NEUROPHYSIOLOGY

GENERAL ORGANIZATION OF THE NERVOUS SYSTEM

By Dr Gul Muhammad

OBJECTIVES

1. Components of the nervous system
2. Their functions and coordination
3. Applied physiology

Nervous System

- Functions
  - ***Sensory input*** – monitoring stimuli occurring inside & outside the body
  - ***Integration*** – interpretation of sensory input
  - ***Motor output*** – response to stimuli by activating effector organs

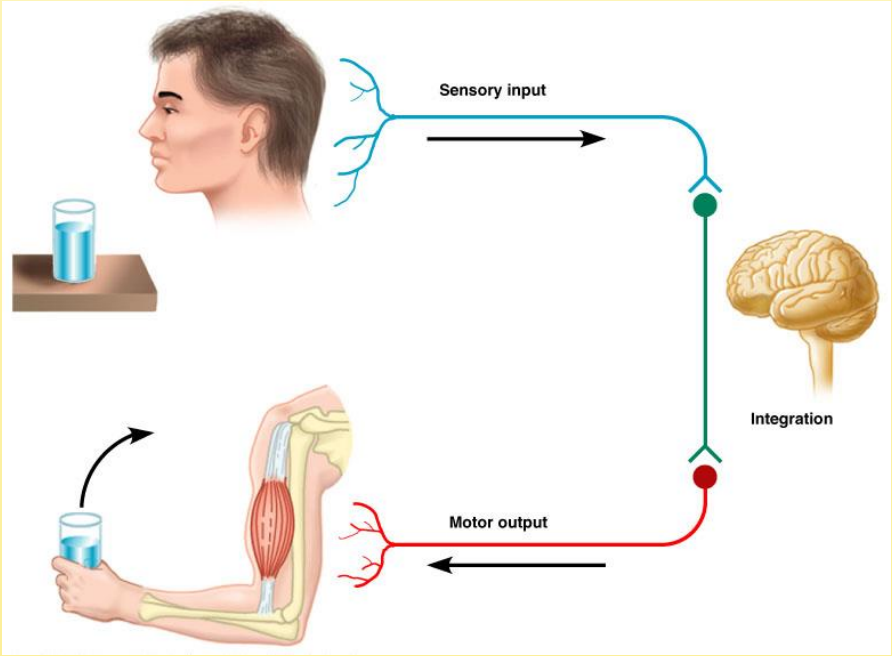
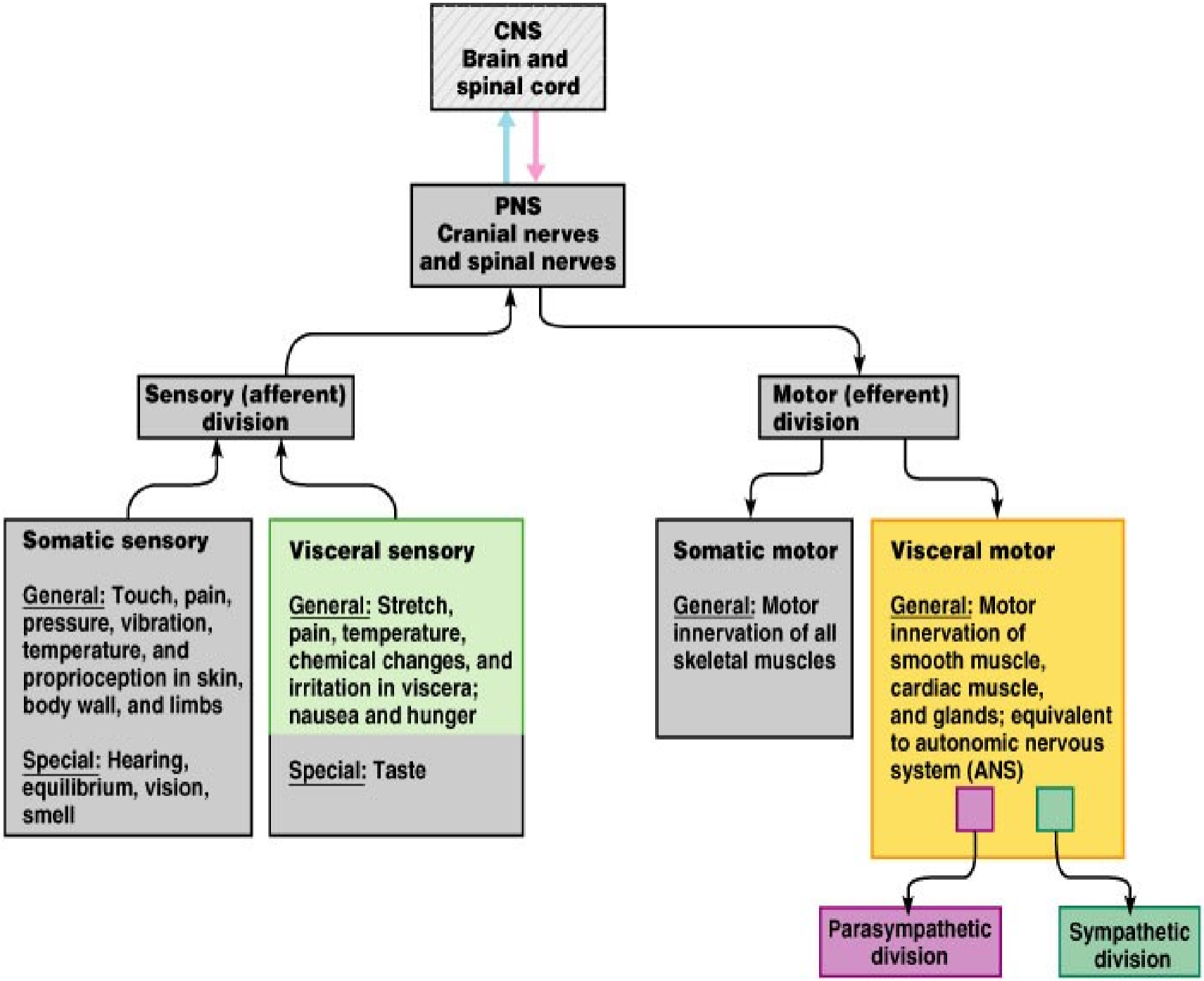
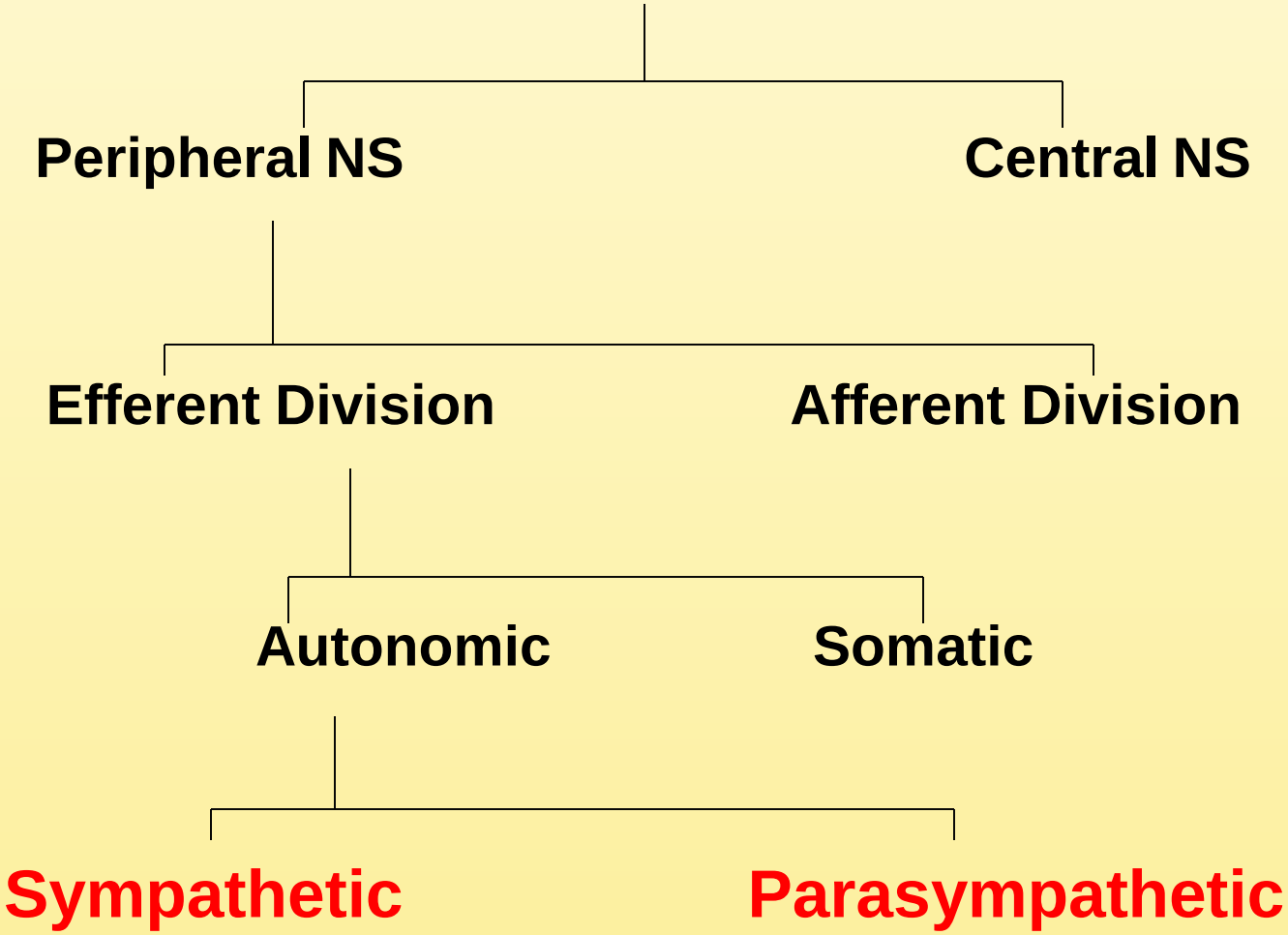


