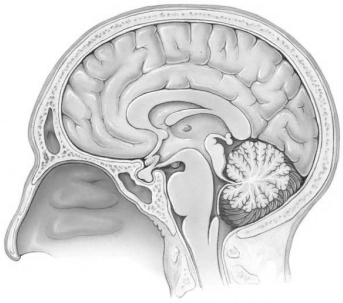
Chapter 38:
The Nervous System and the Senses

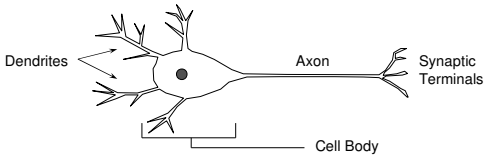


Neurons:

Specialized “excitable” cells that allow for communication throughout the body via electrical impulses

Neuron Anatomy / Function:

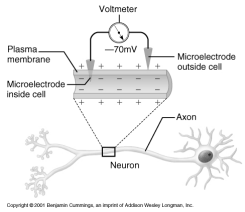
1) Dendrites: Receive information (environment / neurons):
2) Cell Body: Integrate information / initiate response
3) Axon: Conduct signal
4) Synaptic Terminals: Transmit signal (neurons / effector organs)



Neurons Transmit Signal via Action Potentials:

Action Potential (AP): The electrical signal passed along a neuron

- At rest, neurons maintain an electrical difference across their membrane (pg. 666)
  - (-) inside cell; (+) outside cell

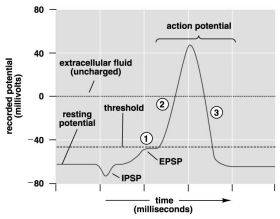


Resting Membrane Potential (RMP)

Neurons Transmit Signal via Action Potentials:

Action Potential (AP): The electrical signal passed along a neuron

- At rest, neurons maintain an electrical difference across their membrane (pg. 666)
  - (-) inside cell; (+) outside cell
- During action potential, charges flip
  (+) inside; (-) outside)



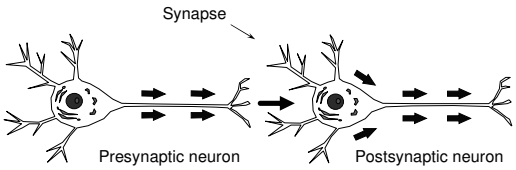
Neurons Transmit Signal via Action Potentials:

Action Potential (AP): The electrical signal passed along a neuron

- At rest, neurons maintain an electrical difference across their membrane (pg. 666)
  - (-) inside cell; (+) outside cell
- During action potential, charges flip
- Action potential propagated down axon

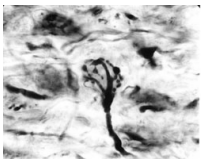
Neurons Communicate at Synapse:

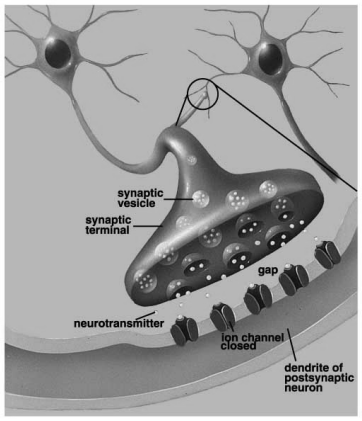
Synapse: Region separating two neurons or neuron and muscle



- Electrical impulse converted to chemical cue (neurotransmitter) and then back to electrical impulse
  - Neurotransmitter may excite or inhibit postsynaptic neuron

Synapse:





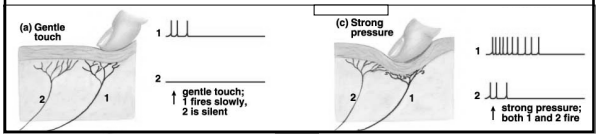
(Figure 38.4)

Common Neurotransmitters:

1) Acetylcholine: Activates skeletal muscle (muscle)
   - Curare blocks Ach receptor
2) Dopamine: Controls movement (brain)
   - Parkinson's Disease
3) Epinephrine: Activates fight-or-flight response (body)
   - a.k.a. Adrenaline
4) Serotonin: Influences mood (brain)
   - Anti-anxiety / anti-depressants
5) Endorphins: Influences mood; reduces pain sensation
   - Runner's high

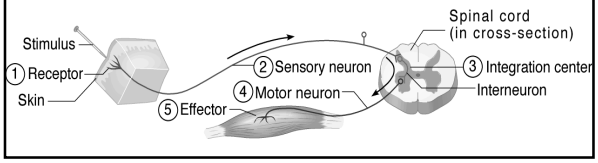
Information Processing in the Nervous System:

1) Determine stimulus type (e.g. light / sound / touch)
   - All APs are similar in structure
     - Wiring pattern in brain distinguishes stimuli
2) Signal intensity of stimulus
   - All APs are similar in size (all-or-none response)
   - Intensity coded by:
     1) Frequency of action potentials
     2) # of neurons responding



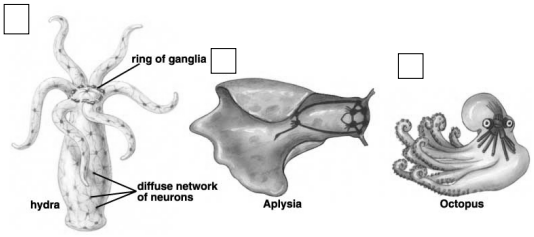
Neural Pathways Direct Behavior:

- Reflex: Involuntary movement in response to stimulus
  - Simplest behavior:
    1) Receptor: Detects stimulus
    2) Sensory neuron: Sends stimulus message
    3) Association neuron: Integrates stimuli
    4) Motor neuron: Activates effector
    5) Effectors: Performs function (muscle / gland)



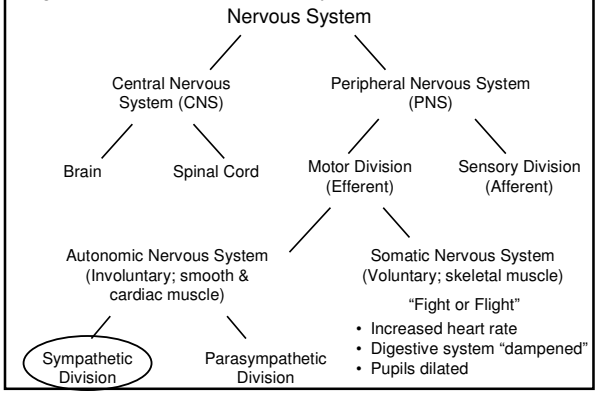
Increased Complexity in Nervous System = Increased centralization

Nerve Net: Nervous tissue woven throughout body (no head)
Cephalization: Nervous tissue centralized in "head" region

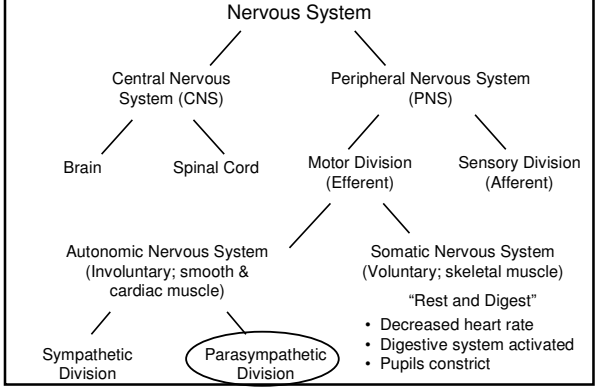


Nerve Net → Cephalization

Organization of Human Nervous System:



Organization of Human Nervous System:

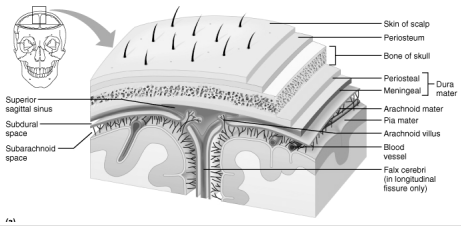


"Rest and Digest"

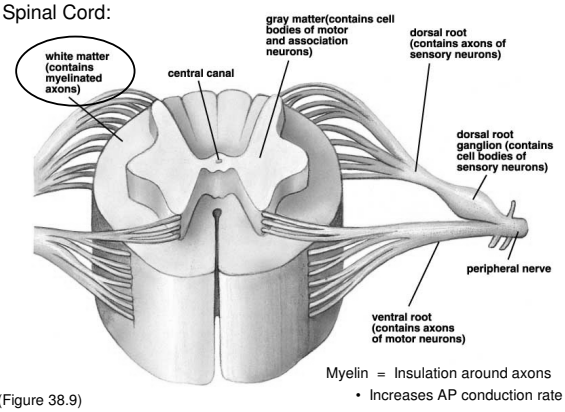
- Decreased heart rate
- Digestive system activated
- Pupils constrict

Protection of Central Nervous System:

1) Bone (Brain = Skull; Spinal Cord = vertebrae)
2) Meninges (Triple-layer of connective tissue)
   - Contains cerebrospinal fluid (cushioning / nourishment)
3) Blood-brain Barrier
   - Selective barrier lining cranial blood vessels



Spinal Cord:

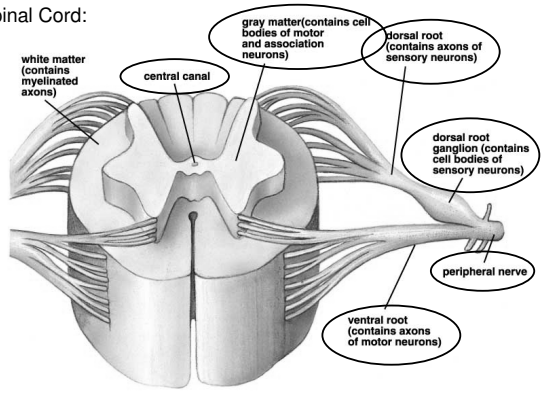


(Figure 38.9)

Myelin = Insulation around axons

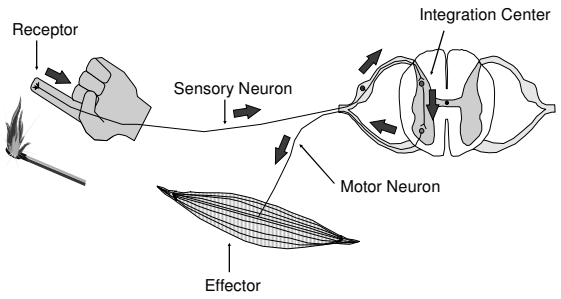
- Increases AP conduction rate

Spinal Cord:

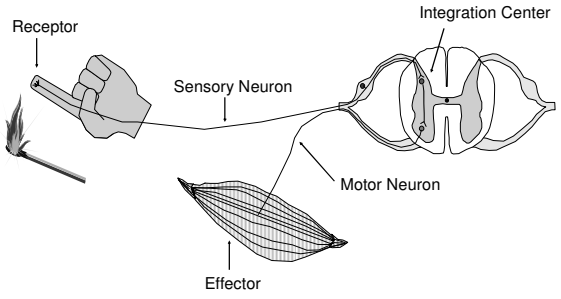


(Figure 38.9)

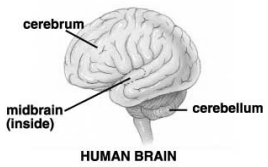
Reflex:



Reflex:



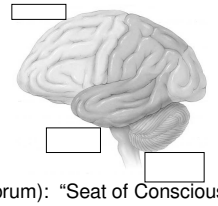
The Brain:



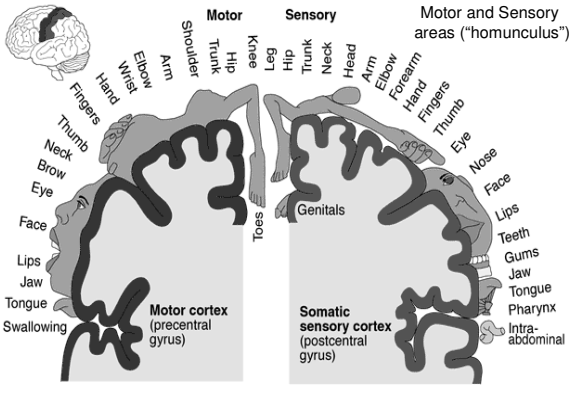
HUMAN BRAIN (Figure 38.11)

1) Hindbrain: Automatic Behaviors
   A) Medulla: Control of breathing, heart rate, blood pressure
   B) Pons: Controls wake/sleep transitions; sleep stages
   C) Cerebellum: Coordinates movement
2) Midbrain: Relay / "Screening" Center
   A) Reticular Formation: Controls arousal of brain
      • Filters sensory input from body
   B) Visual / Auditory Reflex Centers

The Brain:

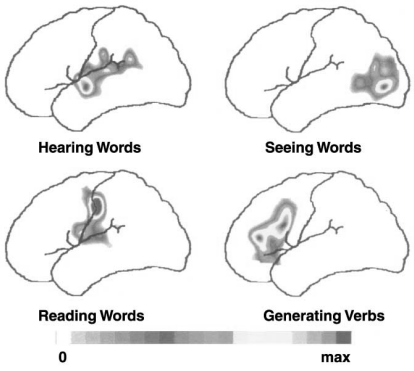

(Figure 38.14)

3) Forbrain (Cerebrum): "Seat of Consciousness"
   A) Cerebral Cortex
      • Divided into two hemispheres (Connection = Corpus Callosum)
         • Left hemisphere controls right side of body (vise versa)
      • Four regions:
         1) Frontal: Primary motor area; complex reasoning
         2) Parietal: Primary sensory area
         3) Temporal: Primary auditory and olfactory areas
         4) Occipital: Primary visual area



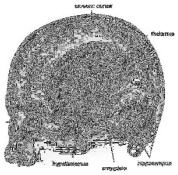
Motor and Sensory areas ("homunculus")

Cortical Regions Involved
in Different Tasks:



(Figure E38-3)

The Brain:



(Figure 38.13)

3) Forbrain (Cerebrum): "Seat of Consciousness"
   B) Limbic System
      - Produce emotions; form memories
      - Hypothalamus: Homeostatic control center
        - Regulation of temperature; water balance; food intake
      - Hippocampus: Formation of long-term memory
   C) Thalamus
      - Relays information from body to limbic system / cerebral cortex

What is a Sensory Receptor?

Answer: Specialized cells that produce signals when acted on by external stimulus

- Transducer: Converts signal from one form to another
  - e.g. Smell: chemical signal $\rightarrow$ electrical signal

Receptors named after stimuli they respond to:

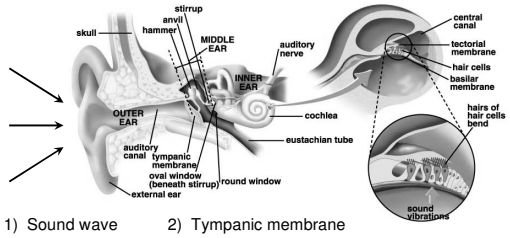
1) Thermoreceptors: Heat / Cold
2) Mechanoreceptors: Vibration; pressure; motion; gravity
3) Photoreceptors: Light (photons)
4) Chemoreceptors: airborne/waterborne molecules
5) Nociceptors: Pain (chemical release)

Sound:

Ear: Sound → Electrical Signal

3) Vibration pass to inner ear (hammer/anvil/stirrup)

4) Vibration enters cochlea; vibrates hair cells



1) Sound wave enters ear (auditory canal)

