I. Biological Psychology and Neurotransmission

Objectives:

- Explain why psychologists are concerned with human biology.
- Describe the parts of a neuron, and explain how its impulses are generated.
- Describe how nerve cells communicate with other nerve cells.
- Describe how neurotransmitters influence behavior, and explain how drugs and other chemicals affect neurotransmission

Everything psychological is simultaneously biological!

Why are psychologists interested in studying the biology of the brain?!

- Our every idea, mood or urge is a biological happening!
- Without our brain and body, we are nobody!
- *Biological Psychologists* study the links between biological activity and psychological events.

History: Brain and the mind has come a long way. Remember Plato and Aristotle?

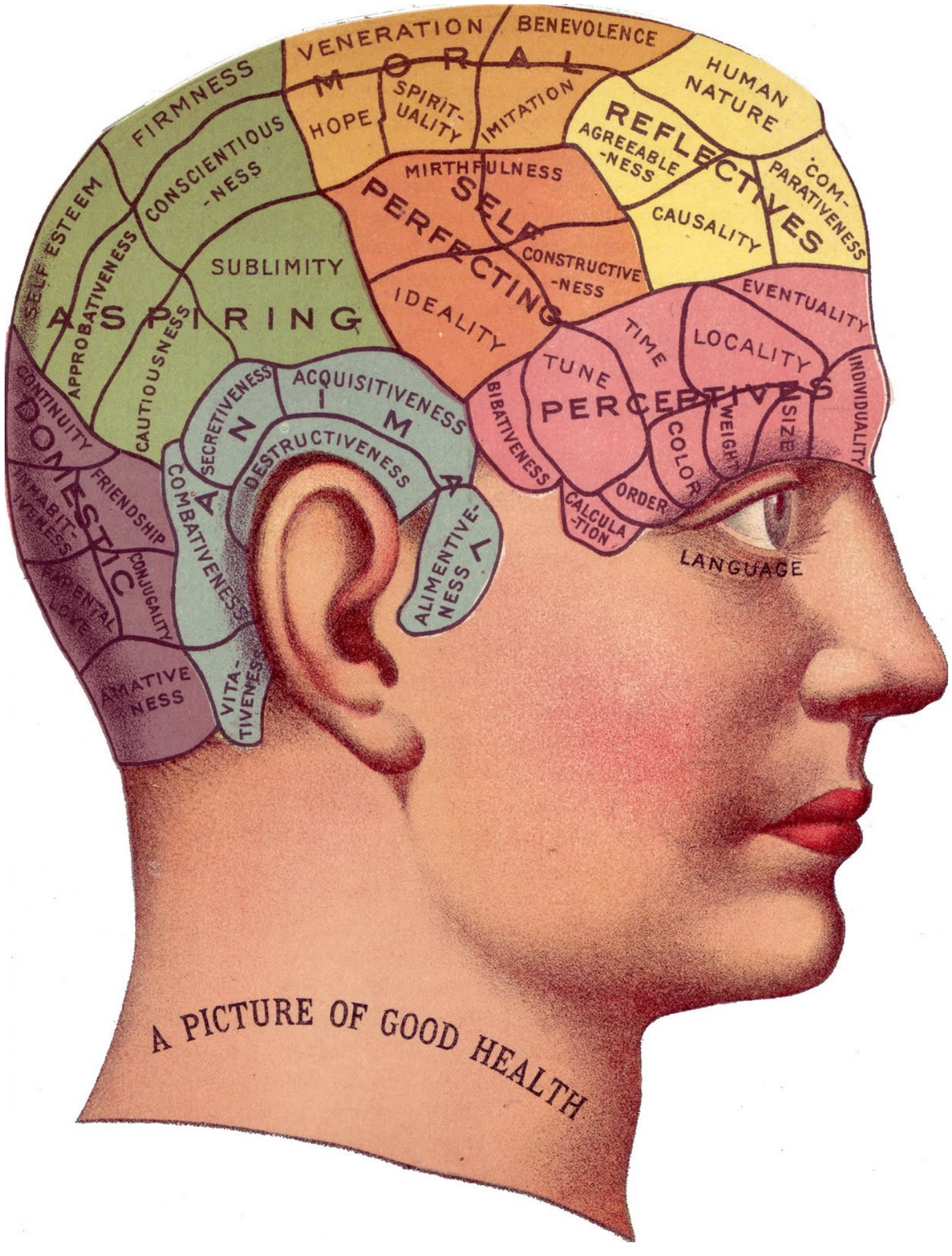
Phrenology (study of the surface of the skull)

Invented by Franz Gall in the early 1800's.

- A theory that claimed that bumps on the skull could reveal our mental abilities and character traits.

- Theory was disproved.

- ★ However, *phrenology* focused the attention that various regions of the brain have particular, specific functions.



A PICTURE OF GOOD HEALTH

Neuron

Appreciate the Neuron!

Neuron: a nerve cell

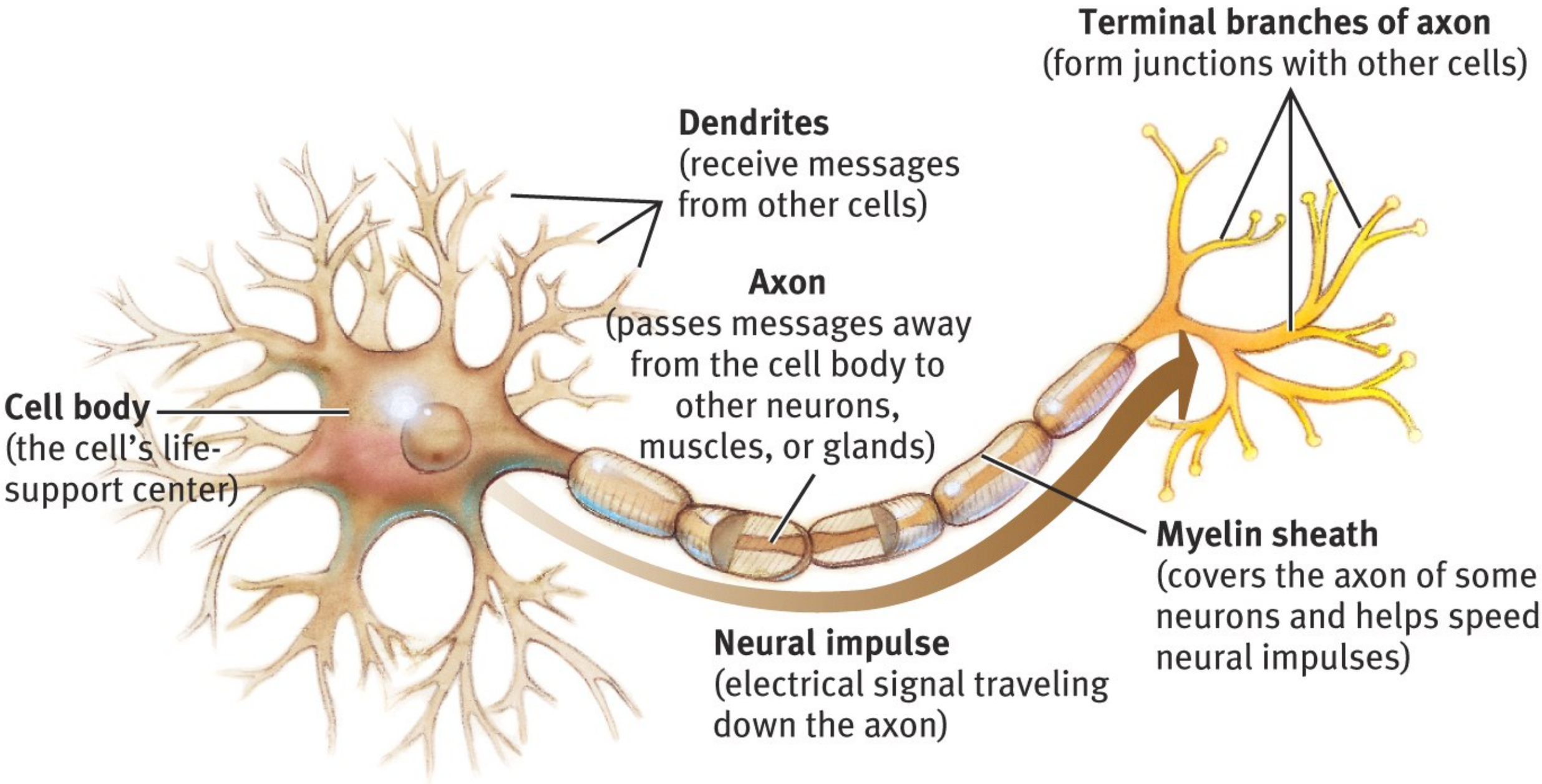
- the basic building block of the nervous system

- our bodies information system is built from 100 billion of interconnected cells called neurons.

- many different types of neurons, but all are composed in the same way.

- ⭐ **Glial Cells:** cells in the nervous system that support, nourish, and protect neurons

Structure of a Neuron



Parts of a Neuron

"The Hardware"

A. Dendrites (Greek for tree)

- The bushy, branching extensions of a neuron that receive messages (pressure, light, sound) and conduct impulses toward the cell body.
- They **receive** information from other nerve cells and send it through the **soma** or cell body.

B. Soma (cell body)

- Stimulus such as sound or pinprick make the soma excited.
- When the arousal reaches a critical level, it will fire.

Parts of a Neuron

"The Hardware"

C. Axons (Greek for axle)

- The extension of a neuron, (long fiber) ending in branching terminal fibers, through which messages are sent to other neurons or to muscles or glands. At the end of the axon are thousands of terminal buttons.