Figure 11.1

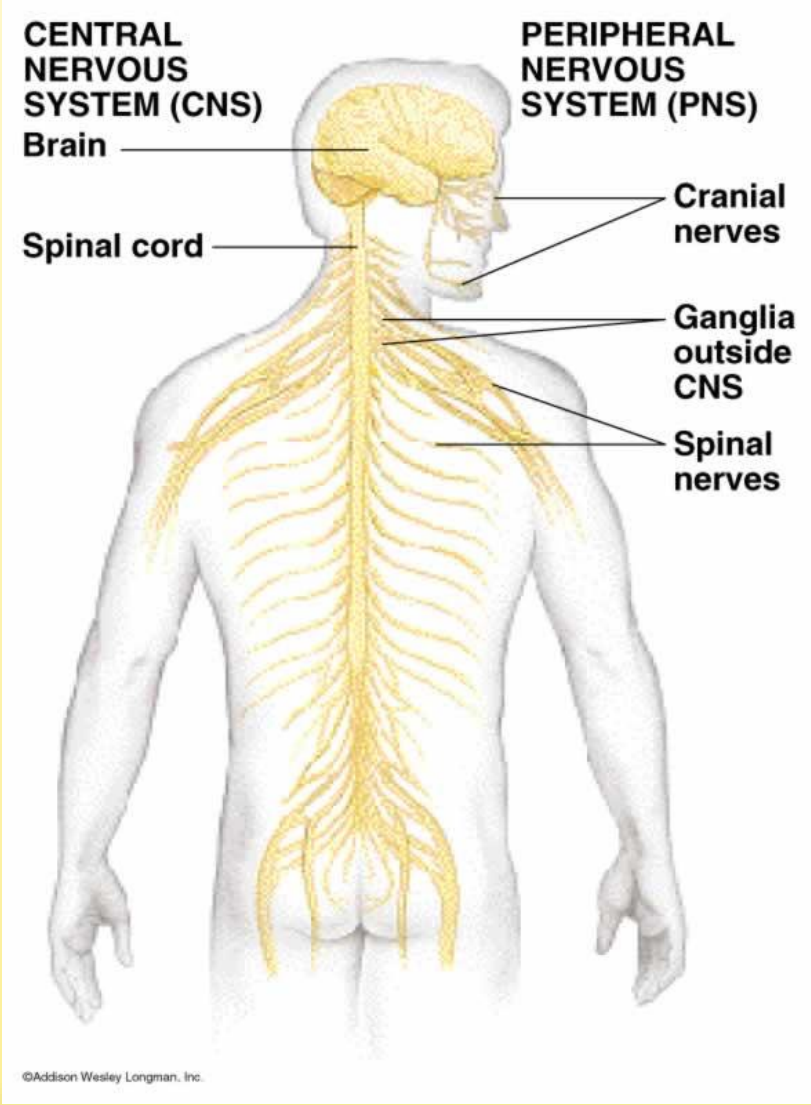

CNS
Brain and spinal cord
PNS
Cranial nerves and spinal nerves
Sensory (afferent) division
Motor (efferent) division
Somatic sensory
General: Touch, pain, pressure, vibration, temperature, and proprioception in skin, body wall, and limbs
Special: Hearing, equilibrium, vision, smell
Visceral sensory
General: Stretch, pain, temperature, chemical changes, and irritation in viscera; nausea and hunger
Special: Taste
Somatic motor
General: Motor innervation of all skeletal muscles
Visceral motor
General: Motor innervation of smooth muscle, cardiac muscle, and glands; equivalent to autonomic nervous system (ANS)
Parasympathetic division
Sympathetic division

Nervous System



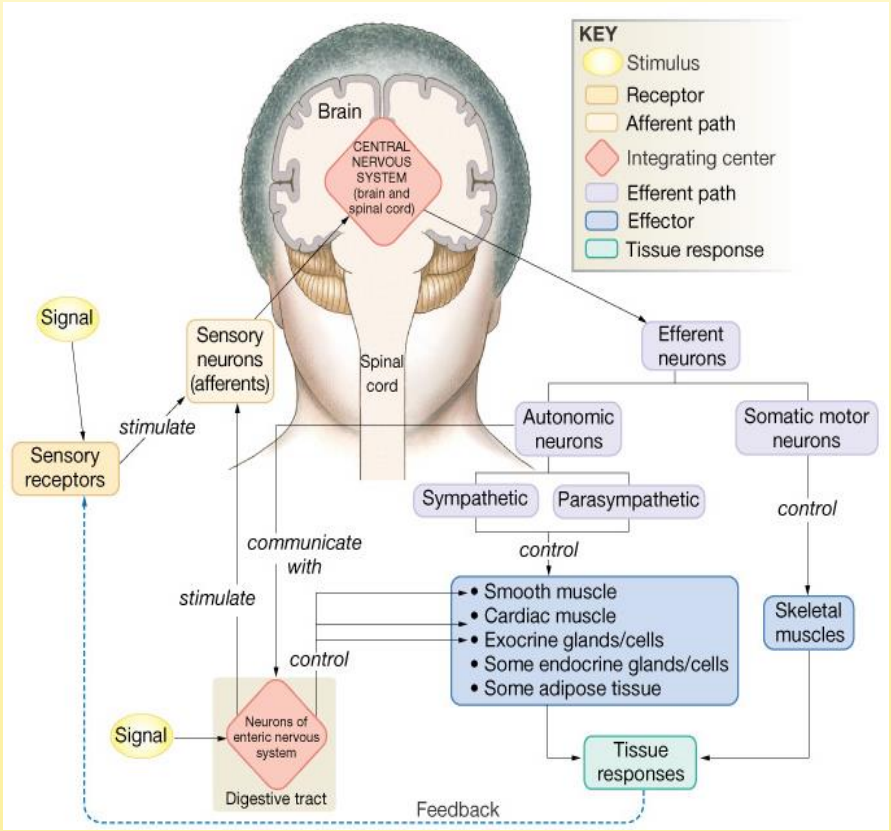
Organization of the Nervous System

- Central nervous system (CNS)
  - Brain and spinal cord
  - Integration and command center
- Peripheral nervous system (PNS)
  - Paired spinal and cranial nerves
  - Carries messages to and from the spinal cord and brain



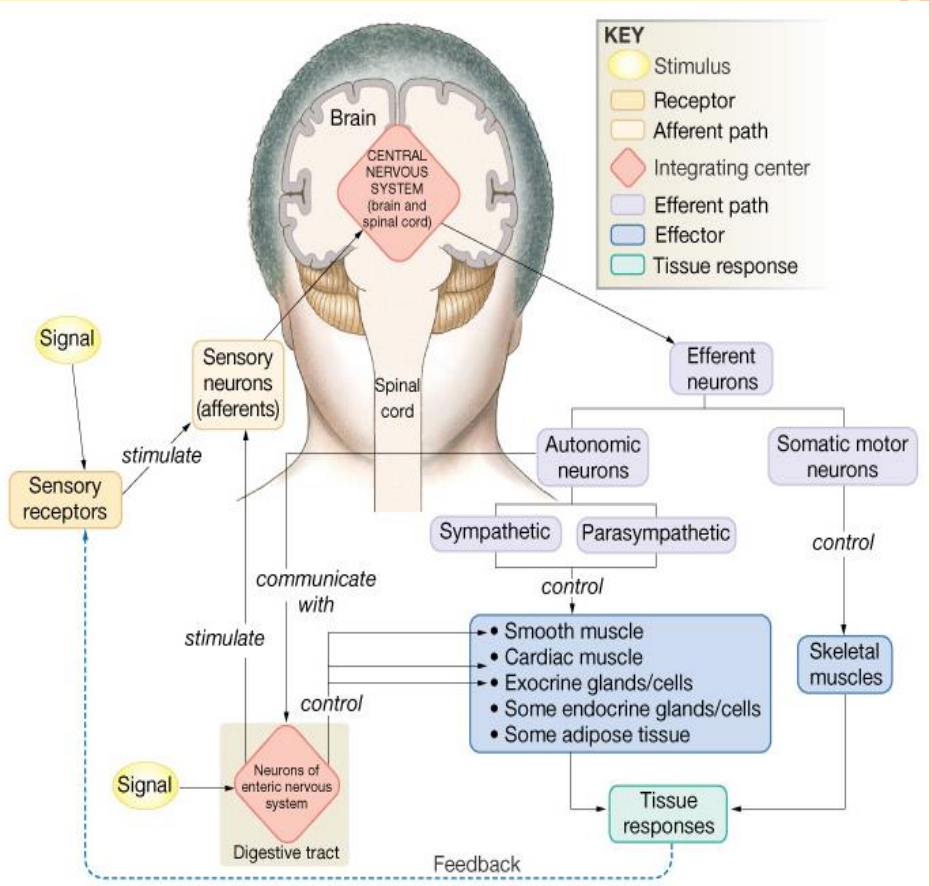
Peripheral Nervous System: Afferent Division

- Afferent (sensory) division – transmits impulses from receptors to the CNS.
  - Somatic afferent fibers – carry impulses from skin, skeletal muscles, and joints
  - Visceral afferent fibers – transmit impulses from visceral organs



Peripheral Nervous System: Efferent Division

- Motor (efferent) division – transmits impulses from the CNS to effector organs. Two subdivisions:
  - **Somatic nervous system** – provides conscious control of skeletal muscles
  - **Autonomic nervous system** – regulates smooth muscle, cardiac muscle, and glands



