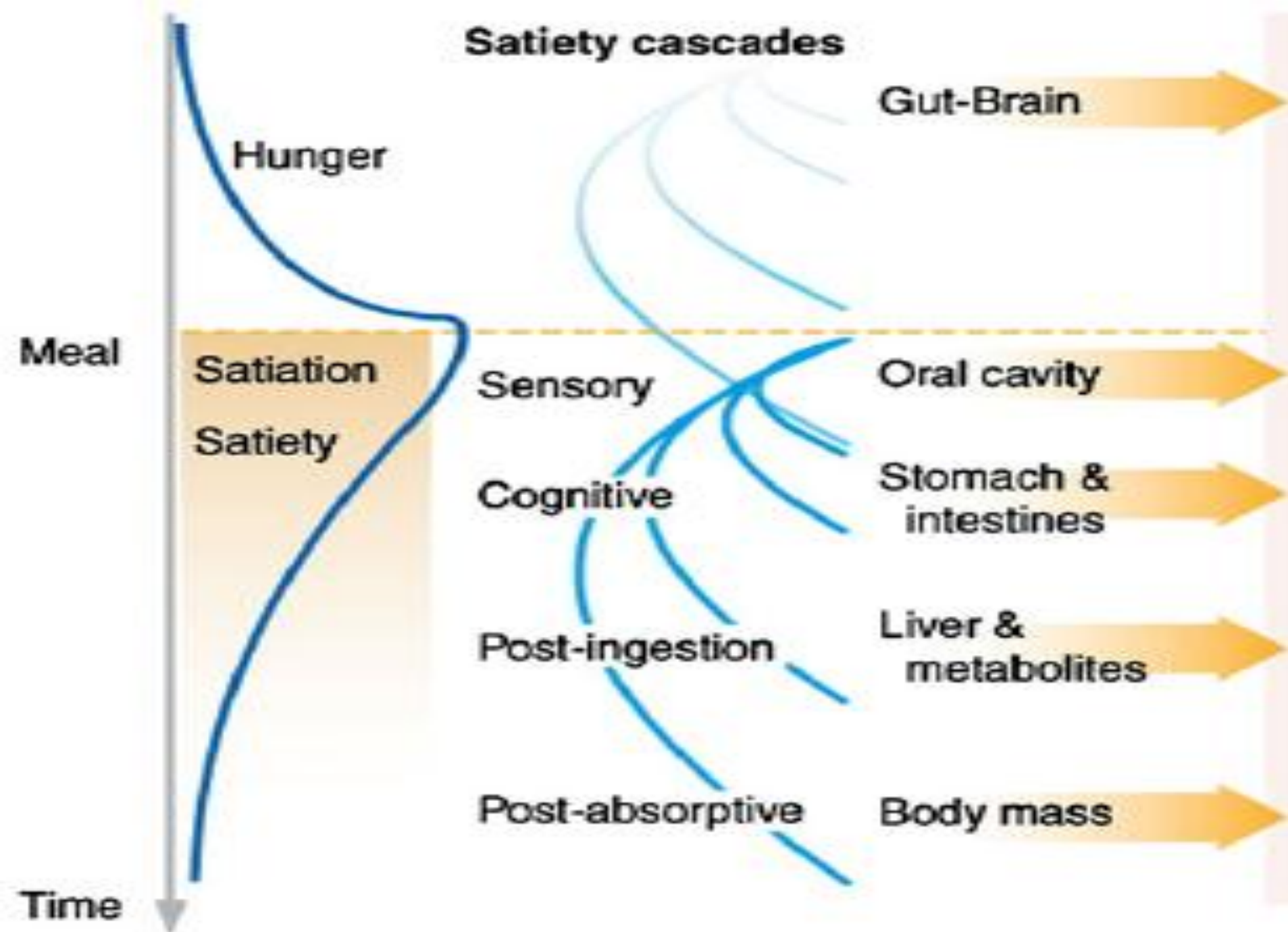
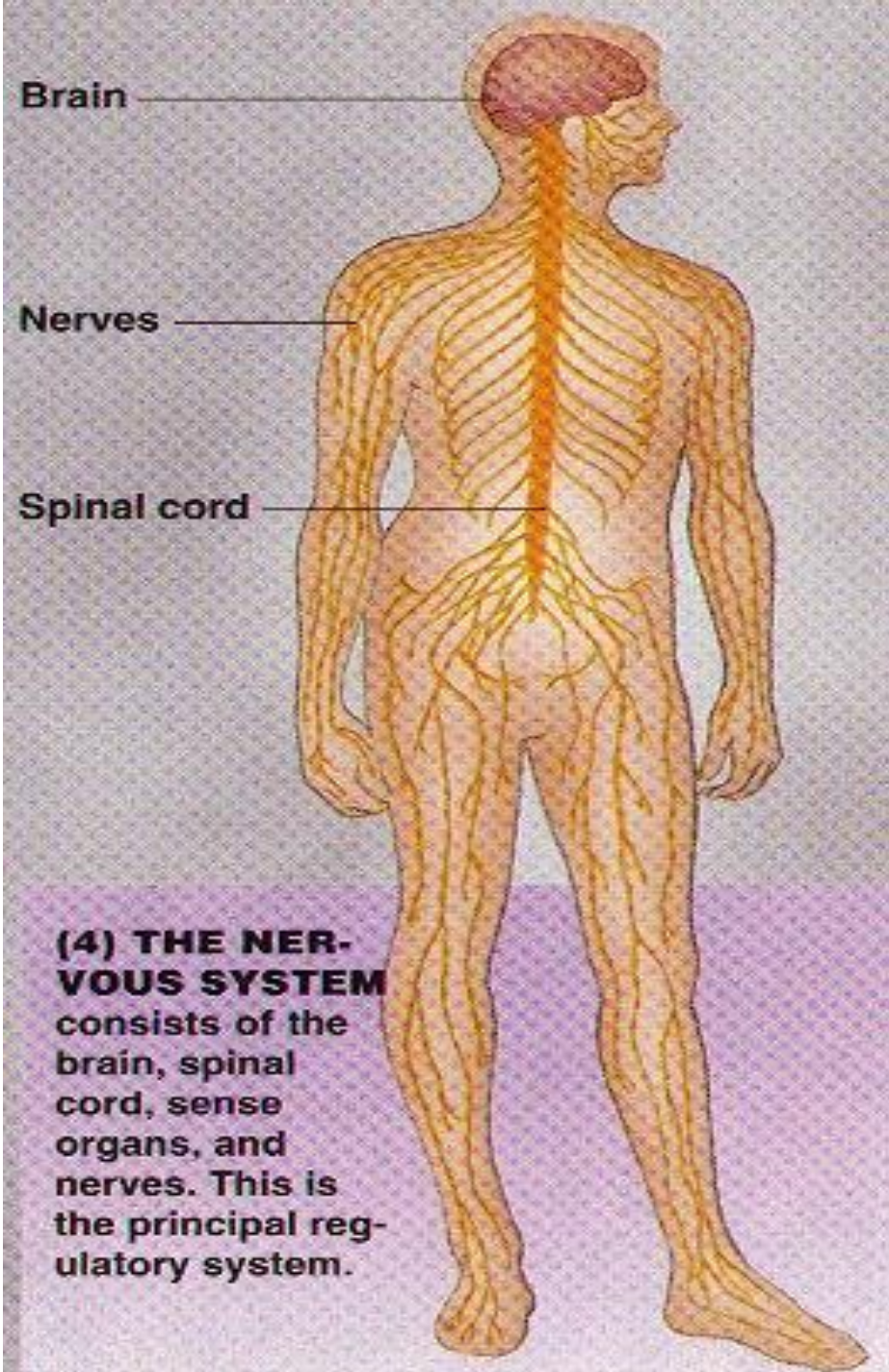


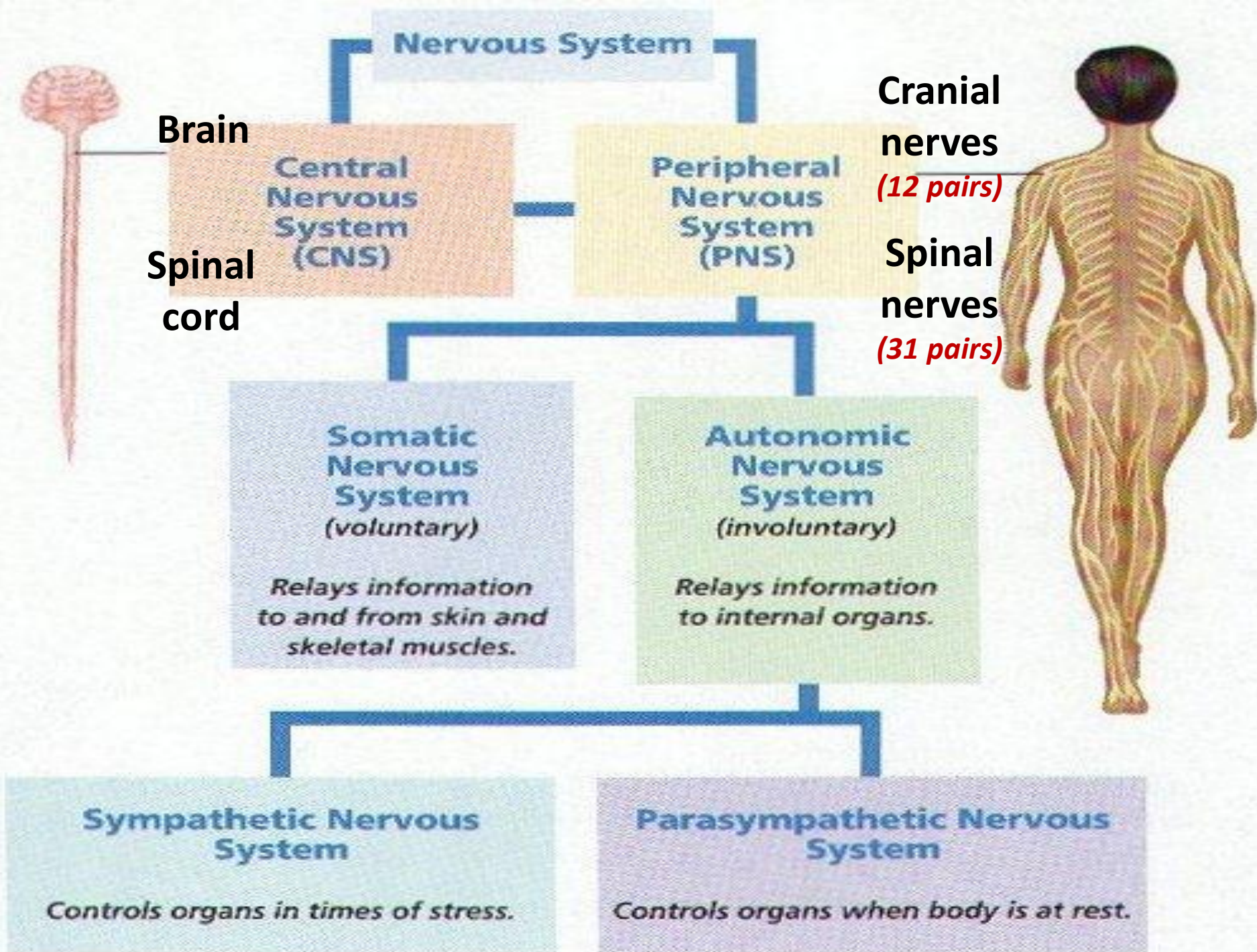
Basic anatomy and physiology of organs involved in satiety

Paola Vitaglione



The nervous system

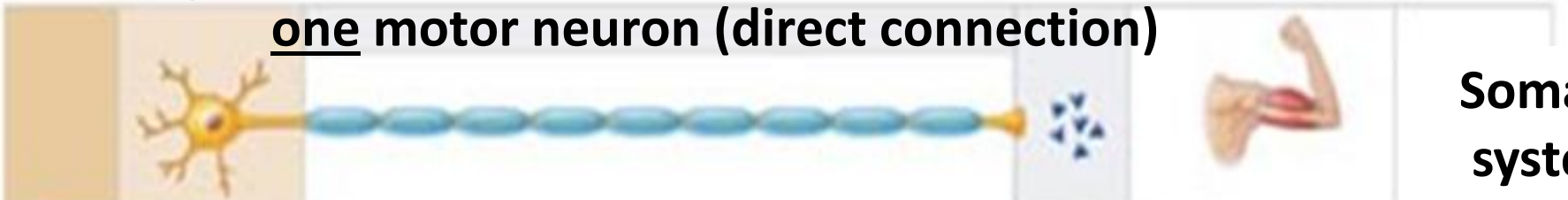




Anatomic differences

CNS

one motor neuron (direct connection)

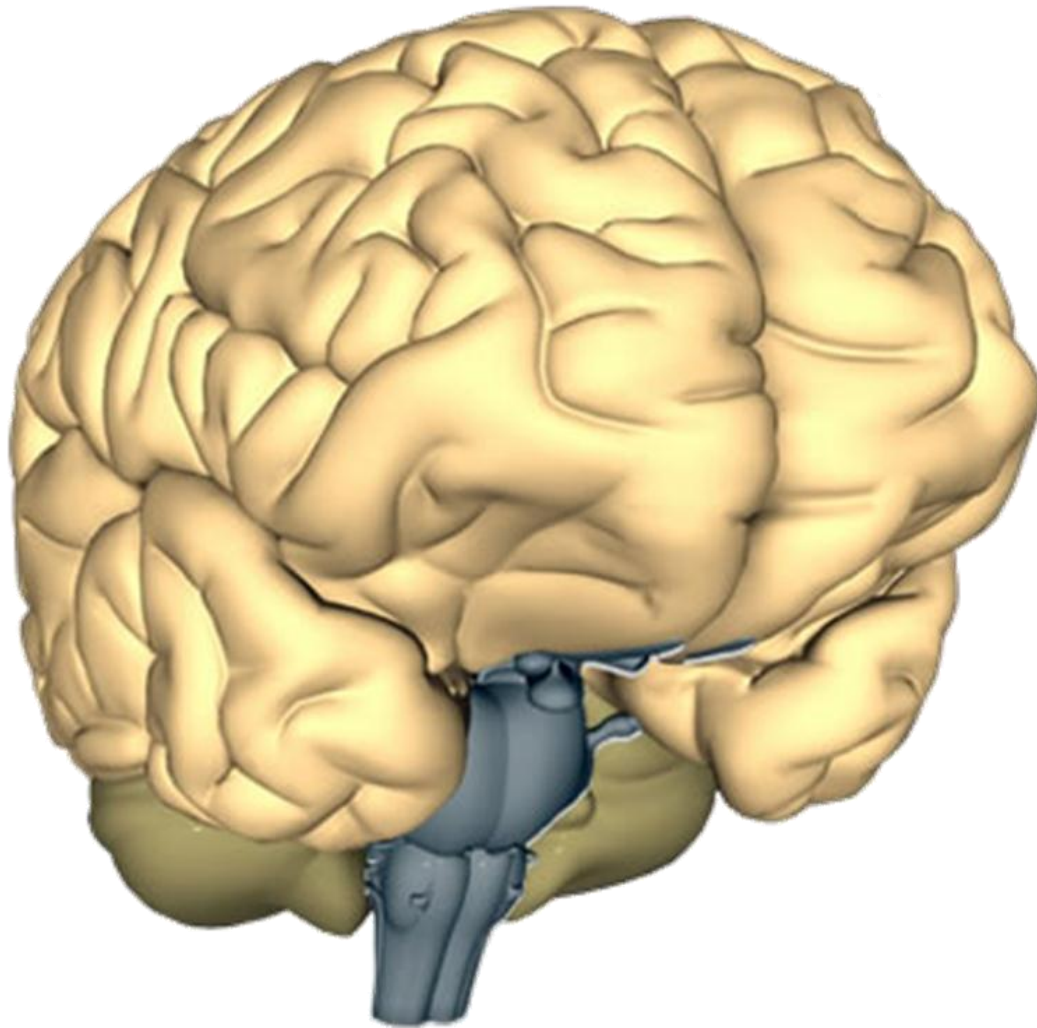


**Somatic
system**

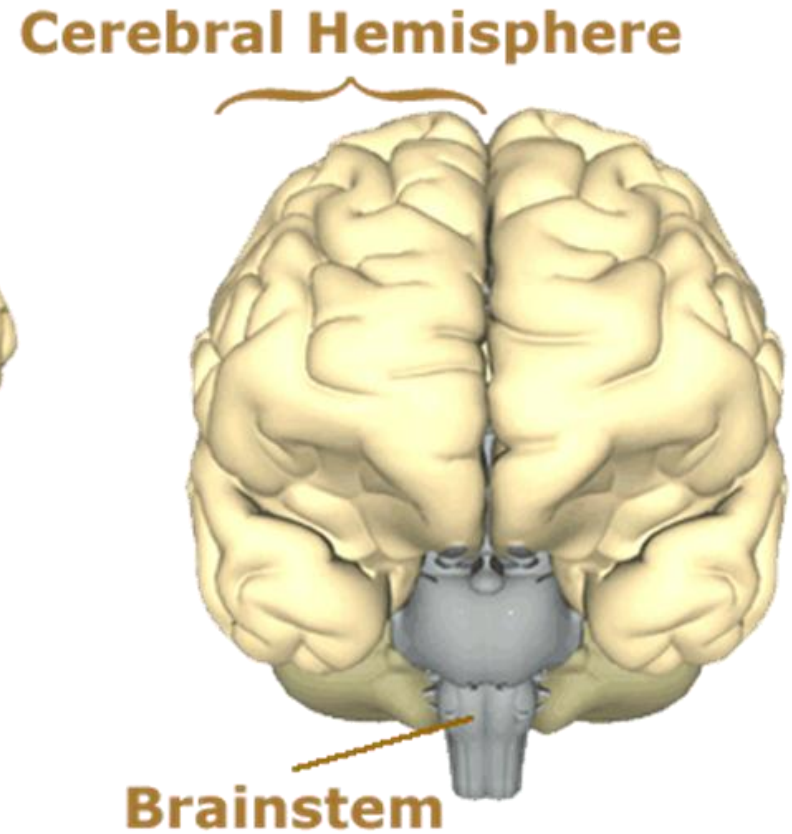
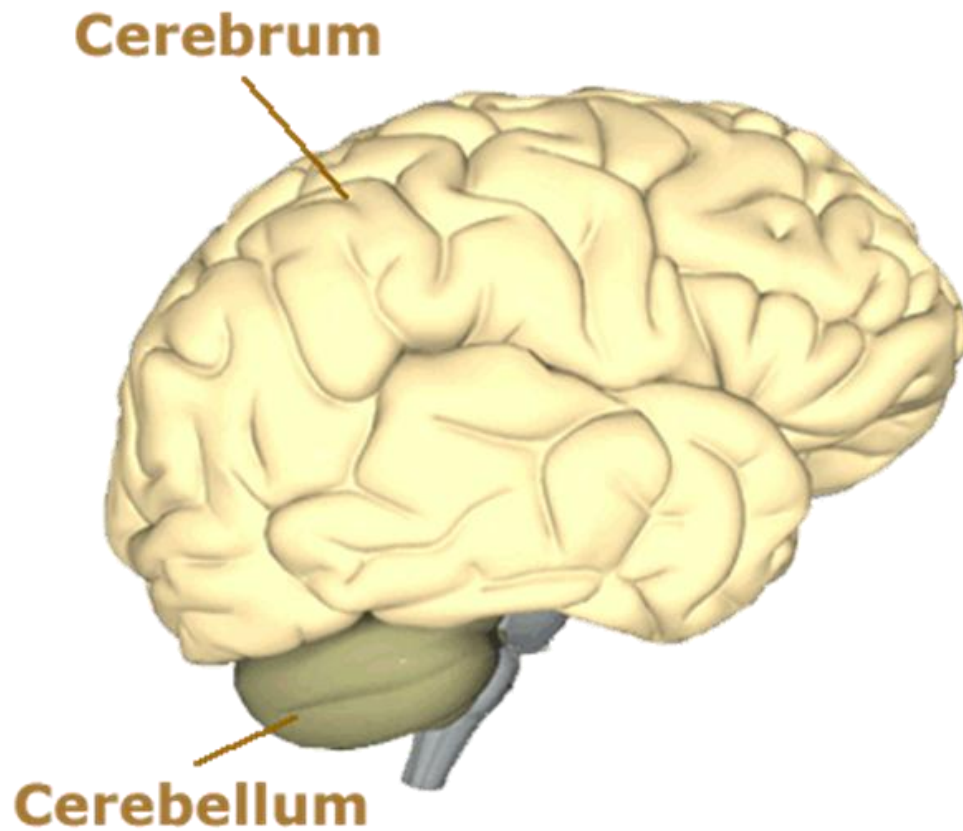
Sympathetic and Parasympathetic

- Innervate mostly the same structures, but cause **opposite** effects (→ **different neurotransmitters**)
- **Sympathetic** – “*fight, flight, or fright*” (→ **Acetylcholine**)
 - activated during exercise, excitement, and emergencies
 - increases heart rate, breathing rate, and blood supply to the skeletal muscles
- **Parasympathetic** – “*rest and digest*” (→ **Norepinephrine**)
 - concerned with conserving energy
 - activated during rest and sleep
 - decreases heart rate, breathing rate, and blood supply to skeletal muscles
 - increases blood supply to digestive organs

The Human Brain

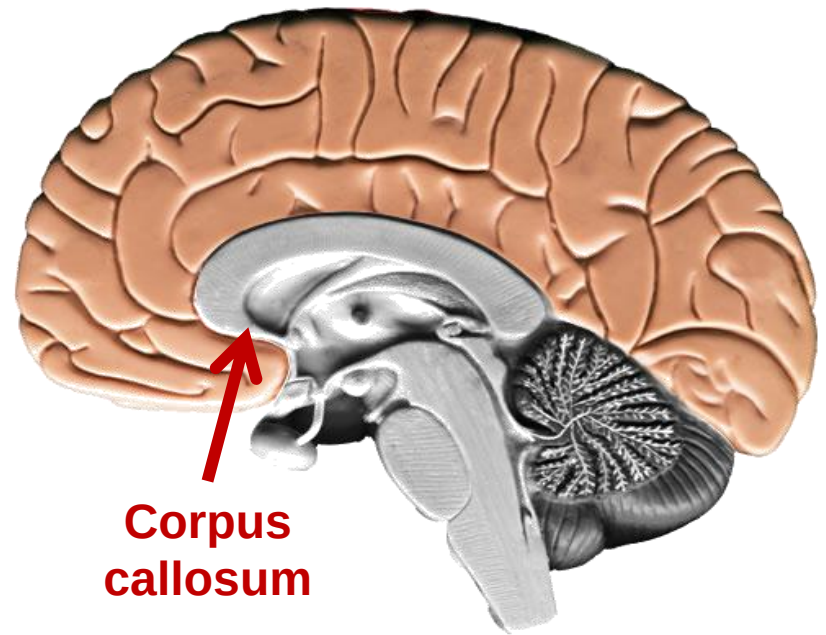


External Brain Structures

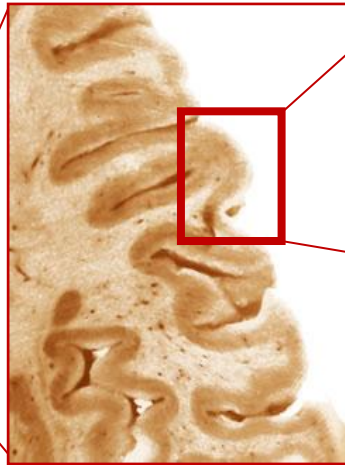
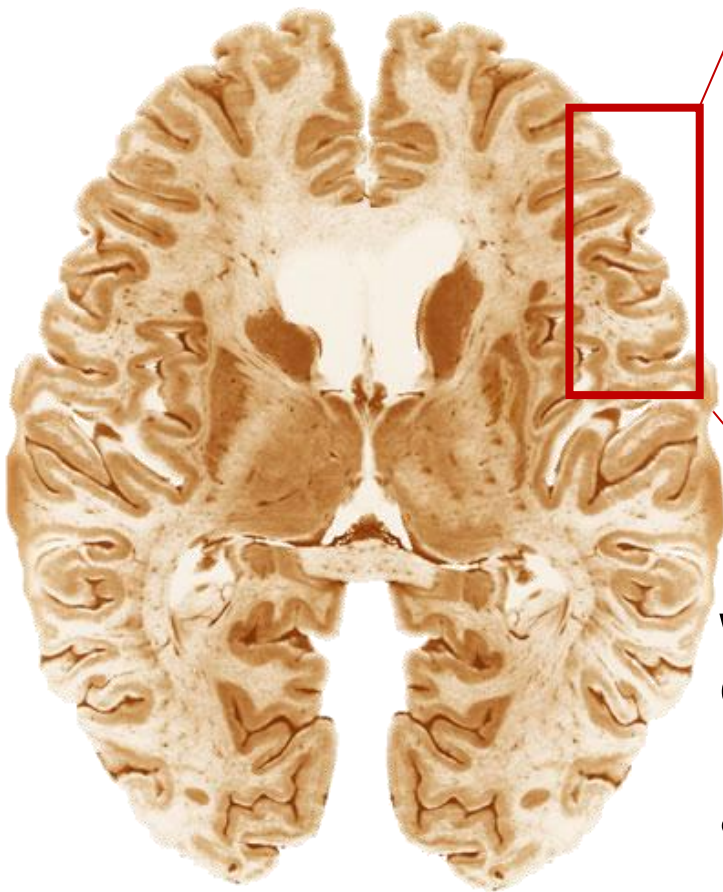


Cerebrum

- The largest portion of the brain
- 2 hemispheres connected at the corpus callosum
- Divided into 5 lobes responsible for different brain functions



The cerebrum's surface



layer
~ 1.5 - 4 mm
thick

Neocortex

where all the highest
cognitive functions take
place (language and
abstract thinking)

a thin layer of cells.



