

Surveying the Chapter: Overview

What We Have in Mind

- Building blocks of the mind: **neurons** and how they communicate (neurotransmitters)
- Systems that build the mind: functions of the parts of the **nervous system**
- Supporting player: the slower-communicating **endocrine system** (hormones)
- Star of the show: **the brain** and its structures

History of Mind

Ancient Conceptions About Mind

Plato correctly placed mind in the brain. However, his student Aristotle believed that mind was in the heart.

Today we believe mind and brain are faces of the same coin. Everything that is psychological is simultaneously biological.

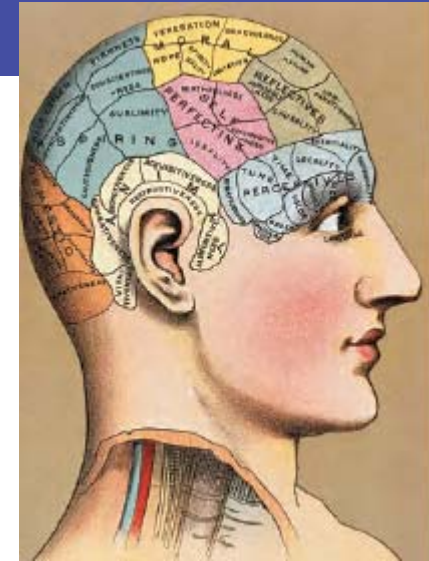
Searching for the self by studying the body

Phrenology

Phrenology
(developed by Franz Gall in the
early 1800's):

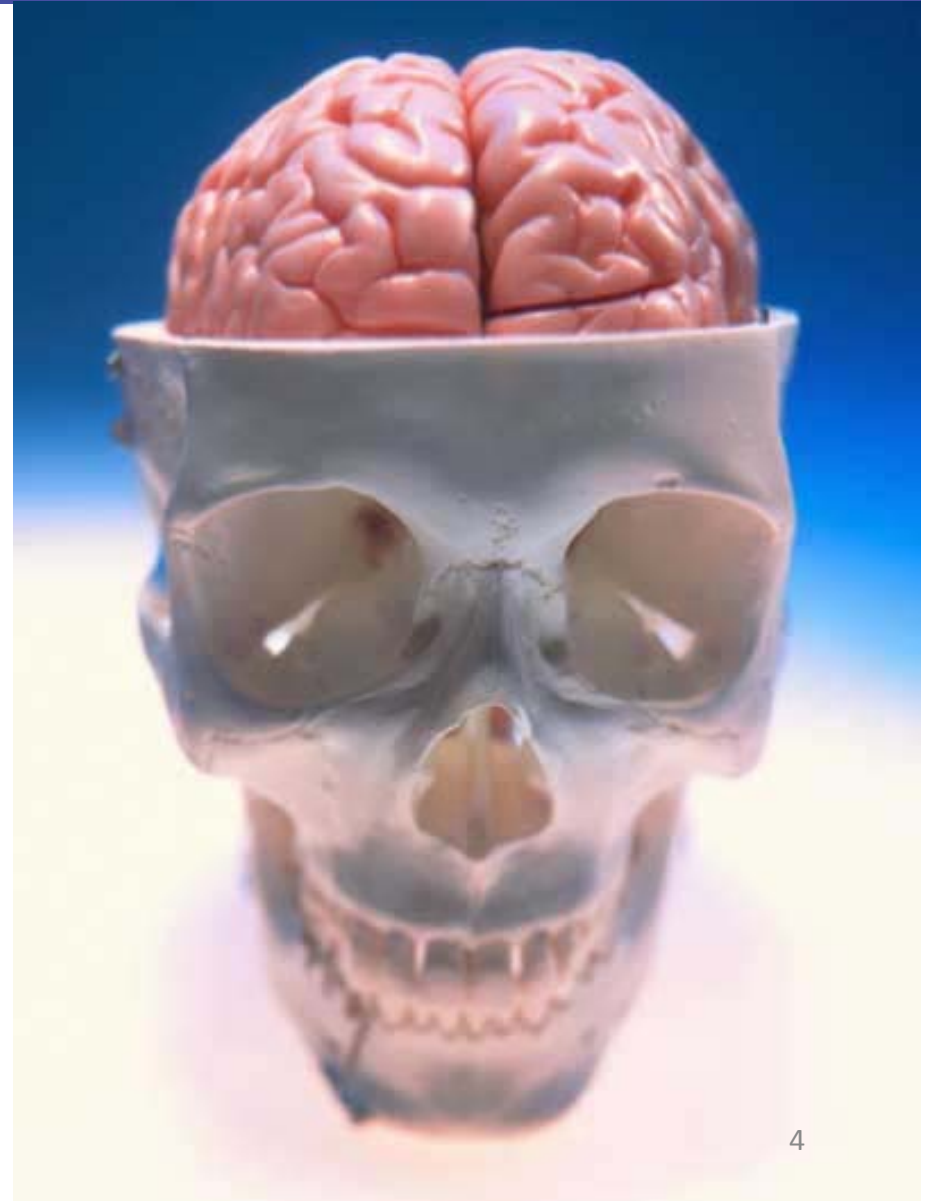
the study of bumps on the skull
and their relationship to mental
abilities and character traits

- Phrenology, though diabolically flawed, yielded one big idea--that the brain might have different areas that do different things (**localization of function**).

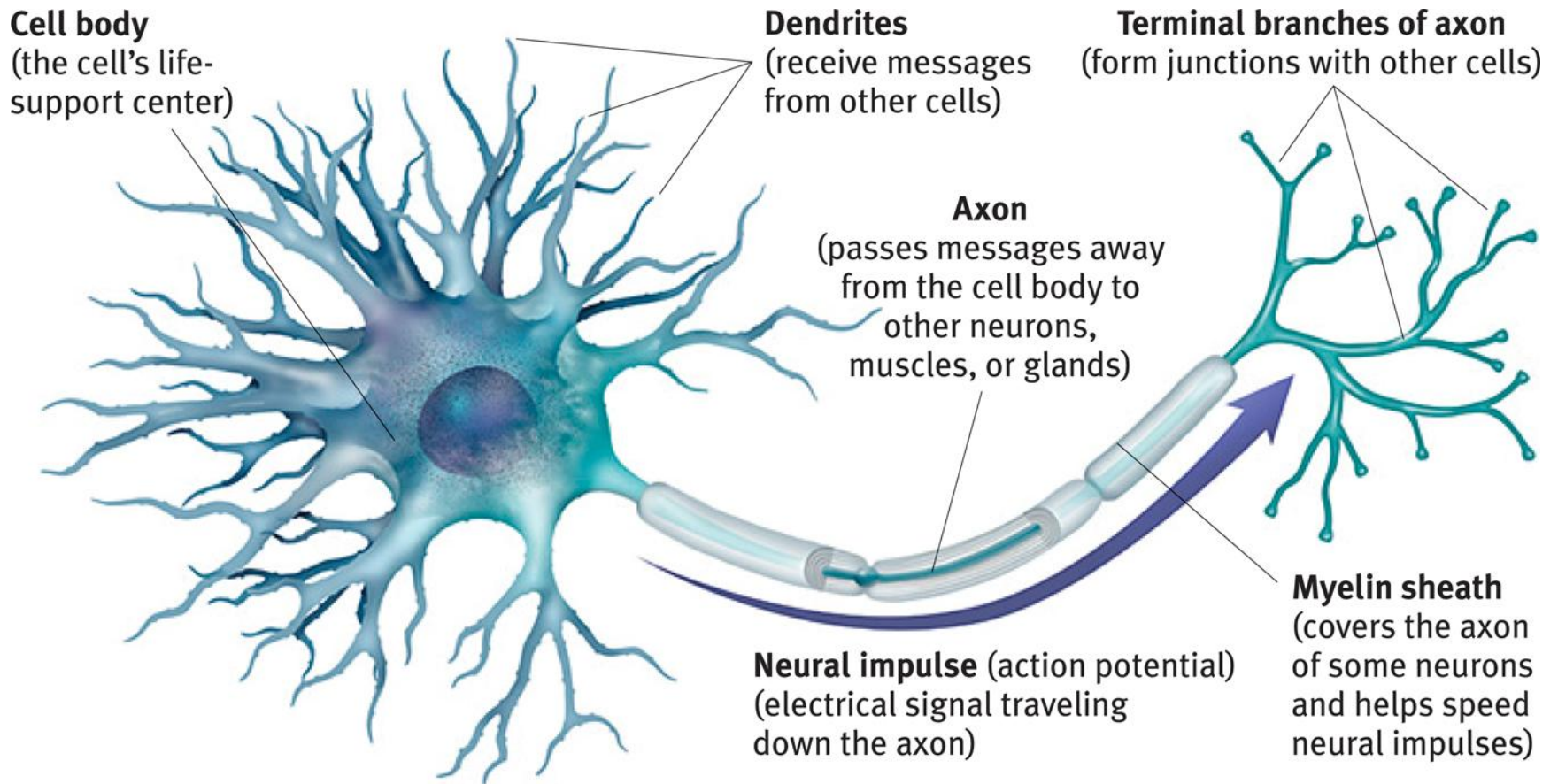


Today's search for the biology of the self: biological psychology

- Biological psychology includes neuroscience, behavior genetics, neuropsychology, and evolutionary psychology.
- All of these subspecialties explore different aspects of: how the nature of mind and behavior is rooted in our biological heritage.
- Our study of the biology of the mind begins with the “atoms” of the mind: **neurons.**



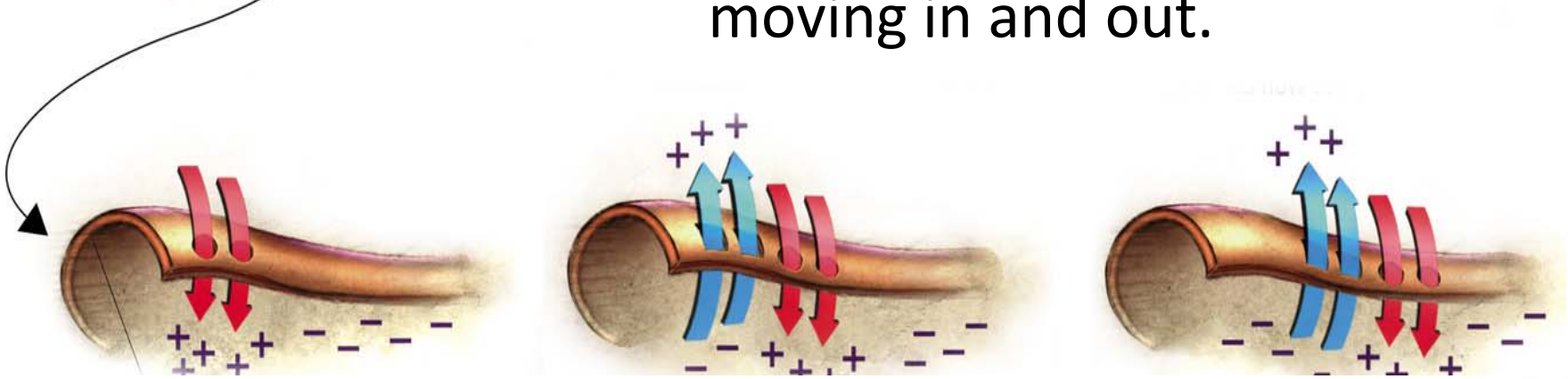
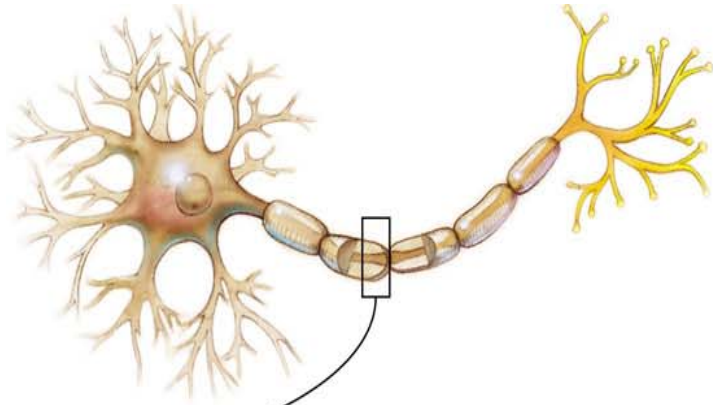
Neurons and Neuronal Communication: The Structure of a Neuron



There are billions of neurons
(nerve cells) throughout the body.

