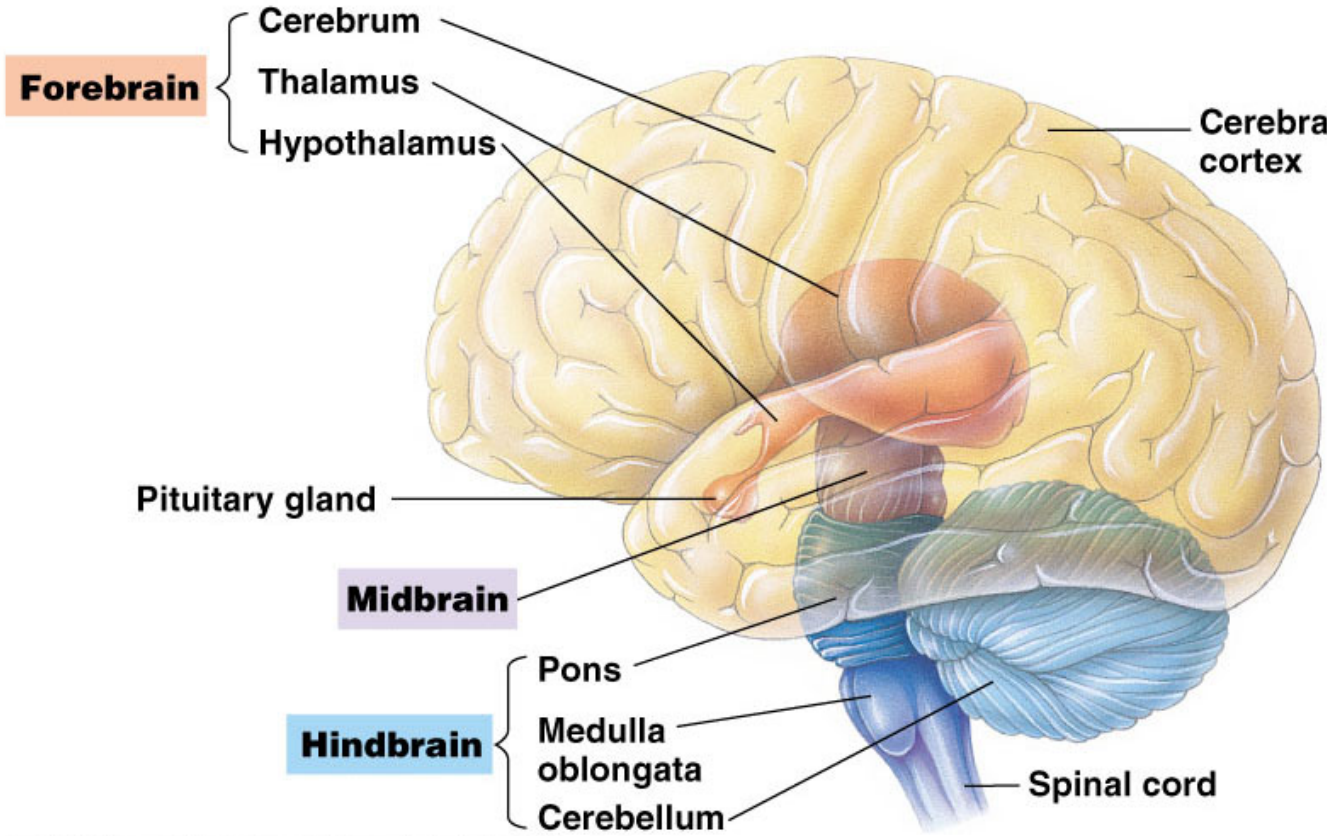
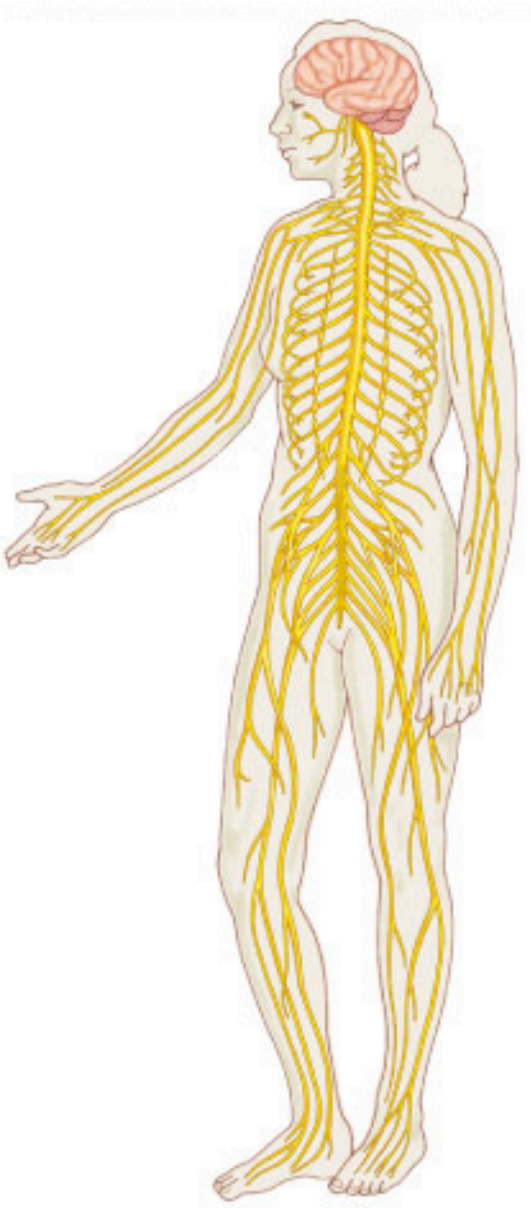
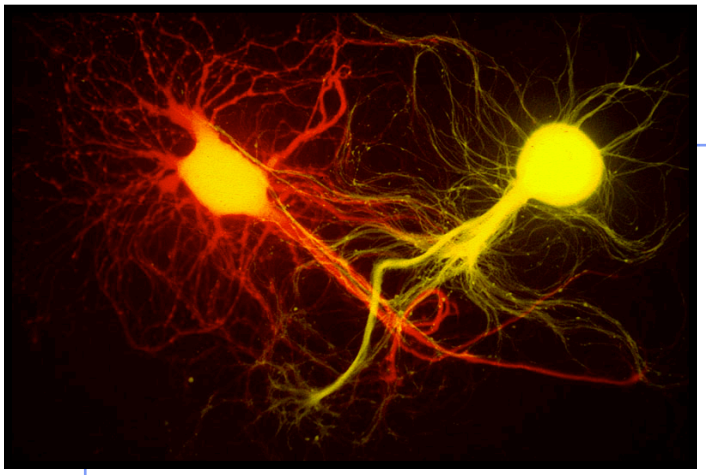
Nervous Systems &

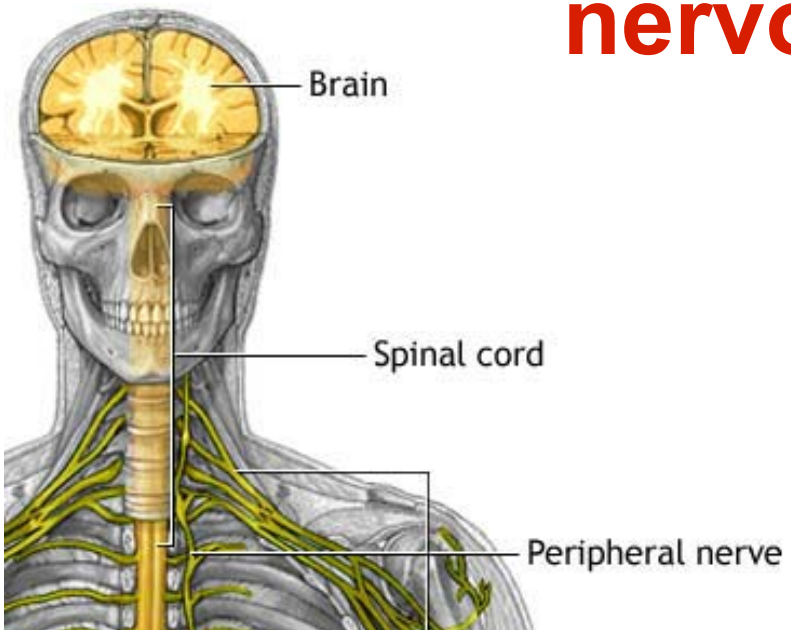
Brain Development

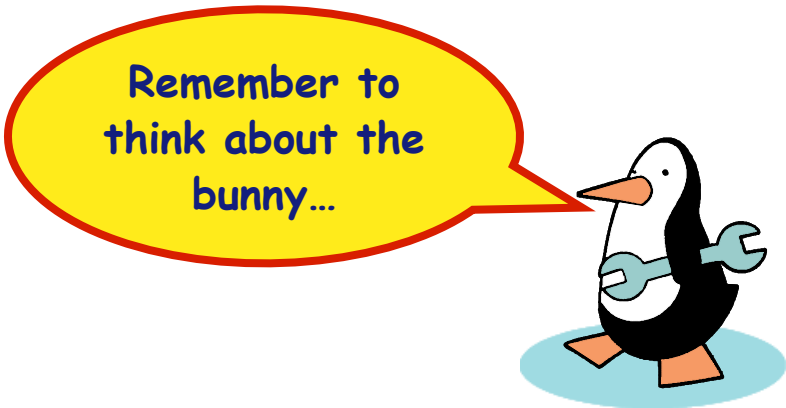






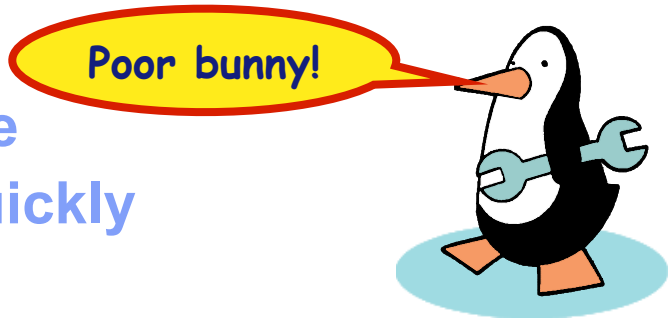
Why do animals need a nervous system?





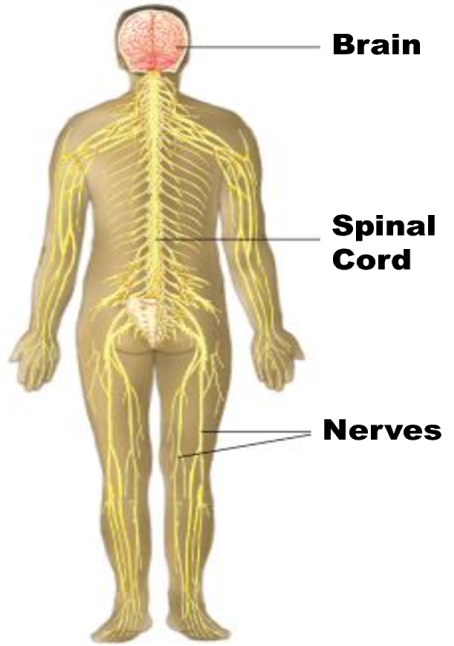
What characteristics do animals need in a nervous system?

- fast
- accurate
- reset quickly

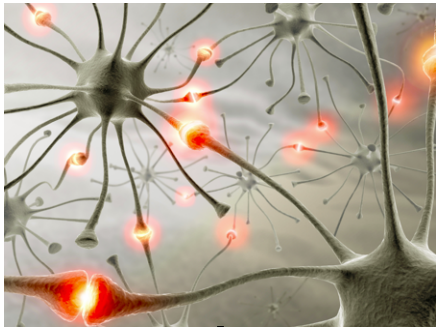


Nervous system is the...

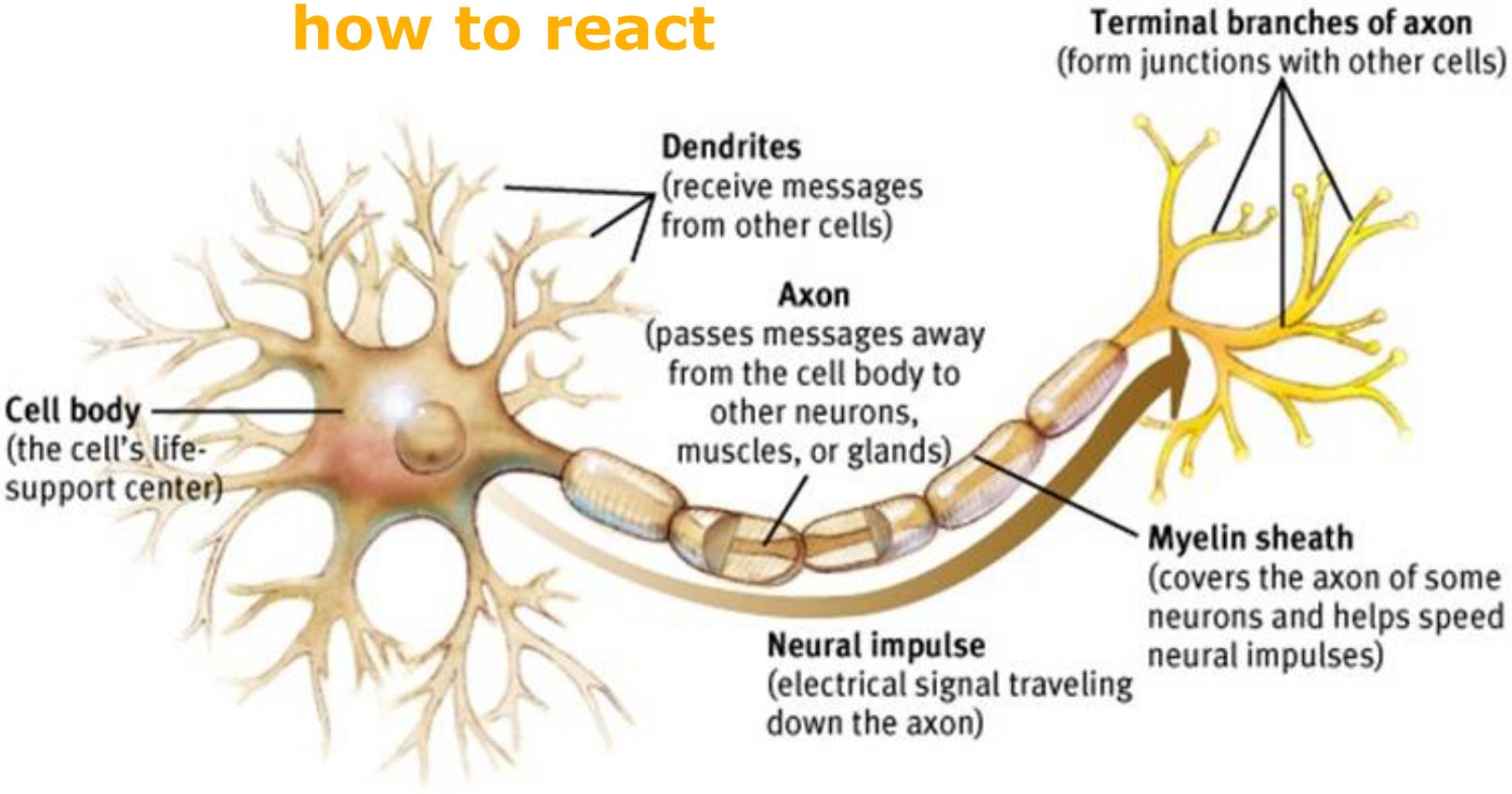
- ... part of an animal's body that regulates and coordinates voluntary and involuntary actions and transmits signals within the organism
  - In addition to the brain, spinal cord, and nerves of your body, organs of the nervous system include…
    - eyes
    - ears
    - sensory organs of taste
    - sensory organs of smell
    - sensory receptors located in the skin, joints, muscles, and other parts of the body



Nervous System

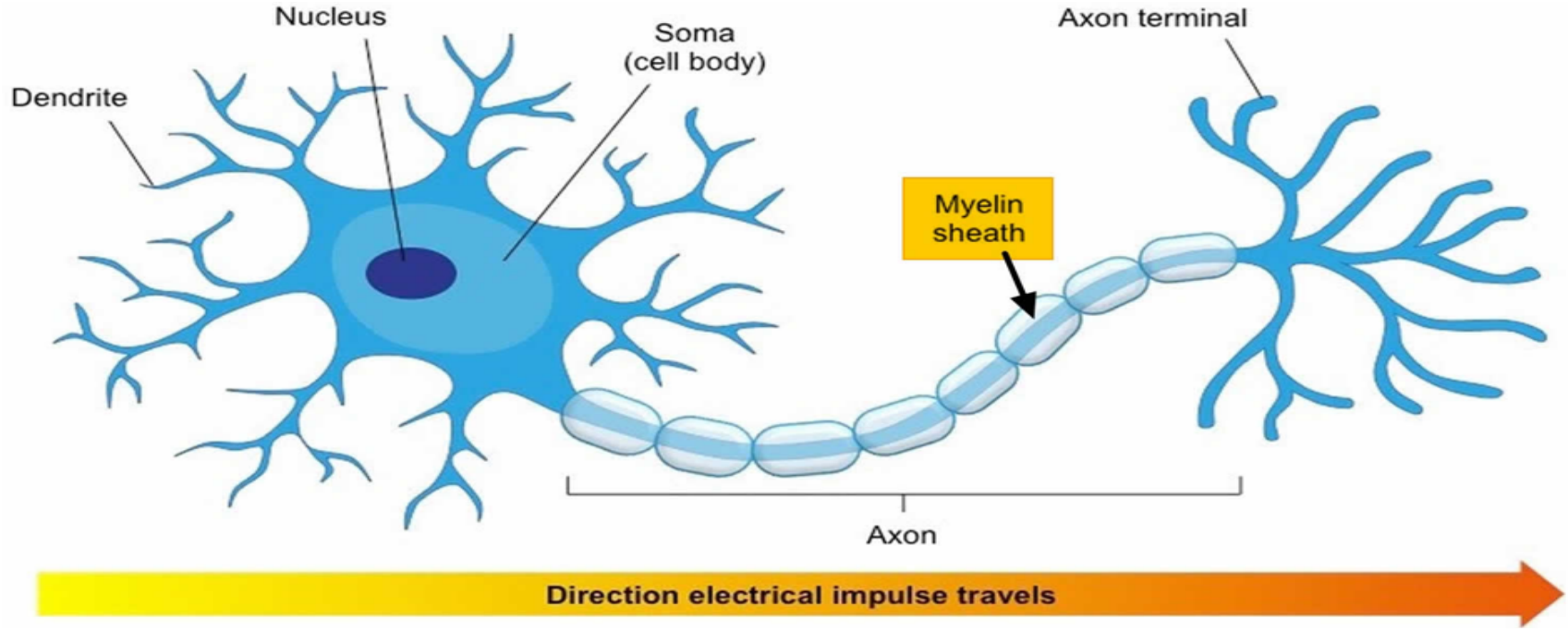


When a message comes into the brain from anywhere in the body, the brain tells the body how to react



A neuron is a nerve cell

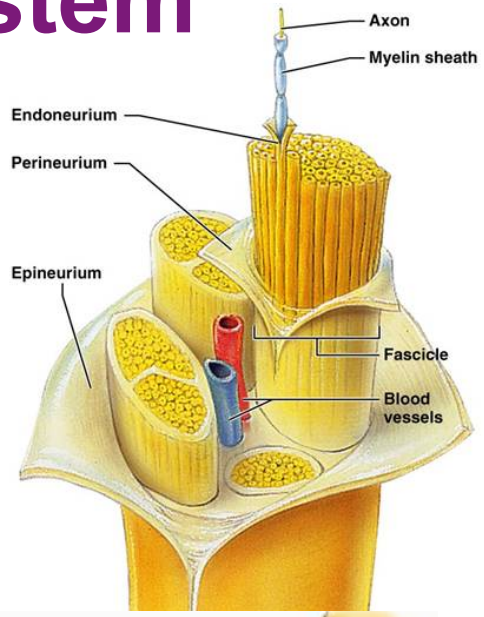
- The neuron is the basic working unit of the nervous system - a specialized cell designed to transmit information to other nerve cells, muscle, or gland cells.
  - Most neurons have a cell body, an axon, and dendrites.
    - The cell body contains the nucleus and cytoplasm.
    - Dendrites extend from the neuron cell body and receive messages from other neurons.
    - The axon extends from the cell body and reaches out to another neuron, a muscle cell, or a gland cell (secretory cell)
      - Communication between a neuron and another cell occurs when the neuron secretes neurotransmitter (name of signaling ligands produced by neurons)