It is convoluted
into hundreds of
folds

25 billion neurons
>62,000 miles axons
300 trillion synapses

The 5 lobes of the Cerebrum

Frontal Lobe

responsible for higher cognitive functions

(Problem solving, Spontaneity, Memory, Language, Motivation, Judgment, Impulse control, Social and sexual behavior)

Temporal Lobe

Responsible for **emotions, smelling, tasting, perception, memory**, understanding music, aggressiveness, and sexual behavior.

Also contains the language area of the brain

Parietal Lobe

Plays a role in sensations of touch, **smell, and taste**, in **sensory** and spatial **awareness**, in eye-hand coordination and arm movement.

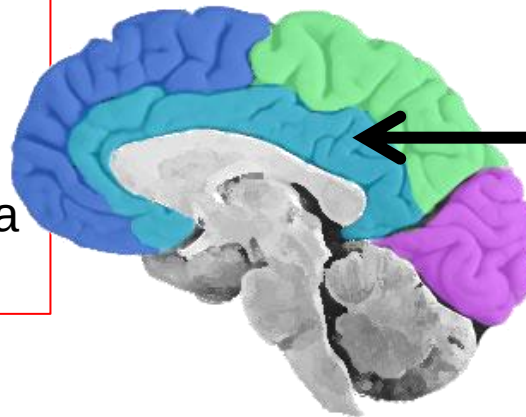
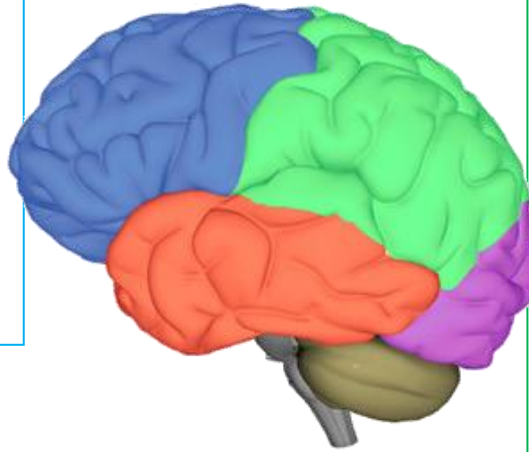
Matches written words with the sound of spoken speech

Occipital Lobe

Controls vision and recognition

Limbic Lobe

located deep in the brain
makes up the limbic system

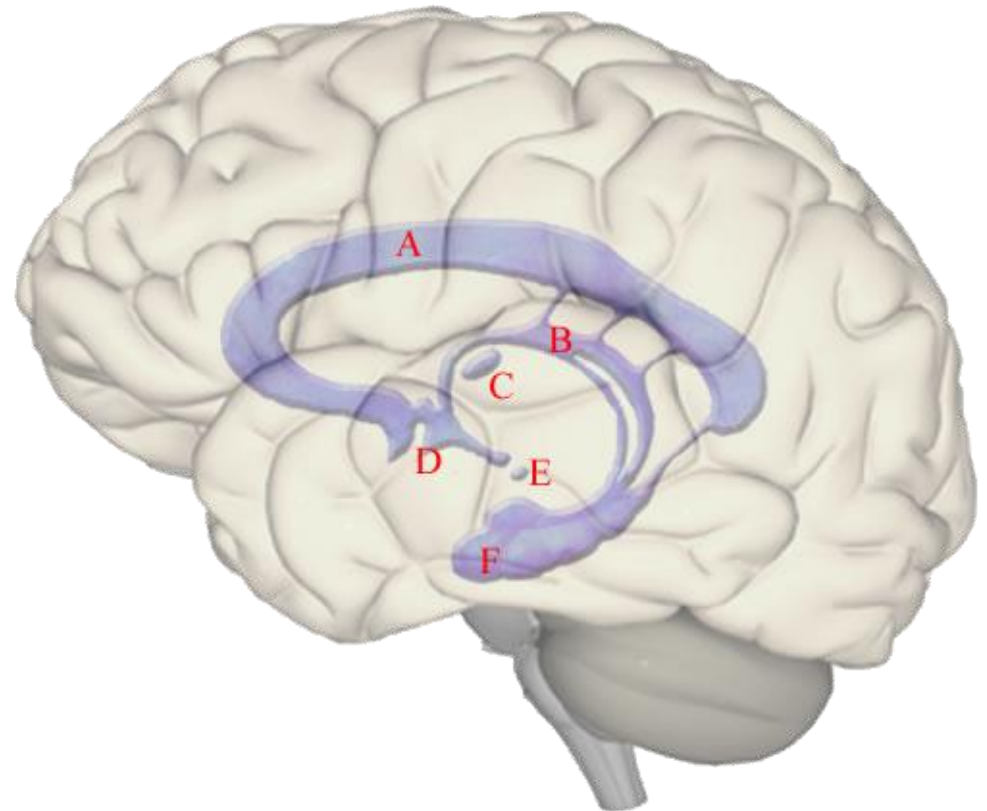


The Limbic System

Area of the brain that regulates emotion and memory.

It directly connects the lower and higher brain functions.

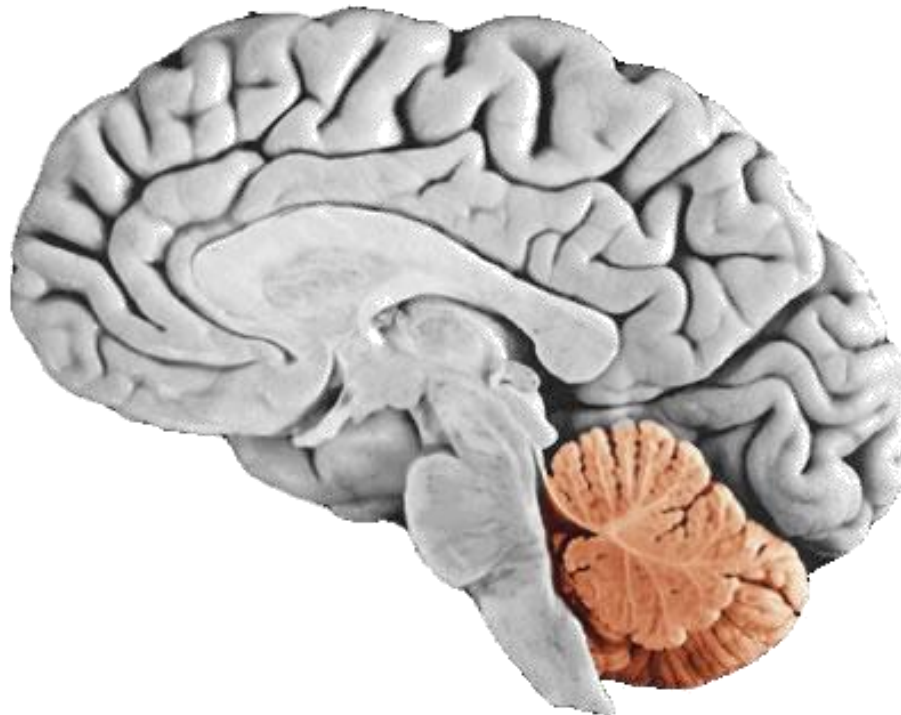
- A. Cingulate gyrus**
- B. Fornix**
- C. Anterior thalamic nuclei**
- D. Hypothalamus**
- E. Amygdaloid nucleus**
- F. Hippocampus**



Cerebellum

It is connected to the brainstem

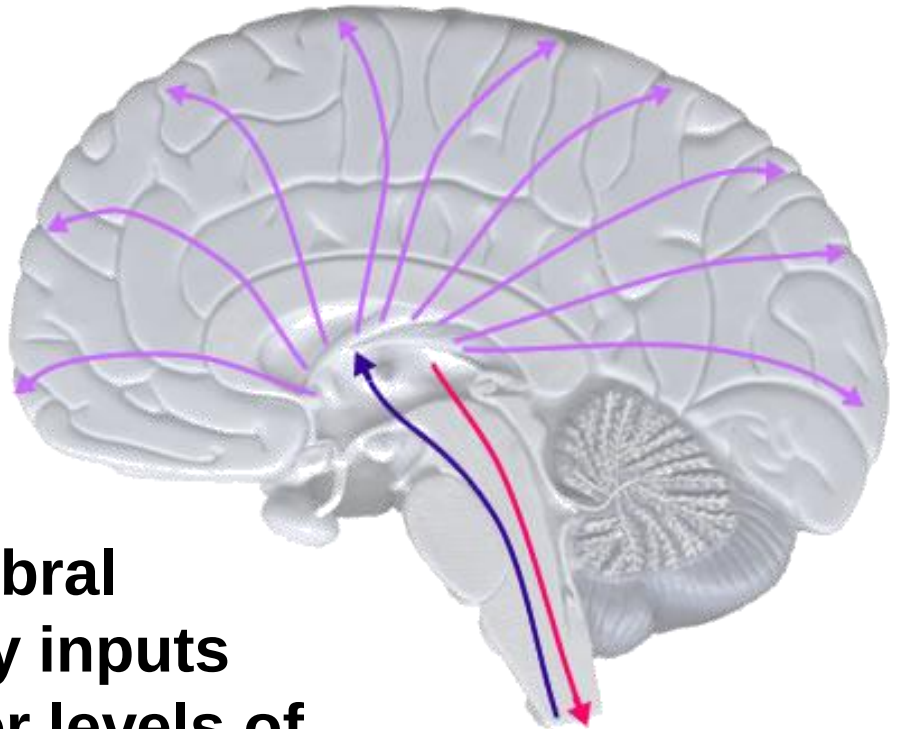
It is the center for body movement and balance.



Thalamus



it sits deep in the brain at the top of the brainstem (“inner room” in Greek)



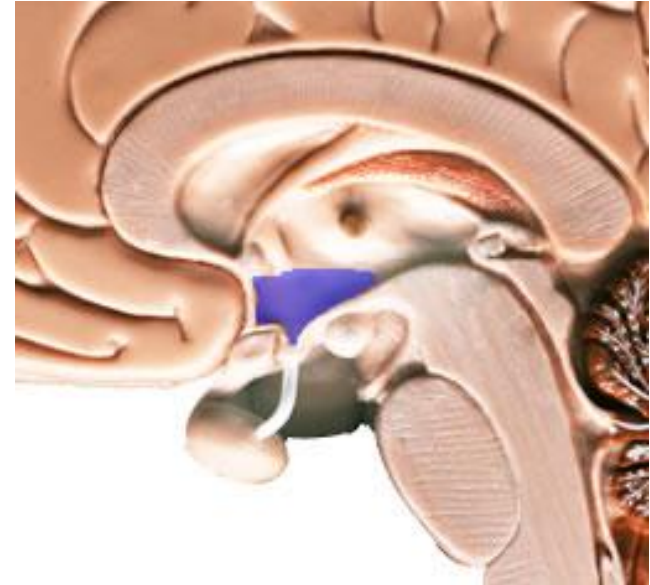
It is the gateway to the cerebral cortex, as nearly all sensory inputs pass through it to the higher levels of the brain.

Hypothalamus

The hypothalamus sits under the thalamus at the top of the brainstem.

It is small but it controls many critical bodily functions:

- **Controls autonomic nervous system**
- **Center for emotional response and behavior**
- **Regulates body temperature**
- **Regulates food intake**
- **Regulates water balance and thirst**
- **Controls sleep-wake cycles**
- **Controls endocrine system**

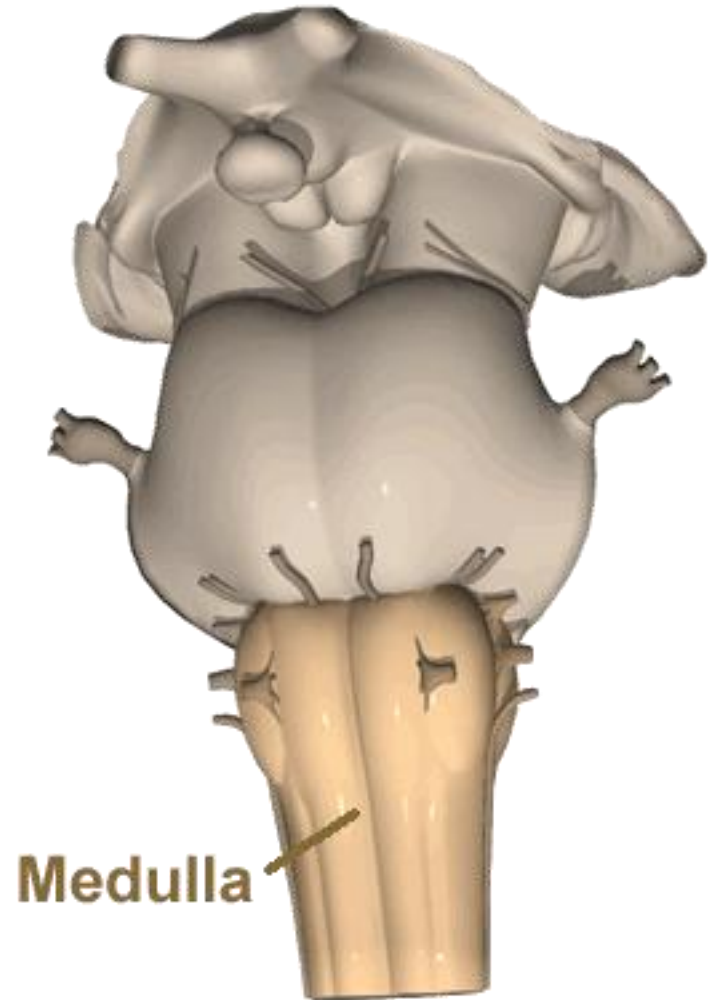


The Medulla Oblongata

The medulla oblongata merges seamlessly with the spinal cord and creates the base of the [brainstem](#).

A control center for vital **involuntary reflexes** such as swallowing, vomiting, sneezing, coughing, and regulation of cardiovascular and respiratory activity.

The medulla is also the origin of many [cranial nerves](#).



The Pons

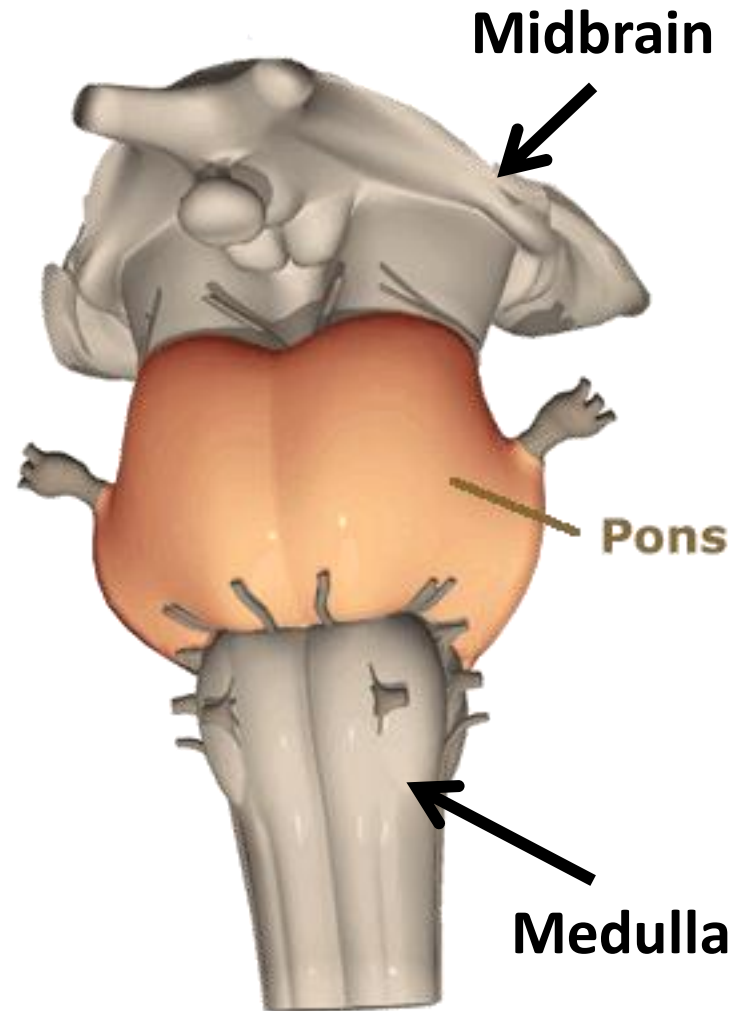
Between the midbrain and the medulla oblongata.

Pons means “bridge” in Latin.

The main function of the pons are:

- to **connect the cerebellum to the rest of the brain**
- to modify the respiratory output of the medulla.

The pons is the origin of several [cranial nerves](#).

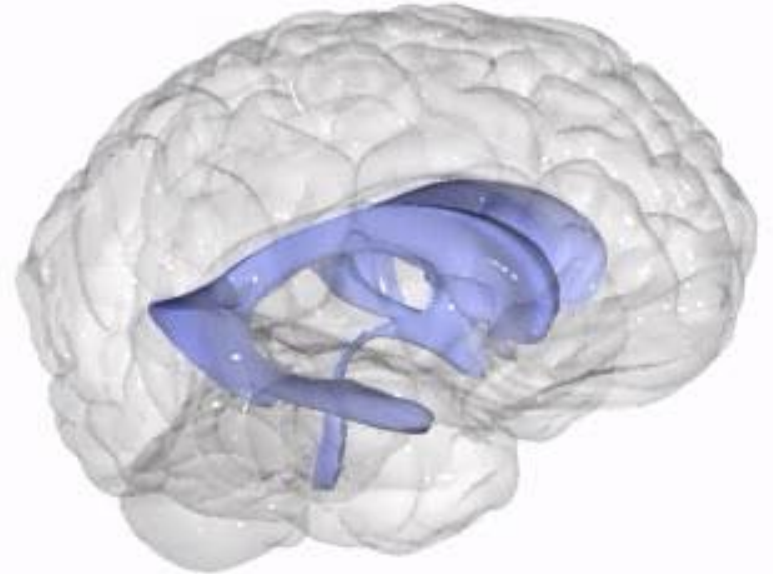


The Ventricles

The ventricles are a complex series of spaces and tunnels through the center of the brain.

The ventricles secrete cerebrospinal fluid, which suspends the brain in the skull.

The ventricles also **provide a route for chemical messengers that are widely distributed through the central nervous system.**

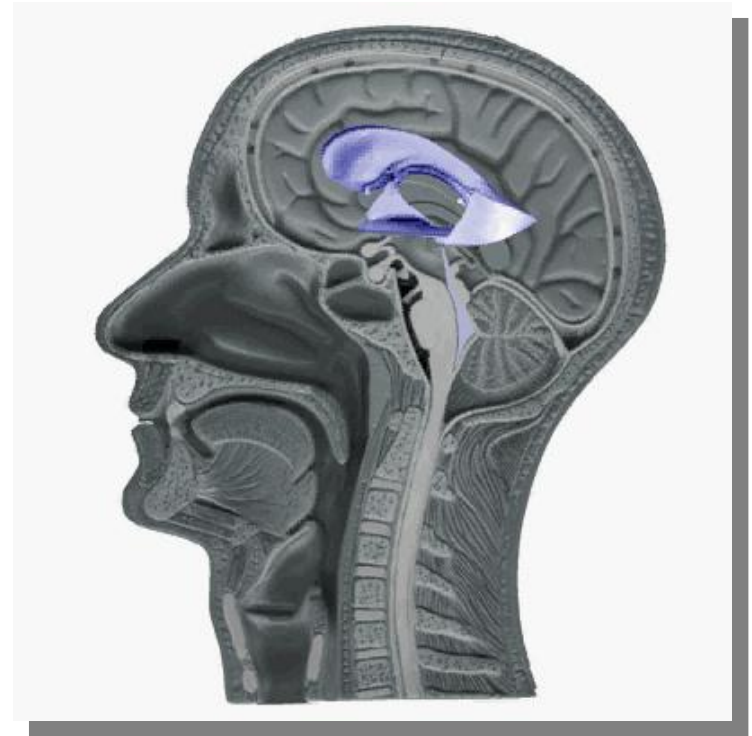


Cerebrospinal Fluid

Cerebrospinal fluid is a colorless liquid that bathes the brain and spine.

It is formed within the ventricles of the brain, and it circulates throughout the central nervous system.

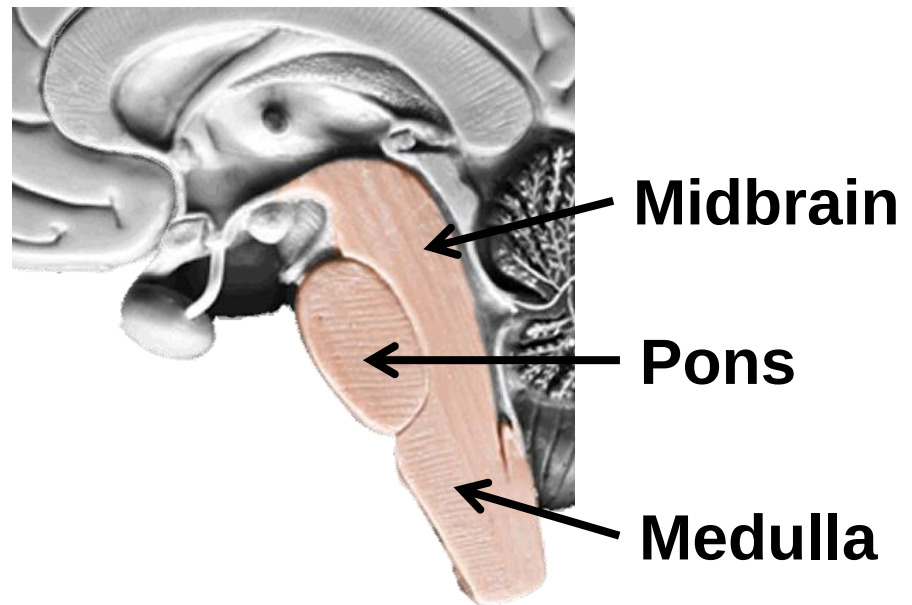
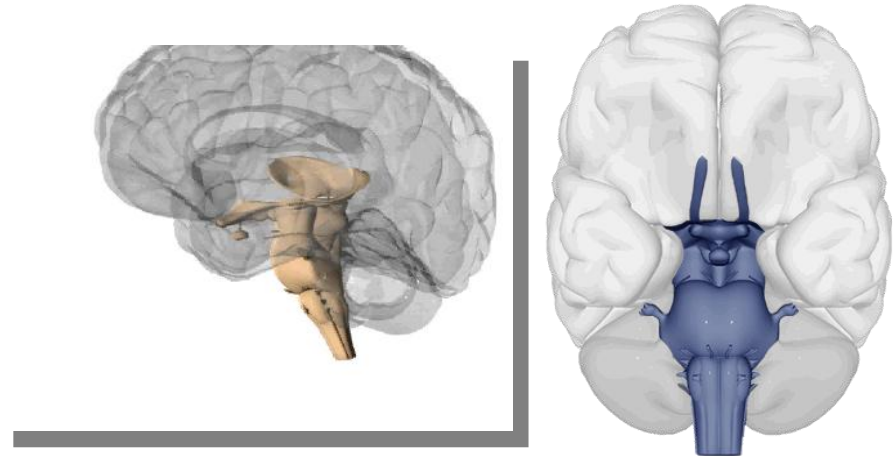
Cerebrospinal fluid fills the [ventricles](#) and [meninges](#), allowing the brain to “float” within the skull.