Action potential: a neural impulse that travels down an axon like a wave

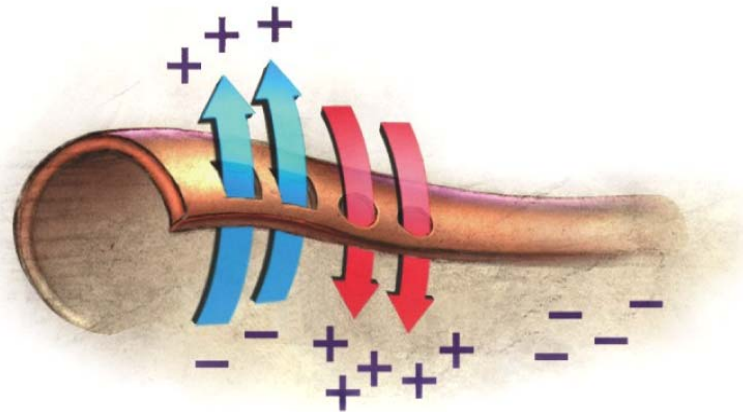
Just as “the wave” can flow to the right in a stadium even though the people only move up and down, a wave moves down an axon although it is only made up of ion exchanges moving in and out.



Depolarization & Hyperpolarization

Depolarization occurs when positive ions enter the neuron, making it **more prone to firing** an action potential.

Hyperpolarization occurs when negative ions enter the neuron, making it **less prone to firing** an action potential.



When does the cell send the action potential?... when it reaches a threshold

How neurons communicate (with each other):

The neuron receives signals from other neurons; some are telling it to fire and some are telling it not to fire.

- When the **threshold** is reached, the action potential starts moving.
- Like a gun, it either fires or it doesn't; more stimulation does nothing.
- This is known as the "**all-or-none**" response.

The action potential travels down the axon from the cell body to the terminal branches.

The signal is transmitted to another cell. However, the message must find a way to cross a gap between cells. This gap is also called **the synapse**.

The **threshold** is reached when excitatory ("Fire!") signals outweigh the inhibitory ("Don't fire!") signals by a certain amount.

Refractory Period & Pumps

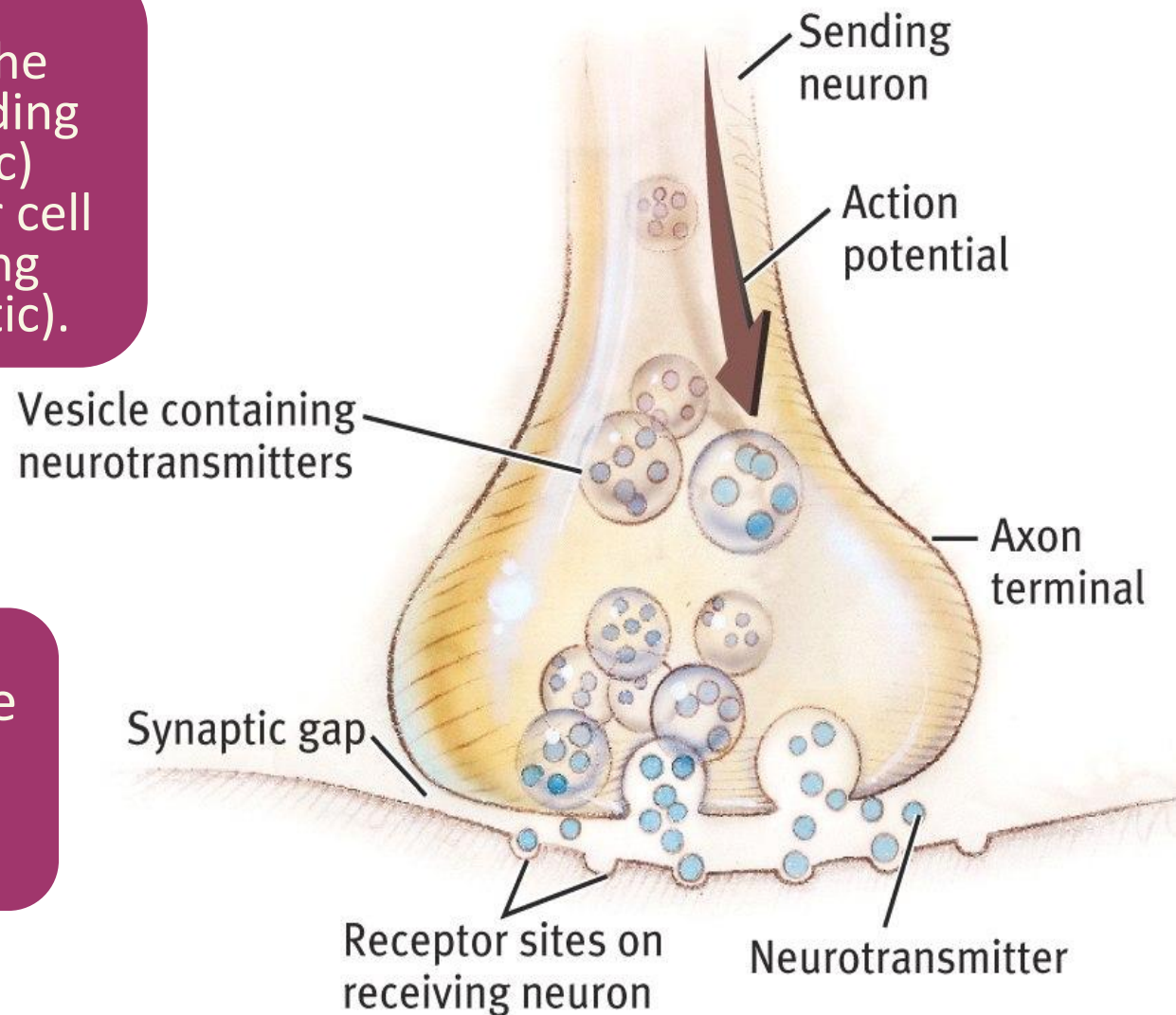
Refractory Period: After a neuron fires an action potential it pauses for a short period to recharge itself to fire again.

Sodium-Potassium Pumps: Sodium-potassium pumps pump positive ions out from the inside of the neuron, making them ready for another action potential.

The Synapse

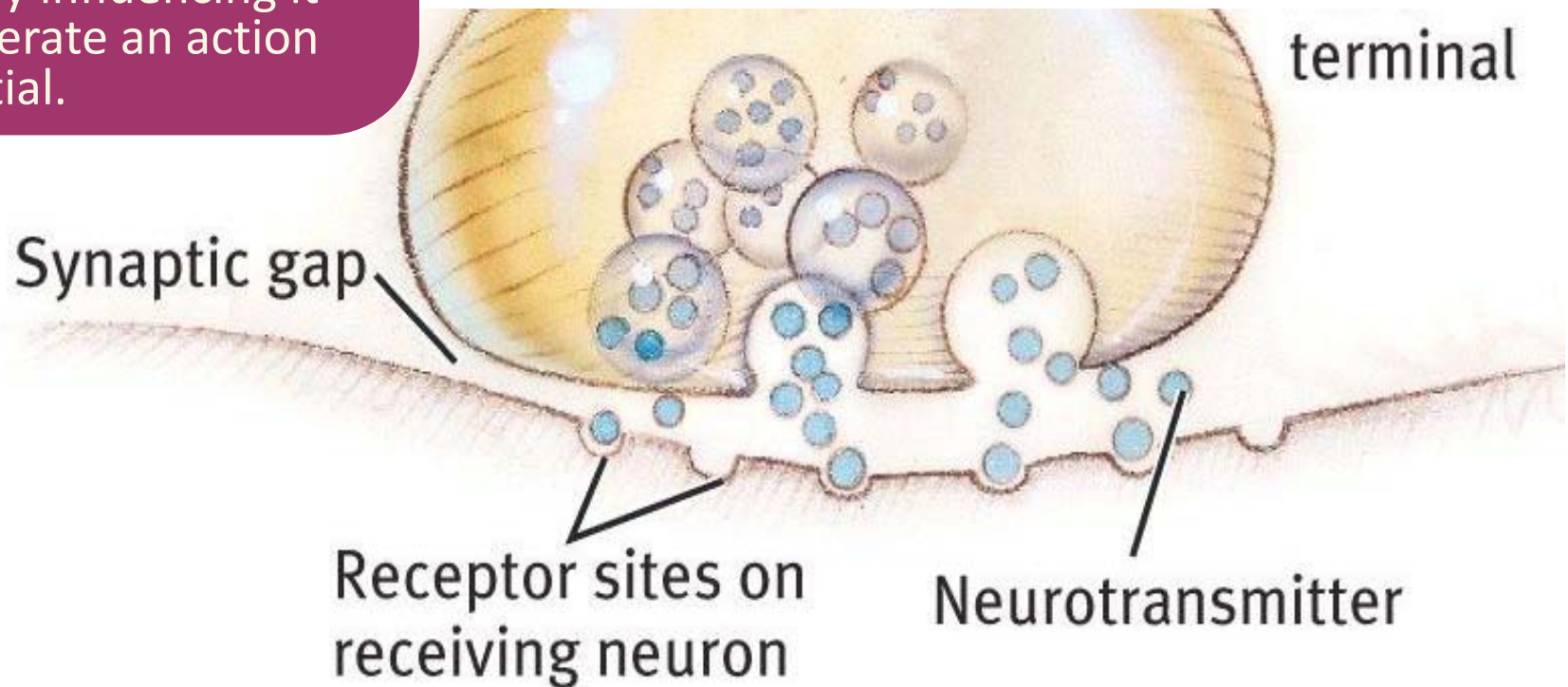
The synapse is a junction between the axon tip of the sending neuron (presynaptic) and the dendrite or cell body of the receiving neuron (postsynaptic).