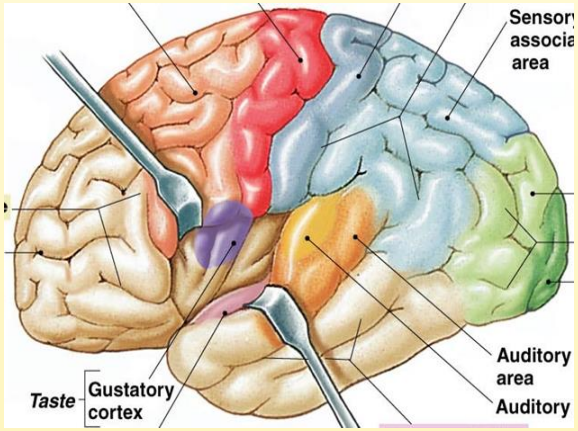
Sensory Nervous System

- **General somatic senses** – receptors are widely spread
  - Touch
  - Pain
  - Vibration
  - Pressure
  - Temperature
- **Proprioceptive senses** – detect stretch in tendons and muscle
  - Body sense – position and movement of body in space
- **Special somatic senses**
  - Hearing
  - Balance
  - Vision
  - Smell
- **Visceral sensory**
  - General visceral senses – stretch, pain, temperature, nausea, and hunger
    - Widely felt in digestive and urinary tracts, and reproductive organs
  - Special visceral senses - taste

Motor Nervous System

- **General somatic motor** – signals contraction of skeletal muscles
  - Under our voluntary control
  - Often called “voluntary nervous system”
- **Visceral motor**
  - Regulates the contraction of smooth and cardiac muscle
  - Makes up autonomic nervous system
  - Controls function of visceral organs
  - Often called “involuntary nervous system” or
    - ***Autonomic nervous system***

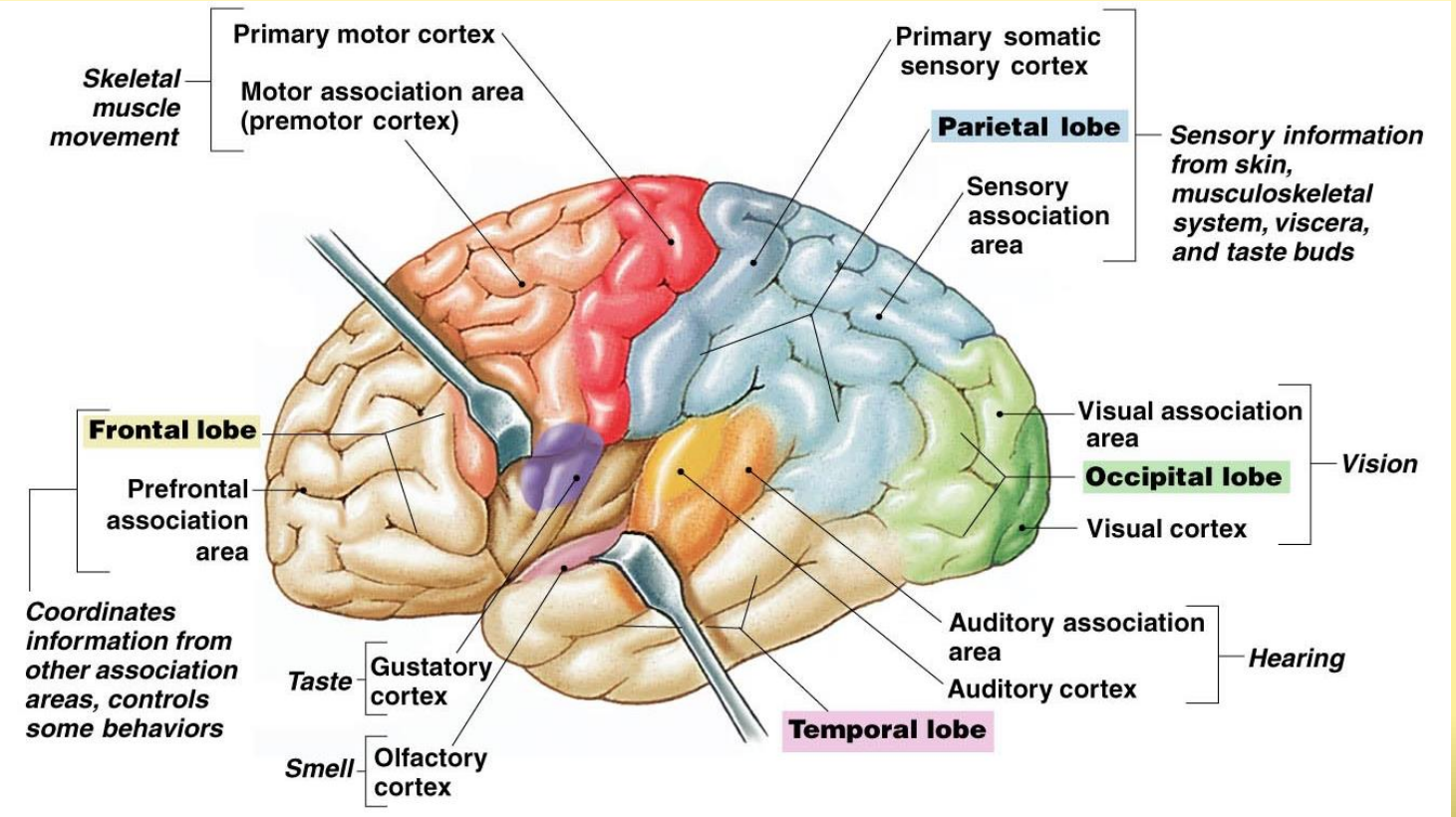
Cerebrum



- Highly developed
- Makes up about 80% of total brain weight (largest portion of brain)
- Inner core houses basal nuclei
- Outer surface is highly convoluted cerebral cortex
  - Highest, most complex integrating area of the brain
  - Plays key role in most sophisticated neural functions

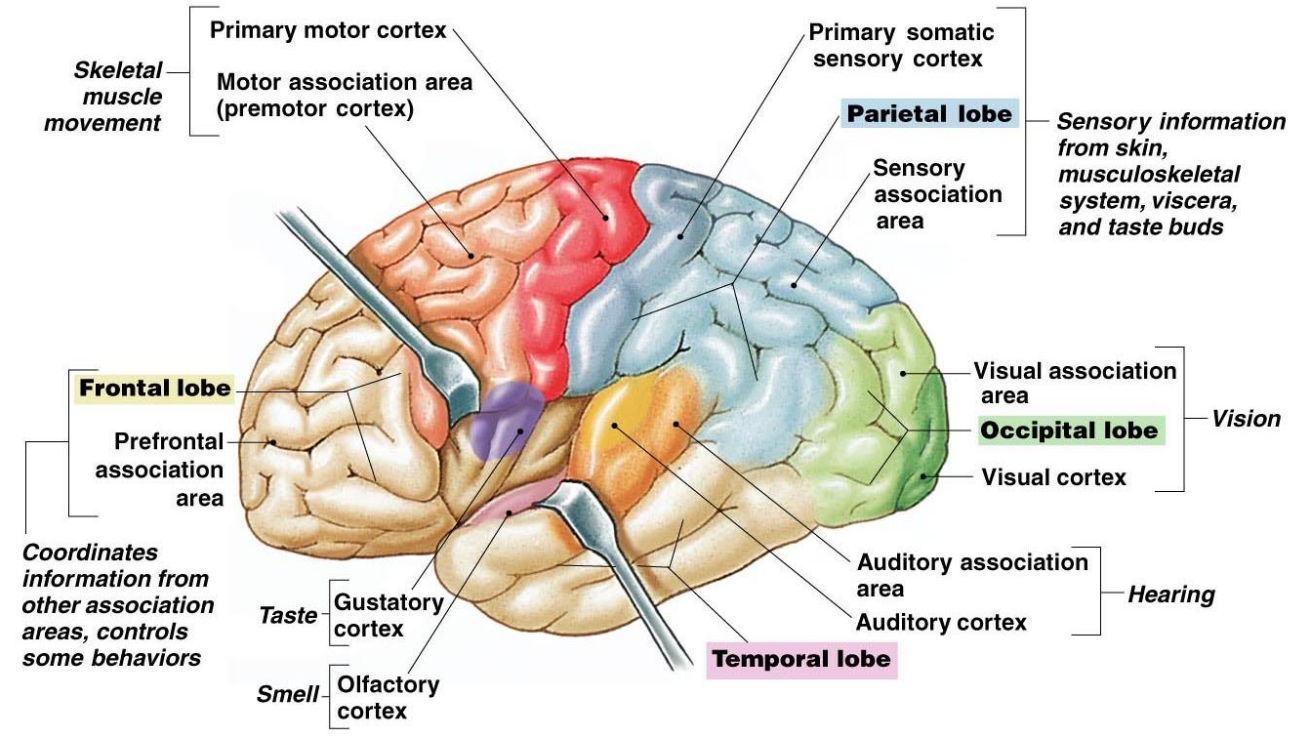
Cerebral Cortex

- Three specializations
  - Sensory areas - sensory input translated into perception
  - Motor areas - direct skeletal muscle movement
  - Association areas - integrate information from sensory and motor areas, can direct voluntary behaviors



Cerebral Cortex

- Each half of cortex divided into four major lobes
  - Occipital lobe - carries out initial processing of visual input
  - Temporal lobe - initial reception of sound sensation, taste, smell
  - Parietal lobe - somatosensory processing
  - Frontal lobe responsible for
    - Voluntary motor activity
    - Speaking ability
    - Elaboration of thought



