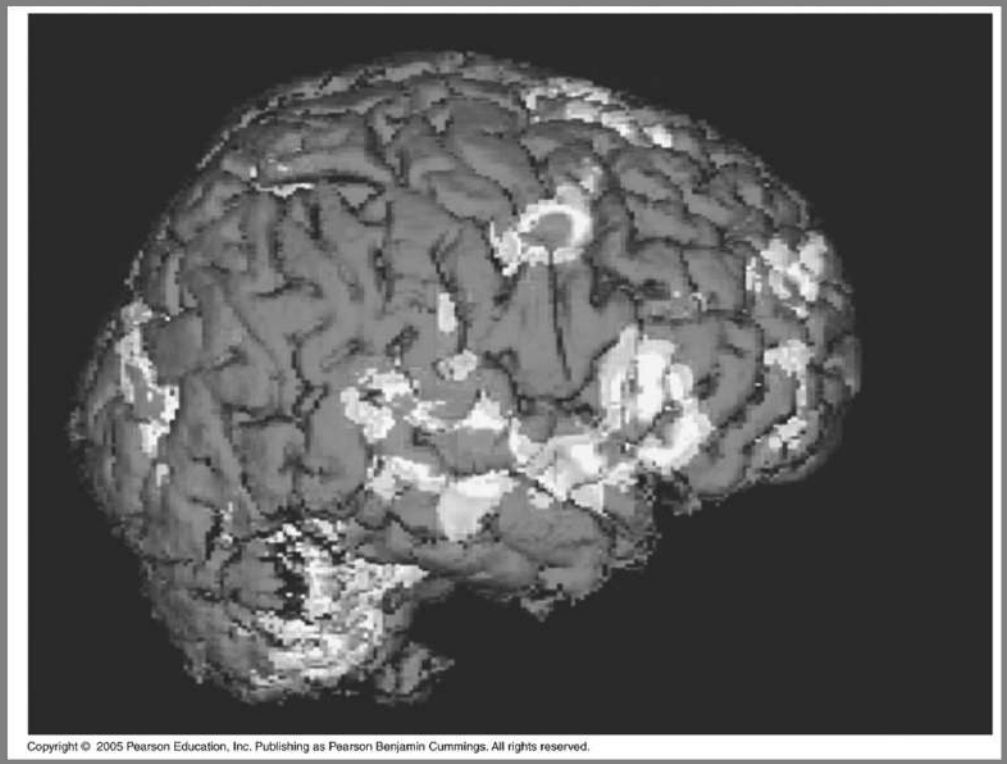



# Nervous Systems

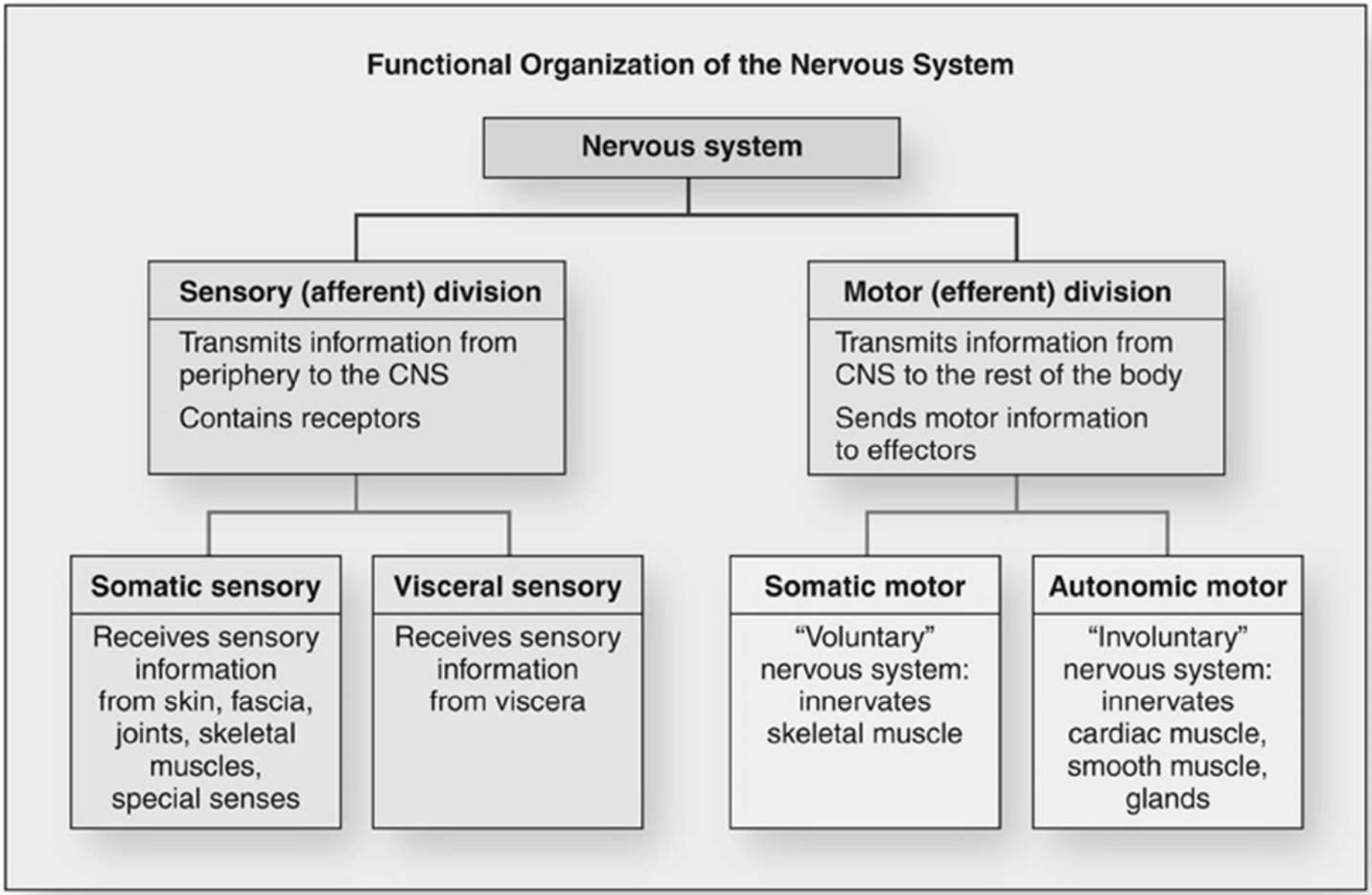
Chapters 48 & 49
Campbell Biology – 11th ed.

