Nervous System

Communication Center

Regulation

Neural *vs.* Hormonal

Nervous System

•The Neural System is only 3% of your body weight, but is the most complex organ system.

•Nervous impulses are fast acting (milliseconds) but short lived.

Overview

•The nervous system includes all neural tissue in the body.

Basic units are:

a. Neurons (individual nerve cells)

b. Neuroglia

- supporting cells
- separate & protect the neurons
- provide supporting framework
- act as phagocytes
- regulate composition of interstitial fluid
- a.k.a. glial cells
- outnumber neurons

Two Anatomical Divisions of The Nervous System

1. **CNS**: Central Nervous System
   - Brain & Spinal Cord
   - Responsible for integrating, processing, & coordinating sensory data and motor commands. ***i.e.-*** stumble example
   - The brain is also the organ responsible for intelligence, memory, learning, & emotion

2. PNS: Peripheral Nervous System

- All nervous tissue outside CNS
- Carries sensory data to CNS, carries motor commands from the CNS.
- Bundles of nerve fibers carry impulses in the PNS are known as peripheral nerves or just "nerves".
- Nerves attached to the brain are called cranial nerves. Nerves attached to the spinal cord are called spinal nerves.

PNS has 2 functional divisions

Afferent Division (Sensory)
•Bring sensory information to CNS from receptors in peripheral nervous tissue & organs.

Efferent Division (Motor)
•Carries motor commands from CNS to muscles & glands, these target organs are called **effectors**.

The Efferent Division is broken into Somatic & Autonomic Components

(SNS) Somatic System: controls skeletal muscle contractions these can be voluntary (conscious) or involuntary (unconscious) {reflexes}.

(ANS) Autonomic System:

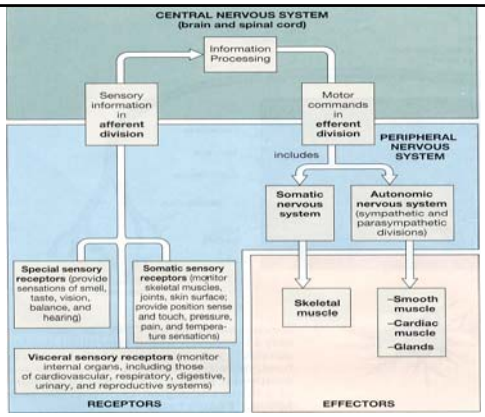
* a.k.a. visceral motor units

*control autonomic, involuntary regulation of smooth muscle, cardiac muscle, & glandular activity.

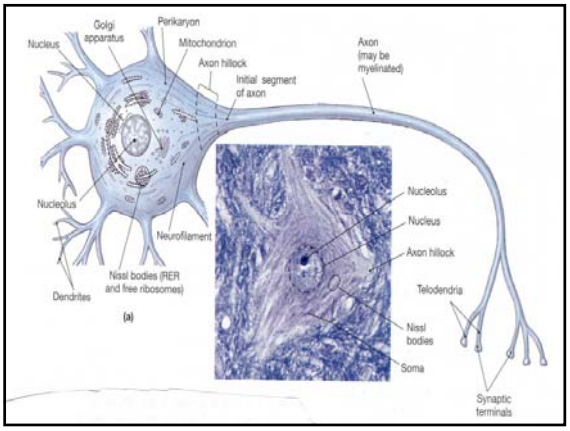
The ANS has a:

sympathetic division
parasympathetic } **antagonistic effects**

•The **sympathetic** (Fight or Flight) increases heart rate, **parasympathetic** decrease heart rate, etc.



Neurons



Perikaryon: contains

1. numerous mitochondria

2. free & fixed ribosomes

3. membranes of rough ER (give perikaryon a grainy appearance)

- Some areas of perikaryon contain RER & free ribosome clusters which stain darkly. These are called **Nissl Bodies.** These give the tissue a grey color and are therefore present in "**gray matter**".
- Typically, perikaryon lacks centrioles which are required for cell division, so the CNS is not generally repaired after an injury.