The Brainstem

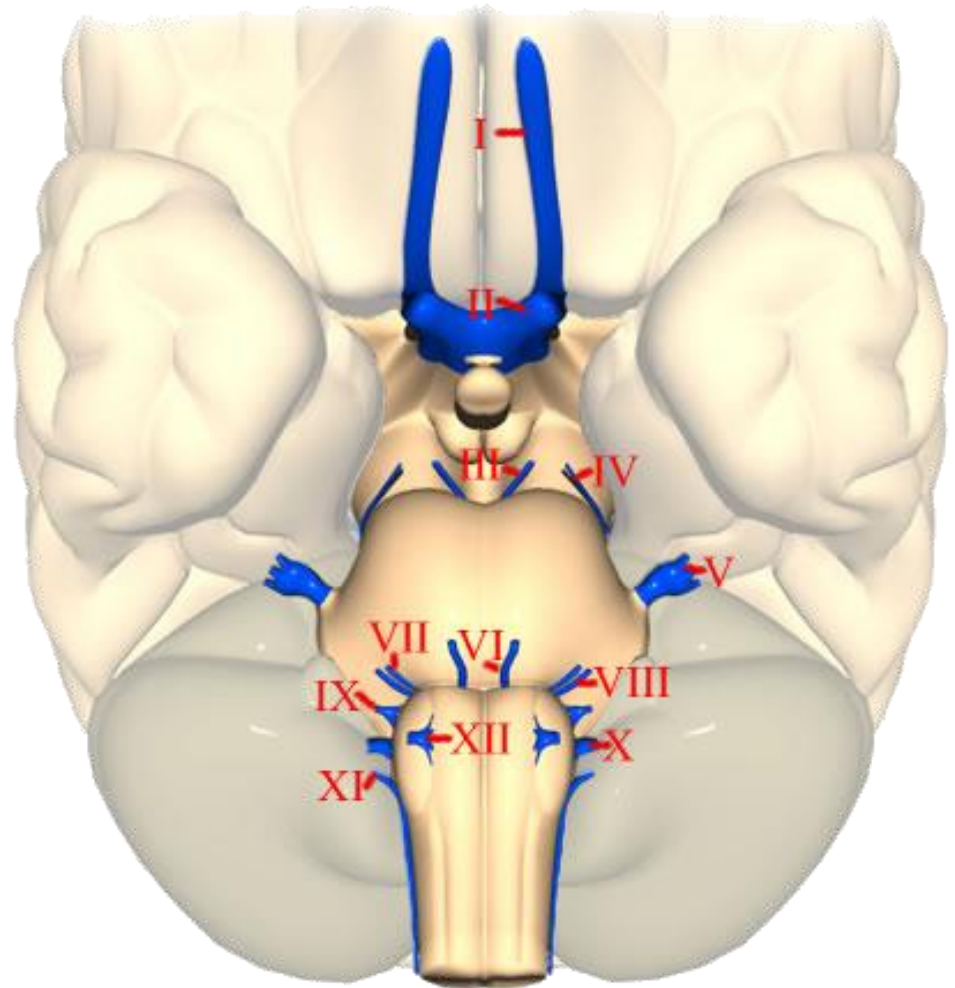
The brainstem is the most primitive part of the brain and controls the **basic functions of life**: breathing, heart rate, swallowing, reflexes to sight or sound, sweating, blood pressure, sleep, and balance.

The brainstem can be divided into three major sections.



The Cranial Nerves

- I. Olfactory nerve
- II. Optic nerve
- III. Oculomotor nerve
- IV. Trochlear nerve
- V. Trigeminal nerve
- VI. Abducens nerve
- VII. Facial nerve
- VIII. Vestibulocochlear nerve
- IX. Glossopharyngeal nerve
- X. Vagus nerve
- XI. Accessory nerve
- XII. Hypoglossal nerve



Brain Functions

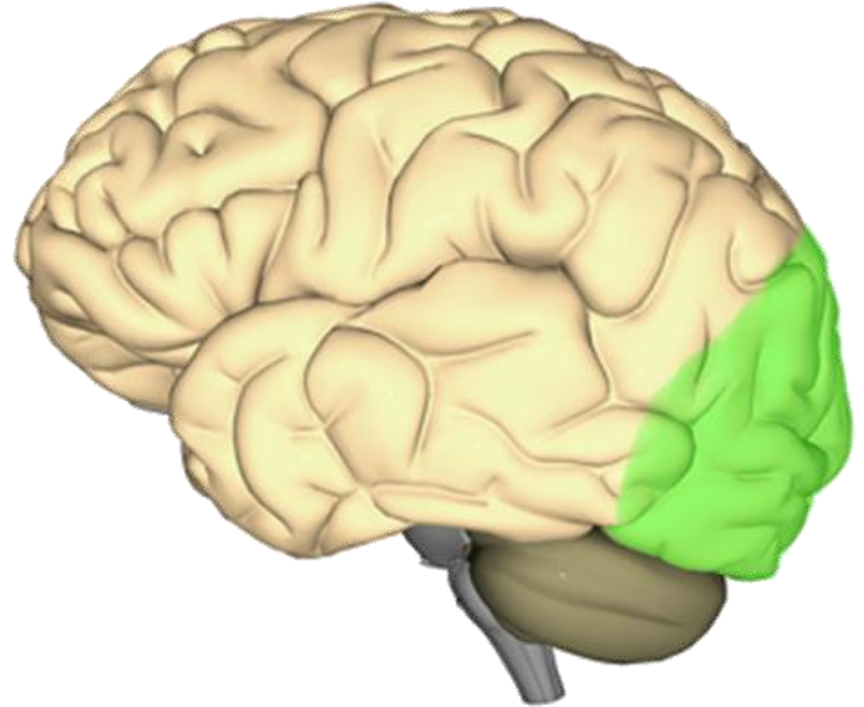
- Vision
- Taste
- Cognition
- Emotion
- Speech
- Language
- Hearing
- Motor Cortex
- Sensory Cortex
- Autonomic Functions

Vision

The visual cortex resides in the occipital lobe of the brain.

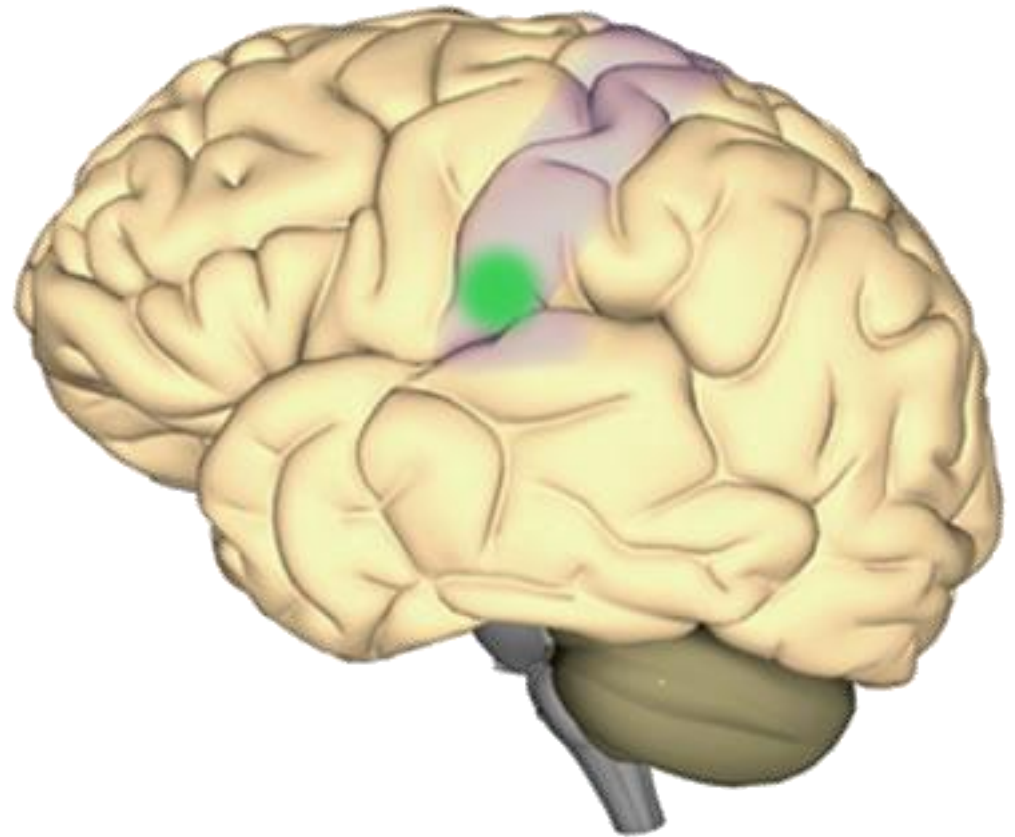
Sensory impulses travel from the eyes via the optic nerve to the visual cortex.

Damage to the visual cortex can result in blindness.



Taste

The gustatory complex (green circle) is the part of the sensory cortex (purple area) that is responsible for taste.

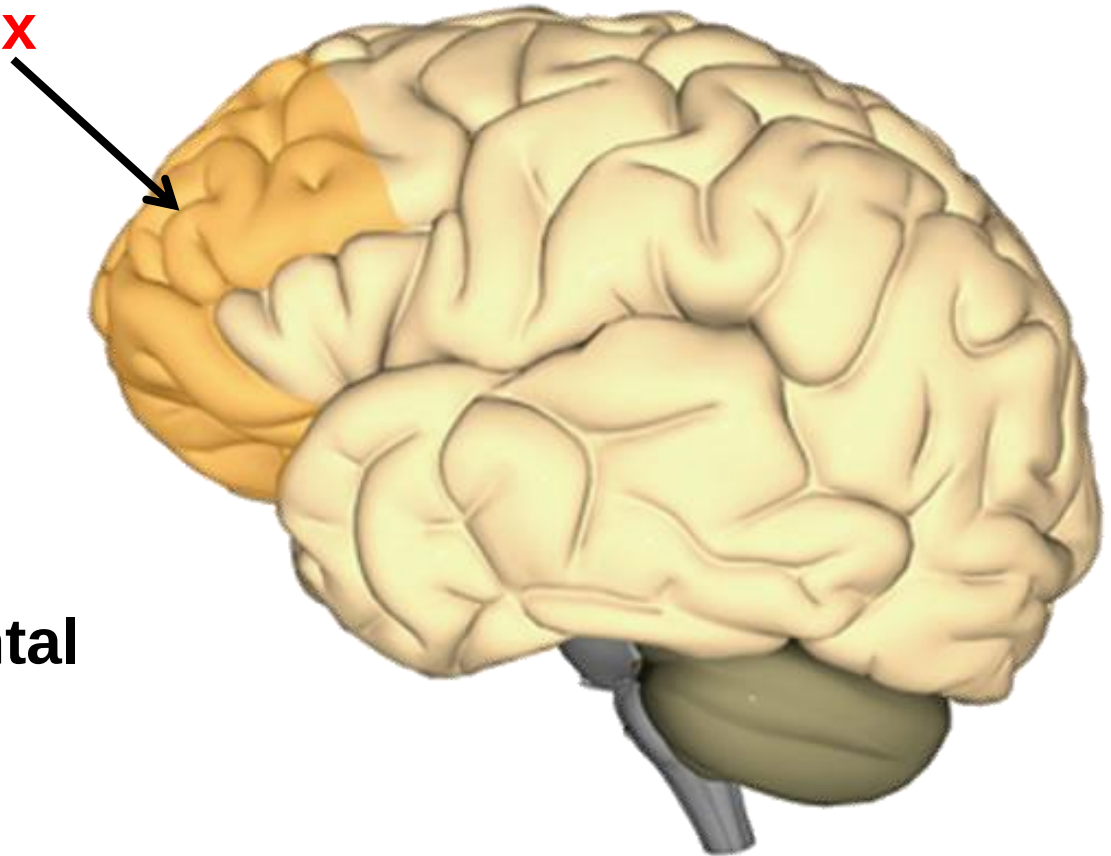


Cognition

The **prefrontal cortex** is involved with:

- Intellect
- complex learning
- personality.

Injuries to the front lobe can cause mental and personality changes.



Emotion

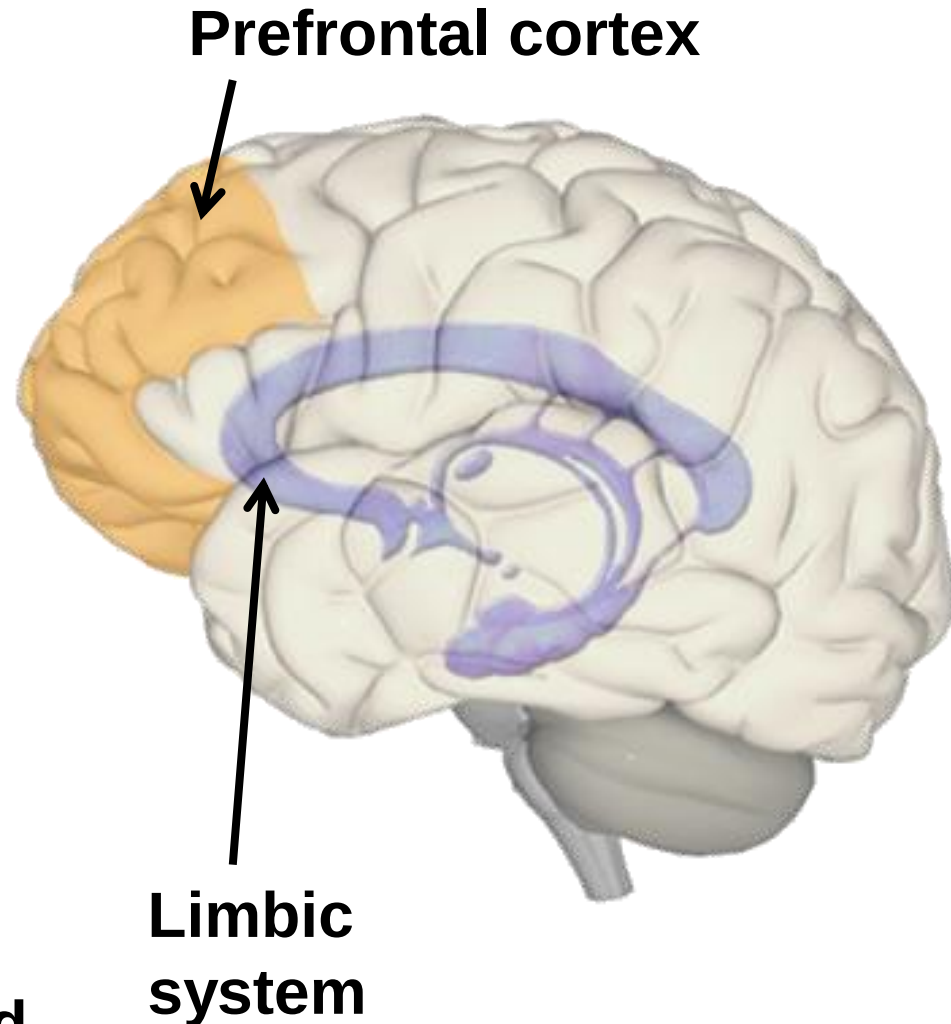
Emotions are an extremely complex brain function.

The emotional core of the brain is the limbic system.

This is where senses and awareness are first processed in the brain.

Mood and personality are mediated through the prefrontal cortex.

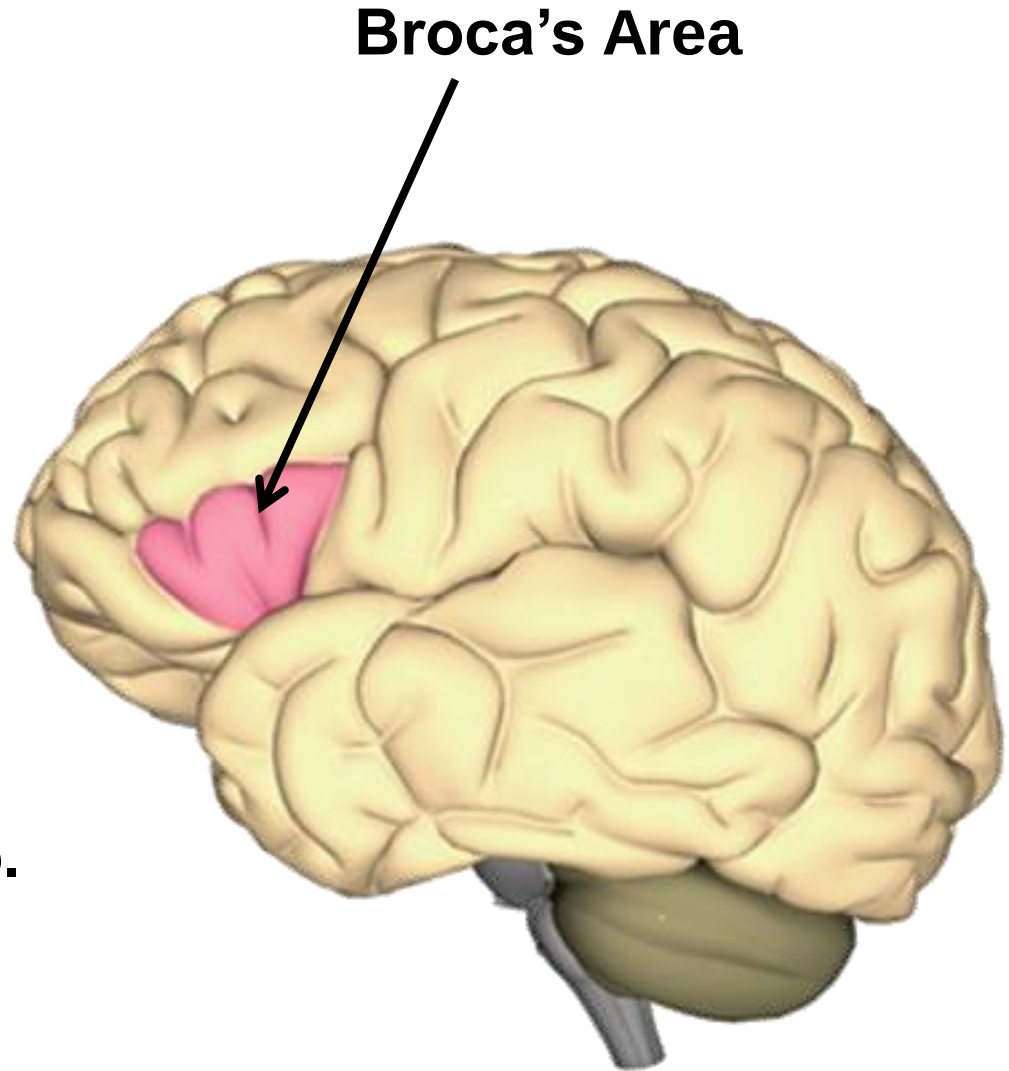
This part of the brain is the center of higher cognitive and emotional functions.



Speech

Broca's area is where we **formulate speech** and the area of the brain that sends **motor instructions** to the motor cortex.

Injury to Broca's area can cause difficulty in speaking. The individual may know what words he or she wishes to speak, but will be unable to do so.

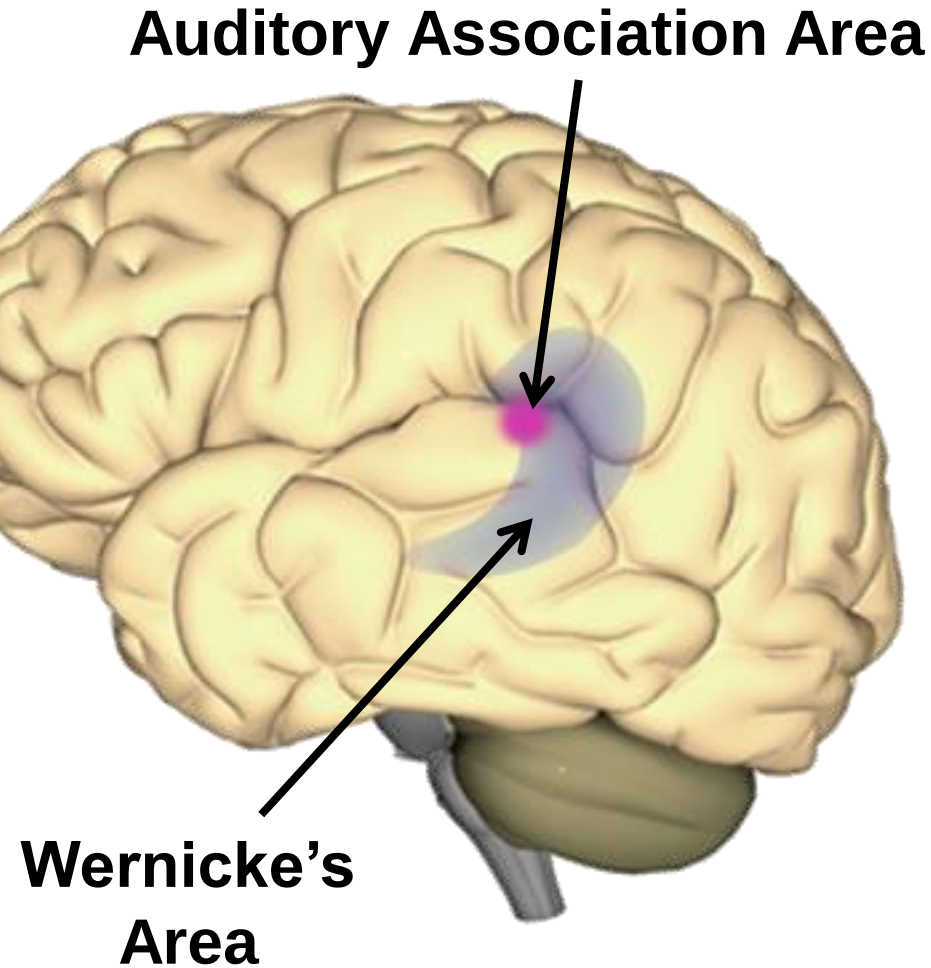


Language

Wernicke's area is a specialized portion of the parietal lobe that recognizes and understands written and spoken language.

Wernicke's area surrounds the [auditory association area](#).

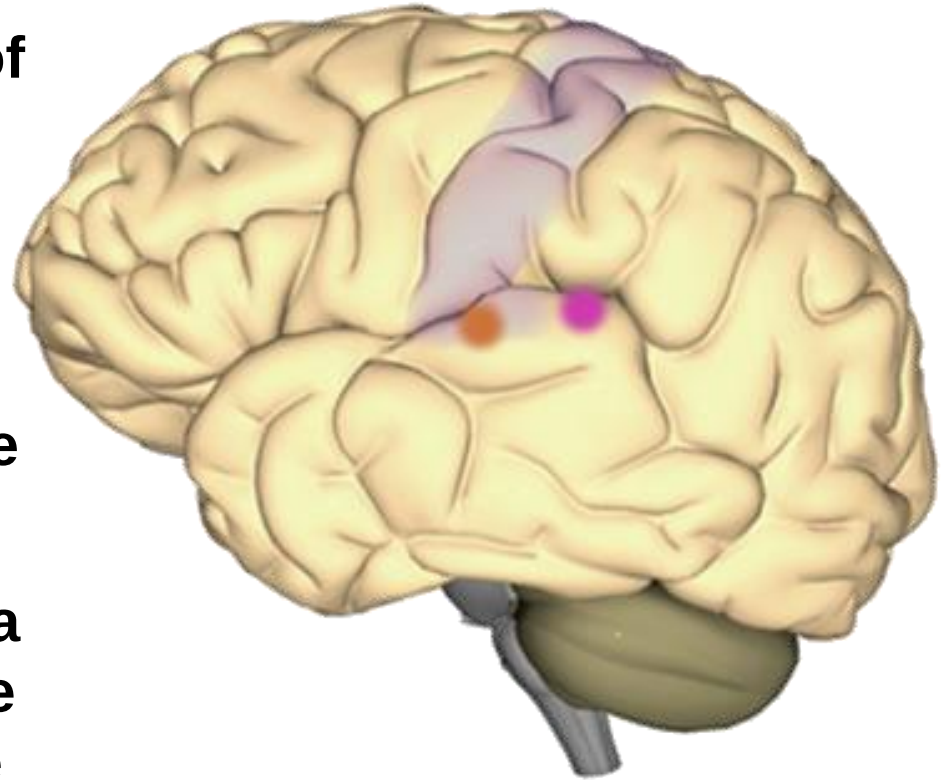
Damage to this part of the brain can result in someone hearing speech, but not understanding it.



Hearing

There are two auditory areas of the brain:

- The primary auditory area (brown circle) is what detects sounds that are transmitted from the ear. It is located in the [sensory cortex](#).
- The auditory association area (purple circle) is the part of the brain that is used to recognize the sounds as speech, music, or noise.