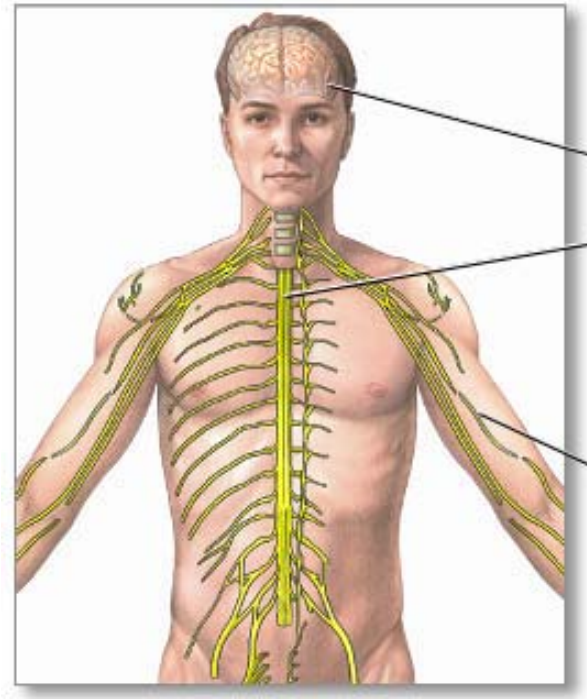


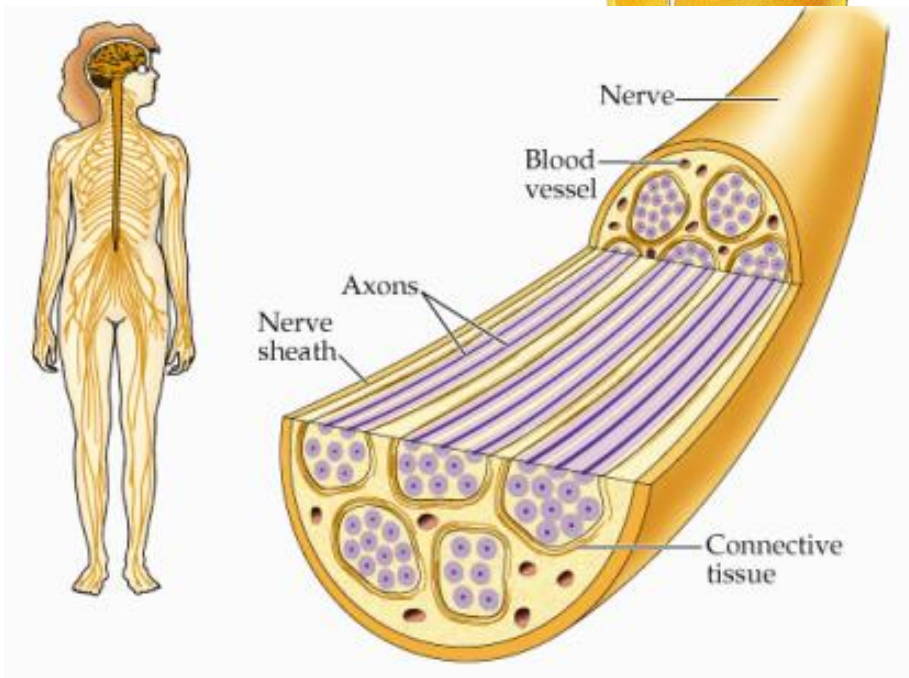
AP

Divisions of the Nervous System

- **Central Nervous System (CNS)**
  - Includes the brain and spinal cord
    - composed on cells like neurons and glia
- **Peripheral Nervous System (PNS)**
  - Includes all the nerves that lead to and from the spinal cord and the rest of the body
    - Includes neurons (& associated glia), organized into nerves

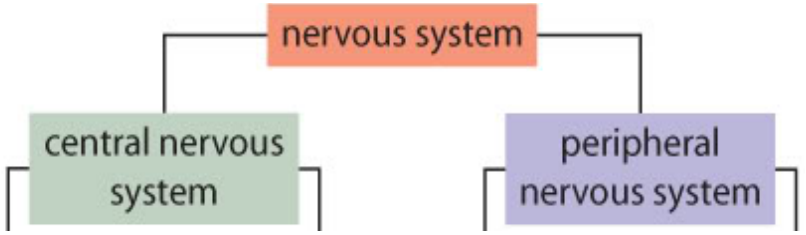


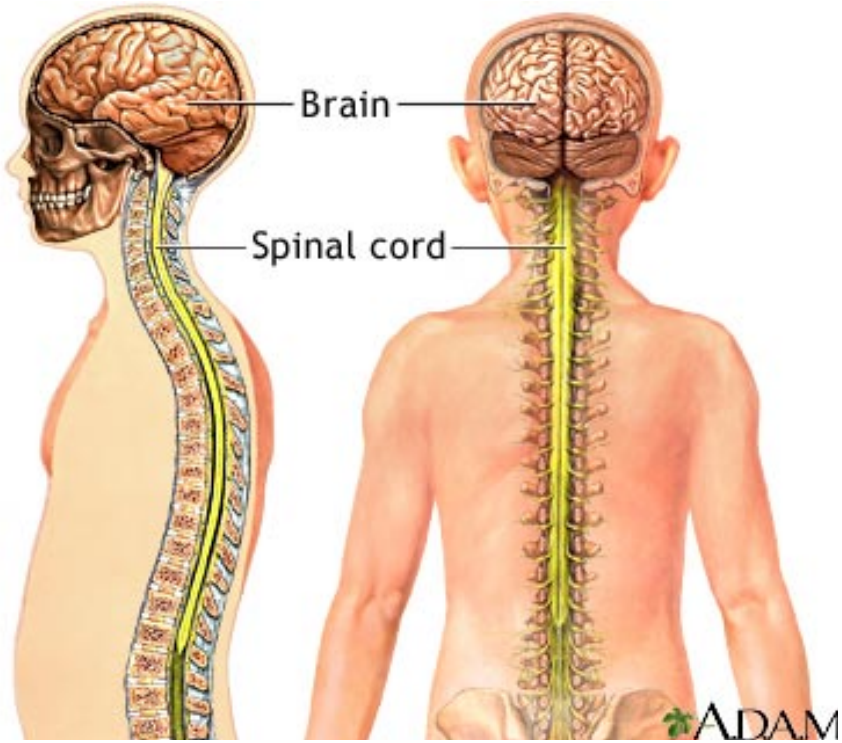




Two divisions of the Vertebrate Nervous Systems

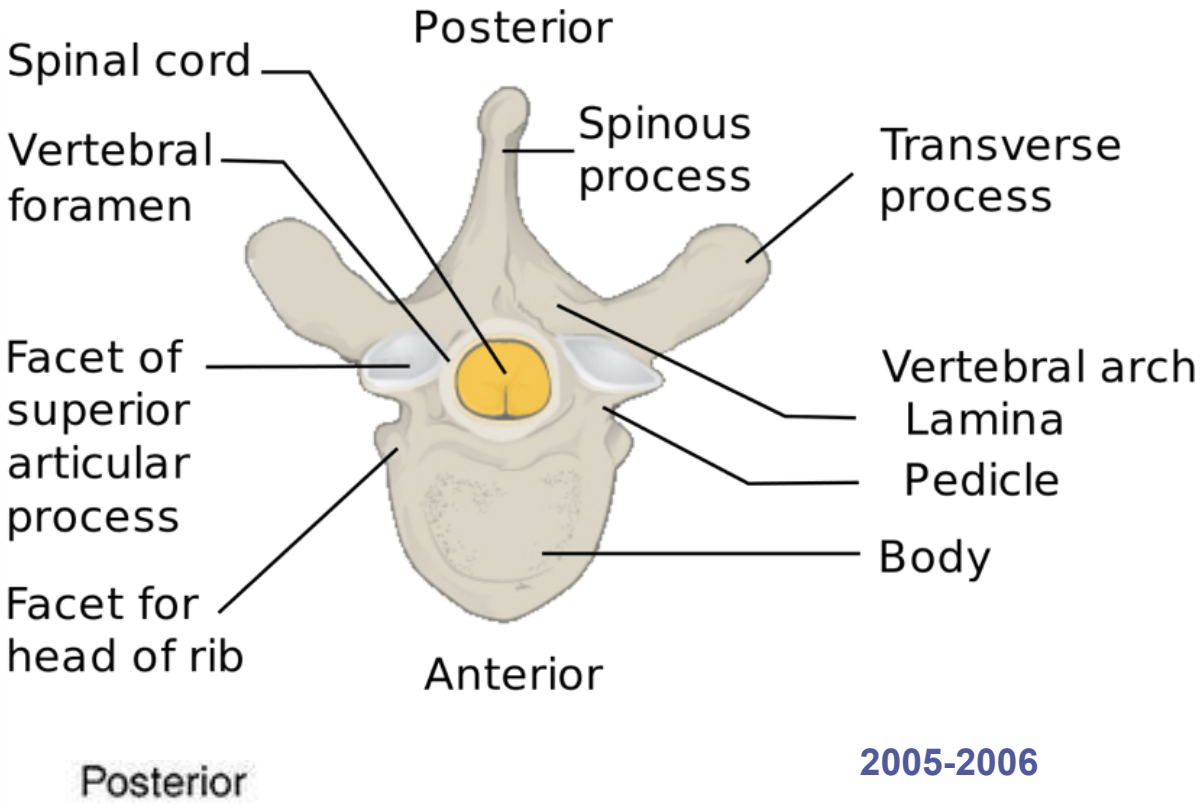
- **Made up of Central Nervous System & Peripheral Nervous System**
  - **Central Nervous System (CNS)**
    1. **Brain**
       - Provides integrative power
    2. **Spinal cord**
       - Conveys information to and from the brain
       - Generates basic patterns of locomotion
       - Involved in simple nerve circuits that produce reflexes
         - Body's automatic responses to certain stimuli





Bones protect the interneurons of the CNS

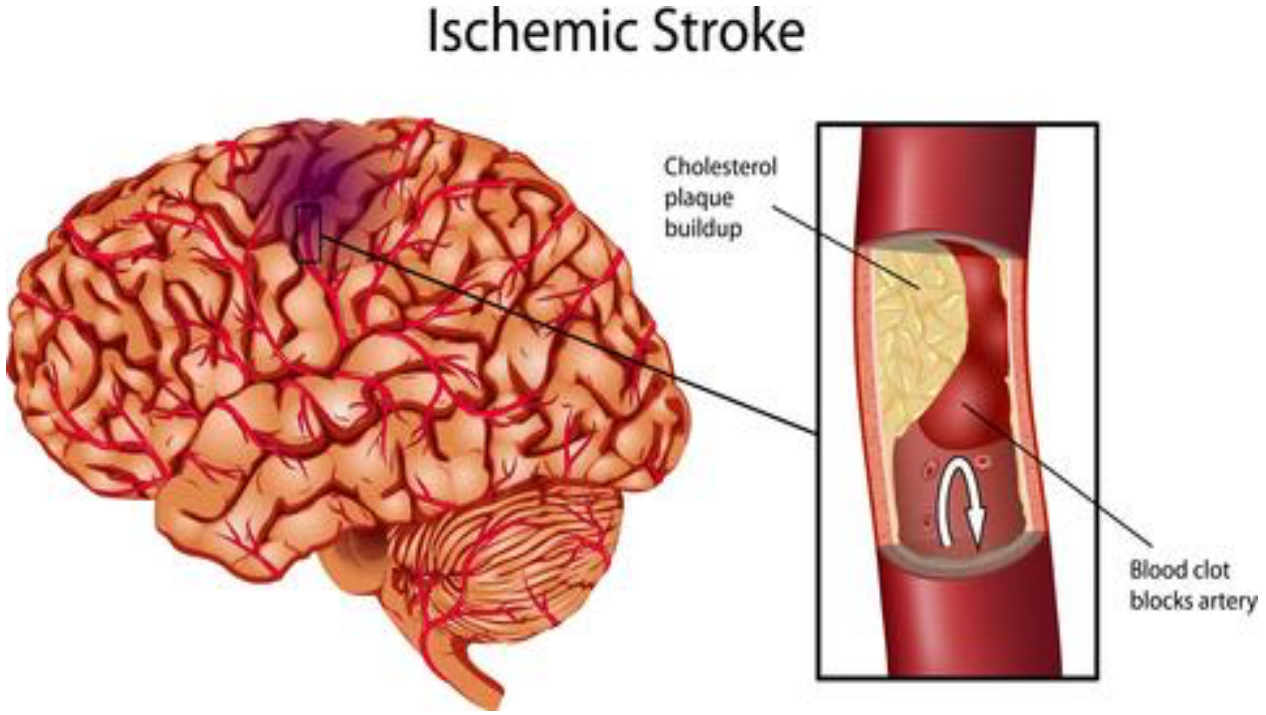
- The CNS consists of your brain and spinal cord.
  - The brain and spinal cord are protected by your skull and vertebrae (which make up the backbone).



Ischemic Strokes

- **Ischemic Strokes (clots) are accountable for around 87% of all cases of stroke.**
  - **Happen as a result of an obstruction of a blood vessel that supplies blood to the brain.**
    - **This occurs due to the development of fatty (lipid-based) deposits (plaques).**

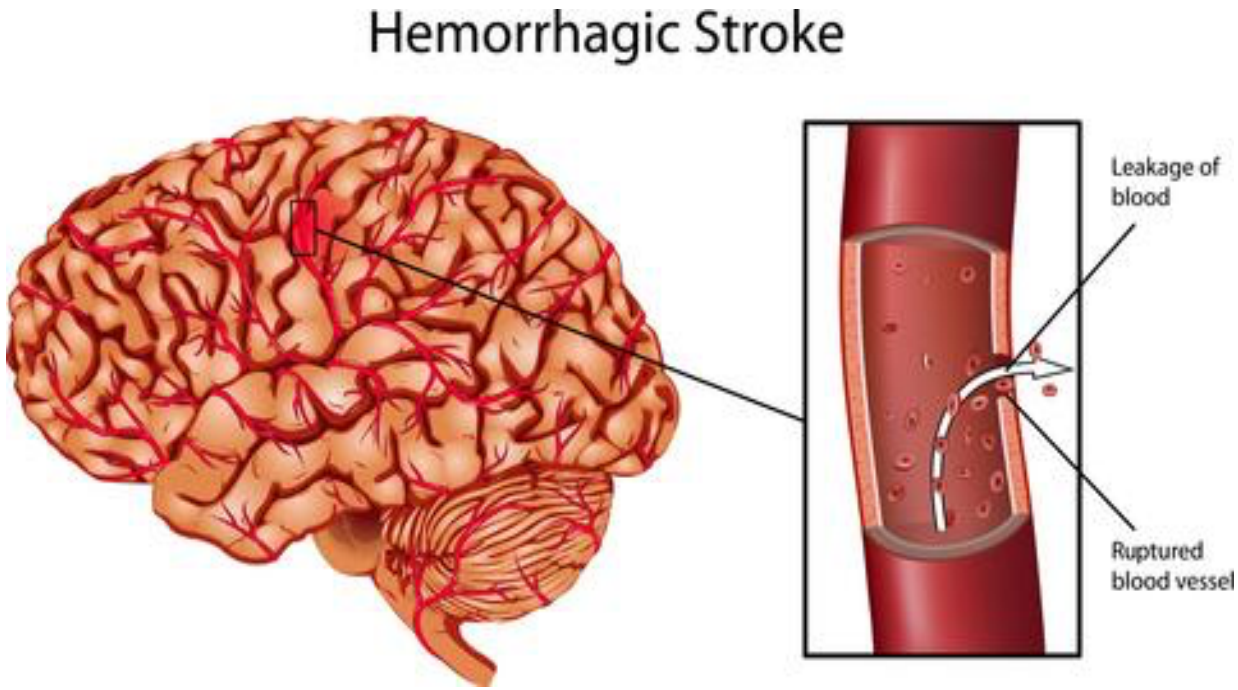
- **Plaque deposits can cause two kinds of obstruction:**
  - **Cerebral Thrombosis (a clot at the blockage)**
  - **Cerebral Embolism (a clot that forms at another location in the circulatory system) which breaks off and travels in the bloodstream until it reaches a vessel that is too small for it to pass.**



Hemorrhagic Strokes & Transient Ischemic Attacks

- **Hemorrhagic Strokes (bleeds) occurs when a weakened blood vessel ruptures and bleeds into the brain.**
  - Blood accumulates and results in either an aneurysm (ballooning of a weakened blood vessel) or arteriovenous malformation(cluster of abnormally formed blood vessels), which could cause vessel to rupture leading to areas of the brain not getting nutrients & oxygens and being exposed to harmful substances.

- **Transient Ischemic (TIA) attacks are warnings/ mini strokes that indicate the likelihood of an Ischemic or Hemorrhagic stroke occurring in the future.**
  - **TIAs involve temporary clots and blockages. they may only last 1 minute and cause no permanent damage to the brain.**



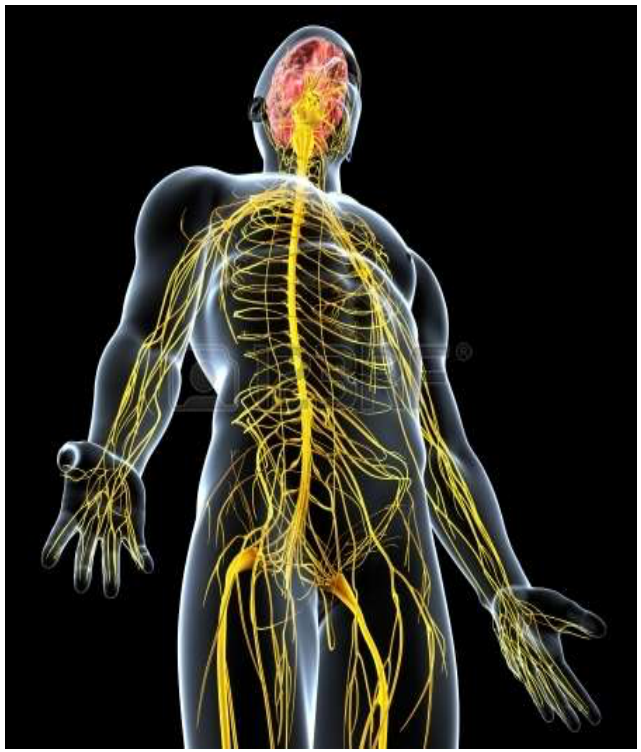
Signs of Stroke

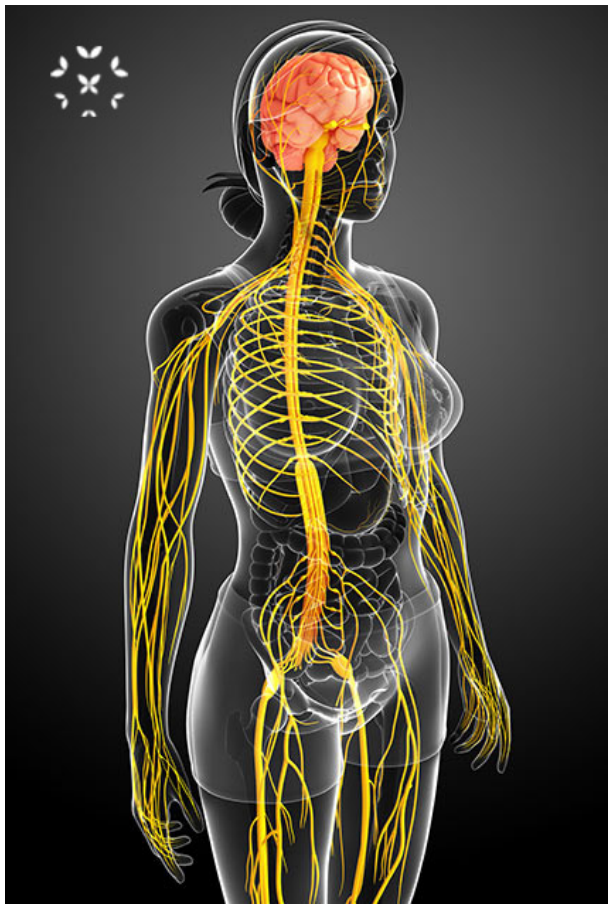
- Up to 80% of strokes could be prevented through lifestyle changes like eating healthy, maintaining a healthy weight, exercising, not smoking and having a low alcohol consumption.
  - That said, anyone of any age can suffer a stroke and rapid treatment leads to the best recovery outcomes!