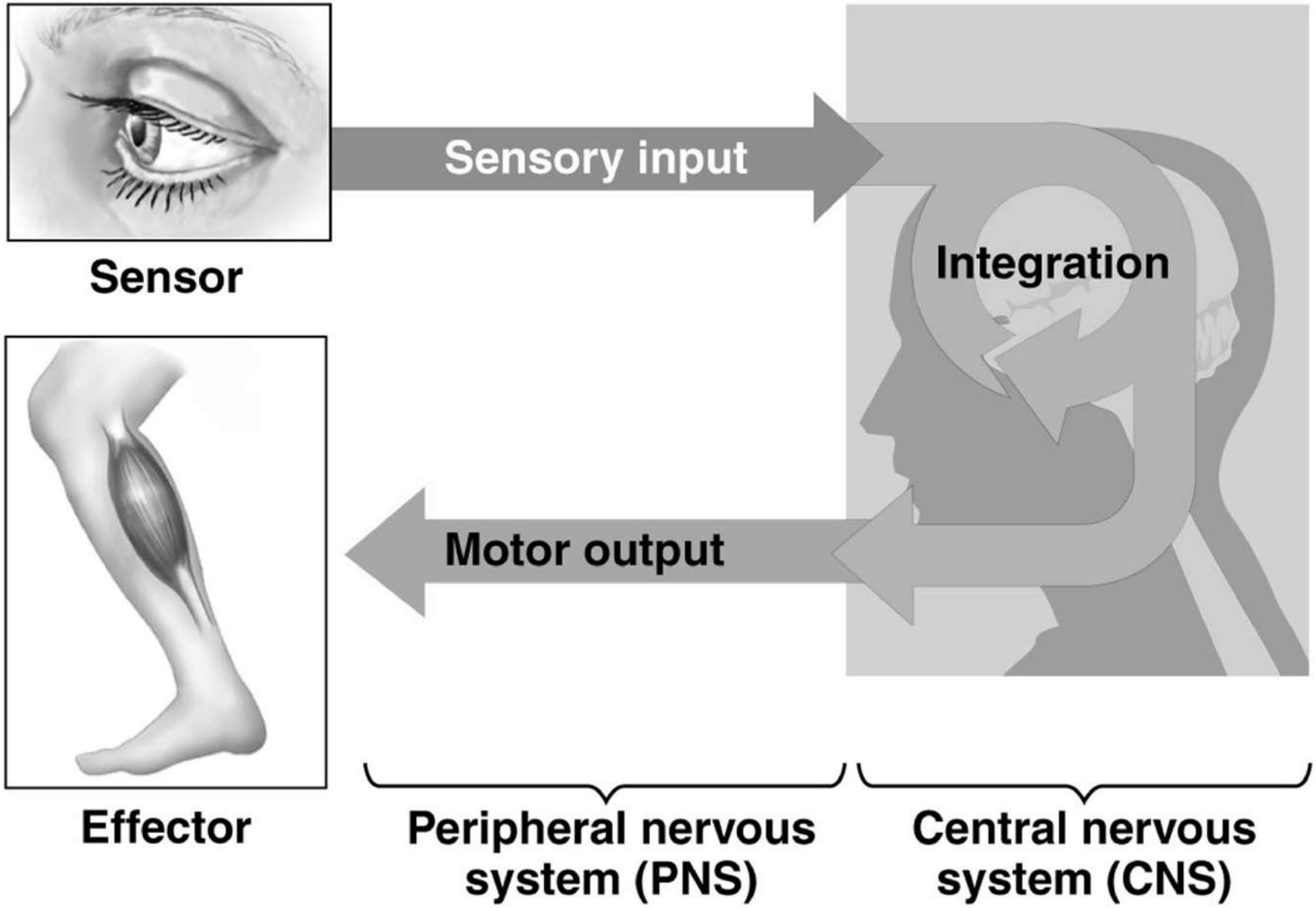
# You must know

- The anatomy of a neuron.
- The mechanisms of impulse transmission in a neuron.
- The process that leads to release of neurotransmitters, and what happens at the synapse.
- How the vertebrate brain integrates information, which leads to an appropriate response.
- Different regions of the brain have different functions.