D. Terminal buttons

- Secrete neurotransmitters

Parts of a Neuron

"The Hardware"

E. Synapse

- Junction where information is transmitted.
- The microscopic ***space*** between the axon tip of the sending neuron and the dendrite of the receiving neuron
- Tiny gap at this junction is called the synaptic gap or cleft

"Like elegant ladies air-kissing so as not to mess their makeup, dendrites and axons don't quite touch." - Poet Diane Ackerman (air kisses)

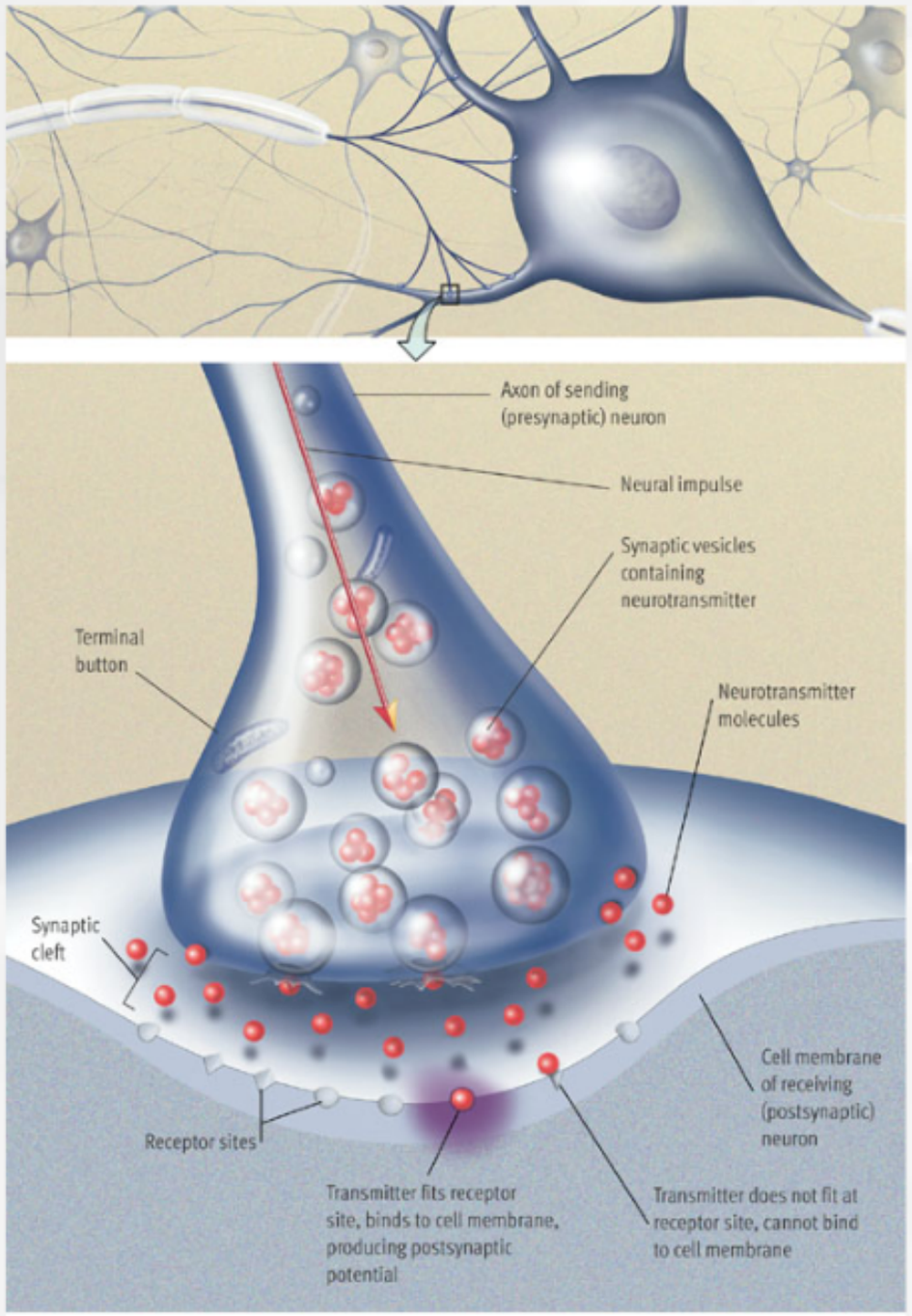


Figure 3.3 The synapse. When a neural impulse reaches an axon's terminal buttons, it triggers the release of chemical messengers called neurotransmitters. The neurotransmitter molecules diffuse across the synaptic cleft and bind to receptor sites on the postsynaptic neuron. A specific neurotransmitter can bind only to receptor sites that its molecular structure will fit into, much like a key must fit a lock.

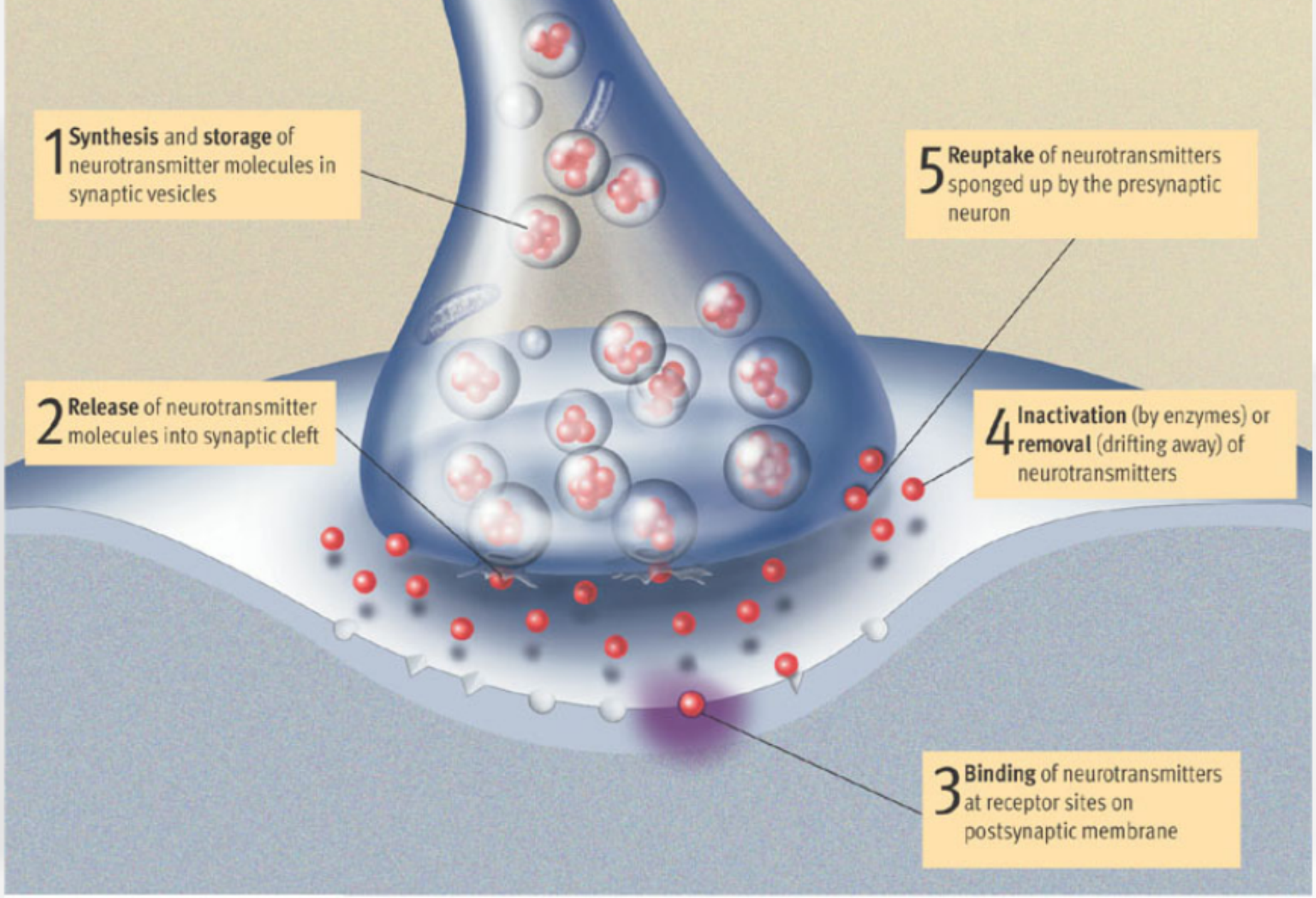


Figure 3.4 Overview of synaptic transmission. The main elements in synaptic transmission are summarized here, superimposed on a blowup of the synapse seen in Figure 3.3. The five key processes involved in communication at synapses are (1) synthesis and storage, (2) release, (3) binding, (4) inactivation or removal, and (5) reuptake of neurotransmitters. As you'll see in this chapter and the remainder of the book, the effects of many phenomena—such as pain, drug use, and some diseases—can be explained in terms of how they alter one or more of these processes (usually at synapses releasing a specific neurotransmitter).

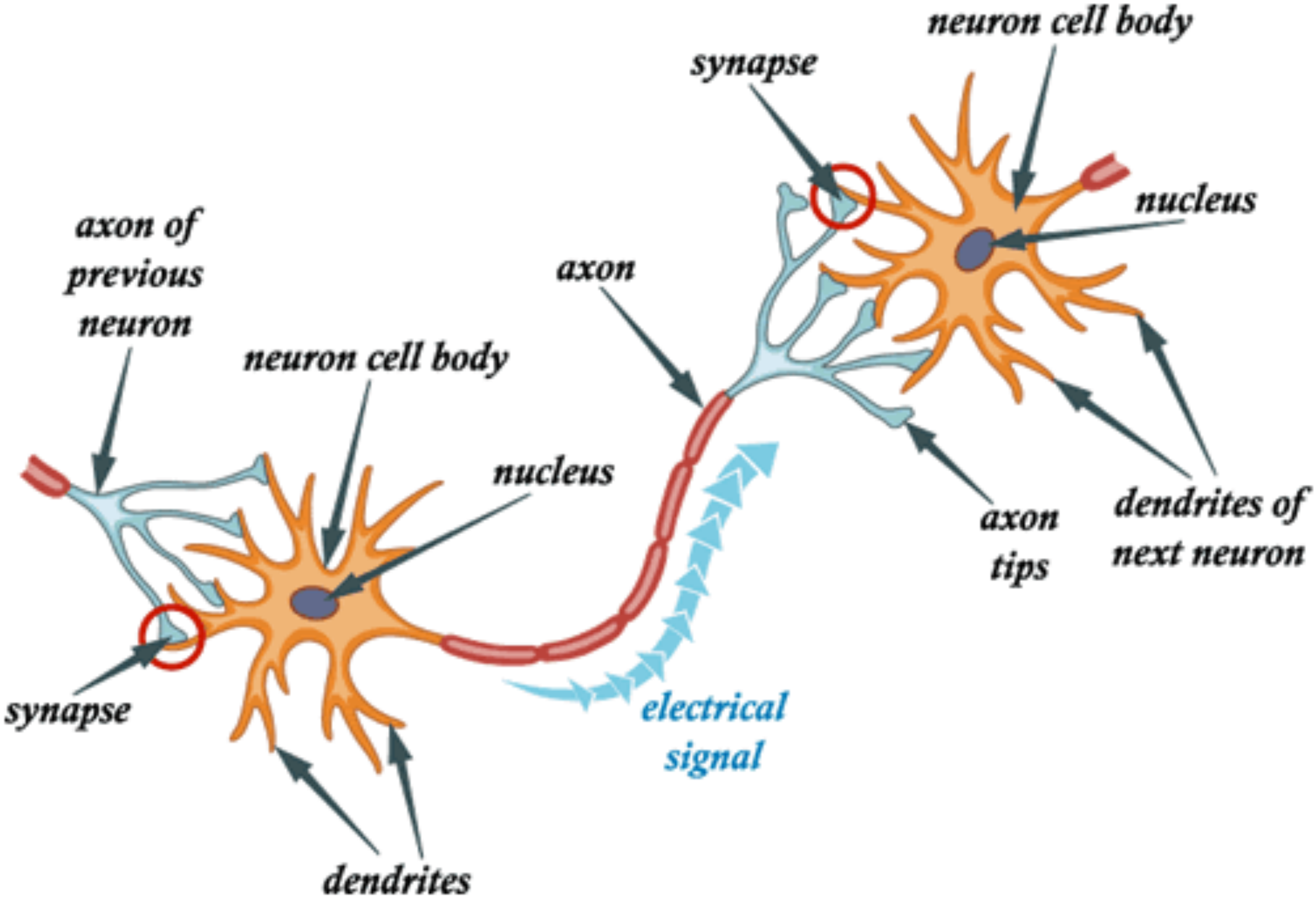
Parts of a Neuron

"The Hardware"