AP

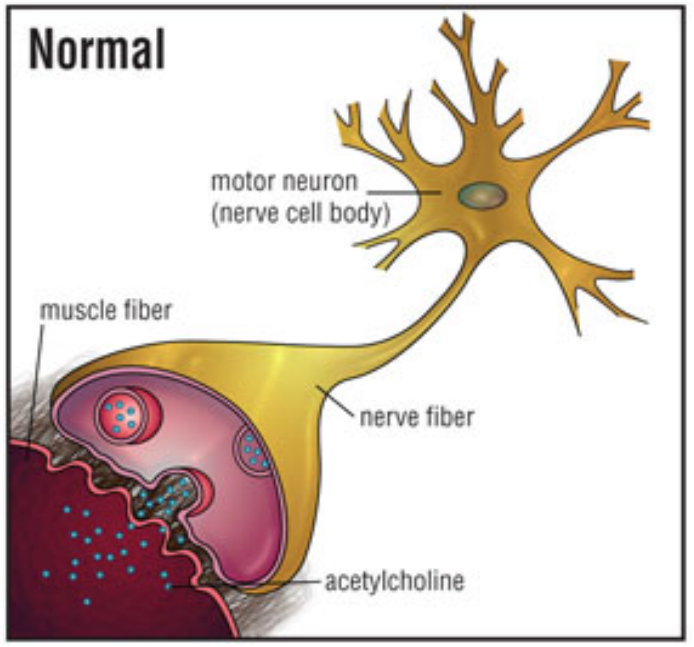
The axons of peripheral neurons are packed together into nerves

- **The human brain contains about 100 billion neurons.**
  - **The PNS consists mainly of the nerves that take information to and from the CNS.**
    - **Unlike the CNS, though, there no bony protection for the PNS.**





Nervous System Function

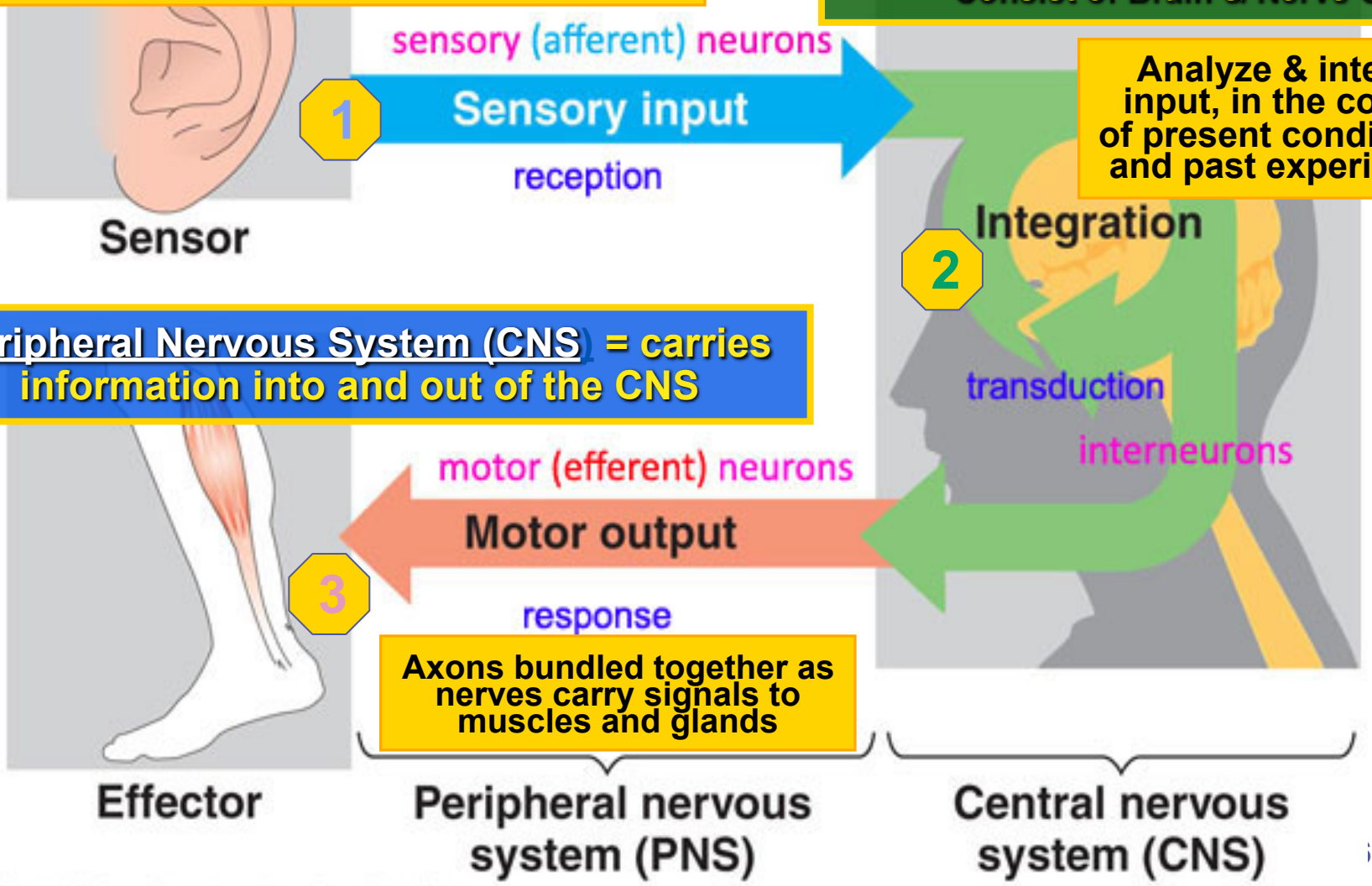


- **Function of the nervous system**
  - Three stages of information processing
    1. Gather sensory input
       - Sensory neurons transmit information from sense organs
         - PNS collects input
           - Eyes, ears, smell, touch, heat, taste, internal conditions like blood pressure, CO_2 levels, muscle tension
    2. Integration
       - Brain analyzes and interprets information
       - Reflexes bypass brain and uses mostly spinal cord
         - Brain and spinal cord filled with interneurons
    3. Motor output
       - Neurons bundled into nerves trigger effector activity (muscles or gland activity)

The three stages of information processing:

Transmit info from sense organs about external stimuli like light, sound, touch, heat, smell, taste & internal conditions like blood pressure, CO2 levels, muscle tension.

Central Nervous System (CNS)
= carries out integration
- Consist of Brain & Nerve Cord

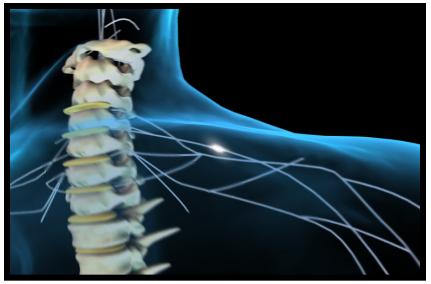


Analyze & interpret input, in the context of present conditions and past experience.

Peripheral Nervous System (CNS) = carries information into and out of the CNS

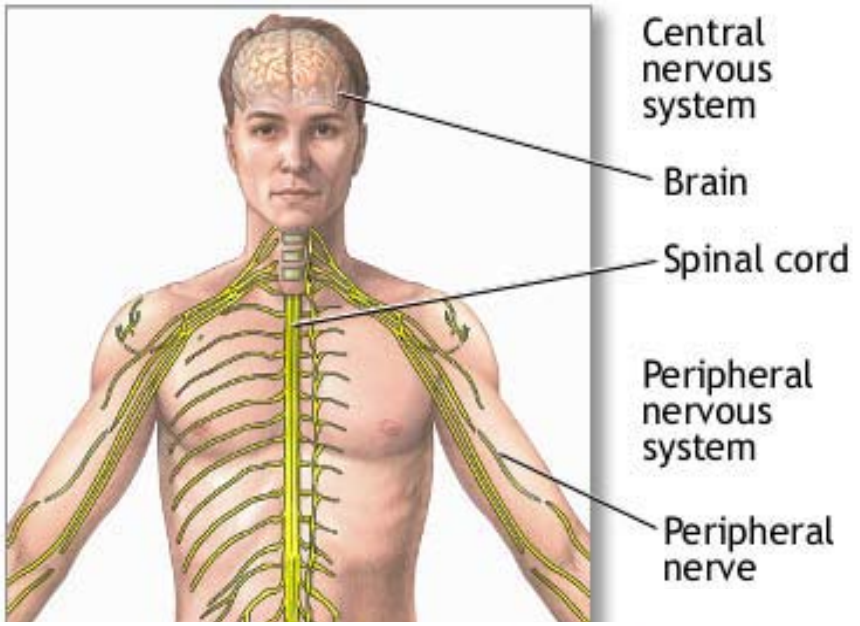
Axons bundled together as nerves carry signals to muscles and glands

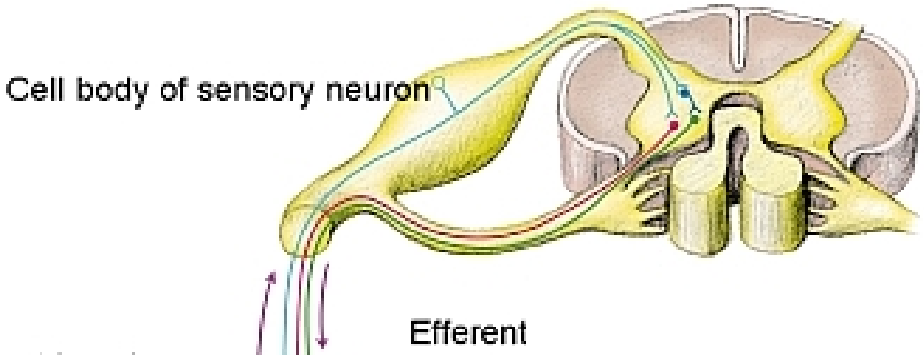
The Peripheral Nervous System (PNS)



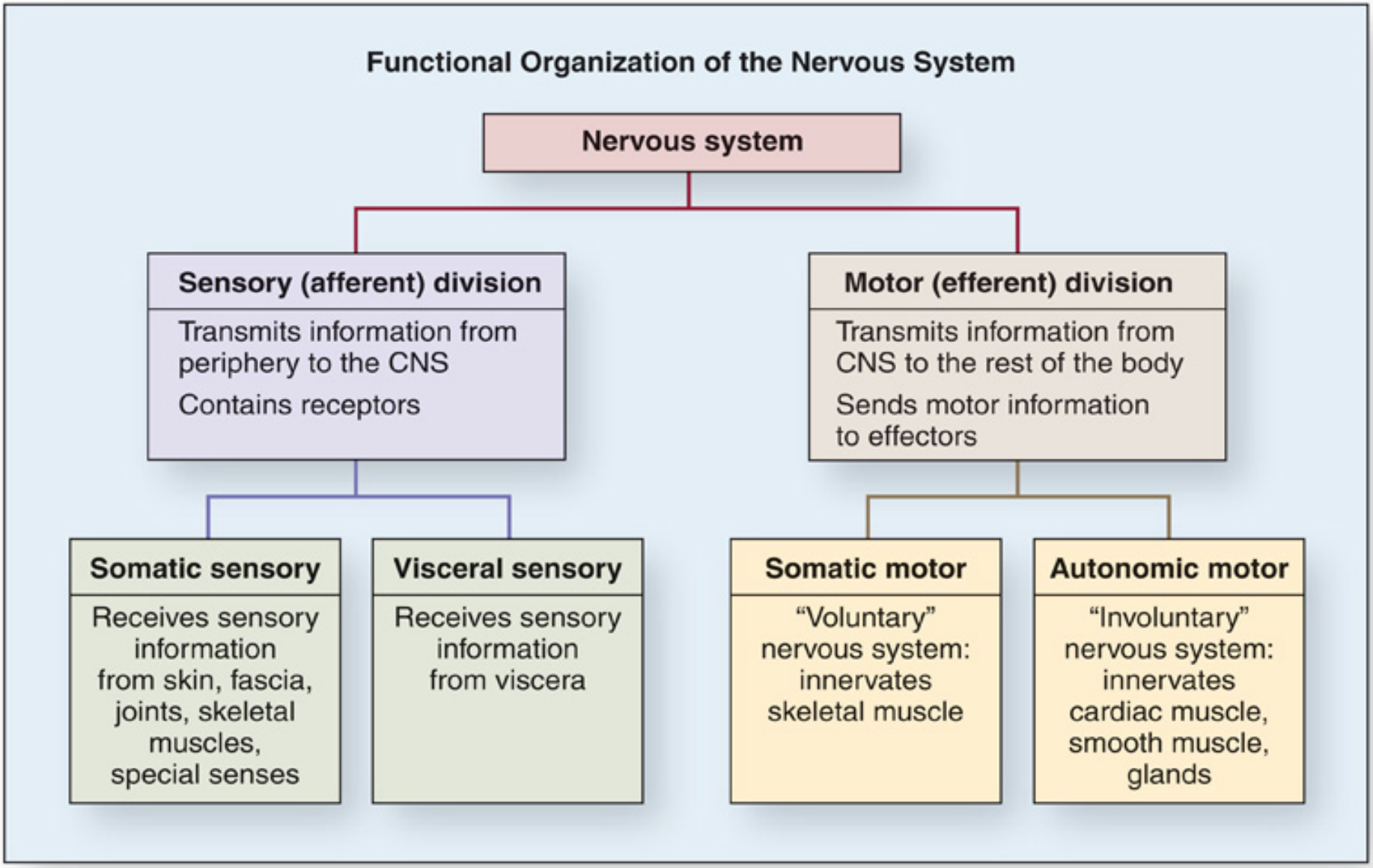
- **PNS transmits info to and from CNS**
  - PNS plays large role in regulating an animal's movement and internal environment

- **PNS divisions**
  1. Afferent (Sensory) Neurons
     - Convey sensory information to the CNS
       - Latin "to bring forward"
  2. Efferent (Motor) Neurons
     - Carry instruction from CNS or spinal cord after integration are carried to muscles, glands, and endocrine cells
       - Latin "to carry off"





Functional Divisions of the Nervous System



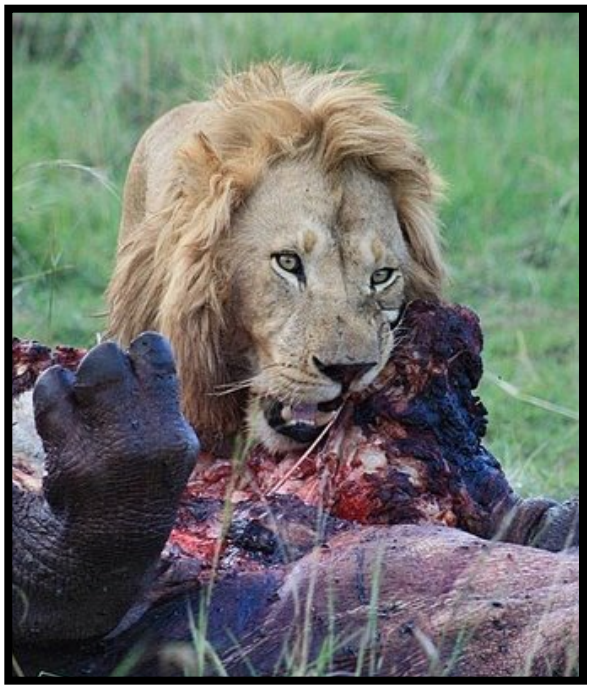
Autonomic Nervous System

- **Autonomic Nervous System can be further subdivided into 3 categories**
  - Sympathetic and Parasympathetic divisions are antagonistic (opposite effects)
  - Enteric Division

1. Sympathetic division

- "fight-or-flight" response
  - Arousal and energy generation
    - Inhibits digestion
    - Stimulates liver to hydrolyze glycogen to release glucose
    - Increase heart rate
    - Release epinephrine (adrenalin) from adrenal medulla

The Three Autonomic Nervous System Divisions



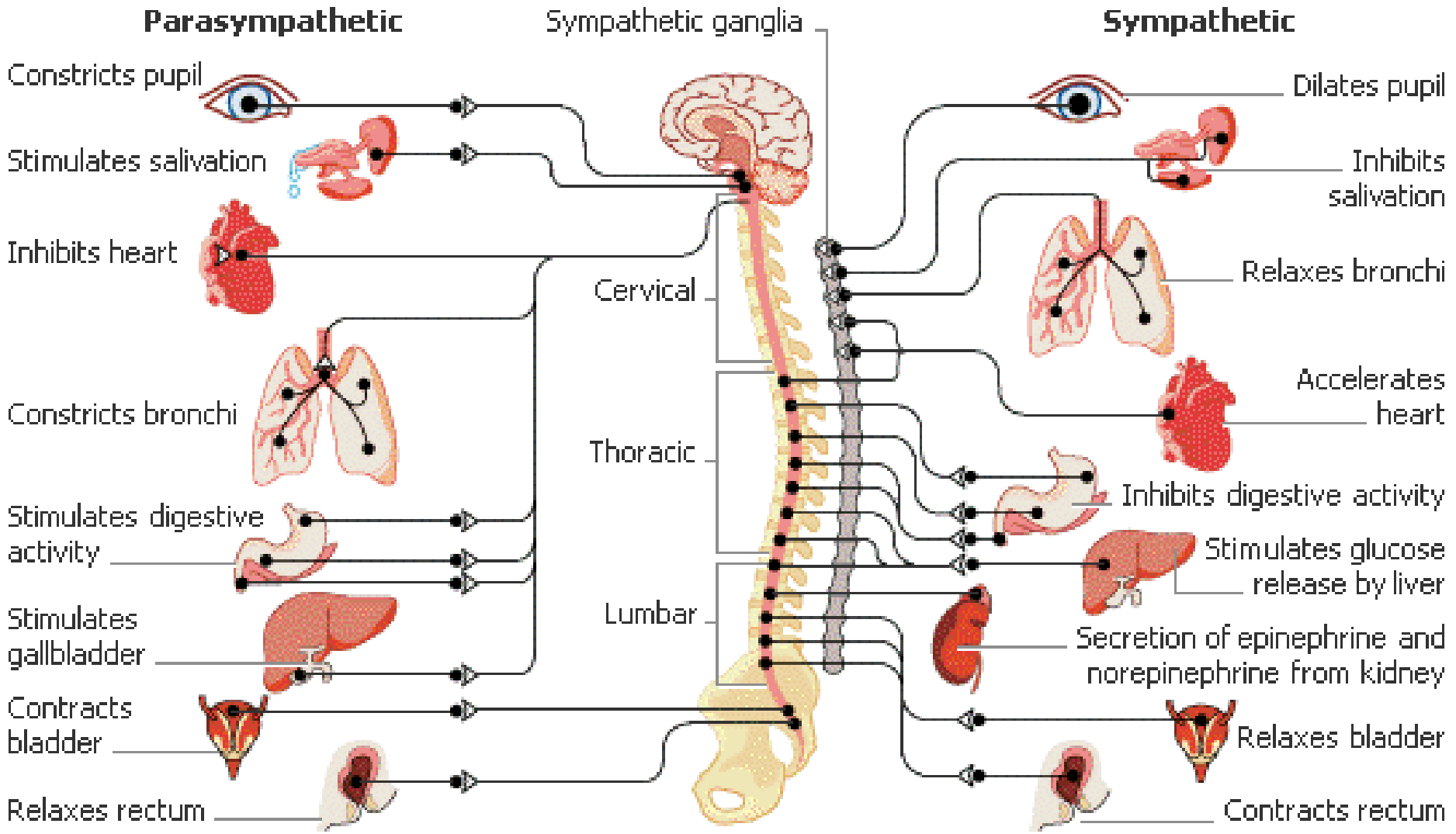
2. Parasympathetic division

- "rest-and-digest" response
  - Promote Calming
    - Lower heart rate
    - Enhance digestion
    - Increase glycogen production

3. Enteric Division

- Neurons involved in the digestive tracts, pancreas, and gallbladder
  - Neurons may control secretion or smooth muscle contraction like peristalsis *(involuntary constriction and relaxation of the muscles of the digestive tract, creating wave-like movements that push the contents of the canal forward)*

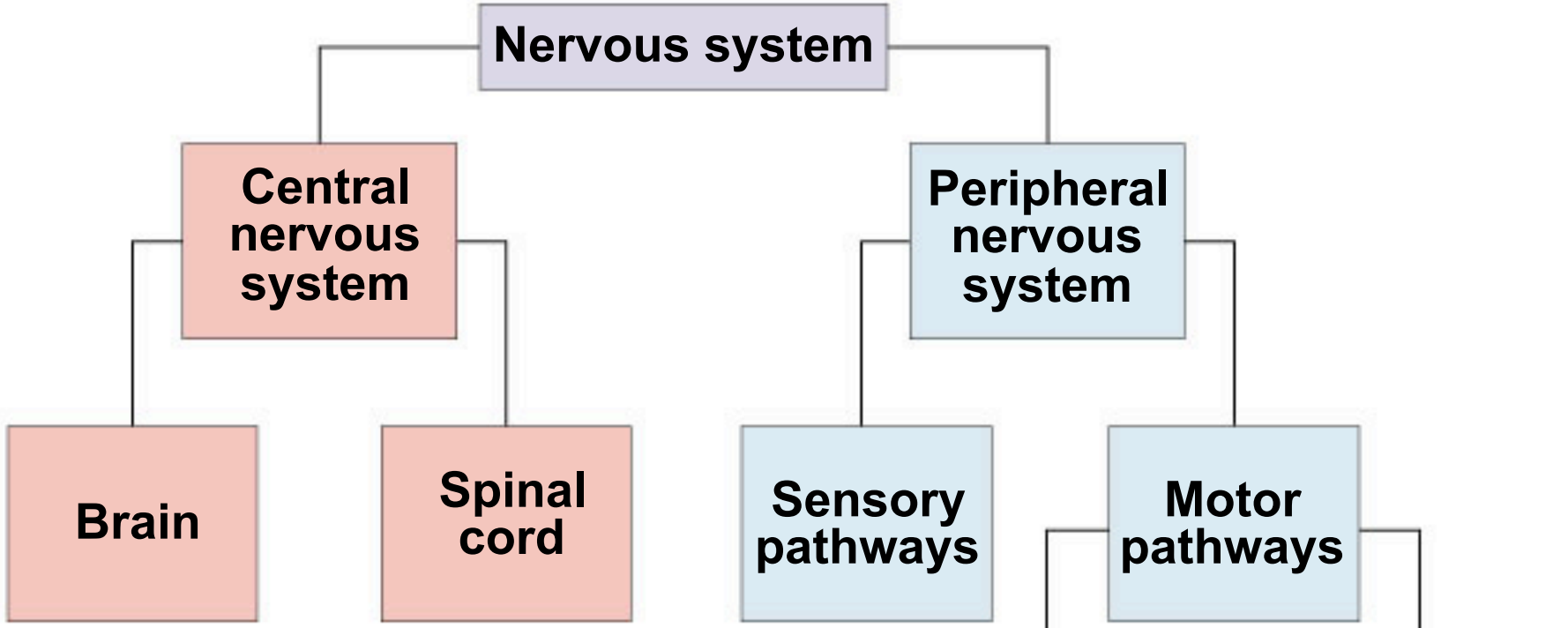
Antagonistic Effects of Parasympathetic & Sympathetic Systems