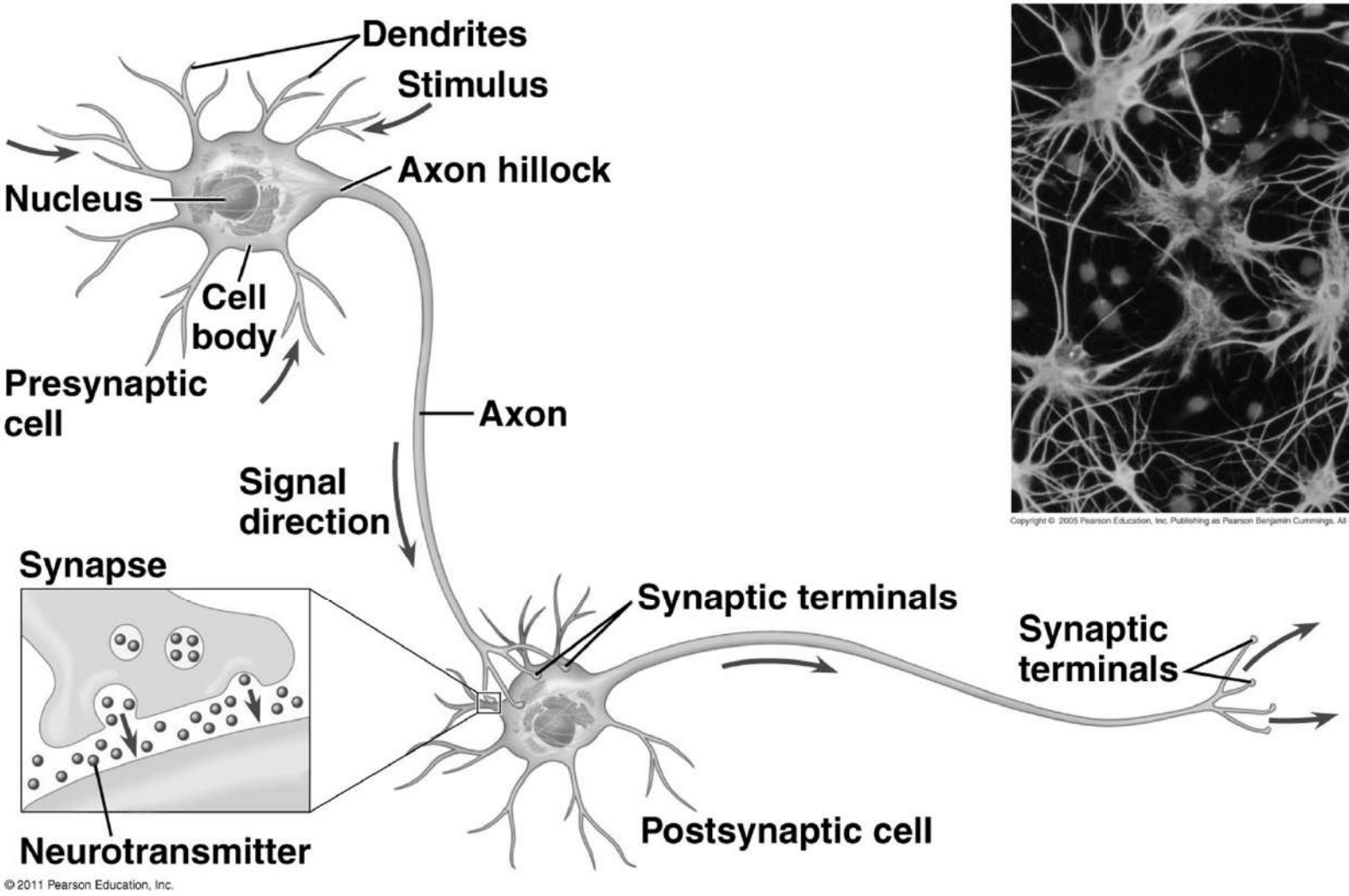
# Organization of the Nervous System

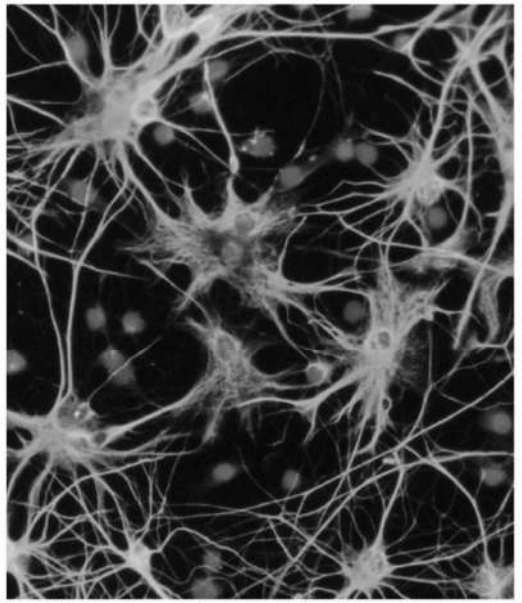
- **Central nervous system (CNS)** = brain + spinal cord
- **Peripheral nervous system (PNS)** = nerves throughout body
  - **Sensory receptors**: collect info
  - **Sensory neurons**: body → CNS
  - **Motor neurons**: CNS → body (muscles, glands)
  - **Interneurons**: connect sensory & motor neurons
- **Nerves** = bundles of neurons
  - Contains motor neurons +/or sensory neurons





# Neuron = dendrite + cell body + axon

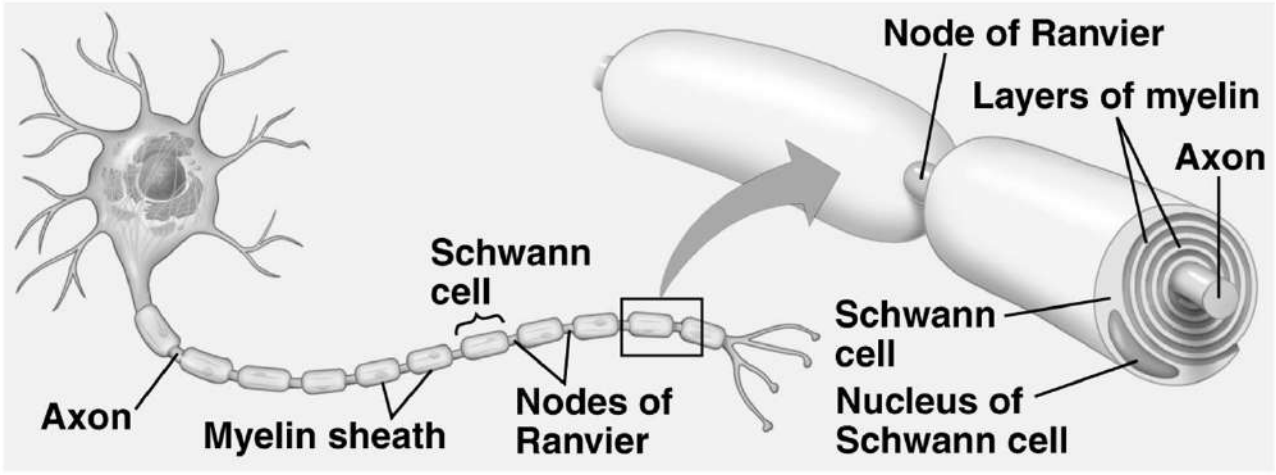