F. Myelin [MY-uh-lin] Sheath

- A layer of fatty cells segmentally encasing the fibers of many neurons (insulating the axons); enables vastly **greater transmission speed** of neural impulses. Formed by Glial cells.

  - ⭐ Multiple Sclerosis, a disease in which the **myelin sheath degenerates**, which results in a slowing of communication to the muscles and loss of muscle control.


axon of previous neuron
neuron cell body
synapse
neuron cell body
axon
nucleus
nucleus
synapse
electrical signal
dendrites
axon tips
dendrites of next neuron

Action Potential

"I sing the body electric." - Walt Whitman

Axons get its electrical energy from charged chemicals, called ions.

Action Potential (general idea)

- A brief electrical charge that travels down an axon, each tripping the next.
- Generated by the movement of *positively charged ions* (electrically charged atoms) in and out of channels in the axon's membrane.
- Fluid outside cell membrane: *positively charged ions*.
- Fluid inside cell membrane: *negatively charged ions*.

Action Potential

"What one neuron tells another neuron is simply how much it is excited!" -Francis Crick

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A. **Resting Potential**- In its resting state, the axons interior (insides) consist of negative potassium ions while the fluid outside the membrane consists of positive sodium ions.

- Positive Sodium (PS)- outside membrane
- Negative Potassium (NP)-inside state

B. **Action Potential**- When the cell body becomes **excited** it fires OR triggers a neural impulse. During an action potential, sodium gates in the neuron open and sodium ions enter the axon bringing a positive charge with them. If it has enough of a positive charge, the neuron will fire.

Action Potential

A neural impulse; a brief electrical charge that travels down an axon.

C. **Sodium/Potassium Pump**- As sodium ions are being pumped in along the axon, a pump in the cell membrane (sodium/potassium pump) transports the sodium ions back to the cell when the action potential is over.

D. **Refractory Period**- Momentary delay where the neuron pumps the positively charged sodium ions back outside. As the action potential continues speedily down the axon, the first section has now completely recharged.

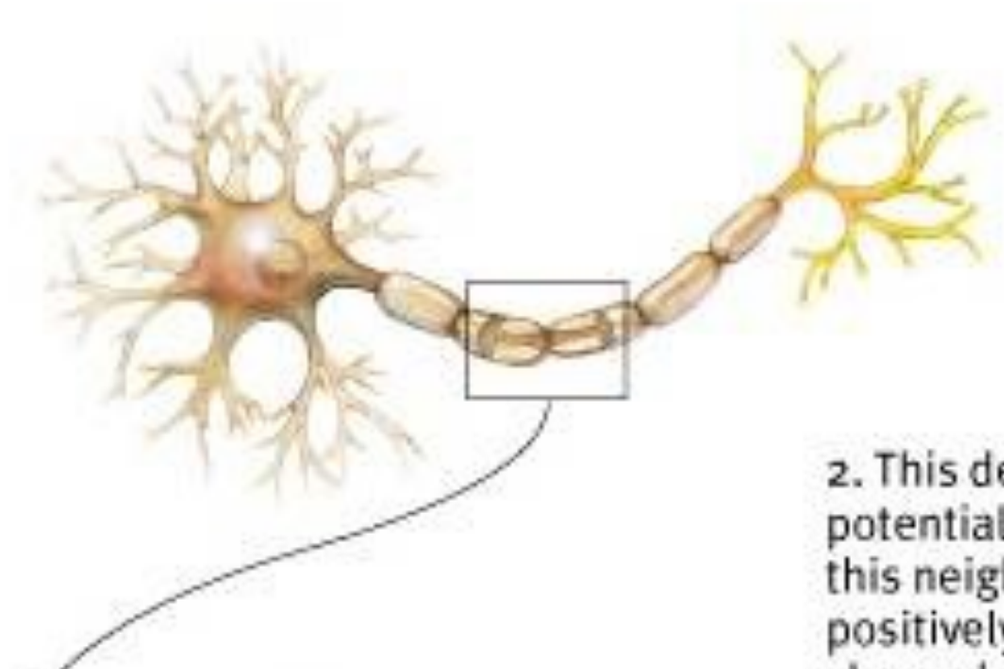
Action Potential

Other terms connected to: Action Potential

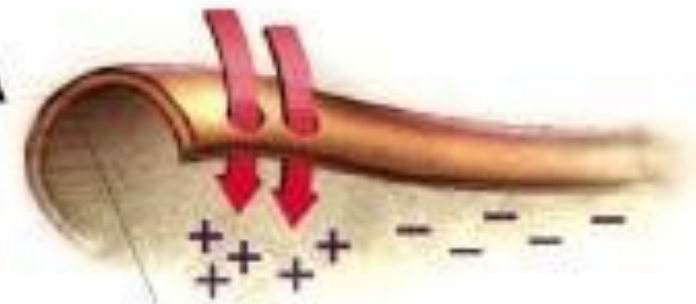
- **Excitatory** neurotransmitters: signal to send the message (accelerator)
- **Inhibitory** neurotransmitters: signal to stop the message (brake)
- **Threshold**: the level of stimulation required to trigger a neural impulse.

EX: If *excitatory* signals exceed *inhibitory* signals..it triggers an AP. Increasing the level of stimulation ABOVE threshold will not increase impulses intensity. **(all-or-none response)**

Action Potential (step by step)

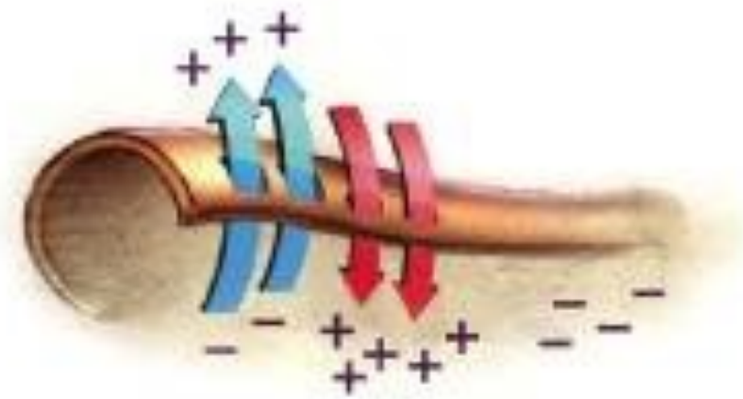


2. This depolarization produces another action potential a little farther along the axon. Gates in this neighboring area now open, and more positively charged atoms rush in, while the positively charged atoms in the previous section of axon exit.



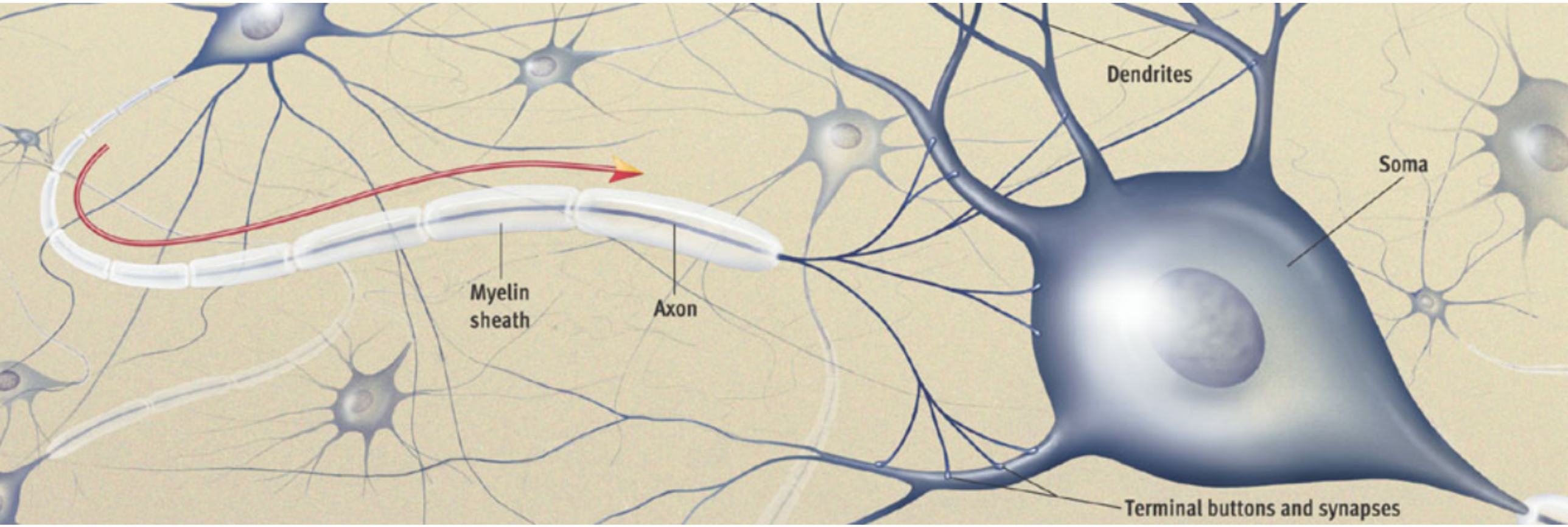
Cell body end of axon

1. Neuron stimulation causes a brief change in electrical charge. If strong enough, this produces depolarization and an action potential.



