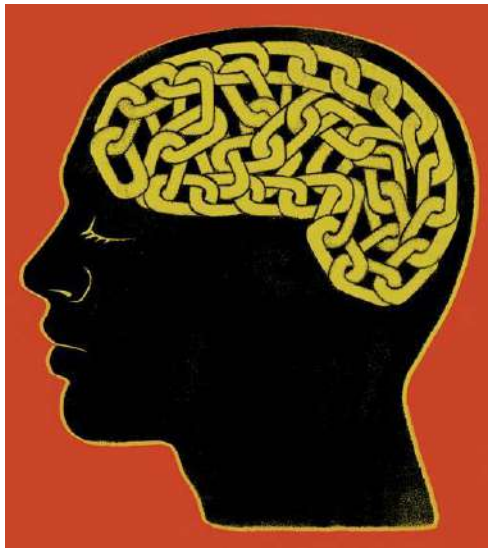


The Biology of Mind

Chapter 2

The Biology of Mind

Neural Communication

- Neurons
- How Neurons Communicate
- How Neurotransmitters Influence Us

The Nervous System

- The Peripheral Nervous System
- The Central Nervous System

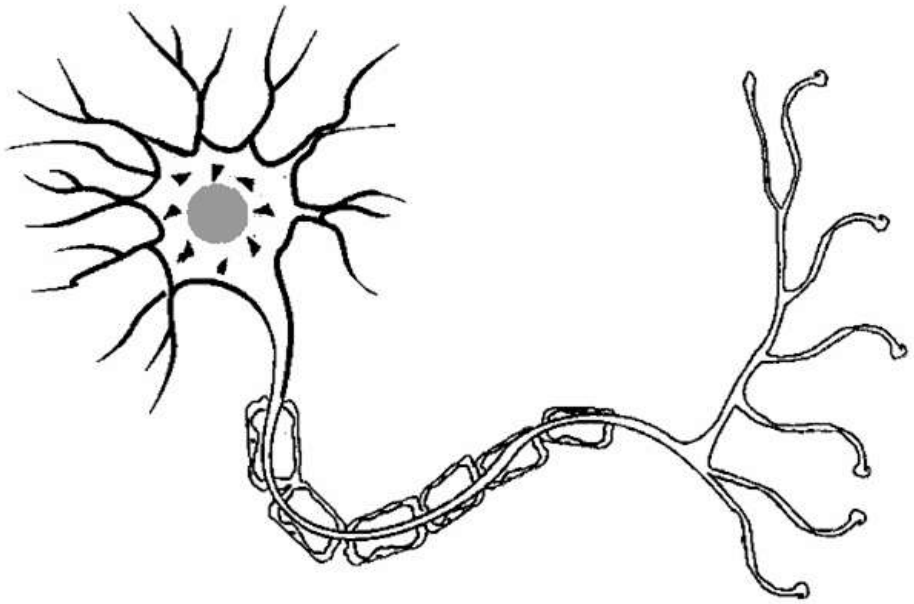
The Endocrine System

The Brain

- The Tools of Discovery: Having our Head Examined
- Older Brain Structures
- The Cerebral Cortex
- Our Divided Brain
- Right-Left Differences in the Intact Brain

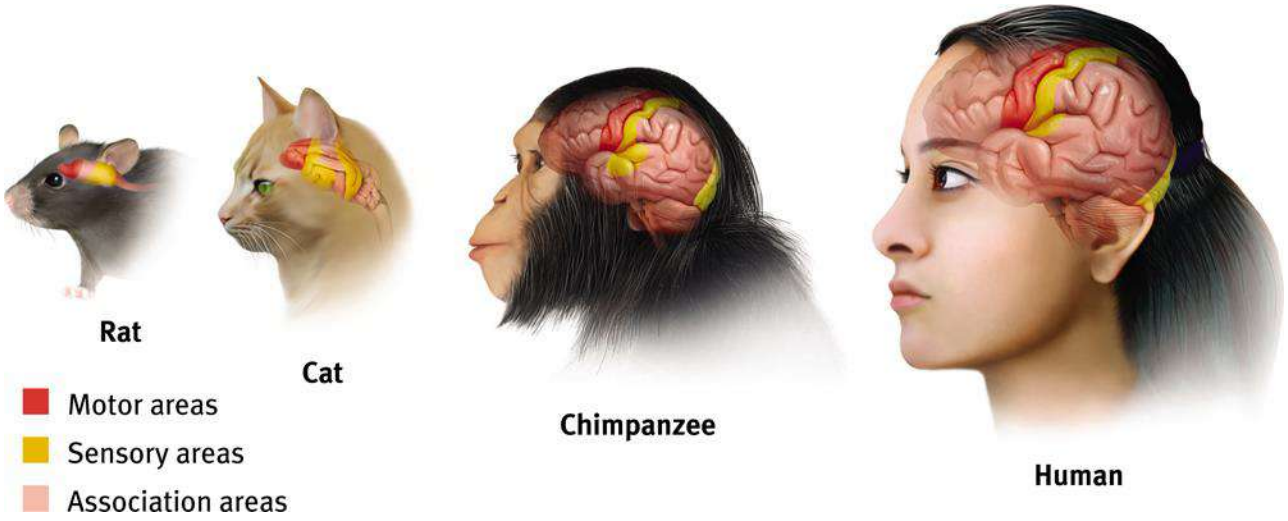
Neural Communication

The body's information system is built from billions of interconnected cells called ***neurons***.



Neural Communication

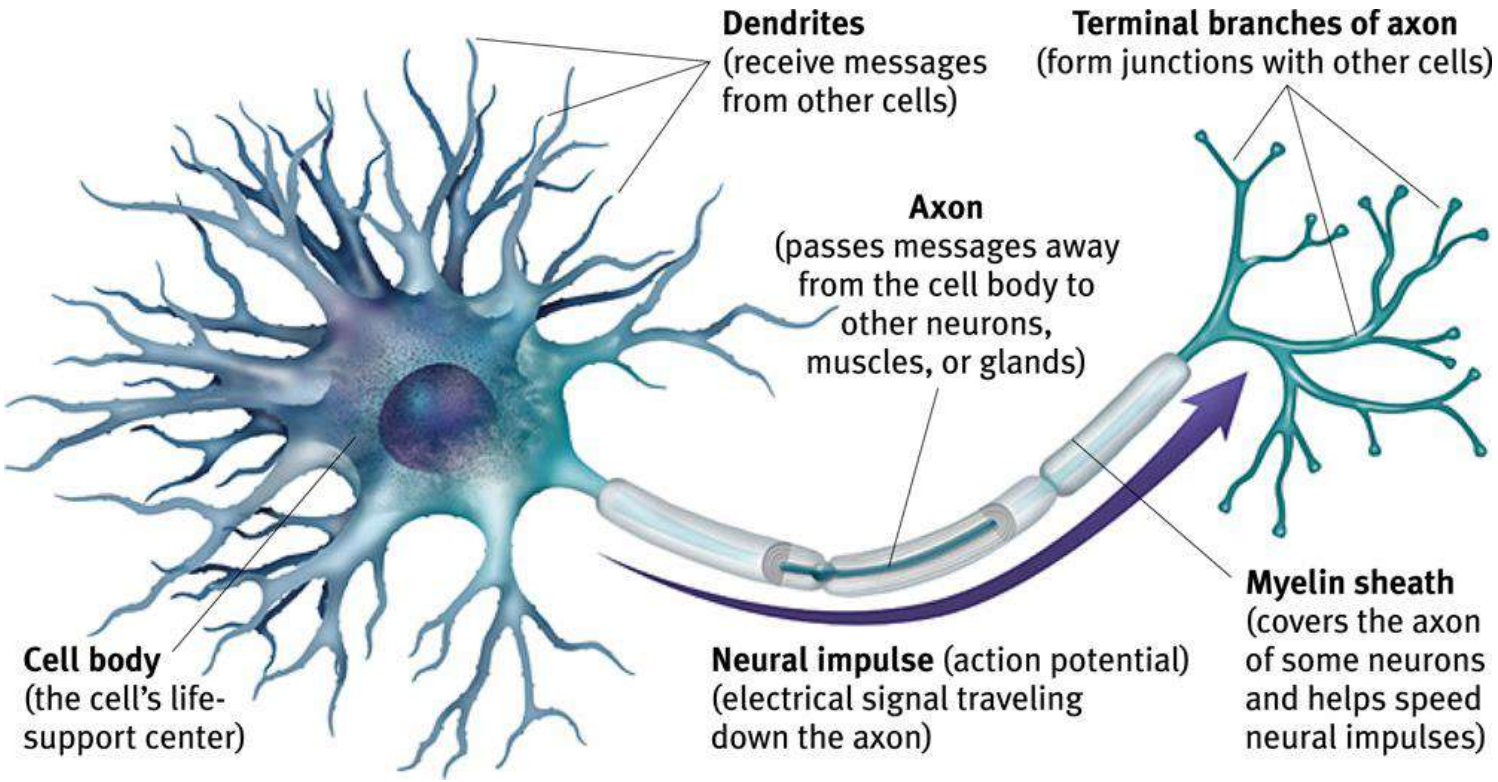
Neurobiologists and other investigators understand that humans and animals operate similarly when processing information.



Note the similarities in the above brain regions, which are all engaged in information processing.

Neuron

A nerve cell, or a neuron, consists of many different parts.



Parts of a Neuron

Cell Body: Life support center of the neuron.

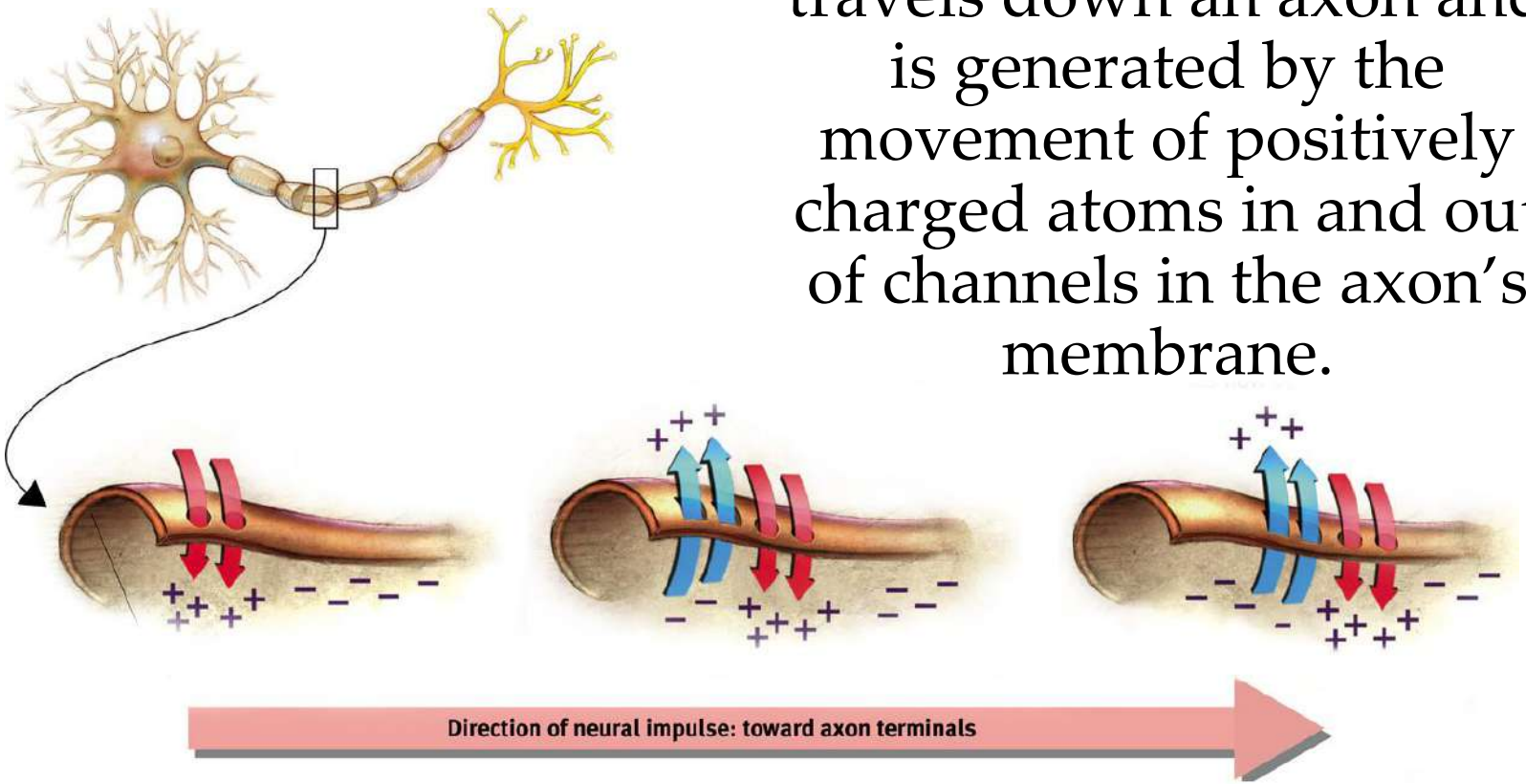
Dendrites: Branching extensions at the cell body. Receive messages from other neurons.

Axon: Long single extension of a neuron, covered with myelin [MY-uh-lin] sheath to insulate and speed up messages through neurons.

Terminal Branches of axon: Branched endings of an axon that transmit messages to other neurons.

Action Potential

A neural impulse. A brief electrical charge that travels down an axon and is generated by the movement of positively charged atoms in and out of channels in the axon's membrane.



Threshold

Threshold: Each neuron receives excitatory and inhibitory signals from many neurons. When the excitatory signals minus the inhibitory signals exceed a minimum intensity (threshold) the neuron fires an action potential.

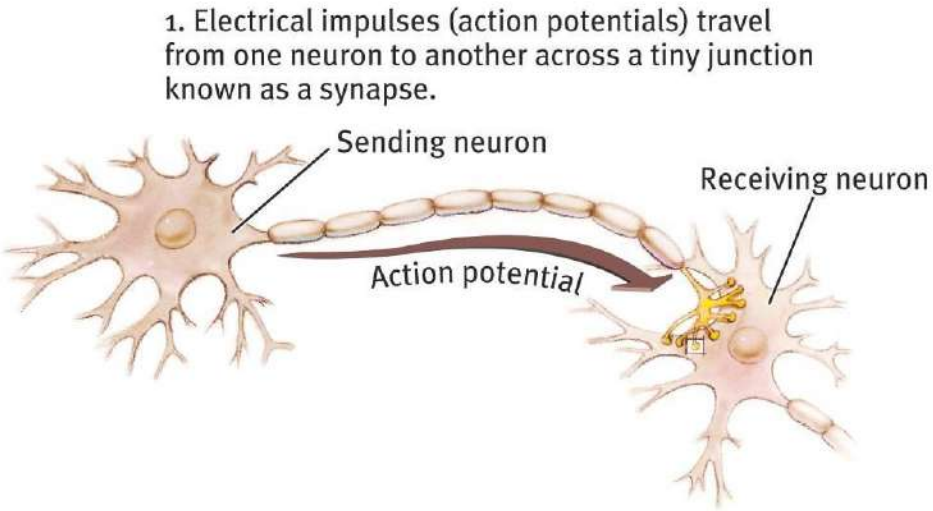
Action Potential Properties

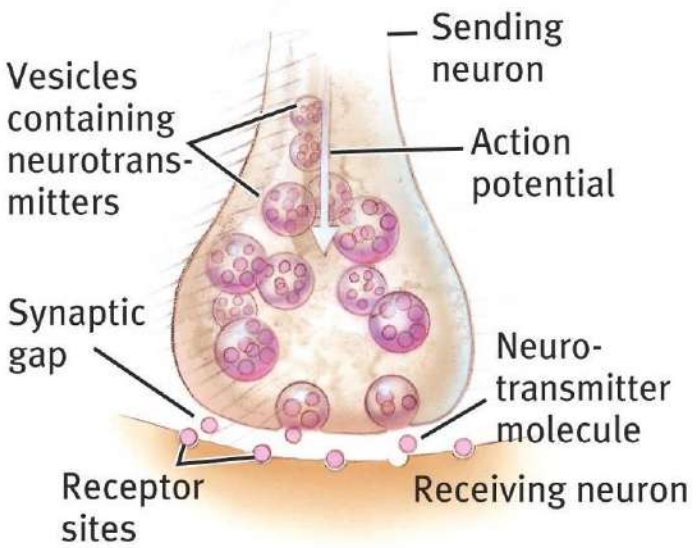
All-or-None Response: A strong stimulus can trigger more neurons to fire, and to fire more often, but it does not affect the action potentials strength or speed.