2) Tympanic membrane vibrates

5) Hair cells release neurotransmitters; Auditory nerve excited

Vision:

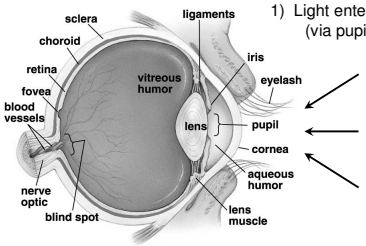
Eye: Light → Electrical Signal

Compound Eye

2) Light focused by lens on retina

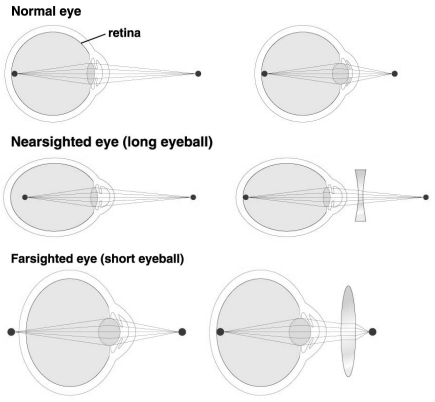
3) Light triggers receptors; optic nerve excited

1) Light enters eye (via pupil)



- Retina = Multi-layered sheet of photoreceptors & neurons
  - Rods: Dim-light vision (most abundant - scattered)
  - Cones: Color vision (Red / green / blue - Fovea)

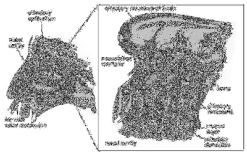
Focusing via Lens:



(Figure 38.20)

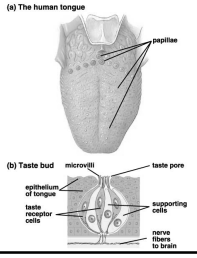
Odor/Taste:

Nose / Tongue: Chemical → Electrical Signal



1) Chemicals enter nasal cavity; bind to receptors (olfactory epithelium)

2) Olfactory bulb excited



1) Dissolved chemicals enter taste buds on tongue (via taste pore)

2) Chemicals bind with receptors; stimulate nerves

- Four primary tastes:
  - Sweet / Salt / Bitter / Sour (scattered)
- Olfaction enhances taste

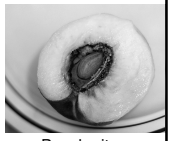
Cats & Catnip

- Genetically controlled
  - ❖33% of cats lack the receptors to react to catnip.
- Oil in the catnip causes the reaction
  - ❖Which is why fresh is better than dried catnip.

Some people cannot taste bitter

- 75% of humans & chimps can taste bitter
- Believed to evolve in both because bitter plants are often poisonous

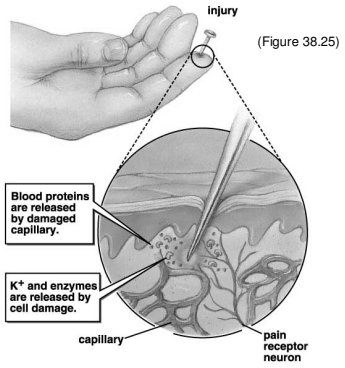
Poison hemlock



Peach pits

Pain is a specialized Chemical Sense:

1) Damaged cells spill chemicals
2) Nociceptors detect [↑] of potassium ion



(Figure 38.25)

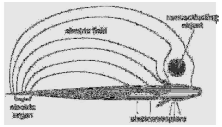
Other Senses:

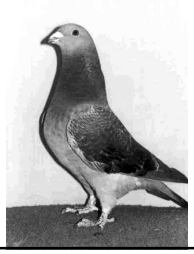
Echolocation:

Animal emits pulse - interprets returning signal

Electrolocation:

Animal produces electrical field - interpret distortion in field





Magnetic Field Detection:

Animals detect and orient based on earth's magnetic field

Echolocation video

- Linky