Biological Basis of Behavior

Chapter 2

Neurons

Basic units of the nervous system

Receive, integrate, and transmit information

The adult human brain has ~180 BILLION cells

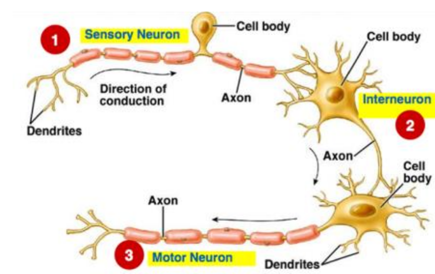
Three Types of Neurons

Sensory/Afferent Neurons- bring info in

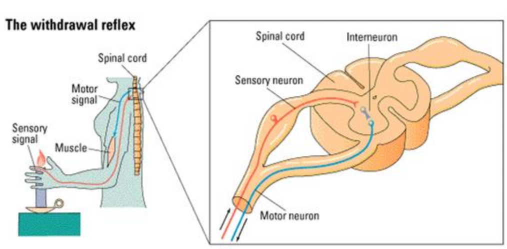
Interneurons- communicates between sensory and motor (in brain and spinal cord)

Motor/Efferent Neurons- send info/movement out

Three Types of Neurons



The Withdrawal Reflex



Transmission of message

Along the neuron – electrical
- This is called an ACTION POTENTIAL

Between two neurons – chemical
- This is called SYNAPTIC TRANSMISSION

Neuron Anatomy

Parts of the Neuron

Dendrite
- the bushy, branching extensions of a neuron that receive messages and conduct impulses toward the cell body

Axon
- the extension of a neuron, ending in branching terminal fibers, through which messages are sent to other neurons or to muscles or glands

Parts of Neuron

Soma- Bulbous end of a neuron that contains the cell nucleus- sometimes called cell body

Axon Hillock- is located at the end of the soma and controls the firing of the neuron.
- If the total strength of the signal exceeds the threshold limit of the axon hillock, the structure will fire a signal (known as an action potential) down the axon.

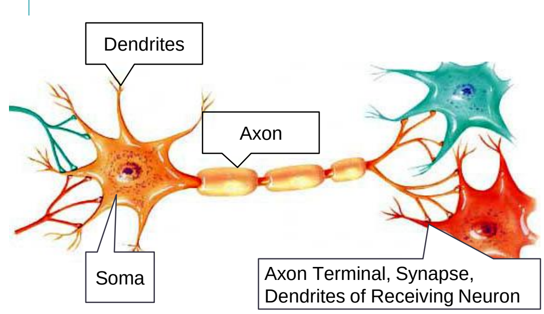
Parts of a Neuron

Axon Terminals-branches off the axon that hold vesicles

Parts of the Neuron

Synapse
- junction between the axon tip of the sending neuron and the dendrite or cell body of the receiving neuron
- tiny gap at this junction is called the *synaptic gap* or *cleft*

Neuron



Glial cells

80-100 billion neurons-10x more glial cells

Glial cells

- Support neurons (literally, provide physical support, as well as nutrients)
- Cover neurons with myelin
- Clean up poisons from bloodstream
- Surround and protect neurons (glia=Greek for glue)
- Rid the brain of neurons killed by old age, disease or injury by engulfing and digesting them

Glial Cells

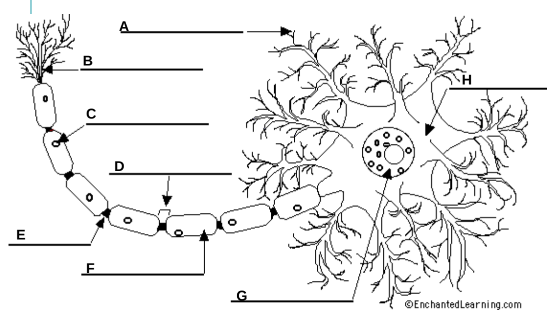
Schwann cells are a variety of glial cell that form the myelin sheath