The synapse is also known as the “**synaptic junction**” or “**synaptic gap.**”

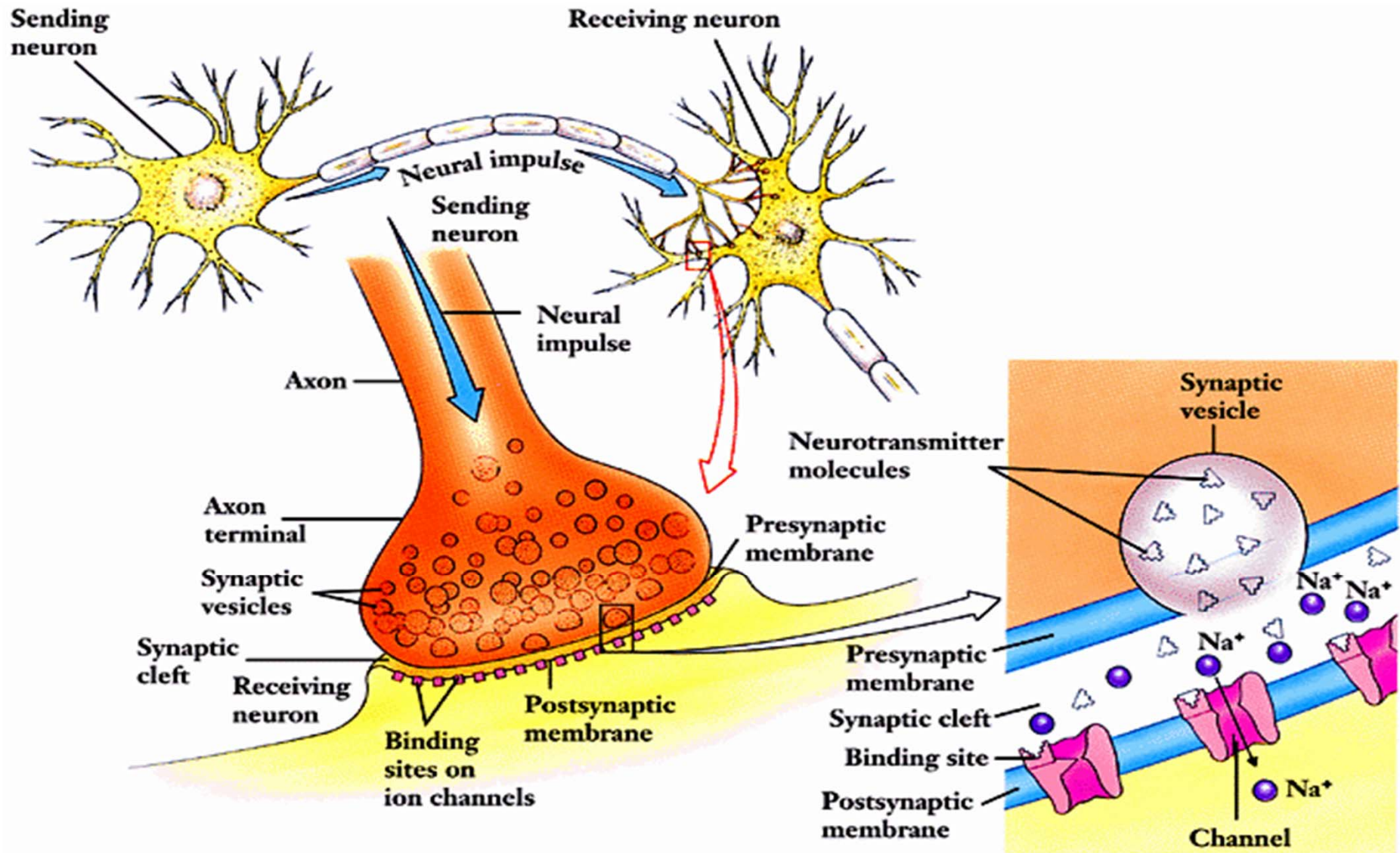


Neurotransmitters (chemicals) released from the sending neuron travel across the synapse and bind to receptor sites on the receiving neuron, thereby influencing it to generate an action potential.

Neurotransmitters

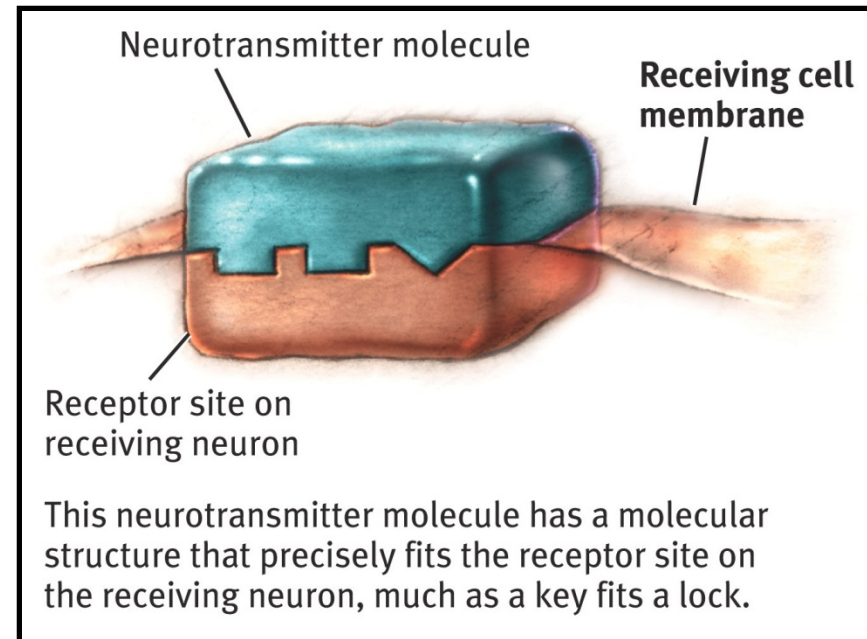
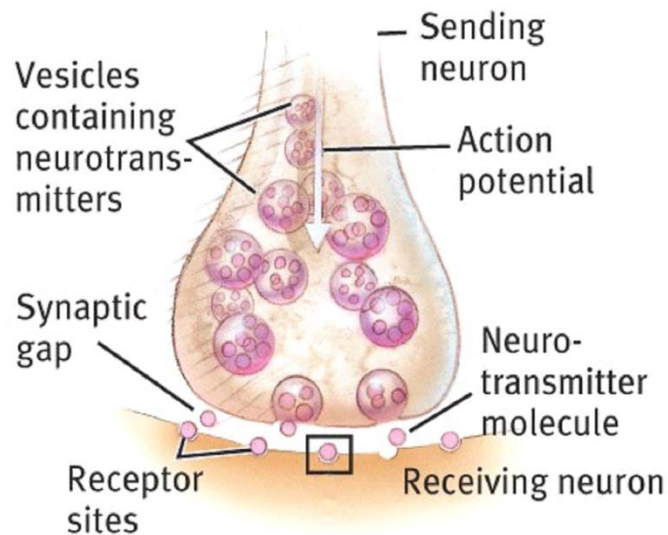


Neural Communication – Between Neurons



Lock & Key Mechanism

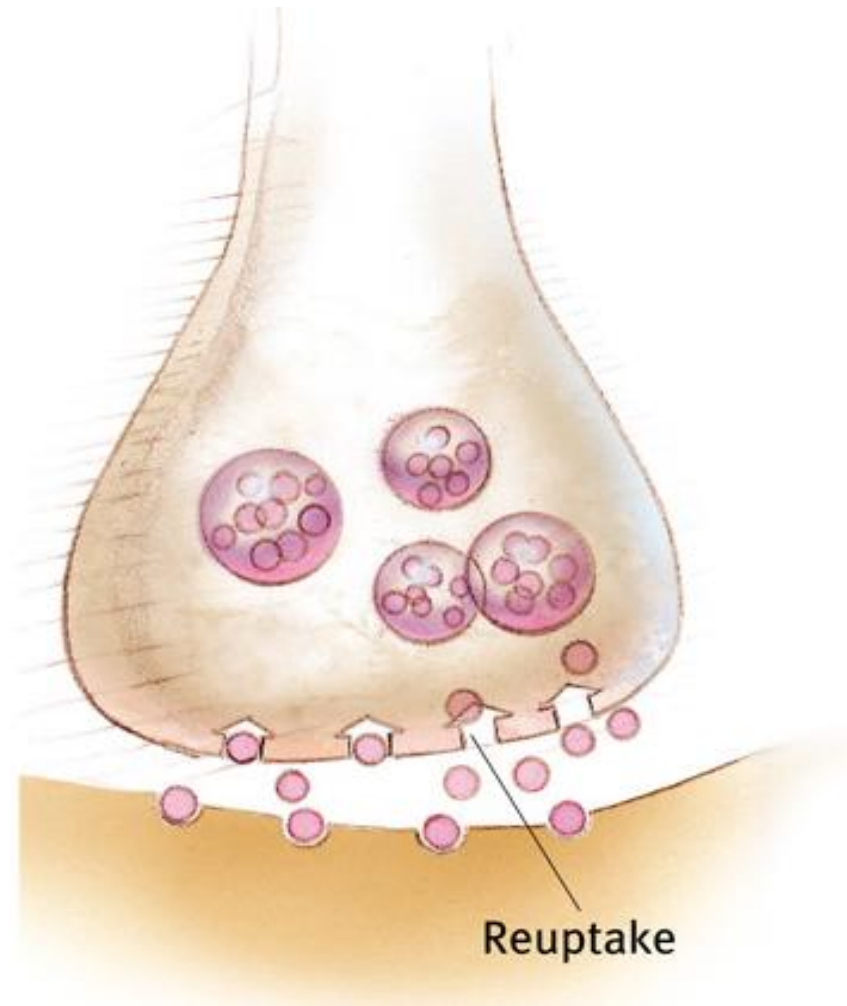
Neurotransmitters bind to the receptors of the receiving neuron in a key-lock mechanism.



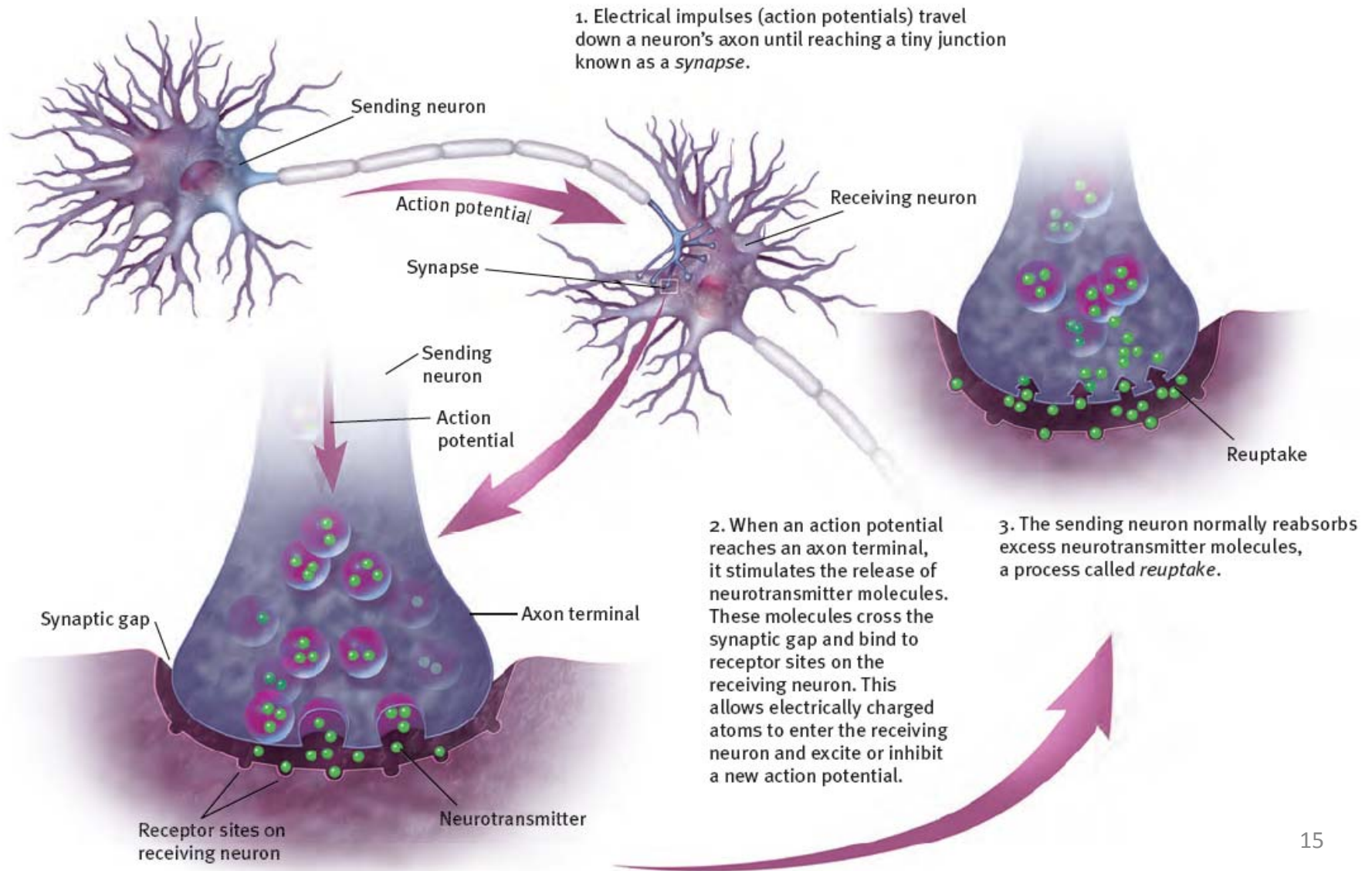
Reuptake: Recycling Neurotransmitters

Reuptake:

After the neurotransmitters stimulate the receptors on the receiving neuron, the chemicals are taken back up into the sending neuron to be used again.