Dendrites

•Typically highly branched

•Sensitive processes

•Each branch has small processes of its own called dendrite spines

•Specialized to receive nervous impulses

•Impulse travel to soma

Axon

•Long cytoplasmic process

• Can propogate an action potential

•Impulses travel away from soma

•The axon has it's own axoplasm and membranous axolemma

•The axonal trunk may have branches called collaterals

The Synapses

•A special site of intercellular communication

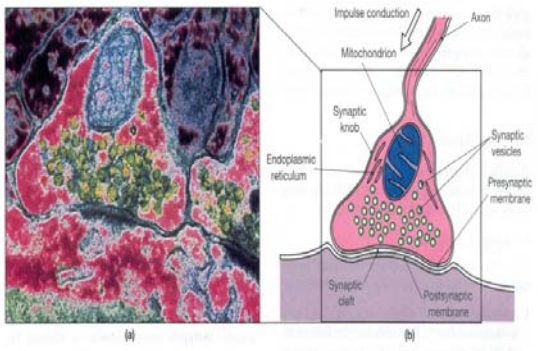
•Two cells at each synapse

a. pre-synaptic cell (synaptic terminals sends impulses)

b. post-synaptic cells (receives the impulses)

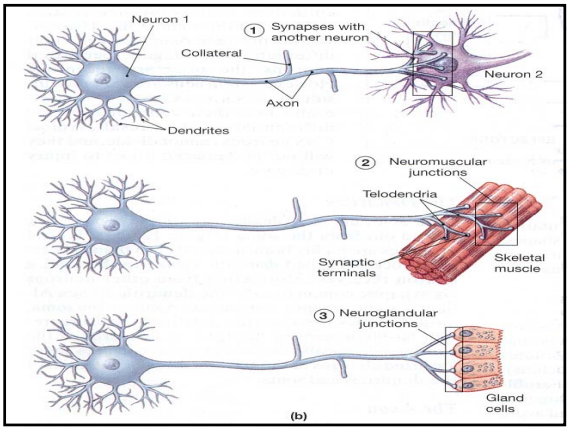
•Generally the impulse transmission proceeds by the release of chemicals called neurotransmitters.

•When a neuron forms a junction w/ a different cell type, it's called a neuroeffector junction.



Two main types of Neuroeffector Junctions

- **neuromuscular junction** (nerve cell communicates w/ a muscle cell)
- **neuroglandular junction** (nerve cell communicates w/ a gland cell)



Neurons are classified in two ways

1. Structurally

a. anaxonic (no axon)
- *axons indistinguishable from dendrites
- *occur in brain & special sensory organs
- *function poorly understood

b. bipolar
- *two distinct processes
- *a dendritic and an axonic end (30cm long total)
- *rare but found in sensory organs (eyes, nose, ear)

c. unipolar
- *dendritic and axonal processes are continuous
- *cell body lies off to one side
- *most sensory cells of PNS are this type
- *can be one meter long

d. multipolar
- *several dendrites, single axon
- *most common neurons in CNS
- *motor command carrying neurons are this type
- *can be 1 meter long

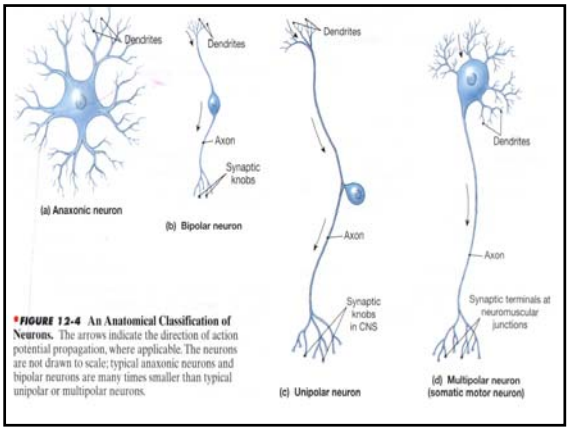


*FIGURE 12-4 An Anatomical Classification of Neurons. The arrows indicate the direction of action potential propagation, where applicable. The neurons are not drawn to scale; typical anaxonic neurons and bipolar neurons are many times smaller than typical unipolar or multipolar neurons.