3. As the action potential continues speedily down the axon, the first section has now completely recharged.

Direction of neural impulse: toward axon terminals



Neural communication

How Neurons Communicate

How do nerve cells communicate with other nerve cells?

Action Potential

Terminal Buttons

Vesicles

- The area where the axon ends, in the terminal buttons, just before the synapse.
- Small containers that look like bubbles. Inside these vesicles are thousands of chemical messengers called *neurotransmitters*.

How Neurons Communicate

Synapse (junction point)

- The terminal buttons, synaptic vesicles containing neurotransmitters are spilled into the synapse. From there if a certain transmitter is the right shape, it will fit in the receptor site of a dendrite sort of like a key into a lock. Neurotransmitters that do not fit are reabsorbed or broken down in a process called ***reuptake***.

How Neurons Communicate

Neurotransmitters

Figure 9.5 NT pathway

- *Chemical messengers* that relay neural messages across the synapse.
- When released by the sending neuron, neurotransmitters travel across the synapse and bind to receptor sites on the receiving neuron, thereby influencing whether it will generate a neural impulse.
- If the message is for arm movement, the vesicles only release neurotransmitters involved in the movement circuit.
- Neurotransmitters influence our motions and our emotions. Excess or deficiencies are linked to psychological disorders.

Examples of Neurotransmitters

Neurotransmitters are produced inside the body. They can excite and inhibit neural communication.

TABLE 2.1

SOME NEUROTRANSMITTERS AND THEIR FUNCTIONS

Neurotransmitter	Function	Examples of Malfunctions
Acetylcholine (ACh)	Enables muscle action, learning, and memory	Undersupply, as ACh-producing neurons deteriorate, marks Alzheimer's disease
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)

Examples of Neurotransmitters

Acetylcholine [ah-seat-el-KO-leen] (ACh)

- Most common, best understood
- A neurotransmitter that, among its functions, triggers muscle contraction
- Involved in memory (a shortage of ACh causes Alzheimer's Disease)

Endorphins [en-DOR-fins]

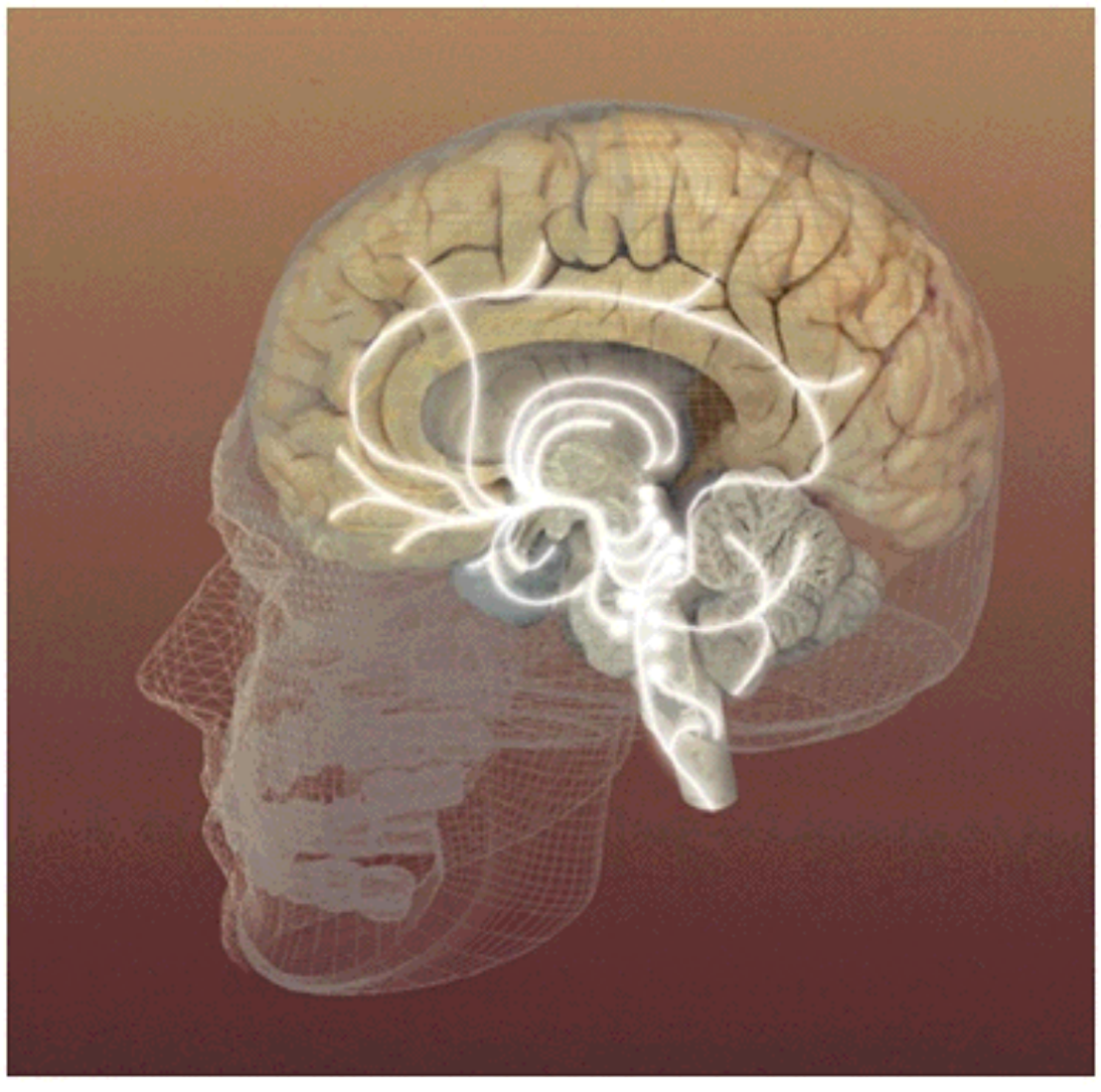
-"morphine within" bodies natural painkiller
- Natural, opiate like neurotransmitters
- Linked to pain control and to pleasure

Dopamine

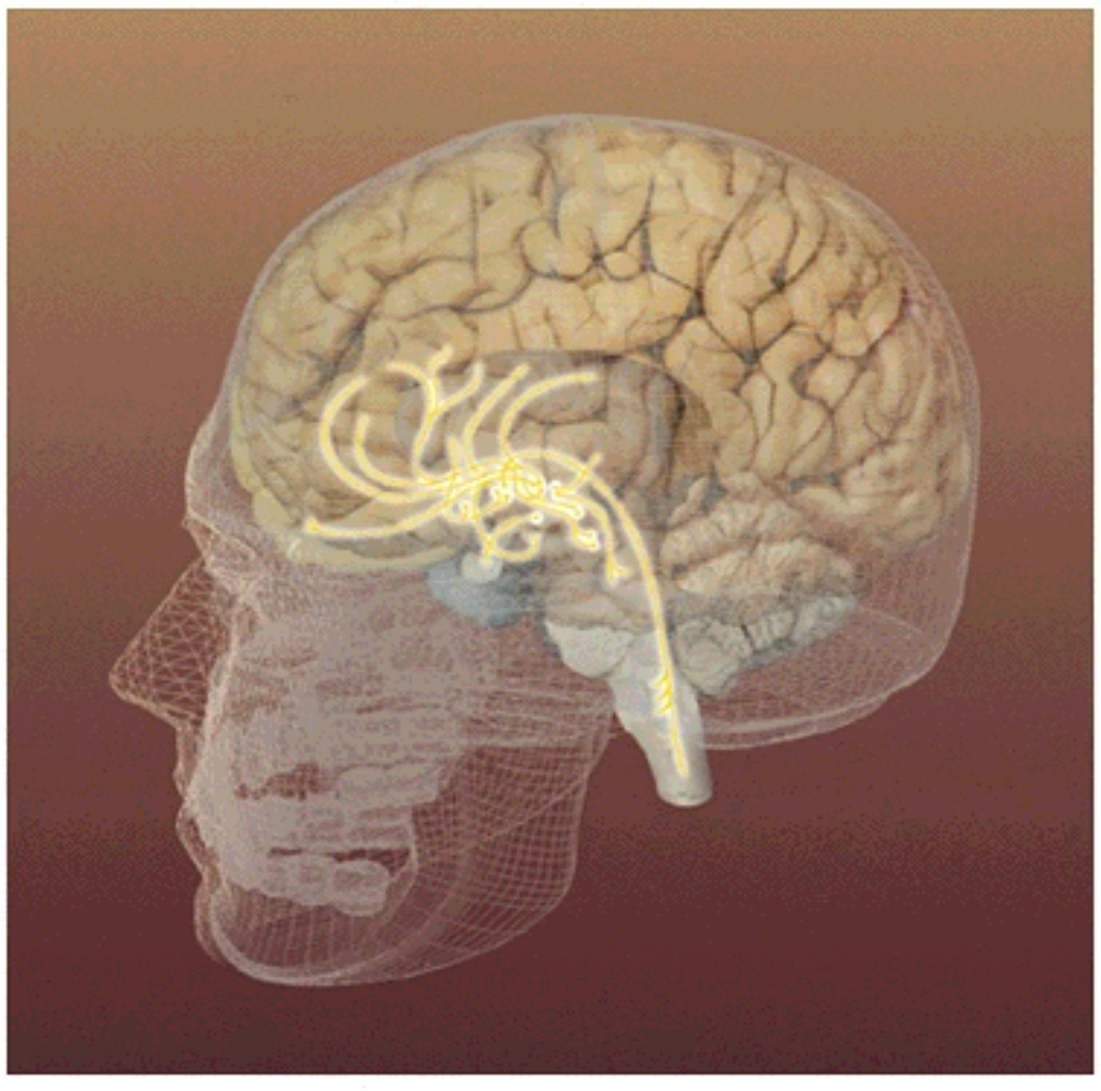
- Influences movement, learning, attention, and emotion.
- Shortage causes Parkinson's disease
- Excessive dopamine linked with schizophrenia