Nodes of Ranvier gaps between glial cells

Myelin Sheath

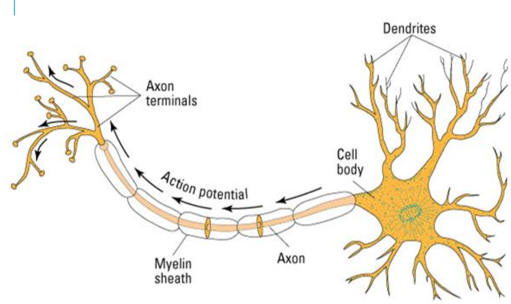
– Fatty material made by glial cells
– Insulates the axon
– Allows for rapid movement of electrical impulses along axon
– Multiple sclerosis is a breakdown of myelin sheath

Speed of neural impulse ranges from 2 – 200+ mph

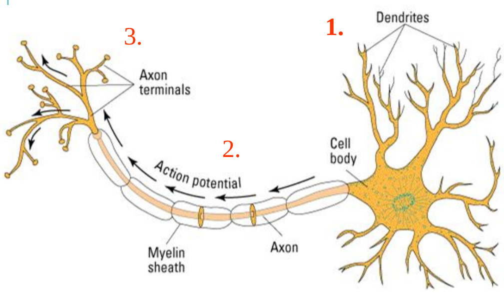


Neural Communication

Specific Parts: The Neuron ***Structure***



Specific Parts: The Neuron
Function



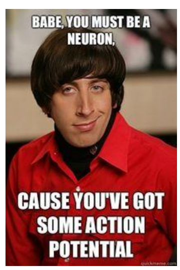
Resting Potential

Resting potential exists when the cell is not electrically active

Waiting for a stimulus to occur

Negatively charged inside the cell- cell is polarized- difference between the charge inside and the charge outside

Action Potential



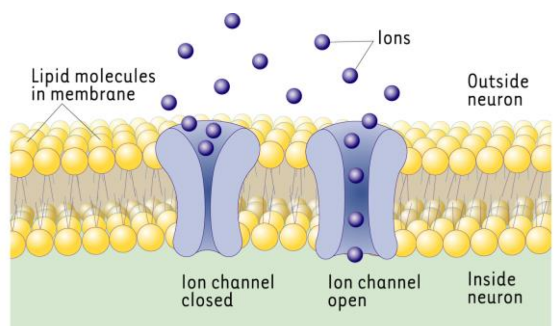
When dendrites are stimulated, the delicate balance is altered

Membrane channels open

Positively charged ions rush in (depolarization)

- Charge = less negative

Causes release of chemicals from terminal buttons



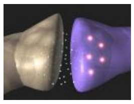
Refractory Period

The neuron needs to reset, return to resting potential and regain its negative charge (Repolarization)

Threshold

- Action potential occurs only when the membrane is stimulated (depolarized) enough so that sodium channels open completely.
- The minimum stimulus needed to achieve action potential is called the threshold stimulus
- https://www.youtube.com/watch?v=YP_P6bYvEjE

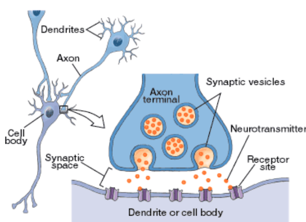
Relay Race



Action Potential starts at dendrite
- Through cell body
- Down Axon
- Axon Terminals
  - How does it get to the next cell's dendrites?
  - Neurons don't touch
    - Synapse = millionth inch gap
    - In synapse = vesicles w/ <u>neurotransmitters</u>

Neural Communication

- Vesicles- small membrane enclosed sac that stores neurotransmitters, release when action potential occurs
  - –Neurotransmitters=chemical molecules released when action potential reaches the end of the neuron



- Impulse releases neurotransmitter from vesicles
- Neurotransmitter enters synaptic gap
- Neurotransmitter binds to receptors on the receiving neuron
- Neurons connect to make a "forest" of nerves that allow different parts of the body to "talk"