AP Bio

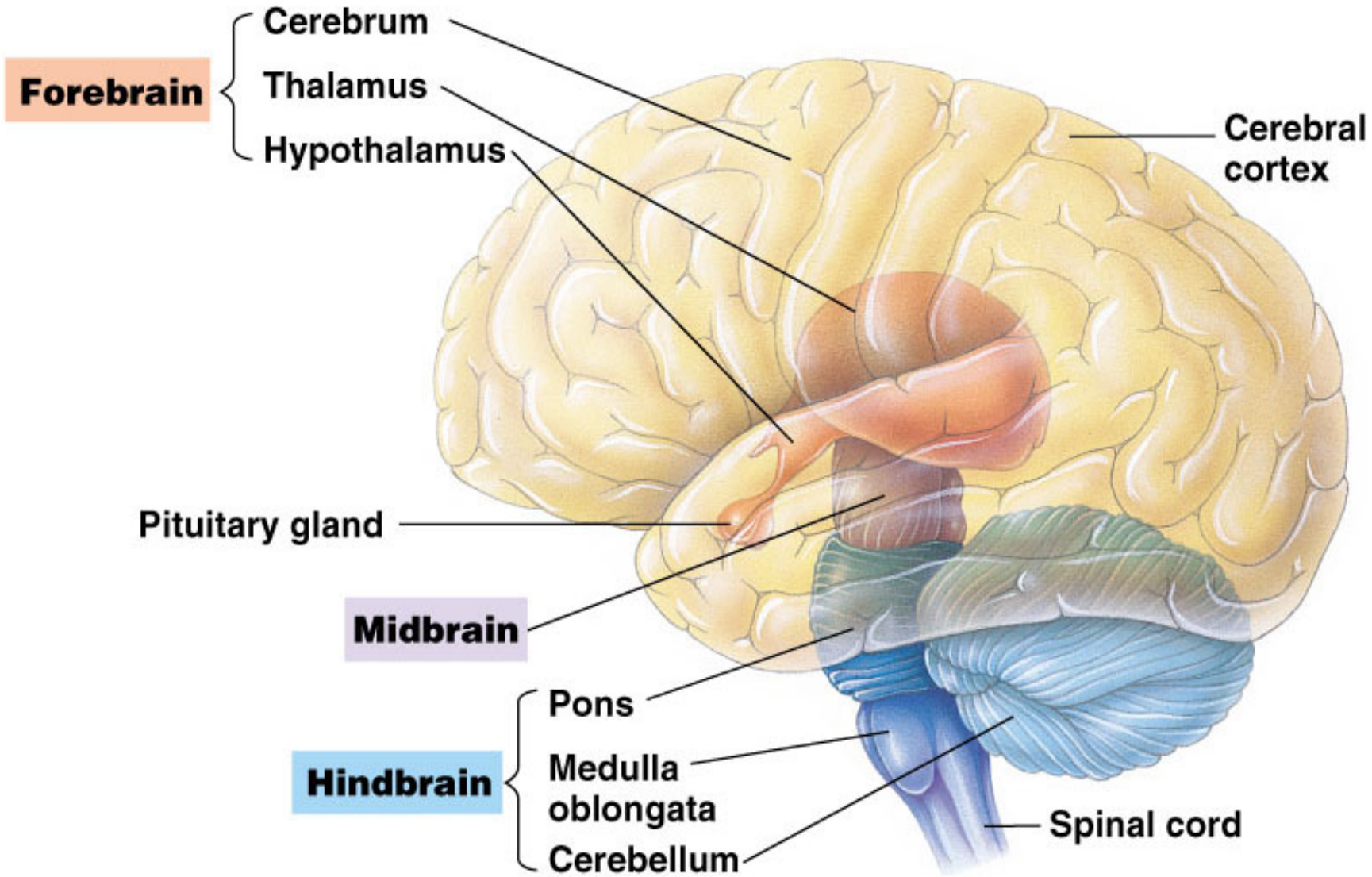
Uses Acetylcholine as Neurotransmitter

Uses Noradrenaline as Neurotransmitters

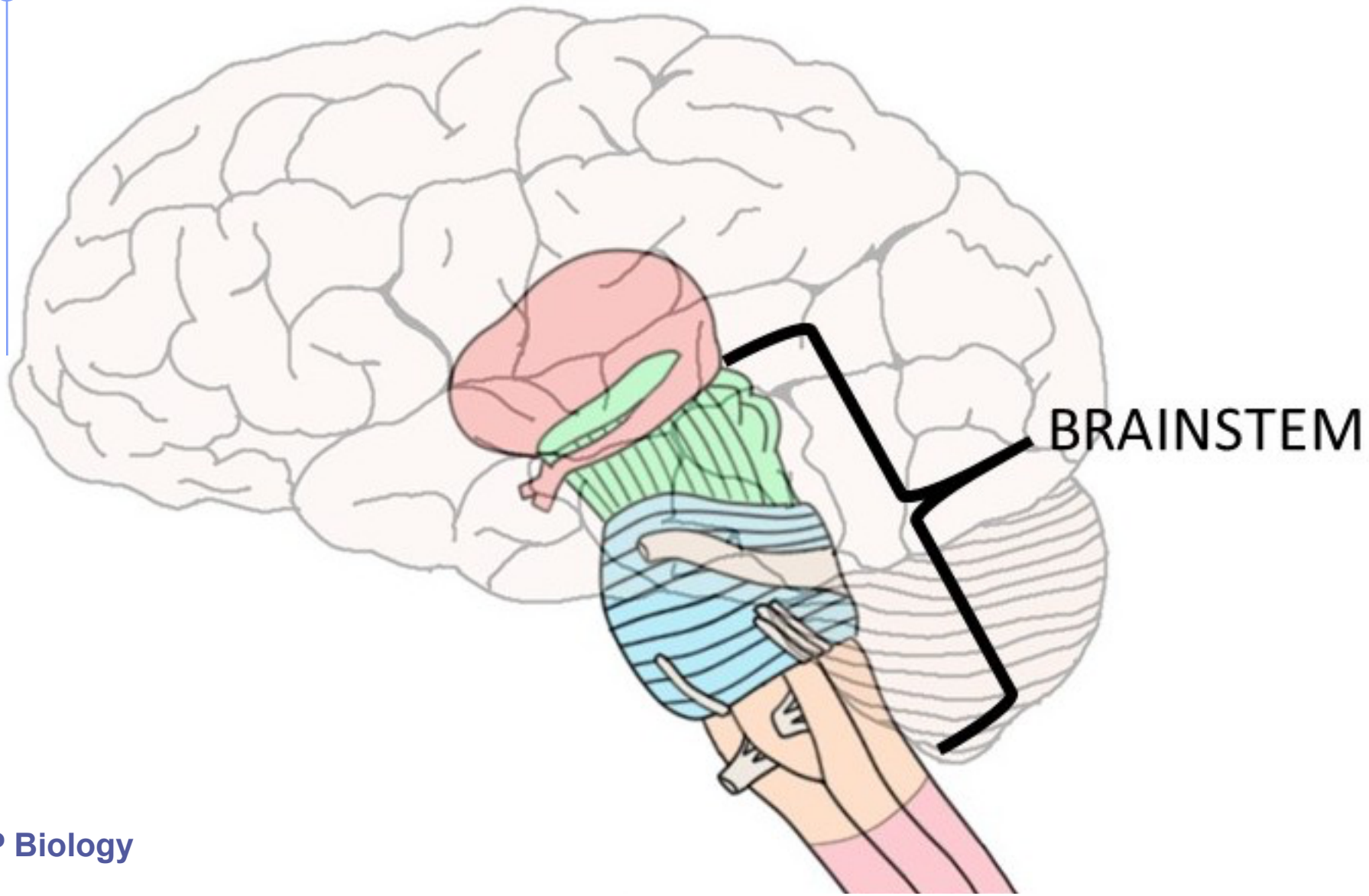


- Sympathetic
  - arousal & energy production
  - "fight or flight"
- Parasympathetic
  - calming & maintenance
  - "rest & digest"

Human brain - *Know how to identify these parts!*

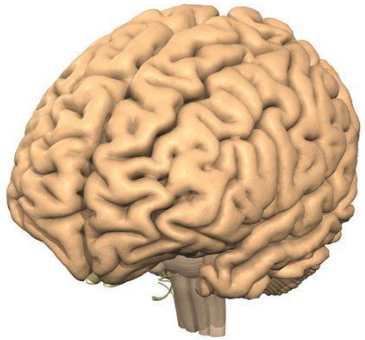


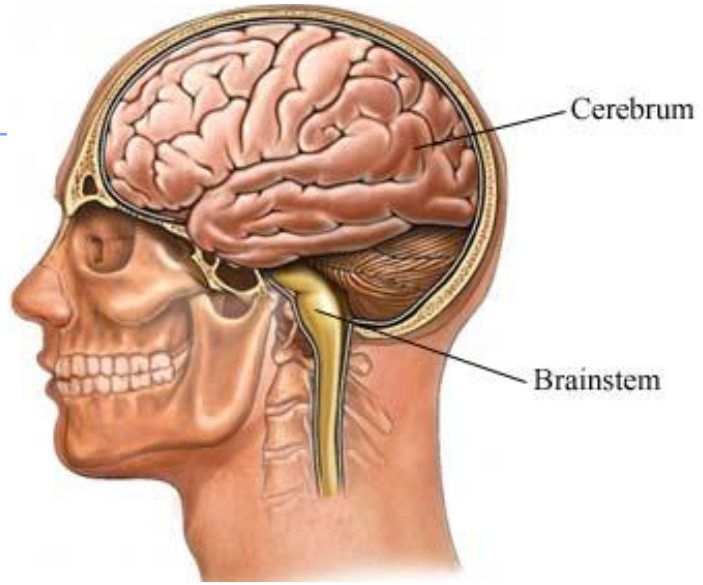
The Brain Stem

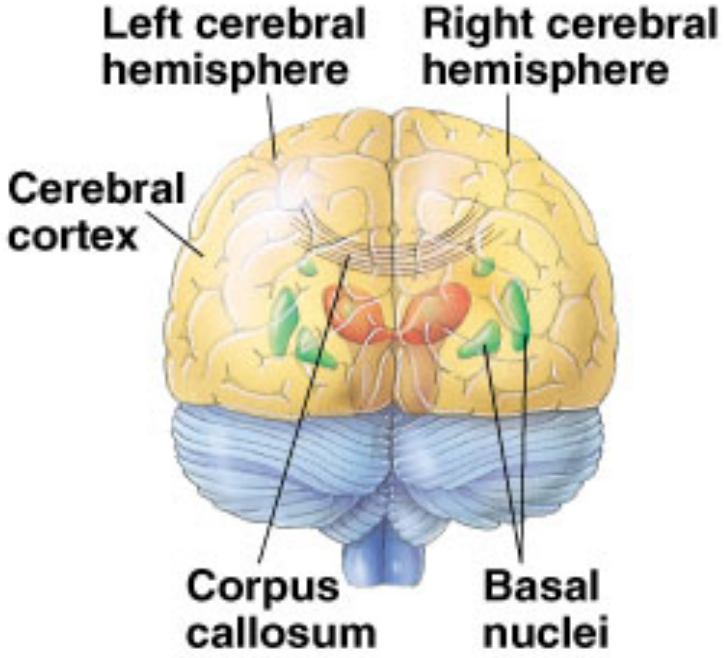


Cerebrum

- The largest part of the brain
  - Responsible for:
    - Movement
    - Sensory Processing
      - Olfaction
      - Gulfaction
      - Touch
      - Vision
      - Hearing
    - Judgment
    - Reasoning
    - Problem Solving
    - Emotions
    - Learning & Memory
    - Language & Communication

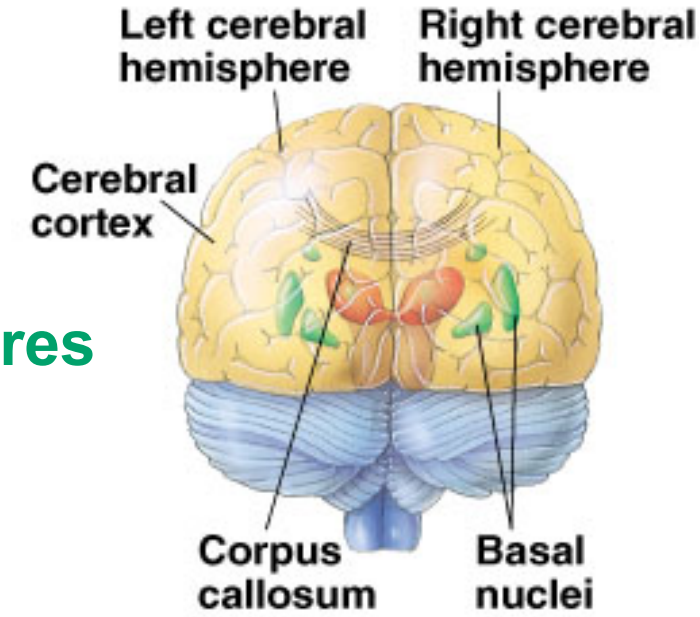






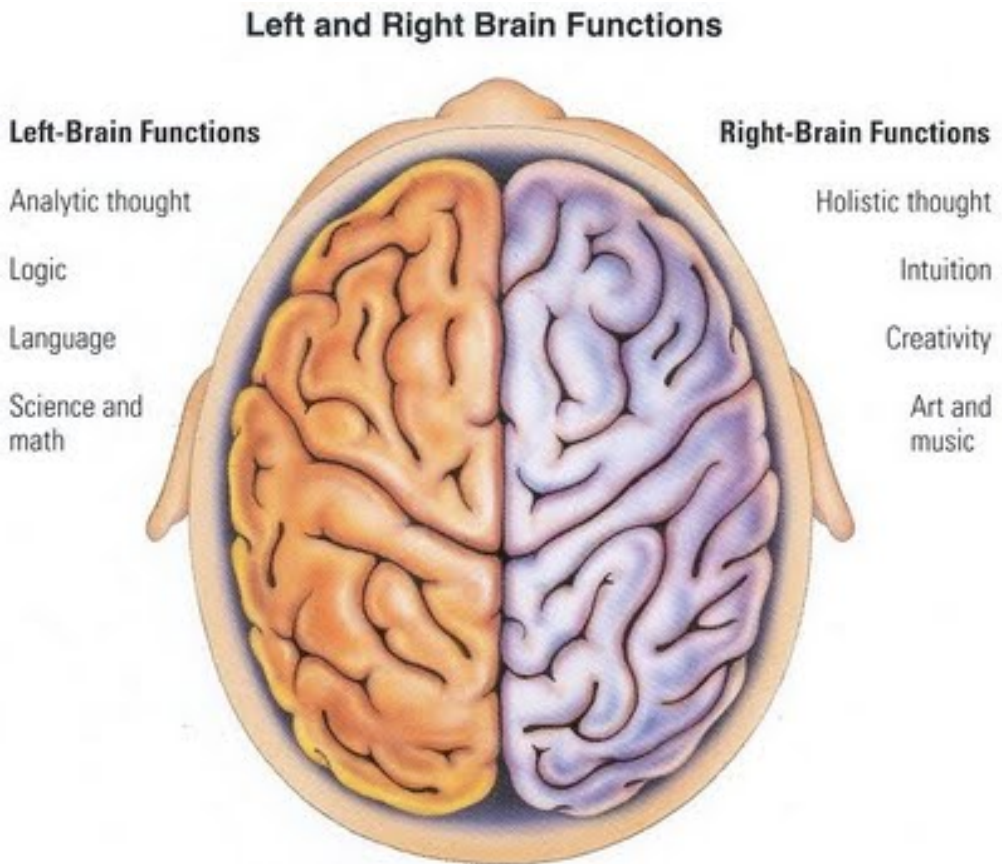
Cerebrum

- Most highly evolved structure of mammalian brain
  - Cerebrum divided into two hemispheres
    - left = controls right side of body
    - right = controls left side of body
    - Each hemisphere has an outer covering of gray matter called the cerebral cortex
      - Perception, voluntary movement and learning
  - Corpus callosum
    - Thick band of axons connecting hemispheres
      - Allow right and left sides to communicate



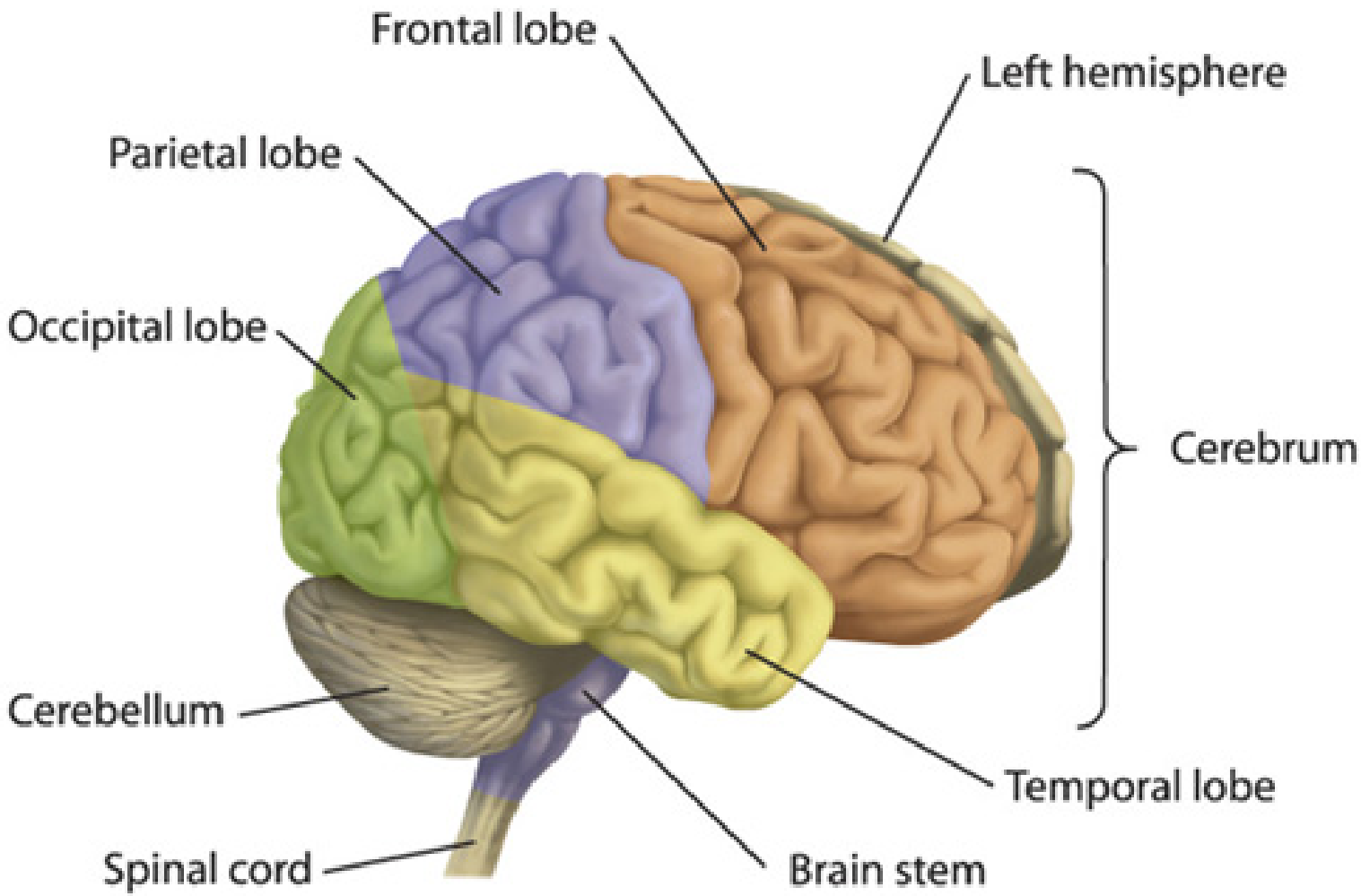
Lateralization of Brain Function

- **Hemispheres perform different functions**
  - **Left hemisphere** (“rational/logical side of the brain”)
    - language, math, logic operations, processing of serial sequences of information, visual & auditory details
    - detailed activities required for motor control
  - **Right hemisphere** (“artistic side of the brain”)
    - pattern recognition, spatial relationships, non-verbal ideation, emotional processing, parallel processing of information



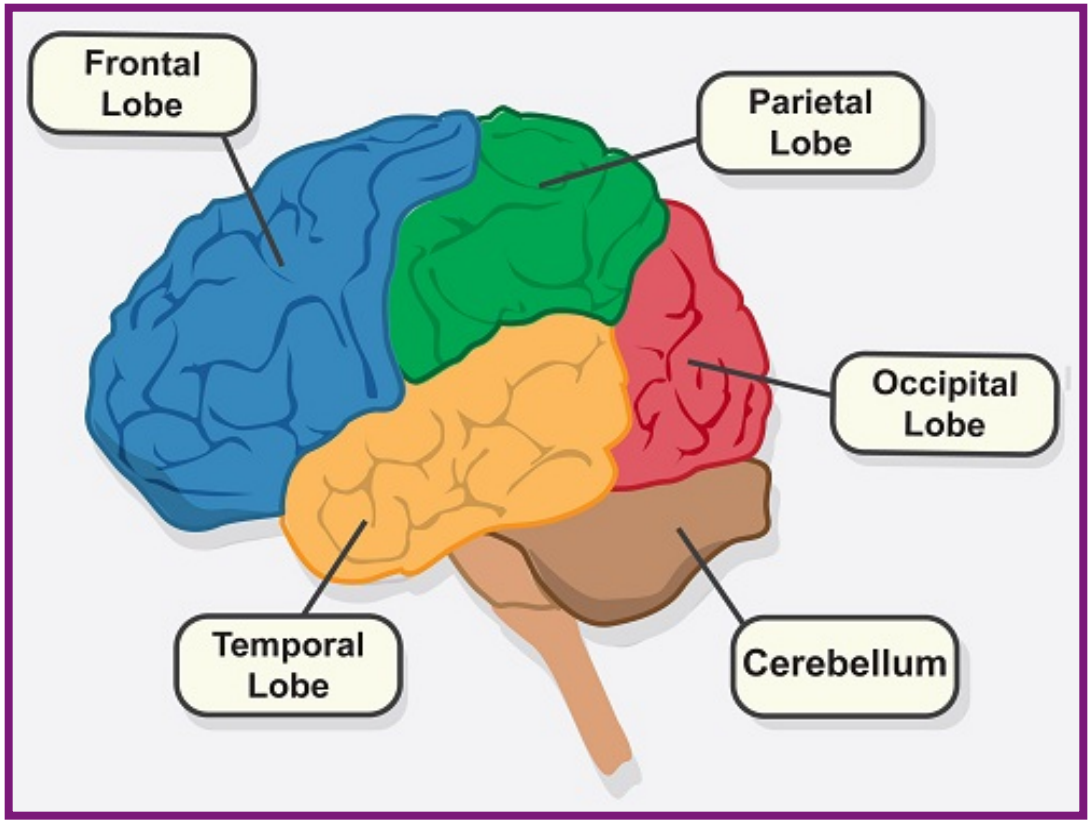
Major areas of our brain -

Know how to identify these areas!