Seratonin

- Affects mood, hunger, sleep and arousal
- Linked to depression



Serotonin Pathways

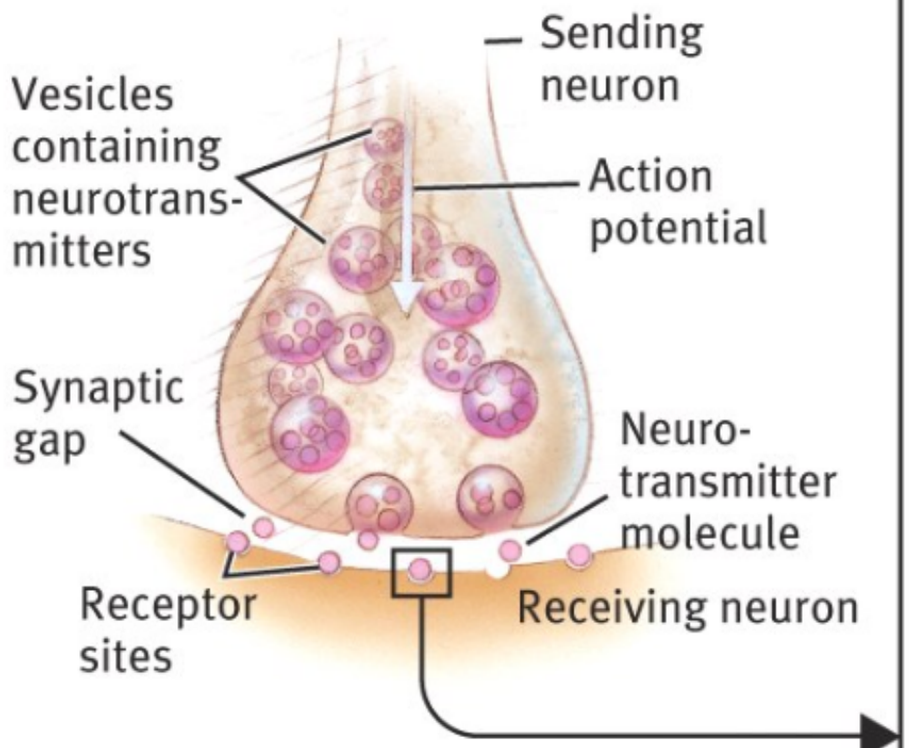


Dopamine Pathways

Drugs and ***other chemicals*** come from <u>outside</u> the body. They can have an *agonistic* effect or an *antagonistic* effect on neurotransmission.

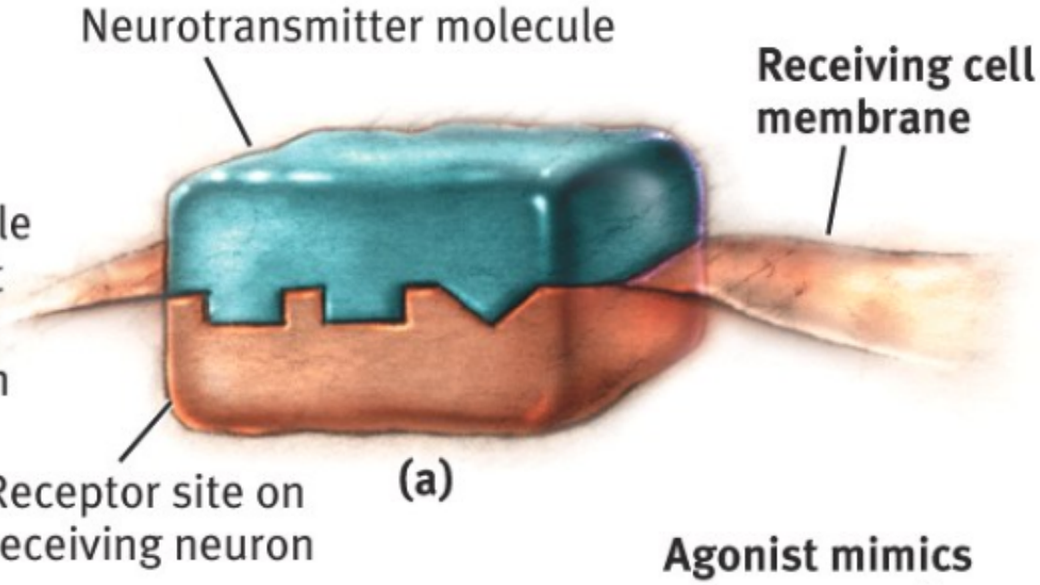
Agonist-excite by mimicking particular neurotransmitters or block their reuptake. (Opiates)

Antagonists-inhibit a neurotransmitter's release or block its effect. (Botulinum toxin blocks ACh release and causes paralysis)

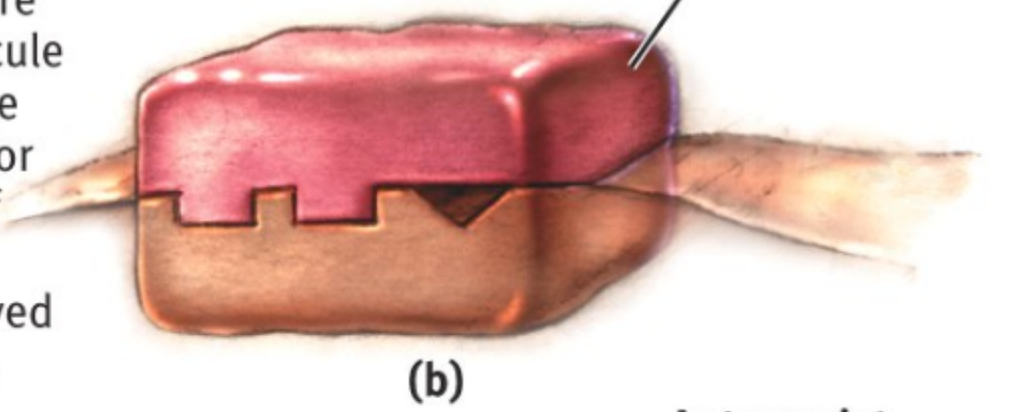


Neurotransmitters carry a message from a sending neuron across a synapse to receptor sites on a receiving neuron.

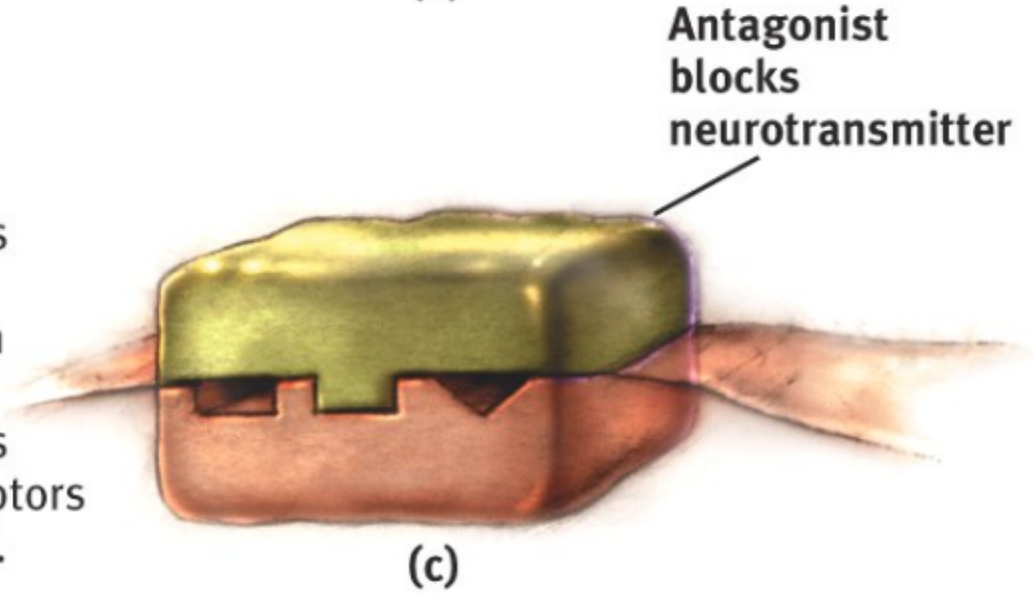
This neurotransmitter molecule has a molecular structure that precisely fits the receptor site on the receiving neuron, much as a key fits a lock.



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.



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.



