Selective Ion Channels

Selective channels select ions for passage based on the charge of the ion, the size of the ion and how much water the ion can attract and hold around it.
Ion channels are either active or passive.

Active channels have gates that either open or close the channel.

Passive channels or leakage channels are always open and allow ions to flow continuously. These channels are located throughout all parts of the neuron.
Voltage Regulated Channels

When a neuron is at rest the voltage regulated gates are closed.

During an action potential, the voltage across the membrane changes with the flux of Na-K causing the voltage channels to open and close.

Ions move through open channels.

Found in axon hillock, nodes of Ranvier, all along unmyelinated axons.
Some neurons have active channels that contain chemically controlled gates.

Neurotransmitters such as acetylcholine (ACH) and GABA bind to chemically gated channels causing them to open. This then permits ions to move across the membrane. Located on dendrites and cell body.
Uniqueness of Ion Channels

Passive channels are responsible for resting membrane potential.

Chemically gated channels are responsible for synaptic potentials or the incoming signals to a neuron.

Voltage gated channels are responsible for the generation and propagation of an action potential - the outgoing signal from the neuron.
Impulse Conduction
Resting Potential

Na+

Sodium channel

m gate

n gate

Plasma membrane

Potassium channel

h gate

K+
Reversal Potential

Sodium channel opens

Potassium channel opens

h gate closes
REPOLARIZATION

1. Extracellular fluid → Inside of Cell
2. Extracellular fluid → Inside of Cell
3. Extracellular fluid → Inside of Cell
4. Extracellular fluid → Inside of Cell
5. Extracellular fluid → Inside of Cell
6. Extracellular fluid → Inside of Cell
Cell body

1 msec

Nodes of Ranvier

Trigger zone

Current flow due to opening of Na⁺ channels

5 msec

Na⁺

10 msec

Saltatory conduction

Leading edge of action potential

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Synapses
When one neuron forms a **gap junction** with another neuron, an electrical synapse is made. Electrical current in the form of ions, flows directly from one neuron to another through the gap junction. These synapses are **ALWAYS excitatory**.
CHEMICAL SYNAPSES

- at a chemical synapse the neuronal membranes are separated by a gap called the **synaptic cleft**. Electrical current CANNOT flow directly from one neuron to another. A chemical called a **neurotransmitter** is released from the sending neuron and carries the signal to the next neuron.
Parts of the Chemical Synapse

- Postsynaptic neuron
- Synaptic vesicles
- Presynaptic neuron
- Synaptic cleft
SYNAPTIC TRANSMISSION
nerve impulse

voltage gated Ca channel

synaptic vesicles

synaptic cleft

neurotransmitters

postsynaptic neuron
1. impulse moves down neuron to axon terminal
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2. Impulse reaches voltage gated Ca channels and the wave of depolarization causes gate to open and Ca ions to move in.
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2. Impulse reaches voltage-gated Ca channels, and the wave of depolarization causes the gates to open, allowing Ca ions to move in.

3. Ca influx recruits synaptic vesicles to migrate to the presynaptic neuron's membrane.
postsynaptic neuron
4. Synaptic vesicles release neurotransmitter into synaptic cleft.
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5. Neurotransmitters attach to specific receptor sites on closed ligand-gated channel.
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6. Neurotransmitter activates channel to open and causes an influx of Na ions triggering an postsynaptic action potential.
Neurotransmitters

**Acetylcholine**
- Major NT found in PNS neuromuscular junction where it excites skeletal muscle, and inhibits cardiac muscle
- is also found in the CNS
- is degraded via acetylcholinesterase

**Glutamate**
- Most common excitatory NT in the CNS
- removed by active pumping back into the presynaptic end bulb

**Gamma amino butyric acid (GABA)**
- Most common inhibitory NT in the CNS
- Anti-anxiety drugs enhance the action of GABA

**Norepinephrine**
- In the brain NE effects sleep and moods.
- In the PNS, NE and epinephrine are main neurotransmitters of sympathetic postganglion synapses
- NE and epinephrine are also produced by the adrenal glands and are responsible for flight or flight responses
- this is a biogenic amine and is degraded enzymatically by monoamine oxidase

**Dopamine**
- Found in the brain is involved in emotional responses and skeletal muscle movement
- this is a biogenic amine and is degraded enzymatically by monoamine oxidase

**Seratonin**
- Found in the brain is involved in temperature regulation, sleeping, sensory perception and moods
- this is a biogenic amine and is degraded enzymatically by monoamine oxidase
Neurotransmitters Continued

Neuropeptides
- widespread throughout CNS and PNS
- some act as hormones

Endorphins and Enkephalins
- involved in natural pain killing
- biochemical derivatives of morphine and heroin
- produce euphoric effects

Nitric Oxide
- is not produced by vesicles like other NE
- is lipid soluble and diffuses out of the neuron
- acts to cause changes in cellular enzymes instead of a membrane receptor
- causes blood vessel vasodilation
- Phagocytes release NO in higher toxic levels to destroy invading cells
Neurotransmitter Removal

NT removal is absolutely necessary for normal synaptic function.
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- Some NT are blocked from reuptake by therapeutic drugs. Neuromodulators as Welbutin and Prozac are **selective serotonin reuptake inhibitors (SSRI)**. By preventing reuptake, stimulation is prolonged.