Neural Communication: Seeing all the Steps Together

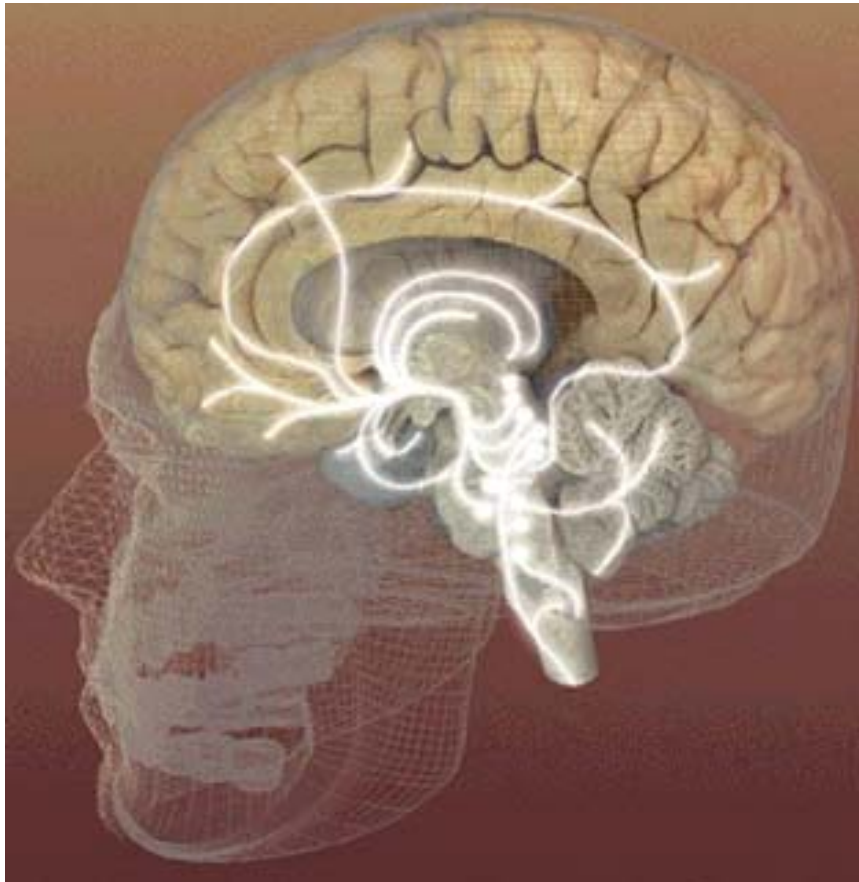


Roles of Different Neurotransmitters

Some Neurotransmitters and Their Functions		
Neurotransmitter	Function	Problems Caused by Imbalances
<i>Serotonin</i>	Affects mood, hunger, sleep, and arousal	Undersupply linked to depression; some antidepressant drugs raise serotonin levels
<i>Dopamine</i>	Influences movement, learning, attention, and emotion	Oversupply linked to schizophrenia; undersupply linked to tremors and decreased mobility in Parkinson's disease and ADHD
<i>Acetylcholine (ACh)</i>	Enables muscle action, learning, and memory	ACh-producing neurons deteriorate as Alzheimer's disease progresses
<i>Norepinephrine</i>	Helps control alertness and arousal	Undersupply can depress mood and cause ADHD-like attention problems
<i>GABA (gamma-aminobutyric acid)</i>	A major inhibitory neurotransmitter	Undersupply linked to seizures, tremors, and insomnia
<i>Glutamate</i>	A major excitatory neurotransmitter; involved in memory	Oversupply can overstimulate the brain, producing migraines or seizures; this is why some people avoid MSG (monosodium glutamate) in food

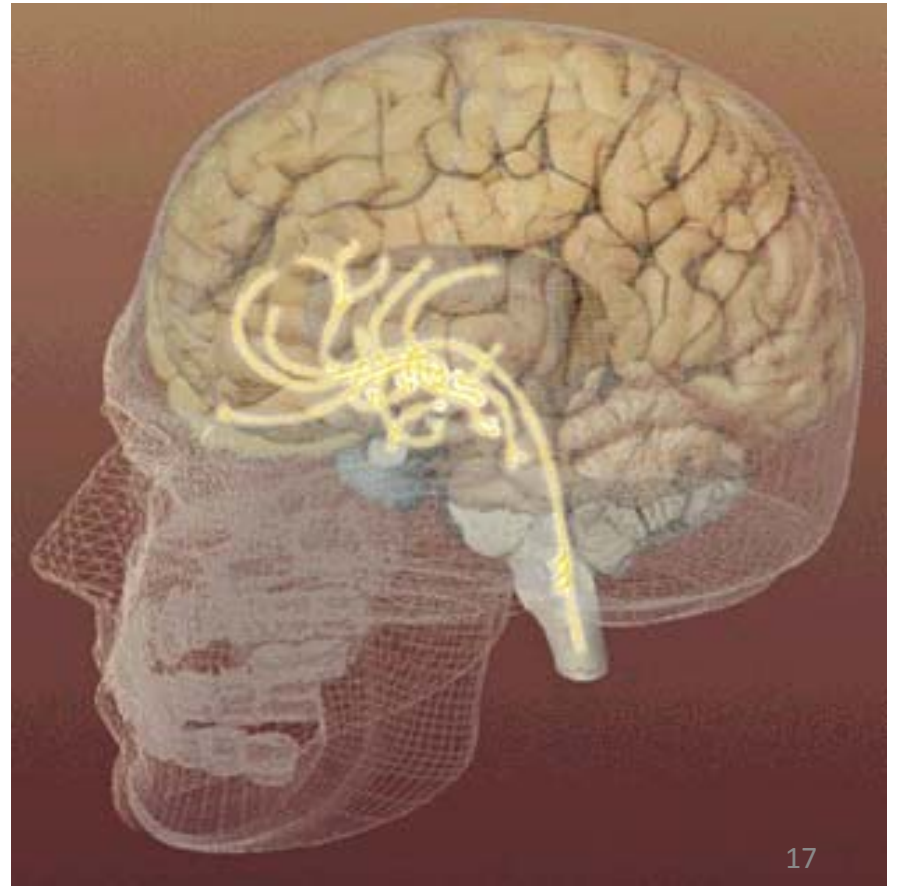
Serotonin pathways

Networks of neurons that communicate with serotonin help regulate mood.



Dopamine pathways

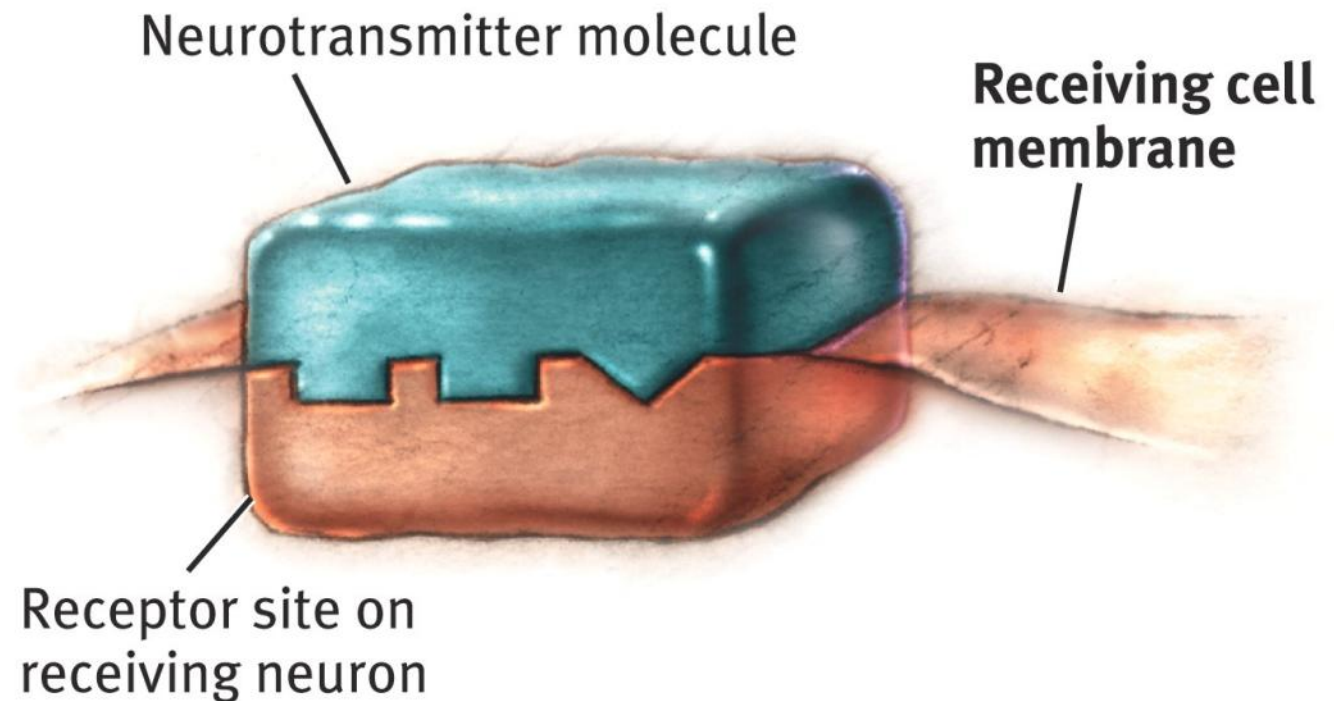
Networks of neurons that communicate with dopamine are involved in focusing attention and controlling movement.



Hearing the message

How Neurotransmitters Activate Receptors

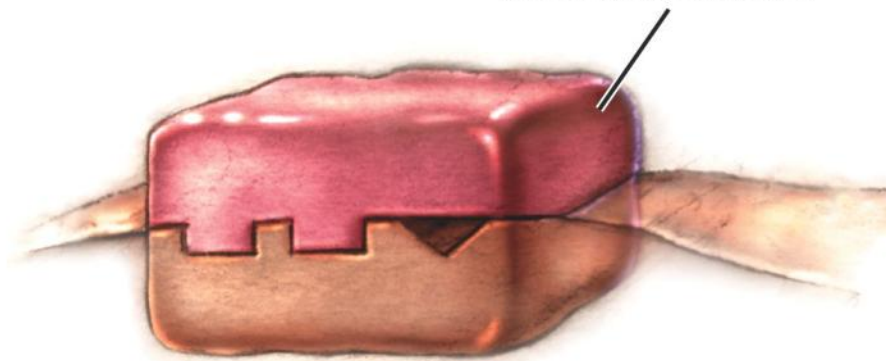
When the key fits, the site is opened.



This neurotransmitter molecule has a molecular structure that precisely fits the receptor site on the receiving neuron, much as a key fits a lock.

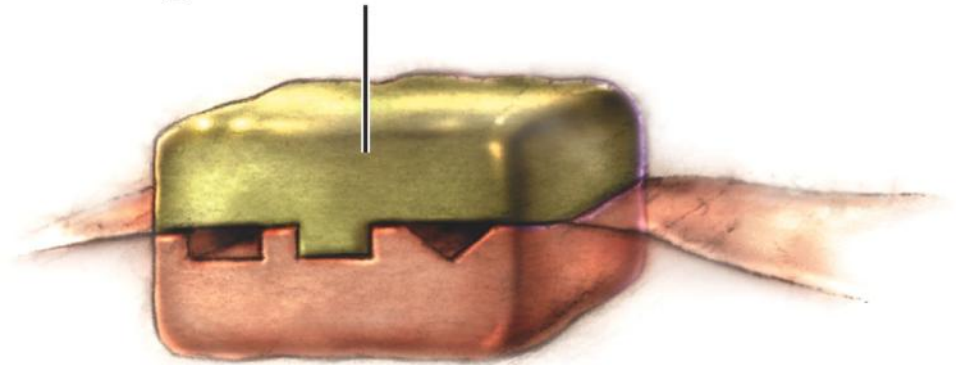
Keys that almost fit: Agonist and Antagonist Molecules

Agonist mimics neurotransmitter



An **agonist** molecule fills the receptor site and activates it, acting like the neurotransmitter. Morphine, for instance, mimics the action of endorphins by stimulating receptors in brain areas involved in mood and pain perception.