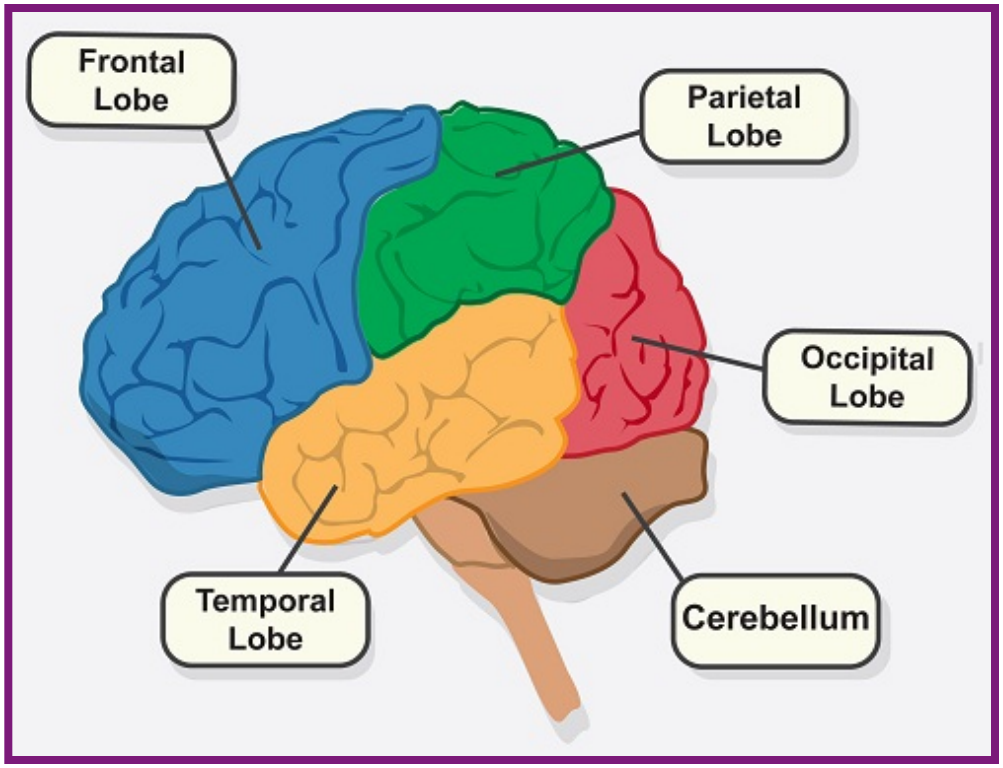
Cerebrum specialization - Frontal Lobe

- Reasoning
- Planning
- Parts of speech
- Movement
- Emotions
- Problem solving



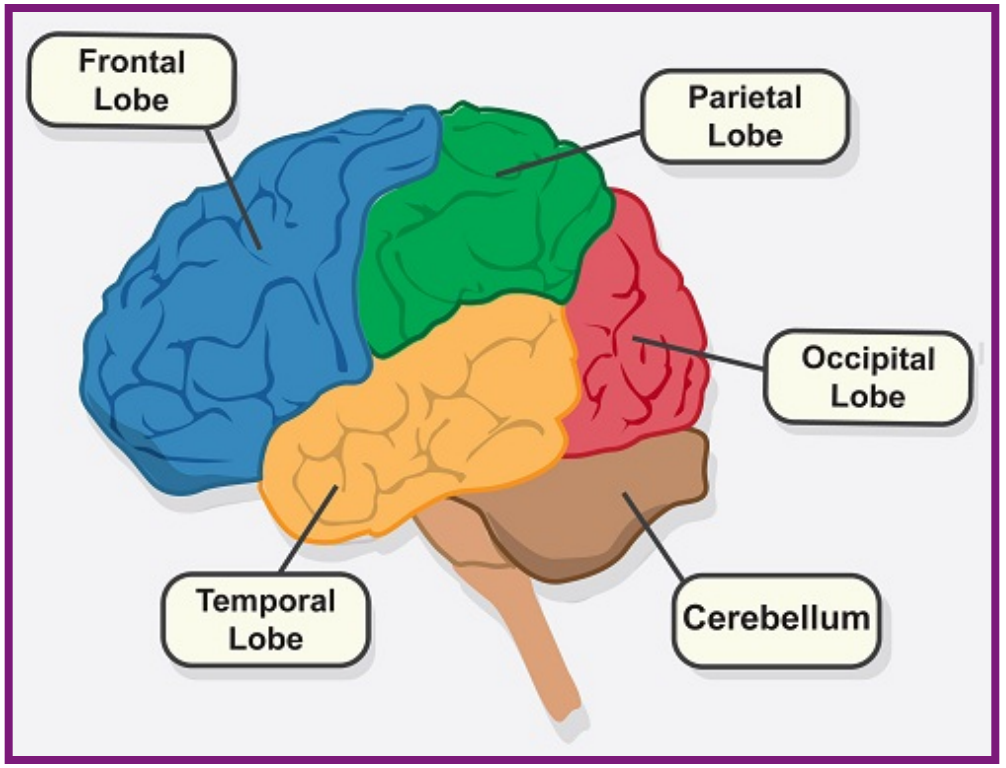
Cerebrum specialization - Parietal Lobe

- Associated with movement
- Orientation
- Recognition
- Perception of stimuli
- Arithmetic
- Spelling



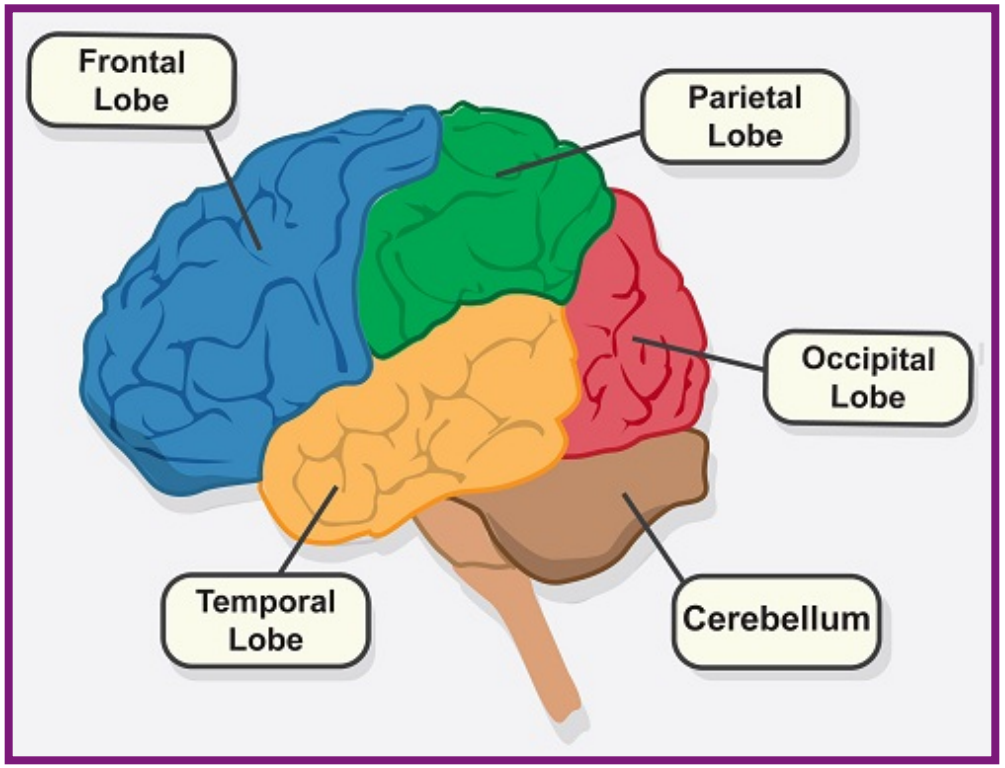
Cerebrum specialization - Temporal Lobe

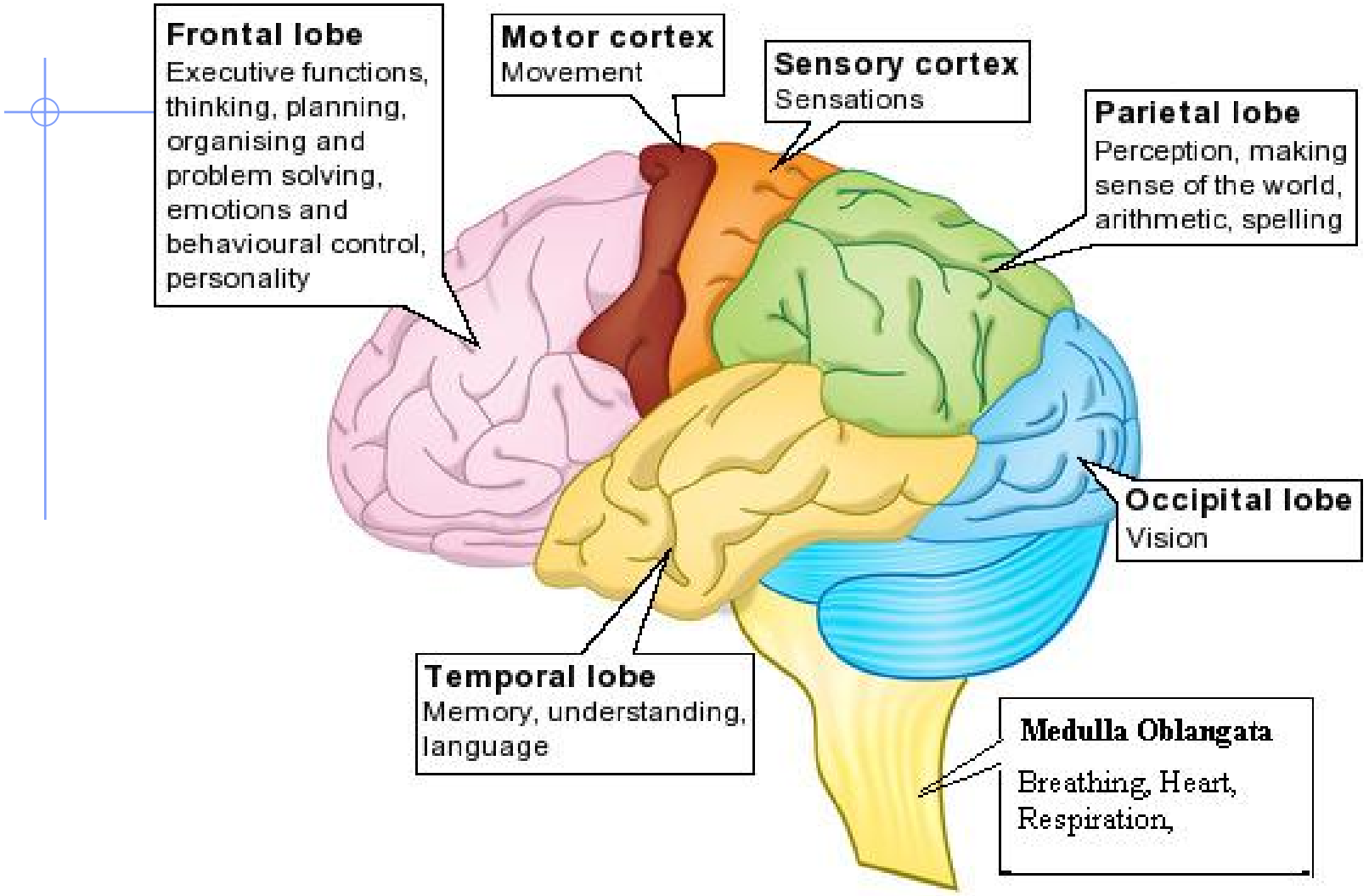
- Associated with perception and recognition of auditory stimuli
- Memory
- Speech & Language



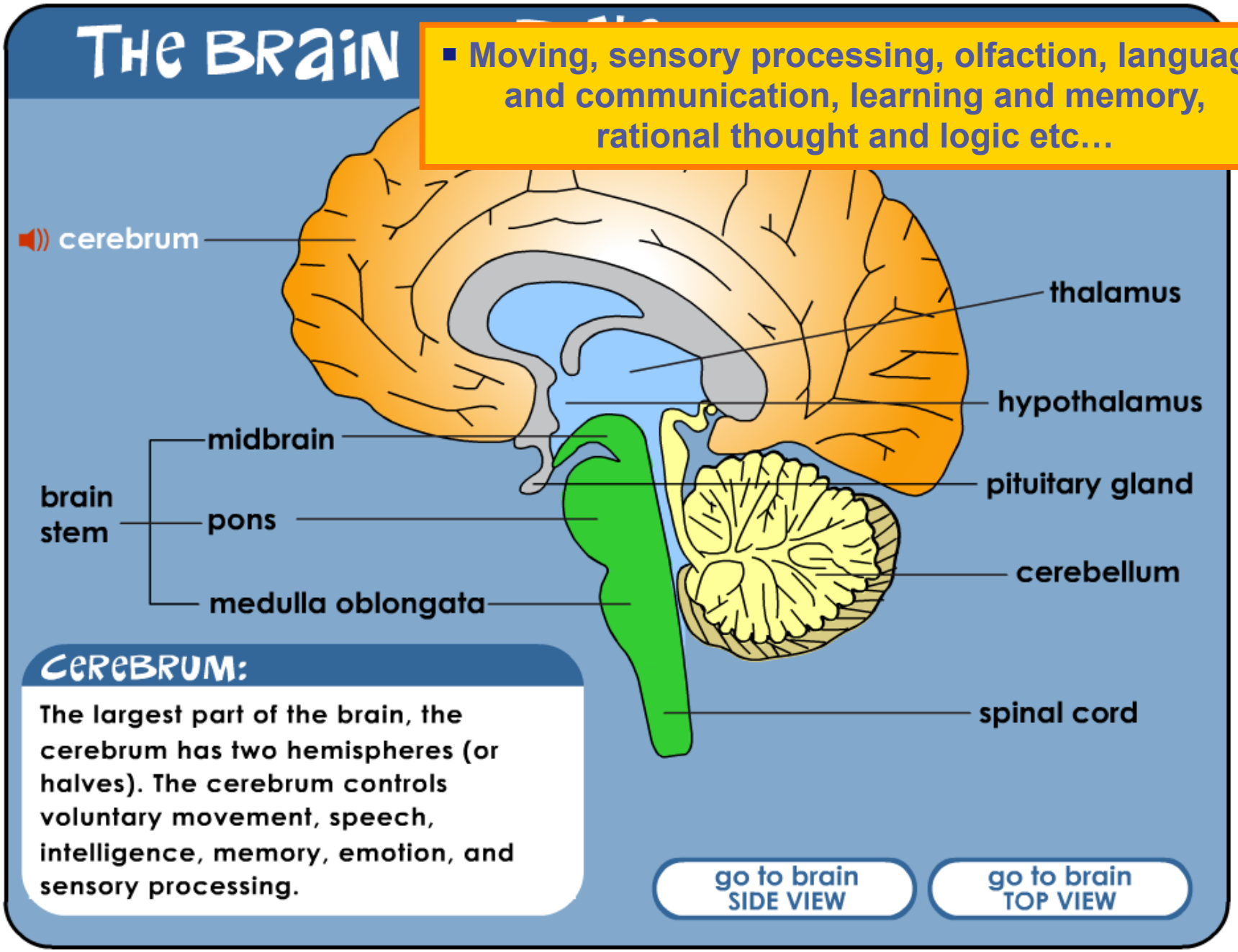
Cerebrum specialization - Occipital Lobe