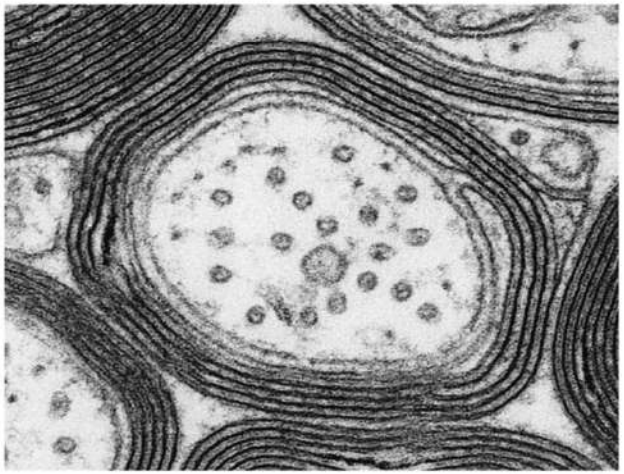



# Neuron

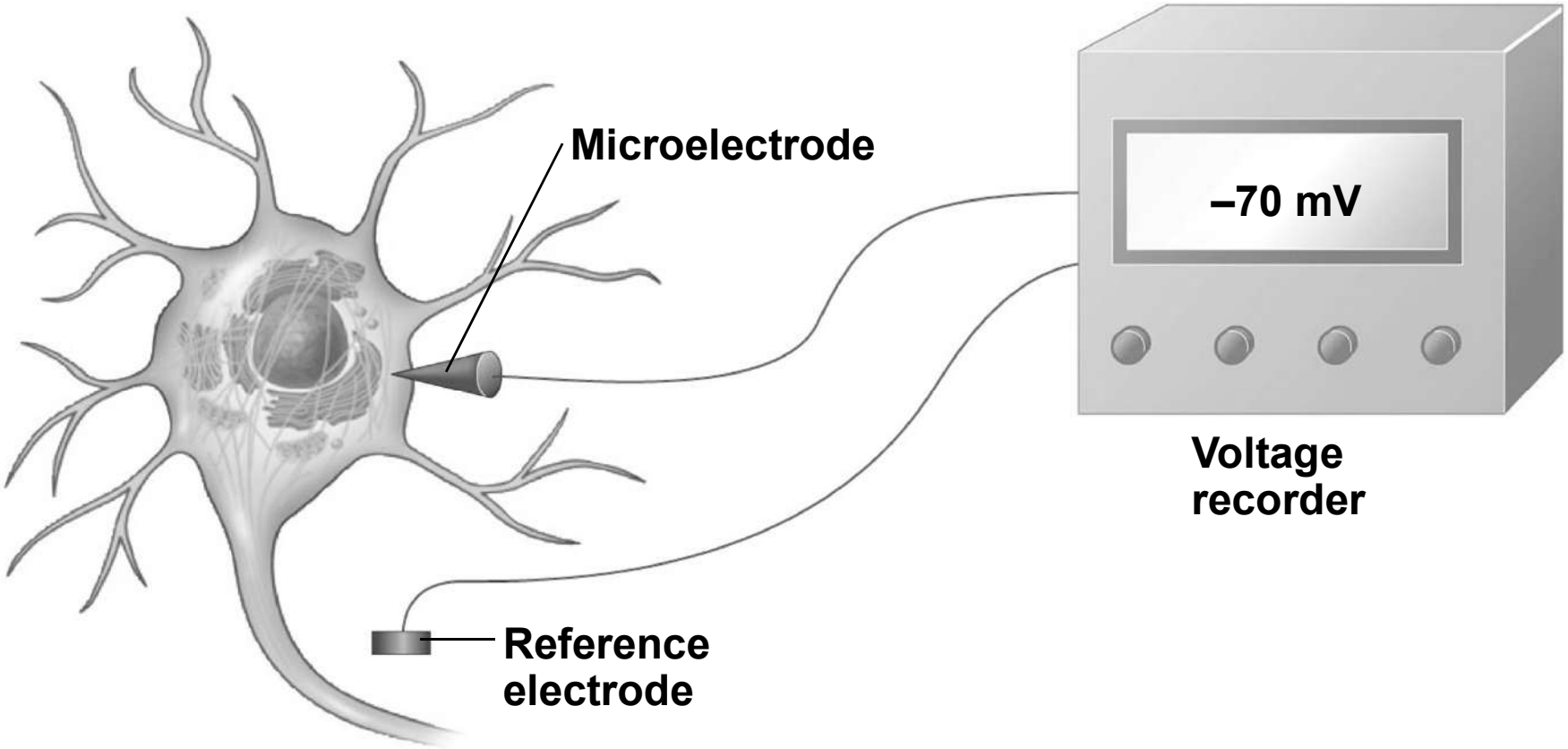
- **cell body**: contains nucleus & organelles
- **dendrites**: receive incoming messages
- **axons**: transmit messages **a**way to other cells
- **myelin sheath**: fatty insulation covering axon, speeds up nerve impulses
- **synapse**: junction between 2 neurons
- **neurotransmitter**: chemical messengers sent across synapse
- **Glia**: cells that support neurons
  - Eg. **Schwann cells** (forms myelin sheath)