Antagonist blocks neurotransmitter

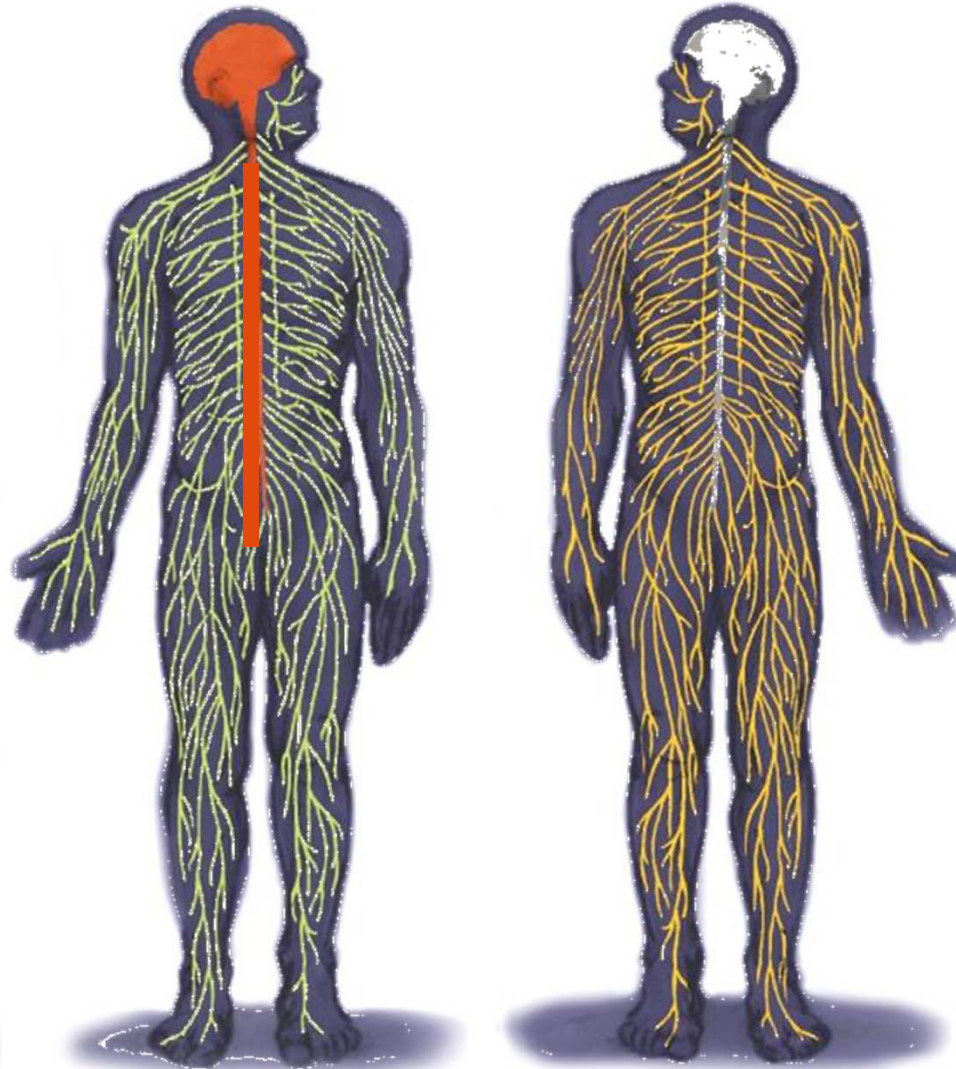


An **antagonist** molecule fills the lock so that the neurotransmitter cannot get in and activate the receptor site. Snake venom causes paralysis by blocking the acetylcholine (ACh) receptors on motor neurons.

The Inner and Outer Parts of the Nervous System

The central nervous system [CNS] consists of the brain and spinal cord.

The CNS makes decisions for the body.

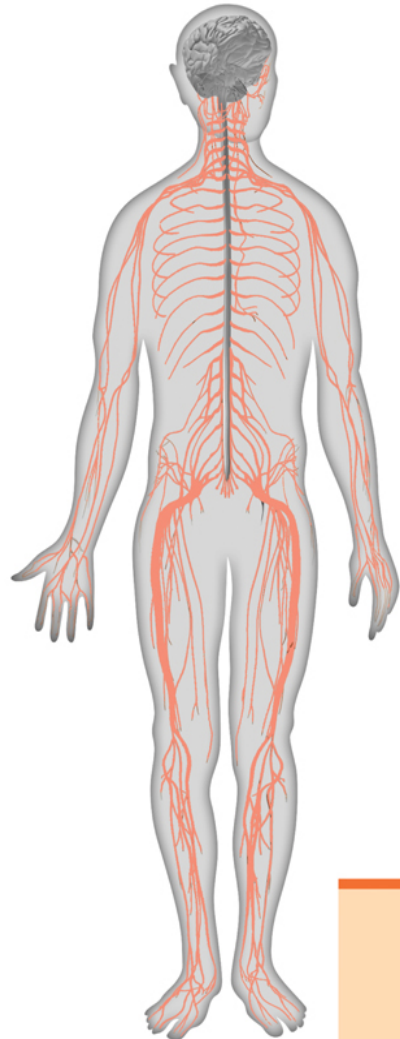


The peripheral nervous system [PNS] consists of 'the rest' of the nervous system.

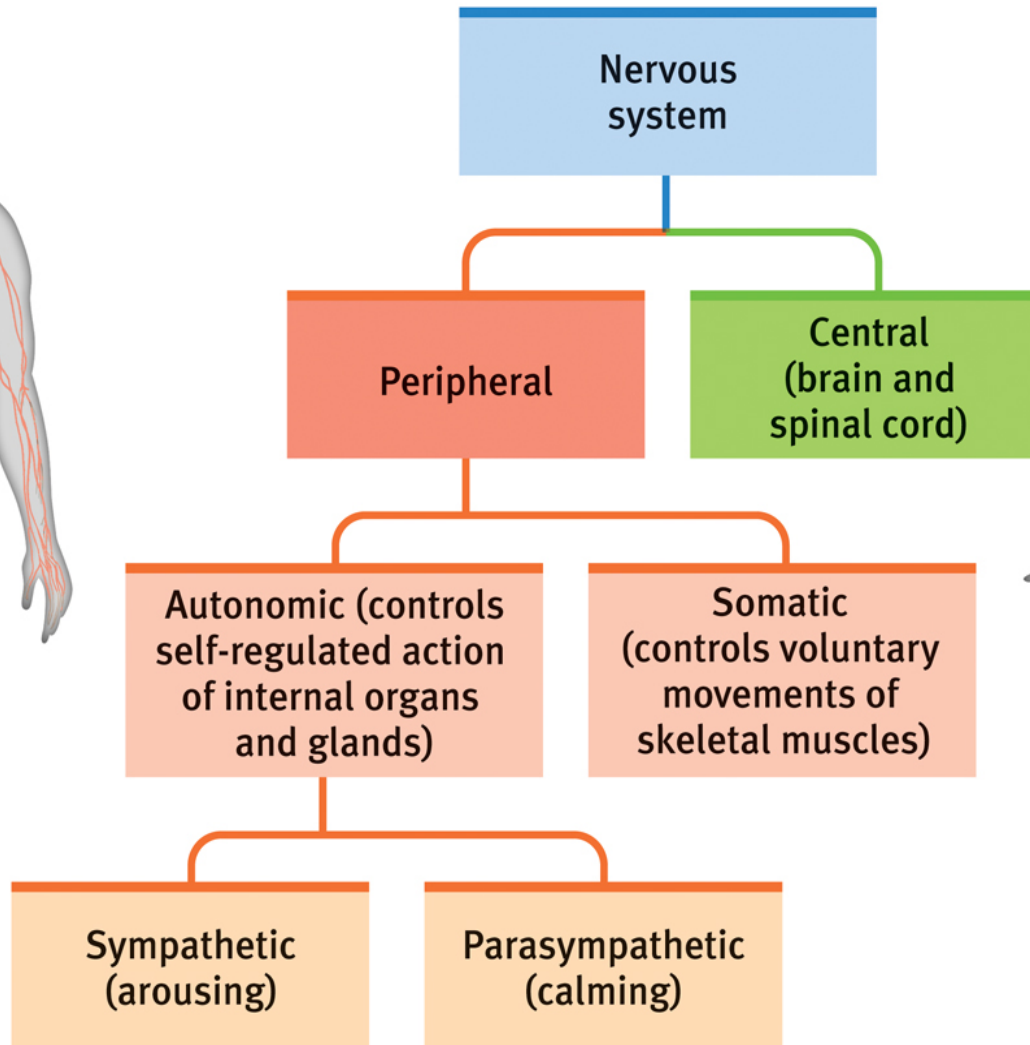
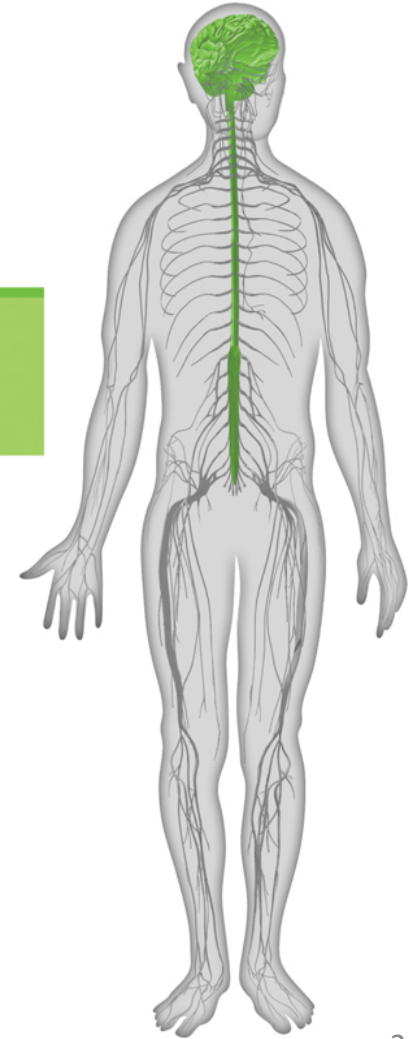
The PNS gathers and sends information to and from the rest of the body.

More Parts of the Nervous System

Peripheral nervous system



Central nervous system



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.