The Whole Picture

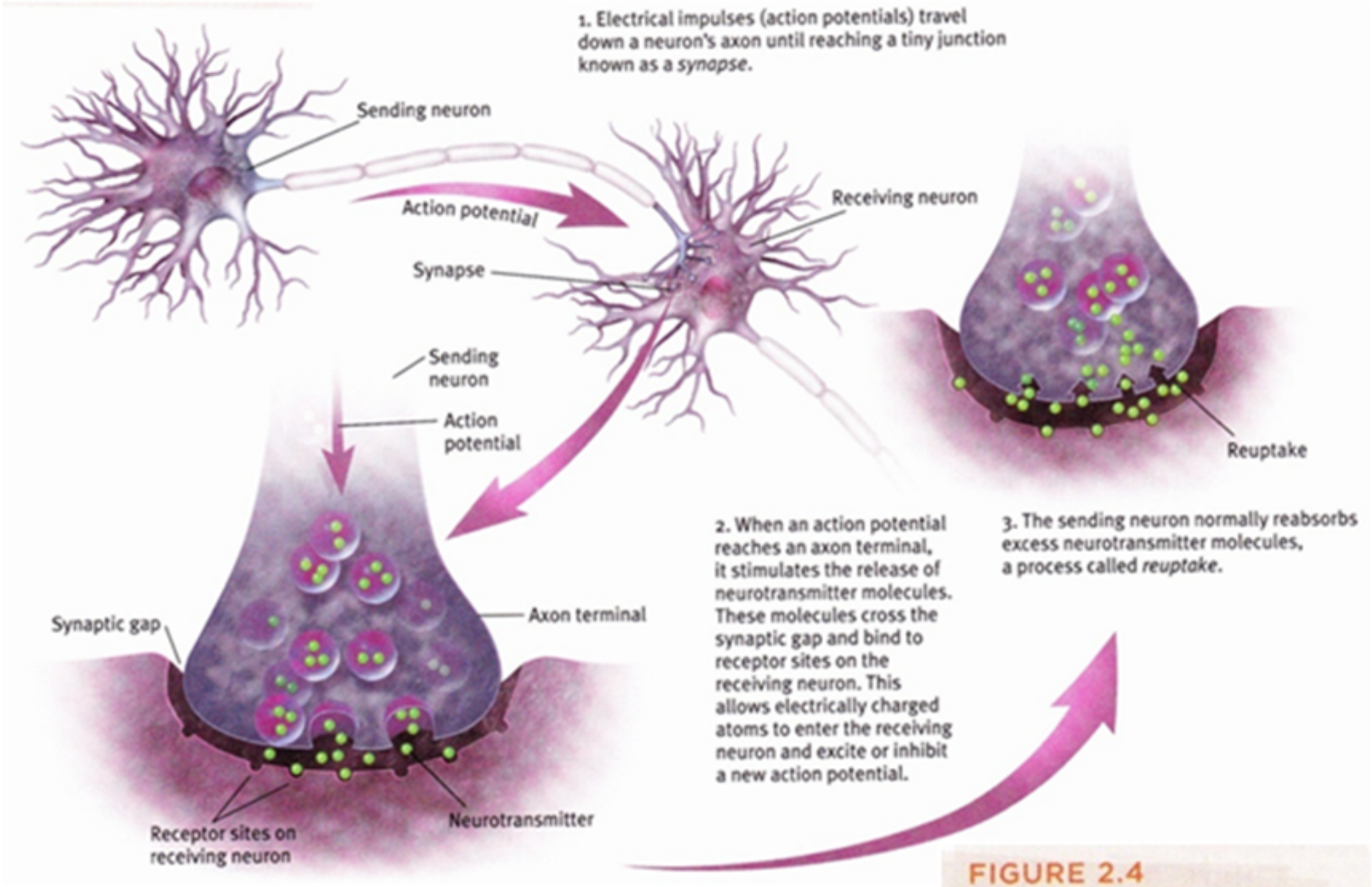


FIGURE 2.4
How neurons communicate

Types of Neurons: Three Types

A. Sensory neuron (afferent neuron)

- Nerve cell that carries incoming messages from sense receptors TOWARDS the brain and spinal cord (CNS).

B. Interneuron

- Nerve cell that relays messages between nerve cells (sensory and motor), especially in the brain and spinal cord.

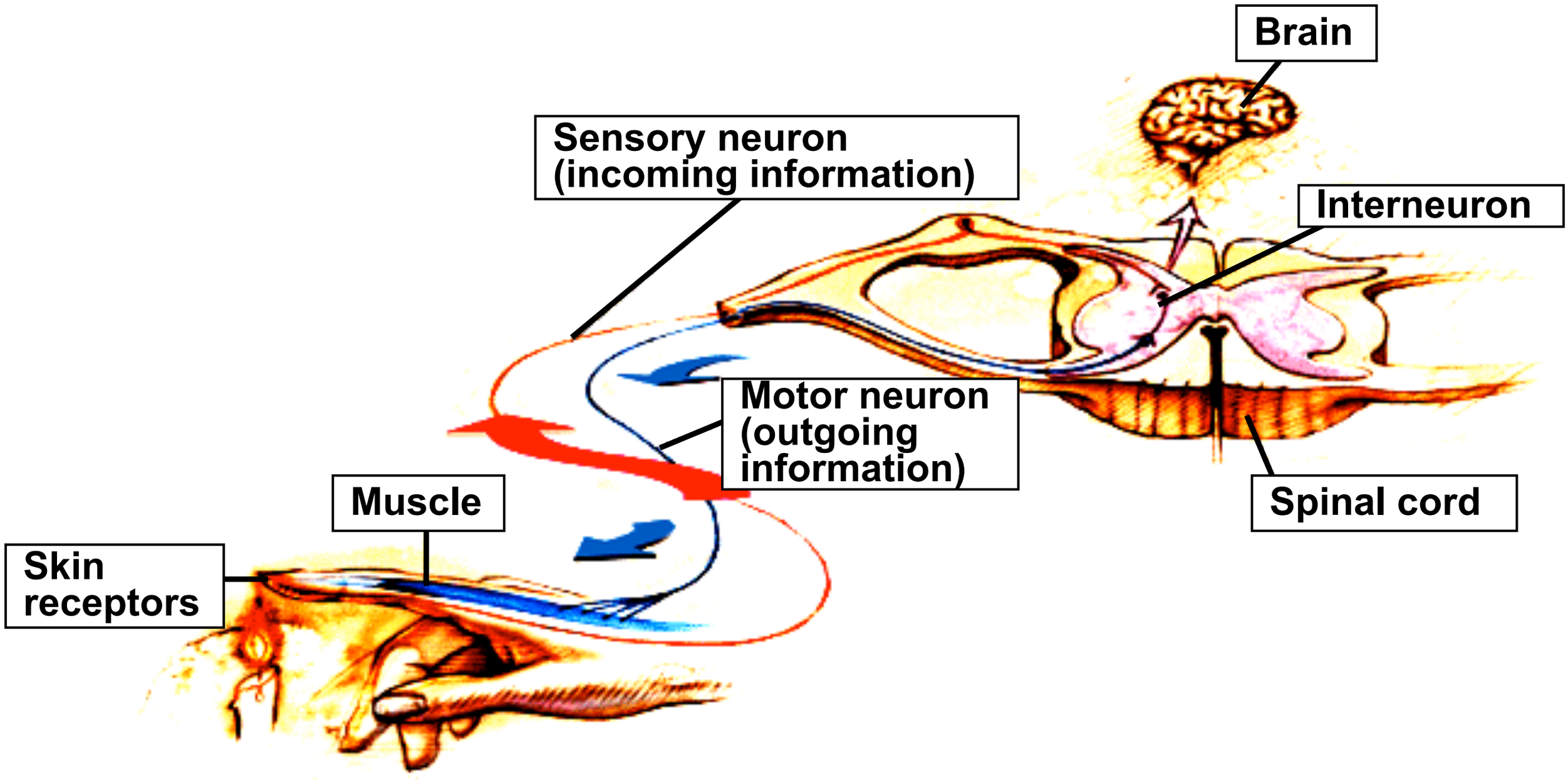
C. Motor neuron (efferent neuron)- nerve cell that carries messages away

- Nerve cell that carries outgoing messages AWAY from the CNS toward the muscle and glands.

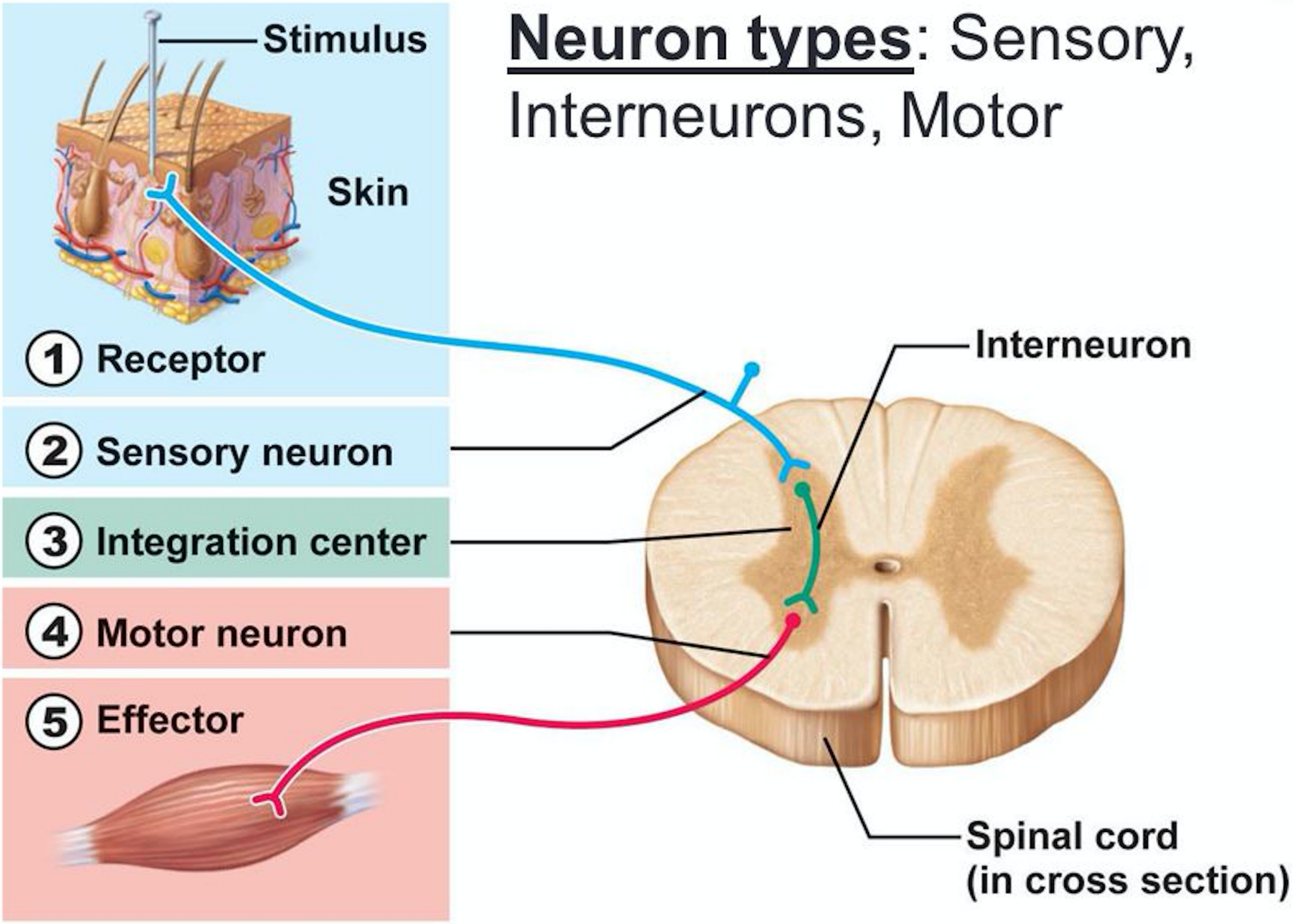
Note: A prime example of all three types of neurons are reflexes.