Functional Areas of the Cerebral Cortex

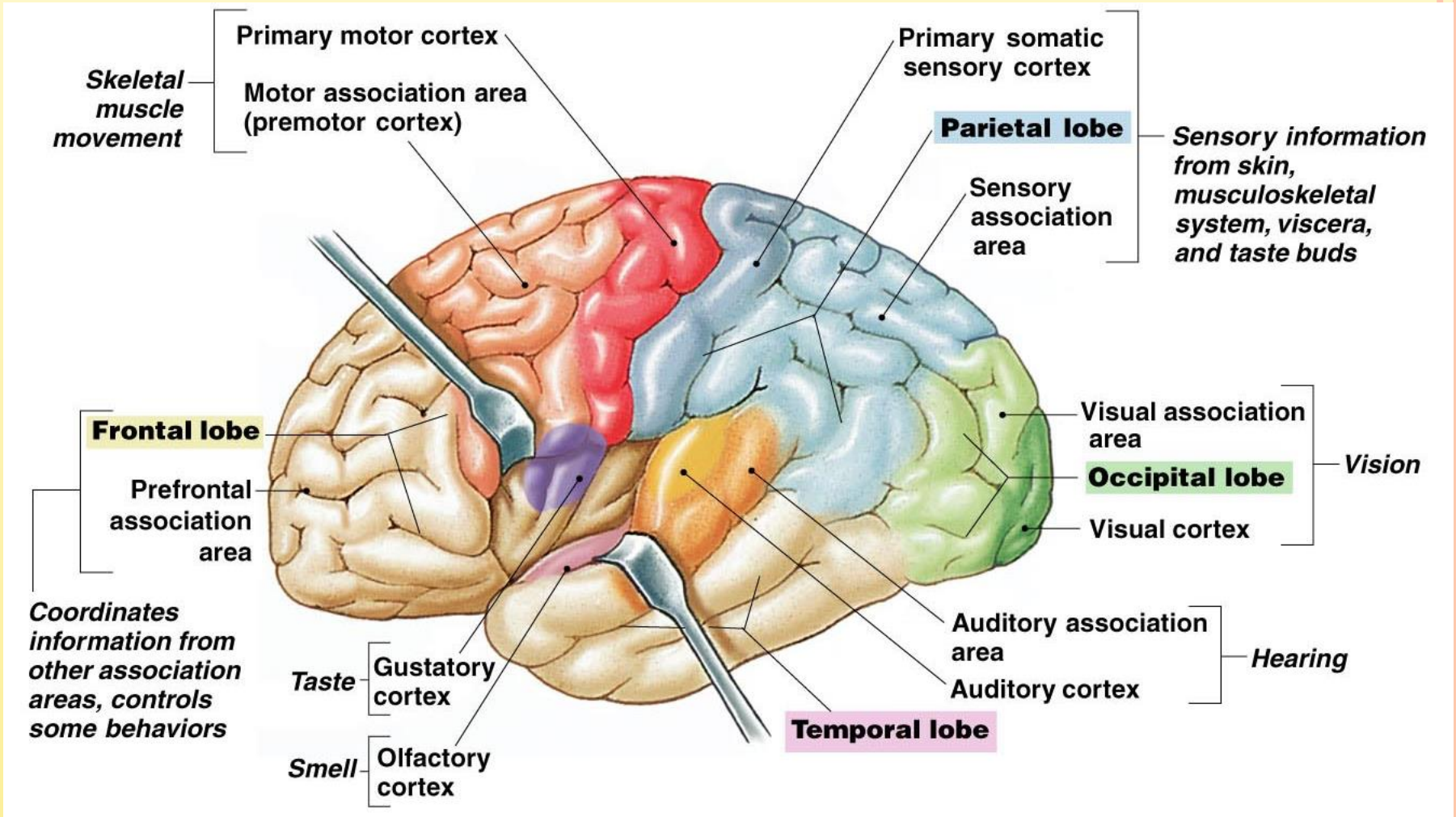
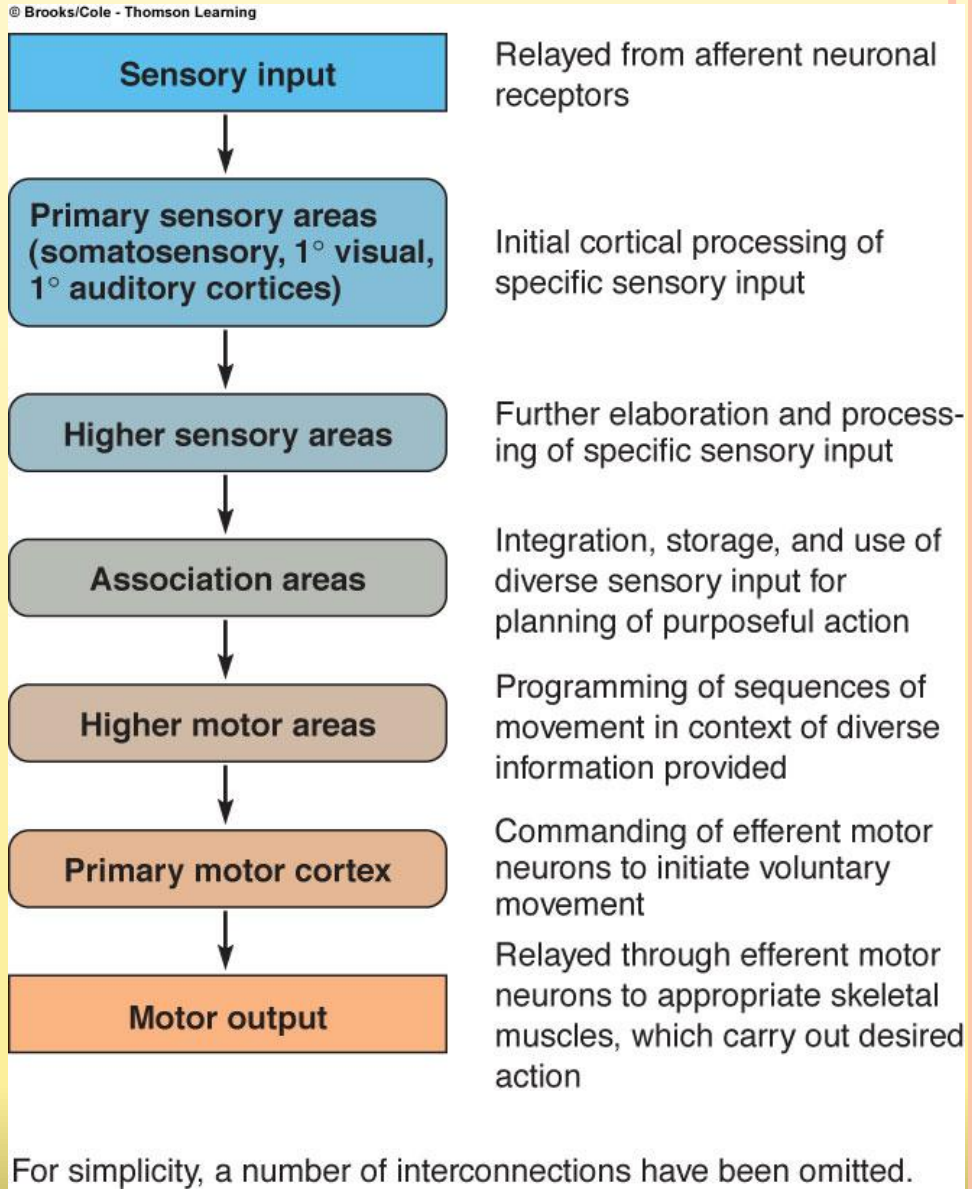