Motor Cortex

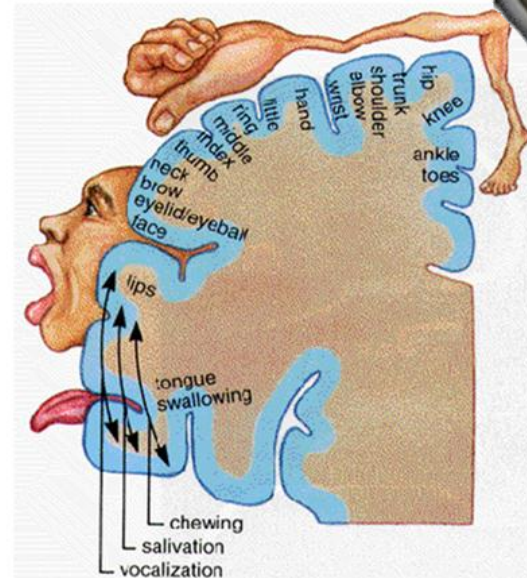
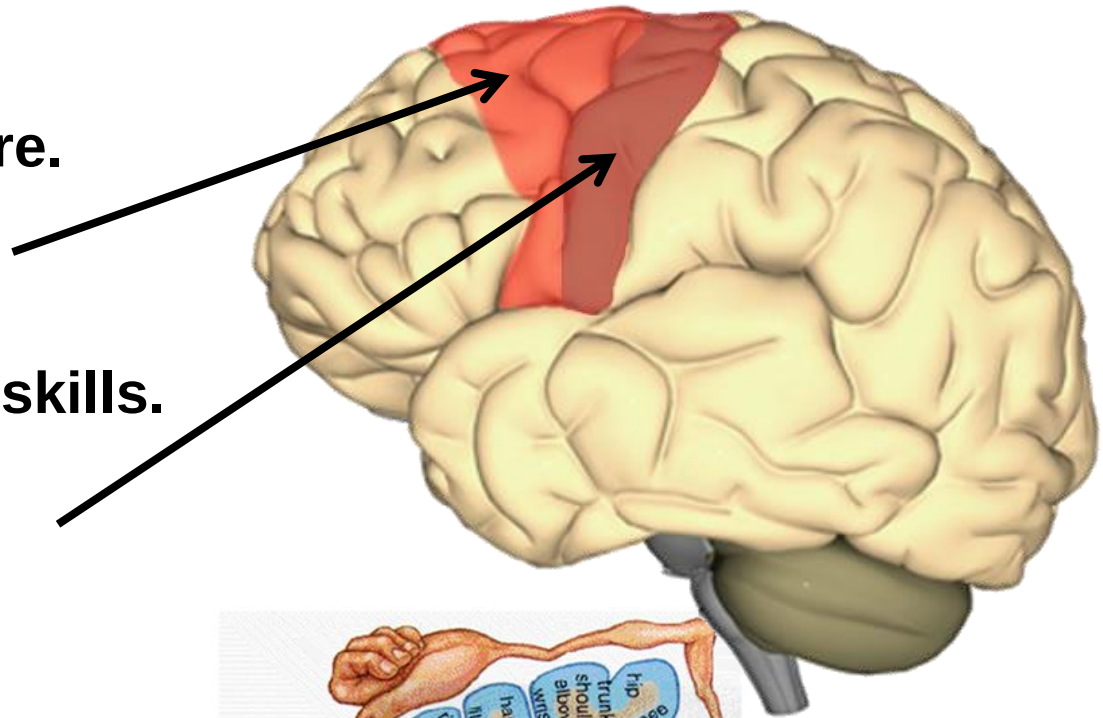
The motor portion of the cerebrum is illustrated here.

The **premotor cortex** is responsible for repetitive motions of learned motor skills.

The **primary motor area** is responsible for control of skeletal muscles.

Different areas of the brain are associated with different parts of the body.

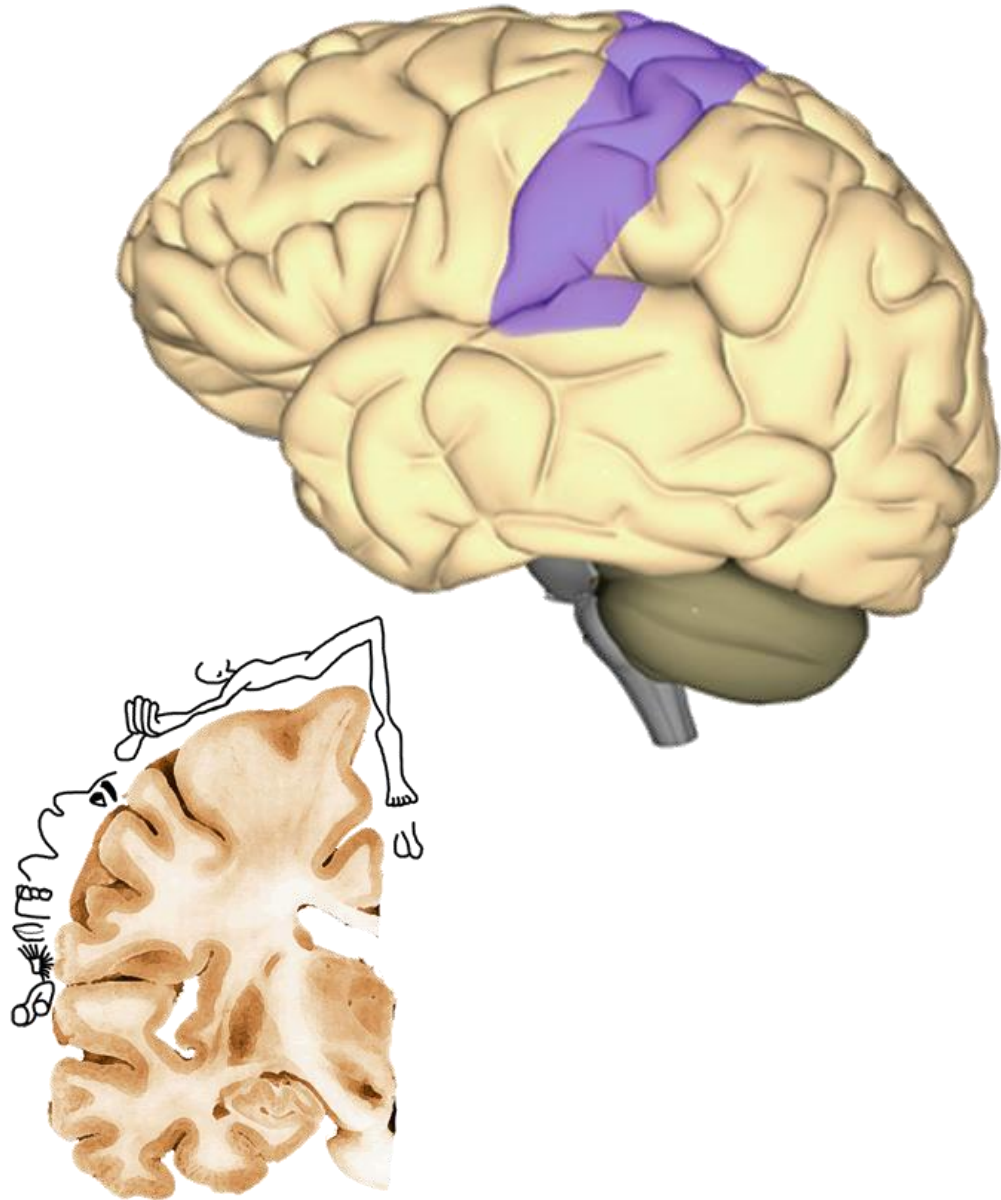
Injury to the motor cortex can result in motor disturbance in the associated body part.



Sensory Cortex

Different areas of the brain are associated with different parts of the body, as can be seen below.

Injury to the sensory cortex can result in sensory disturbance in the associated body part.

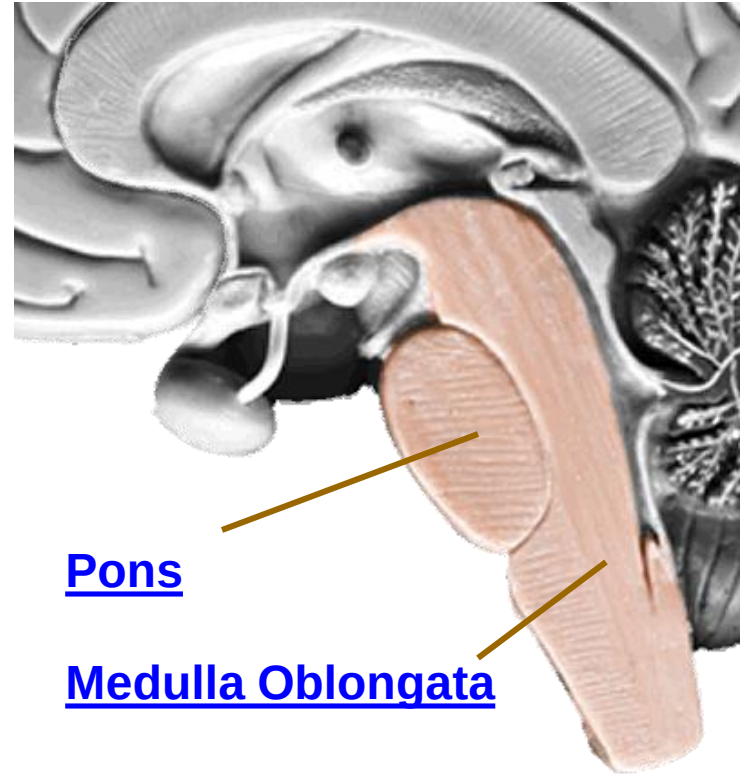


Autonomic Functions

The brainstem controls the basic functions of life.

Damage to these areas of the brain are usually fatal:

- The pons plays a critical role in respiration.
- The medulla oblongata is responsible for respiration and cardiovascular functions.



Phineas Gage's story

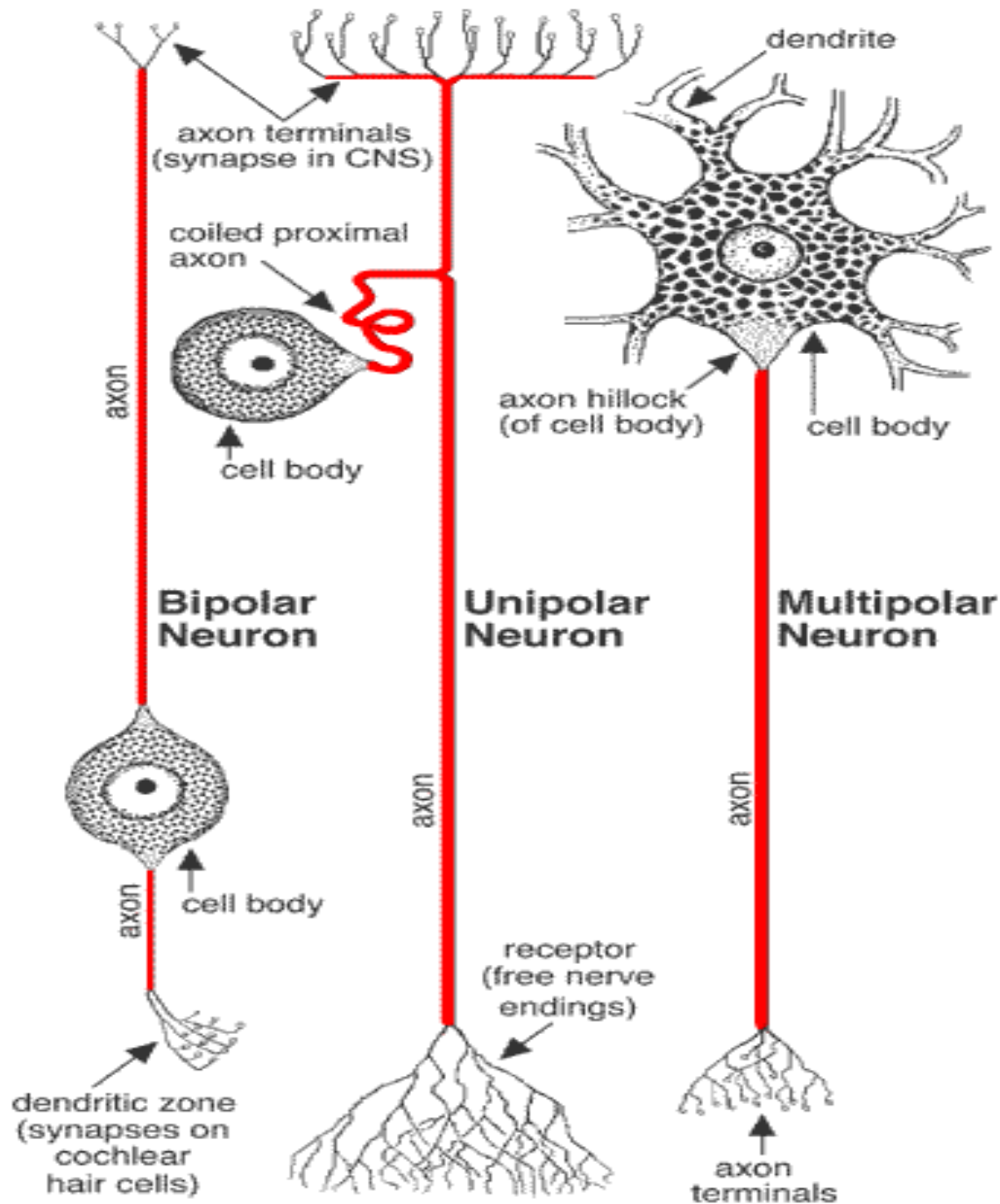


http://en.wikipedia.org/wiki/Phineas_Gage

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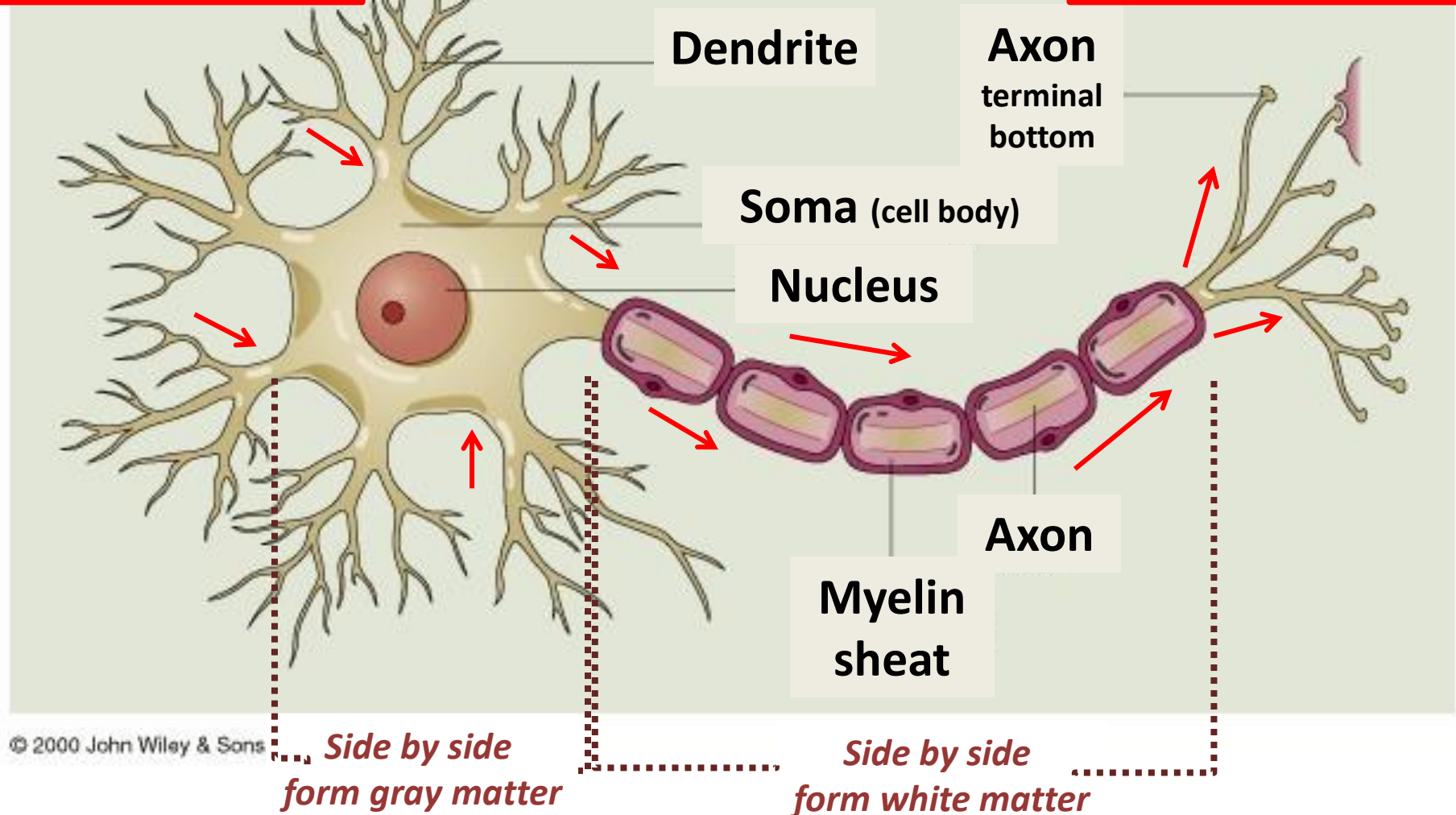
Neurons



The neuron

Collects impulse
from a nerve cell or
a sensory organ

Transmits info to
other neurons



TYPES OF NEURONS

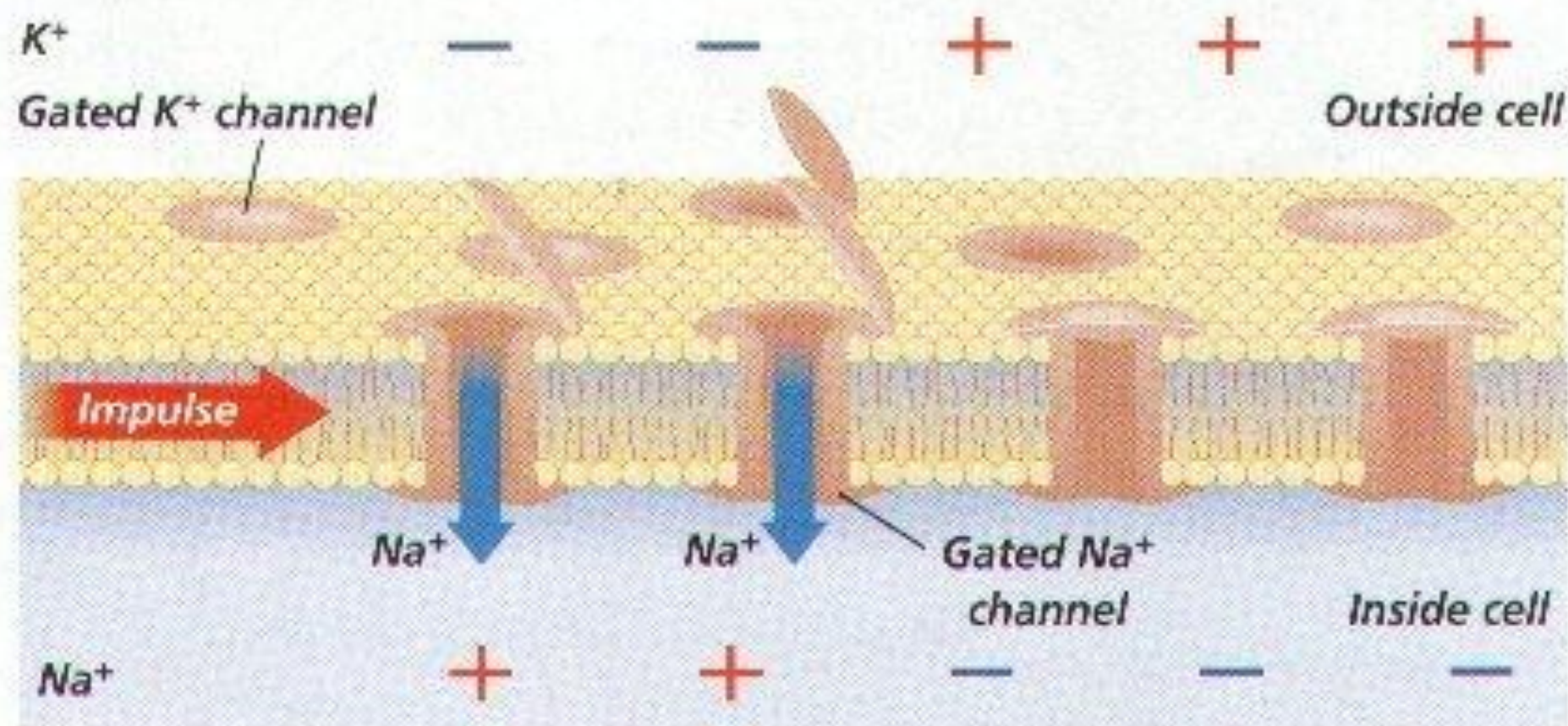
- *Afferent or sensory neurons*: neurons that receive stimuli from the outside environment and transmit them toward the brain.
- *Efferent neurons, motor neurons*, or *motoneurons*: neurons that carry impulses in the opposite direction, away from the brain and other nerve centers to muscles
- *Interneuron*: neurons found in the brain and spinal cord, conducts impulses from afferent to efferent neurons.

A nerve impulse is “all-or-none”

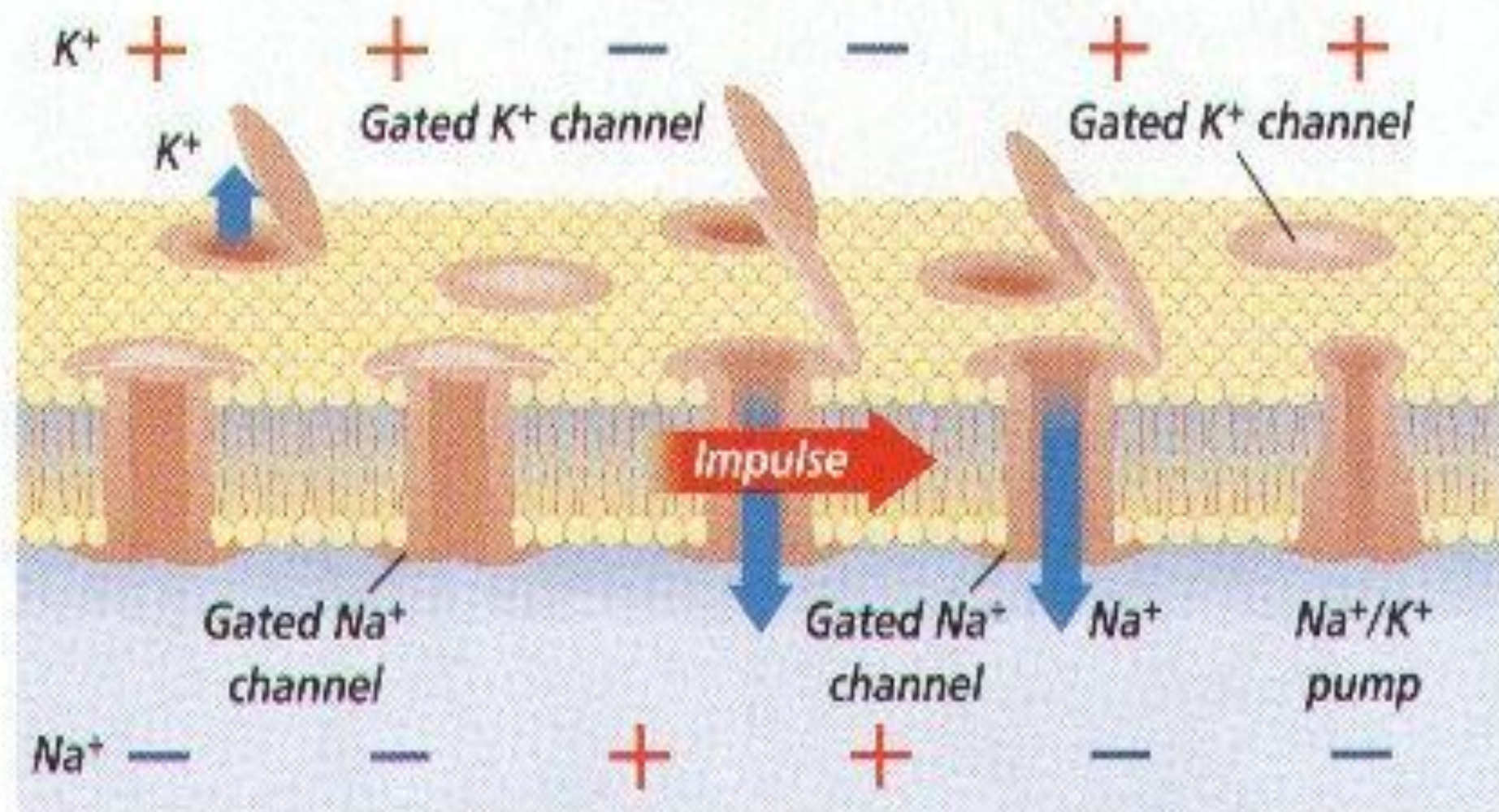
... it either goes or not, and there's no halfway!