# Schwann cells and the myelin sheath

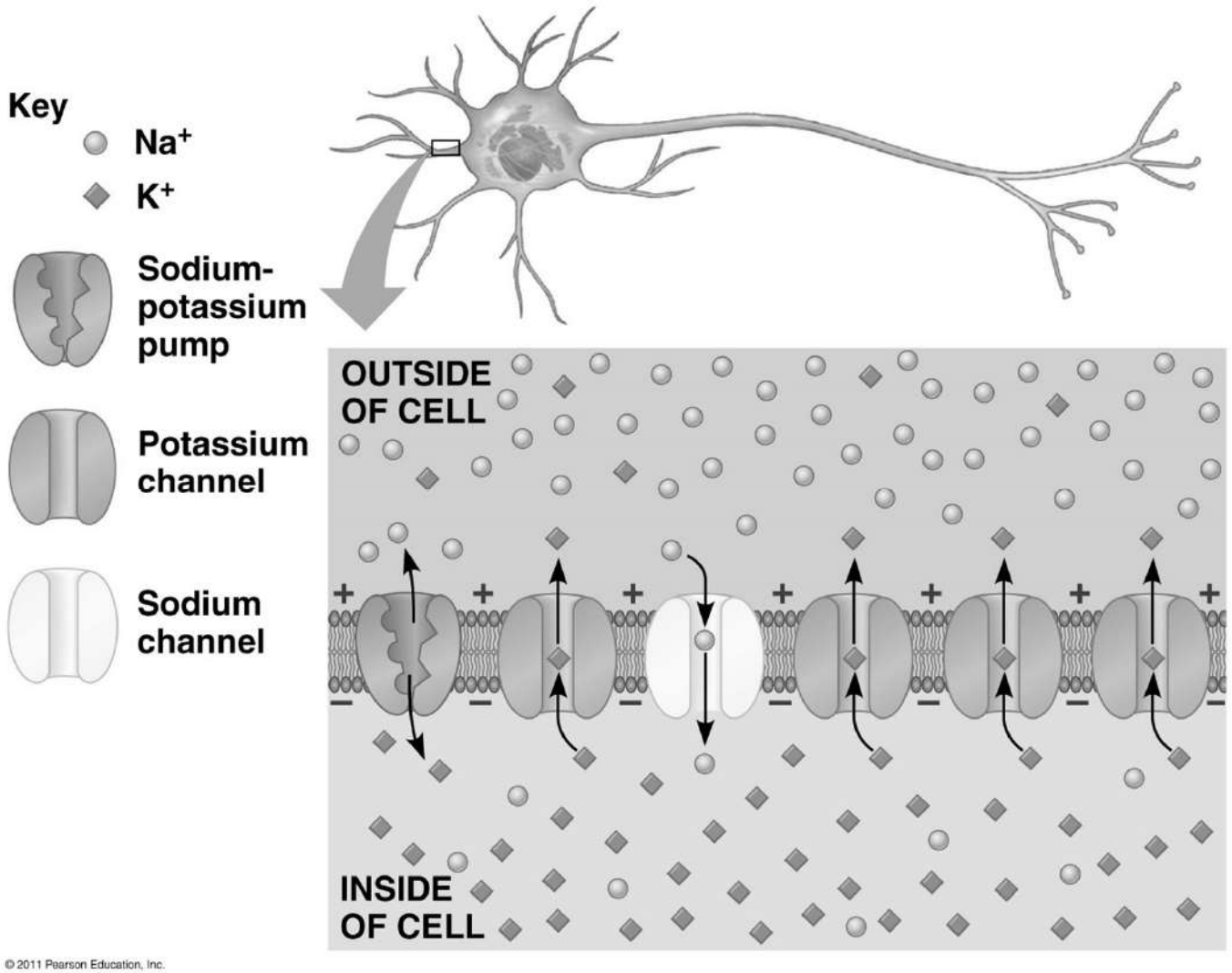


# Membrane Potential: difference in electrical charge across cell membrane

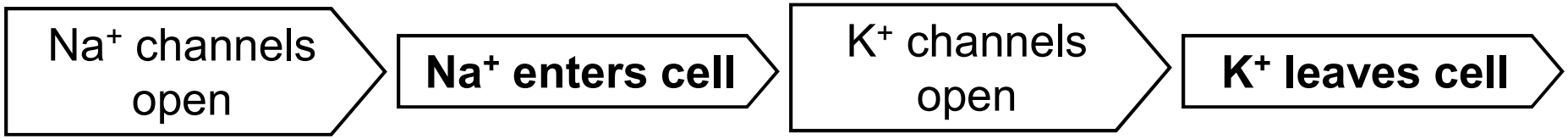


# The $Na^+/K^+$ pump (using ATP) maintains a negative potential inside the neuron.

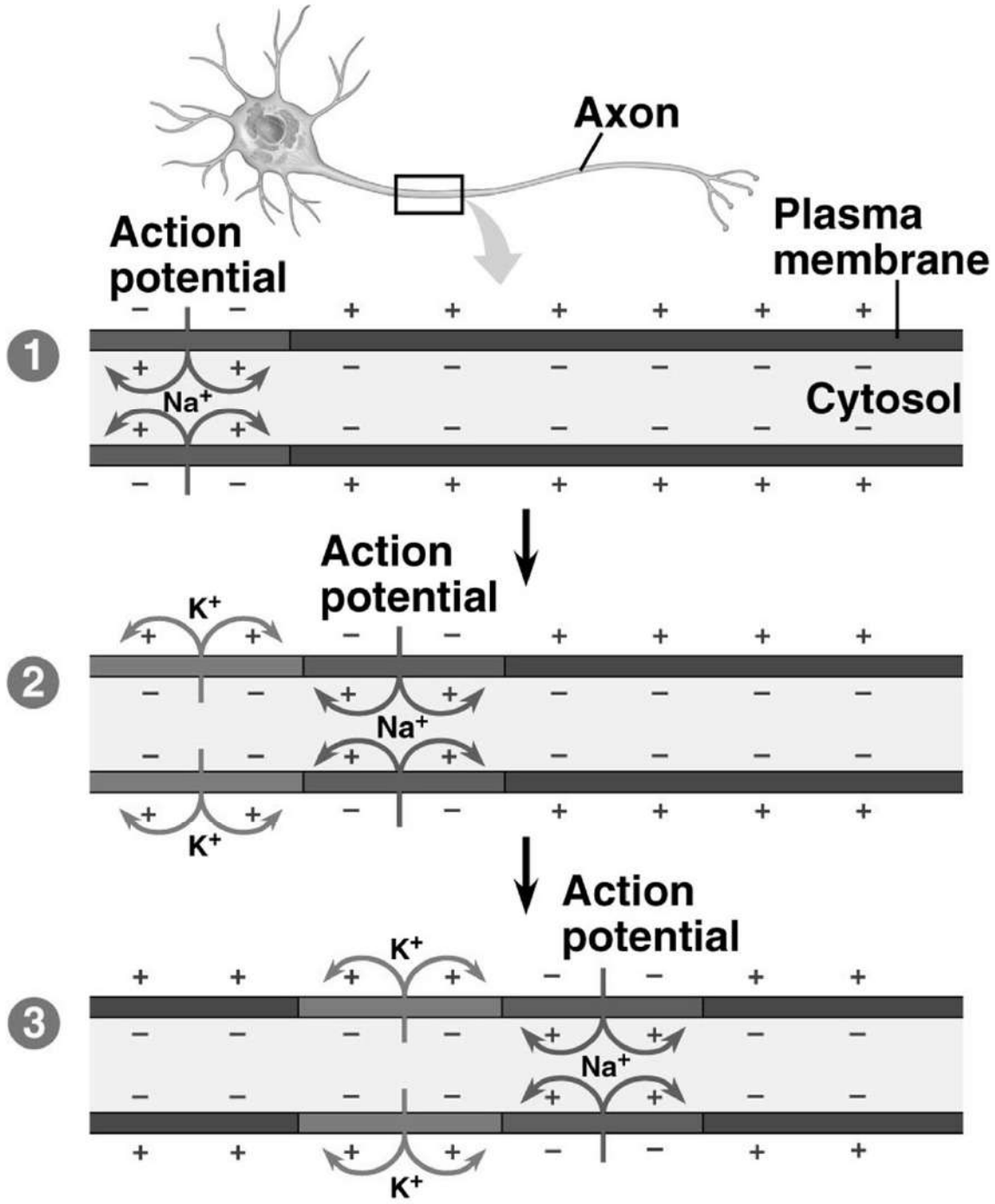


# Action potentials (nerve impulses) are the signals conducted by axons

- **Resting potential**: membrane potential at rest; ***polarized***
  - ↑$Na^+$ outside, ↑$K^+$ inside cell
  - Voltage-gated $Na^+$ channel = CLOSED
- **Nerve impulse**: stimulus causes a change in membrane potential
  - **Action potential:** neuron membrane ***depolarizes***
  - All-or-nothing response