Reuptake

Excess neurotransmitters are reabsorbed by the sending neuron to be used again

Remaining neurotransmitters are destroyed by the enzyme monoamine oxydase (MAO)

All or Nothing Response

If a nerve responds at all to a stimulus then it must respond completely

Greater intensity of stimulation does not produce a stronger signal

The frequency of the response signal strength of a stimulus

Crossing the Divide
http://learn.genetics.utah.edu/content/addiction/crossingdivide/

Neurotransmitters

Neurotransmitters

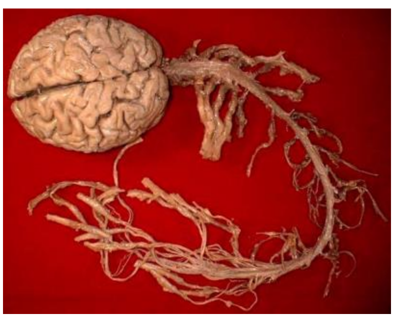
chemical messengers that traverse the synaptic gaps between neurons

https://www.youtube.com/watch?v=haNoq8UbSyc

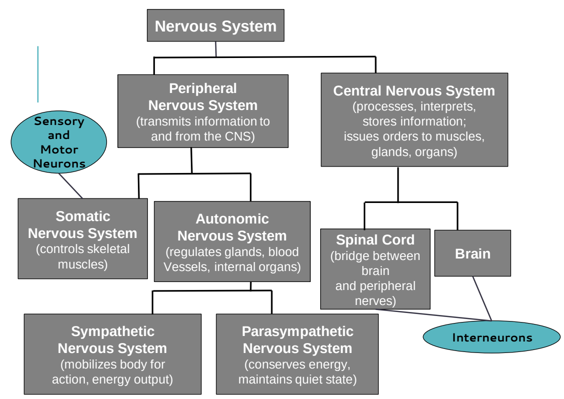
Neurotransmitters

Excitatory neurotransmitters bring the dendrite closer to threshold by allowing positive ions to rush in.

Inhibitory neurotransmitters take the dendrite further away from threshold by allowing negative ions to rush in



The Nervous System



Hormones vs. Neurotransmitters

Both:

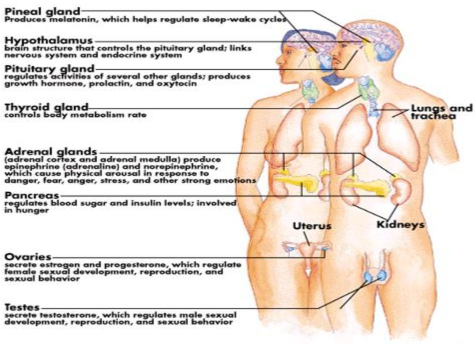
- common origin, in evolutionary history
- may have similar (or identical) actions
- may be chemically similar (or identical:)
  - norepinephrine = both hormone & neurotransmitter
    - hormone secreted by adrenal glands
    - excitatory neurotransmitter in nervous system

Hormones vs. Neurotransmitters

But:

- Hormones into bloodstream, neurotransmitters in synapse.
- Hormones (usually) have variety of responses
  - NTs localized and specific

Endocrine System



Endocrine Key Players

Hypothalamus

- Hypothalamus releases hormones or releasing factors which in turn cause pituitary gland to release its hormones

Endocrine Key Players

Pituitary Gland

- “Master endocrine gland”
- Produces hormones that control hormone production in other endocrine glands
- Controls growth hormones
  - A very poor diet can stop a child from growing by stopping the release of growth hormones.
  - Too much pituitary hormone leads to gigantism, too little to dwarfism

Endocrine Key Players

Adrenal Glands

- Involved in stress response
- Prepares us for emergencies, activates the sympathetic nervous system
- Hormones released include:
  - epinephrine (a.k.a. adrenaline)
  - norepinephrine (a.k.a. noradrenaline)

More Endocrine Glands

Thyroid gland – regulates metabolism, activity levels, and weight

Pineal gland - sleep and wakefulness (melatonin)