- A neuron needs a **threshold stimulus**, the minimum level of stimulus needed, to trigger the Na-K pump to go and the impulse to travel.
- A neuron cannot immediately fire again; it needs time for the sodium and potassium to return to their places and everything to return to normal. This time is called the **refractory period**.

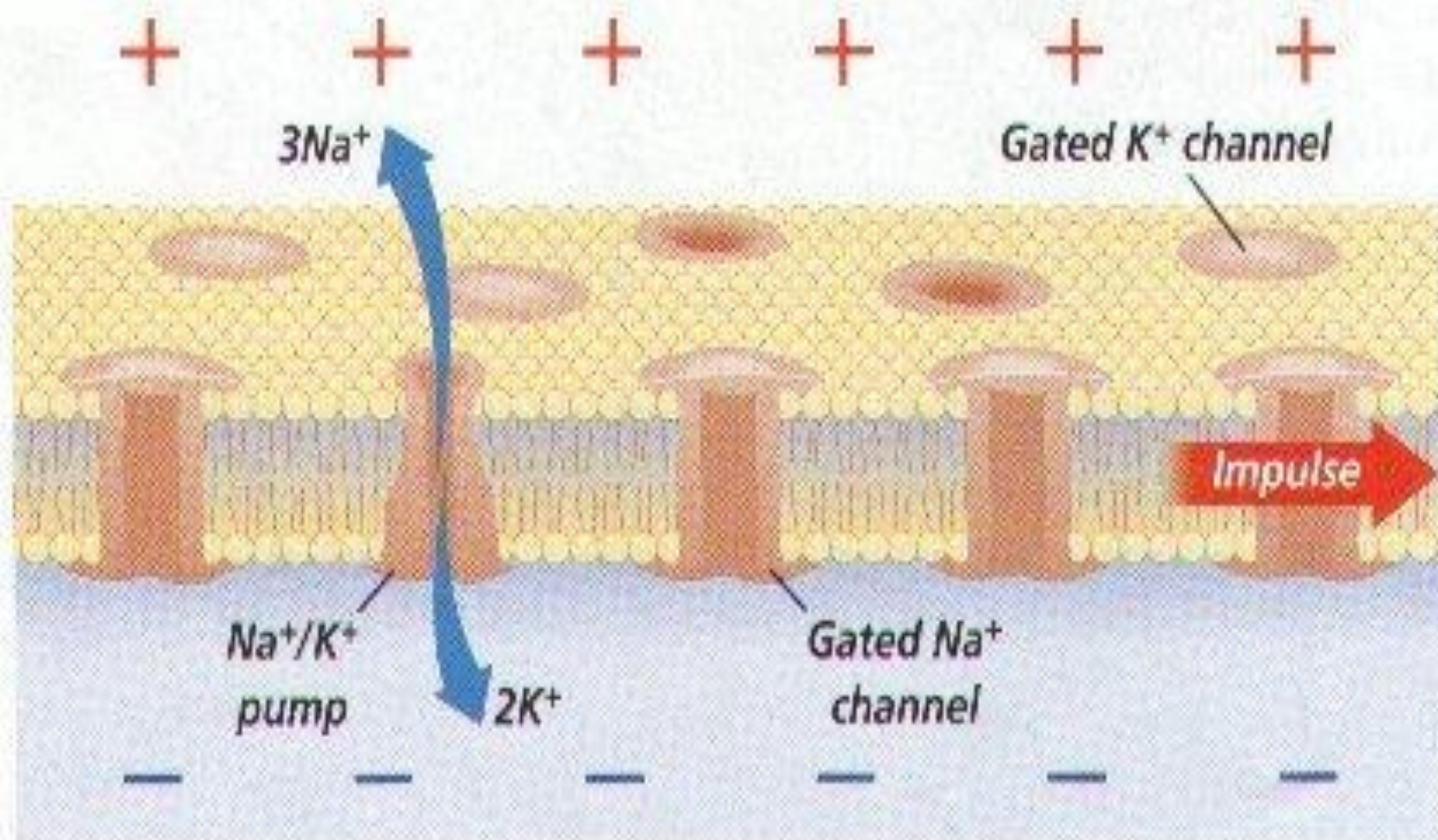
A wave of depolarization moves down the axon of a neuron.



- A** Gated sodium channels open, allowing sodium ions to enter and make the inside of the cell positively charged and the outside negatively charged.

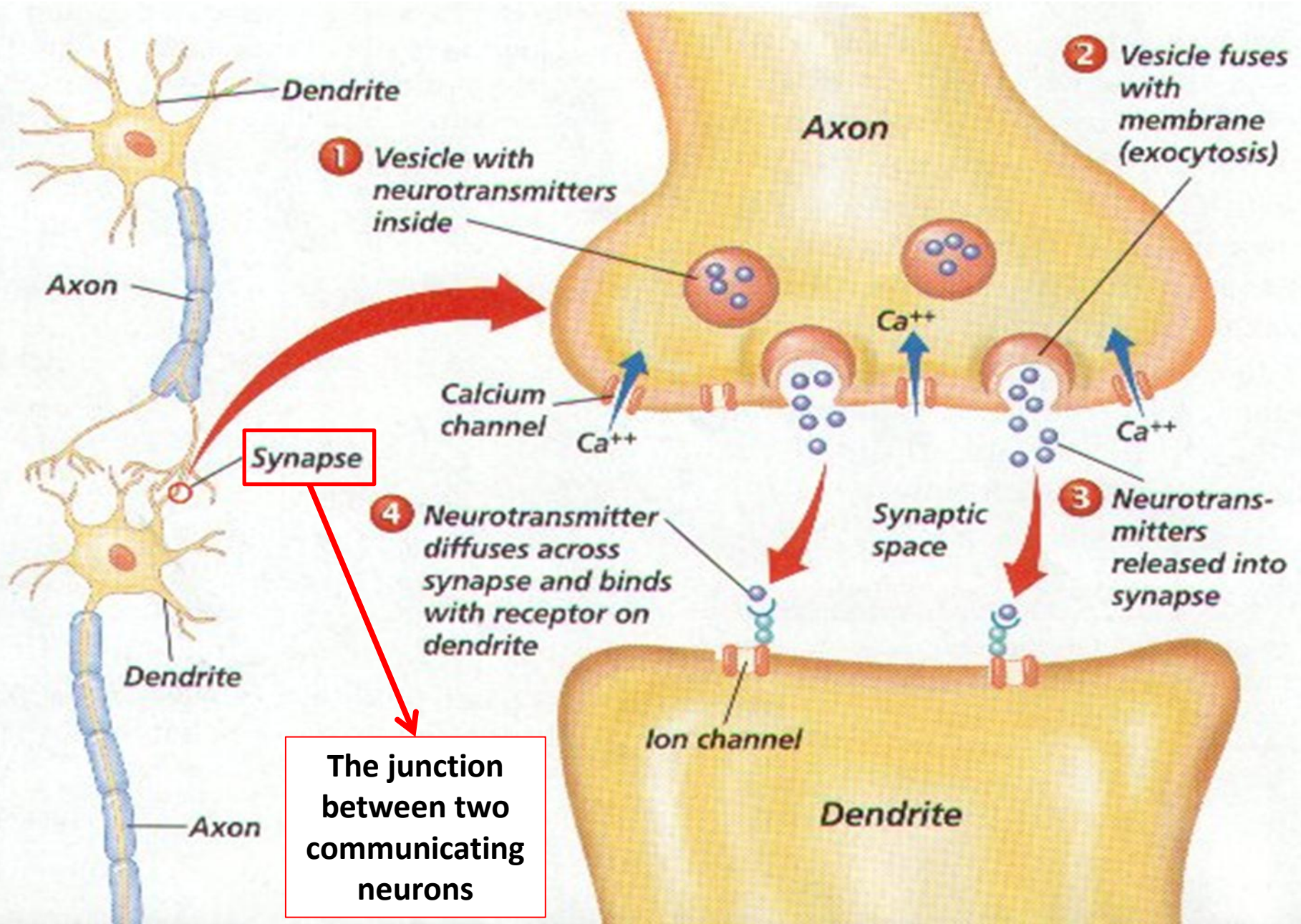


- B** As the impulse passes, gated sodium channels close, stopping the influx of sodium ions. Gated potassium channels open, letting potassium ions out of the cell. This action repolarizes the cell.



- C** As gated potassium channels close, the Na^+/K^+ pump restores the ion distribution.

Synaptic Transmission



Neurotransmitters:

Excitatory and Inhibitory Actions

- Neurotransmitters that **increase postsynaptic membrane permeability to sodium ions** may trigger impulses and are thus **excitatory**.
- Other neurotransmitters may **decrease membrane permeability to sodium ions**, reducing the chance that it will reach threshold, and are thus **inhibitory**.
- The effect of the postsynaptic neuron depends on which presynaptic knobs are activated.

A matter of receptor!

The effects of Acetylcholine (ACh) and Norepinephrine (NE) on their effectors are not consistently either excitation or inhibition; the effect depends on both the neurotransmitter AND the receptor to which it attaches

- for example, when a somatic motor neuron releases ACh at a neuromuscular junction, it is excitatory → the skeletal muscle contracts
- however, when a parasympathetic, postganglionic motor neuron releases ACh at a cardiac muscle fiber, it is inhibitory → the heart rate of contraction slows down

General Functions of the Nervous System

Sensory receptors at the ends of peripheral nerves gather information and convert it into nerve impulses.

When sensory impulses are integrated in the brain as perceptions, this is the integrative function of the nervous system.

Conscious or subconscious decisions follow, leading to motor functions via effectors.

The nervous system sorts and interprets incoming information before directing a response.

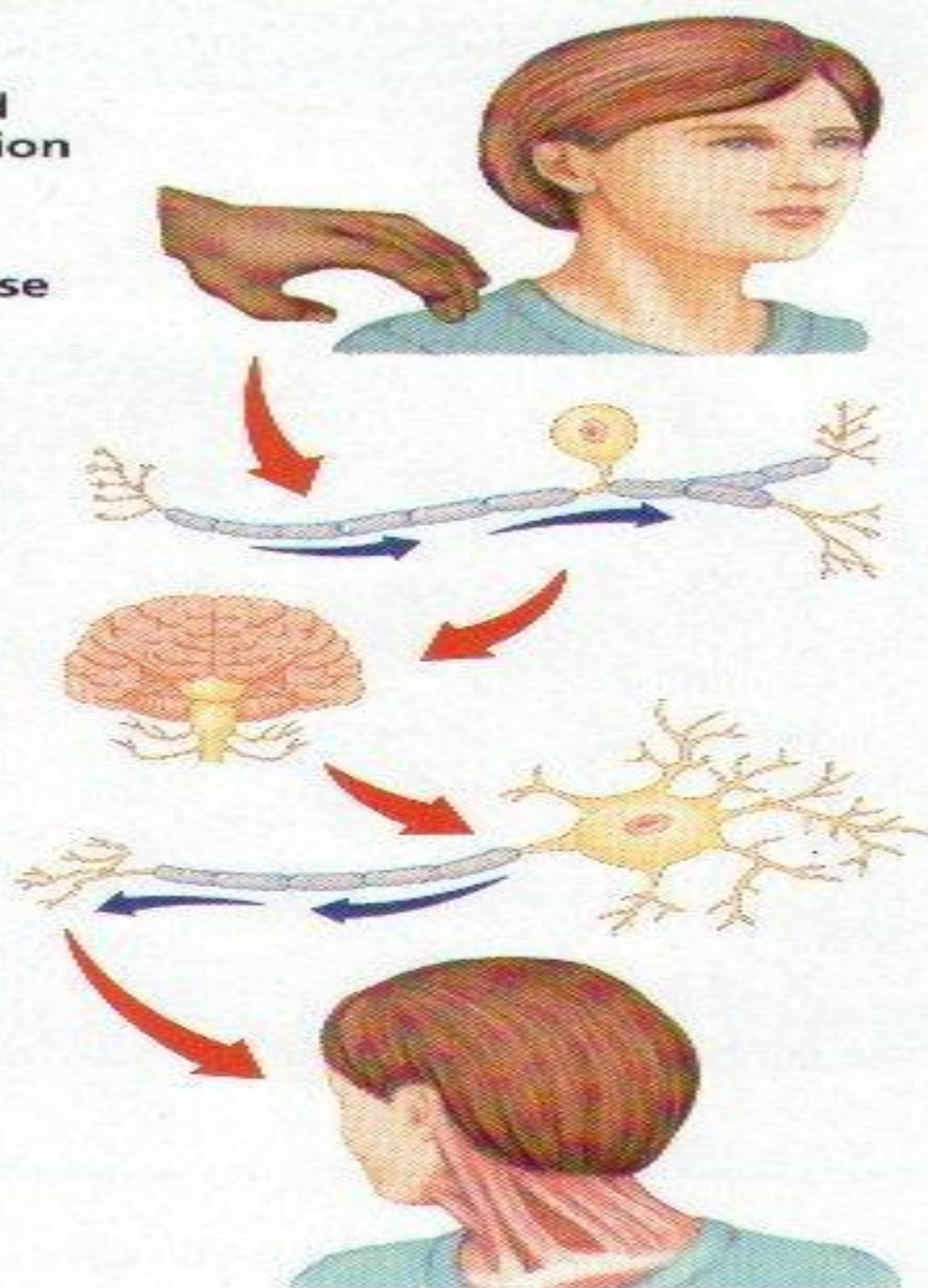
A Receptors in the skin sense a tap or other stimulus.

B Sensory neurons transmit the touch message.

C The message is interpreted. A response is sent to the motor neurons.

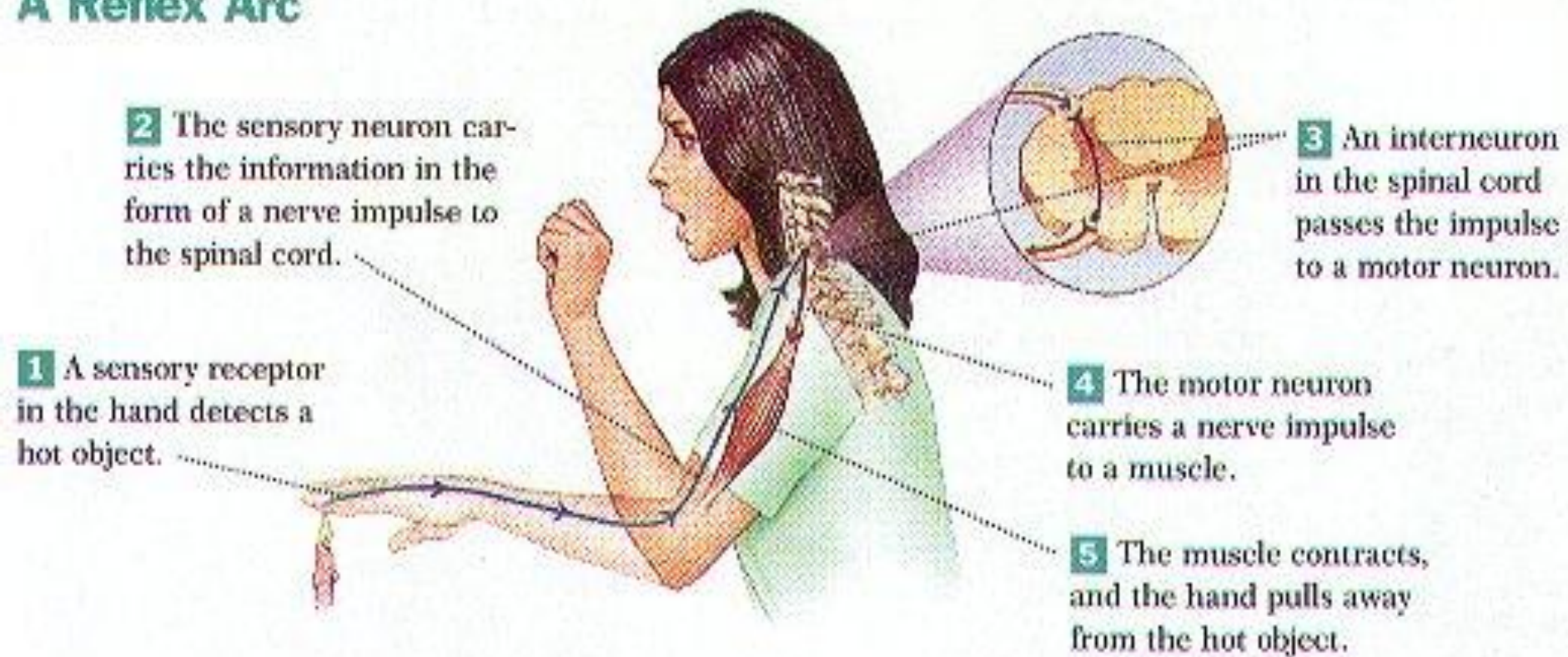
D Motor neurons transmit a response message to the shoulder muscles.

E The neck muscles are activated, causing the head to turn.



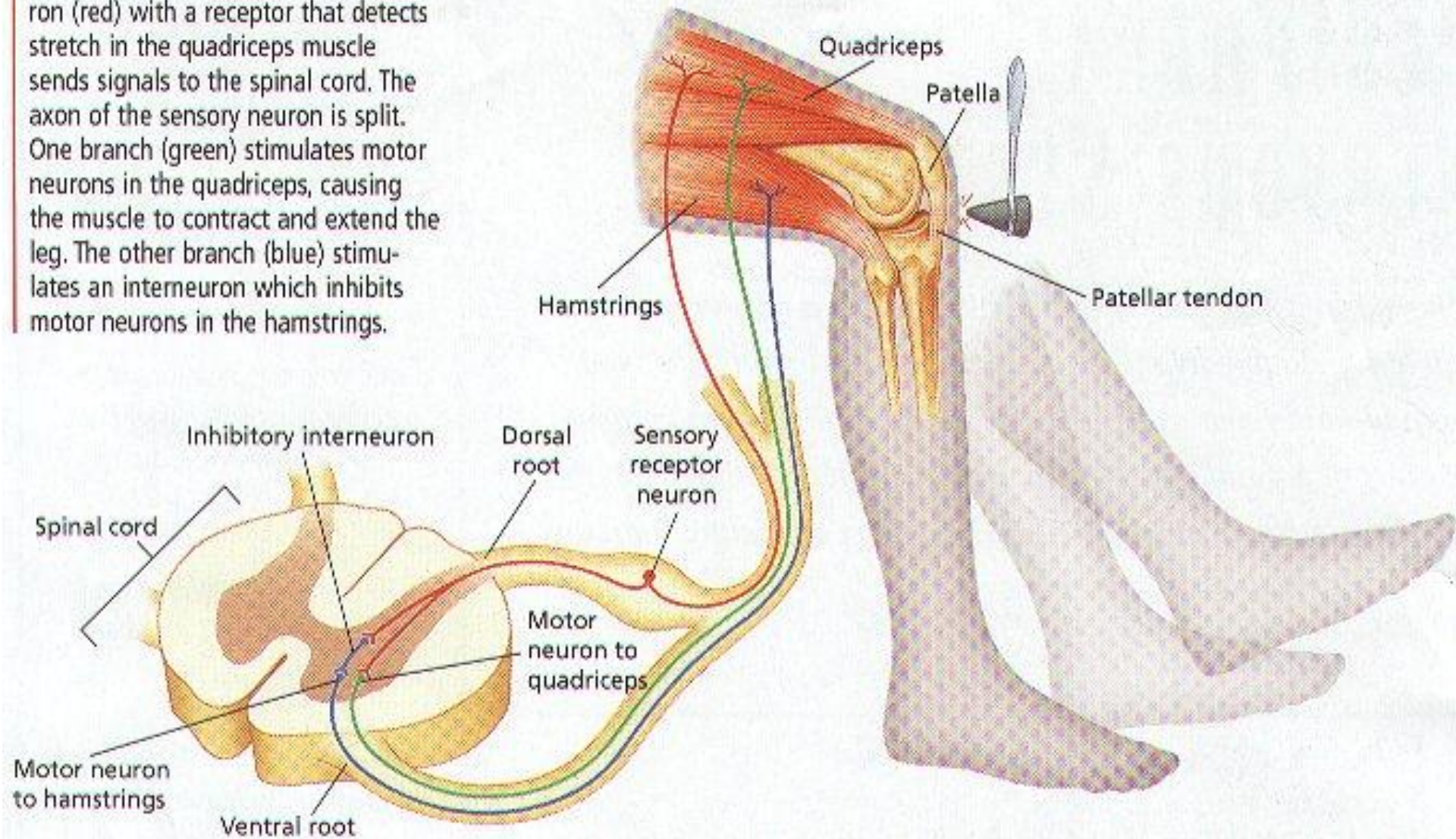
Reflex Arc

A Reflex Arc



Patellar reflex

In the patellar reflex, a sensory neuron (red) with a receptor that detects stretch in the quadriceps muscle sends signals to the spinal cord. The axon of the sensory neuron is split. One branch (green) stimulates motor neurons in the quadriceps, causing the muscle to contract and extend the leg. The other branch (blue) stimulates an interneuron which inhibits motor neurons in the hamstrings.