2. Functional Classification

a. Sensory Neurons

*Afferent division of PNS

*Carry sensory impulses from sensory receptors → CNS

*These neurons are called **<u>afferent fibers</u>**

*there are ≈ 10 million sensory neurons in the human body

Somatic sensory neurons: monitor the external environment, and or position in it.

Visceral sensory neurons: monitor internal conditions and the status of the various organ systems.

Receptors are broadly categorized as:

exteroceptors: provide information about external environment.
*Touch, temp., sight, taste, pressure, smell, hearing.

proprioceptors: monitor the position and movement of skeletal muscles & joints.

interoceptors: monitor digestive, respiratory, CV, urinary, repro systems and provide some taste, deep pressure & pain sensation.

Motor Neurons

- Efferent division of PNS
- Motor commands: instructions from CNS → peripheral effectors
- Stimulates or modifies activity of peripheral tissue, organ, or organ system.
- there are ≈500,000 motor neurons in the human body
- These are called **efferent fibers**

Somatic motor neurons: innervate skeletal muscles, voluntary control

Visceral motor neurons: innervate all peripheral effectors other than muscles.

c. Interneurons

- a.k.a. association neurons
- situated btn. sensory & motor neurons
- located only and entirely in the brain & spinal cord
- ≈20 billion interneurons (most abundant neurons)
- Responsible for:
  a. distribution of sensory information
  b. coordination of motor activity

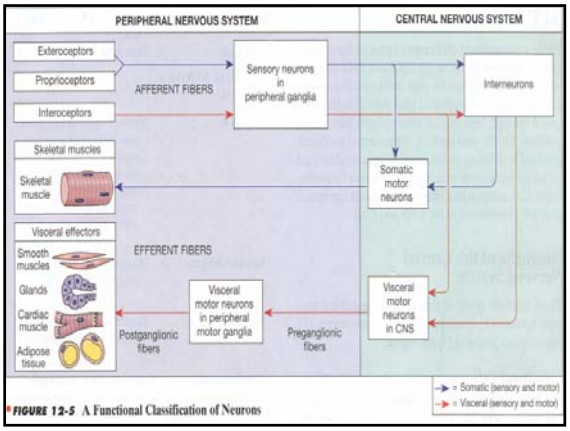
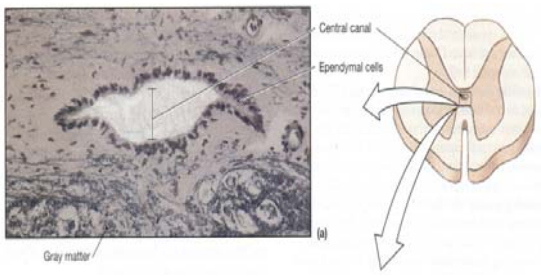


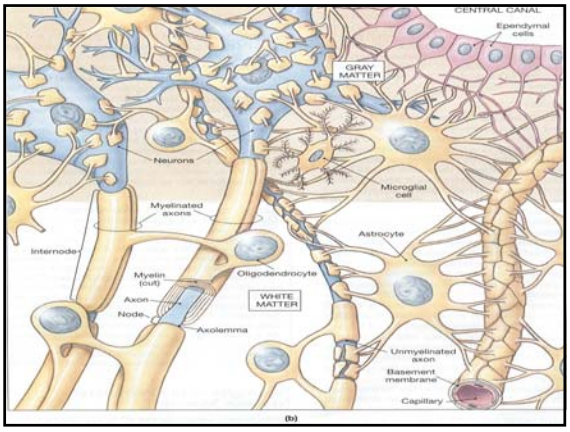
FIGURE 12-5 A Functional Classification of Neurons