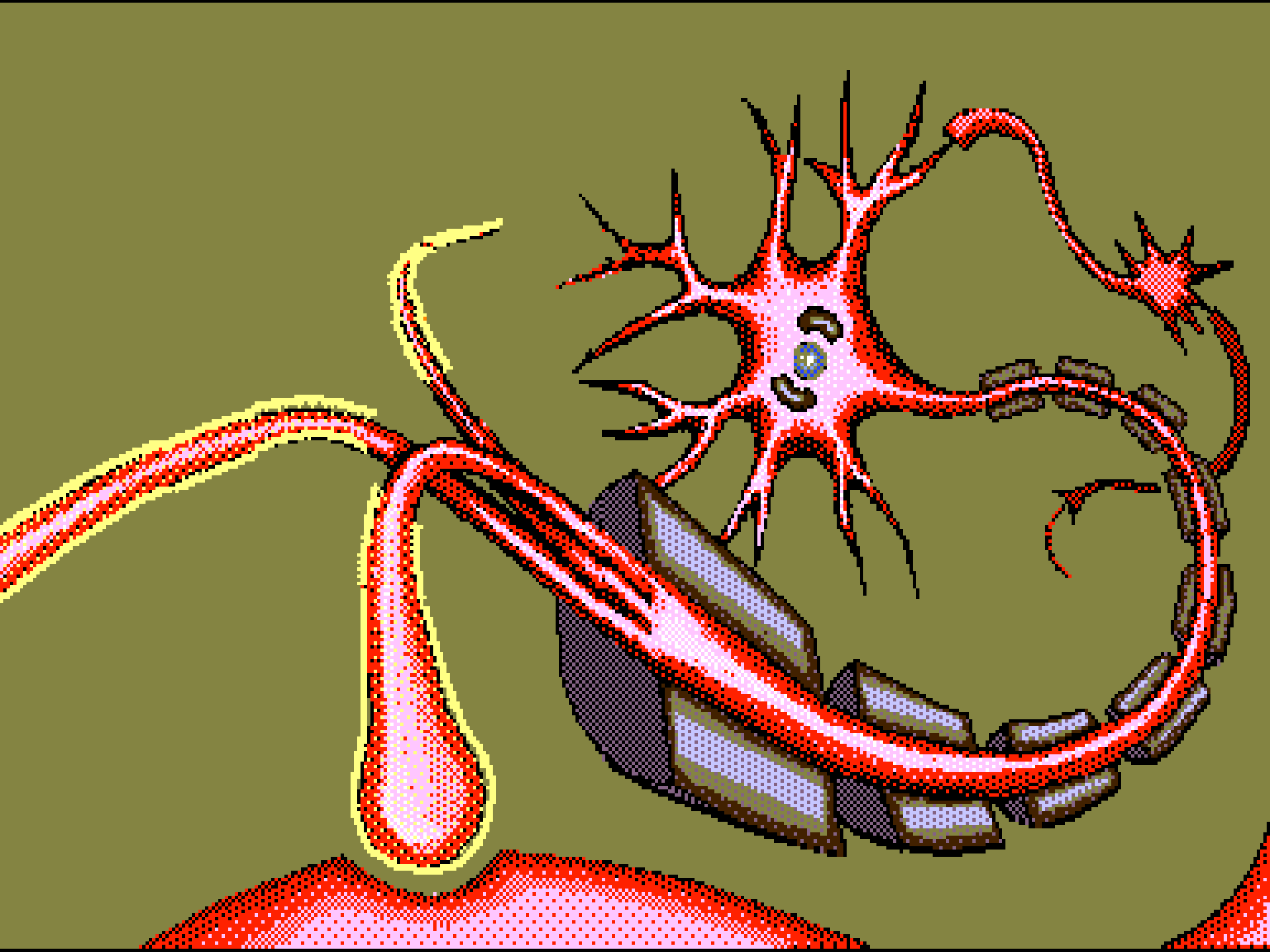
Intensity of an action potential remains the same throughout the length of the axon.

Synapse

Synapse [SIN-aps] a junction between the axon tip of the sending neuron and the dendrite or cell body of the receiving neuron. This tiny gap is called the *synaptic gap* or *cleft*.

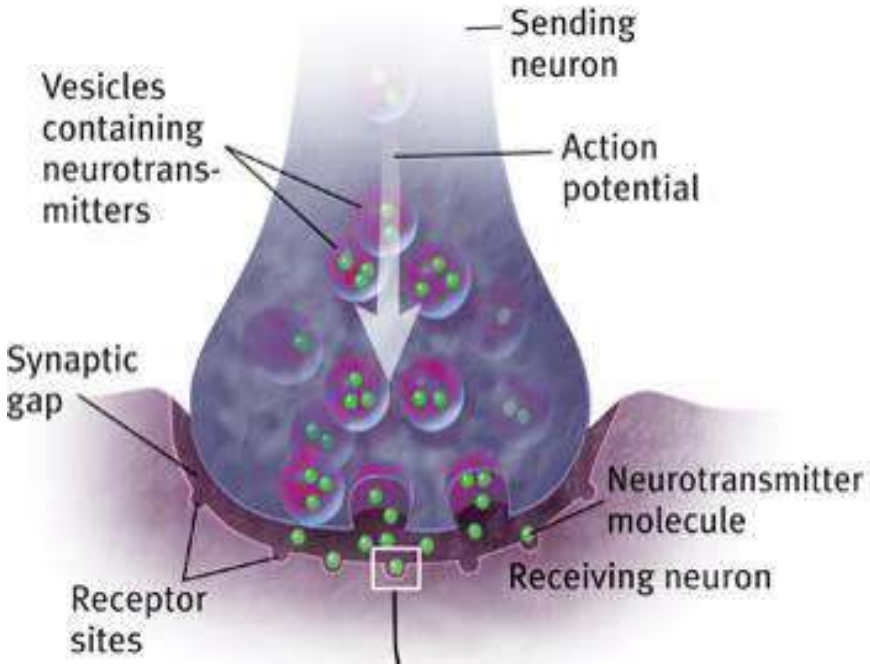






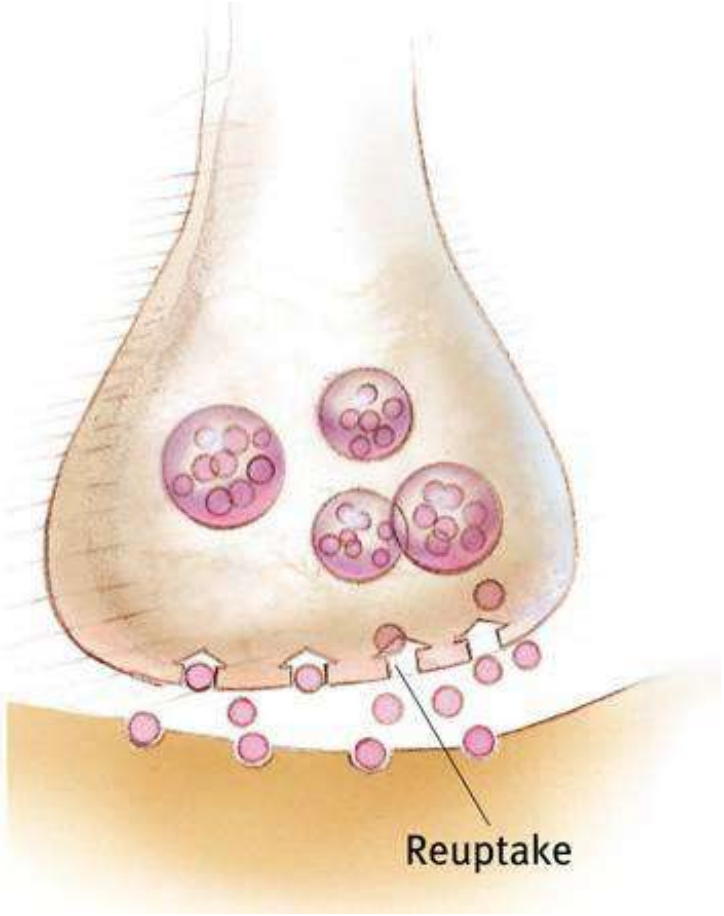
Neurotransmitters

Neurotransmitters (chemicals) released from the sending neuron travel across the synapse and bind to receptor sites on the receiving neuron, thereby influencing it to generate an action potential.



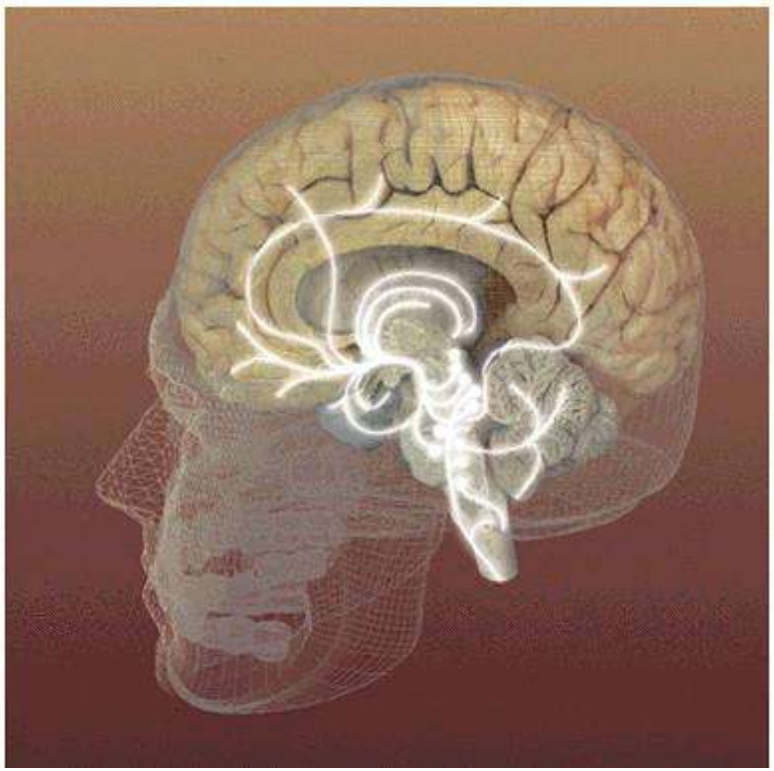
Reuptake

Neurotransmitters in the synapse are reabsorbed into the sending neurons through the process of reuptake. This process applies the brakes on neurotransmitter action.



How Neurotransmitters Influence Us

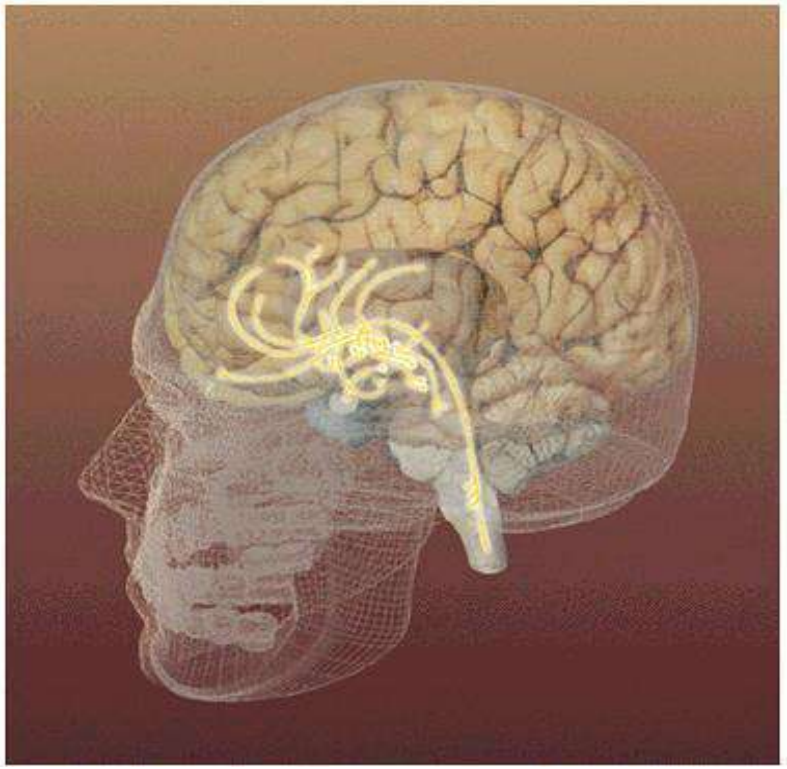
Serotonin pathways are involved with mood regulation.



From *Mapping the Mind*, Rita Carter, © 1989 University of California Press

Dopamine Pathways

Dopamine pathways are involved with diseases such as schizophrenia and Parkinson's disease.



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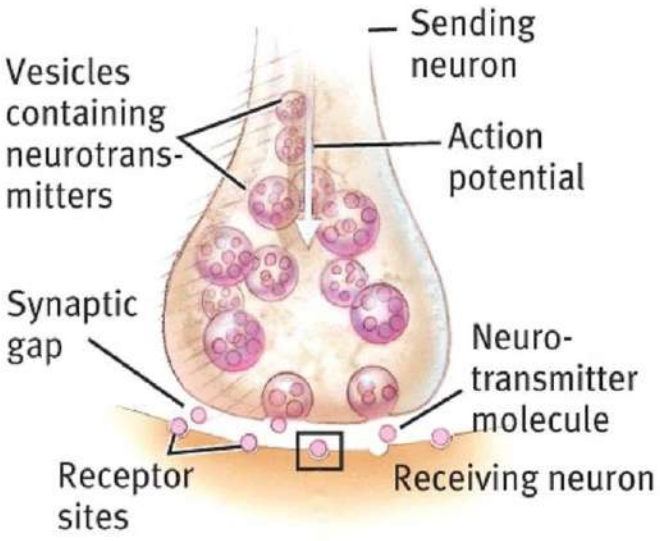
Neurotransmitters

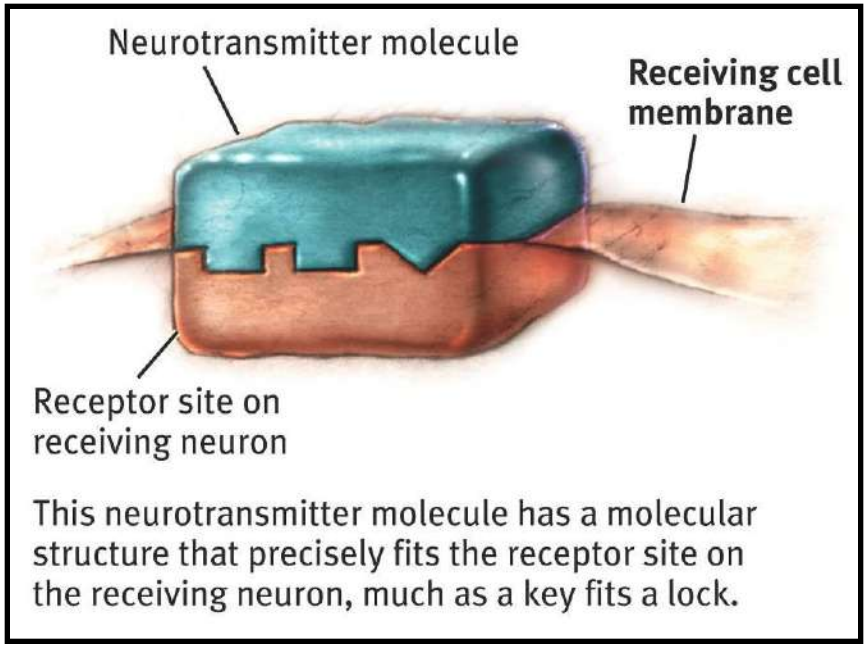
SOME NEUROTRANSMITTERS AND THEIR FUNCTIONS

Neurotransmitter	Function	Examples of Malfunctions
Acetylcholine (ACh)	Enables muscle action, learning, and memory.	With Alzheimer's disease, ACh-producing neurons deteriorate.
Dopamine	Influences movement, learning, attention, and emotion.	Excess dopamine receptor activity linked to schizophrenia. Starved of dopamine, the brain produces the tremors and decreased mobility of Parkinson's disease.
Serotonin	Affects mood, hunger, sleep, and arousal.	Undersupply linked to depression; Prozac and some other antidepressant drugs raise serotonin levels.
Norepinephrine	Helps control alertness and arousal.	Undersupply can depress mood.
GABA (gamma-aminobutyric acid)	A major inhibitory neurotransmitter.	Undersupply linked to seizures, tremors, and insomnia.
Glutamate	A major excitatory neurotransmitter; involved in memory.	Oversupply can overstimulate brain, producing migraines or seizures (which is why some people avoid MSG, monosodium glutamate, in food).

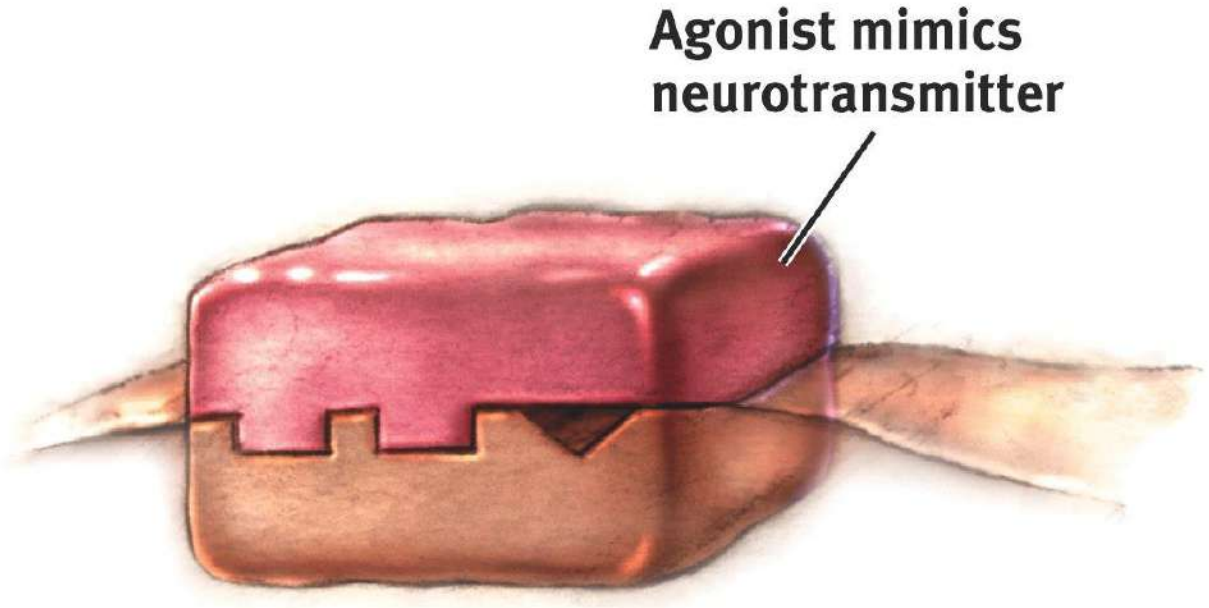
Lock & Key Mechanism

Neurotransmitters bind to the receptors of the receiving neuron in a key-lock mechanism.