Figure 9-15

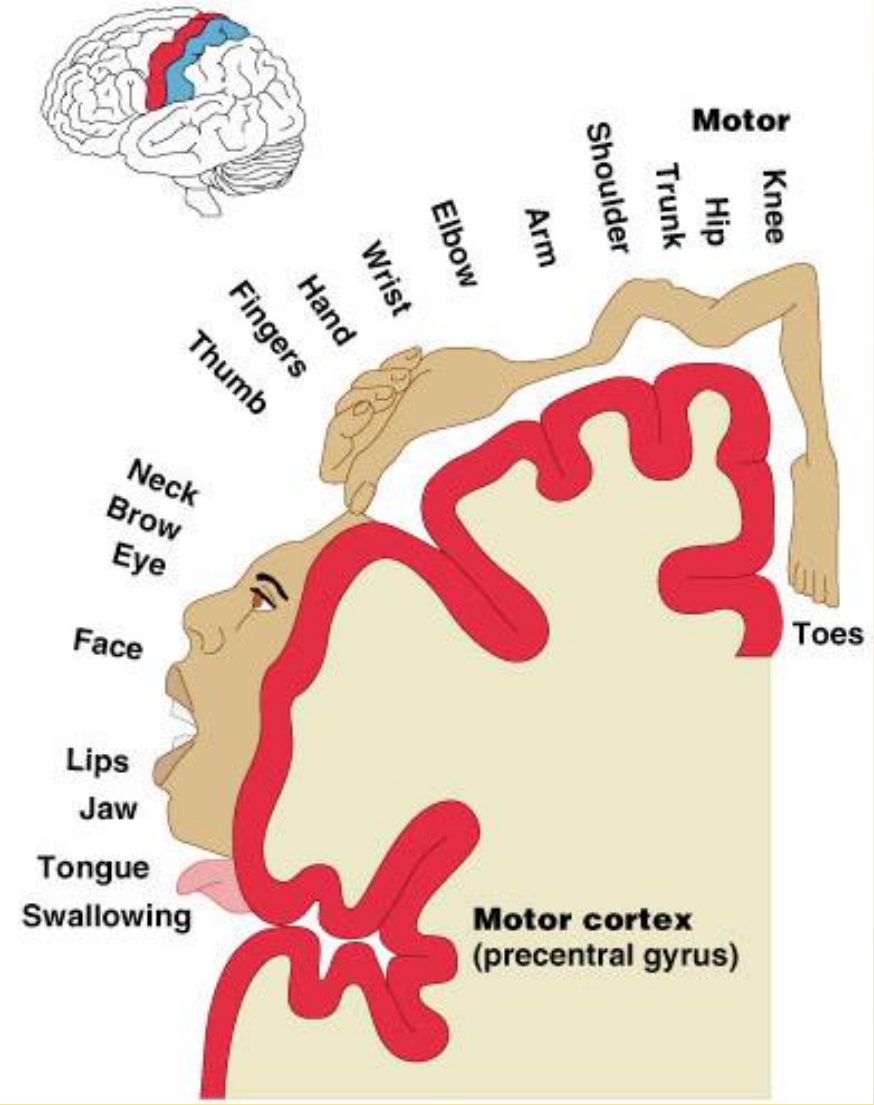
Cerebral Cortex

- Schematic Linking of Various Regions of the Cortex



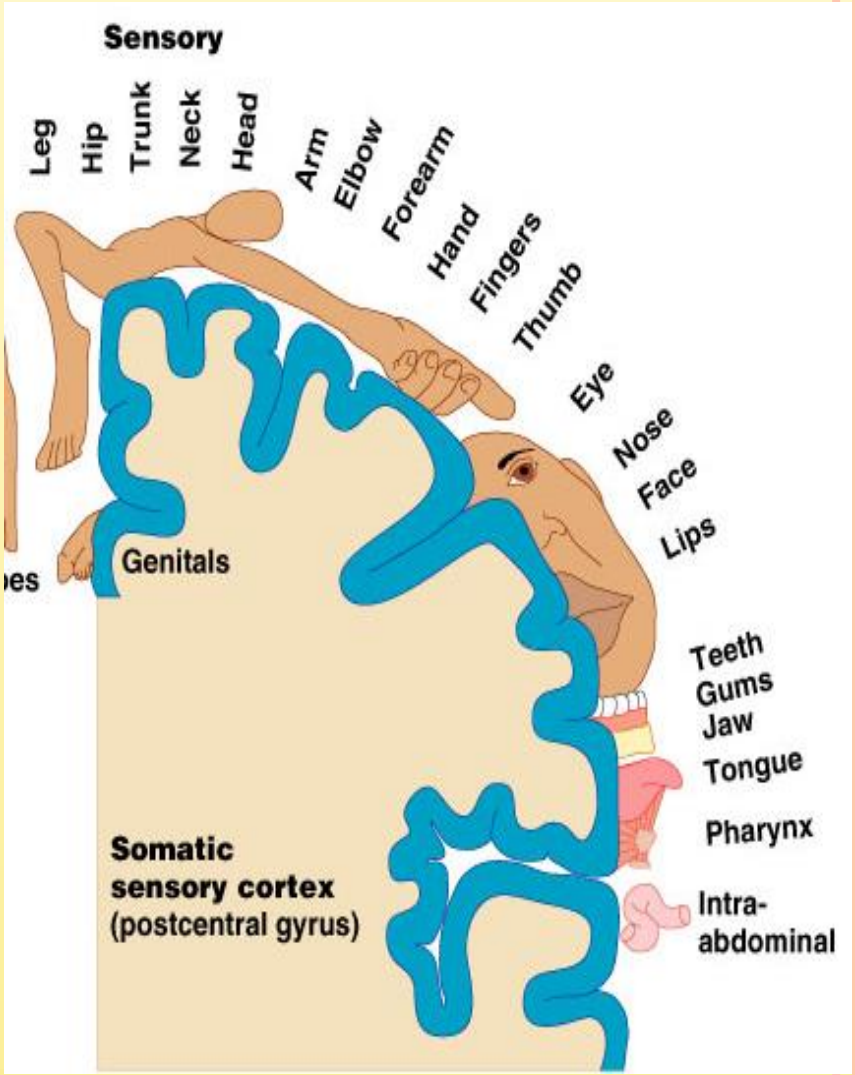
Primary Motor Cortex

- Located in the precentral gyrus
- Composed of pyramidal cells whose axons make up the corticospinal tracts
- Allows conscious control of precise, skilled, voluntary movements
- Motor homunculus – caricature of relative amounts of cortical tissue devoted to each motor function

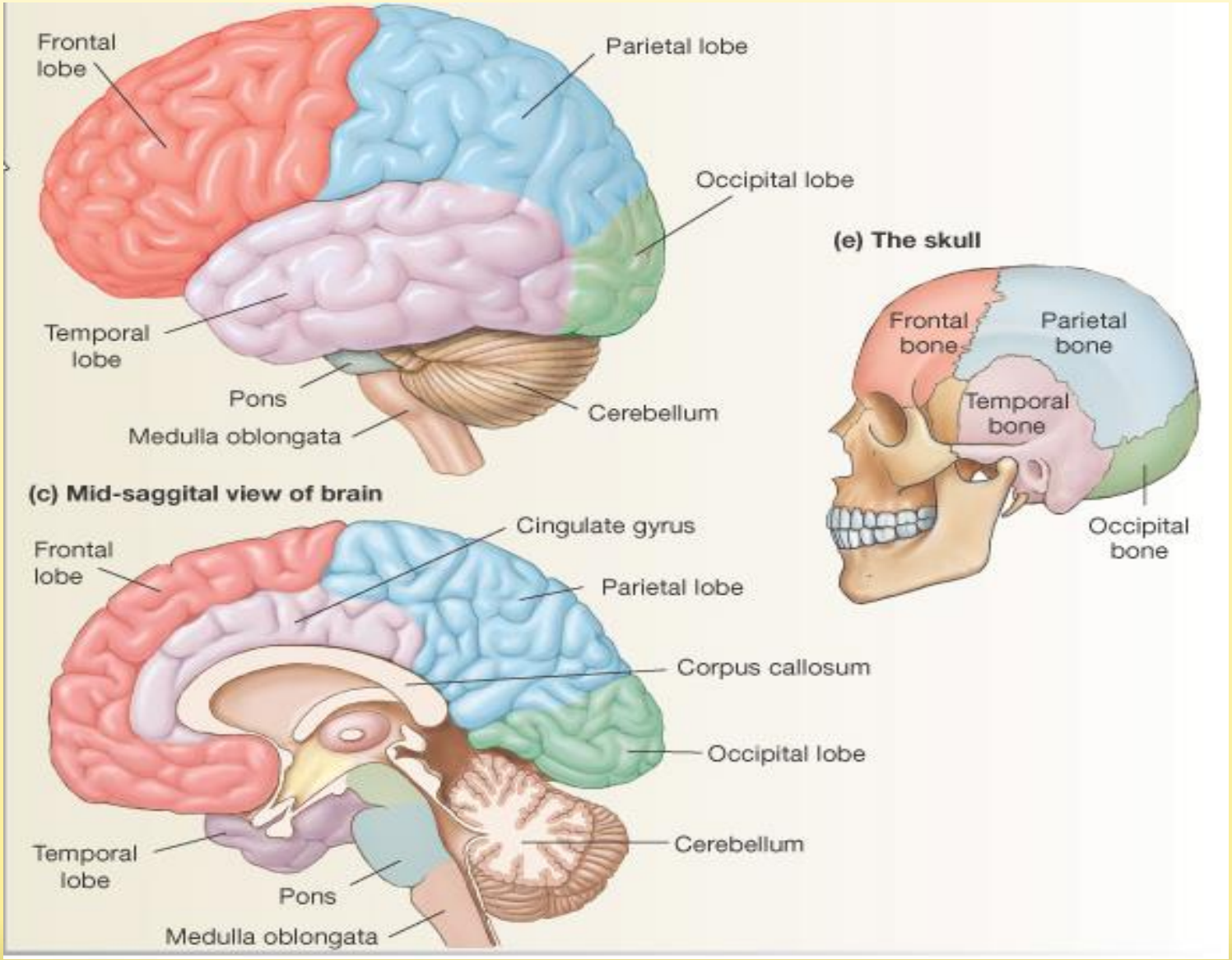


Primary Somatosensory Cortex

- Located in the postcentral gyrus, this area:
  - Receives information from the skin and skeletal muscles
  - Exhibits spatial discrimination
- Somatosensory homunculus – caricature of relative amounts of cortical tissue devoted to each sensory function

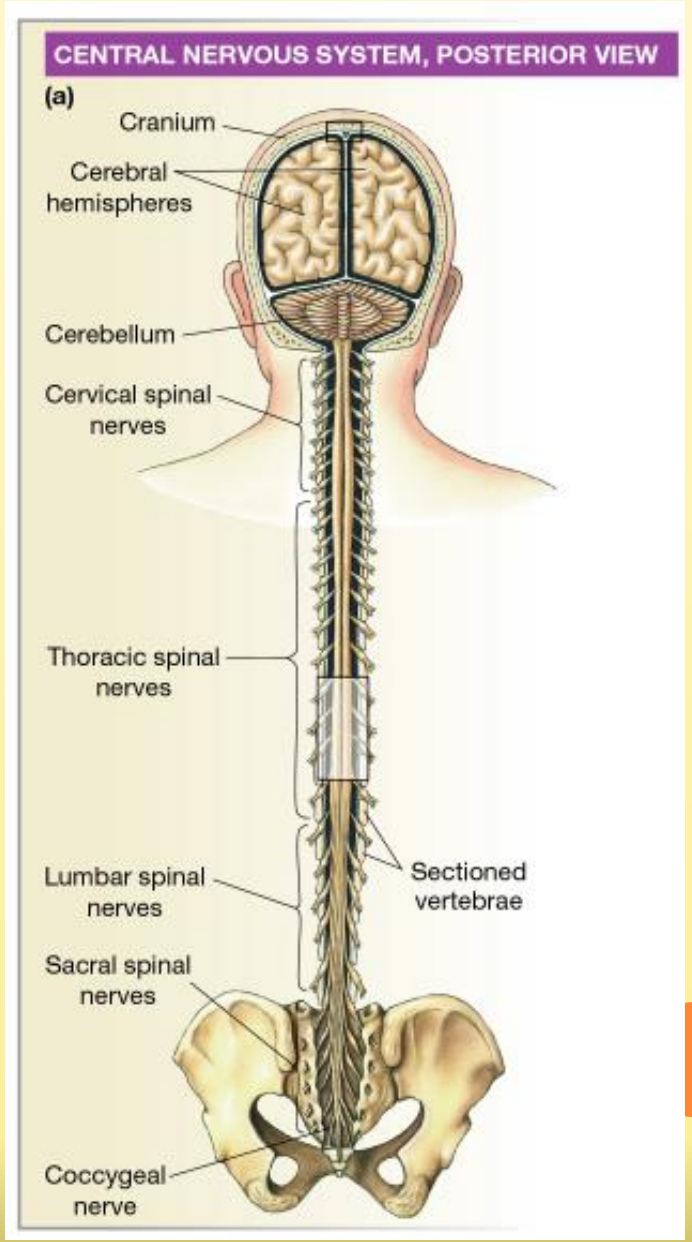


Brain Overview



Central Nervous System:

- Brain
- Spinal cord



Spinal Cord Regions

- Cervical
- Thoracic
- Lumbar
- Sacral

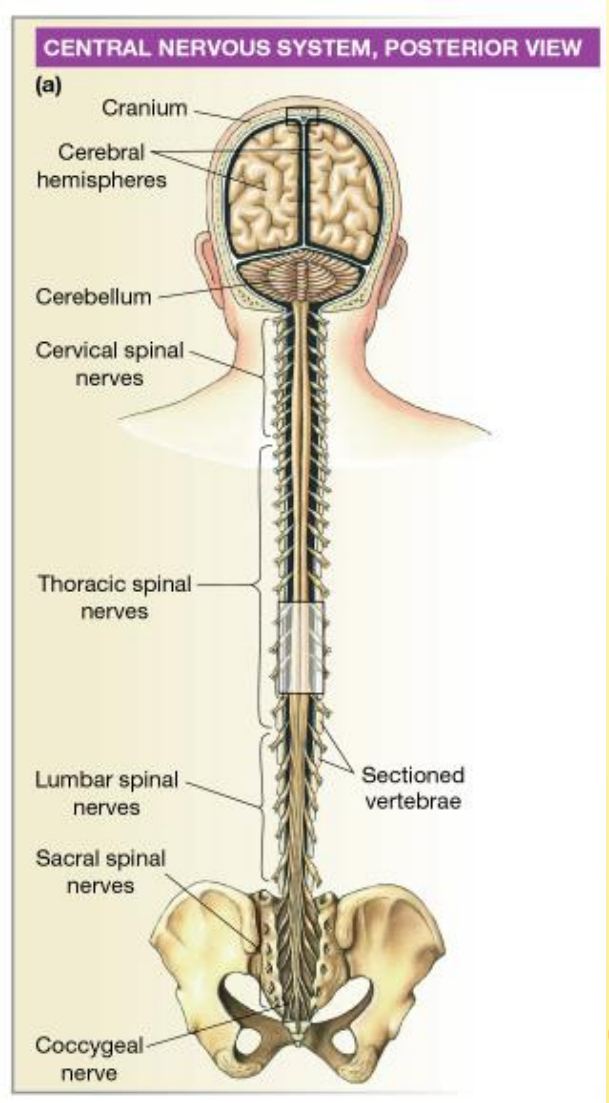
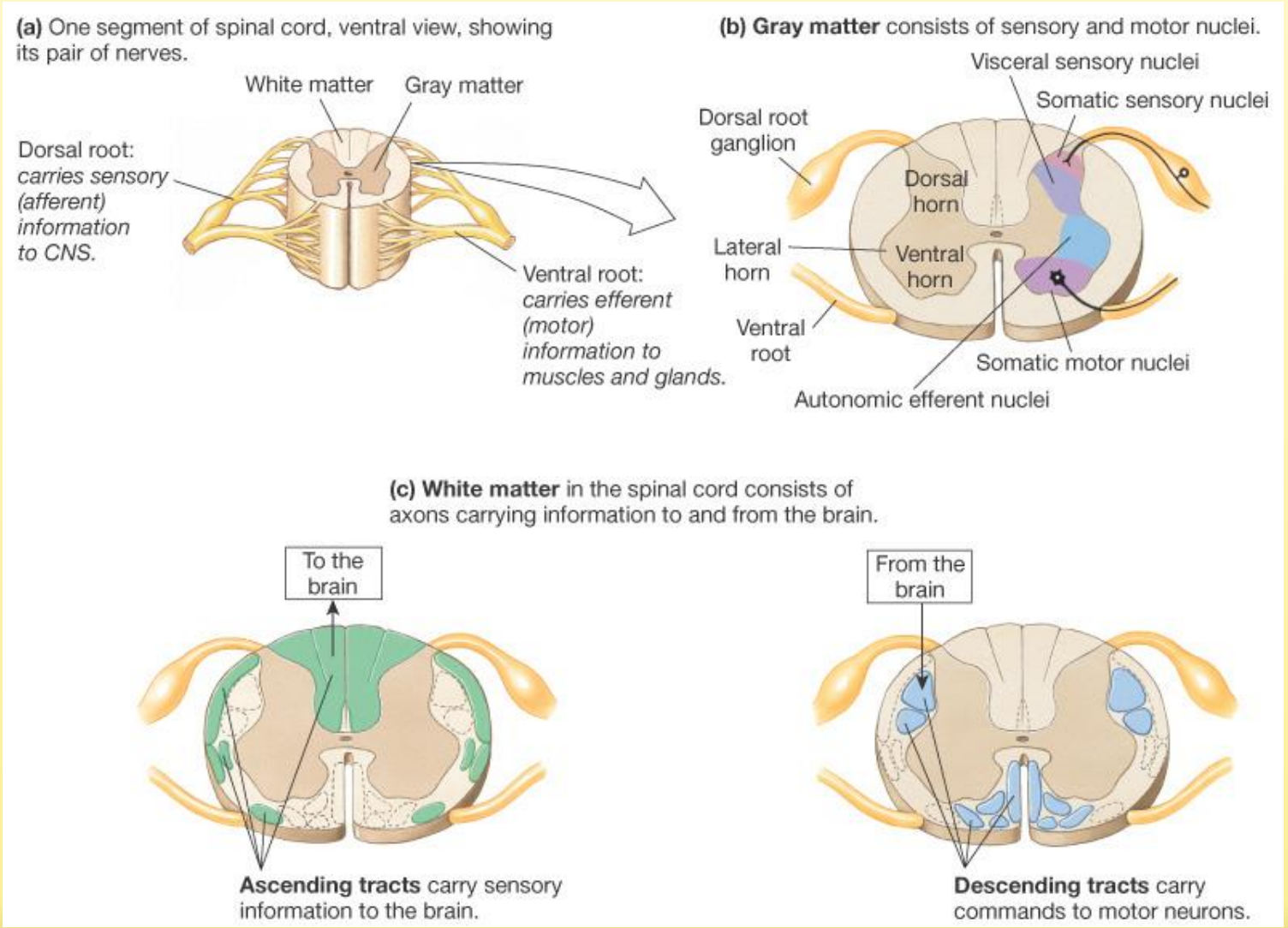