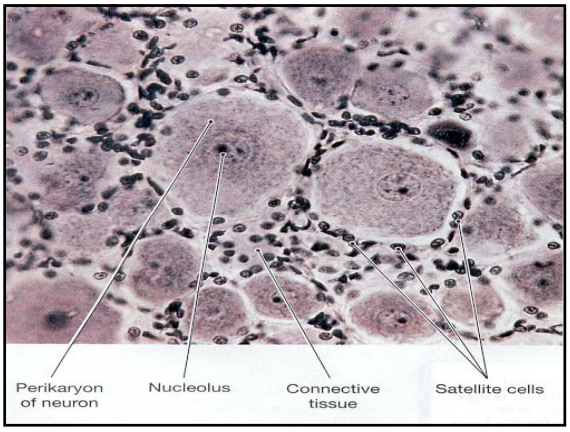
Neuroglia

CNS: Cell Type	Function
Astrocyte	maintain blood brain barrier, provide structural support, regulate (ION, nutrient, dissolved gas) conc., absorb & recycle neurotransmitters, assist in tissue repair
Oligodendrocyte	mylenate CNS axons, provide structural framework
Microglia	remove cell debris, wastes & pathogens by phagocytosis
Ependymal Cells	line cavities (ventricles) in the brain & spinal cord, assist in protection, circulation and monitoring of CSF



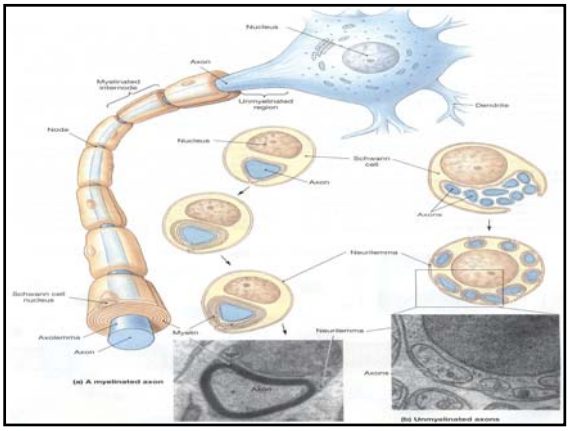
PNS: Cell Type	Function
Satellite Cells	surround neuron cell bodies & ganglia
Schwann Cells	cover all axons in PNS, responsible for mylenation, participate in injury repair.





Myelin sheath - A spiral membrane that surrounds the axon of some neurons. The membrane is composed of fatty (lipoprotein) membranes. There is an analogy with the insulation of electrical wires. In the PNS This sheath is produced by glial cells called ***Schwann cells***. Neurons whose axons are myelinated are referred to as ***white matter*** while unmyelinated neurons are called ***gray matter***.

Nodes of Ranvier - Gaps in the myelin sheath. The only place where the plasma membrane is exposed. These nodes function in ***saltatory conduction***.



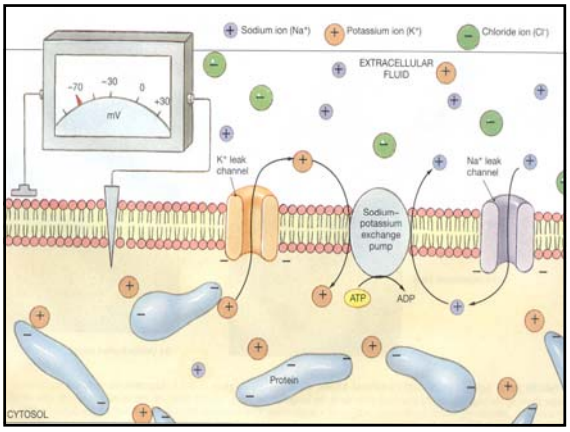
Multiple Sclerosis - A progressive destruction of the myelin sheath of neurons in the CNS. The sheaths deteriorate to hardened scars or plaques, in multiple regions, thus the name. The plaques interfere with nerve impulse transmission. The average age of onset is 33. The disease is unpredictable. Some people experience complete remissions, while others gradually accumulate neurological problems. MS does not necessarily shorten life.

Neurophysiology

The Transmembrane Potential

•The **electrochemical gradient** is the sum of all chemical and electrical forces acting across the membrane.

•The resting potential of a neuron, about -70 mV, is determined chiefly by the membrane permeability to potassium ions.