The digestive system

Subdivisions of the system

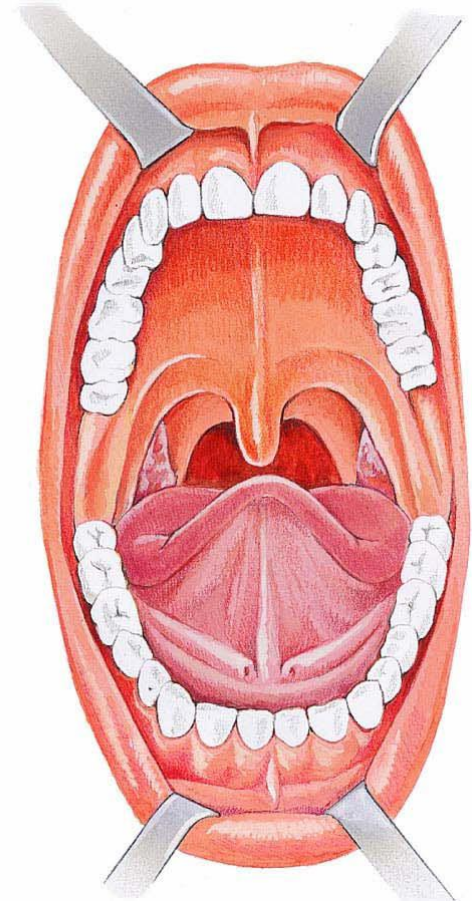
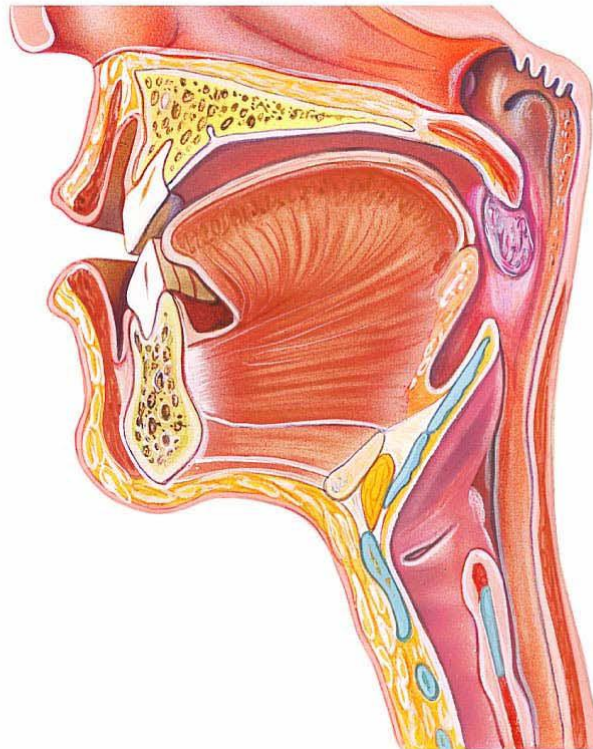
- Alimentary Canal
 - Tube through which food/waste actually passes
 - Mouth, pharynx, esophagus, stomach, SI, and LI
- Accessory Organs
 - Are connected to and involved with the alimentary canal –but no food/waste passes through them
 - Teeth, tongue, salivary glands, liver, gallbladder, and pancreas

Steps in Digestion:

- Ingestion
- Propulsion
- Mechanical Digestion
- Chemical Digestion
- Absorption
- Defecation

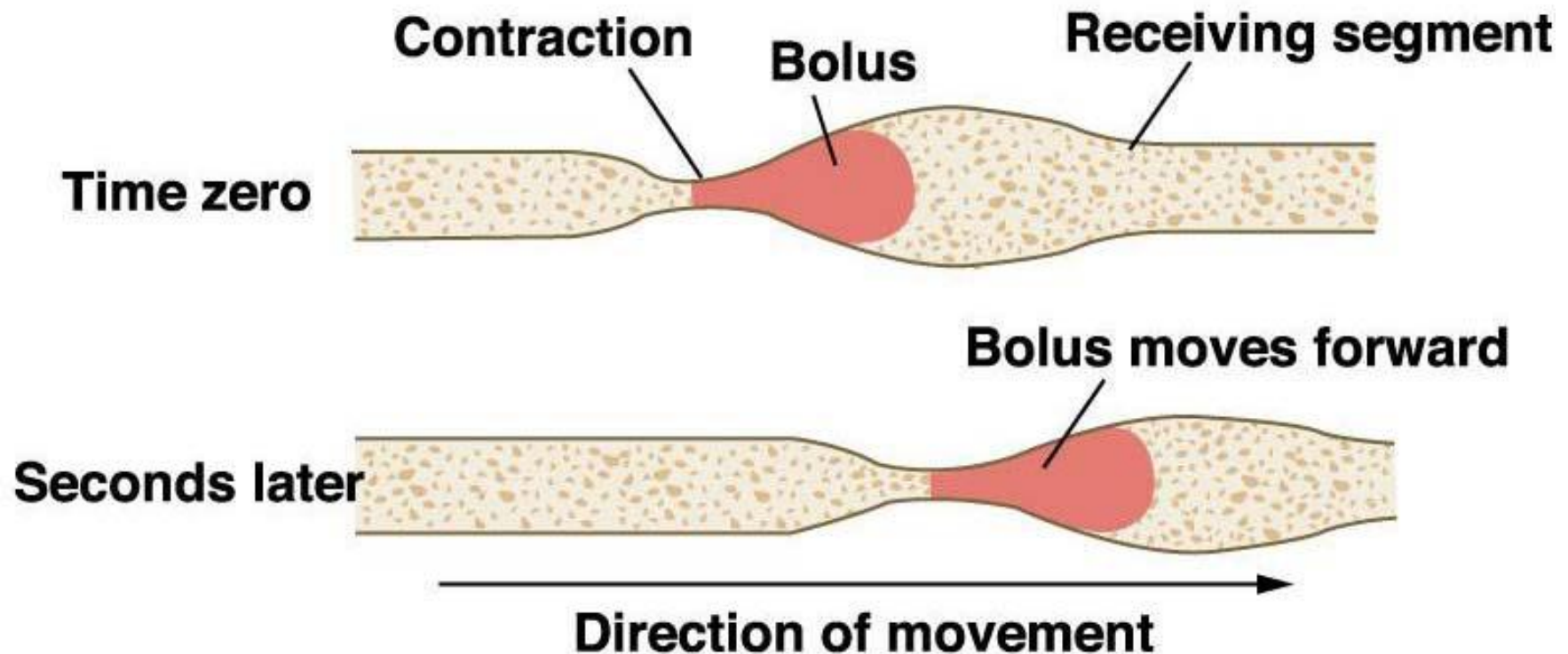
Ingestion

- Physical process



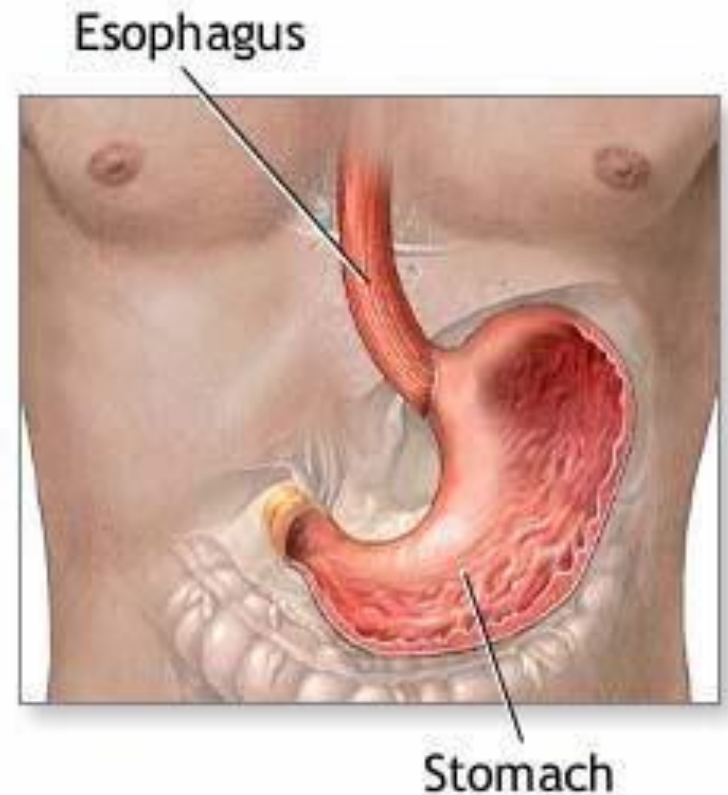
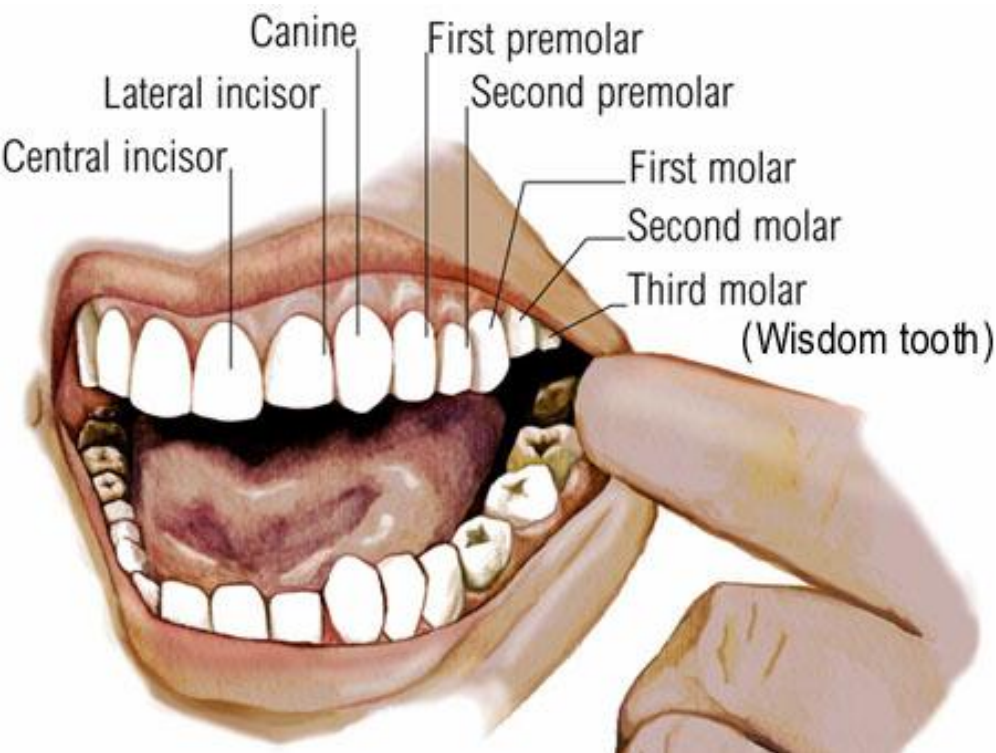
Propulsion – Deglutition & Peristalsis

Peristaltic contractions are responsible for forward movement



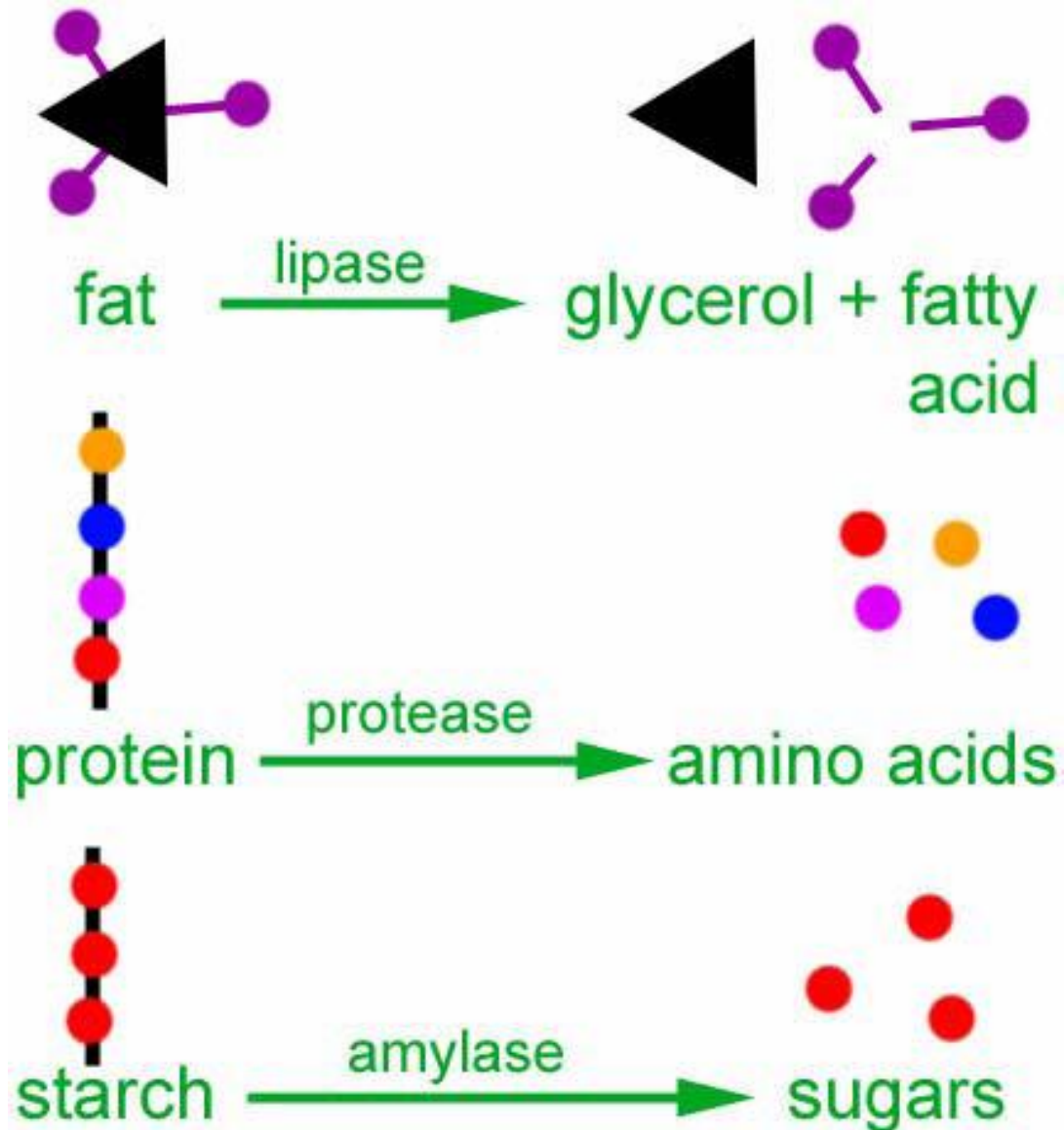
Mechanical Digestion

- Initially chewing, continued in stomach
- Function is to:



Chemical Digestion

- Three major nutrient types
- Where does each take place?
- What is the end product of each?

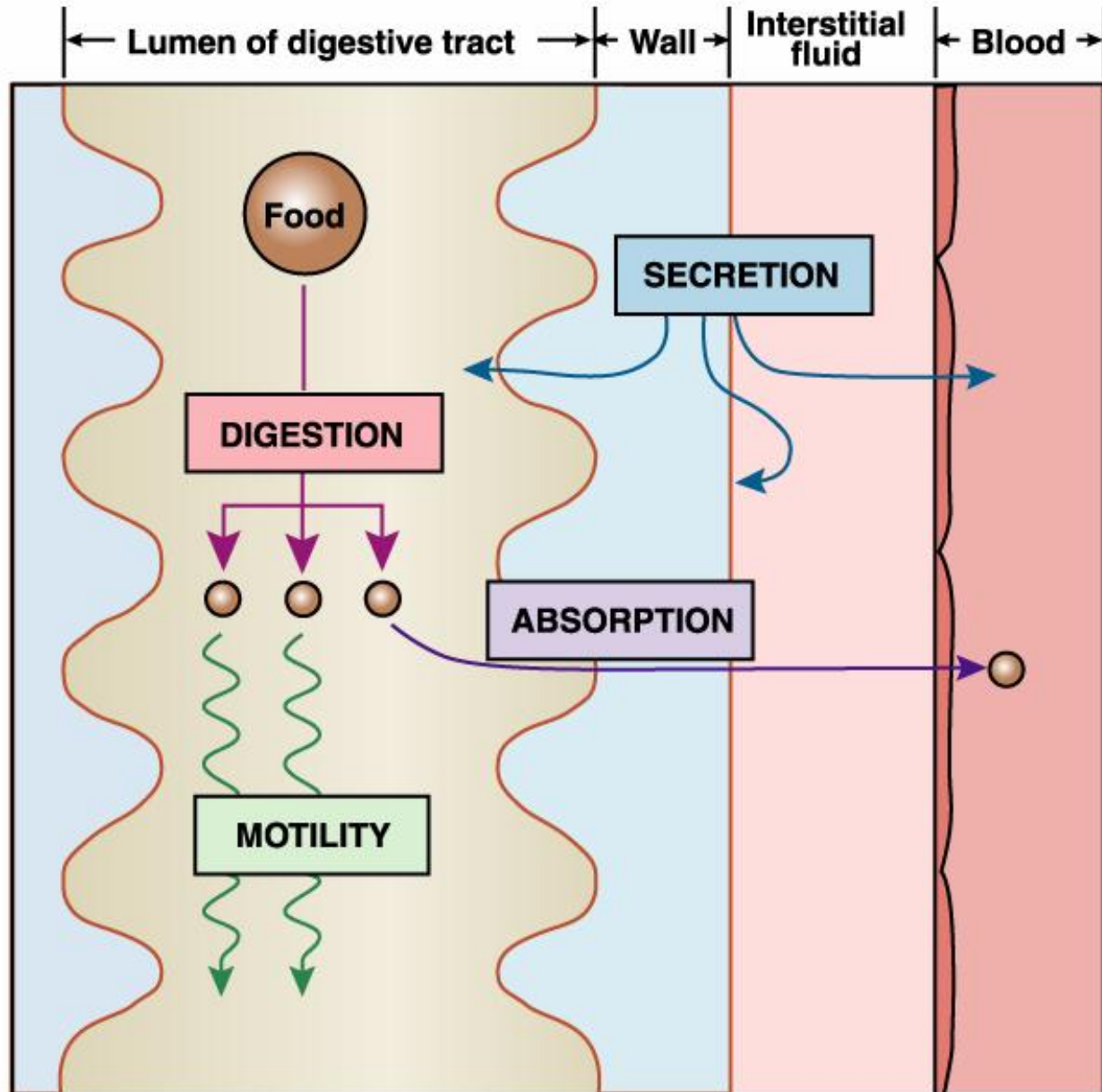


Absorption

- Where are nutrients absorbed?
- What is their next stop?



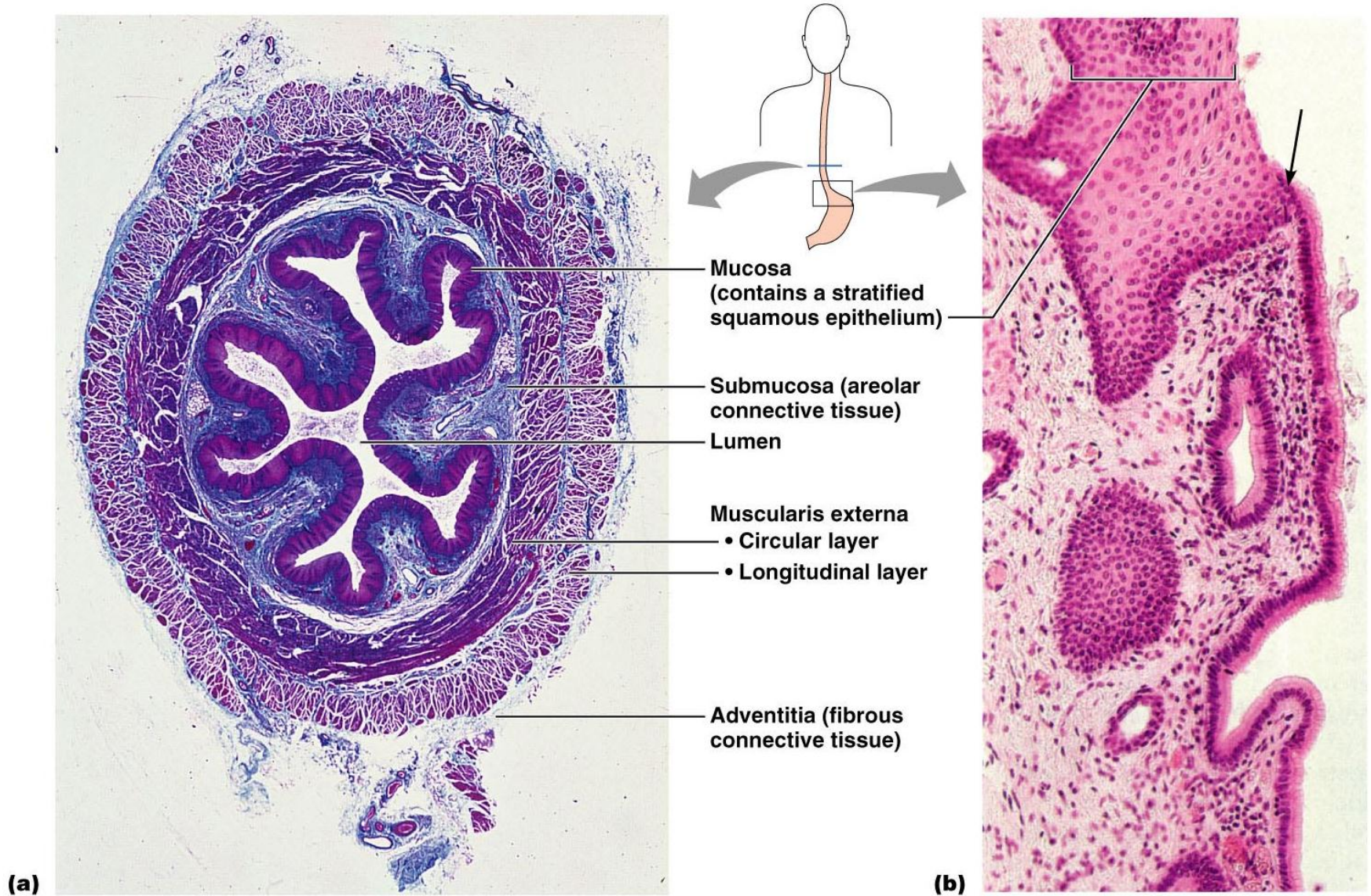
Defecation of waste



Digestive Processes in the Mouth

- **Mouth is a major player in gustatory system (Taste buds, saliva effect on aroma and tastes)**
- Food is ingested
- Mechanical digestion begins (chewing)
- Propulsion is initiated by swallowing
- Salivary amylase begins chemical breakdown of starch
- The pharynx and esophagus serve as conduits to pass food from the mouth to the stomach

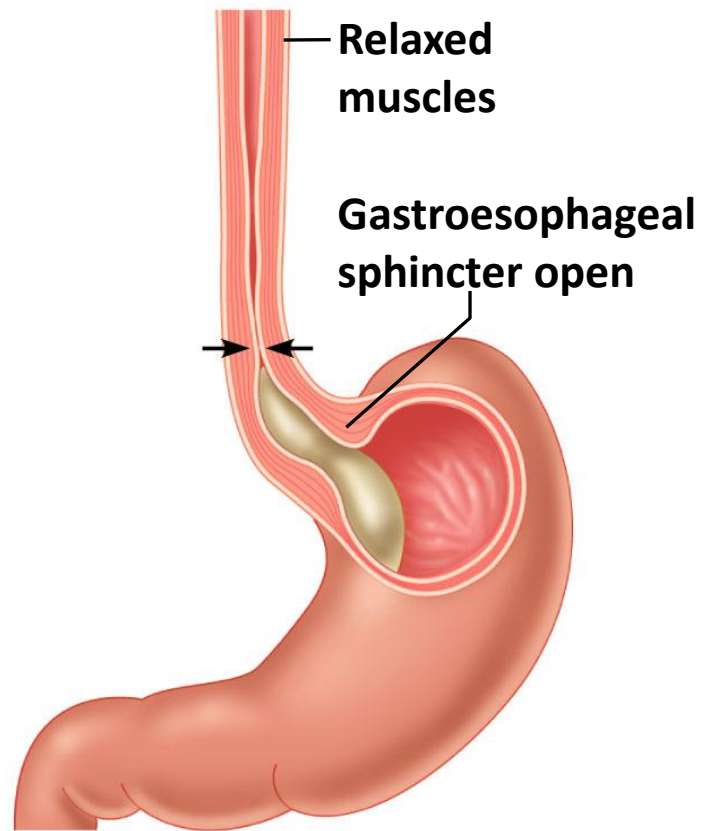
Esophagus



Deglutition (Swallowing)

- Coordinated activity of the tongue, soft palate, pharynx, esophagus, and 22 separate muscle groups
- Buccal phase – bolus is forced into the oropharynx
- Pharyngeal-esophageal phase – controlled by the medulla and lower pons
 - All routes except into the digestive tract are sealed off
- Peristalsis moves food through the pharynx to the esophagus

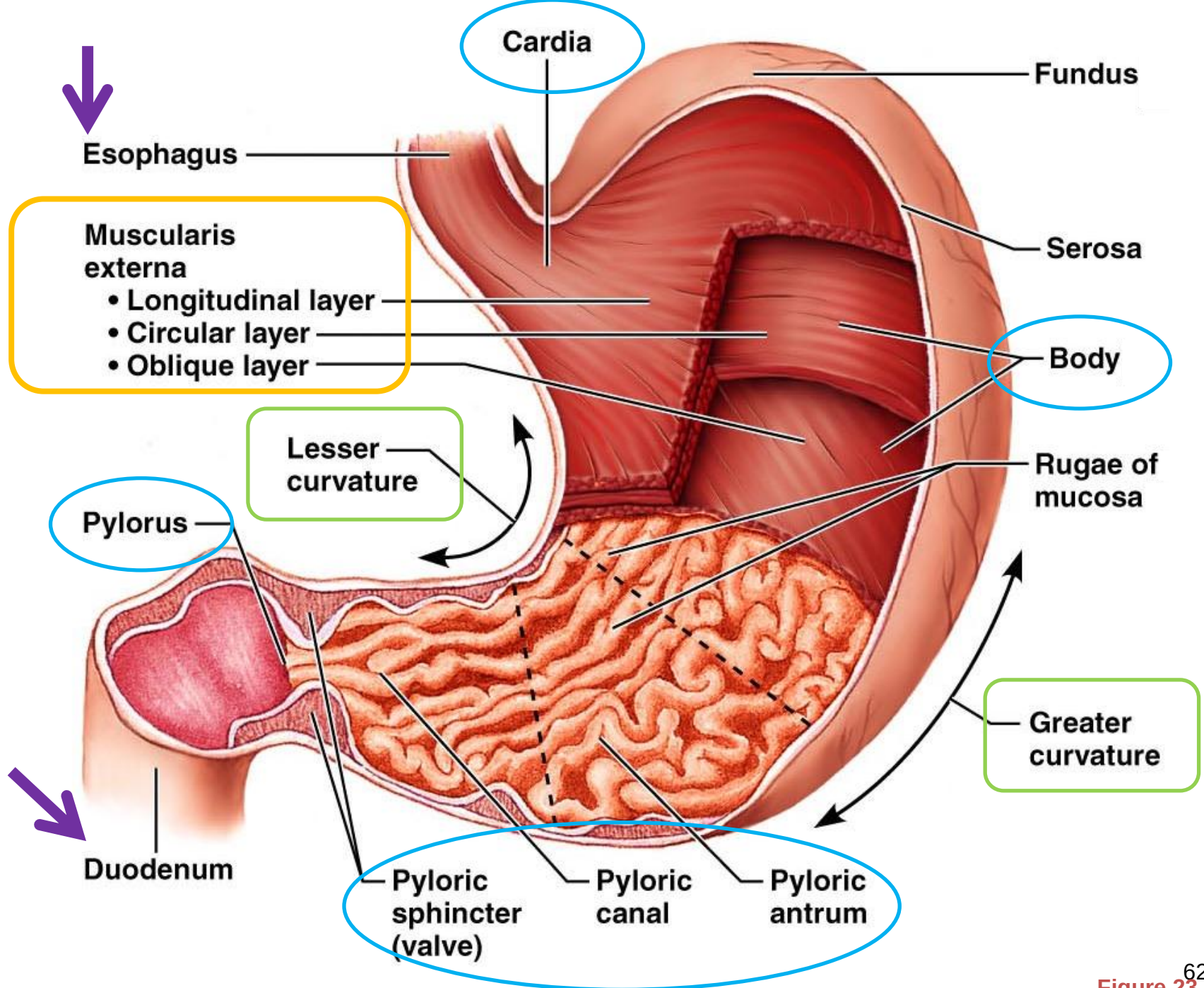
Deglutition (Swallowing)