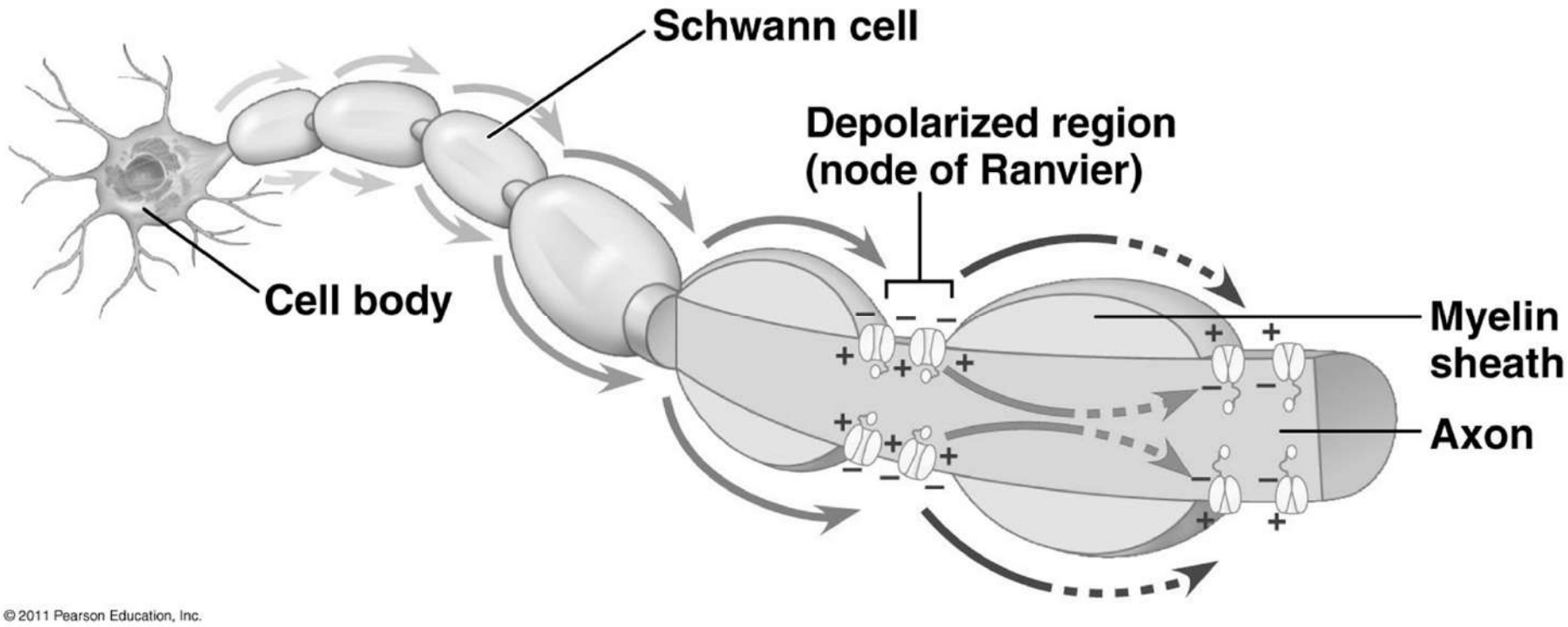


# Conduction of an action potential



# Nerve Impulse Animation

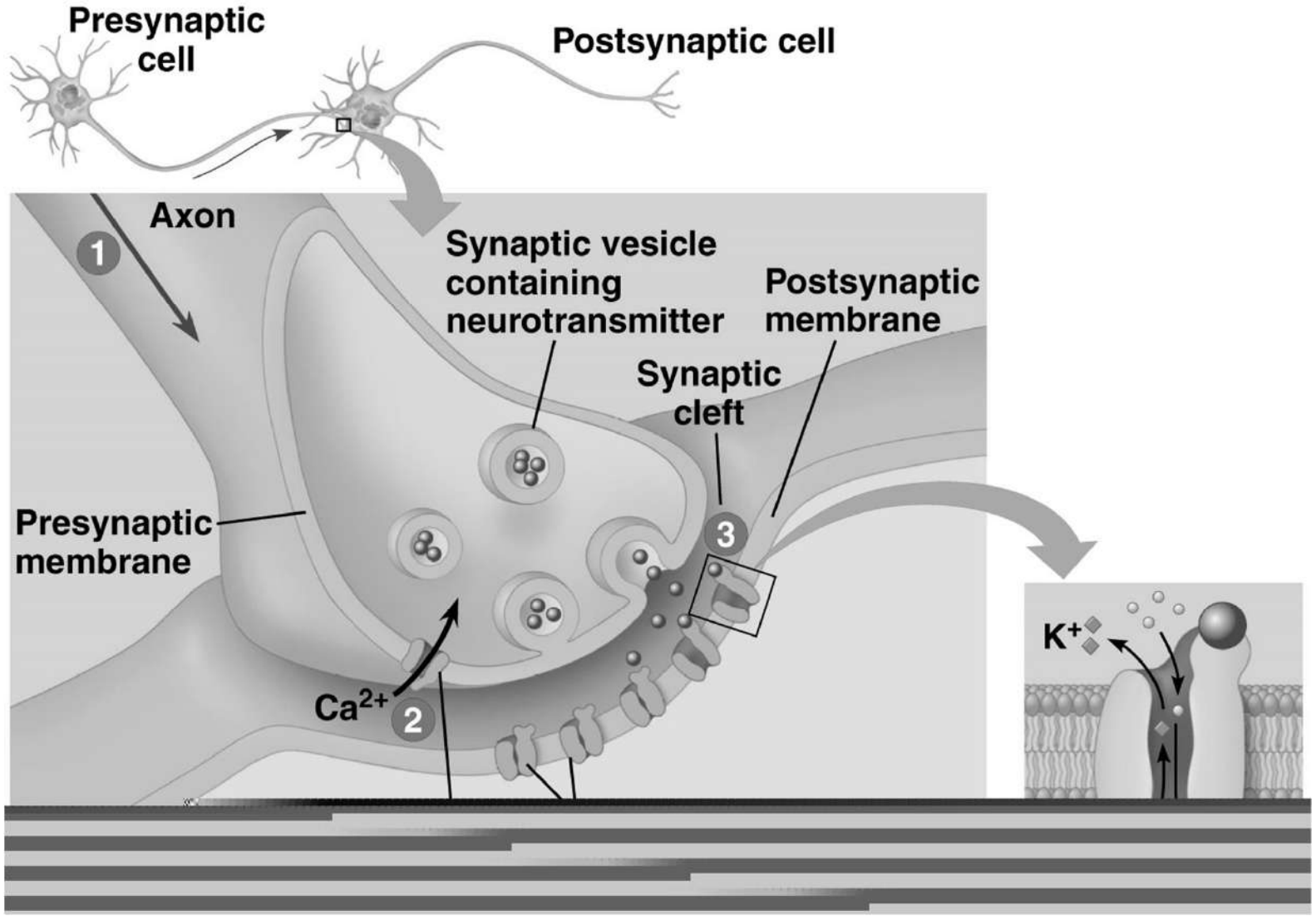
## Saltatory conduction: nerve impulse jumps between *nodes of Ranvier* (unmyelinated gaps) → speeds up impulse




**Saltatory conduction speed: 120 m/sec**

# BioFlix: How Synapses Work

# Cell communication: neurotransmitter released at synapses
## Axon (presynaptic cell) → Dendrite (postsynaptic cell)



# Examples of Neurotransmitters

- Acetylcholine (ACh): stimulates muscles, memory formation, learning
- Epinephrine: (adrenaline) fight-or-flight
- Norepinephrine: fight-or-flight
- Dopamine: reward, pleasure ("high")
  - Loss of dopamine → Parkinson's Disease
- Serotonin: well-being, happiness
  - Low levels → Depression
- GABA: inhibitory NT
  - Affected by alcohol