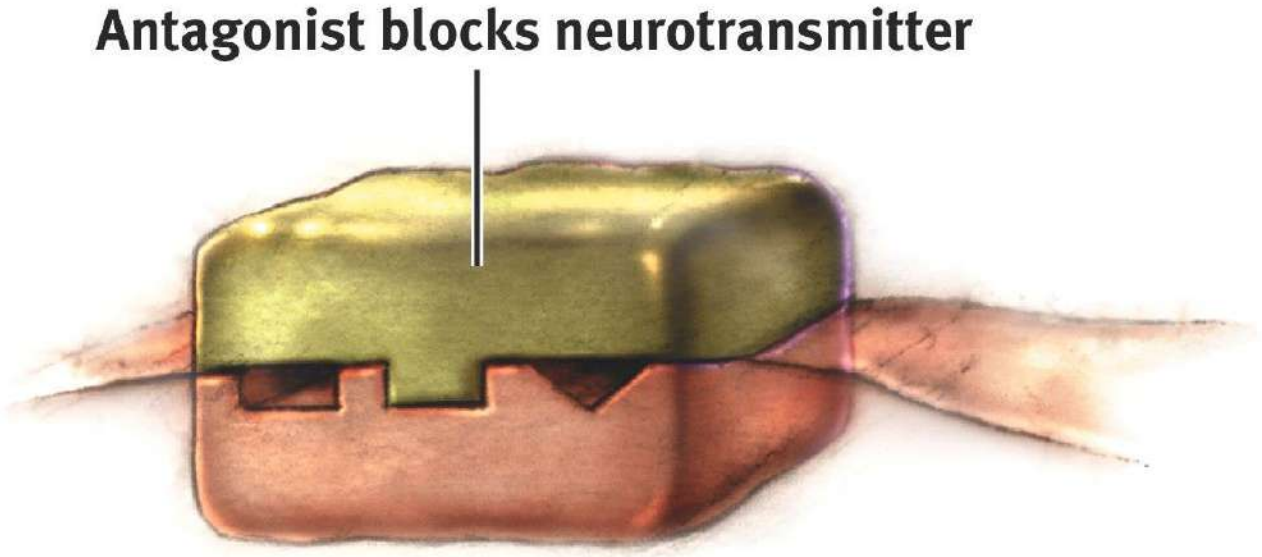


Agonists



This agonist molecule excites.It is similar enough in structure to the neurotransmitter molecule that it mimics its effects on the receiving neuron. Morphine, for instance, mimics the action of endorphins by stimulating receptors in brain areas involved in mood and pain sensations.

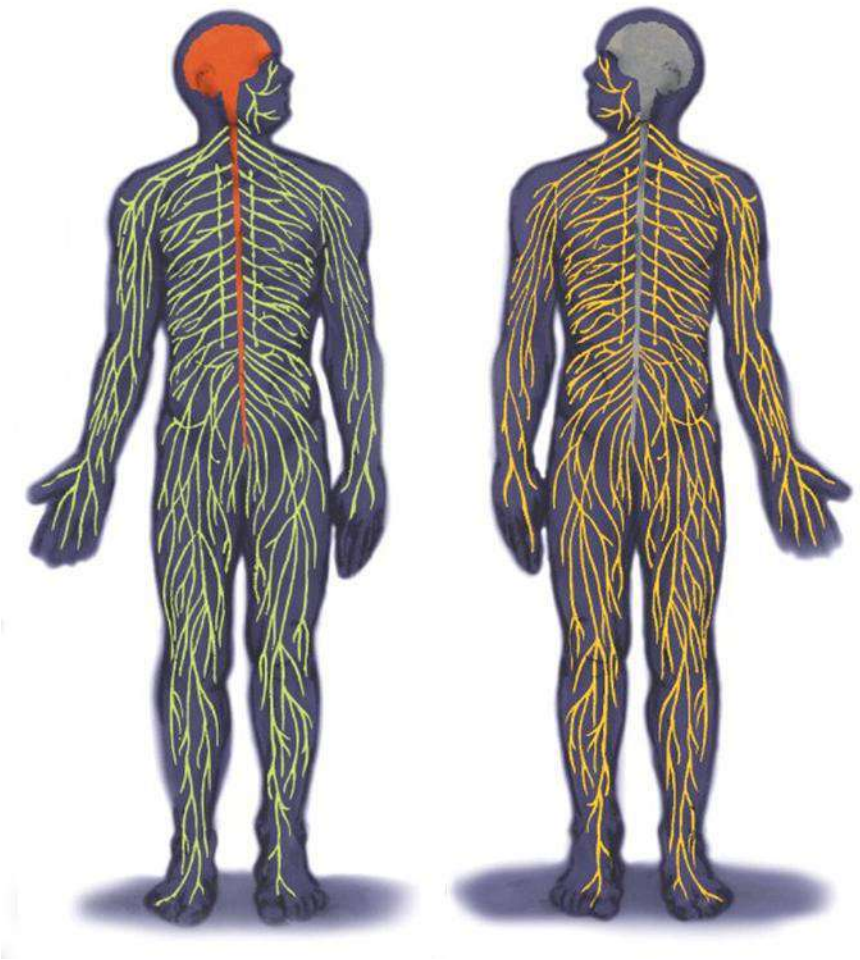
Antagonists



This antagonist molecule inhibits. It has a structure similar enough to the neurotransmitter to occupy its receptor site and block its action, but not similar enough to stimulate the receptor. Curare poisoning paralyzes its victims by blocking ACh receptors involved in muscle movement.

Nervous System

Central Nervous System (CNS)



Peripheral Nervous System (PNS)

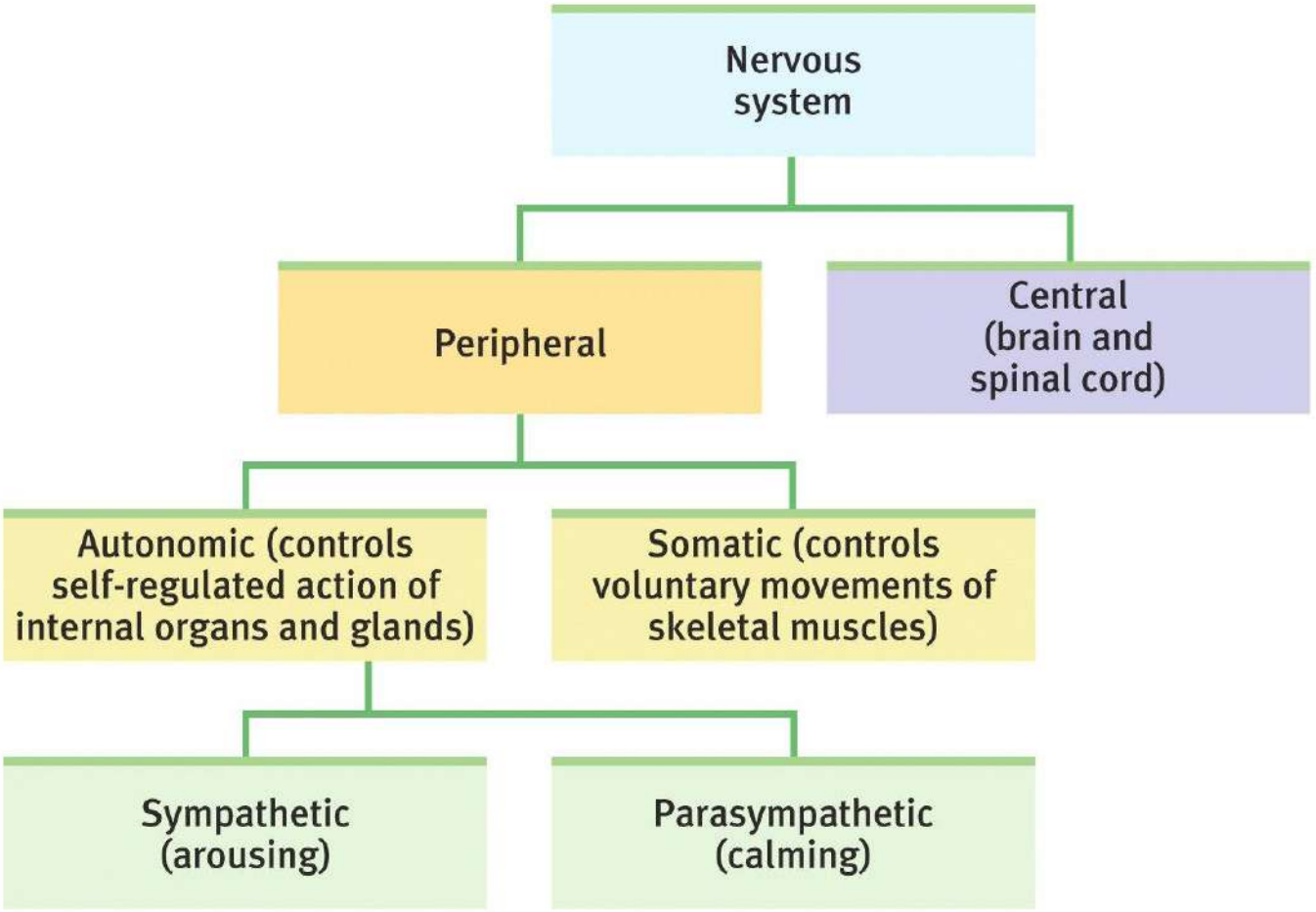
The Nervous System

Nervous System: Consists of all the nerve cells. It is the body's speedy, electrochemical communication system.

Central Nervous System (CNS): the brain and spinal cord.

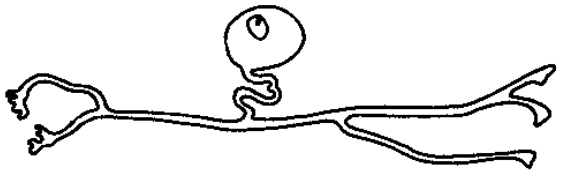
Peripheral Nervous System (PNS): the sensory and motor neurons that connect the central nervous system (CNS) to the rest of the body.

The Nervous System

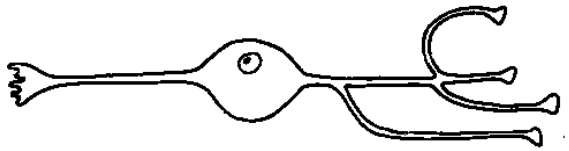


Kinds of Neurons

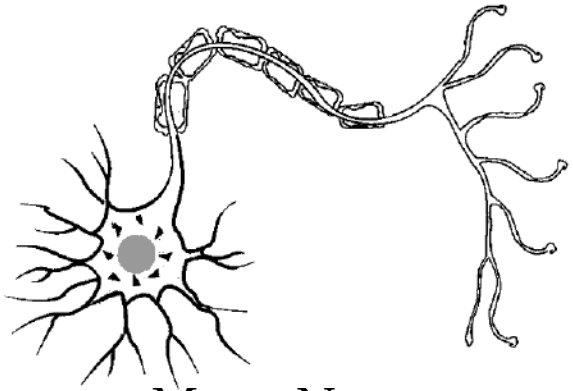
Sensory Neurons carry incoming information from the sense receptors to the CNS. Motor Neurons carry outgoing information from the CNS to muscles and glands. Interneurons connect the two neurons.



Interneuron Neuro
(Unipolar)



Sensory Neuron
(Bipolar)



Motor Neuron
(Multipolar)

Peripheral Nervous System

Somatic Nervous System: The division of the peripheral nervous system that controls the body's skeletal muscles.

Autonomic Nervous System: Part of the PNS that controls the glands and other muscles.

The Nerves

Nerves consist of neural "cables" containing many axons. They are part of the peripheral nervous system and connect muscles, glands, and sense organs to the central nervous system.

Autonomic Nervous System (ANS)

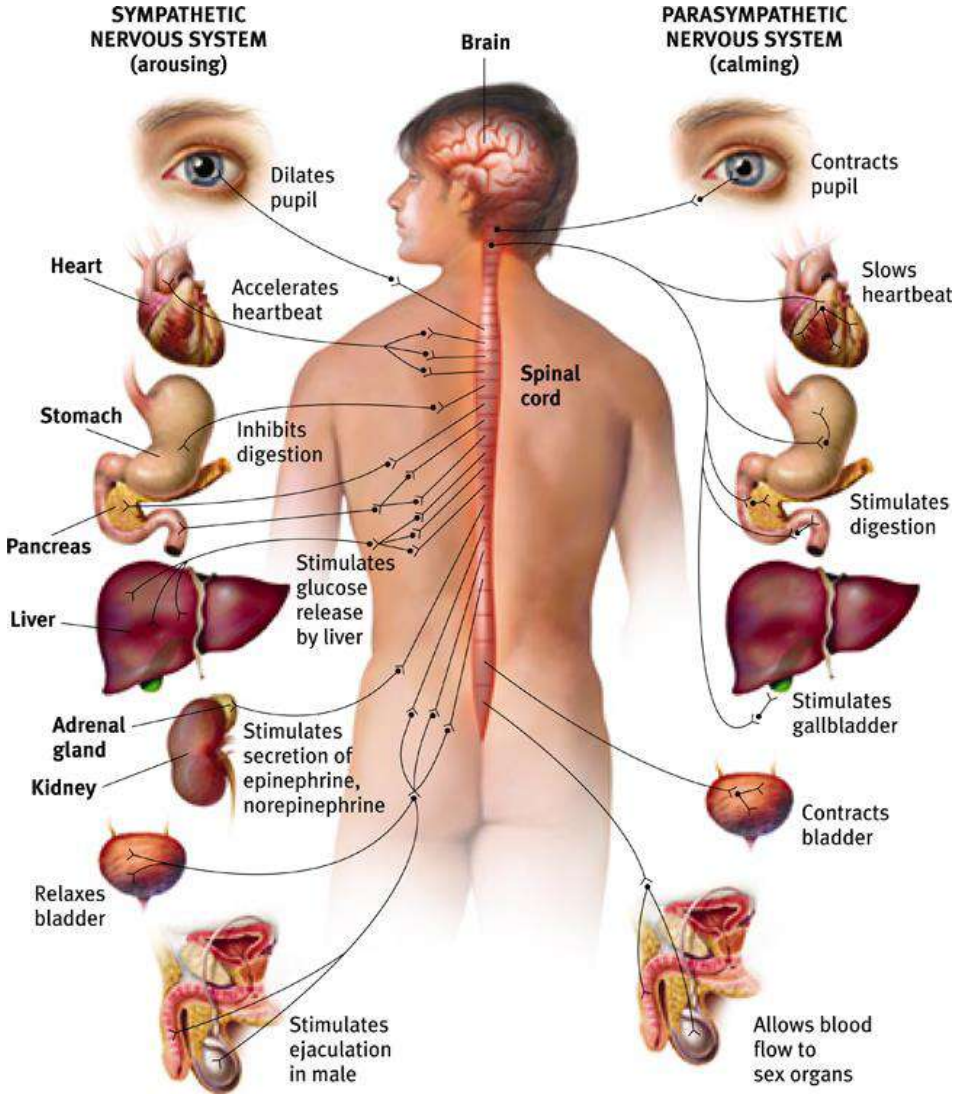
Sympathetic Nervous System: Division of the ANS that arouses the body, mobilizing its energy in stressful situations.

Parasympathetic Nervous System: Division of the ANS that calms the body, conserving its energy.

Autonomic Nervous System (ANS)

Sympathetic NS
"Arouses"
(fight-or-flight)

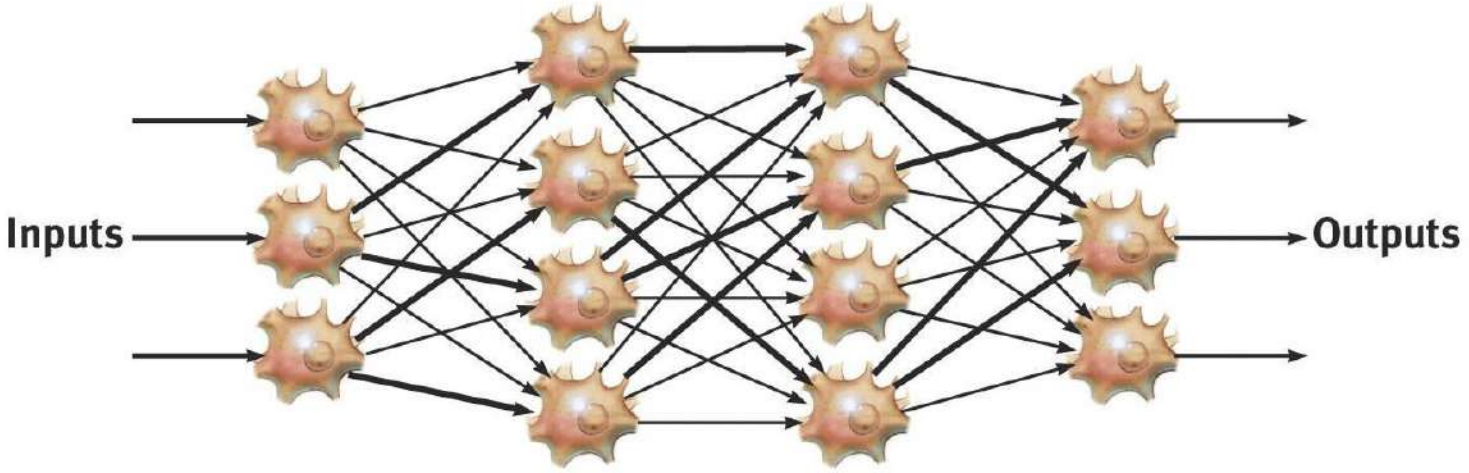
Parasympathetic NS
"Calms"
(rest and digest)



Central Nervous System

The Brain and Neural Networks

Interconnected neurons form networks in the brain. Theses networks are complex and modify with growth and experience.