CELL MEMBRANE POTENTIAL

1. A cell membrane is usually ***polarized*** as a result of an unequal distribution of ions.

2. Distribution of ions.

a) The distribution of ions is due to the presence of pores and channels in the membranes which allow passage of some ions, but not others. K+ pass more easily through cell membranes than do Na+.

3. Resting potential

a) There is a high concentration of Na+ *outside* the membrane and a high concentration of K+ *inside* the membrane.

b) There are large numbers of negative ions inside the cell.

c) In a resting cell, more positive ions leave the cell than enter. Therefore, the outside of the membrane develops a positive charge.

4. Potential changes

a) Stimulation of a membrane affects its resting potential.

b) When it's resting potential decreases, a membrane becomes ***depolarized***.

c) Potential changes are subject to ***summation***.

d) If threshold potential is achieved, an action potential is triggered.

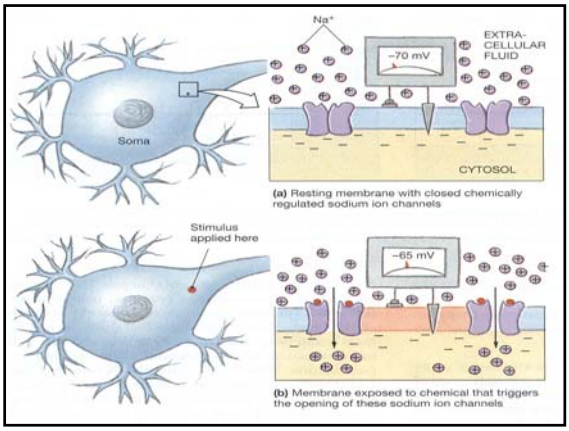
5. Action potential – The actual nerve impulse.

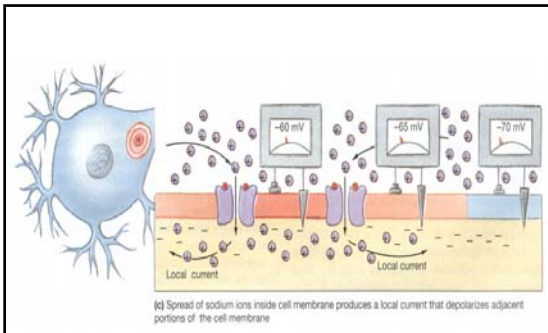
a) When a threshold stimulus is provided, the sodium channels open, and Na+ diffuse inward, causing depolarization.

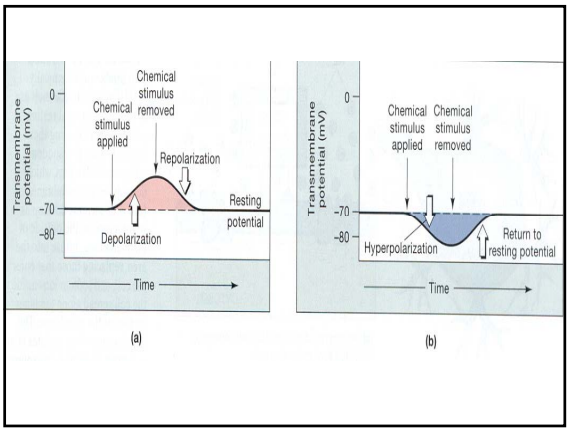
b) At the same time, potassium channels open, and K+ diffuse outward causing repolarization.

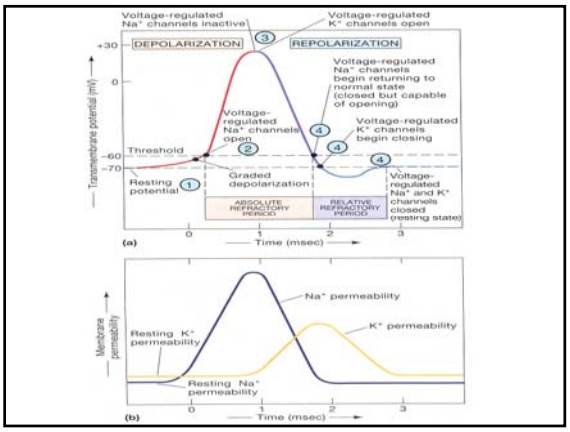
c) This rapid change in potential is called an ***action potential***.

d) Many action potentials can occur before an active transport mechanism reestablishes the original resting potential.