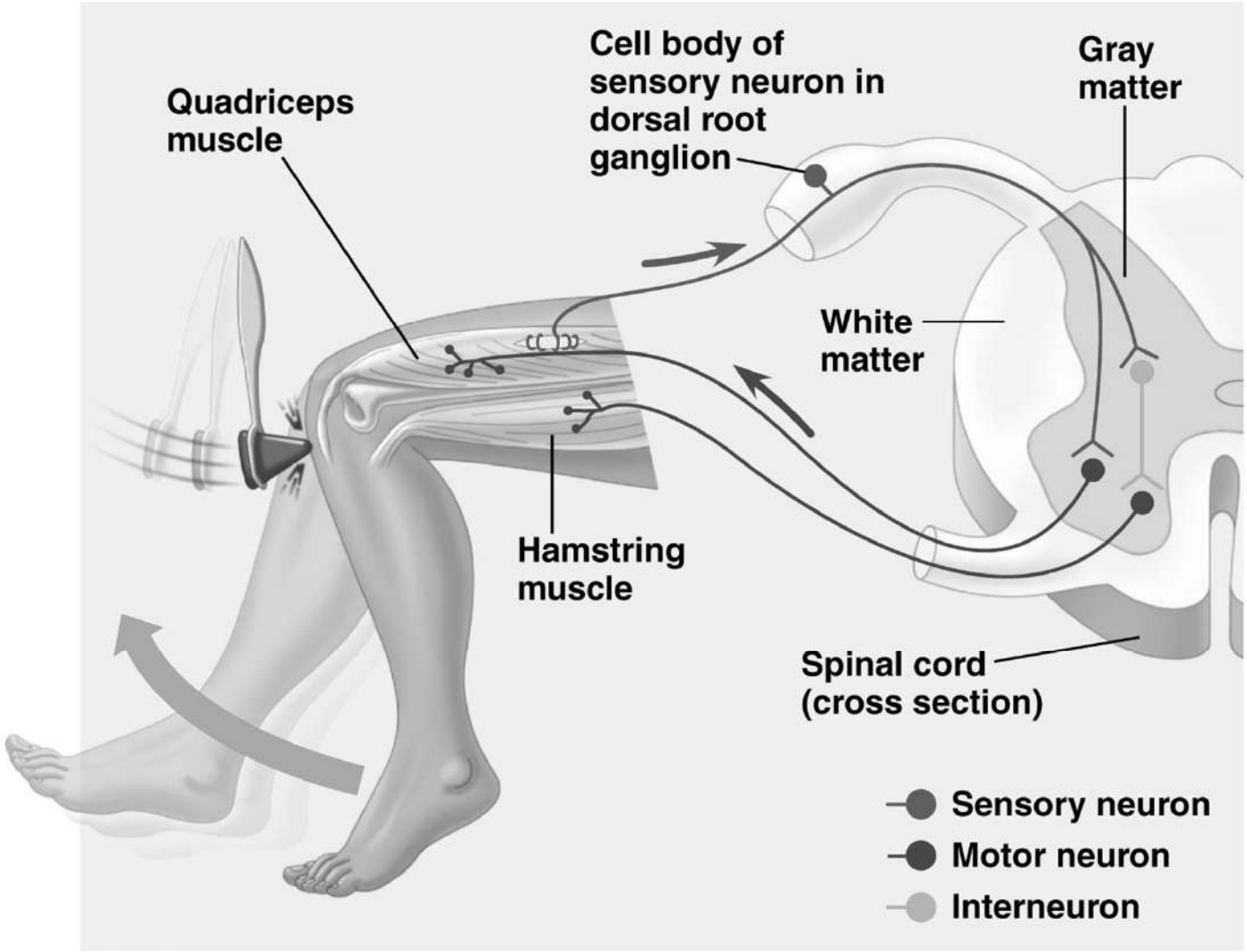
# Nervous System Disorders

- **LSD/mescaline** – bind to serotonin and dopamine receptors → hallucinations
- **Prozac** – enhances effect of serotonin by inhibiting uptake after release
- **Morphine, heroin** – bind to endorphin receptors → decrease pain perception
- **Viagra** – increase NO (nitric oxide) effects → maintain erection
- **Alzheimer's Disease (AD)** – develop senile plaques, shrinkage of brain tissue

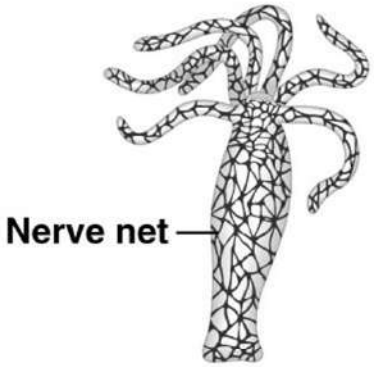
# Reflexes

- Simple, automatic response to a stimulus
- Conscious thought not required
- **Reflex arc**:
  1. Stimulus detected by **receptor**
  2. Sensory neuron
  3. Interneuron (spinal cord or brain stem)
  4. Motor neuron
  5. Response by **effector organ** (muscles, glands)

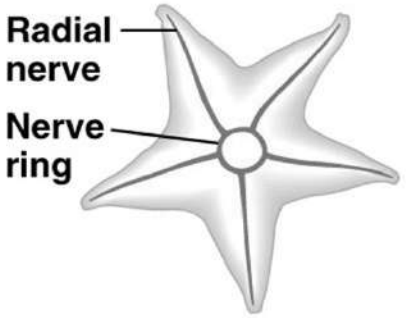
# Knee-jerk reflex



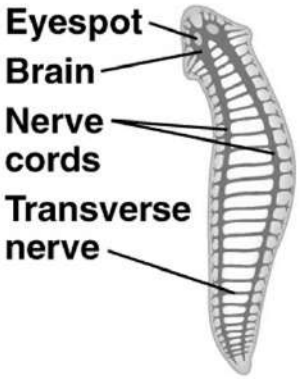
# Evolution of Nervous Systems



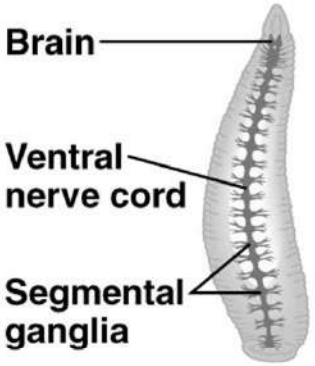

(a) Hydra (cnidarian)



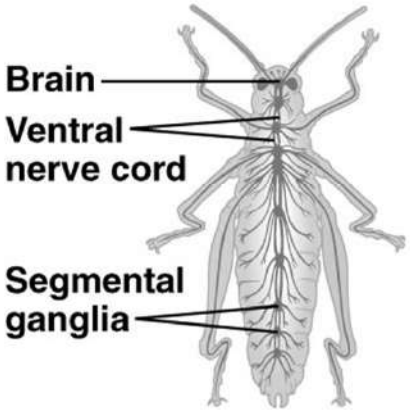

(b) Sea star (echinoderm)



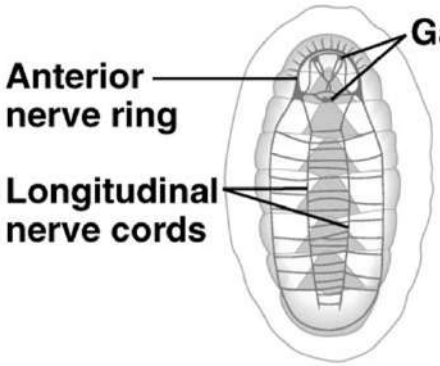

(c) Planarian (flatworm)



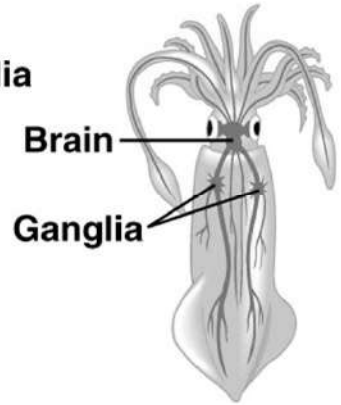

(d) Leech (annelid)



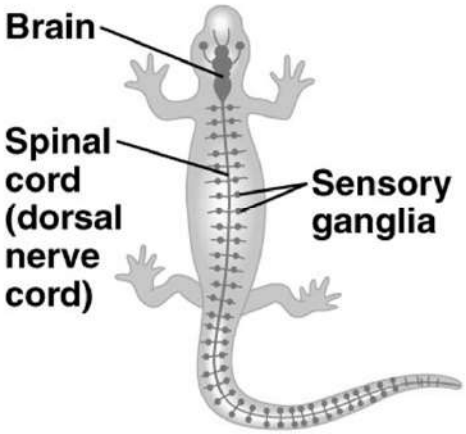

(e) Insect (arthropod)




(f) Chiton (mollusc)