Pancreas - regulates blood sugar level

Ovaries and testes - secrete sex hormones such as testosterone and estrogen

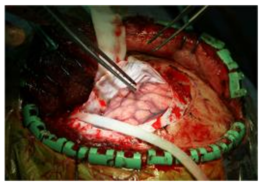
The Brain

How do we study the brain?

two main methods for understanding how different parts of the brain perform different functions:

“Broken Brain” Patients- case studies

Neuroimaging



“Broken brain” patients

Before there was “brain imaging” technology, the only way to learn about brain function was to study “broken brain” patients, patients with specific damage to their brains

Case Studies

The logic:

- If a person who has a damaged brain part X cannot do task Y…
- Then, in a *normal* brain, part X must (help) do task Y.
- Example: Phineas Gage (frontal lobe damaged = loss of ability to plan, loss of emotional control)

These *case studies* of patients are still useful today.

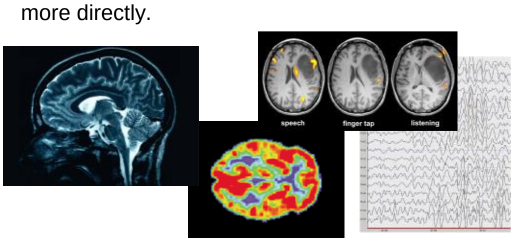
Lesions

The ability to destroy tiny clusters of brain cells.

Textbook pg 61

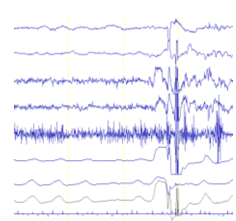
Brain Scans

Today, psychologists can use many techniques to understand the brain's structure and function more directly.



Electroencephalogram (EEG)

In an EEG, electrodes are placed on the skull. The electrodes detect and transmit the electrical activity of the brain's neurons.

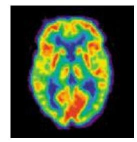


Computerized Axial Tomography (CT scan)

CT or CAT scans take X-rays of the brain from many different angles, giving us a picture of the brain's structure.

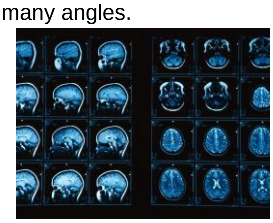
Positron Emission Tomography (PET)

In a PET scan, radioactive elements are injected into the blood. A computer traces the elements to see which parts of the brain are using the most amount of blood (are most active).



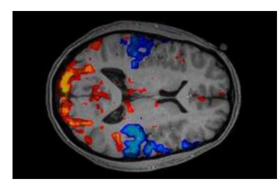
Magnetic Resonance Imaging (MRI)

An MRI uses magnetic fields and radio waves to give a picture of the brain from many angles.



Functional Magnetic Resonance Imaging (fMRI)

An fMRI measures blood flow to each area of the brain to show us a picture of the brain's activities.



New Technology?

Trimodal brain scan combining EEG/PET/MRI readings!

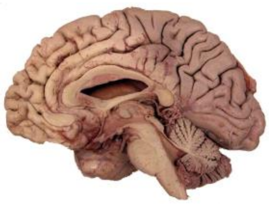
Brain Structures

Brainstem (hindbrain)

Description- Stem like portion of the brain, composed of the midbrain, pons and medulla oblongata

General Functions

- Homeostasis
  - (keeps you alive and in equilibrium)



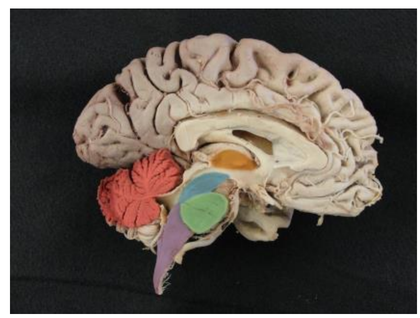
Brainstem (hindbrain)

Specific Functions

- Medulla: control of blood pressure, heart rate, breathing
- Pons: sleep, movement
- Reticular formation: awareness, regulates the activity level of the body (through core of medulla)
- Cerebellum: coordination of rapid movements and balance