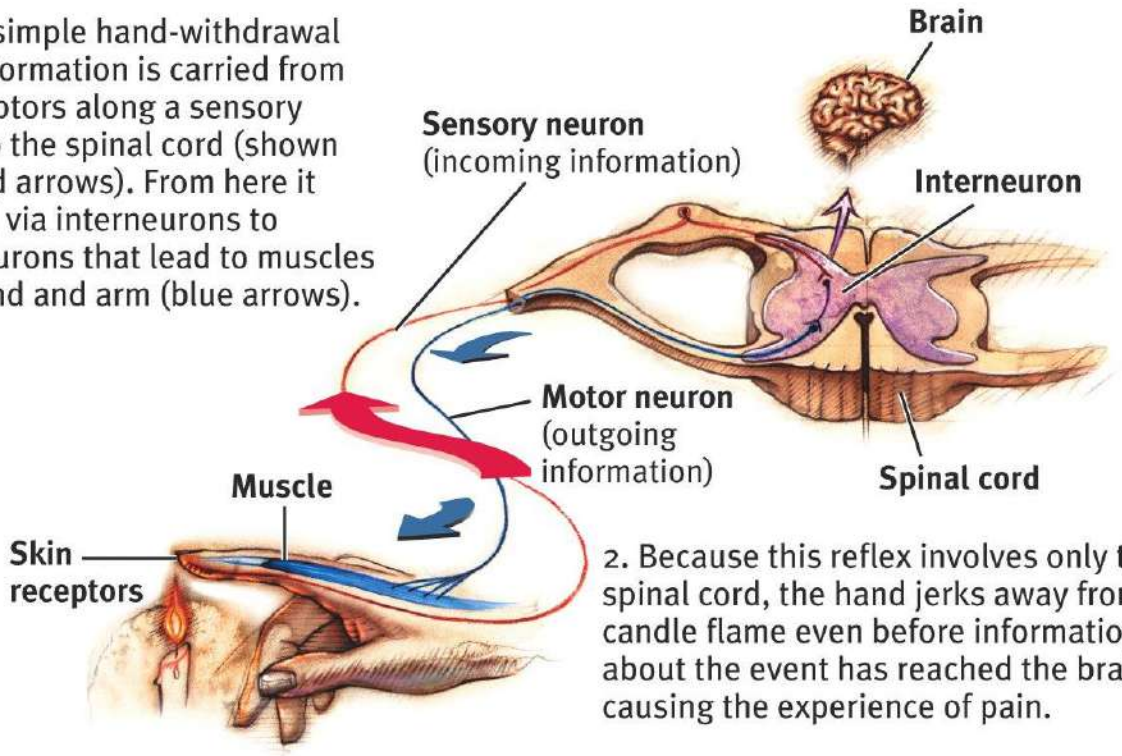


Complex Neural Network

Central Nervous System

The Spinal Cord and Reflexes

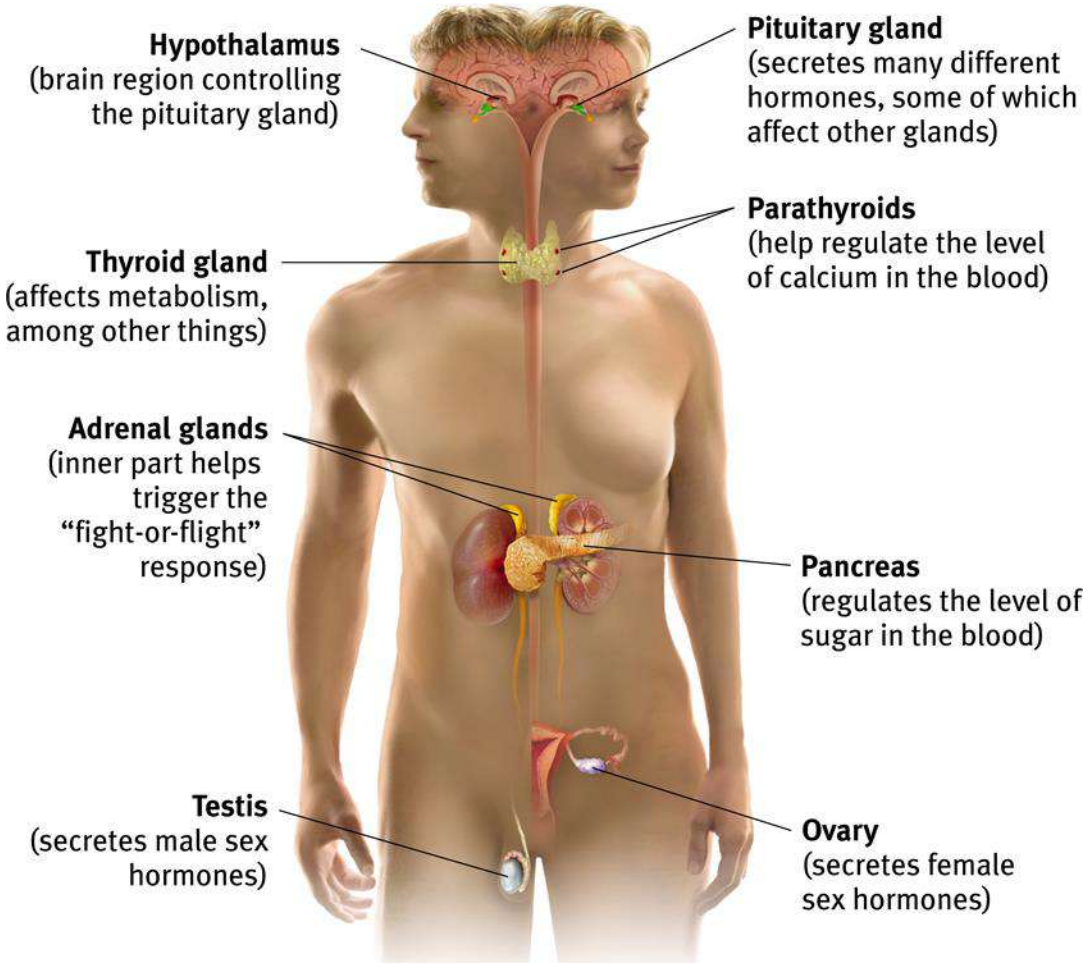
1. In this simple hand-withdrawal reflex, information is carried from skin receptors along a sensory neuron to the spinal cord (shown by the red arrows). From here it is passed via interneurons to motor neurons that lead to muscles in the hand and arm (blue arrows).



2. Because this reflex involves only the spinal cord, the hand jerks away from the candle flame even before information about the event has reached the brain, causing the experience of pain.

Simple Reflex

The Endocrine System



The Endocrine System is the body's "slow" chemical communication system. Communication is carried out by hormones synthesized by a set of glands.

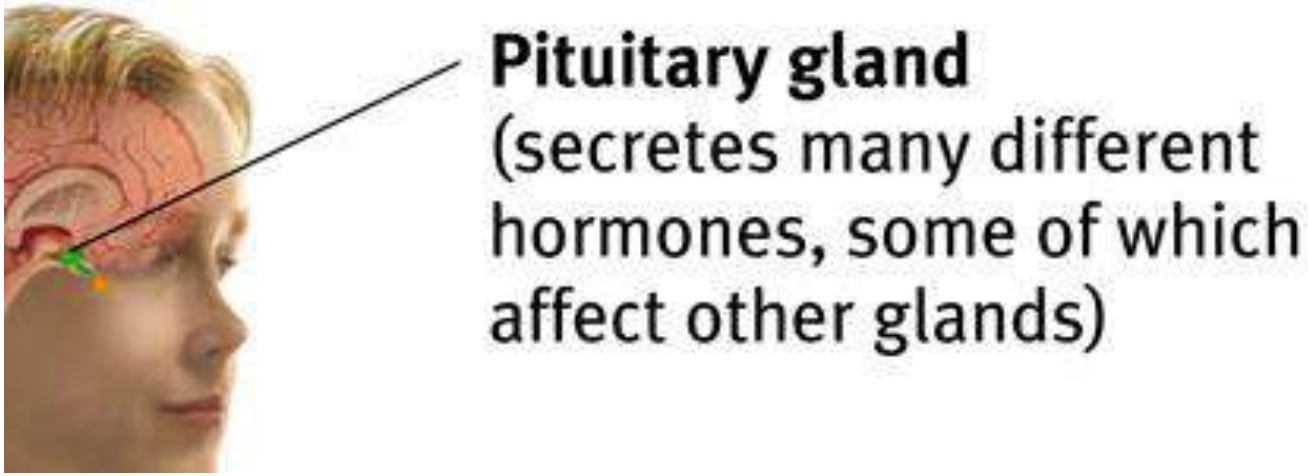
Hormones

Hormones are chemicals synthesized by the endocrine glands that are secreted in the bloodstream. Hormones affect the brain and many other tissues of the body.

For example, epinephrine (adrenaline) increases heart rate, blood pressure, blood sugar, and feelings of excitement during emergency situations.

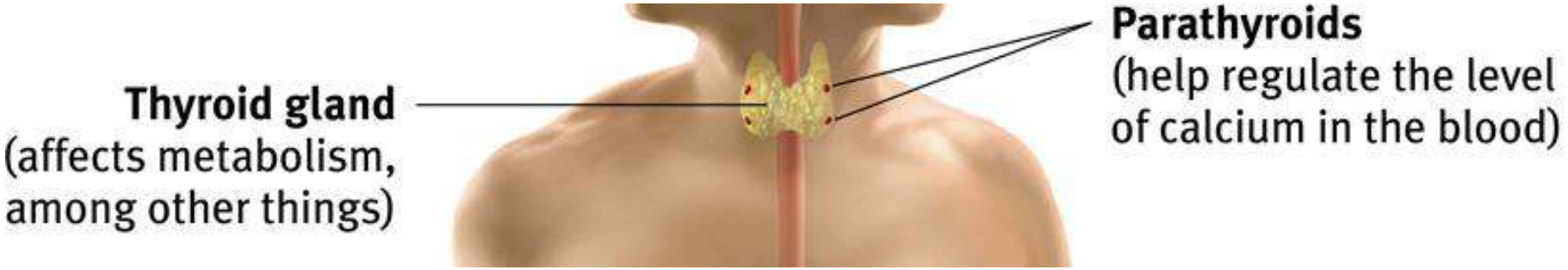
Pituitary Gland

Is called the “master gland.” The anterior pituitary lobe releases hormones that regulate other glands. The posterior lobe regulates water and salt balance.



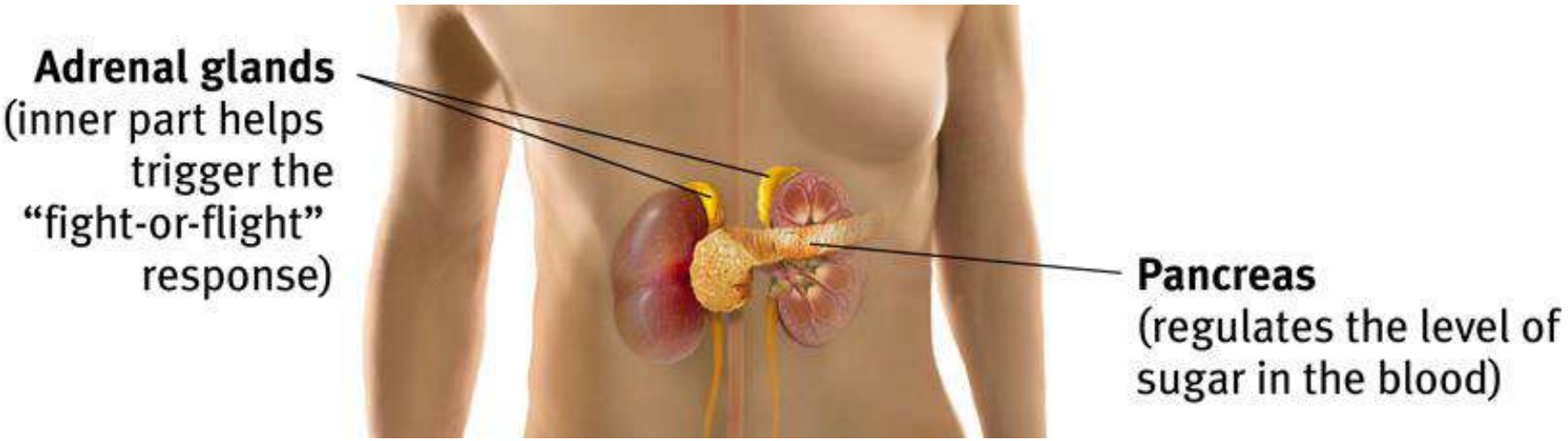
Thyroid & Parathyroid Glands

Regulate metabolic and calcium rate.



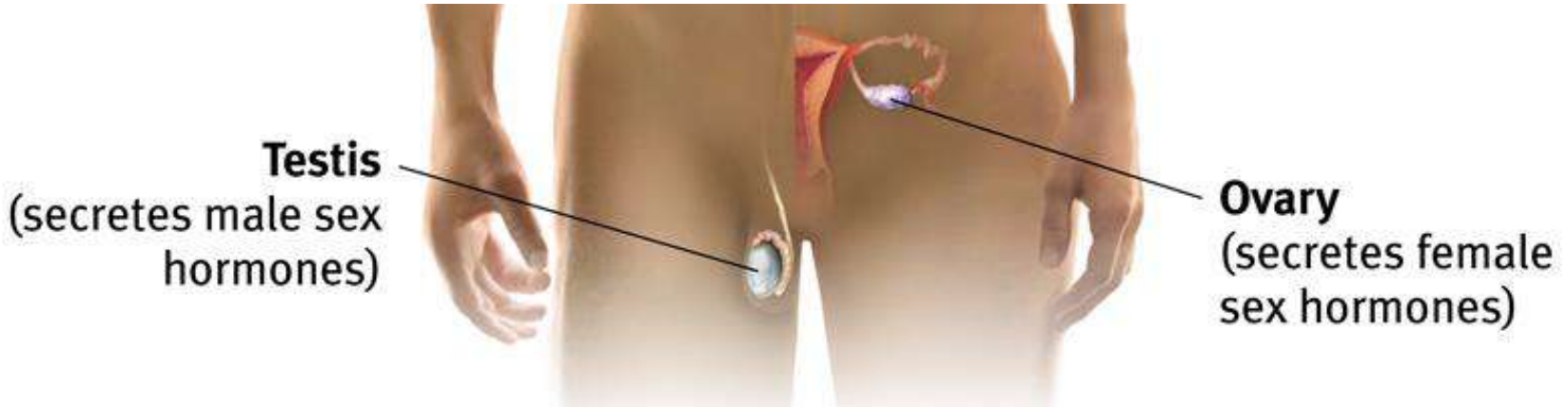
Adrenal Glands

Adrenal glands consist of the adrenal medulla and the cortex. The medulla secretes hormones (epinephrine and norepinephrine) during stressful and emotional situations, while the adrenal cortex regulates salt and carbohydrate metabolism.



Gonads

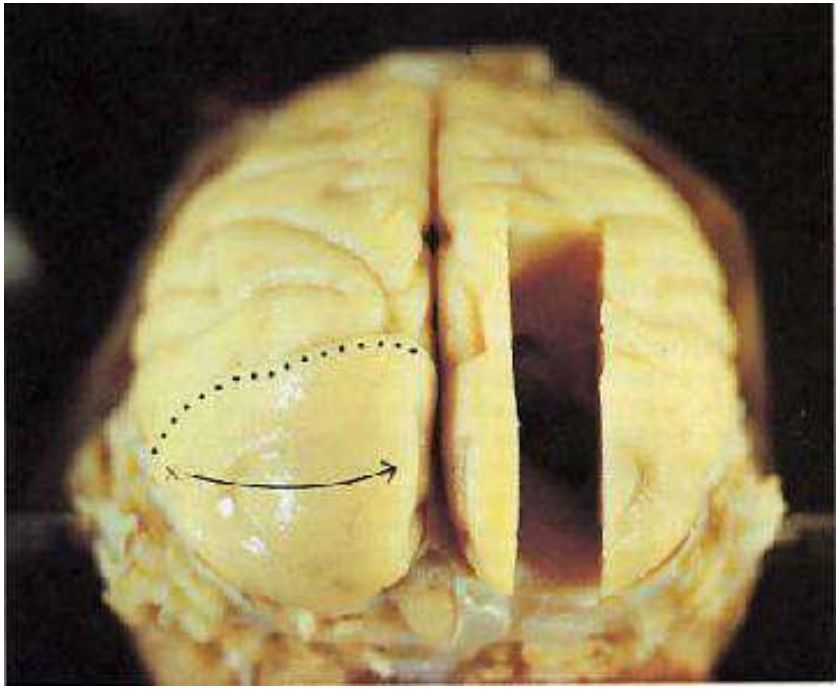
Sex glands are located in different places in men and women. They regulate bodily development and maintain reproductive organs in adults.



The Brain

Techniques to Study the Brain

A brain lesion experimentally destroys brain tissue to study animal behaviors after such destruction.