Figure 9-4a: ANATOMY SUMMARY: The Central Nervous System

Spinal Cord Organization



Meningeal Layers

- Meningeal layer of the brain cushion and protect delicate neural tissue

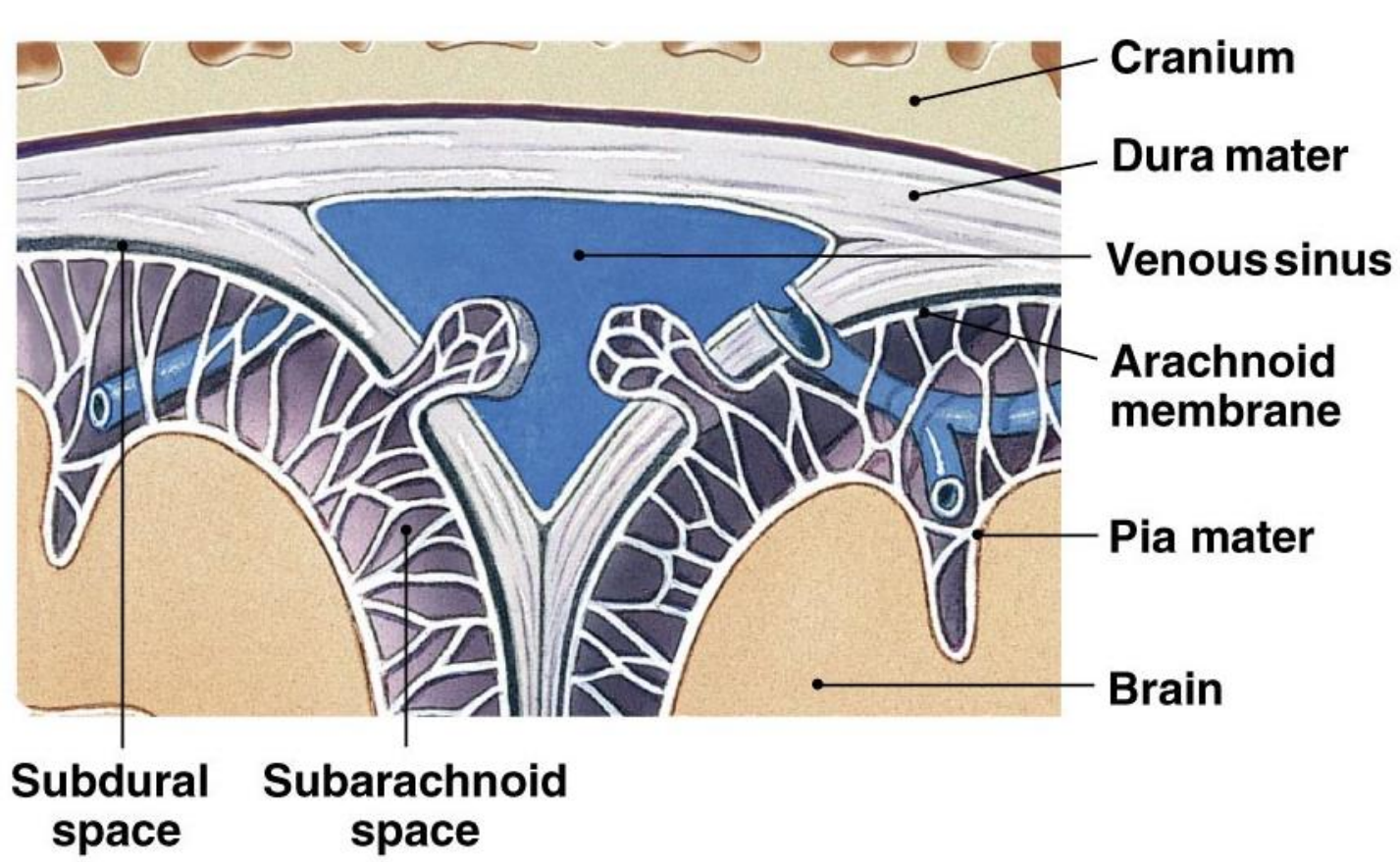
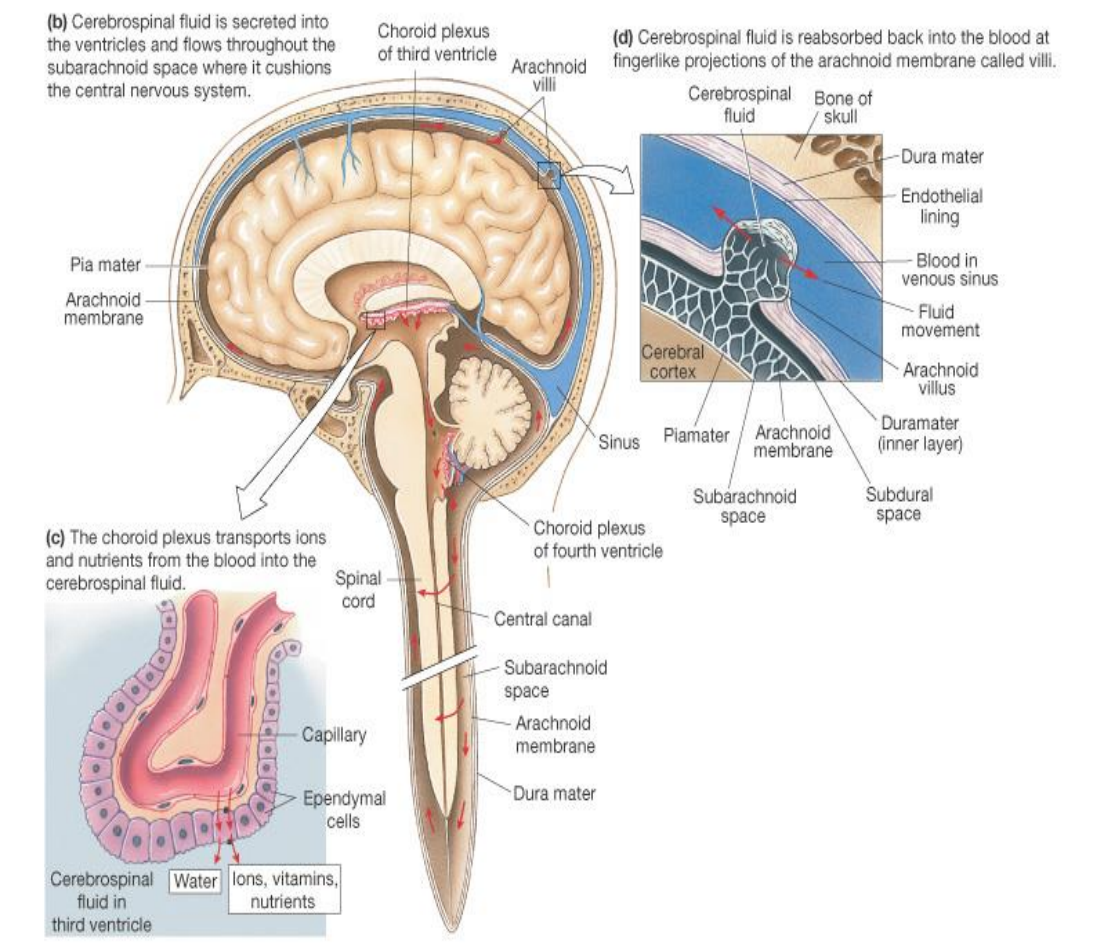


Figure 9-4b

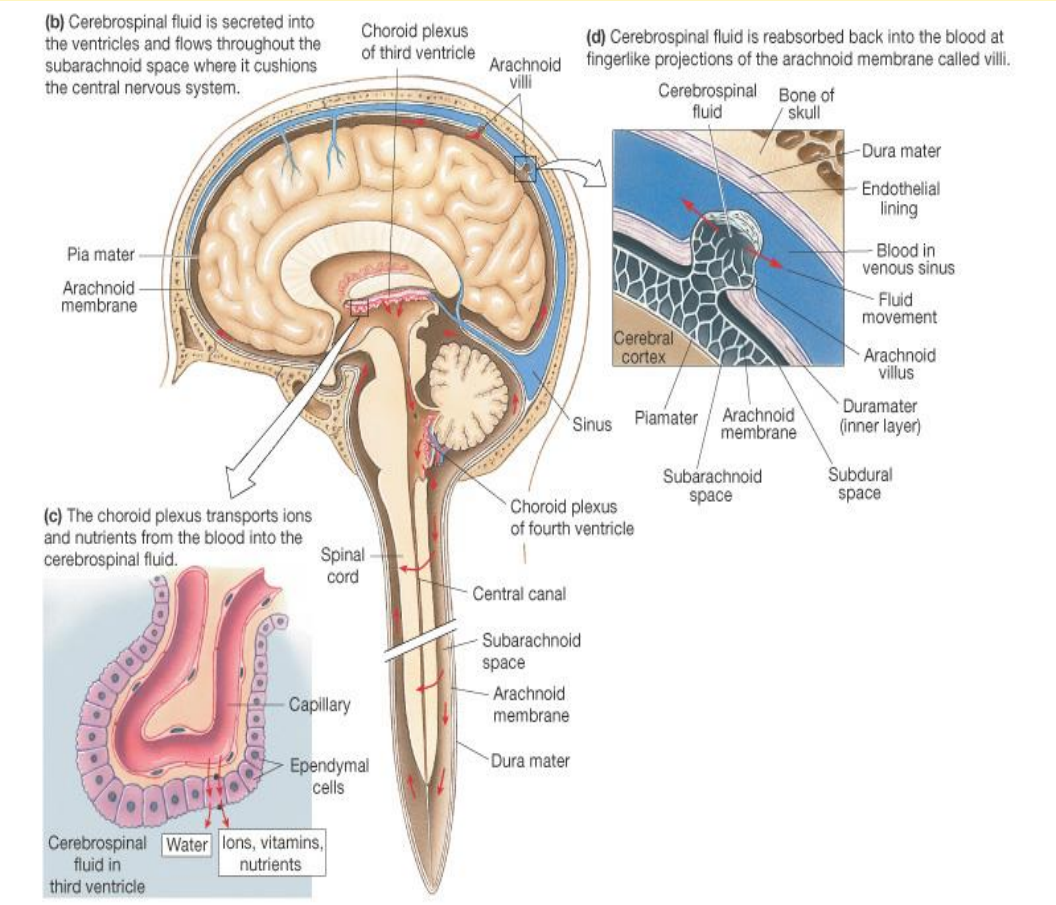
Cerebrospinal Fluid

- Shock absorbing medium
- Provides a optimum and stable environment for generating nerve impulses
- Provides a medium for the exchange of nutrients and wastes between blood and nervous tissue



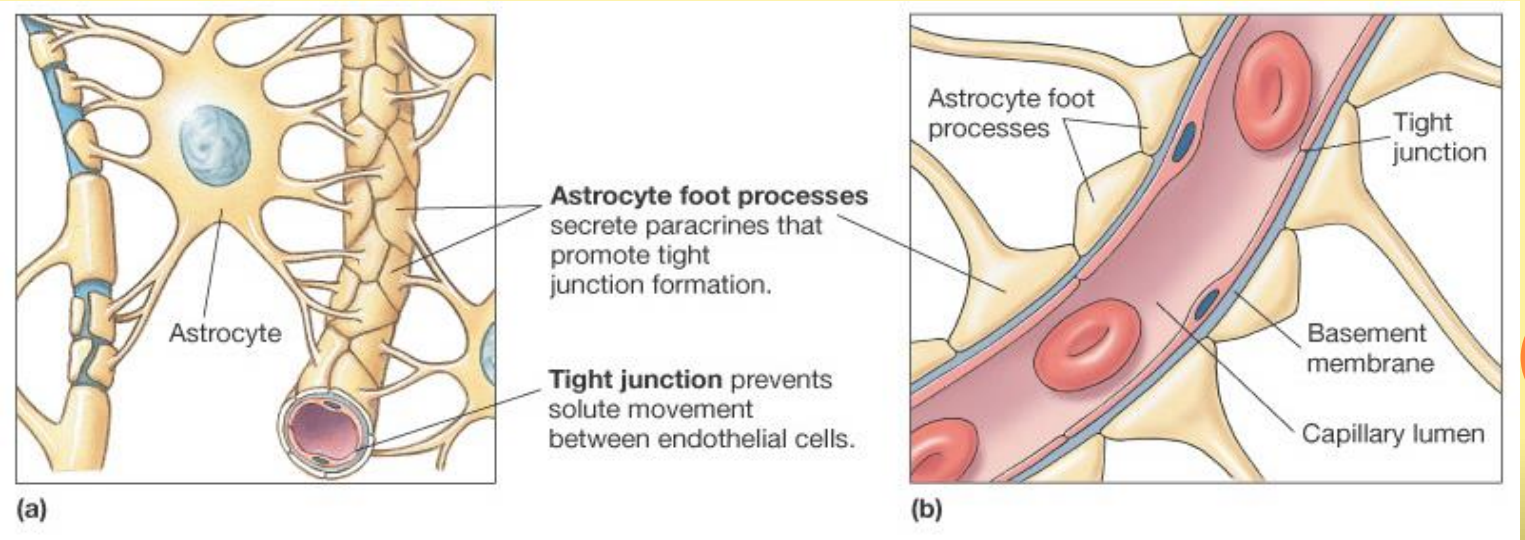
Cerebrospinal Fluid

- Formed by selective transport across ependymal cells
- Volume 125-150 ml and is replaced > 3 times/day, flow maintained by 10 mmHg pressure gradient
- Path: ventricles → subarachnoid space, reabsorbed into blood in dural sinuses through arachnoid villi