Thalamus (Part of the Forebrain)

- function: relay station for your senses
  - EX: sends incoming sensory information to appropriate part of the brain



Cerebellum Medulla Pons Midbrain
RAS (runs inside) Thalamus

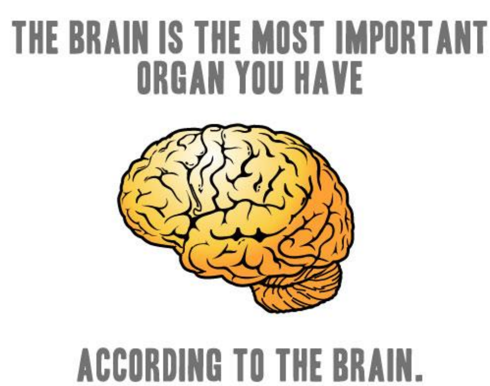
Limbic System (part of forebrain)

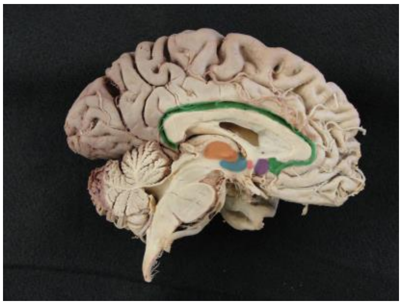
General Function

- Emotion and memory

Specific Functions

- Hippocampus: memory
- Pituitary: endocrine system
- Amygdala: fear and emotions
- Hypothalamus: motivational behavior
  - Hunger, thirst, sleep cycles, etc.
  - Link between NS and Endocrine through pituitary



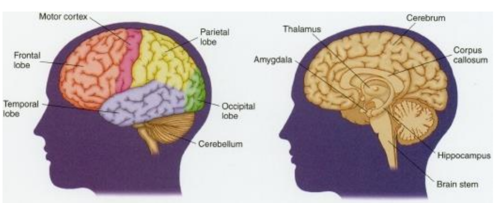


Hippocampus Amygdala Pituitary Gland
Thalamus Hypothalamus

The Cerebral Cortex

Cerebral Cortex

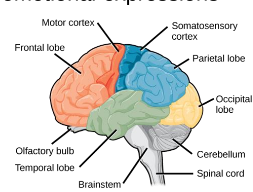
outermost layer of the brain, ultimate control and information center for the brain

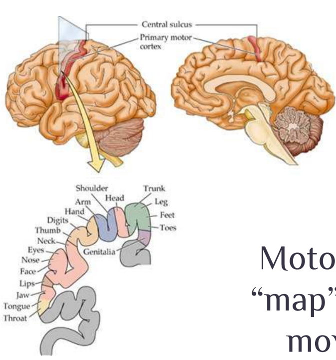


Frontal Lobe

- <u>Location:</u> "front" of cerebral cortex
- <u>Functions:</u>
  - involved with voluntary motor control
  - movements, control of emotional expressions and moral behavior.

<u>motor strip (motor cortex):</u> controls voluntary body movement *IN YOUR FRONTAL LOBE!*

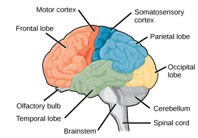




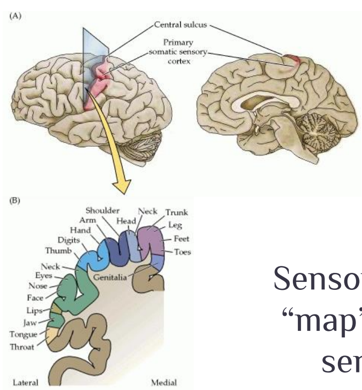
Motor Cortex: "map" of bodily movement

If your body parts were in proportion to the size of their representations on the motor cortex…