Hubel (1990)

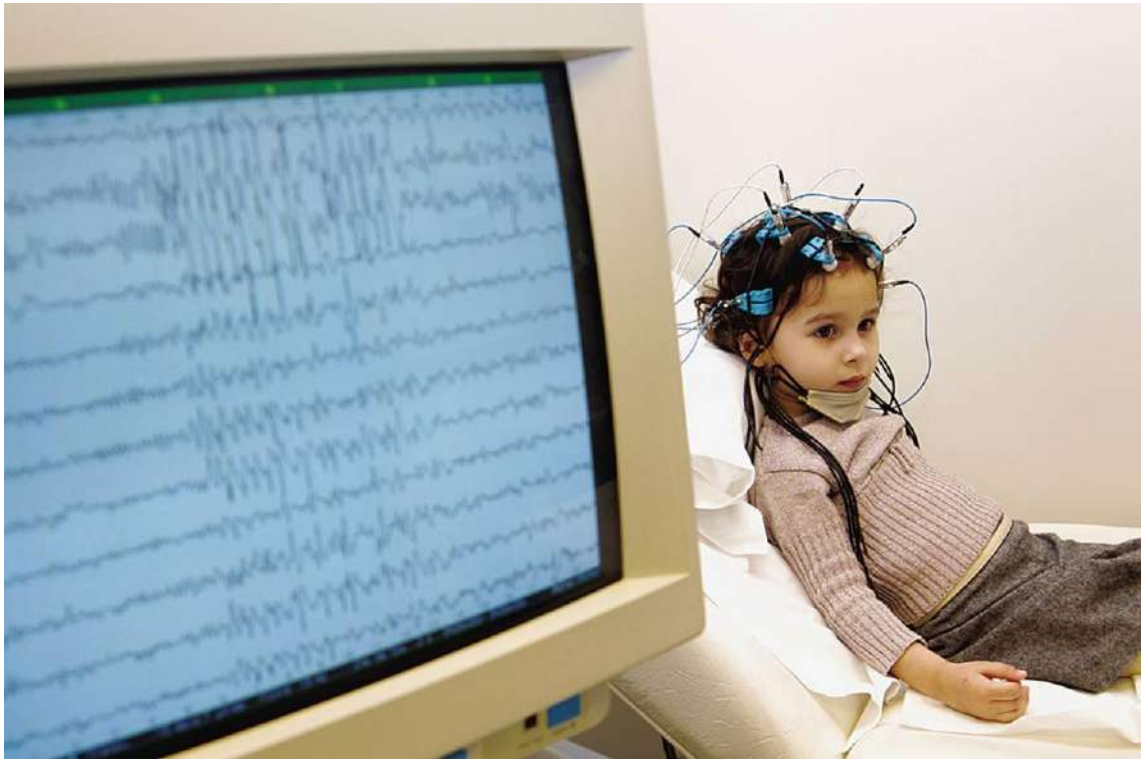
Clinical Observation

Clinical observations have shed light on a number of brain disorders. Alterations in brain morphology due to neurological and psychiatric diseases are now being catalogued.

Tom Landers/ Boston Globe

Electroencephalogram (EEG)

An amplified recording of the electrical waves sweeping across the brain's surface, measured by electrodes placed on the scalp.



AJ Photo/ Photo Researchers, Inc.

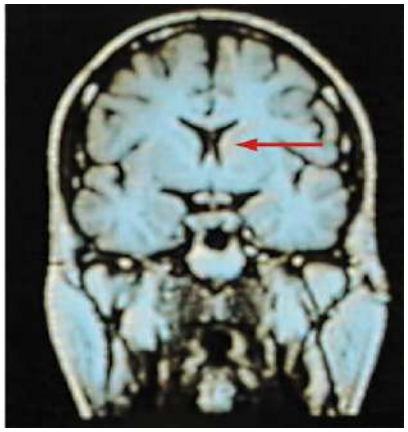
PET Scan

PET (positron emission tomography) Scan is a visual display of brain activity that detects a radioactive form of glucose while the brain performs a given task.

Courtesy of National Brookhaven National Laboratories

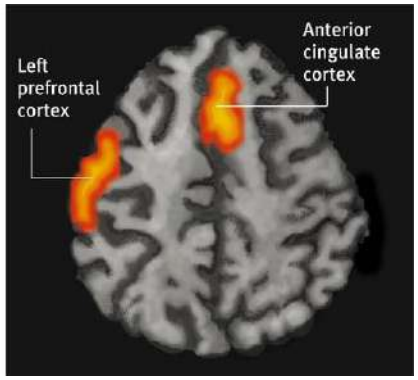
MRI Scan

MRI (magnetic resonance imaging) uses magnetic fields and radio waves to produce computer-generated images that distinguish among different types of brain tissue. Top images show ventricular enlargement in a schizophrenic patient. Bottom image shows brain regions when a participants lies.



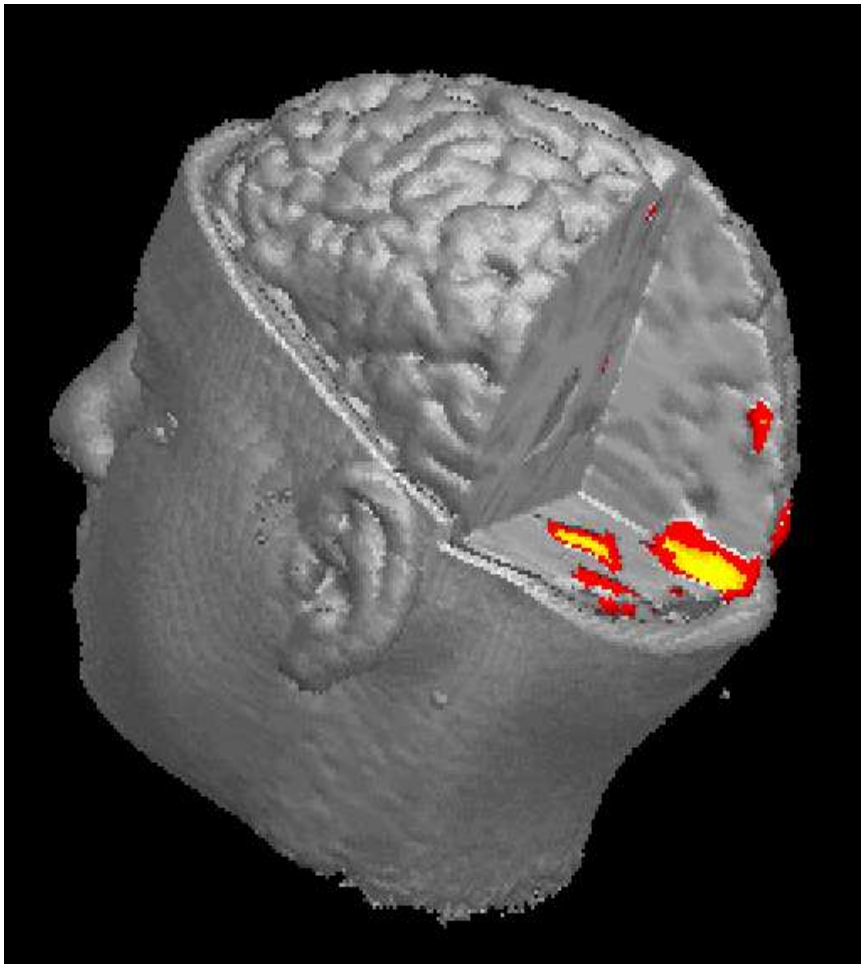
Both photos from Daniel Weinberger, M.D., CBDB, NIMH

James Salzano/ Salzano Photo



Lucy Reading/ Lucy Illustrations

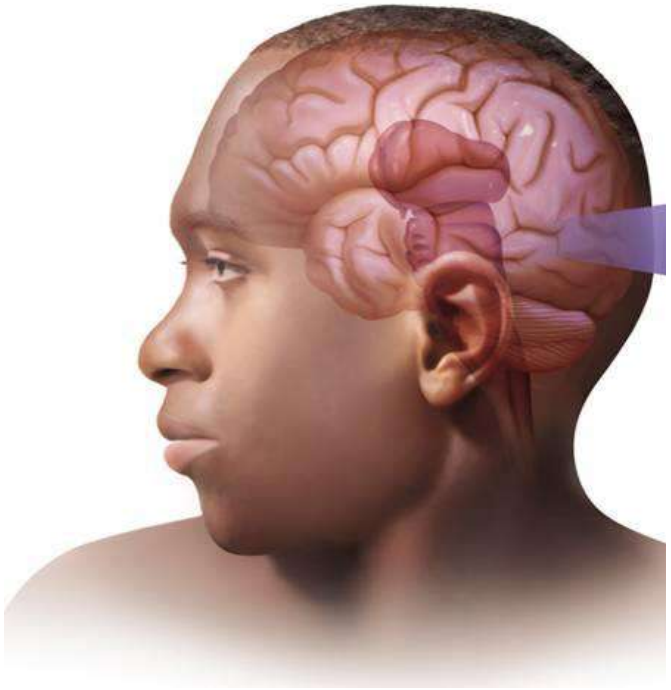
fMRI



- Functional MRI
- Specialized MRI scan used to measure the hemodynamic response (change in blood flow) related to neural activity in the brain or spinal cord of humans or other animals.
- It is one of the most recently developed forms of neuroimaging.

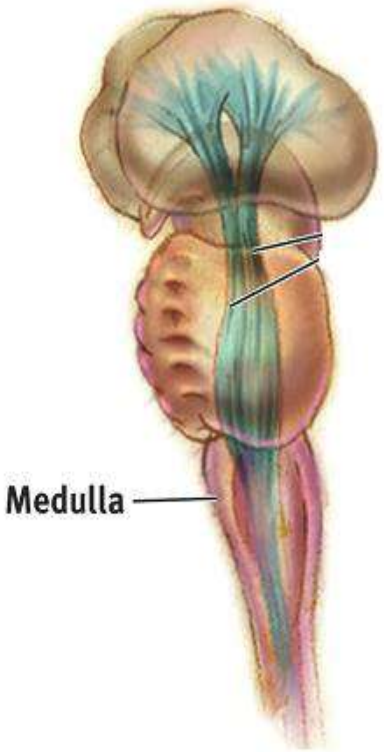
The Brain:
Older Brain Structures

The Brainstem is the oldest part of the brain, beginning where the spinal cord swells and enters the skull. It is responsible for automatic survival functions.



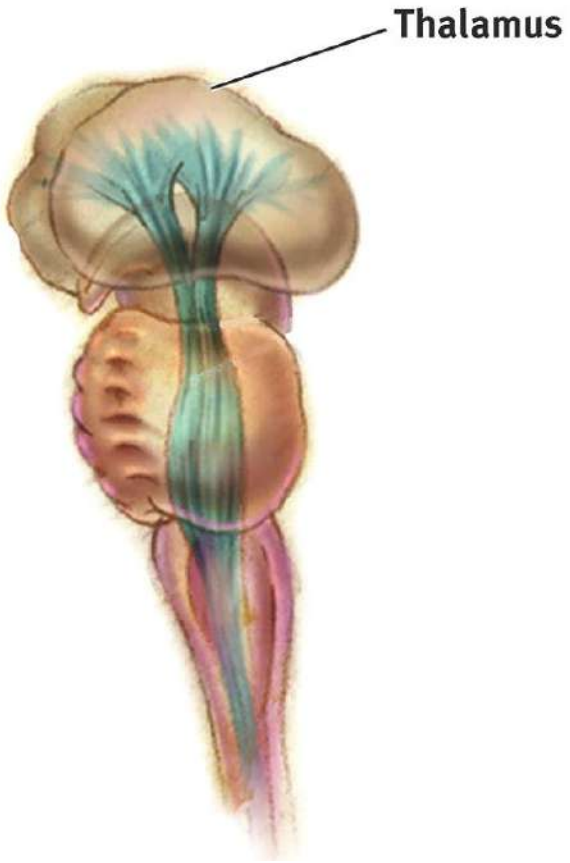
Brainstem

The Medulla [muh-DUL-uh] is the base of the brainstem that controls heartbeat and breathing.



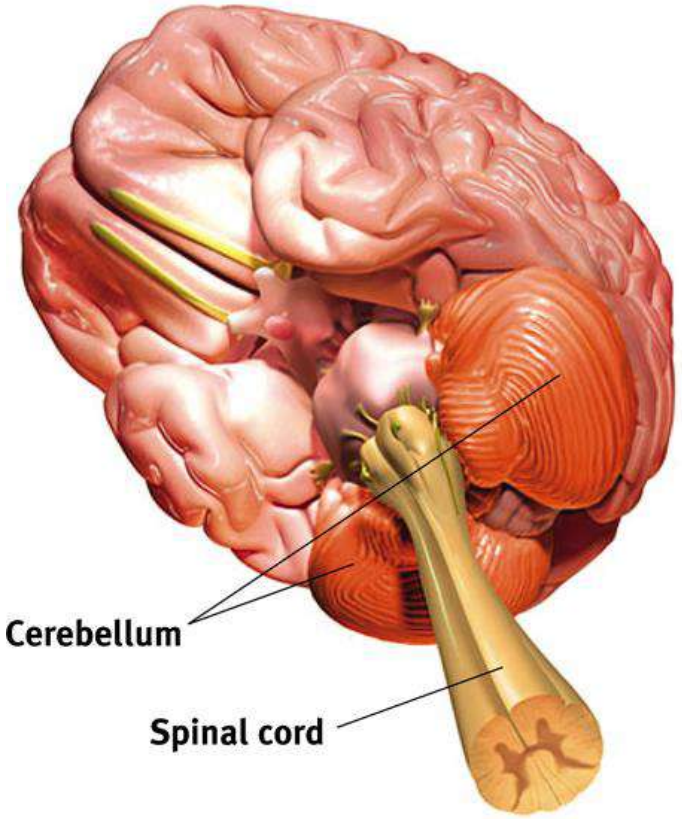
Brainstem

The Thalamus [THAL-uh-muss] is the brain's sensory switchboard, located on top of the brainstem. It directs messages to the sensory areas in the cortex and transmits replies to the cerebellum and medulla.



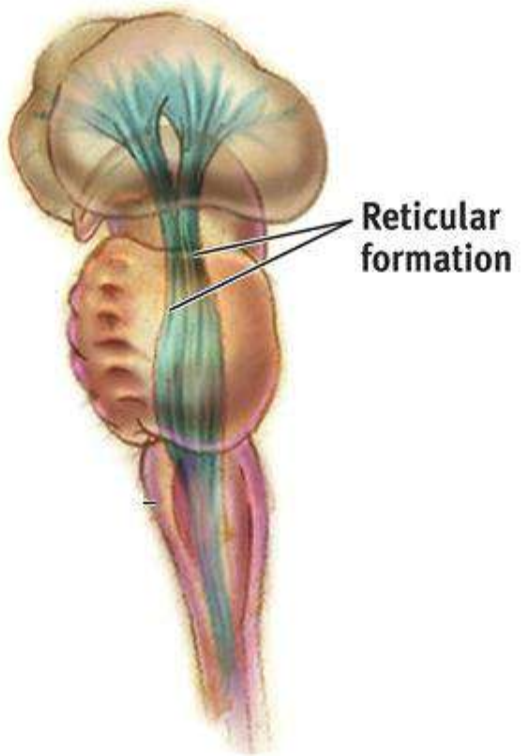
Cerebellum

The “little brain” attached to the rear of the brainstem. It helps coordinate voluntary movements and balance.

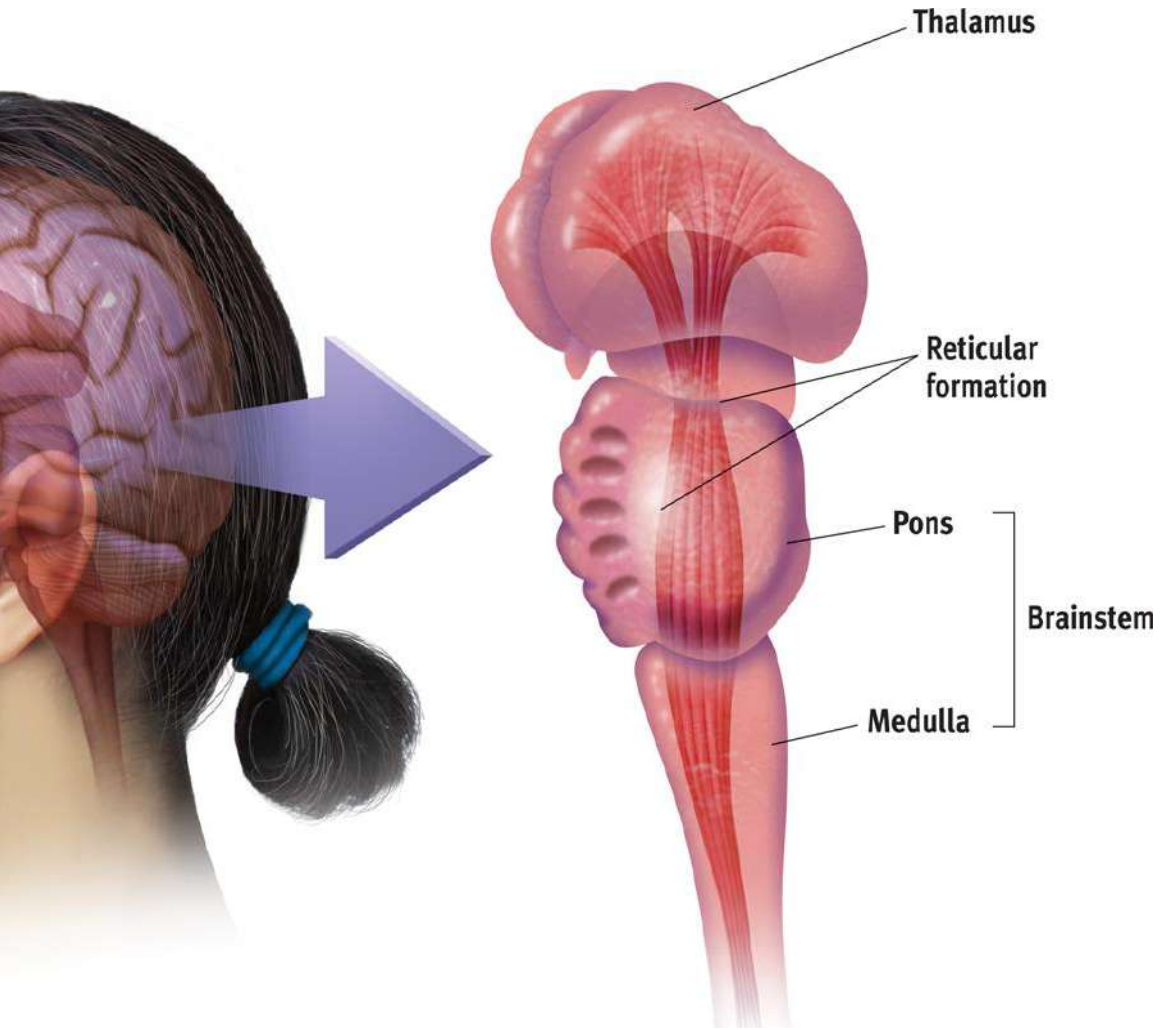


Brainstem

Reticular Formation is a nerve network in the brainstem that plays an important role in controlling arousal.