NERVE IMPULSE

1. **Impulse conduction**
   - **a**) Unmyelinated fibers conduct impulses that travel over their entire surfaces.
   - **b**) Myelinated fibers conduct impulses more rapidly. (Saltatory conduction)

2. **All-or-none response**
   - **a**) A nerve impulse is conducted in an ***all-or-none*** manner whenever a stimulus of threshold intensity is applied to a fiber.

Synaptic Transmission

•An action potential traveling along an axon is a **nerve impulse**. At a synapse btn. two neurons, information passes from **presynaptic neuron** to the **postsynaptic neuron**. A synapse may also involve other types of postsynaptic effector cells.

•A synapse may be either electrical (with direct physical contact btn. cells) or chemical (involving a neurotransmitter).

Electrical Synapses

•**Electrical synapses** are relatively rare in the CNS and PNS. At an electrical synapse, the presynaptic and postsynaptic cell membranes are bound by interlocking membrane proteins at a gap junction. Pores within these proteins permit the passage of local currents, and the two neurons act as if they shared a common cell membrane.

Chemical Synapses

•**Chemical synapses** are more common than electrical synapses. **Excitatory** neurotransmitters cause depolarization and promote action potential generation, whereas **inhibitory neurotransmitters** cause hyperpolarization and depress action potential generation.

•The effect of a neurotransmitter on the postsynaptic membrane depends on the properties of the receptor, not on the nature of the neurotransmitter.

•**Cholinergic synapses** release the neurotransmitter acetylcholine (ACh).

•**Adrenergic synapses** release **norephinephrine (NE),** also called **noradrenaline**. Other important neurotransmitters include **dopamine**, **serotonin**, and **gama aminobutyric acid (GABA)**.

Acetylcholine - voluntary movement of the muscles

Norepinephrine - wakefulness or arousal

Dopamine - voluntary movement and emotional arousal

Serotonin - memory, emotions, wakefulness, sleep and temperature regulation

GABA (gamma aminobutyric acid) - motor behaviour

Drugs & Synaptic Function

- Many drugs interfere with key steps in synaptic transmission process.

These drugs may:

1. Interfere with transmitter synthesis

2. Alter the rate of transmitter release

3. Prevent transmitter activation

4. Prevent transmitter from binding to receptors

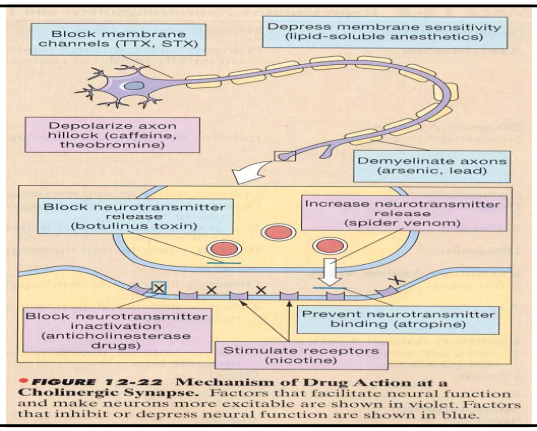


FIGURE 12-22 Mechanism of Drug Action at a Cholinergic Synapse. Factors that facilitate neural function and make neurons more excitable are shown in violet. Factors that inhibit or depress neural function are shown in blue.

•**Botulinus toxin** blocks the release of Ach at the presynaptic membrane causing paralysis.

•The **venom of a black widow spider** has the opposite effect. It causes a massive release of ACh that causes intense muscular cramps and spasms.

•**Caffeine** depolarizes axon hillock.

•**Nicotine** binds to ACh receptor sites and stimulates the postsynaptic membrane.