Parietal Lobe

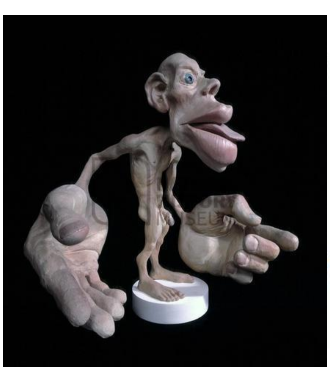


- Location: "top" of cerebral cortex
- Functions:
  - processing sensory information, the location of parts of the body as well as interpreting visual information and processing language and mathematics.
  - **sensory cortex (somatosensory cortex)**: "mental map" of your body (touch) *IN YOUR PARIATAL LOBE!*



Sensory Cortex: "map" of touch sensation

If your body parts were in proportion to the size of their representations on the sensory cortex...

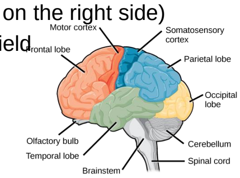


Occipital Lobe

- Location: "back" of cerebral cortex
- Functions: vision and visual association
  - left side ~ right visual field

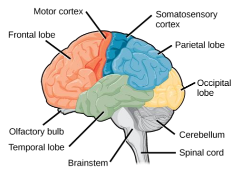
    (= everything you see on the right side)
  - right side ~ left visual field

    (= everything you see on the left side)



Temporal Lobe

- Location: "side" of cerebral cortex (beneath temple/above ear)
- Functions:
  - Hearing (auditory processing)
  - Language
  - Equilibrium
  - Emotion
  - Memory

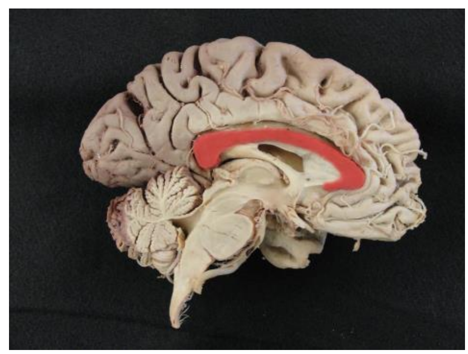


Which part of the cerebral cortex would control… ?

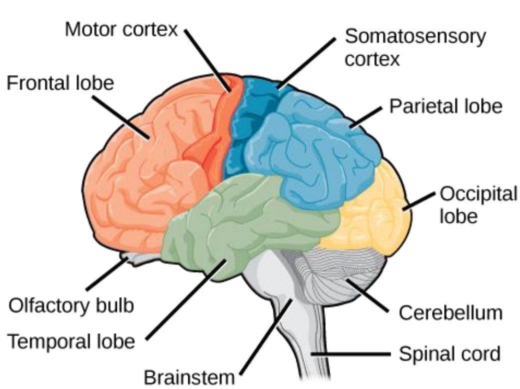
- Understanding what you hear?
  - Temporal Lobe
- Understanding what you see on the left?
  - Right Occipital Lobe
- Understanding what you feel (touch)?
  - Sensory Cortex- Parietal Lobe
- Making plans?
  - Frontal Lobe
- Moving your right hand?
  - Left Motor Cortex- Frontal Lobe

Corpus Callosum

The link between the left and right brain
- Sends signals between each side
- Motor and sensory pathways are contralateral
  - See on left, processed on right



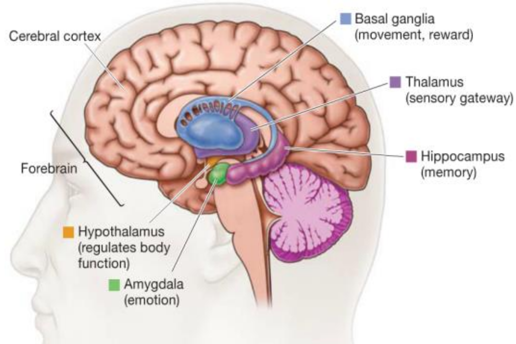
Corpus Callosum



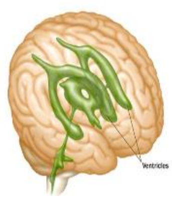
Other Brain Structures

Basal Ganglia

- Linked to the Thalamus
- responsible for involuntary movements such as tremors.
- The basal ganglia are abnormal in a number of important neurologic conditions, including Parkinson's disease and Huntington's disease.