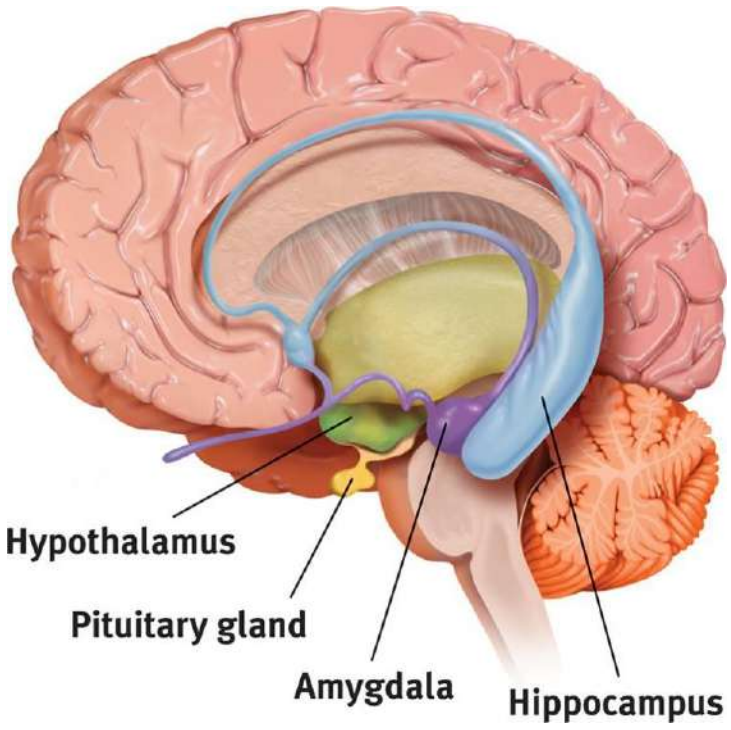
Pons



- Regulating body movement, attention, sleep, and alertness.
- Aids in coordinating movements.

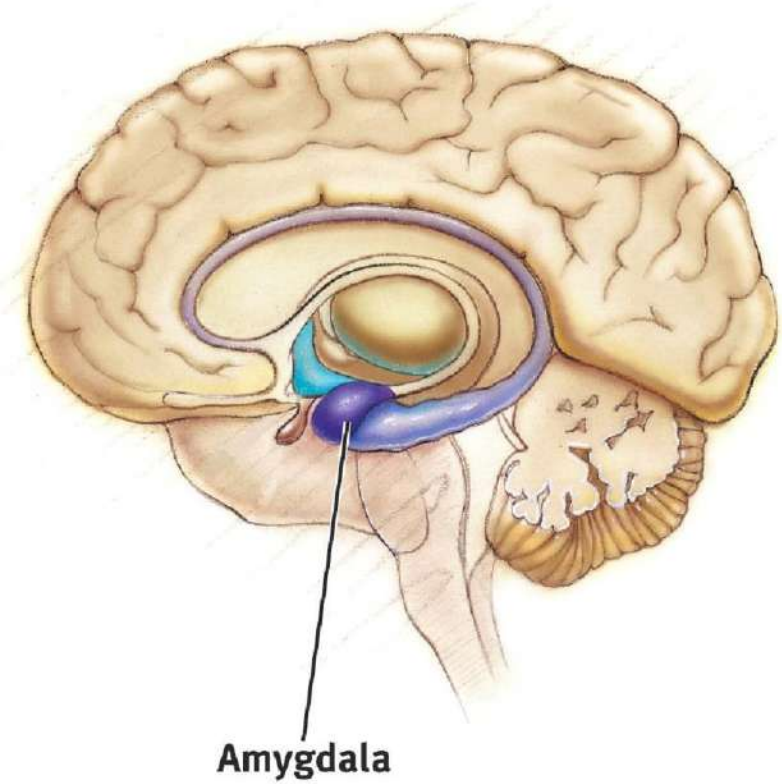
The Limbic System

The Limbic System is a doughnut-shaped system of neural structures at the border of the brainstem and cerebrum, associated with emotions such as fear, aggression and drives for food and sex. It includes the hippocampus, amygdala, and hypothalamus.



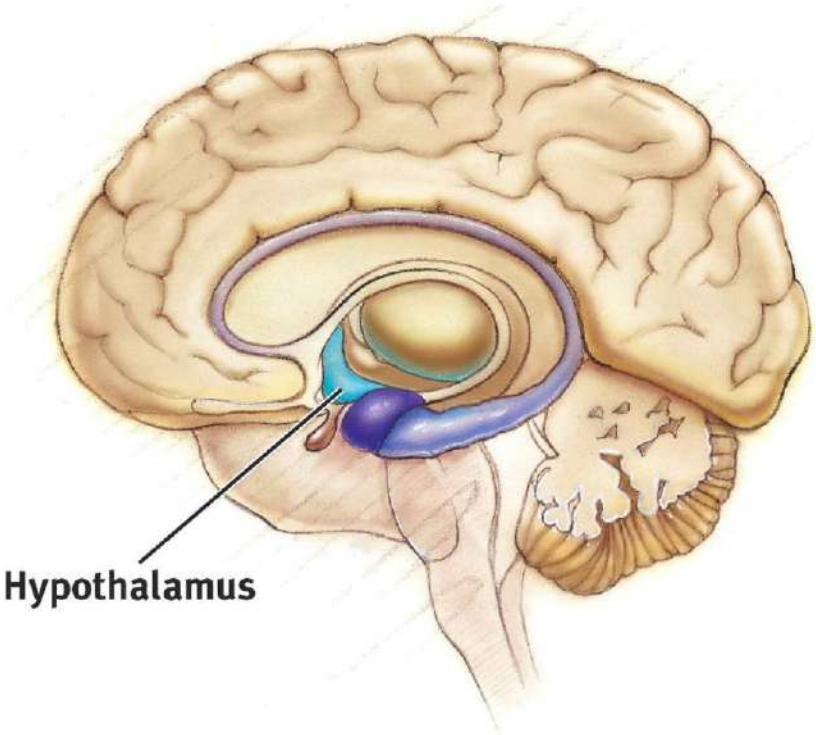
Amygdala

The Amygdala [ah-MIG-dah-la] consists of two lima bean-sized neural clusters linked to the emotions of fear and anger.



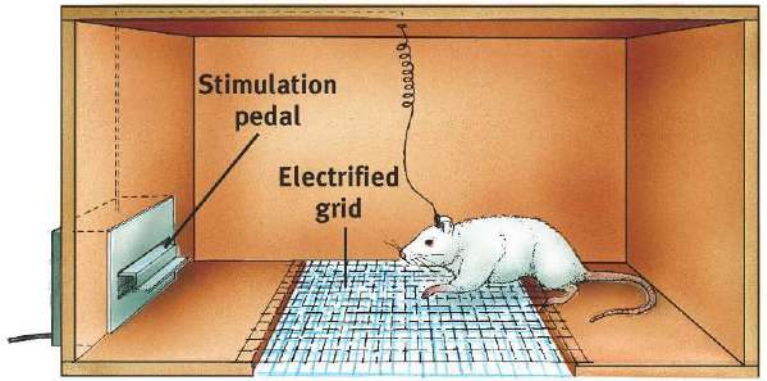
Hypothalamus

The Hypothalamus lies below (*hypo*) the thalamus. It directs several maintenance activities like eating, drinking, body temperature, and control of emotions. It helps govern the endocrine system via the pituitary gland.



Reward Center

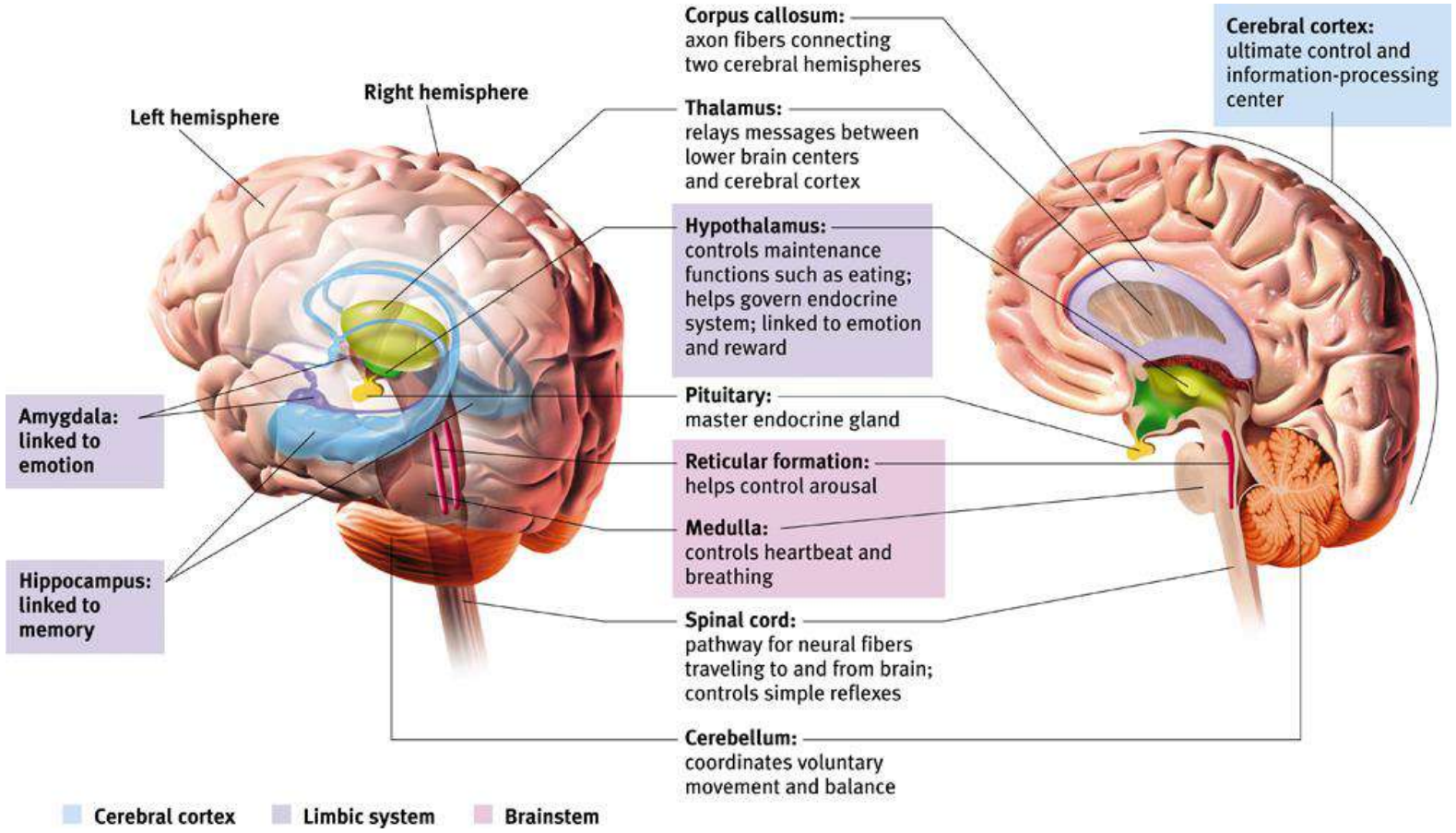
Rats cross an electrified grid for self-stimulation when electrodes are placed in the reward (hypothalamus) center (top picture). When the limbic system is manipulated, a rat will navigate fields or climb up a tree (bottom picture).



Sanjiv Talwar, SUNY Downstate

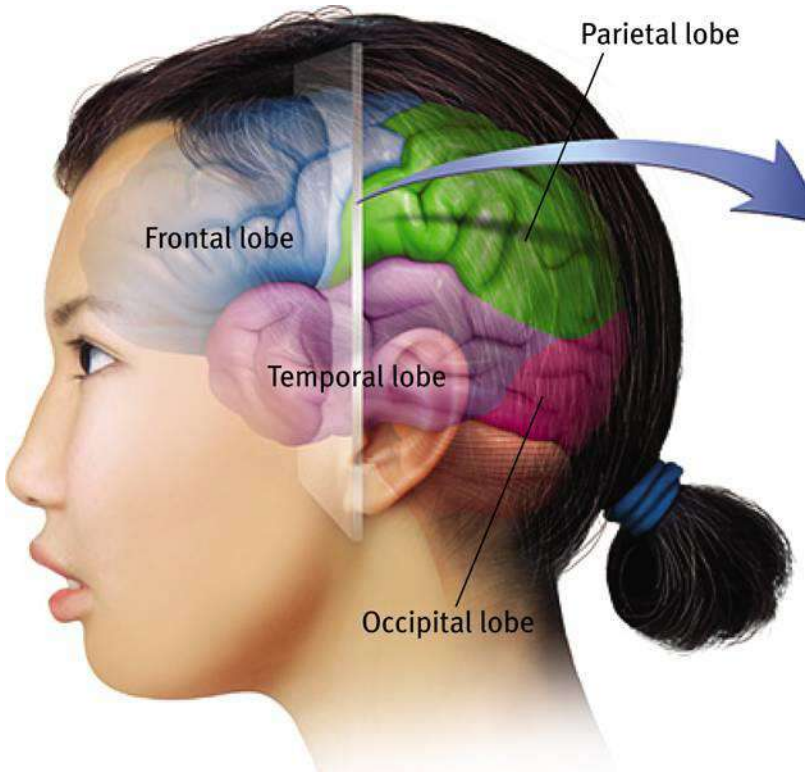
The Cerebral Cortex

The intricate fabric of interconnected neural cells that covers the cerebral hemispheres. It is the body's ultimate control and information processing center.

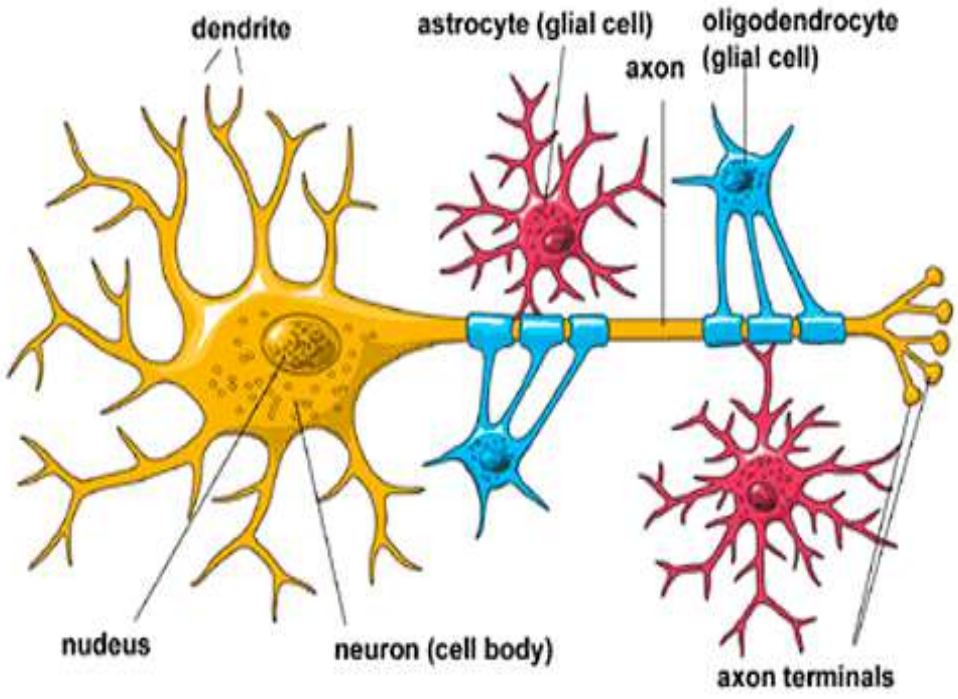


Structure of the Cortex

Each brain hemisphere is divided into four lobes that are separated by prominent fissures. These lobes are the frontal lobe (forehead), parietal lobe (top to rear head), occipital lobe (back head) and temporal lobe (side of head).



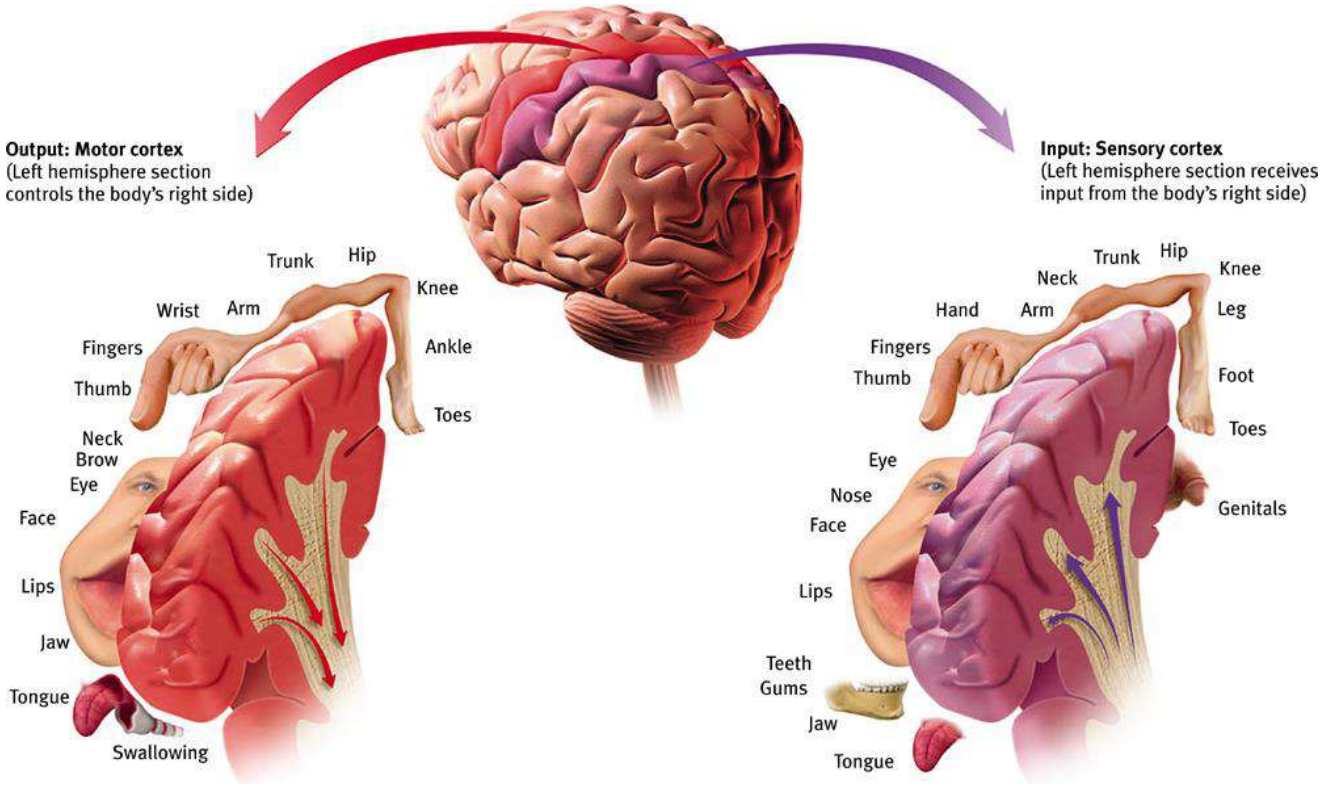
Structure of the Cortex
Glial Cells



- "Glue Cells"- spidery nerve cells in cerebral cortex
- Provide nutrients and insulating myelin, guide neural connections and mop up ions and neurotransmitters.
- May play a role in learning and thinking.