- **associated with visual processing**

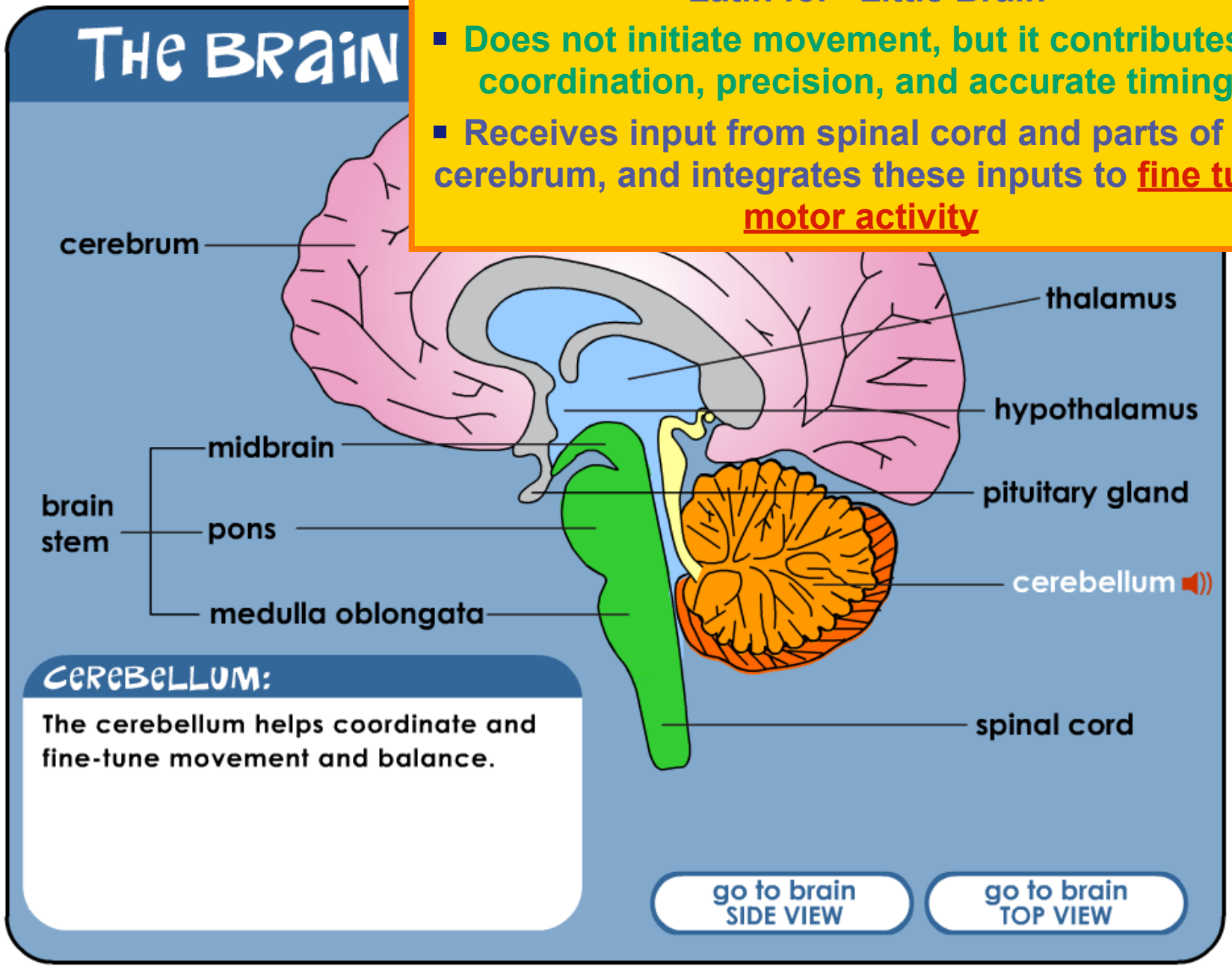


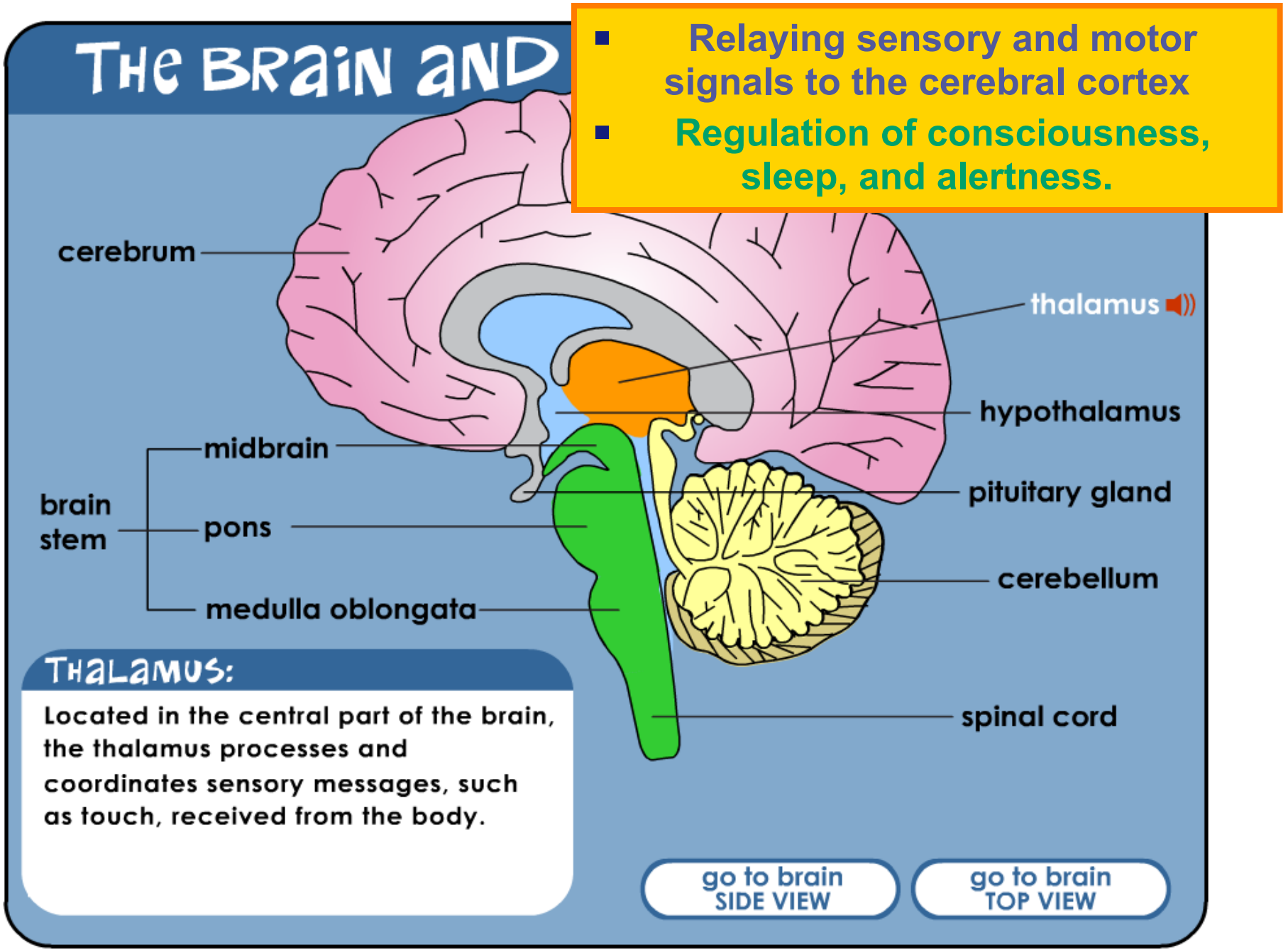


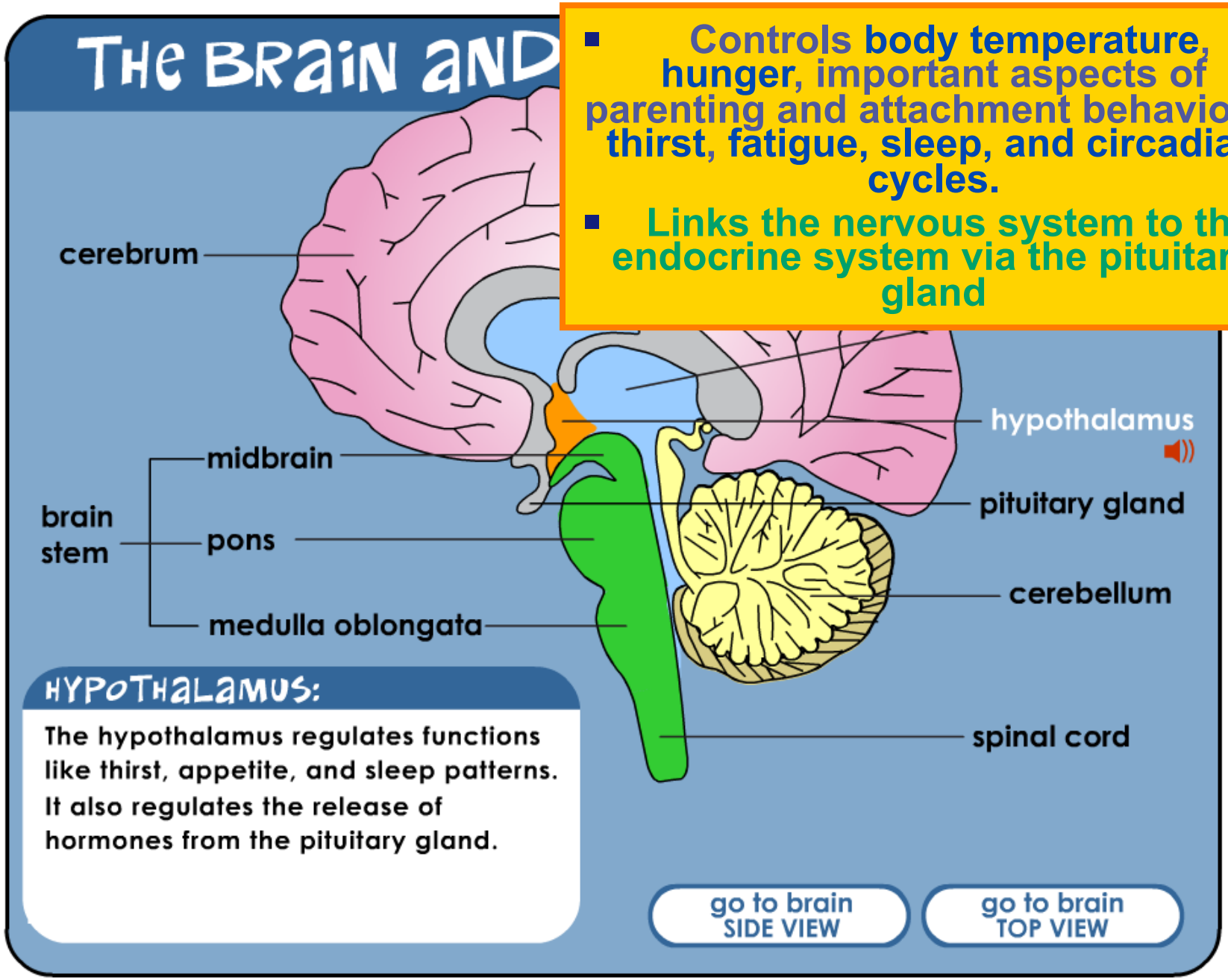
The cerebral cortex (the outer layer of the brain) is highly wrinkled - makes the brain more efficient, because it can increase the surface area of the brain and the amount of neurons within it.


THE BRAIN
Moving, sensory processing, olfaction, language and communication, learning and memory, rational thought and logic etc…
cerebrum
thalamus
hypothalamus
midbrain
brain stem
pons
medulla oblongata
pituitary gland
cerebellum
spinal cord
CEREBRUM:
The largest part of the brain, the cerebrum has two hemispheres (or halves). The cerebrum controls voluntary movement, speech, intelligence, memory, emotion, and sensory processing.
go to brain SIDE VIEW
go to brain TOP VIEW

- Latin for "Little Brain"
- Does not initiate movement, but it contributes to coordination, precision, and accurate timing.
- Receives input from spinal cord and parts of the cerebrum, and integrates these inputs to fine tune motor activity

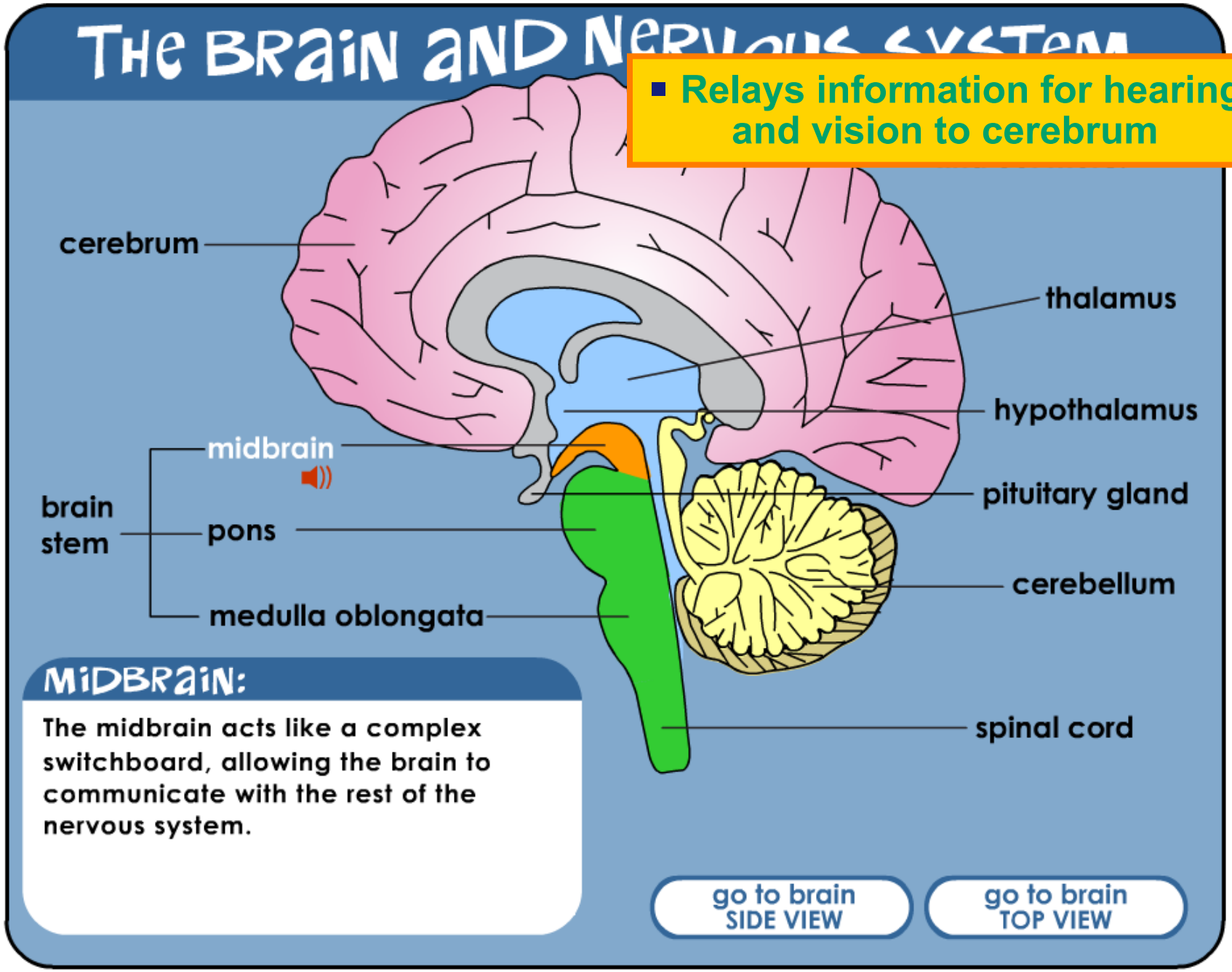



THE BRAIN AND
Relaying sensory and motor signals to the cerebral cortex
Regulation of consciousness, sleep, and alertness.
cerebrum
thalamus
hypothalamus
midbrain
brain stem
pons
medulla oblongata
pituitary gland
cerebellum
spinal cord
THALAMUS:
Located in the central part of the brain, the thalamus processes and coordinates sensory messages, such as touch, received from the body.
go to brain SIDE VIEW
go to brain TOP VIEW

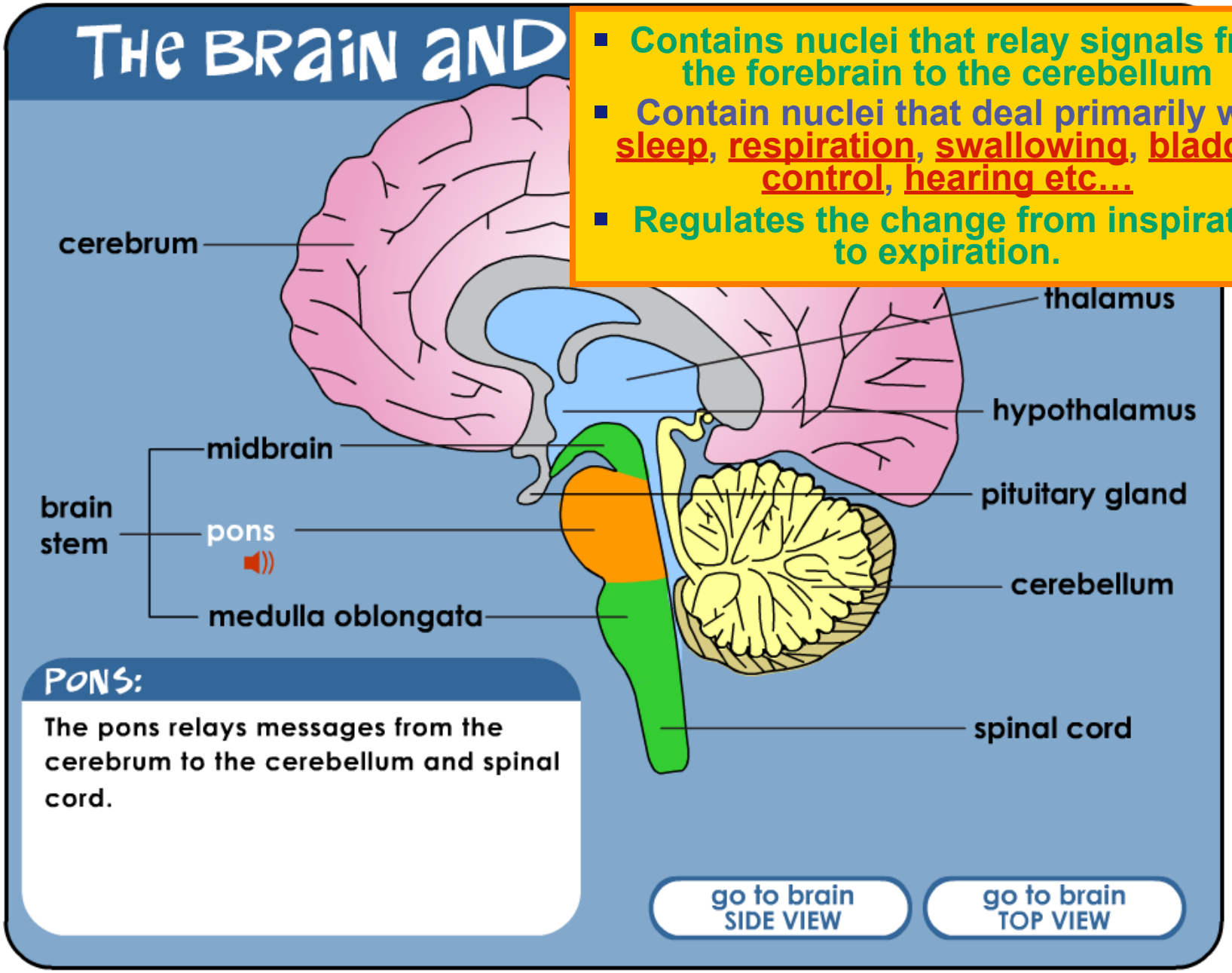


- Controls body temperature, hunger, important aspects of parenting and attachment behaviors, thirst, fatigue, sleep, and circadian cycles.
- Links the nervous system to the endocrine system via the pituitary gland

AP


THE BRAIN AND NERVOUS SYSTEM
Relays information for hearing and vision to cerebrum
cerebrum
thalamus
hypothalamus
midbrain
brain stem
pons
medulla oblongata
pituitary gland
cerebellum
spinal cord
MIDBRAIN:
The midbrain acts like a complex switchboard, allowing the brain to communicate with the rest of the nervous system.
go to brain SIDE VIEW
go to brain TOP VIEW

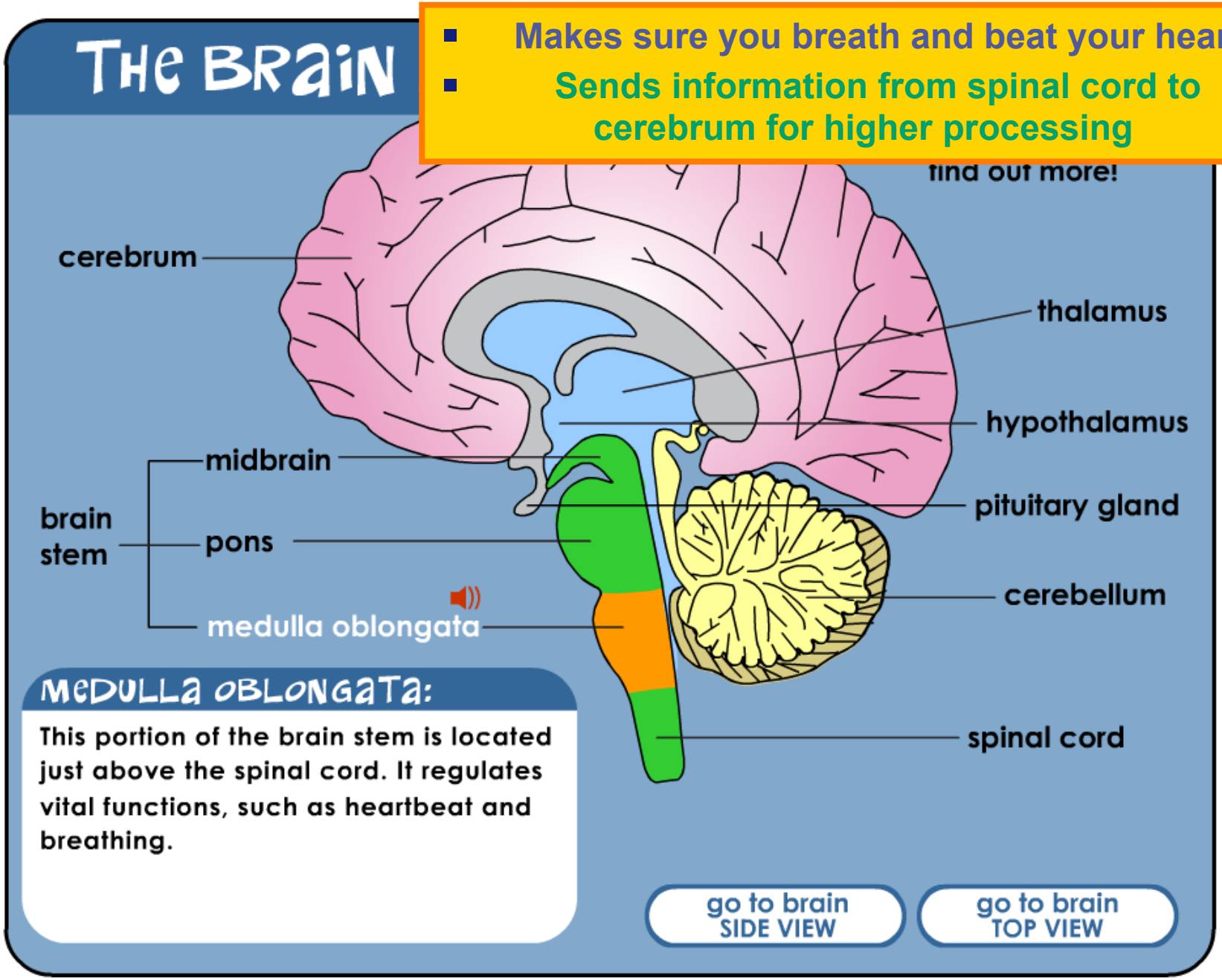
AP



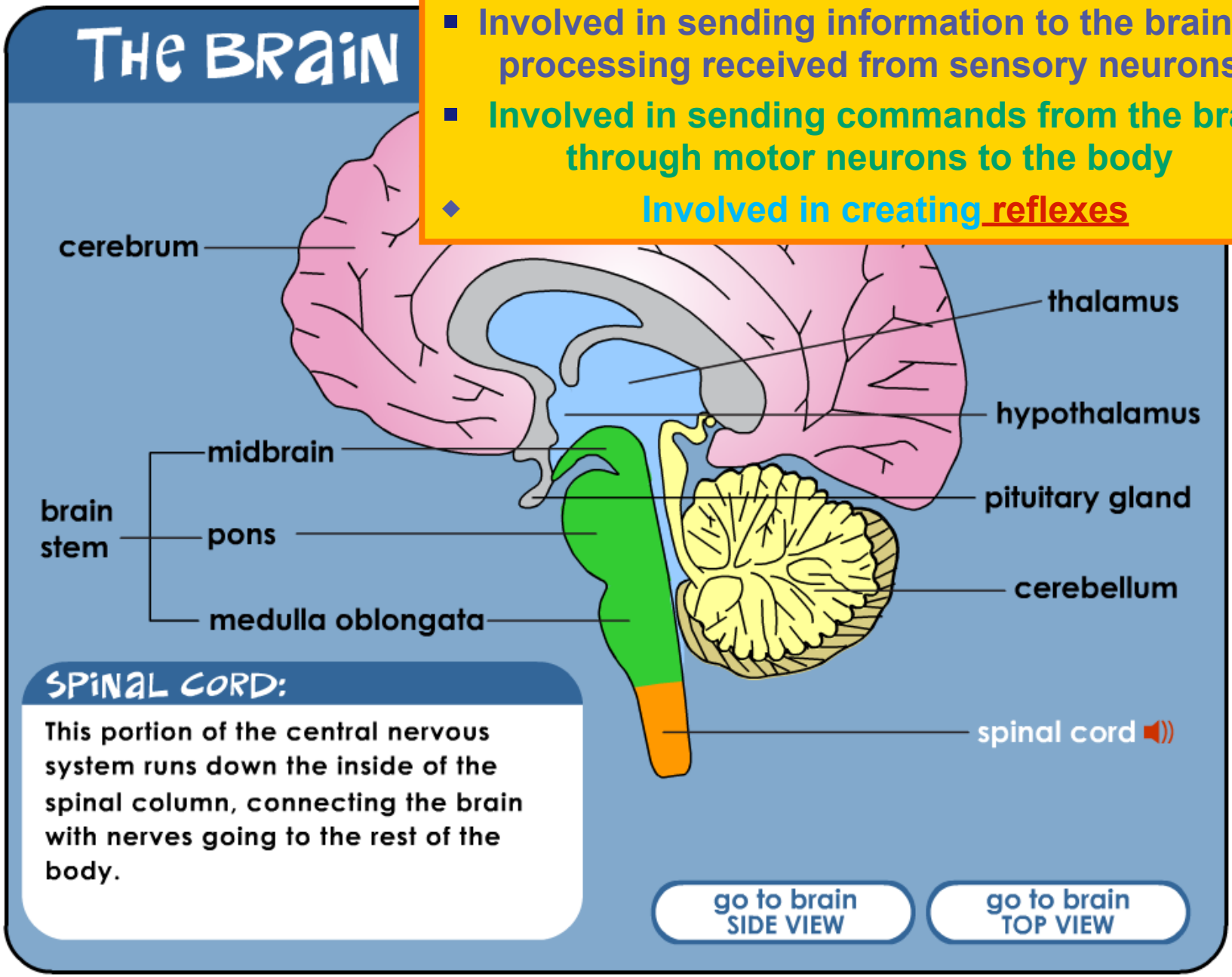
- Contains nuclei that relay signals from the forebrain to the cerebellum
- Contain nuclei that deal primarily with sleep, respiration, swallowing, bladder control, hearing etc…
- Regulates the change from inspiration to expiration.