Reflex:

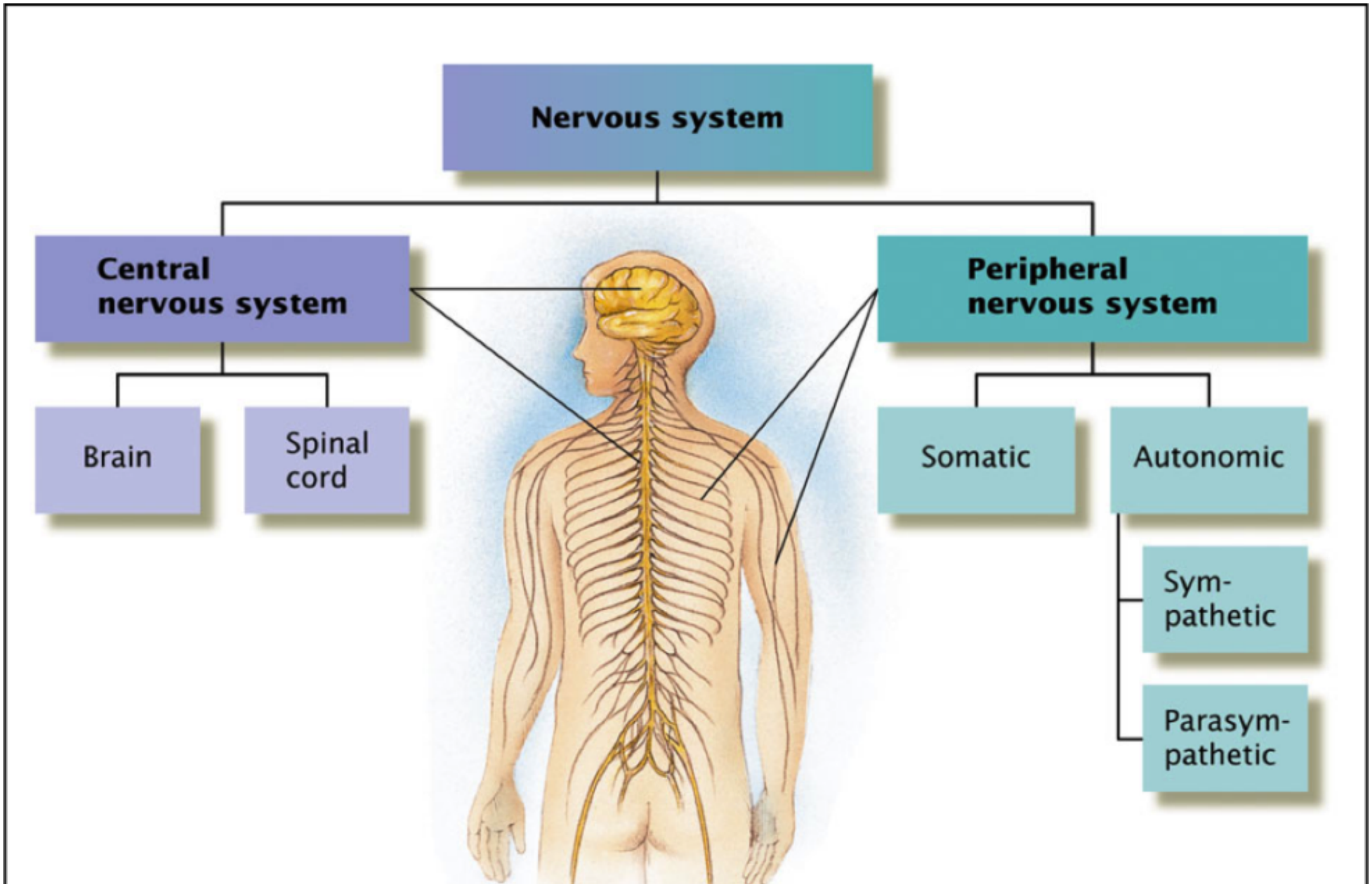
- A simple, automatic, inborn response to a sensory stimulus.



Neuron types: Sensory, Interneurons, Motor



II. The Nervous and Endocrine Systems



II. The Nervous and Endocrine Systems

A. Nervous System

- The body's speedy, electrochemical communication system consists of all the nerve cells of the peripheral and central nervous systems

Central Nervous System (CNS)

- The brain and spinal cord
- Connects Peripheral Nervous System to the brain
- Controls reflexes

Module 10

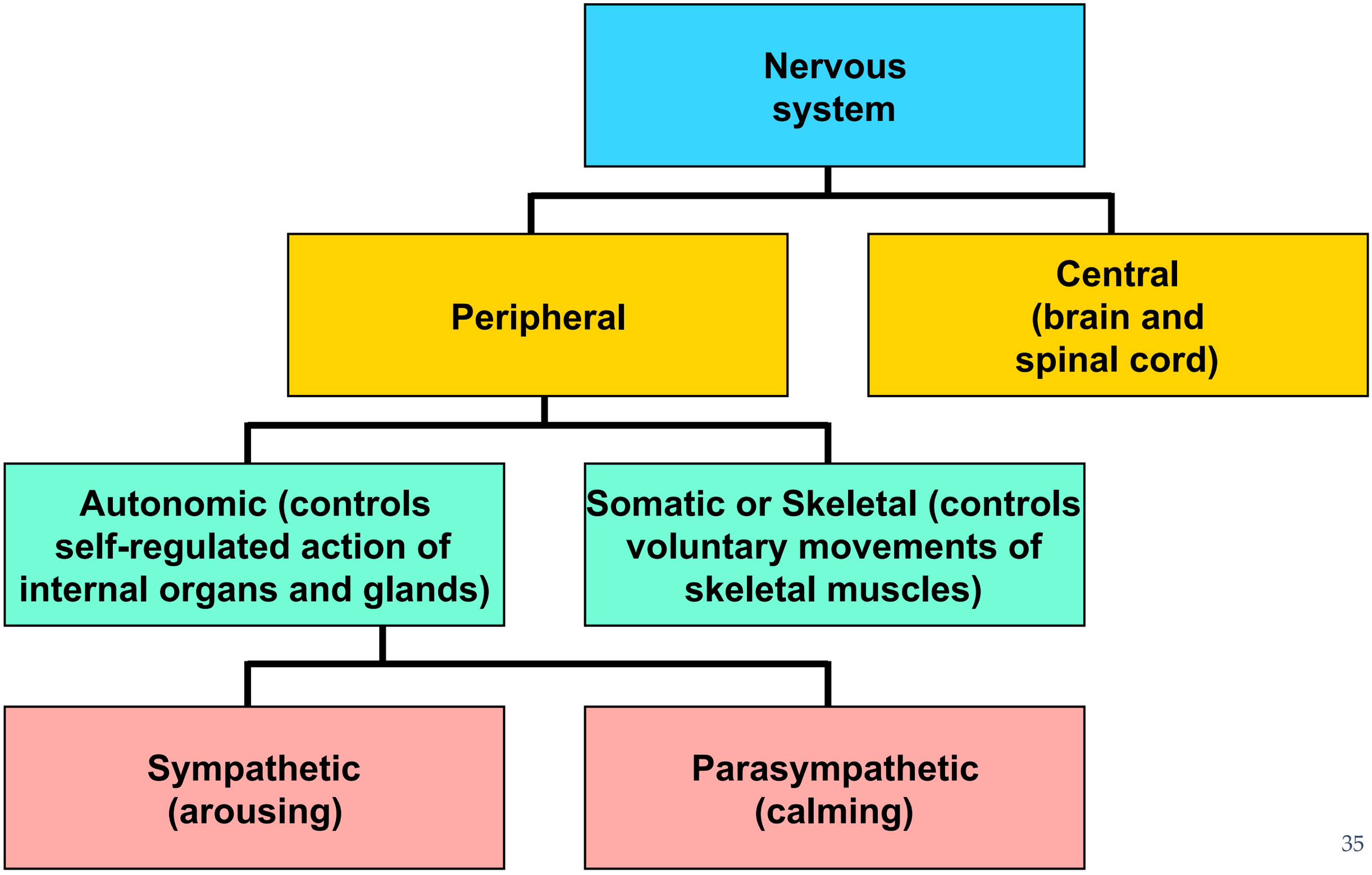
Peripheral Nervous System (PNS)

- The sensory and motor neurons that connect the central nervous system (CNS) to the rest of the body. Consists of autonomic nervous system and somatic nervous system.

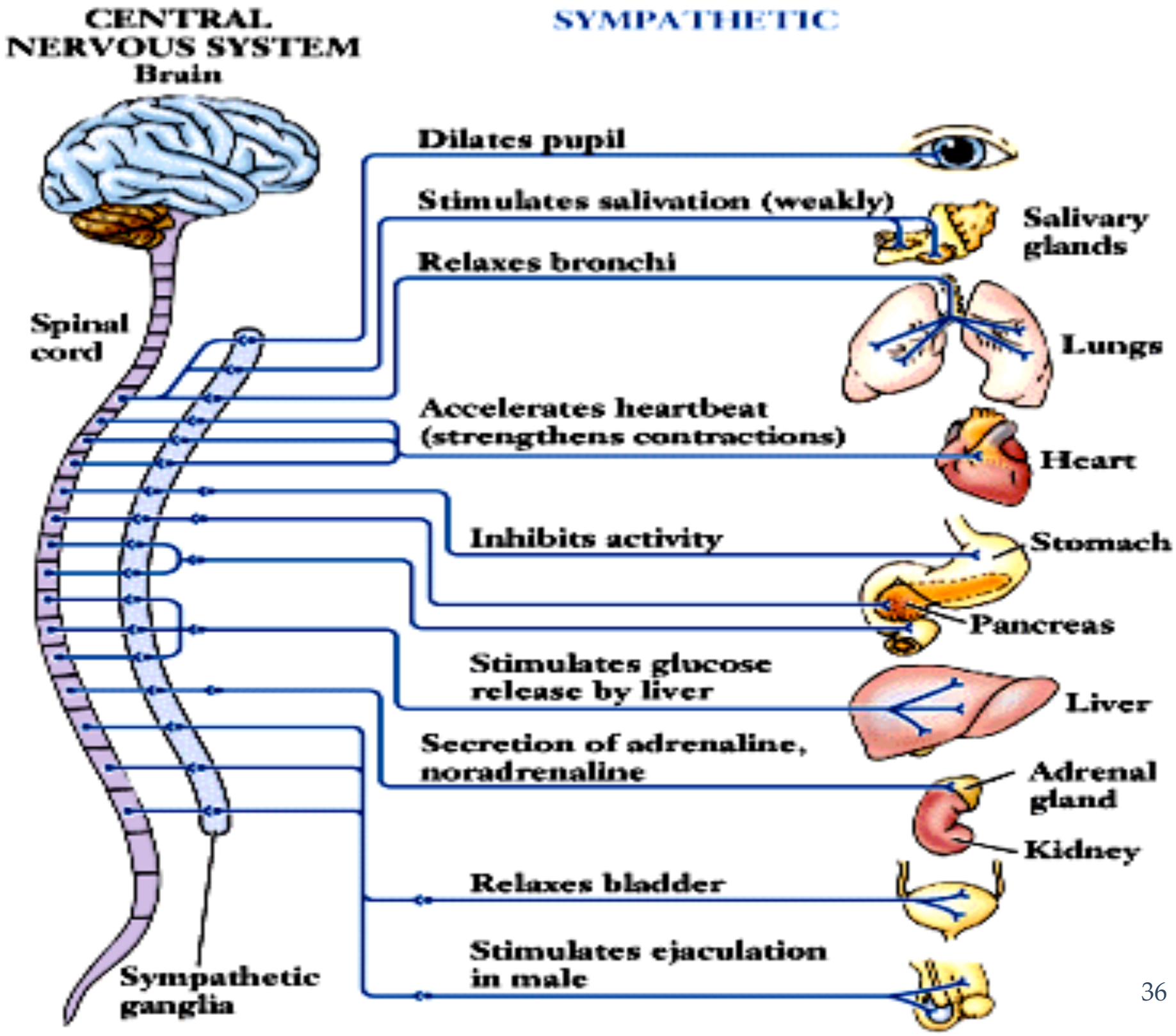
1. *Autonomic Nervous System (*controls the parts of our body that work *automatically)*- controls the glands and muscles of our internal organs. For example: regulates heartbeat, breathing, and digestion. The ANS is a dual system.
   - ✦ *Sympathetic Nervous System*- main job is to **arouse** and excite. Accelerates blood pressure and raises your heartbeat in response to stress. (gas pedal)
   - ✦ *Parasympathetic Nervous System*- main job **is** to ***calm*** you down. Decreases heart rate, lowers blood sugar, etc…(brake)