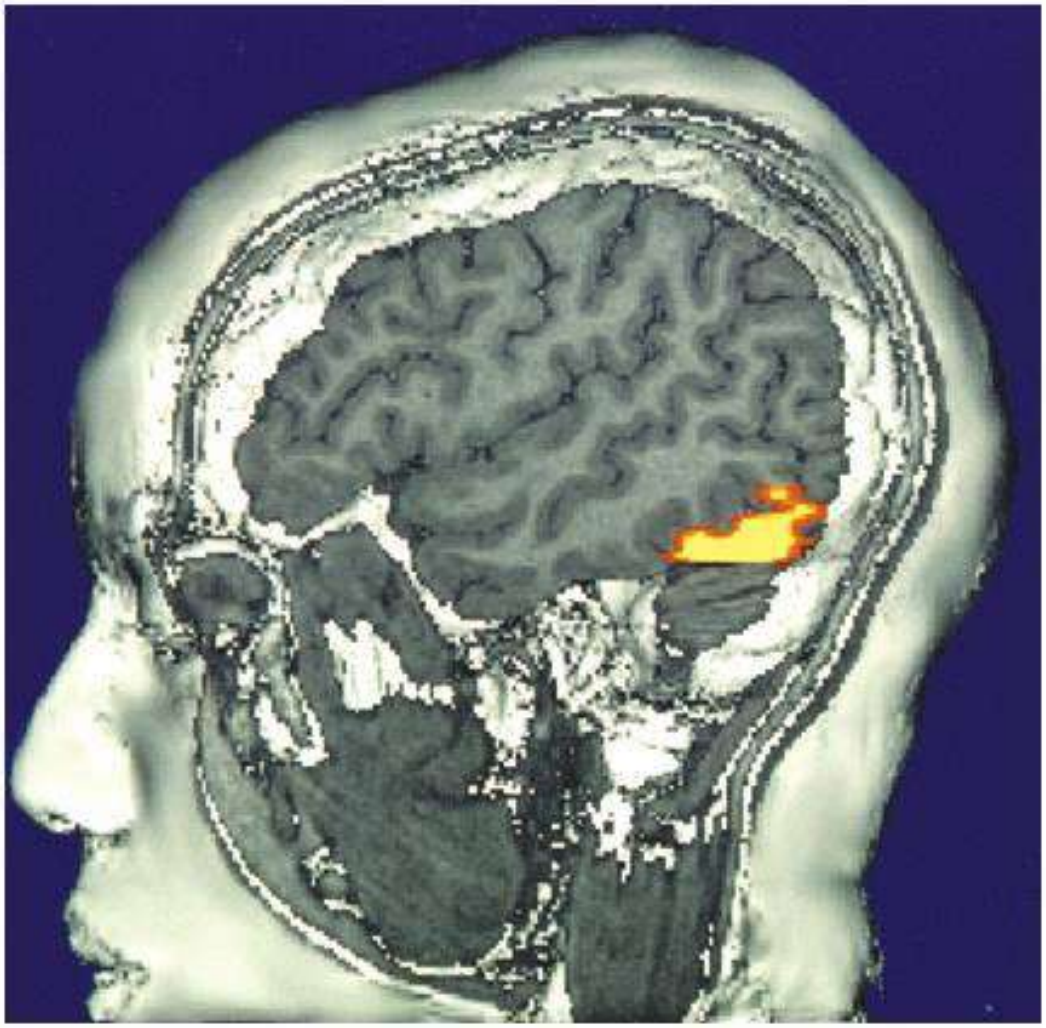
Functions of the Cortex

The Motor Cortex is the area at the rear of the frontal lobes that control voluntary movements. The Sensory Cortex (parietal cortex) receives information from skin surface and sense organs.



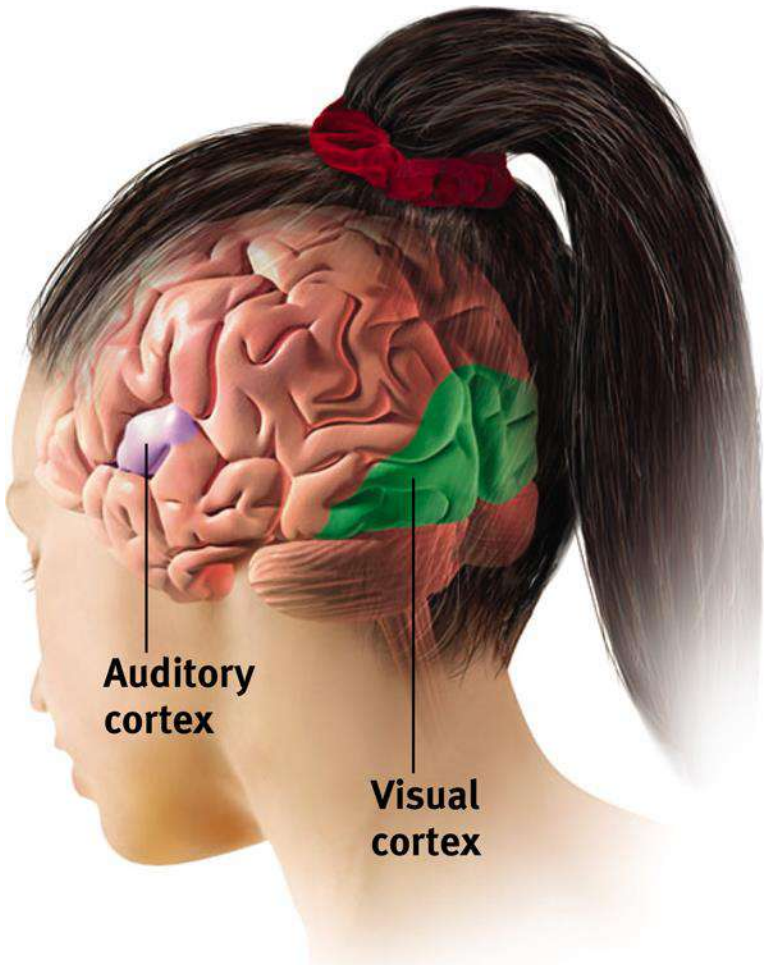
Sensory Cortex -Visual Function

The functional MRI scan shows the visual cortex is active as the subject looks at faces.



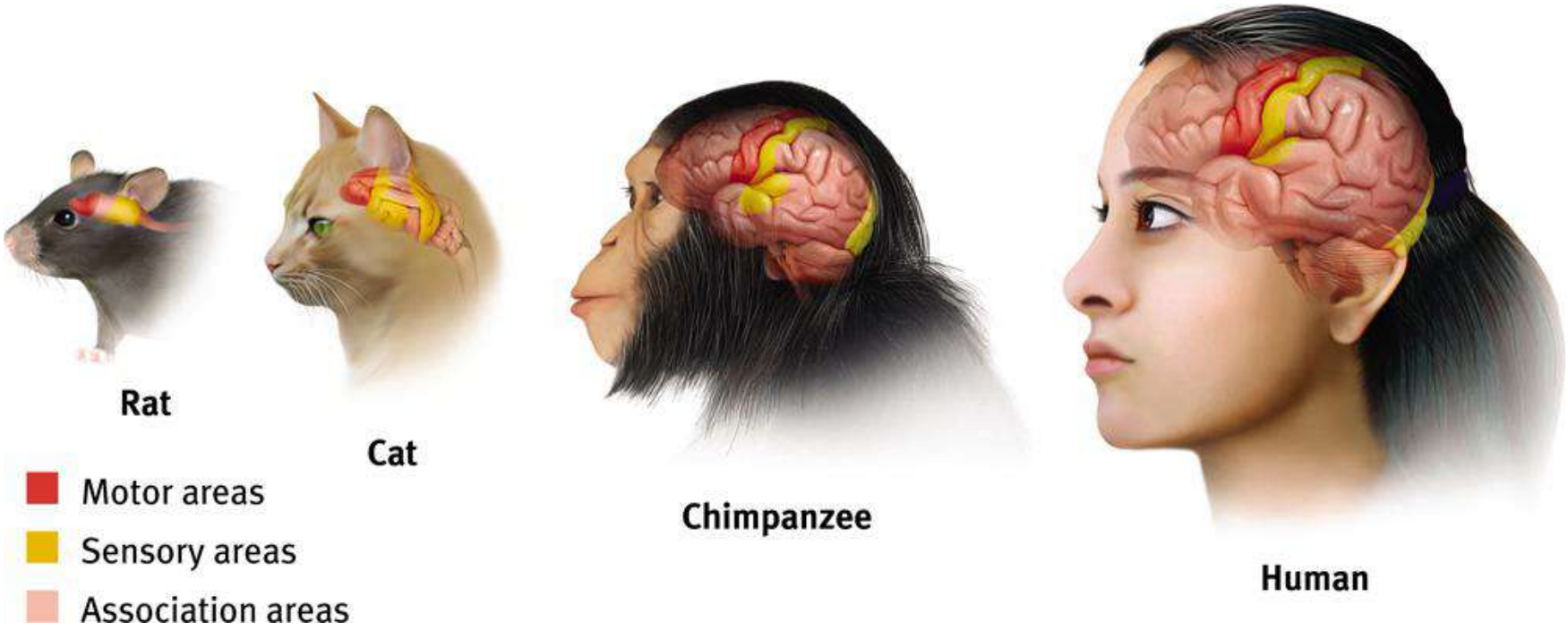
Sensory Cortex - Auditory Function

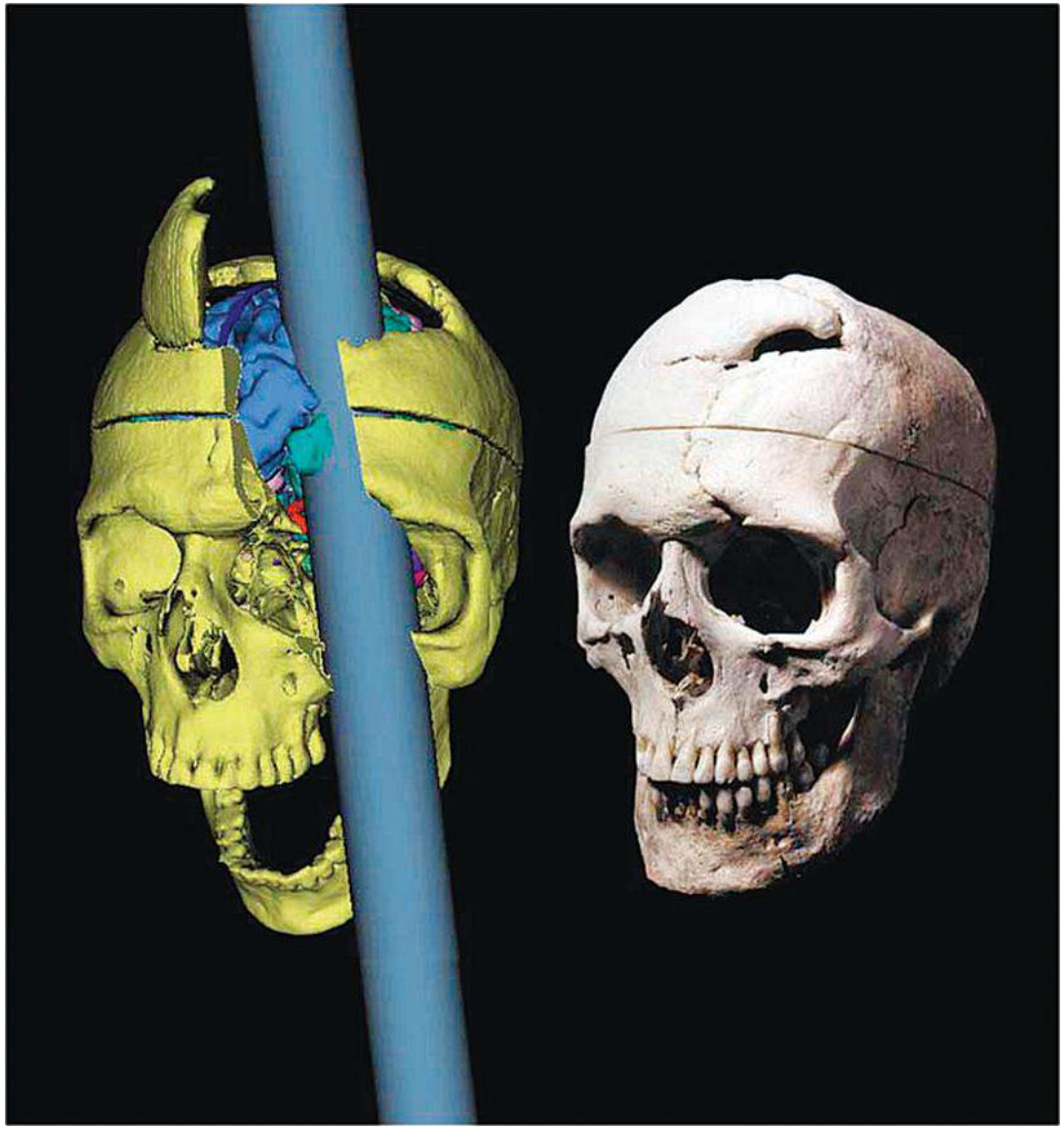
The functional MRI scan shows the auditory cortex is active in patients who hallucinate.



Association Areas

More intelligent animals have increased "uncommitted" or association areas of the cortex.