AP

- Makes sure you breath and beat your heart
- Sends information from spinal cord to cerebrum for higher processing



AP


THE BRAIN
Involved in sending information to the brain for processing received from sensory neurons
Involved in sending commands from the brain through motor neurons to the body
Involved in creating reflexes
cerebrum
thalamus
hypothalamus
midbrain
brain stem
pons
medulla oblongata
pituitary gland
cerebellum
spinal cord
SPINAL CORD:
This portion of the central nervous system runs down the inside of the spinal column, connecting the brain with nerves going to the rest of the body.
go to brain SIDE VIEW
go to brain TOP VIEW

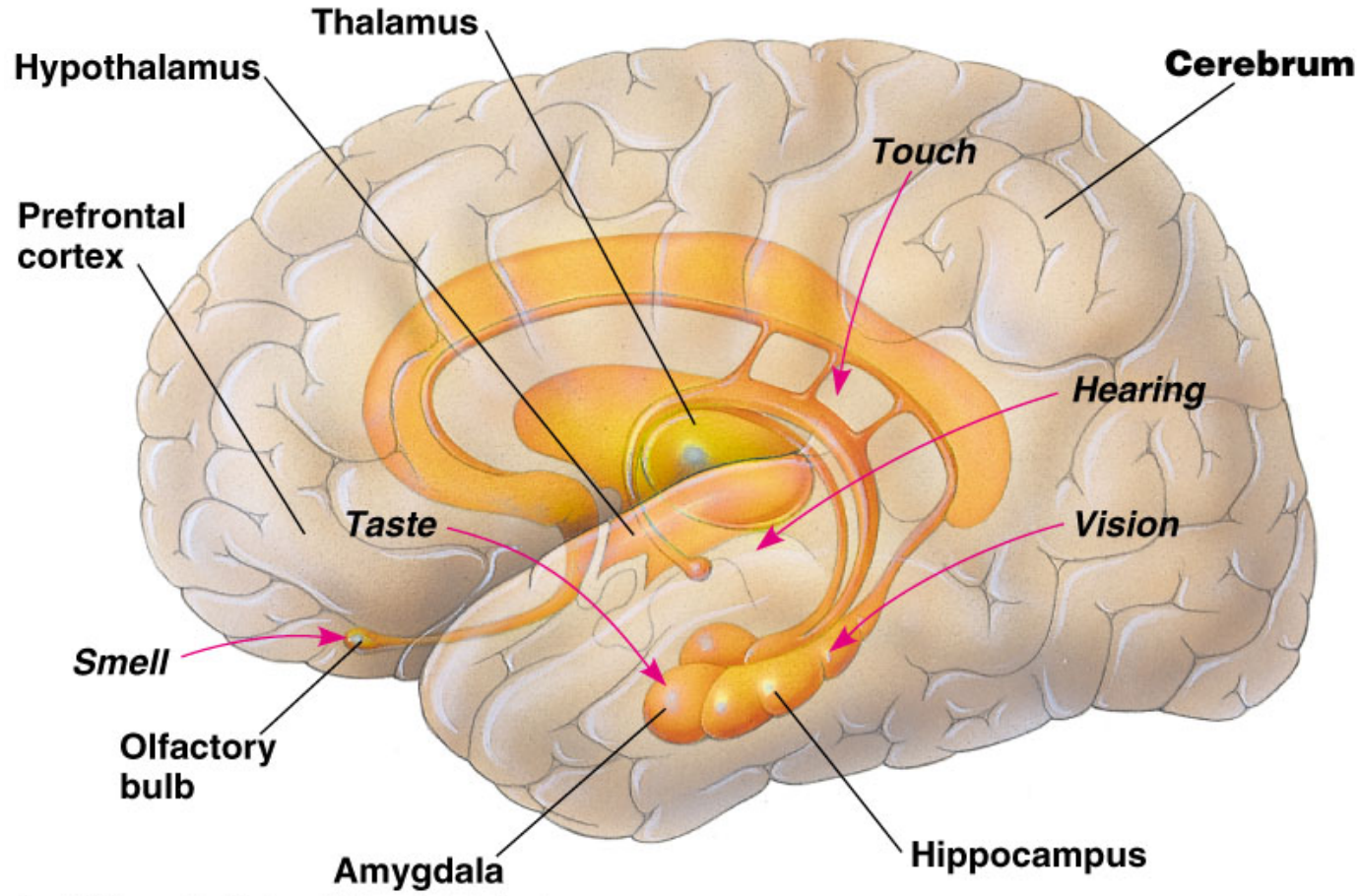
AP

Limbic system (Latin "limbus" meaning "border")

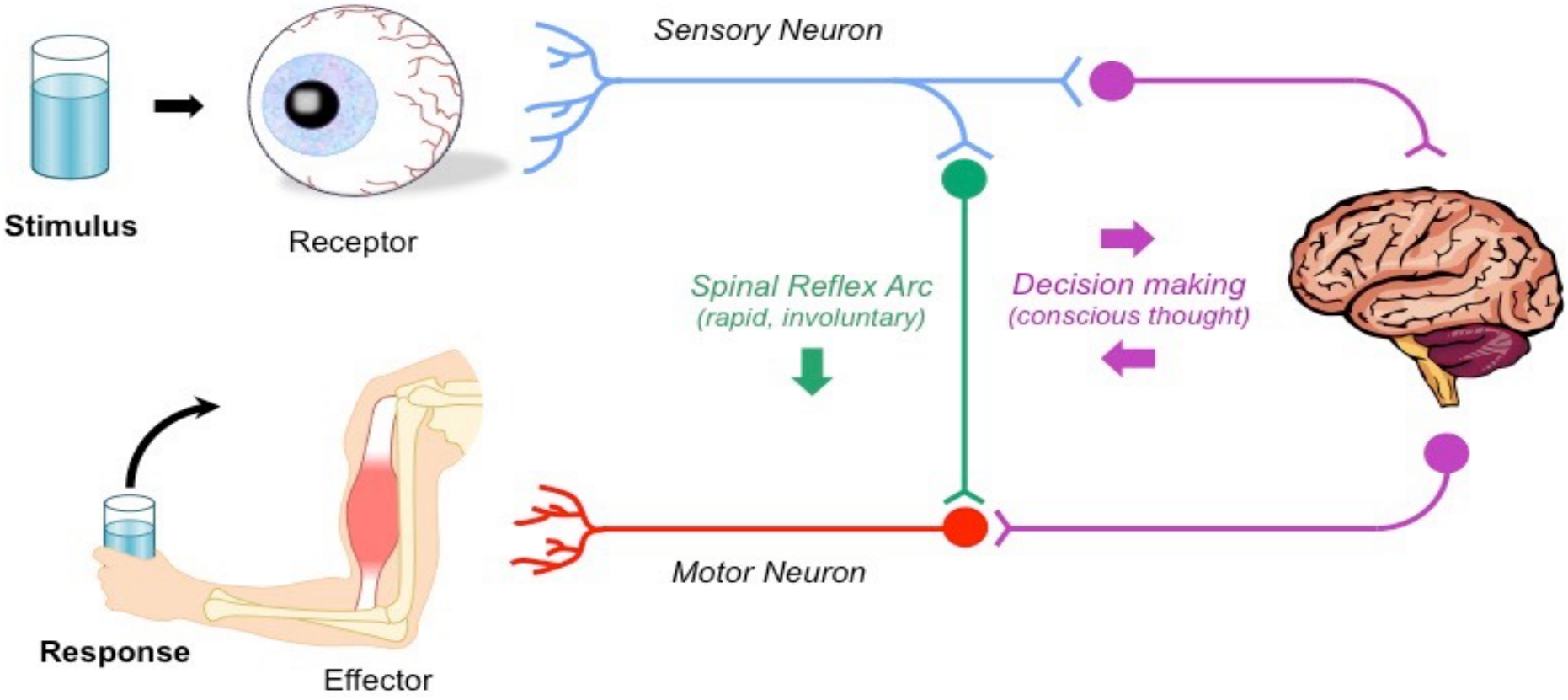
Mediates basic emotions (fear, anger) and is involved in emotional bonding

Amygdala = establishes emotional memory

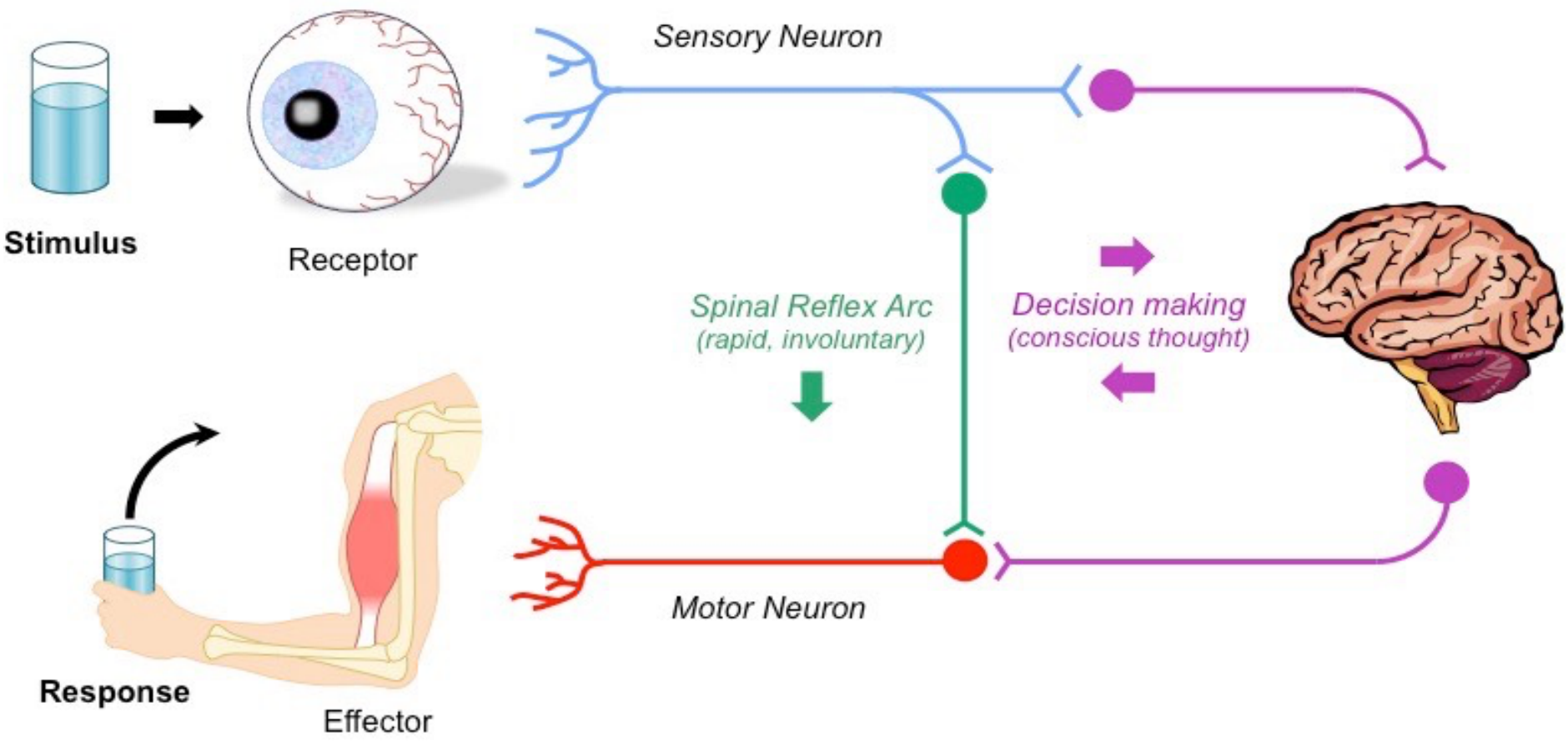
Amygdala involved in recognizing emotional content of facial expression & transferring short term into long term memory



- **The basic pathway for a nerve impulse is described by the stimulus response model**
  - **A stimulus is a change in the environment (either external or internal) that is detected by a receptor**
  - **Receptors transform the stimuli into nerve impulses that are transmitted to the brain where decision-making occurs**
  - **When a response is selected, the signal is transmitted via neurons to effectors, promoting a change in the organism's behavior**

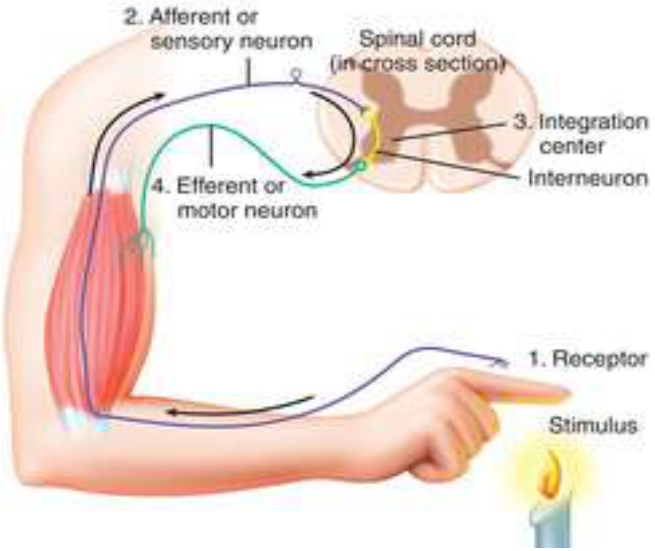


- **Some responses may be involuntary and occur without conscious thought – these actions are called reflexes**
  - **Reflex actions do not involve the brain – instead sensory information that enters the CNS' spinal cord is directly relayed to motor neurons within the spine**
  - **This results in a faster response, but one that does not involve conscious thought or deliberation**



Simplest Nerve Circuit

- **Though the brain is the center of integration for sensory information and motor commands originate here, *some responses initially bypass the brain altogether!***
  - **Reflex = automatic response involving the spinal cord (and sometimes the brain stem) but not the higher order centers of the brain**
  - **In vertebrates, most sensory neurons do not pass directly into the brain, but synapse in the spinal cord to interneurons that carry the information relayed by sensory neurons up to the brain via the spinal cord.**

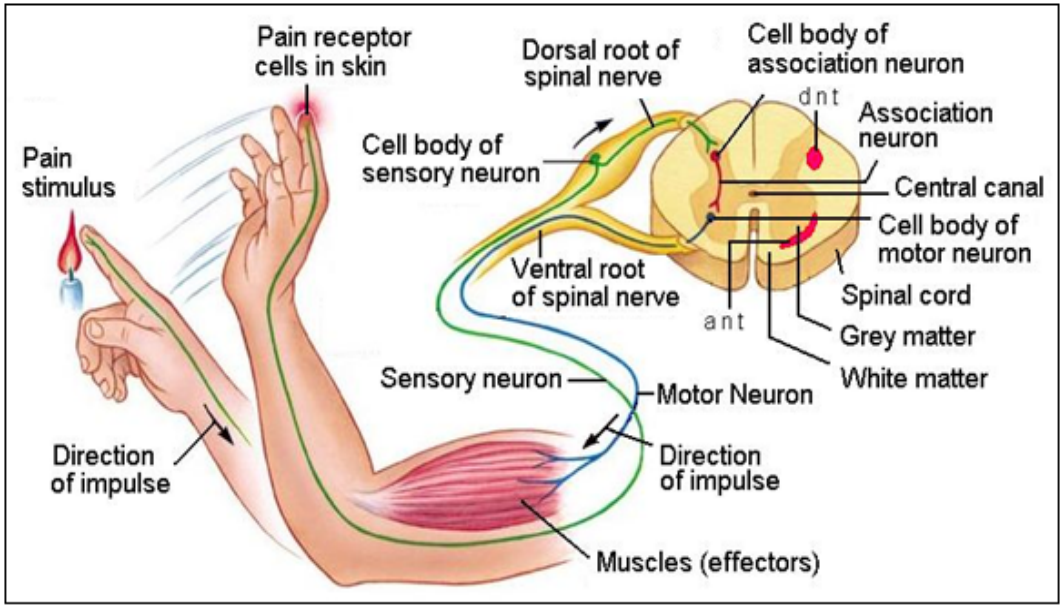


In a reflex, information bypasses integration in the brain, allowing for faster reflex actions to occur by activating spinal motor neurons without the delay of routing signals through the brain.

- **However, the brain will receive the sensory input while the reflex is being carried out and the analysis of the signal from sensory PNS neurons takes place after the reflex action has taken place.**

Reflex Arc

- **How does info travel along a reflex arc?**

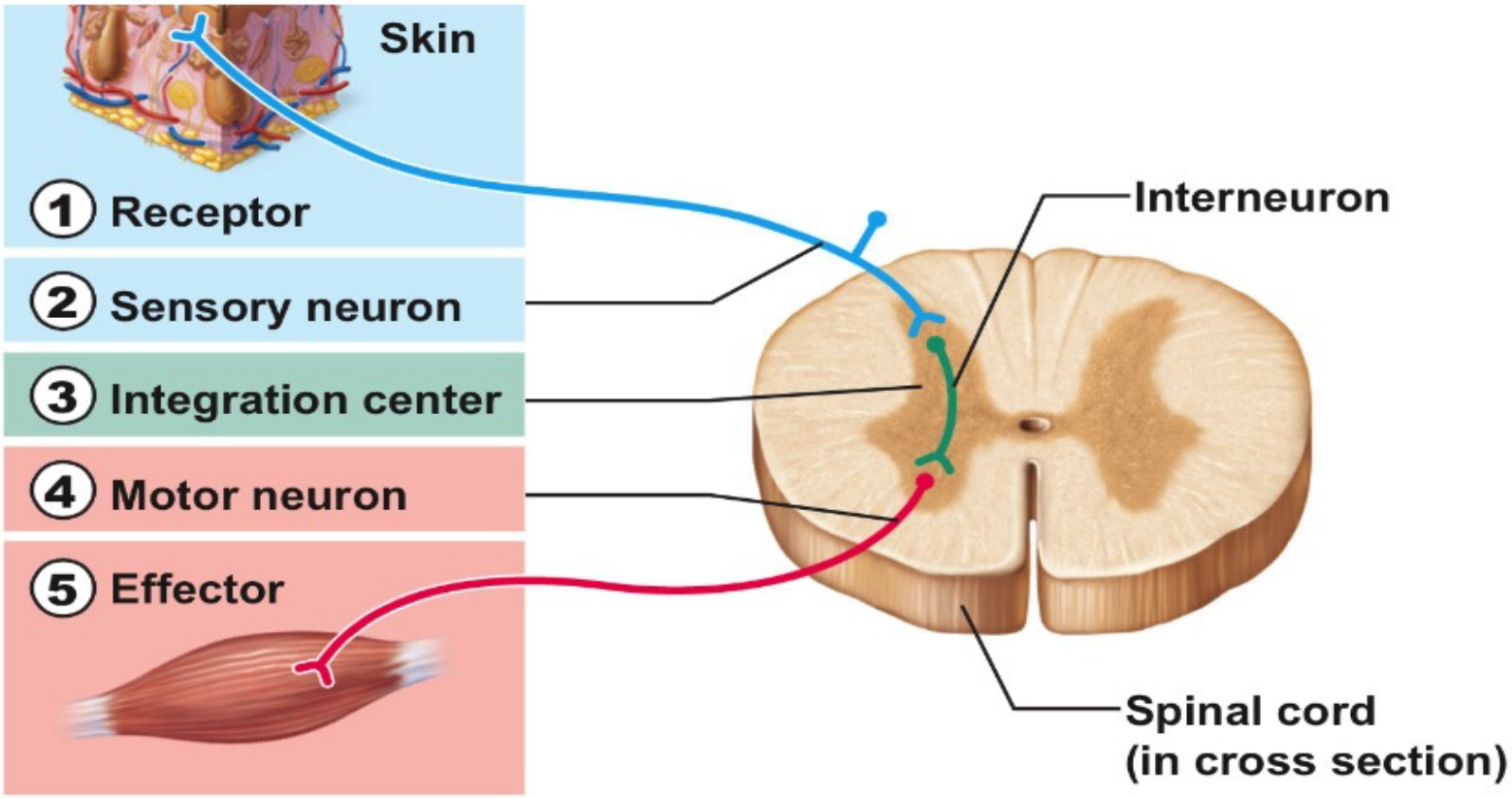


1. **Somatic receptors in the skin, muscles, organs, and tendons respond to a external or internal stimulus**
2. **Afferent nerve fibers carry signals from the receptors to the spinal cord (which may carry signal to brainstem)**
3. **An integrating center is activated involving interneurons of the spinal cord or brainstem**
4. **Efferent nerve fibers carry motor nerve signals from the spinal cord to the muscles**
5. **Effector muscle innervated by the efferent nerve fiber carries out the response.**