Autonomic Nervous System (ANS)

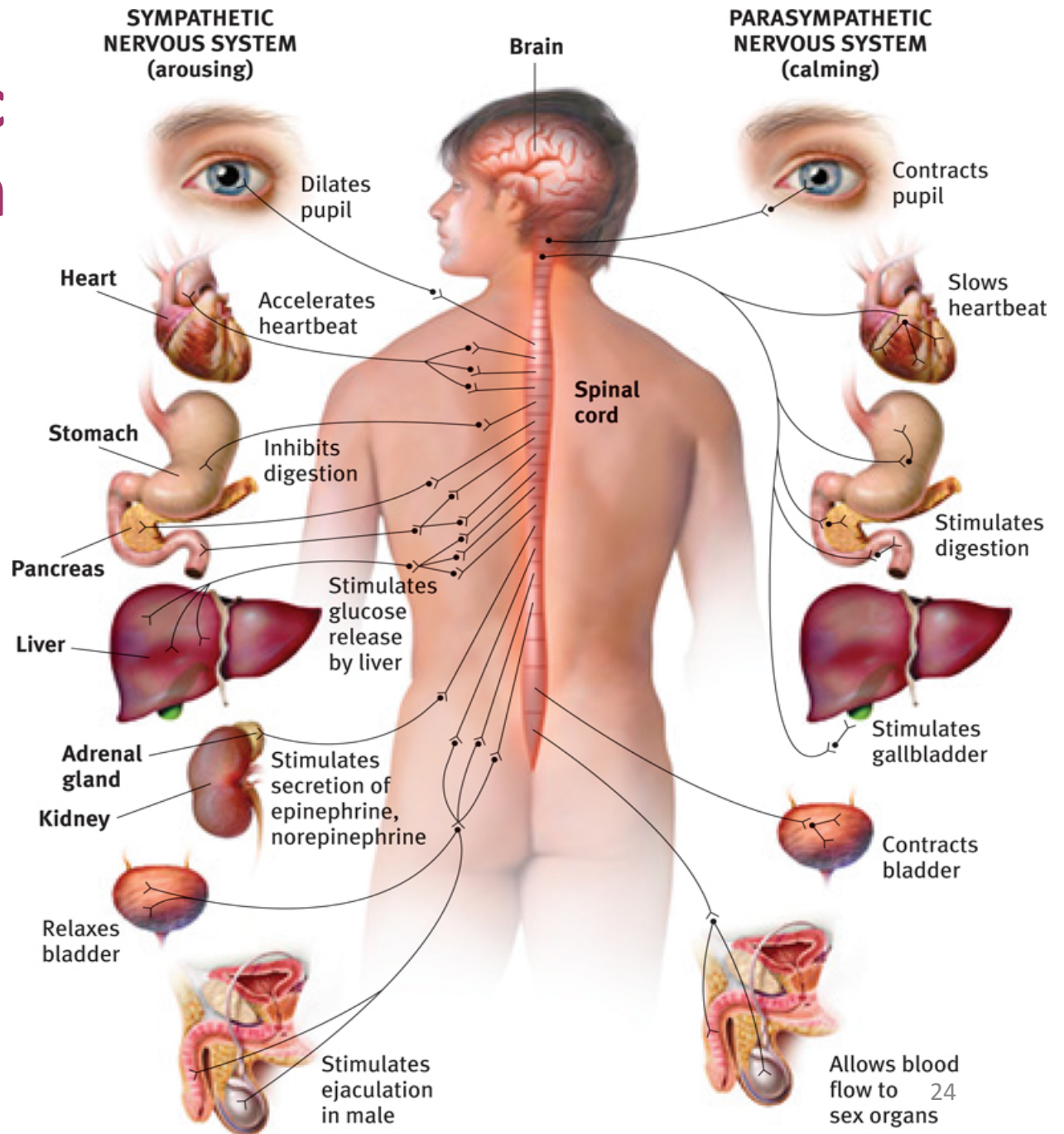
Sympathetic Nervous System: Division of the ANS that arouses the body, mobilizing its energy in stressful situations.

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

The Autonomic Nervous System

The sympathetic NS arouses (fight-or-flight)

The parasympathetic NS calms (rest and digest)



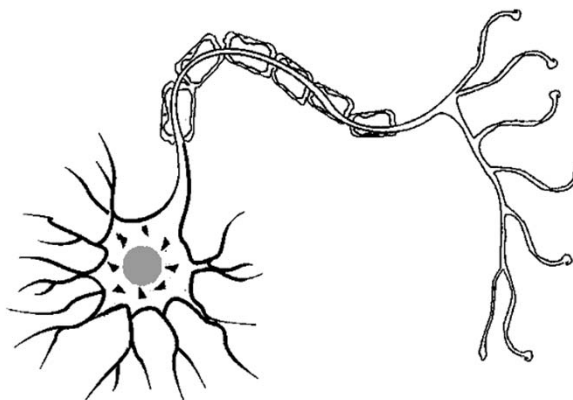
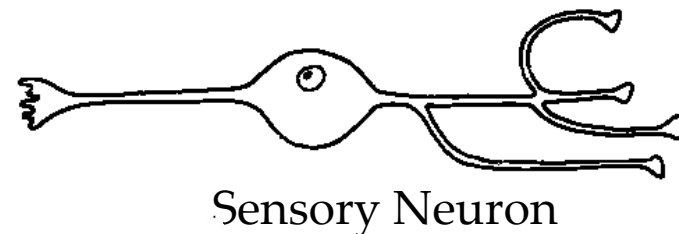
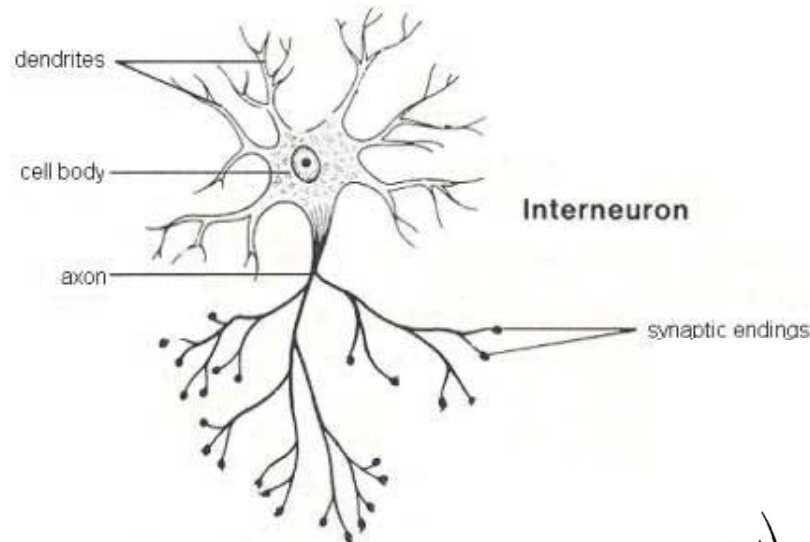
The Nerves

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.



Kinds of Neurons

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

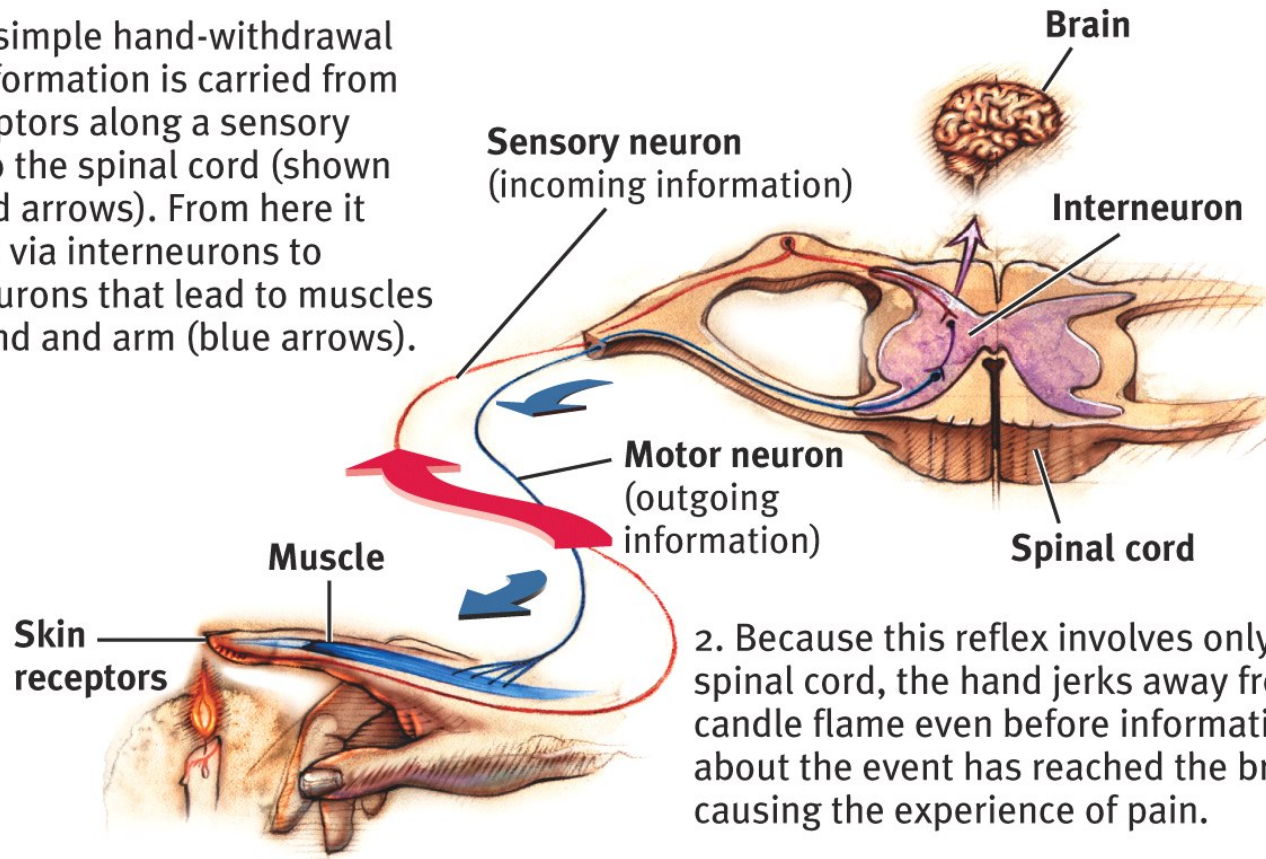


Motor Neuron

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.