2. *Somatic Nervous System*- Communicates with sense organs and voluntary muscles. Controls voluntary movements.

The Nervous System

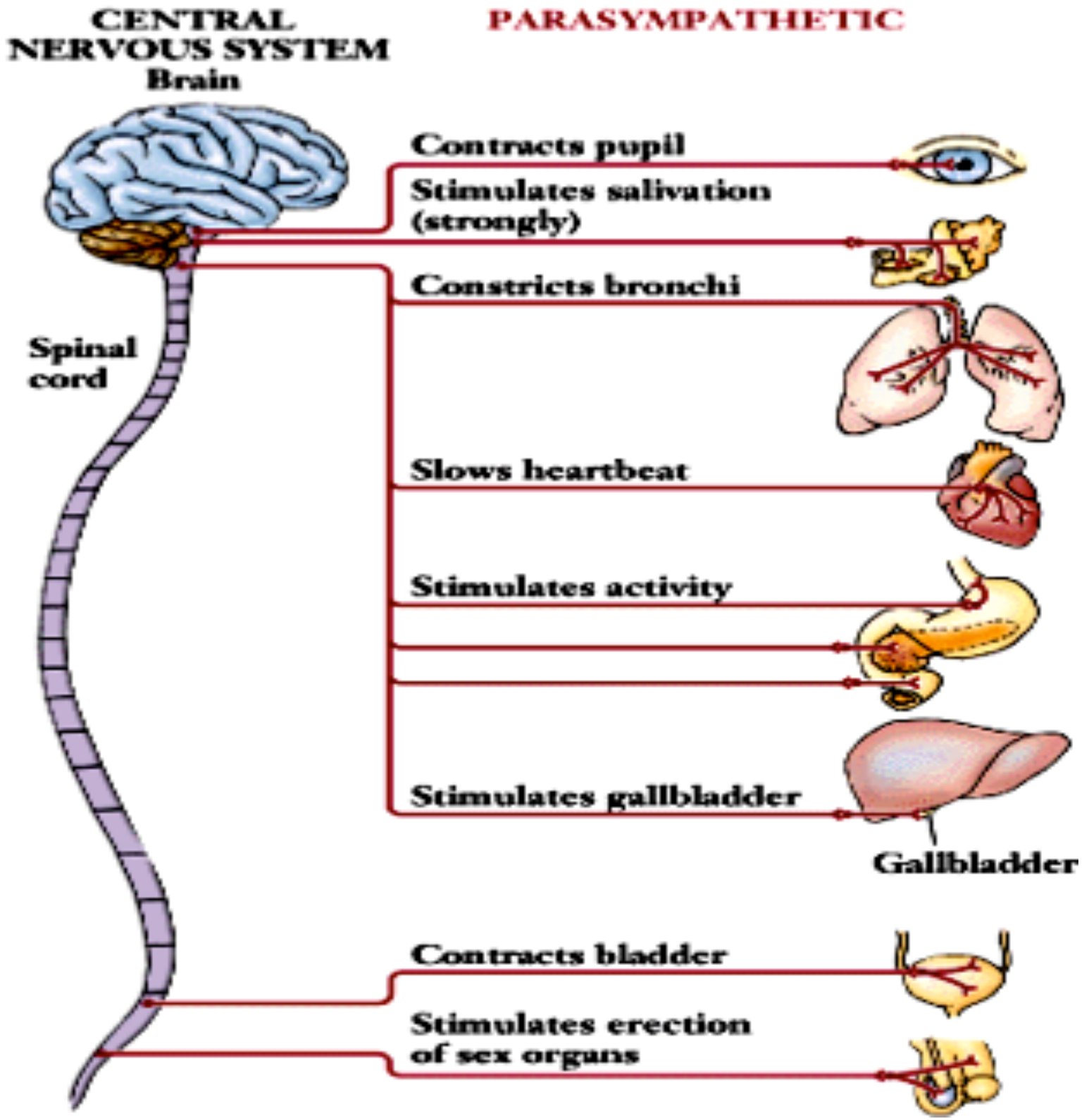


The Nervous System



See Figure 10.2

The Nervous System



See Figure 10.2

II. The Nervous and Endocrine Systems

B. Endocrine System: body's "slow" chemical communication system.

Pineal Gland

- Produces melatonin that helps regulate circadian rhythms.
- Associated with *Seasonal Affective Disorder*.

Pituitary Gland (growth hormone, vasopressin, oxytocin)

- Called the "master gland" because it secretes many different hormones, some of which affect other glands.
- Controlled by the **Hypothalamus**
- E.G. HGH, Thyroid, Egg and Sperm production

Thyroid Gland (thyroxine & triiodothyronine)

- Stimulates metabolic activities

Parathyroids (parathyroid hormone)

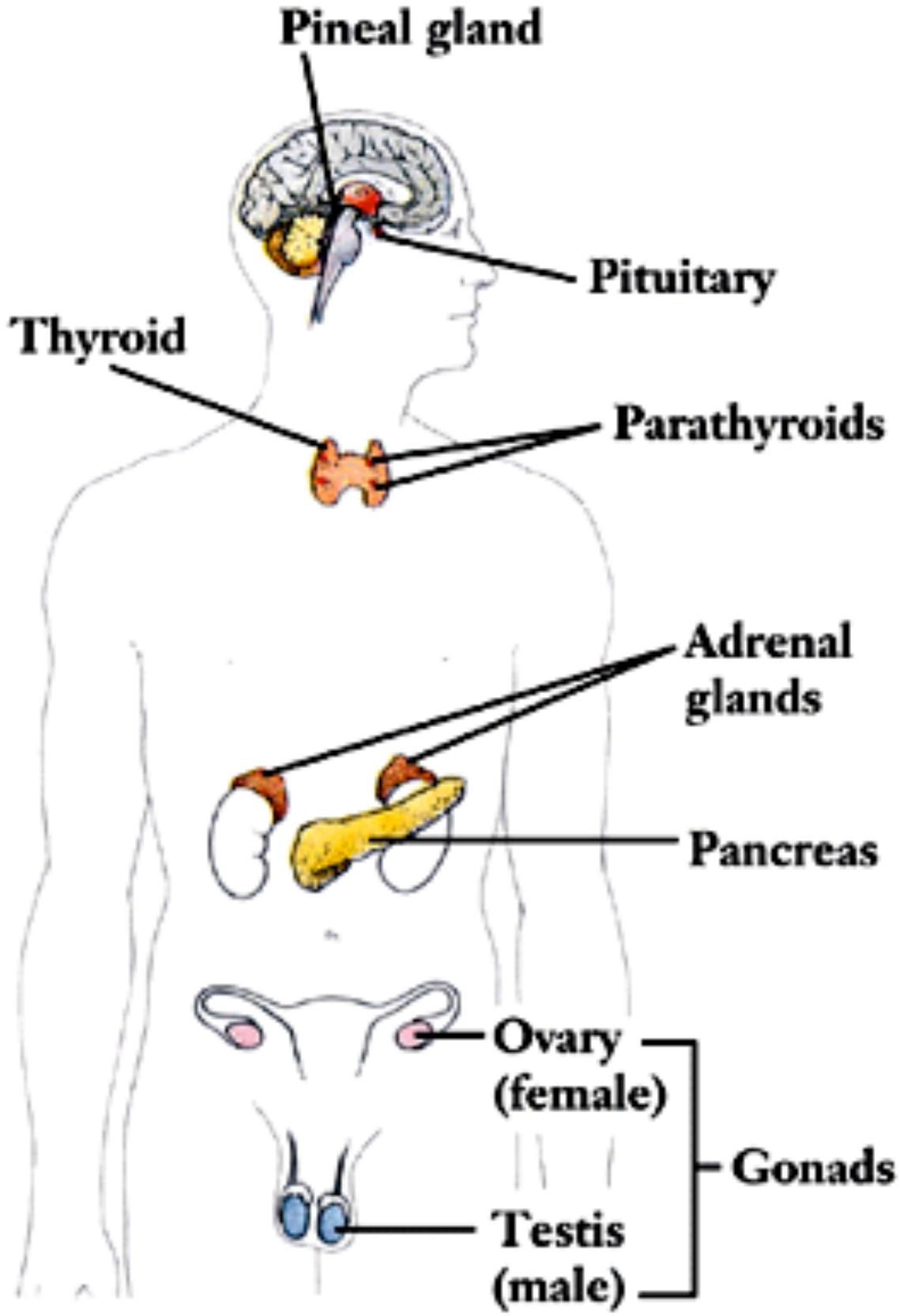
- Maintains calcium ion levels in the blood for normal neuron functioning.

Adrenal Gland

- Produces cortisol (a stress hormone)
- Secretes adrenaline and noradrenaline which prepares the body for the flight or fight response.

Pancreas (insulin)

- Regulates blood sugar (glucose) that fuels all behavioral processes


Pineal gland
Pituitary
Thyroid
Parathyroids
Adrenal glands
Pancreas
Ovary (female)
Testis (male)
Gonads