Reflex Arc

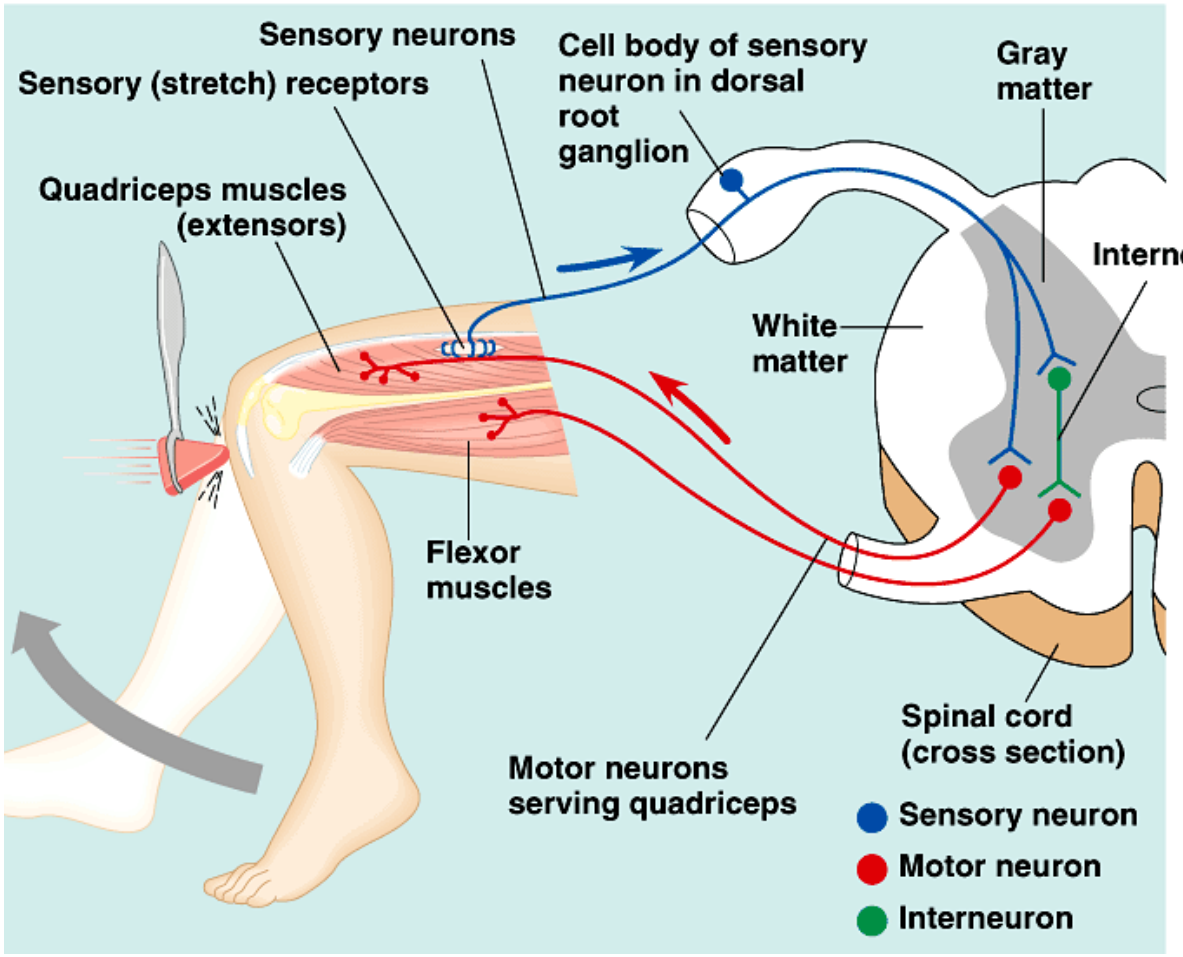
A reflex arc is the pathway followed by nerves which...

1. carry sensory information from the receptor to the spinal cord, and then
2. carry the response generated by the spinal cord to effector organ(s) during a reflex action.



Though the brain is the center of integration for sensory information and motor commands originate here, *some responses initially bypass the brain altogether!*

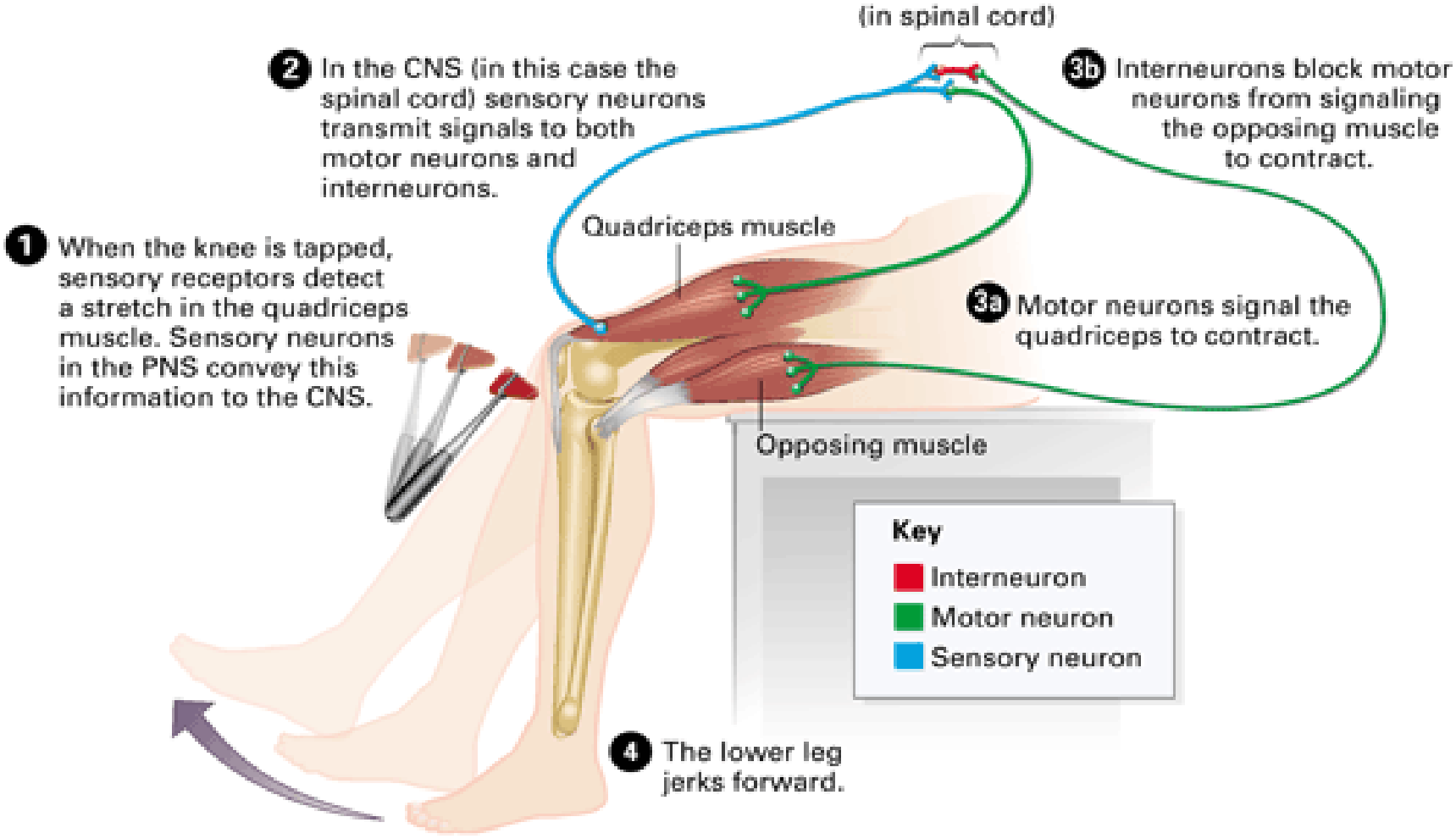
- **Reflex = automatic response**
  - signal travels shorter distance - from PNS to spinal cord then out to body's effector cells
    - no higher level processing
      - *the brain didn't decide to send out this command*

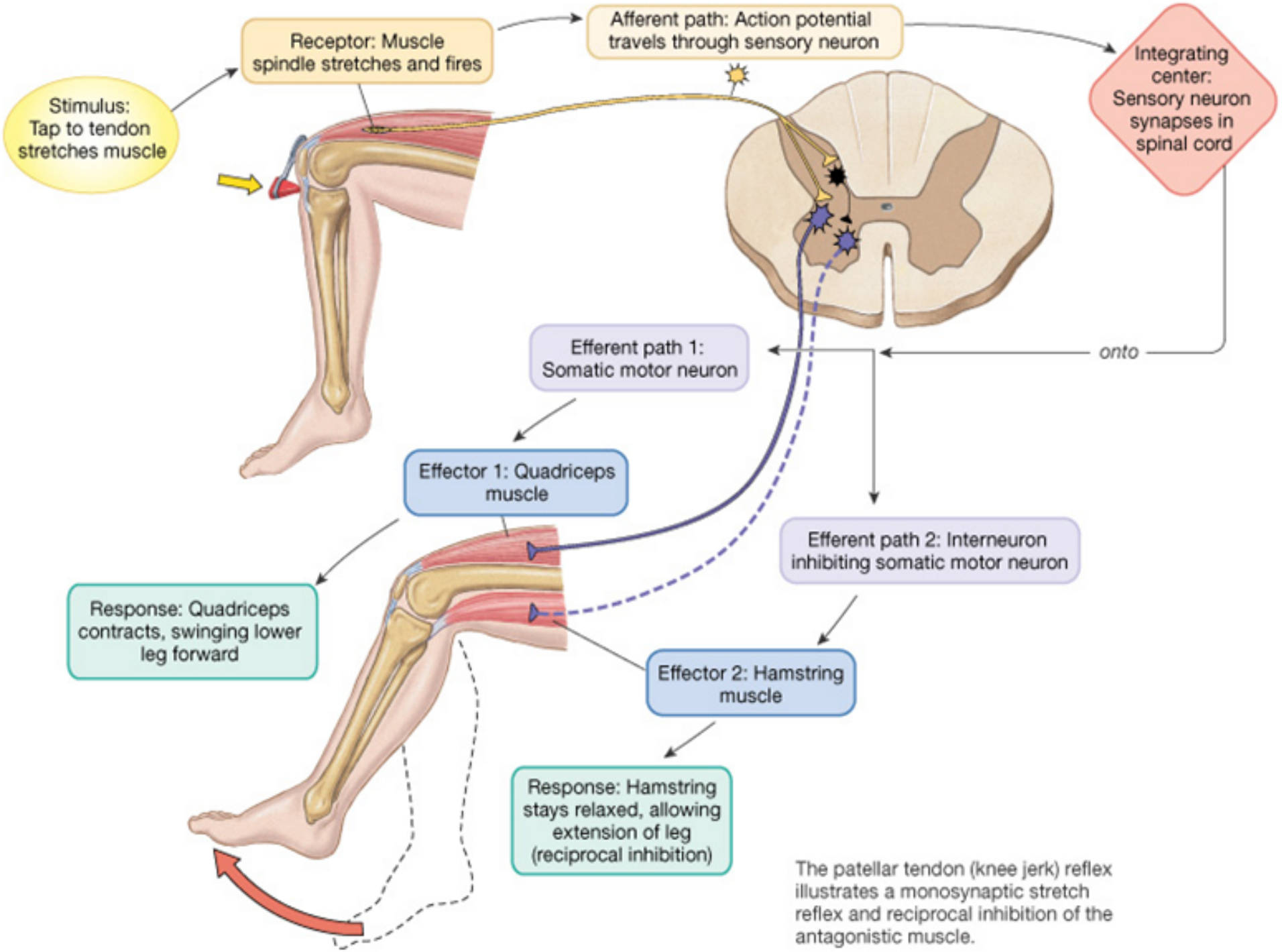


- **Reflexes result in rapid automatic responses**
- **Reflexes have adaptive values** *(improve an organisms ability to survive and thus go on to reproduce)*:
  - controls certain essential actions
  - don't need to take extra time to think & make decisions about response so you decrease chance of injury or harm
    - Blinking
    - Balance
    - Pupil dilation
    - Startle response
    - Emetic/Vomiting reflex
    - etc...

Reflexes

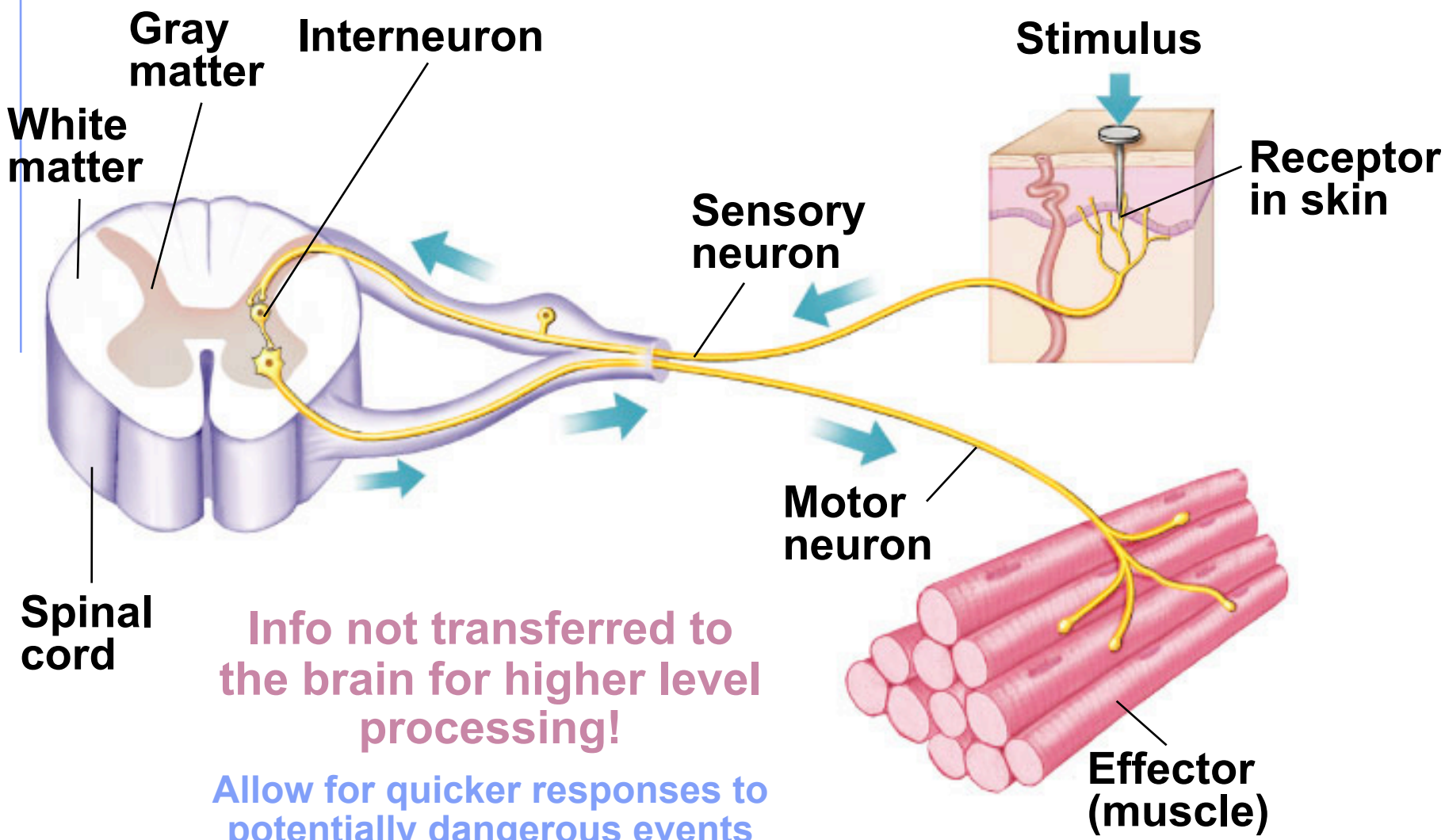
- **Rapid, automatic responses known as reflexes bypass the brain so that the body responds to external, possibly harmful or important, stimuli faster to increase survivability.**





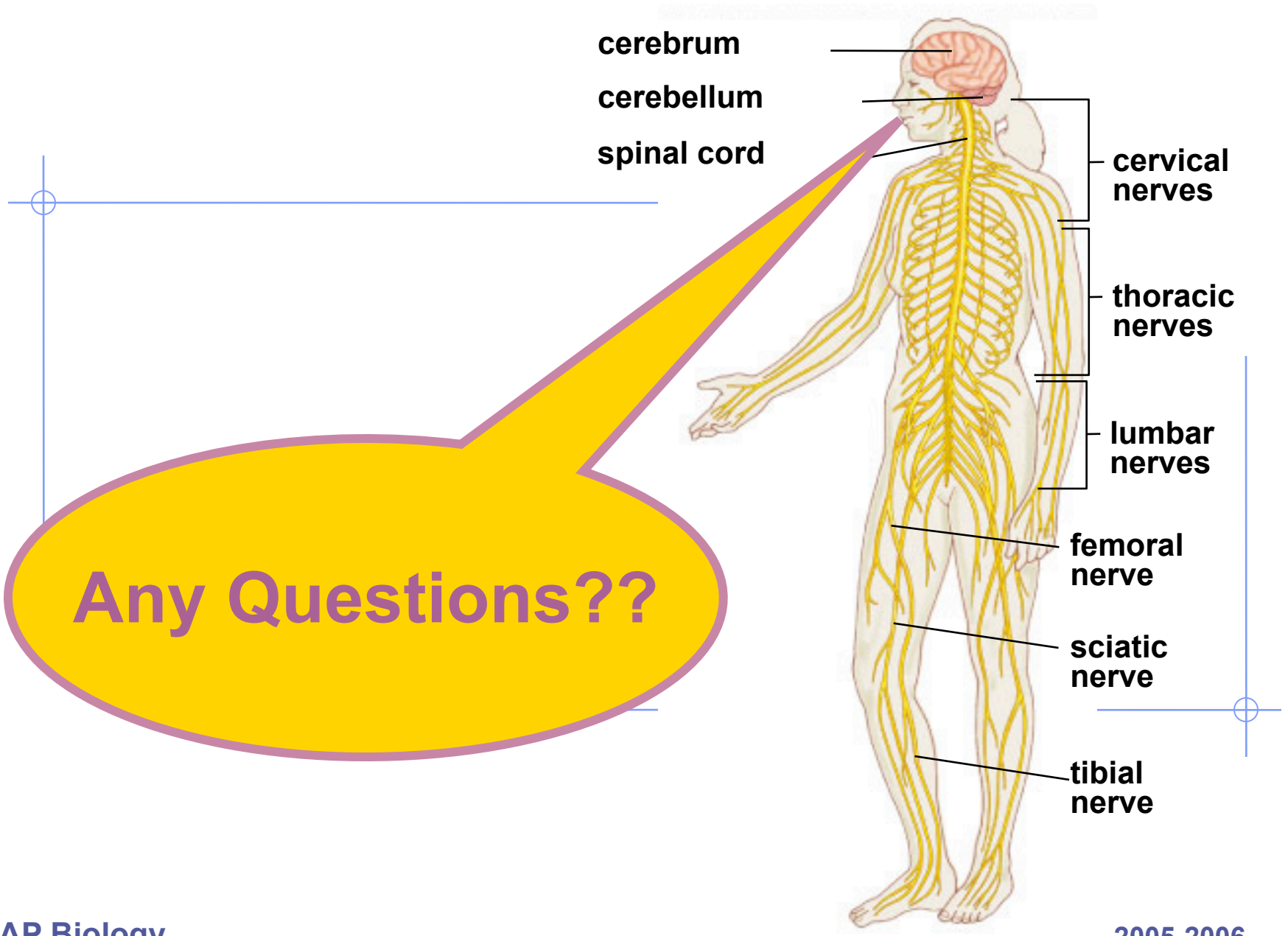
The patellar tendon (knee jerk) reflex illustrates a monosynaptic stretch reflex and reciprocal inhibition of the antagonistic muscle.

Eye Blink or Pain Withdrawal Reflex



Info not transferred to the brain for higher level processing!

Allow for quicker responses to potentially dangerous events


cerebrum
cerebellum
spinal cord
cervical nerves
thoracic nerves
lumbar nerves
femoral nerve
sciatic nerve
tibial nerve
Any Questions??