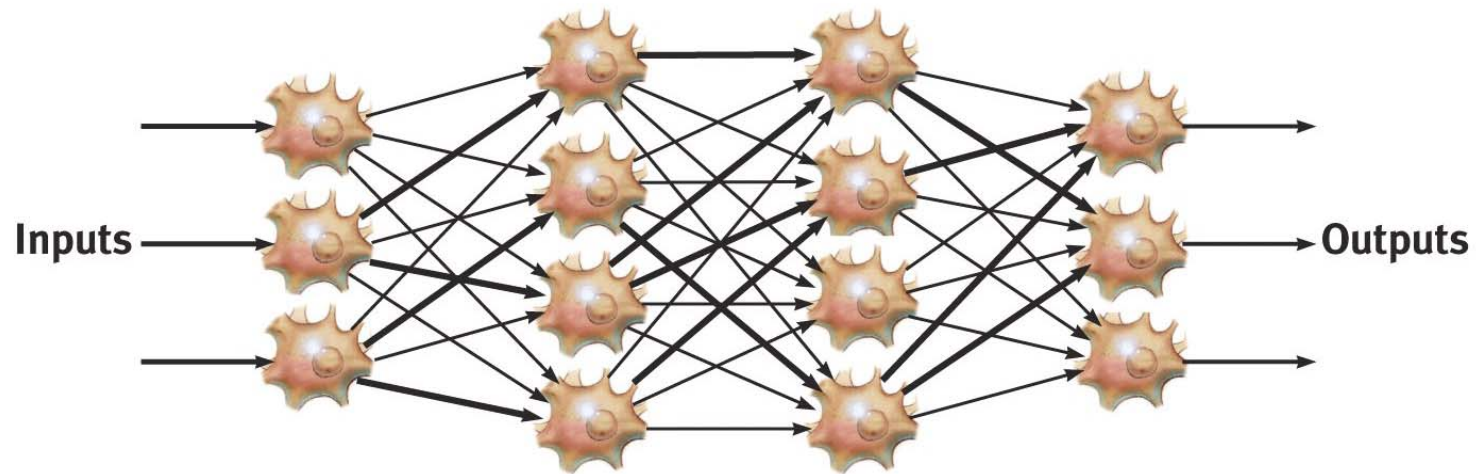


Simple Reflex

Central Nervous System

The Brain and **Neural Networks**

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

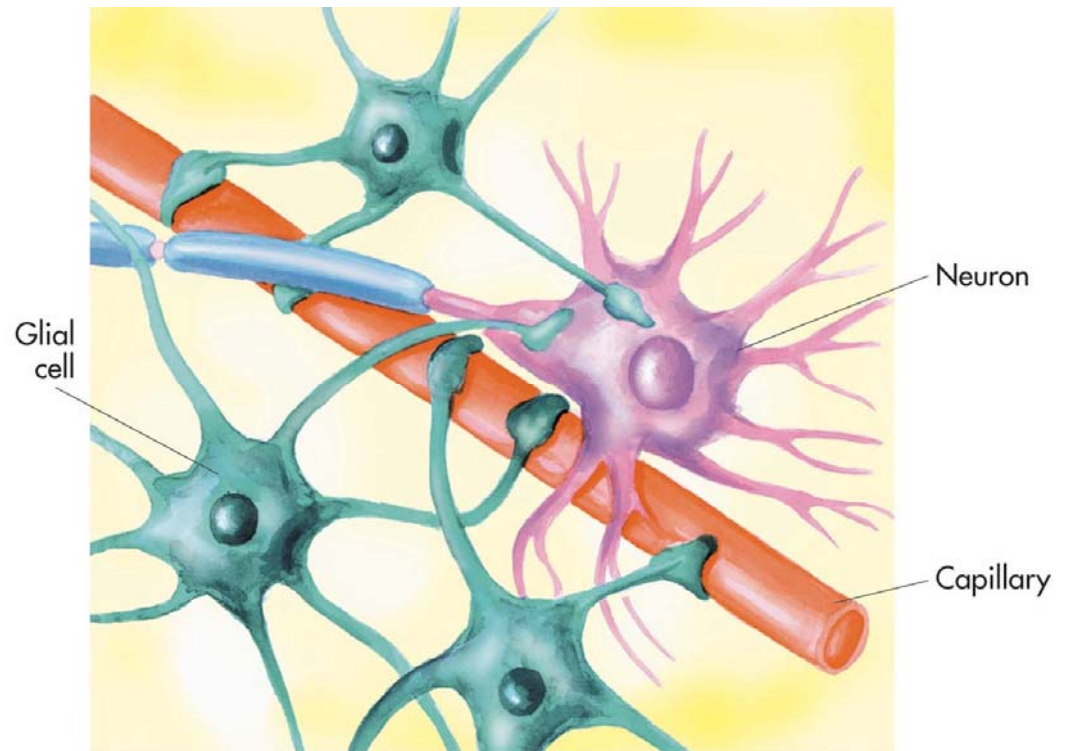


Complex Neural Network

Kinds of Glial Cells

Glial (“glue”) cells provide various types of support for neurons. Glia are much smaller than neurons, but they outnumber neurons by 10 to 1, thus accounting for over 50% of the brain’s volume. **Astrocytes** provide nutrition to neurons.

Oligodendrocytes and **Schwann** cells insulate neurons as myelin.



Astrocytes

Investigating the Brain and Mind:



How did we move beyond phrenology and get inside the skull and under the “bumps”?

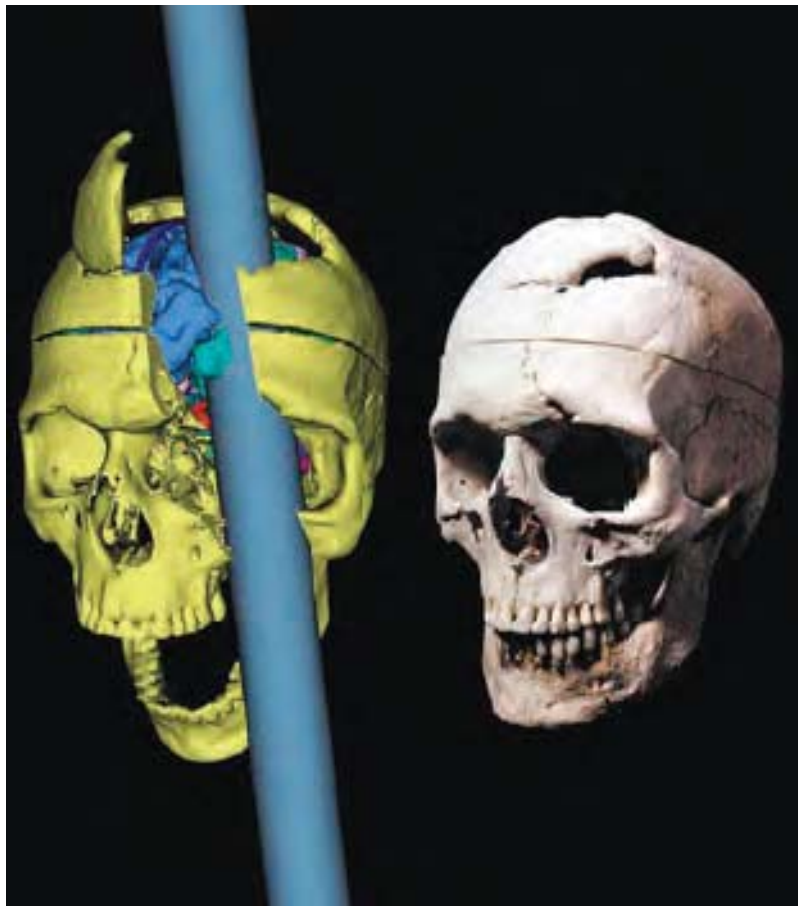
- by finding what happens when part of the brain is damaged or otherwise unable to work properly
- by looking at the structure and activity of the brain: CAT, MRI, fMRI, and PET scans

Strategies for finding out what is different about the **mind** when part of the **brain** isn't working normally:

- case studies of **accidents** (e.g. Phineas Gage)
- case studies of split-brain patients (corpus callosum cut to stop seizures)
- lesioning brain parts in animals to find out what happens
- chemically numbing, magnetically deactivating, or electrically stimulating parts of the brain

Studying cases of brain damage

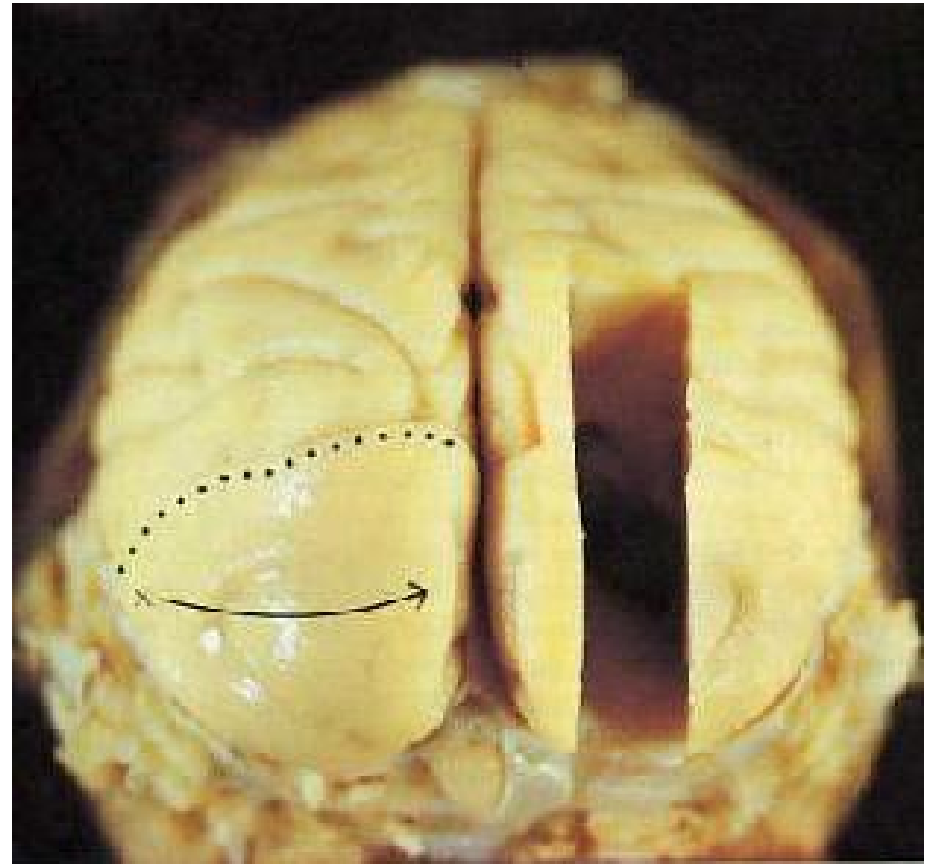
When a stroke or injury damages part of the brain, we have a chance to see the impact on the mind.



Intentional brain damage:

Lesions (surgical destruction of brain tissue)

- performed on animals
- has yielded some insights, especially about less complex brain structures
- no longer necessary, as we now can chemically or magnetically deactivate brain areas to get similar information



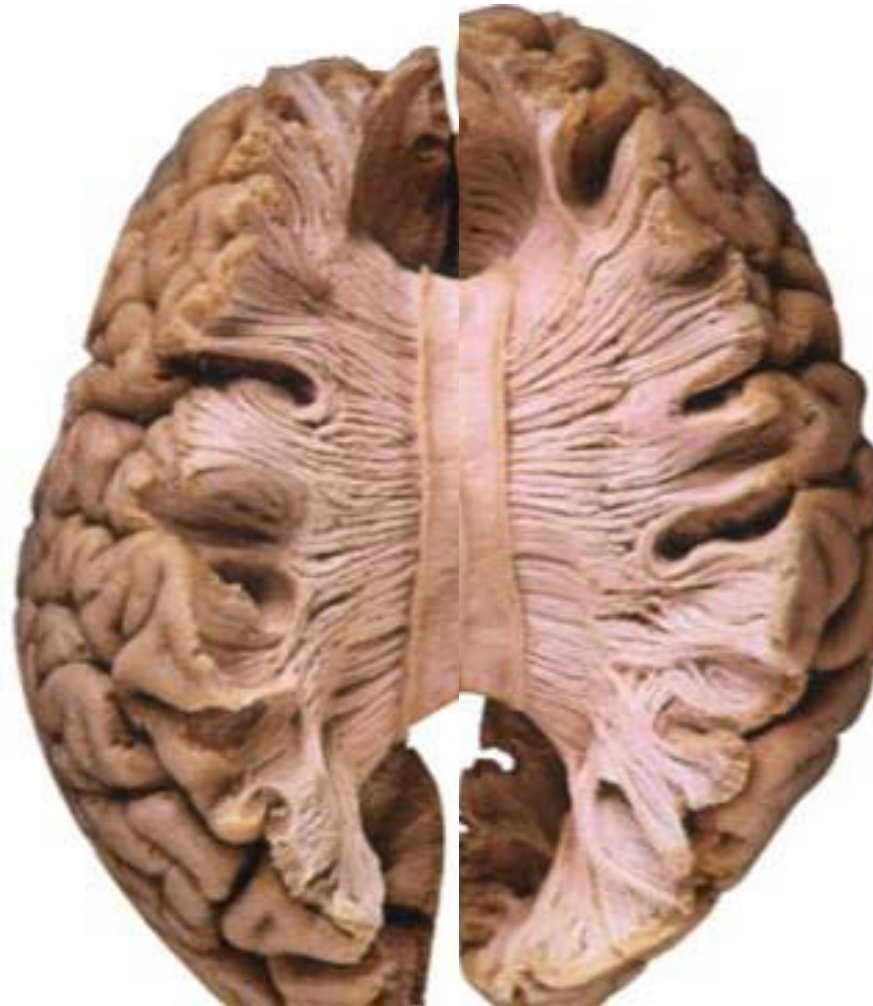
Clinical Observation

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.