(e)

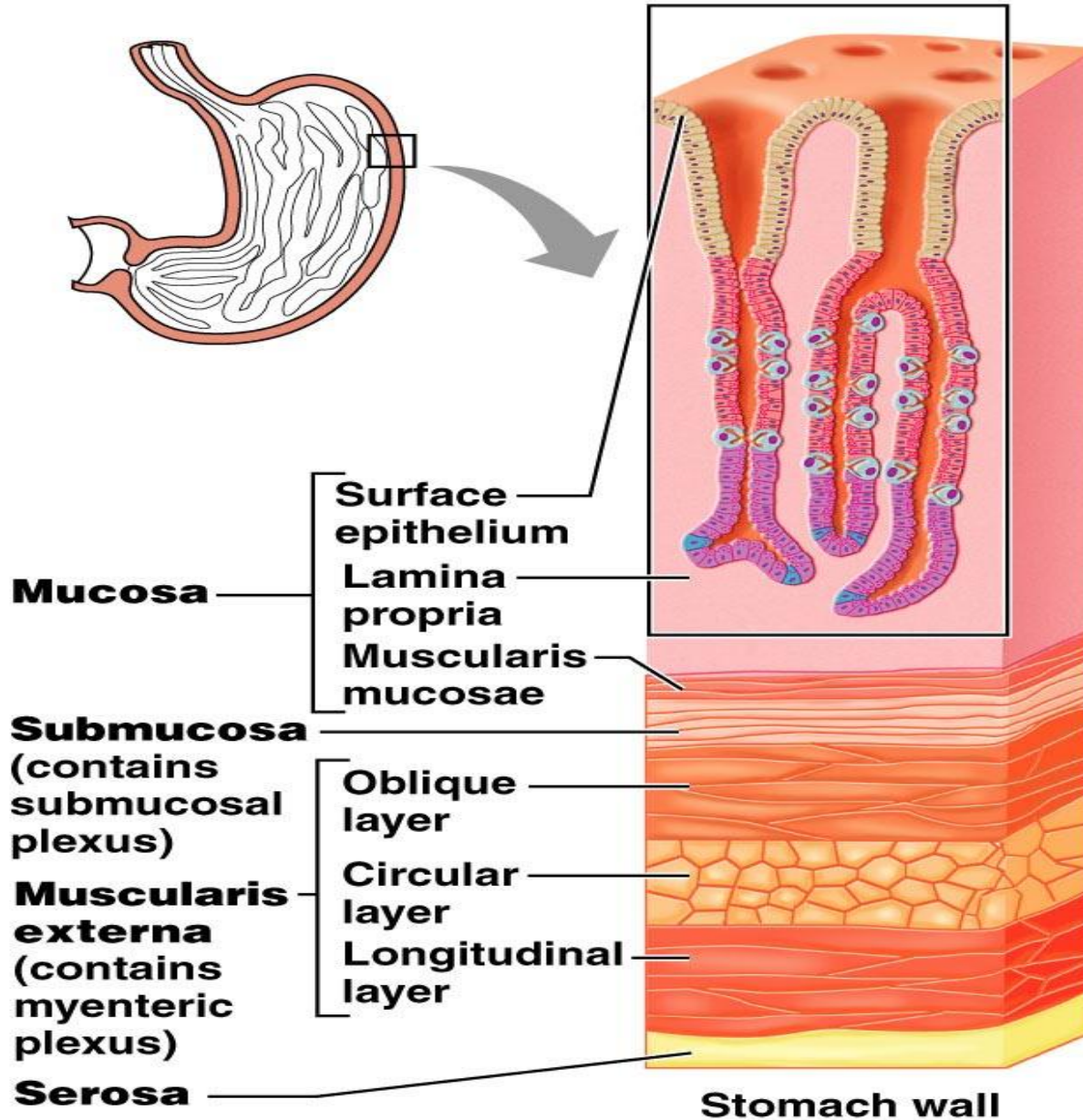
Stomach

- Chemical breakdown of proteins begins and food is converted to chyme



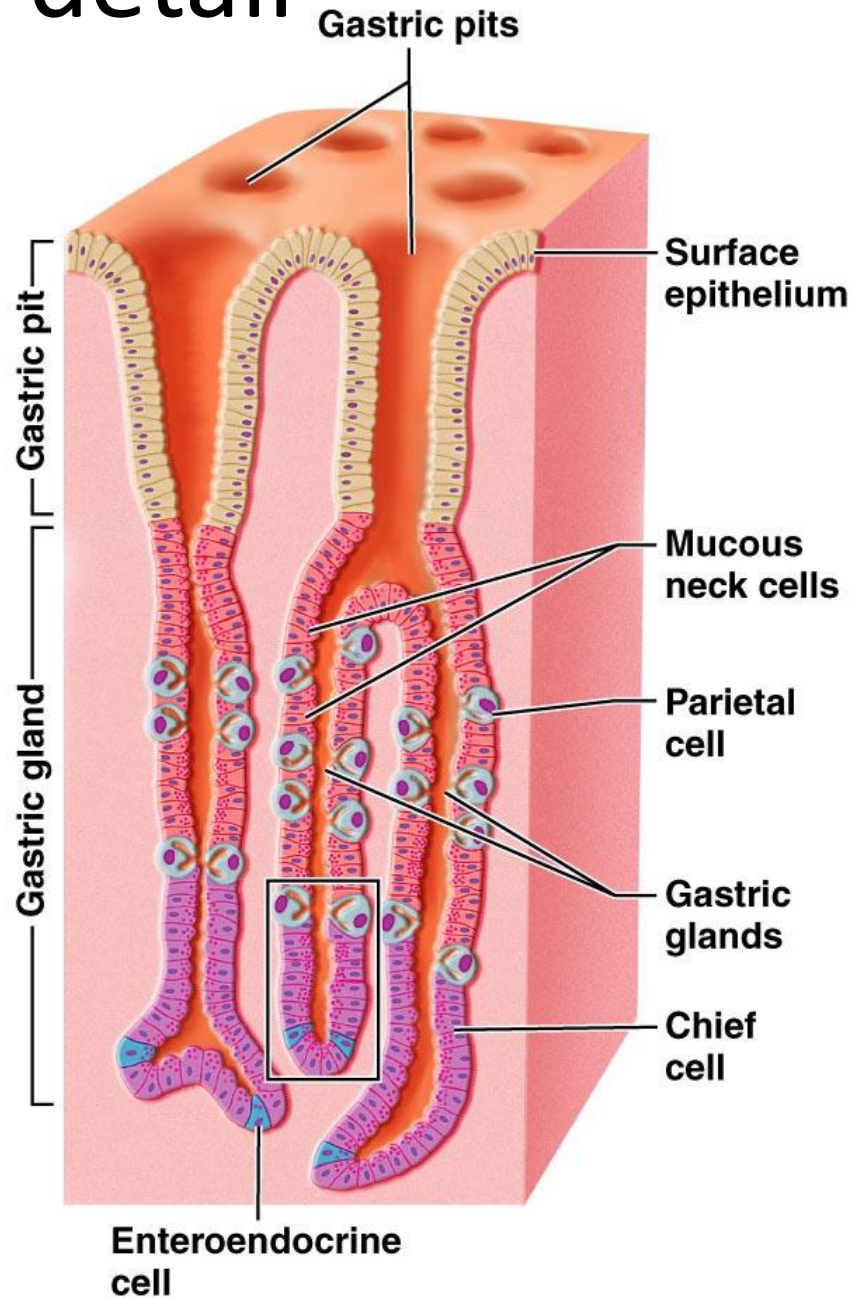
62
Figure 23.14a

Microscopic Anatomy



(a)

More in detail

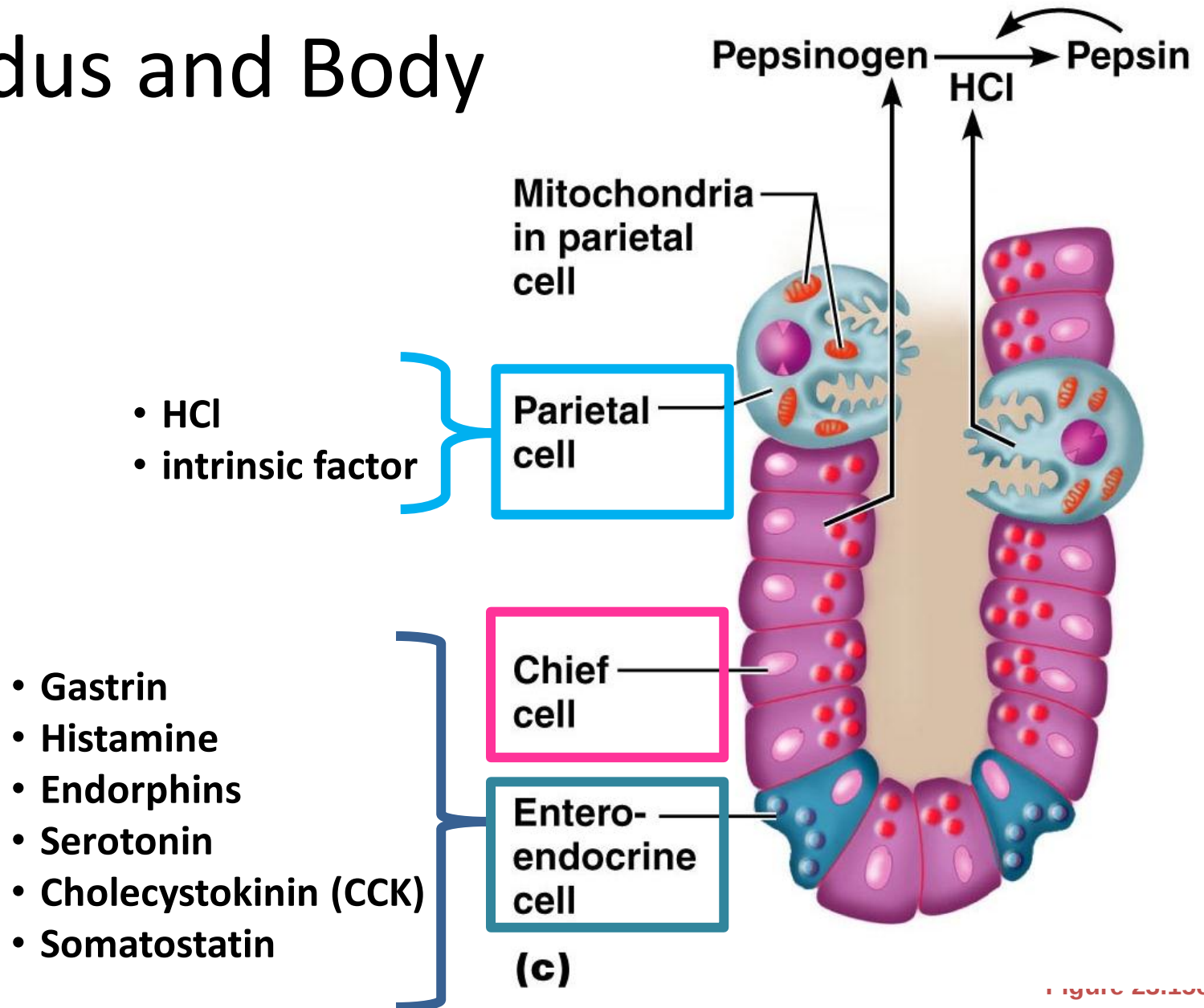


bicarbonate-rich mucus

(b)

Glands of the Stomach

Fundus and Body



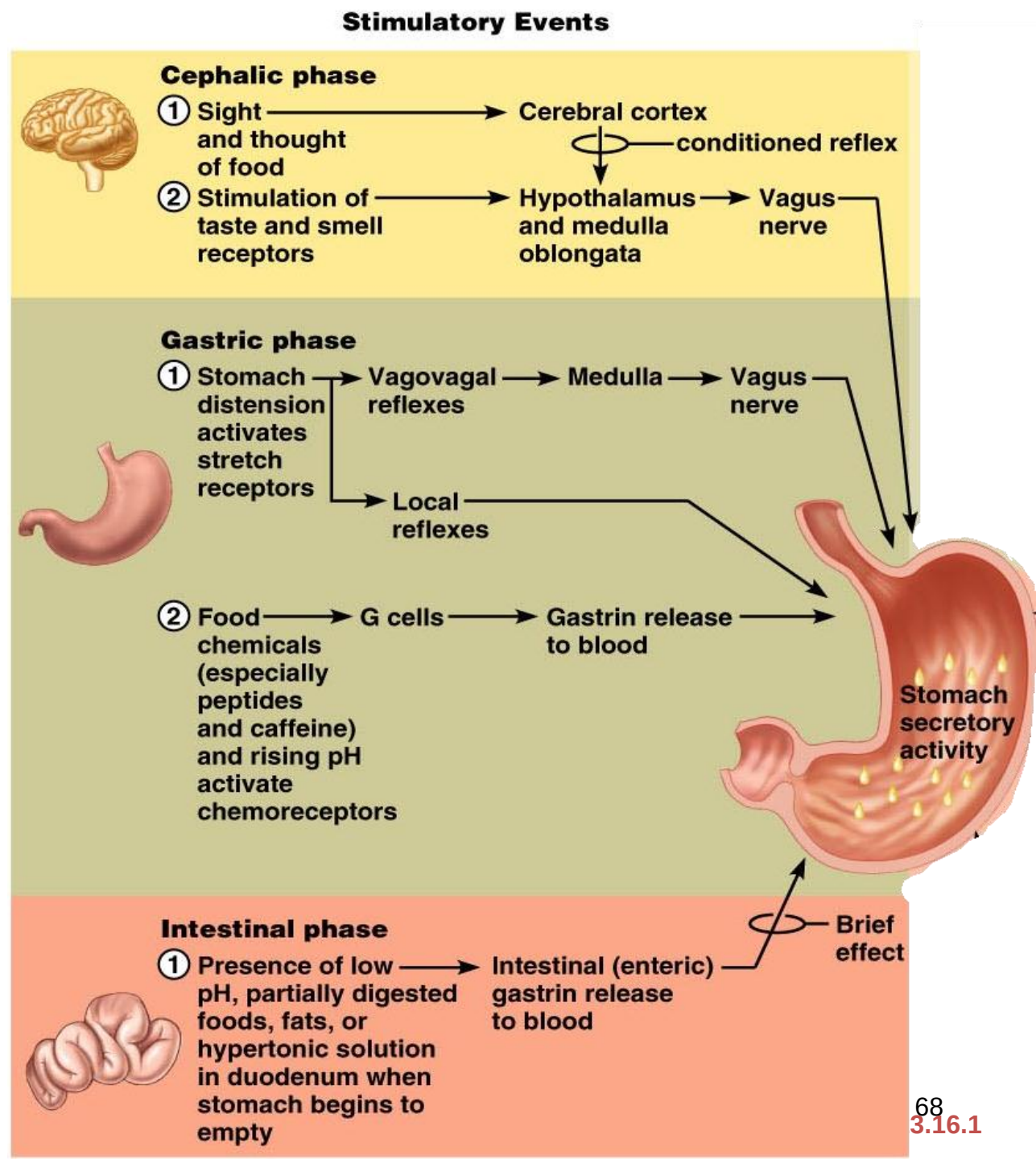
Digestion in the Stomach

- The stomach:
 - Holds ingested food
 - Degrades this food both physically and chemically
 - Delivers chyme to the small intestine
 - Enzymatically digests proteins with pepsin
 - Secretes intrinsic factor required for absorption of vitamin B₁₂

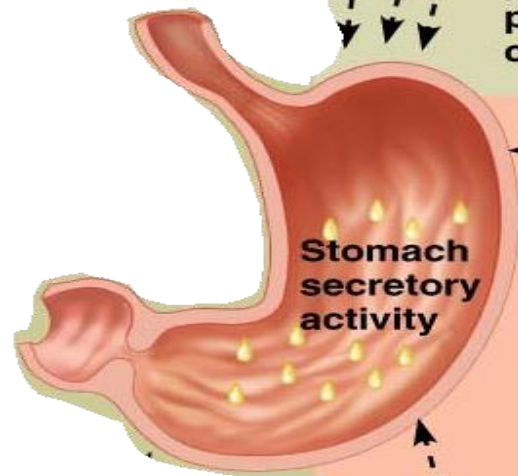
Regulation of Gastric Secretion

- Neural and hormonal mechanisms regulate the release of gastric juice
- Stimulatory and inhibitory events occur in three phases
 1. **Cephalic (reflex) phase:** prior to food entry
 2. **Gastric phase:** once food enters the stomach
 3. **Intestinal phase:** as partially digested food enters the duodenum

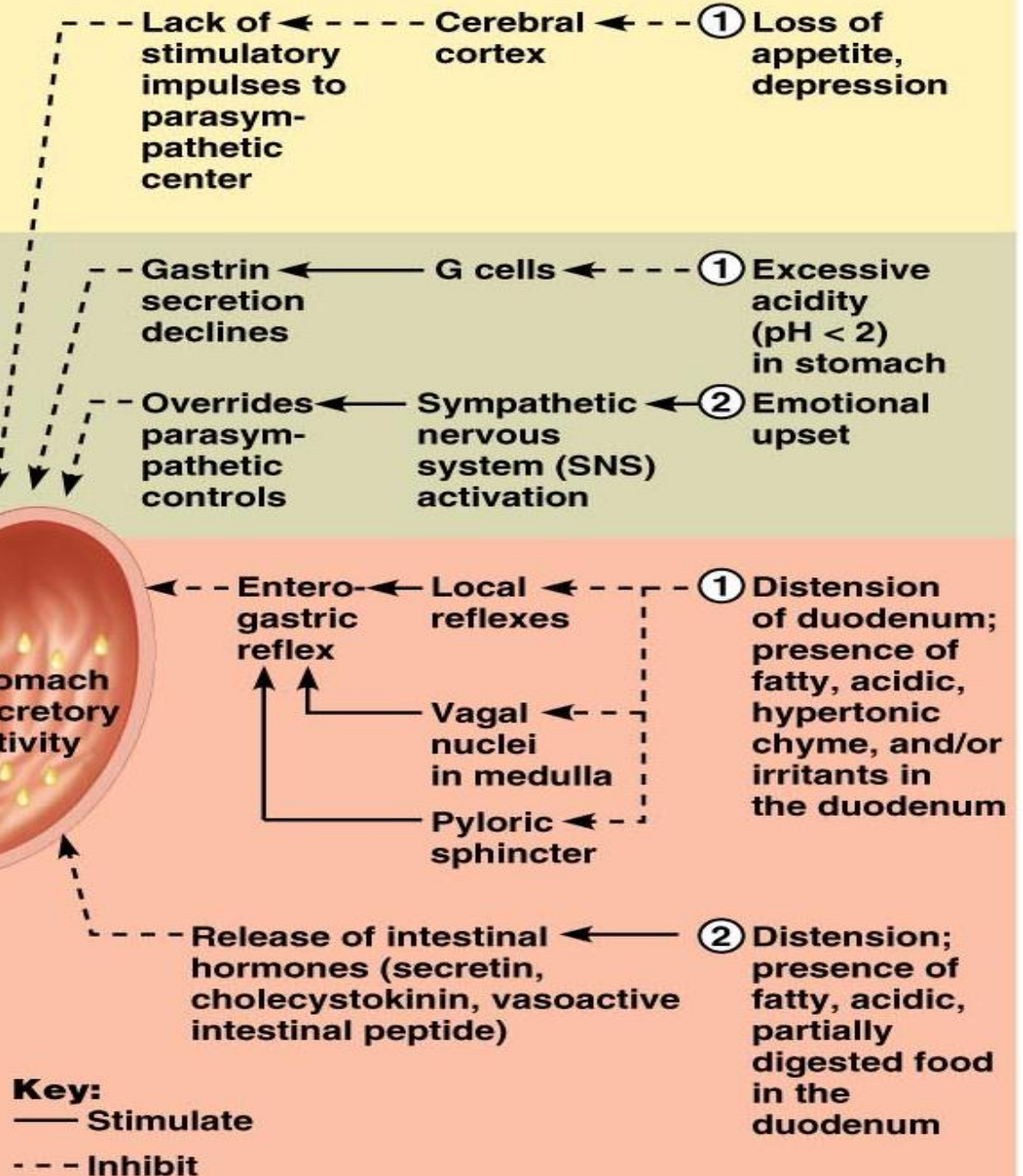
Release of Gastric Juice: Stimulatory Events



Release of Gastric Juice: Inhibitory Events



Inhibitory Events



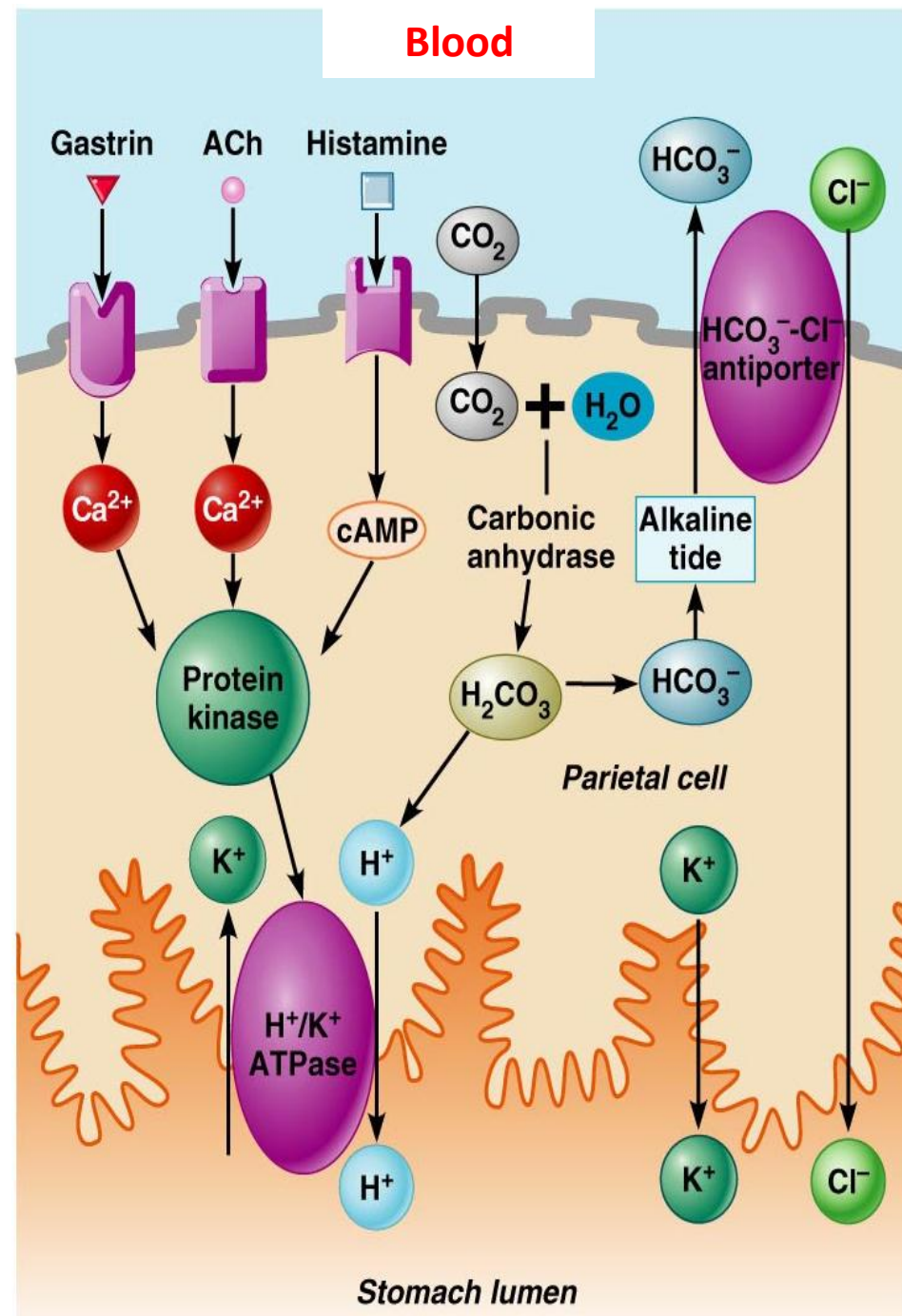
Regulation and Mechanism of HCl Secretion