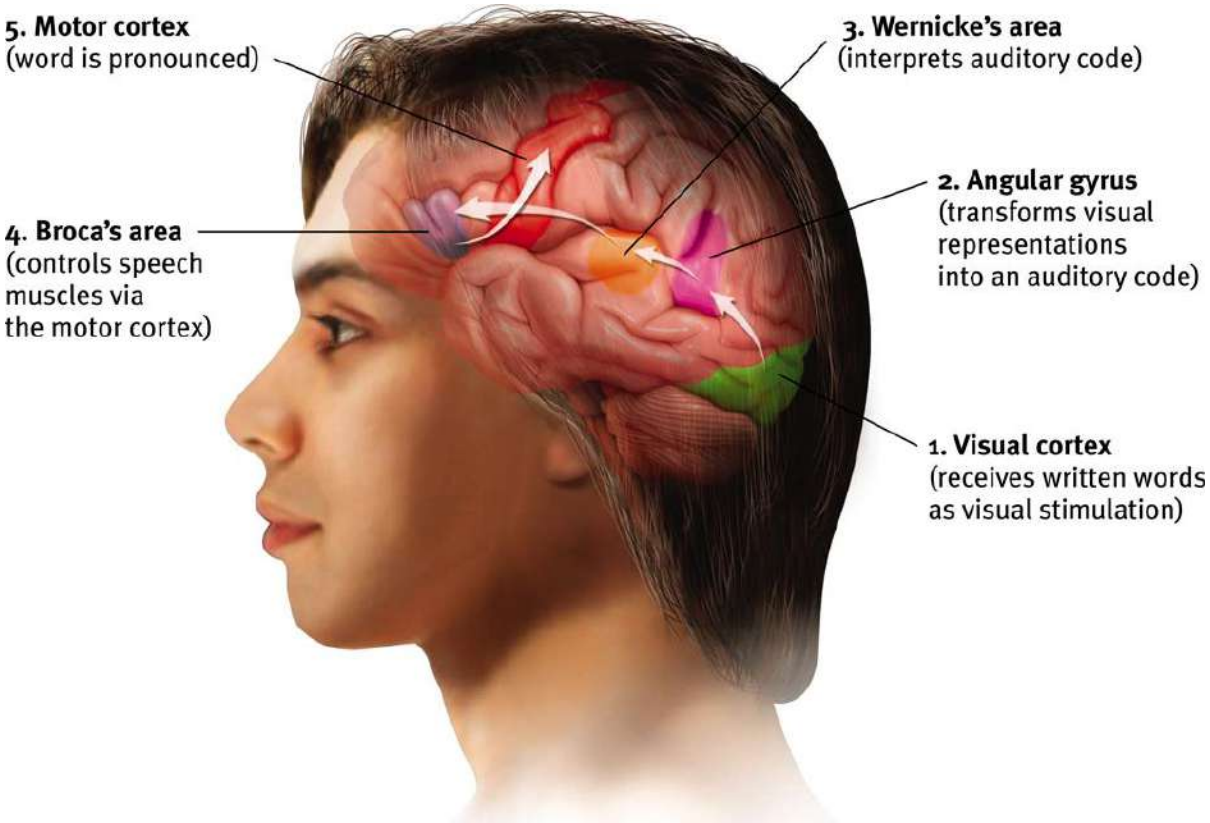




The Case of Phineas Gage

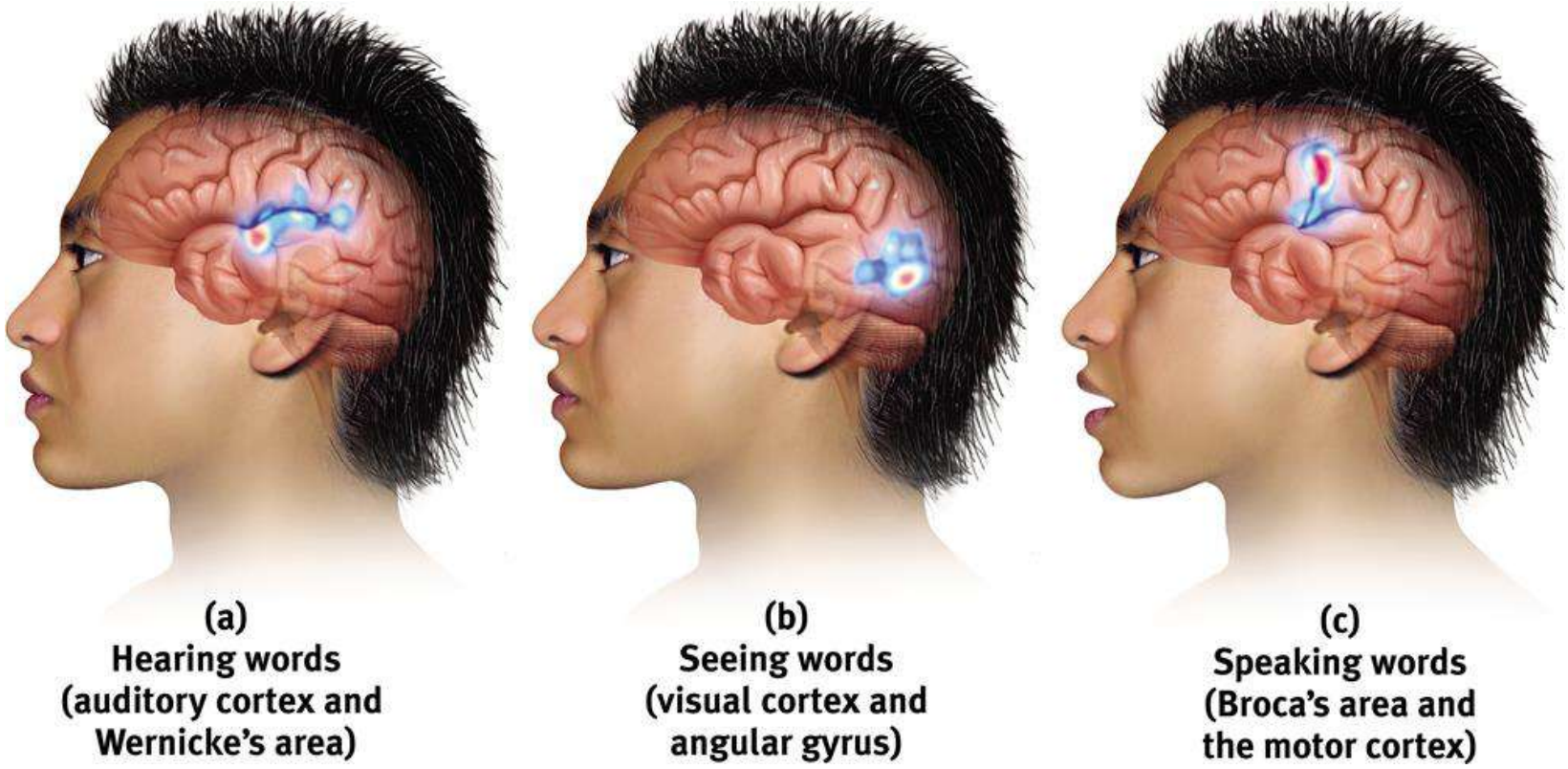
Language

Aphasia is an impairment of language, usually caused by left hemisphere damage either to Broca's area (impaired speaking) or to Wernicke's area (impaired understanding).



Specialization & Integration

Brain activity when hearing, seeing, and speaking words



The Brain's Plasticity

The brain is sculpted by our genes but also by our experiences.

Plasticity refers to the brain's ability to modify itself after some types of injury or illness.

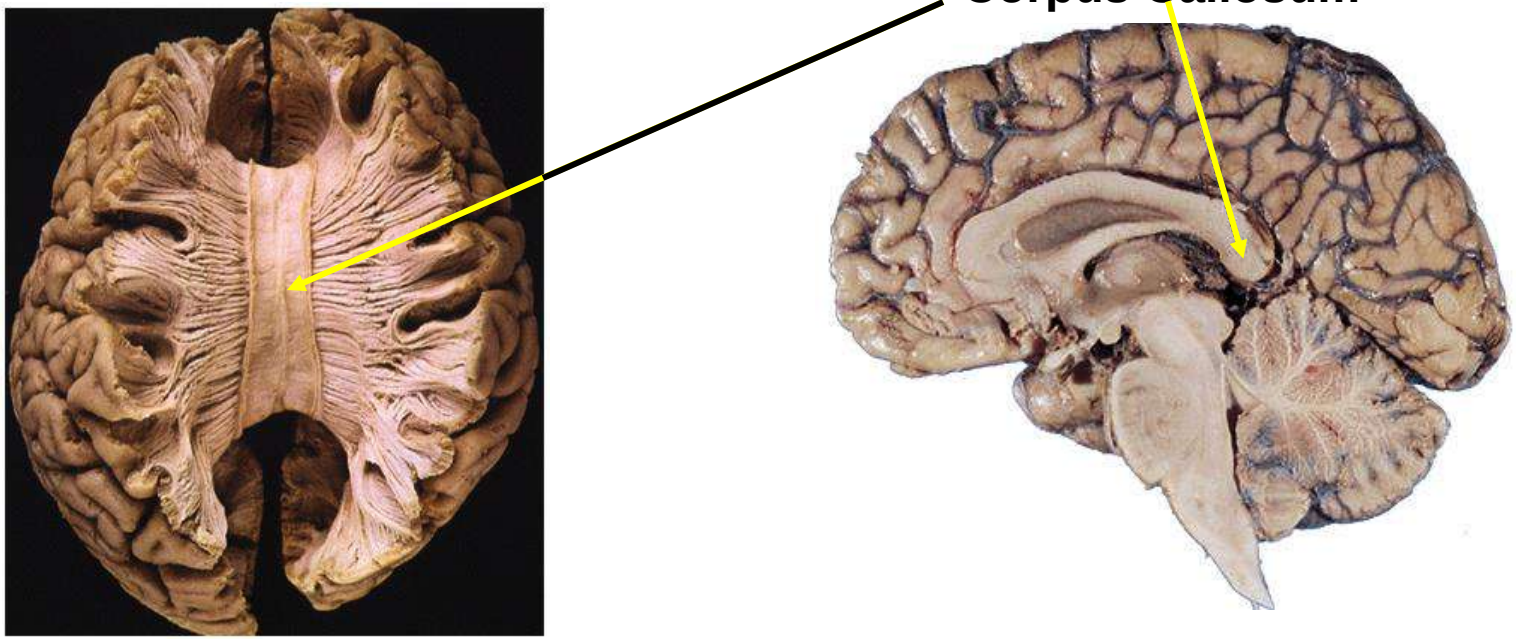
Our Divided Brain

Our brain is divided into two hemispheres.

The **left hemisphere** processes reading, writing, speaking, mathematics, and comprehension skills. In the 1960s, it was termed as the dominant brain.

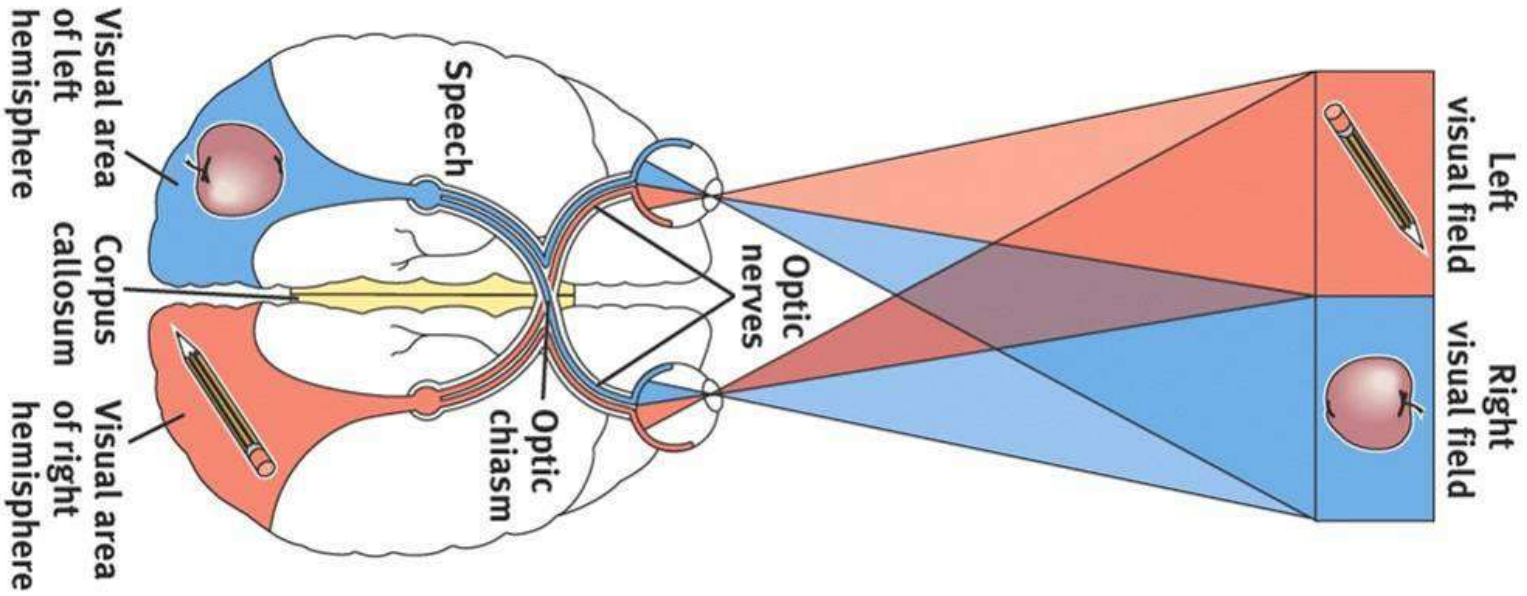
Splitting the Brain

A procedure in which the two hemispheres of the brain are isolated by cutting the connecting fibers (mainly those of the corpus callosum) between them.

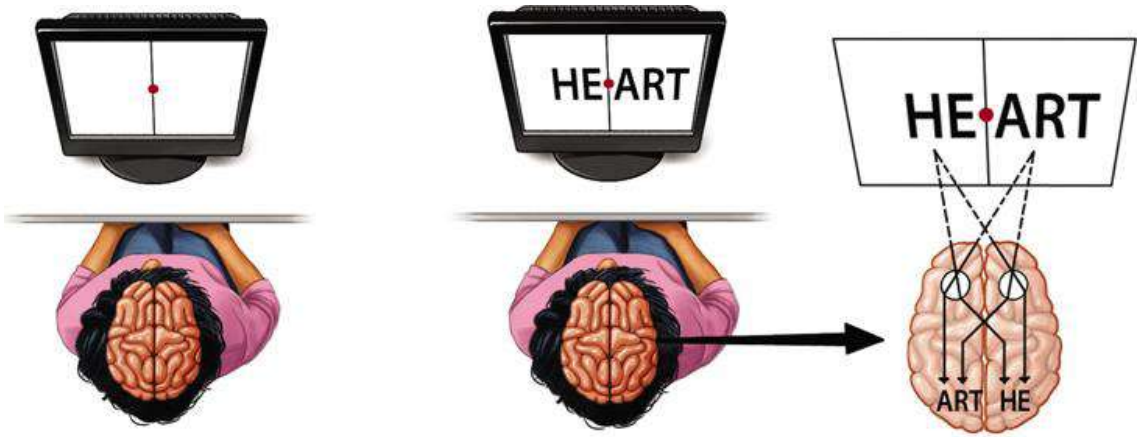


Split Brain Patients

With the corpus callosum severed, objects (apple) presented in the right visual field can be named. Objects (pencil) in the left visual field cannot.



Divided Consciousness

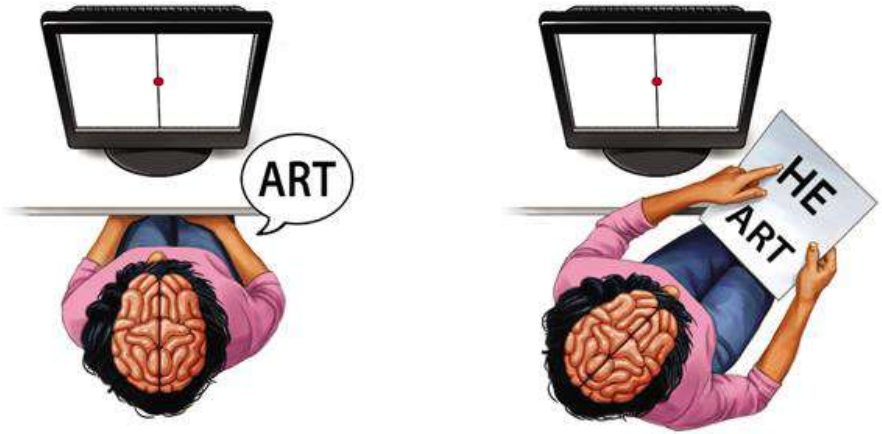


"Look at the dot."

(a)

Two words separated by a dot are momentarily projected.

(b)



"What word did you see?" or "Point with your left hand to the word you saw."

(c)

Try This!

Try drawing one shape with your left hand and one with your right hand, simultaneously.

BBC

Right-Left Differences in the Intact Brain

People with intact brains also show left-right hemispheric differences in mental abilities.

A number of brain scan studies show normal individuals engage their right brain when completing a perceptual task and their left brain when carrying out a linguistic task.

Find a partner!!!
Or a mirror!!!

Right Brain Dominance in the Eyes

- **right-brain dominant Jewel structure**
- **notice there are more/larger/stronger brown dots (jewels) in the left iris indicating more activity in the right hemisphere.**

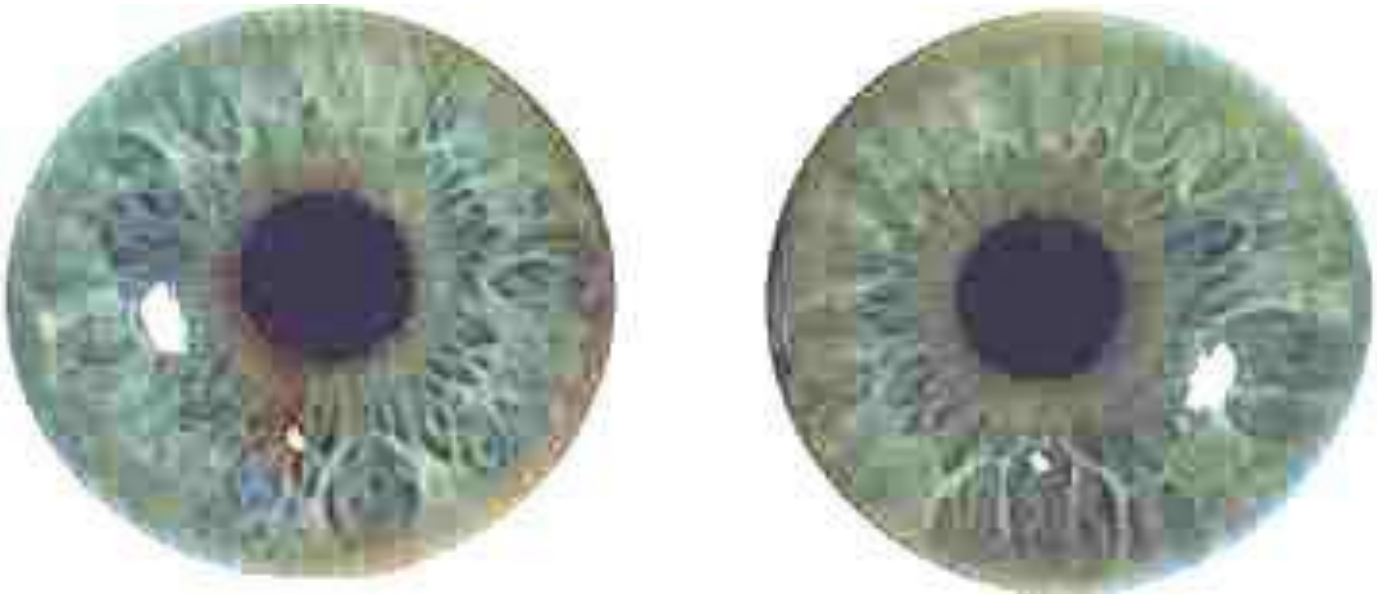
Right Brain Dominance in the Eyes

- **A right-brain dominant Flower structure**
- **notice there are more/larger/stronger fiber petals (flowers) in the left iris indicating more activity in the right hemisphere.**

Left Brain Dominance in the Eyes

- **A left-brain dominant Jewel structure**
- **notice there are more/larger/stronger jewels in the right iris indicating more activity in the left hemisphere.**

Left Brain Dominance in the Eyes



- **A left-brain dominant Flower structure**
- **notice there are more/larger/stronger flowers in the right iris indicating more activity in the left hemisphere.**

Generally this thumb is an indication of the non-dominant hemisphere (higher moon in left thumb = right hemisphere dominant; higher moon in right thumb = left hemisphere dominant). You might prefer to regard it as the "pointier" moon indicates the dominant hemisphere. This indicator does take some time to reflect a shift in dominance.

- " Which leg do you pref
- If it is your right leg, the left brain dominant, co preference sugges hemispheric preferenc attempt this test with a or an injury in one leg more likely to be deter or injury than the domina