Split-Brain Patients

- “Split” = surgery in which the connection between the brain hemispheres is cut in order to end severe full-brain seizures
- Study of split-brain patients has yielded insights discussed at the end of the chapter

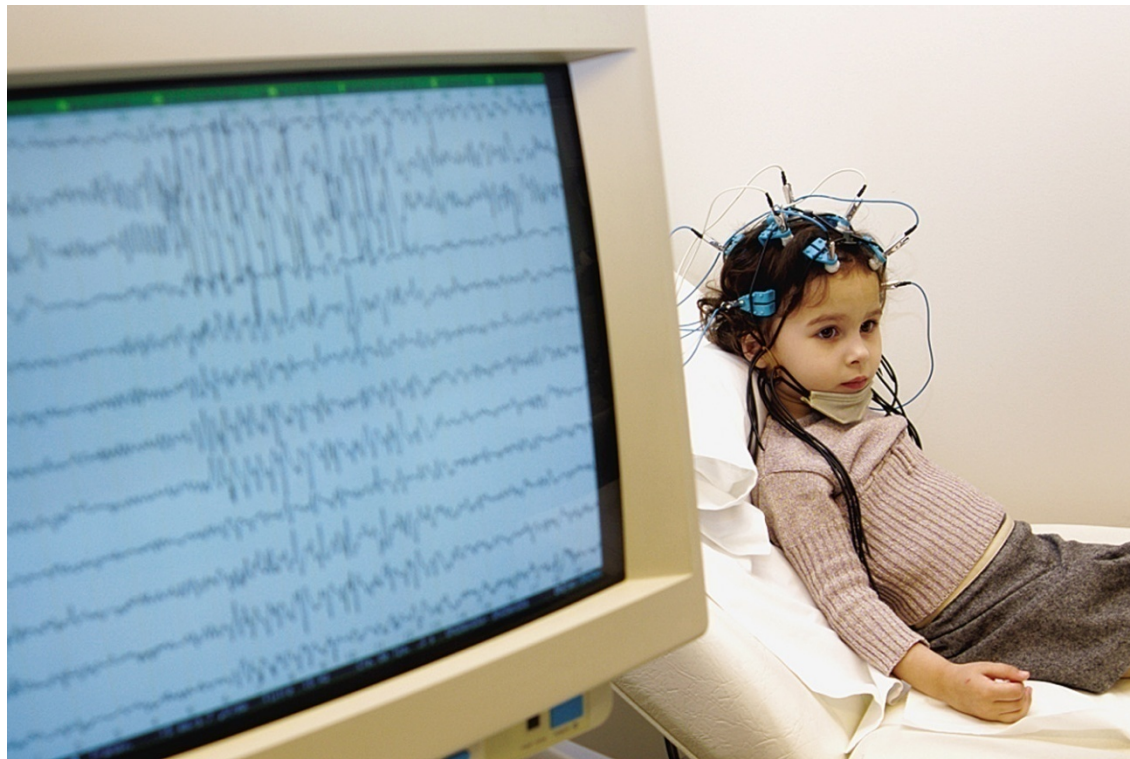


We can stimulate parts of the brain to see what happens

- Parts of the brain, and even neurons, can be stimulated electrically, chemically, or magnetically.
- This can result in behaviors such as giggling, head turning, or simulated vivid recall.
- Researchers can see which neurons or neural networks fire in conjunction with certain mental experiences, and even specific concepts.

Electroencephalogram (EEG)

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

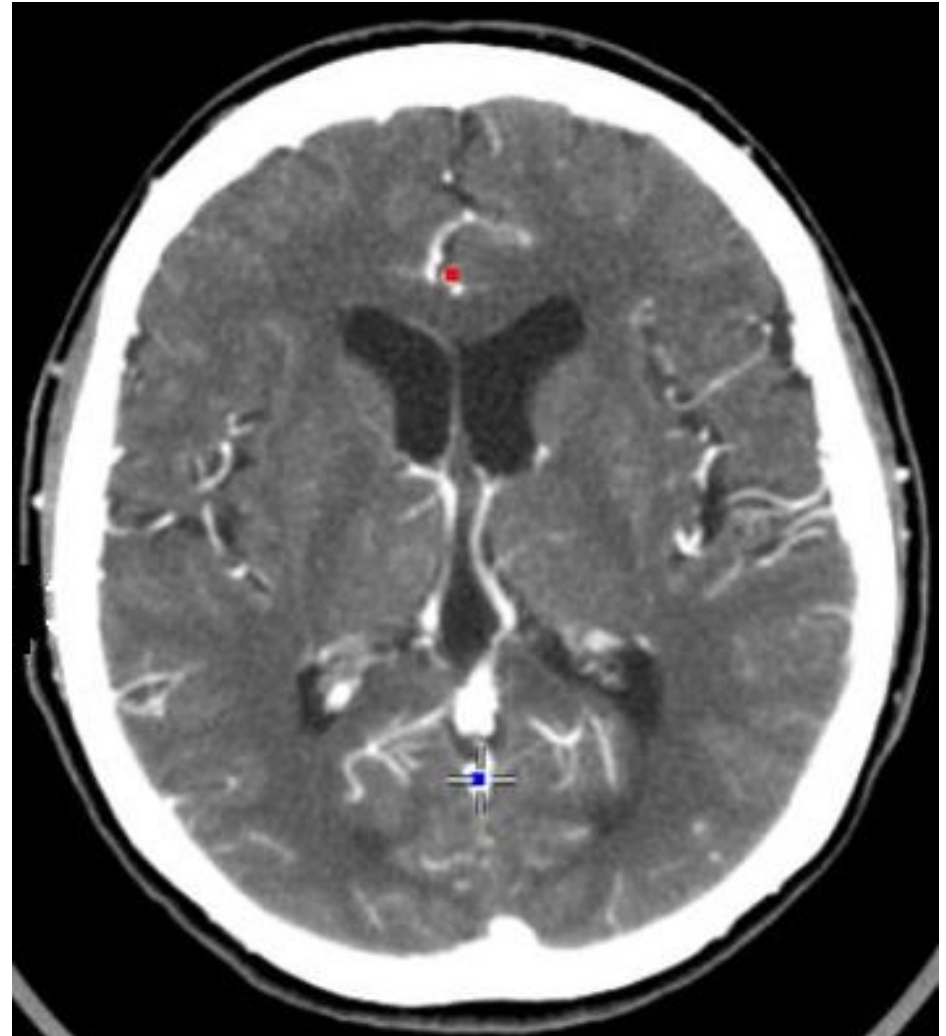


AJ Photo/ Photo Researchers, Inc.

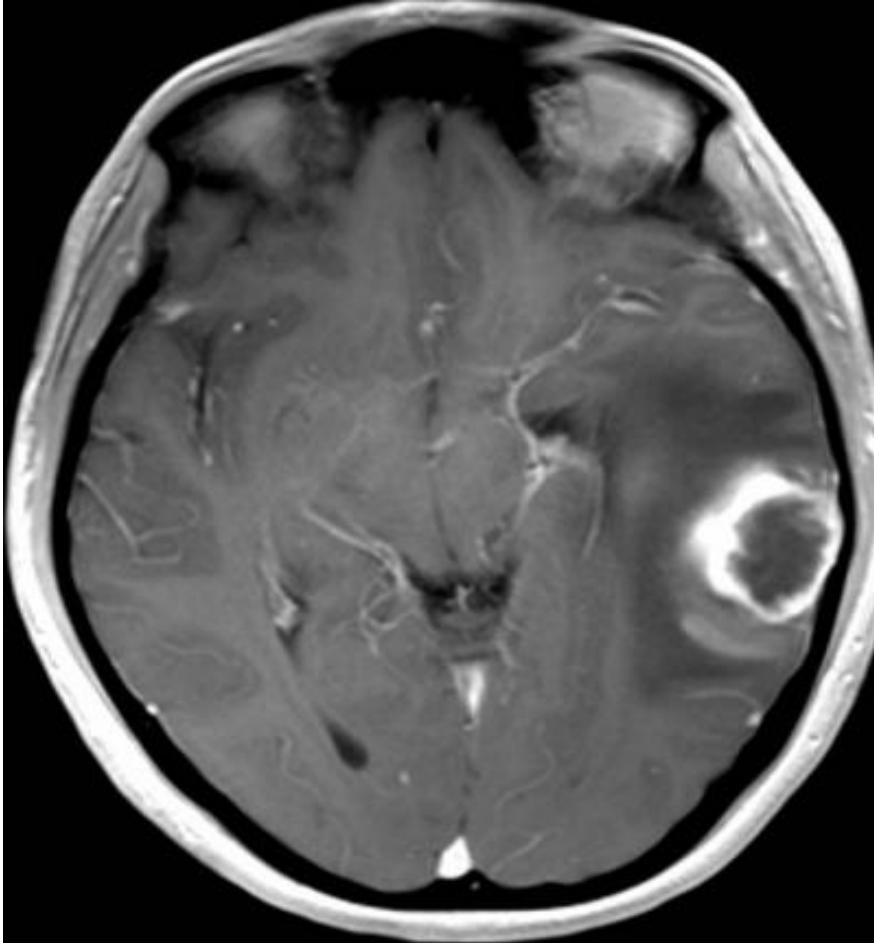
CAT Scan

A computerized axial tomography scan is an x-ray procedure that combines many x-ray images with the aid of a computer to generate cross-sectional views and, if needed, three-dimensional images of the internal organs and structures of the body.

Computerized axial tomography is more commonly known by its abbreviated names, CT scan or CAT scan. A CT scan is used to define normal and abnormal structures in the body and/or assist in procedures by helping to accurately guide the placement of instruments or treatments.



Abnormal CAT Scans



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.

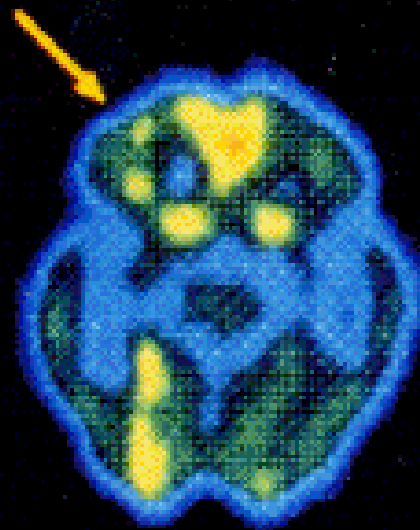


Courtesy of National Brookhaven National Laboratories

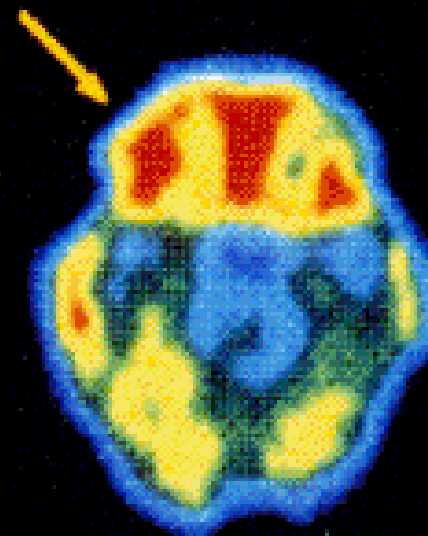
PET Scan

Obsessive Compulsive Disorder

High Orbital Glucose Metabolism



Normal
Control

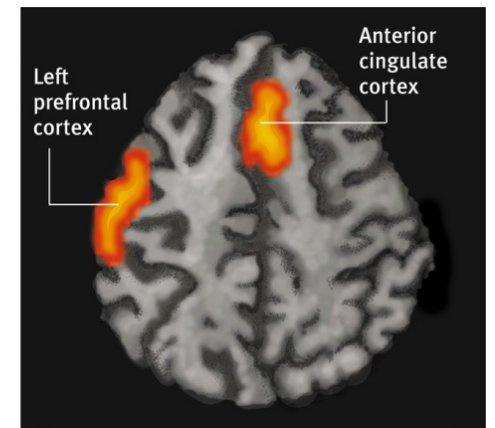


Obsessive
Compulsive

54.3
52.0
49.6
47.2
44.9
42.5
40.2
37.8
35.4
33.1
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28.3
26.0
23.6
21.3
18.9
16.5
14.2
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MRI Scan

MRI (magnetic resonance imaging) and fMRI use 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 participant lies.



MRI Scan

How MRI Works ©2008 HowStuffWorks

1 Atoms spin in random directions, like tops, around their individual magnetic fields.

2 In magnetic field produced by MRI, atoms line up either north or south.

About half the atoms go each way, but there are a few unmatched atoms.

3 When radio frequency pulse is applied, the unmatched atoms spin the other way.

4 When the radio frequency is turned off, the extra atoms return to normal position, emitting energy.

5 The energy sends a signal to a computer. The computer uses a mathematical formula to convert the signal into an image.