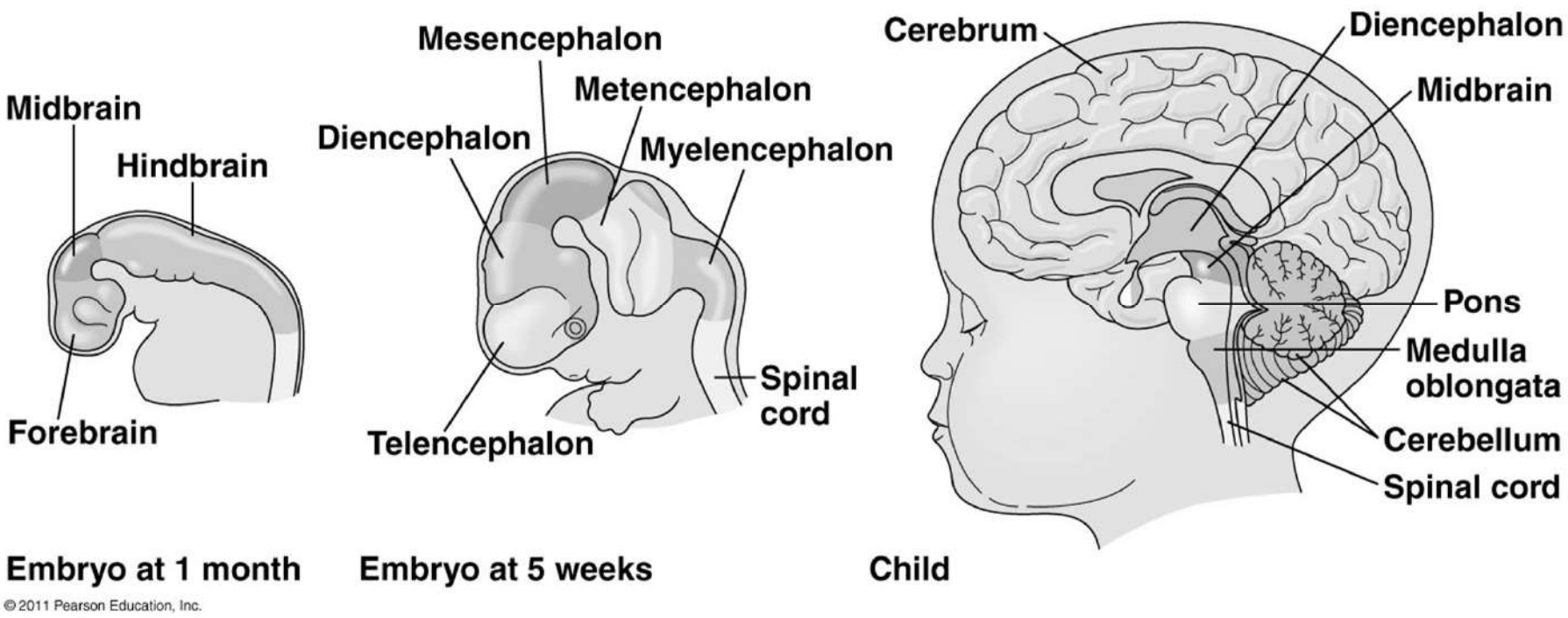



(g) Squid (mollusc)



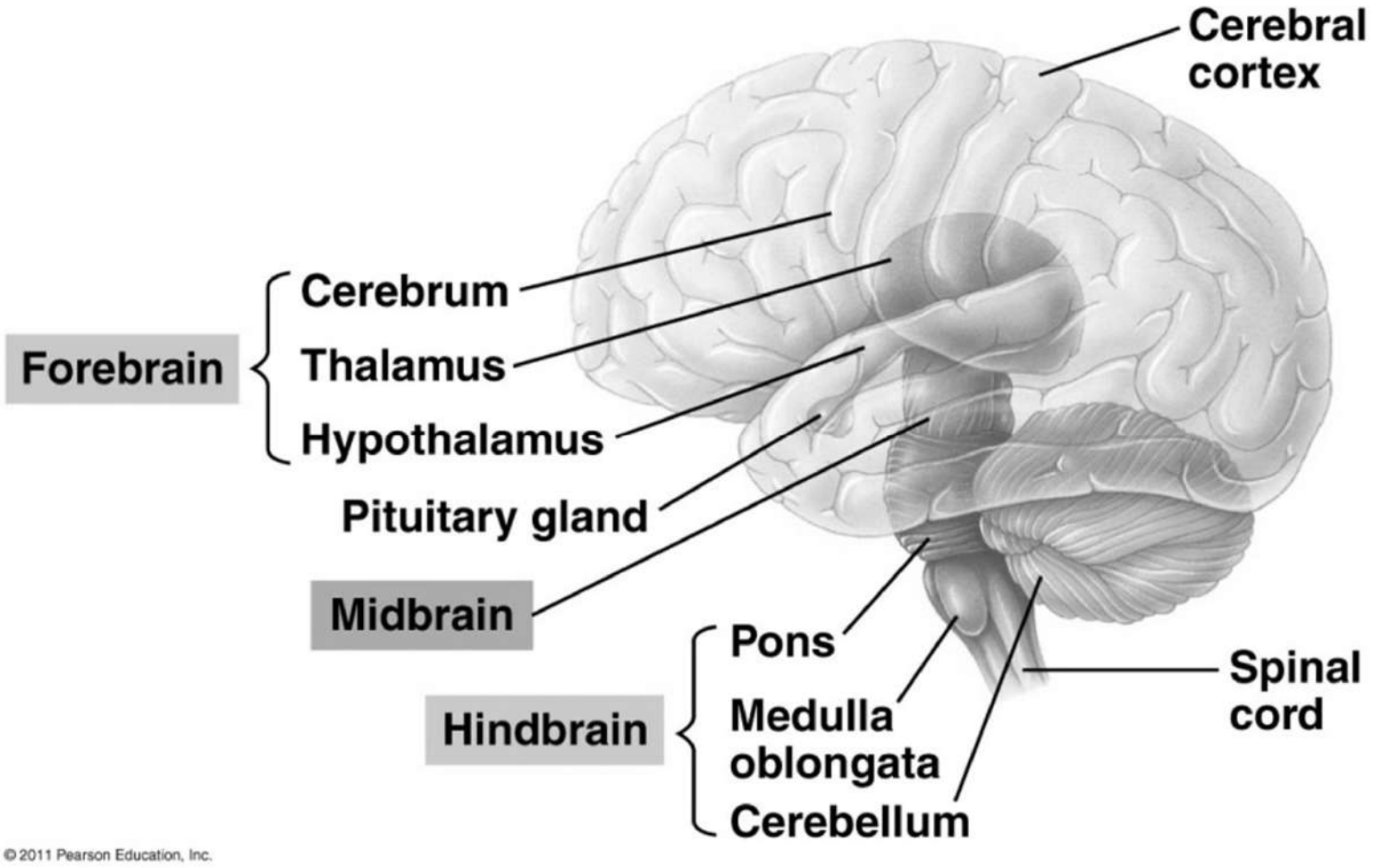

(h) Salamander (vertebrate)

# Vertebrate brain is regionally specialized






Major Regions: forebrain, midbrain, hindbrain




- Forebrain → cerebrum
- Midbrain → brainstem
- Hindbrain → cerebellum

# Human Brain

| Structure | Function |
|---|---|
| **Cerebrum** | • Information processing (learning, emotion, memory, perception, voluntary movement)<br>• Right & Left cerebral hemispheres<br>• ***Corpus callosum***: connect hemispheres |
| **Brainstem** | *Oldest evolutionary part*<br>•Basic, autonomic survival behaviors<br>•**Medulla oblongata** –breathing, heart & blood vessel activity, digestion, swallowing, vomiting<br>•Transfer info between PNS & CNS |
| **Cerebellum** | • Coordinate movement & balance<br>• Motor skill learning |

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**Grey matter**: neuron cell bodies, unmyelinated axons
**White matter**: fatty, myelinated axons