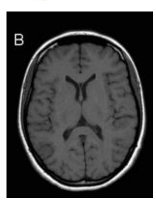


Ventricles

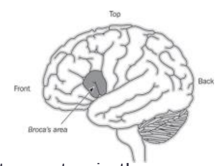


Spaces in the brain containing cerebrospinal fluid (CSF) the four functions of CSF include:

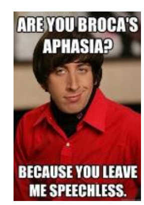
- **Protection:** the CSF protects the brain from damage by "buffering" the brain.
- **Buoyancy:** because the brain is immersed in fluid, the net weight of the brain is reduced from about 1,400 gm to about 50 gm.
- **Excretion of waste products:** the one-way flow from the CSF to the blood takes potentially harmful metabolites, drugs and other substances away from the brain.
- **Endocrine medium for the brain:** the CSF serves to transport hormones to other areas of the brain.



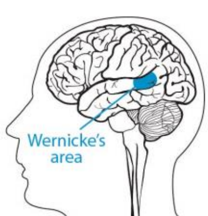
Broca's Area



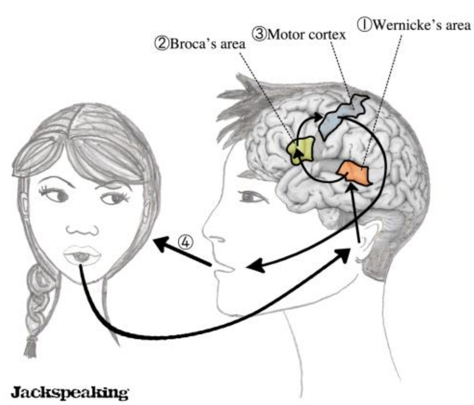
- An area of the cerebral motor cortex in the frontal lobe of the brain that is responsible for speech development.
- Damage to Broca's area can cause speech disorders.

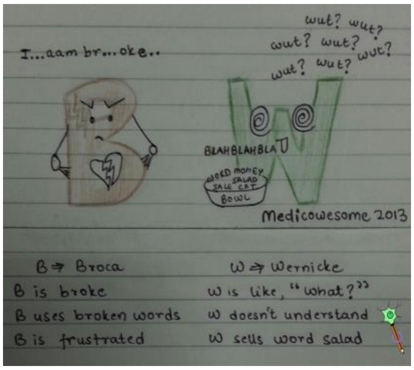


Wernicke's Area



- region of the brain that is important in language development.
- Located on the temporal lobe on the left side of the brain and is responsible for the comprehension of speech (Broca's area is related to the production of speech).
- Language development or usage can be seriously impaired by damage to this area of the brain.





Hemispheres of the Brain

Left vs Right Hemisphere

Compare the functions of two "symmetric" parts of the brain. How do they compare?

- different but related functions
  - left temporal lobe: language (vocabulary, grammar)
  - right temporal lobe: tone of voice, emotion of speech
- same function, different side of body
  - motor strip:
    - left brain --> controls right side of body
    - right brain --> controls left side of body
  - visual cortex:
    - left brain --> "sees" right visual field
    - right brain --> "sees" left visual field

More on left & right hemispheres

- split by fissure, connected by corpus callosum
  - left ~ speech, language, logic, writing
  - right ~ spatial reasoning, art, music, emotions, and *some* aspects of creativity
- Often, one side has "dominance".
  - Normally, left & right hemispheres work together.

Split Brain Studies (Gazzaniga)

•Visual/Spatial relationship

•Picture flashed on right (processed left): object described verbally without deficit

•Picture flashed on left (processed right): object cannot be described or identified verbally but when asked, the patient could reach for the correct object

•Right hemisphere superiority for visuospatial
•Left hemisphere superiority for language