HCl secretion is stimulated by ACh, histamine, and gastrin through second-messenger systems

Release of hydrochloric acid:

- Is low if only one ligand binds to parietal cells
- Is high if all three ligands bind to parietal cells

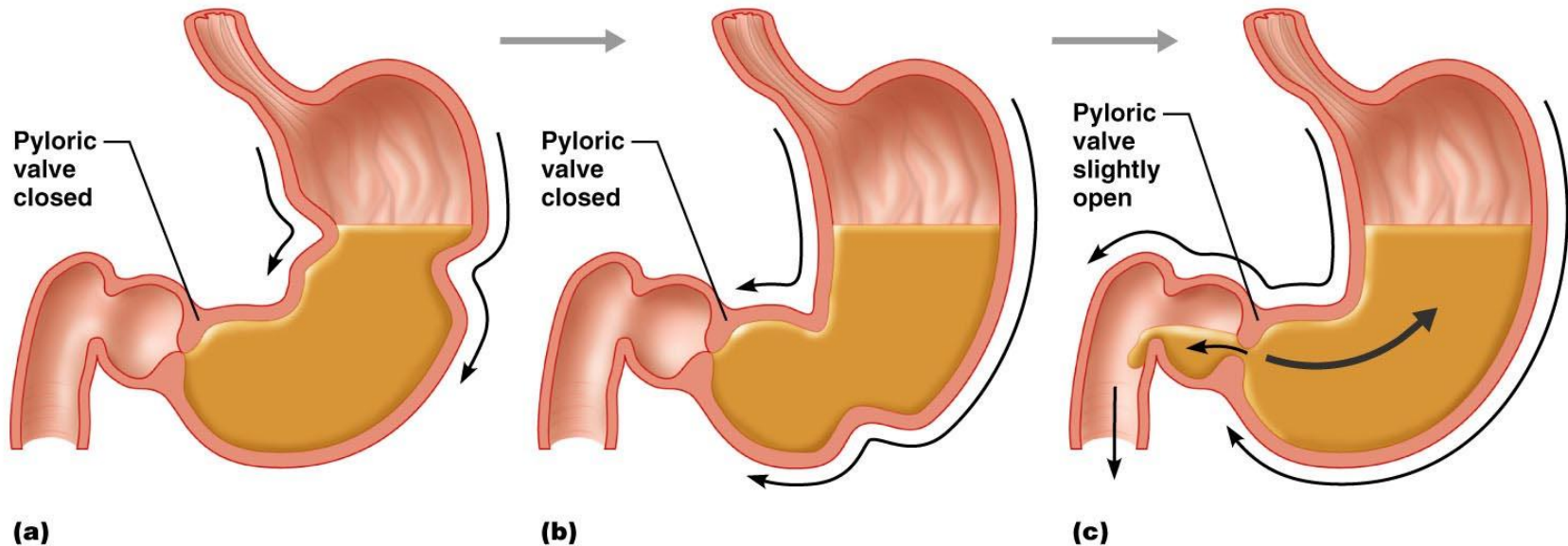
Antihistamines block H_2 receptors and decrease HCl release



Response of the Stomach to Filling

- Stomach pressure remains constant until about 1L of food is ingested
- Relative unchanging pressure results from reflex-mediated relaxation and plasticity
- Reflex-mediated events include:
 - Receptive relaxation – as food travels in the esophagus, stomach muscles relax
 - Adaptive relaxation – the stomach dilates in response to gastric filling
- Plasticity – intrinsic ability of smooth muscle to exhibit the stress-relaxation response

Gastric Contractile Activity



- Peristaltic waves move toward the pylorus at the rate of 3 per minute
- Most vigorous peristalsis and mixing occurs near the pylorus
- Chyme is either:
- delivered in small amounts to the duodenum or
- backward into the stomach for further mixing

Regulation of Gastric Emptying

- Gastric emptying is regulated by:
 - The neural enterogastric reflex
 - Hormonal (enterogastrone) mechanisms
- These mechanisms inhibit gastric secretion and duodenal filling

Regulation of Gastric Emptying

- Carbohydrate-rich chyme quickly moves through the duodenum
- Fat-laden chyme is digested more slowly causing food to remain in the stomach longer

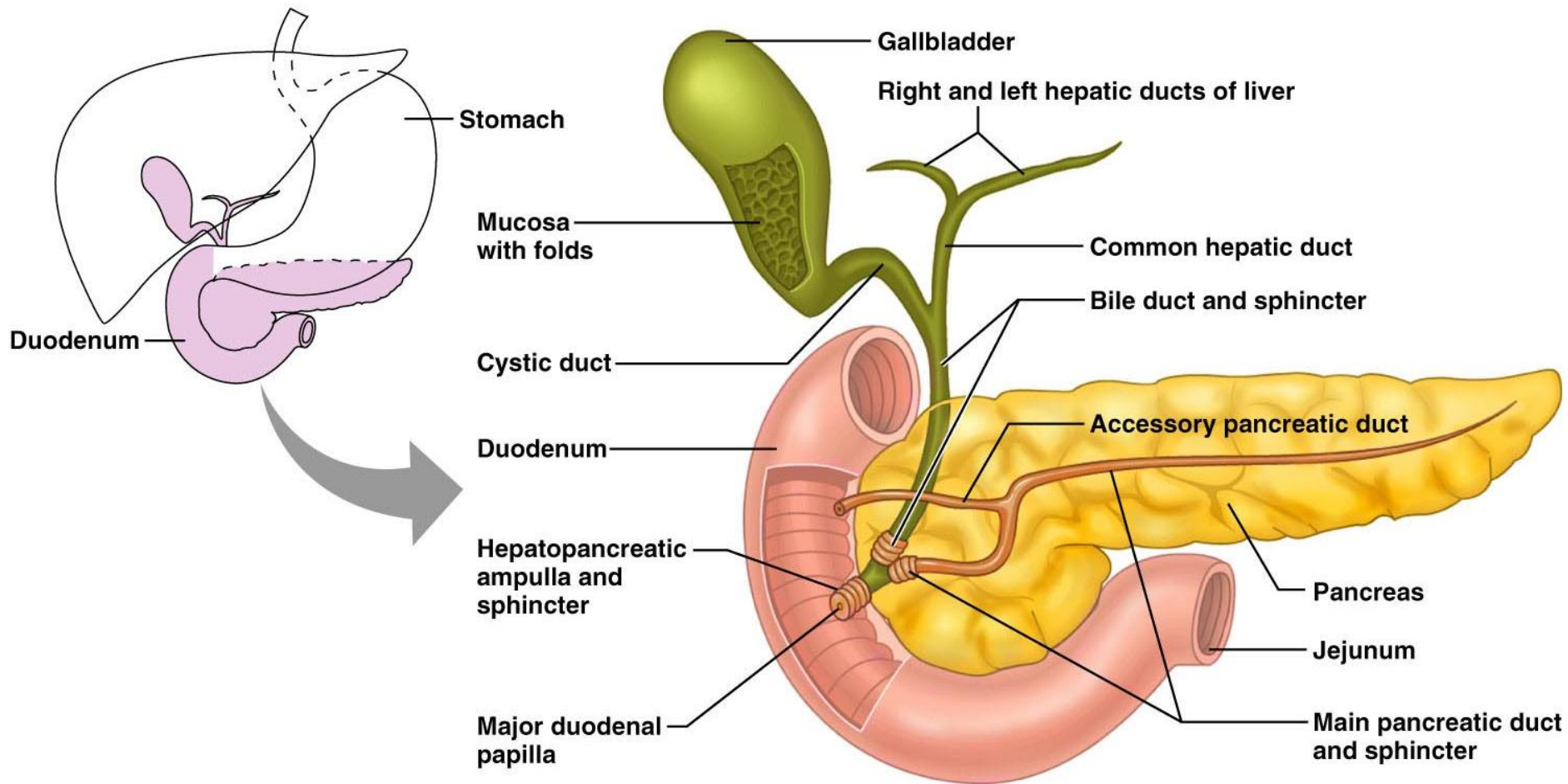
Small Intestine: Gross Anatomy

- Runs from pyloric sphincter to the ileocecal valve
- Has three subdivisions: duodenum, jejunum, and ileum

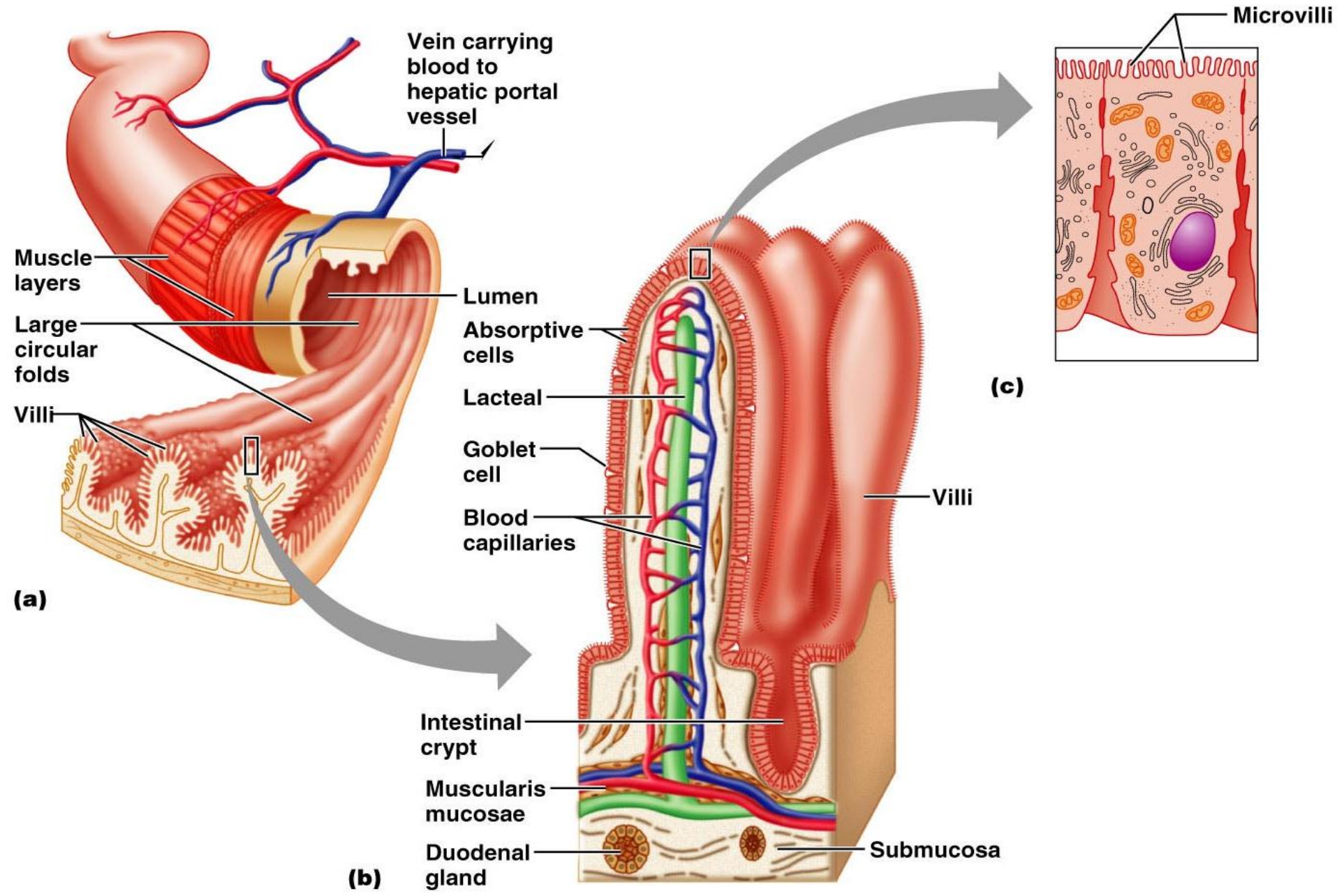
Small Intestine: Microscopic Anatomy

- Structural modifications of the small intestine wall increase surface area
 - Plicae circulares: deep circular folds of the mucosa and submucosa
 - Villi – fingerlike extensions of the mucosa
 - Microvilli – tiny projections of absorptive mucosal cells' plasma membranes

Duodenum and Related Organs



Small Intestine: Microscopic Anatomy



Small Intestine: Histology of the Wall

- The epithelium of the mucosa is made up of:
 - Absorptive cells and goblet cells
 - Enteroendocrine cells
 - Interspersed T cells called intraepithelial lymphocytes (IELs)
 - IELs immediately release cytokines upon encountering Antigens

Small Intestine: Histology of the Wall

- Cells of intestinal crypts secrete intestinal juice
- Peyer's patches are found in the submucosa
- Brunner's glands in the duodenum secrete alkaline mucus

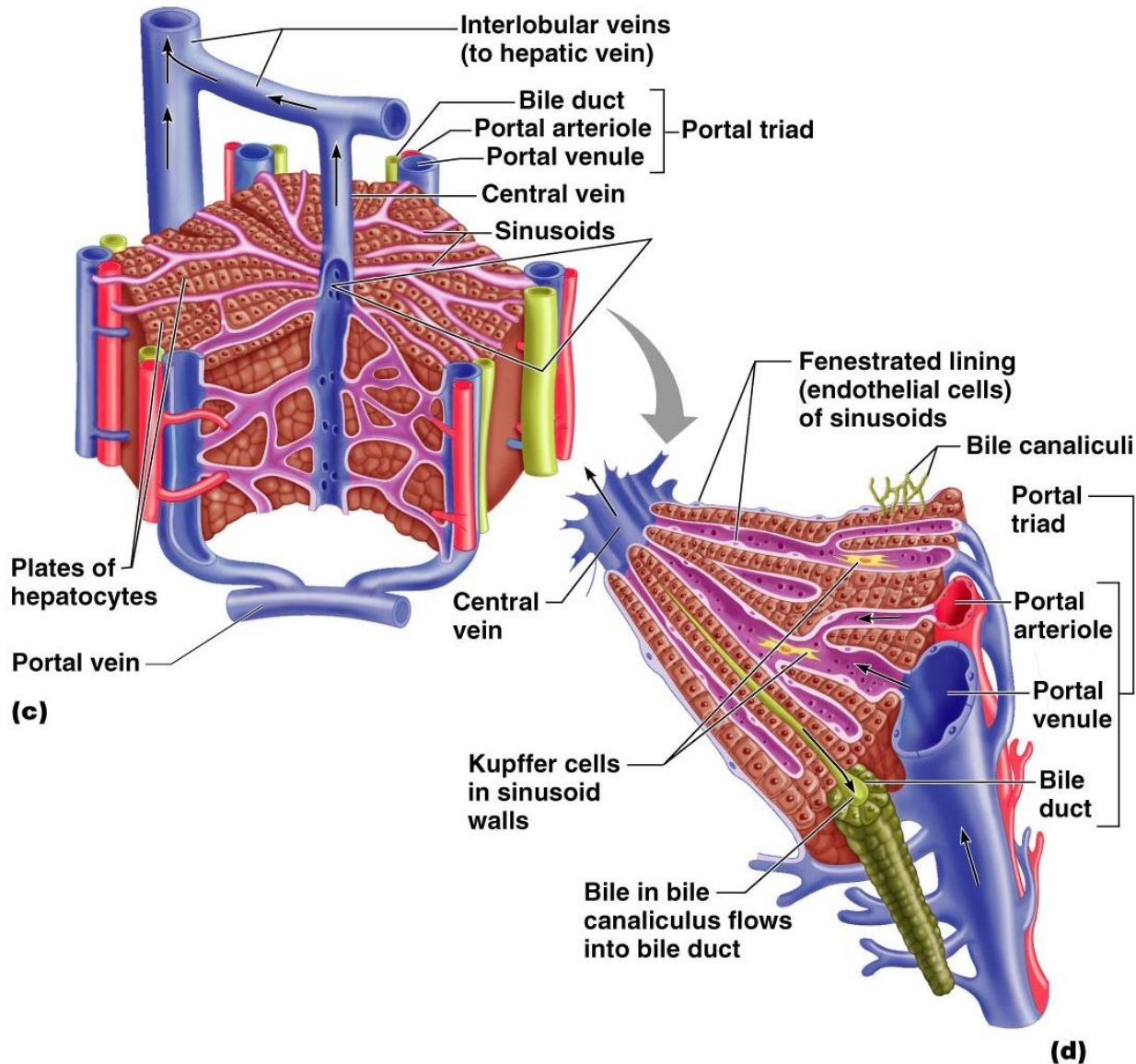
Intestinal Juice

- Secreted by intestinal glands in response to distension or irritation of the mucosa
- Slightly alkaline and isotonic with blood plasma
- Largely water, enzyme-poor, but contains mucus

Liver

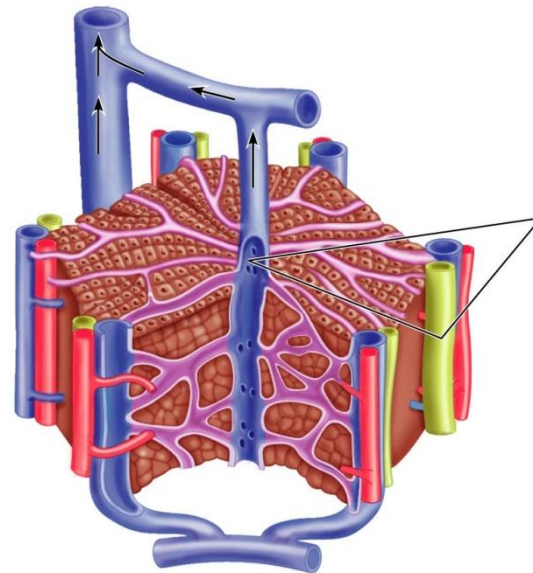
- The largest gland in the body
- Superficially has four lobes – right, left, caudate, and quadrate
- The falciform ligament:
 - Separates the right and left lobes anteriorly
 - Suspends the liver from the diaphragm and anterior abdominal wall

Microscopic Anatomy of the Liver



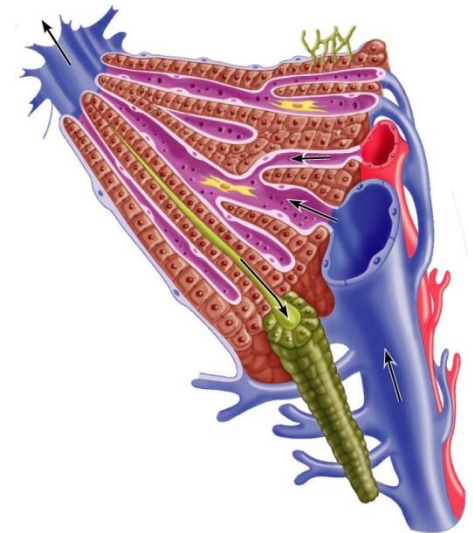
Liver: Microscopic Anatomy

- Hexagonal-shaped liver lobules are the structural and functional units of the liver
 - Composed of hepatocyte (liver cell) plates radiating outward from a central vein
 - Portal triads are found at each of the six corners of each liver lobule



Liver: Microscopic Anatomy

- Portal triads consist of a bile duct and
 - Hepatic artery – supplies oxygen-rich blood to the liver
 - Hepatic portal vein – carries venous blood with nutrients from digestive viscera



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Figure 23.24d

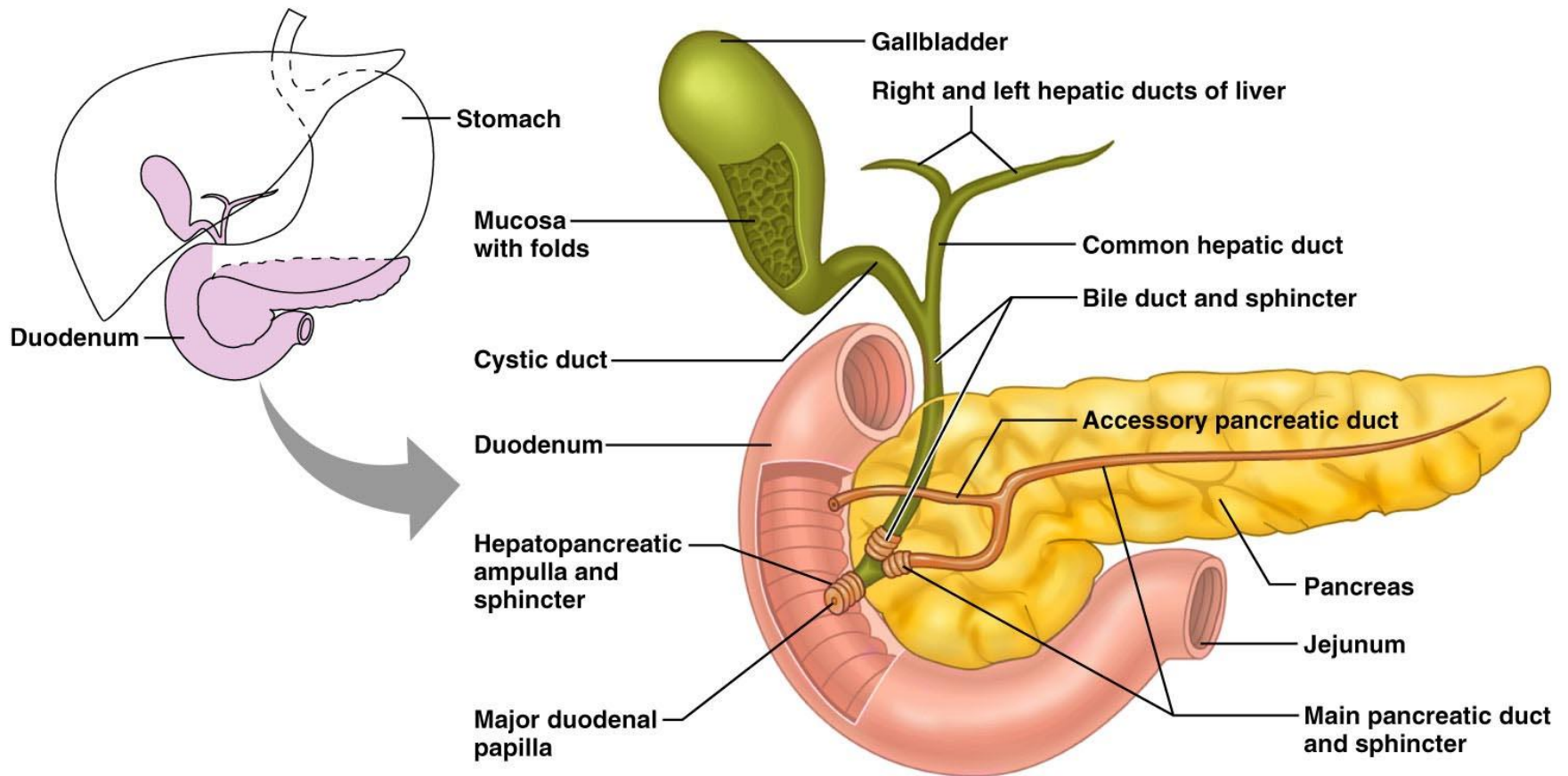
Liver: Microscopic Anatomy

- Hepatocytes' functions include:
 - Production of bile
 - Processing bloodborne nutrients
 - Storage of fat-soluble vitamins
 - Detoxification

Liver: Associated Structures

- The **lesser omentum** anchors the liver to the stomach
- The **hepatic blood vessels** enter the liver at the porta hepatis
- The **gallbladder** rests in a recess on the inferior surface of the right lobe

Gallbladder and Associated Ducts



The Gallbladder

- Thin-walled, green muscular sac on the ventral surface of the liver
- Stores and concentrates bile by absorbing its water and ions
- Releases bile via the cystic duct, which flows into the bile duct

Liver: Associated Structures

- Bile leaves the liver via:
 - Bile ducts, which fuse into the common hepatic duct
 - The common hepatic duct, which fuses with the cystic duct
 - These two ducts form the bile duct

Composition of Bile

- A yellow-green, alkaline solution containing bile salts, bile pigments, cholesterol, neutral fats, phospholipids, and electrolytes
- Bile salts are cholesterol derivatives that:
 - Emulsify fat
 - Facilitate fat and cholesterol absorption
 - Help solubilize cholesterol
- Enterohepatic circulation recycles bile salts
- The chief bile pigment is bilirubin, a waste product of heme

Regulation of Bile Release