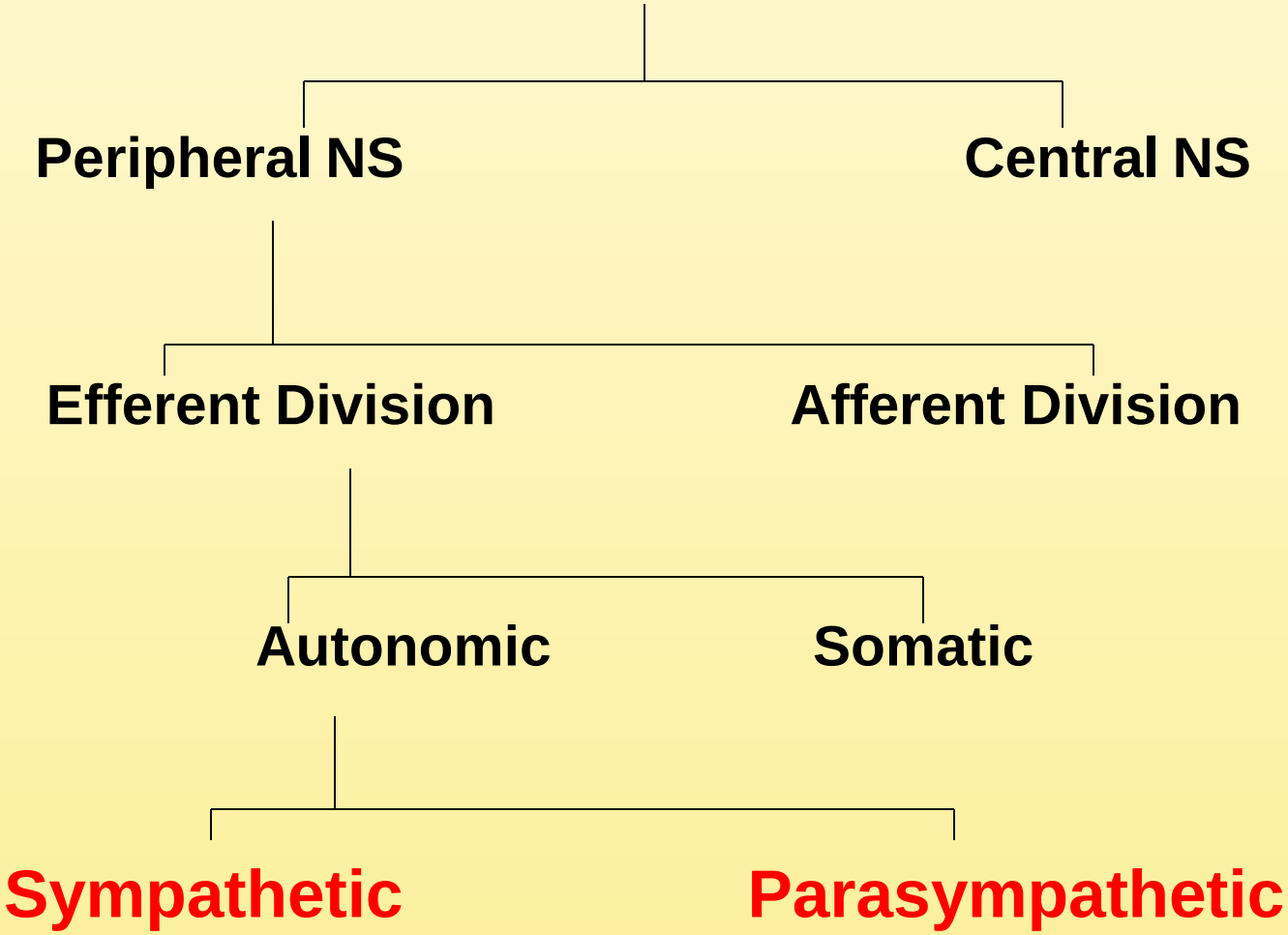


Blood Brain Barrier

- Extensive capillaries & sinuses
- Tight junctions promoted by astrocyte
- Limits permeability for most molecules except O2, CO2, alcohol, steroids, H2O
- Protects brain: hormones & circulating chemicals
  - Protects CNS from chemical fluctuations
  - Prevents entry of harmful substances
  - Prevents entry of molecules that could act as neurotransmitters
- Brain receives 15% of blood pumped by heart
- Brain responsible for about half of body's glucose consumption
- Membrane transporters move glucose from plasma into the brain interstitial fluid



SUMMARY OF THE NERVOUS SYSTEM



AUTONOMIC NERVOUS SYSTEM

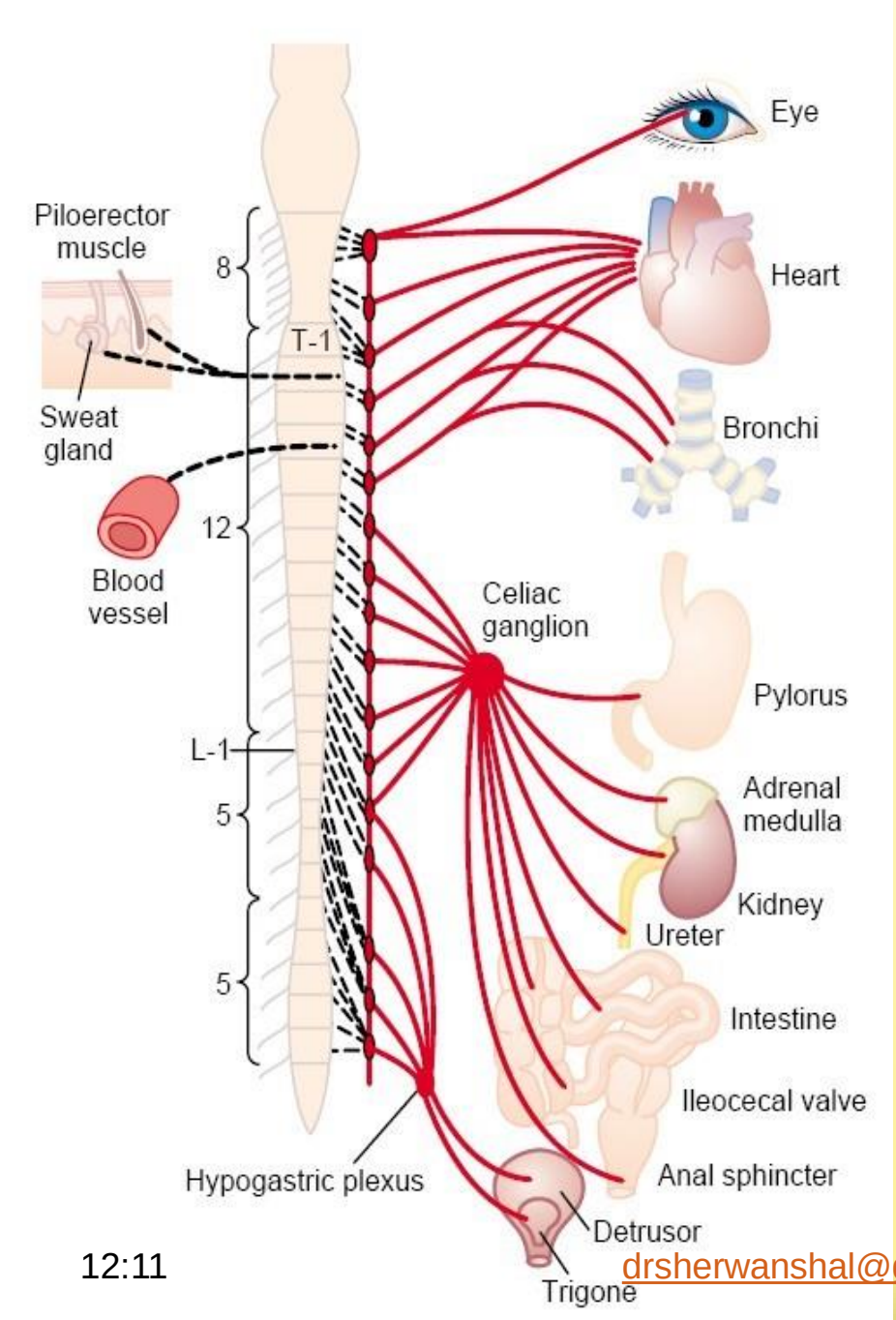
1) SYMPATHETIC
(THORACOLUMBAR) DIVISION.

2) PARASYMPATHETIC
(CRANIOSACRAL) DIVISION.

Autonomic System

- Two divisions:
  - sympathetic
  - Parasympatheitic
- Control involuntary functions
  - heartbeat
  - blood pressure
  - respiration
  - perspiration
  - digestion
- Can be influenced by thought and emotion

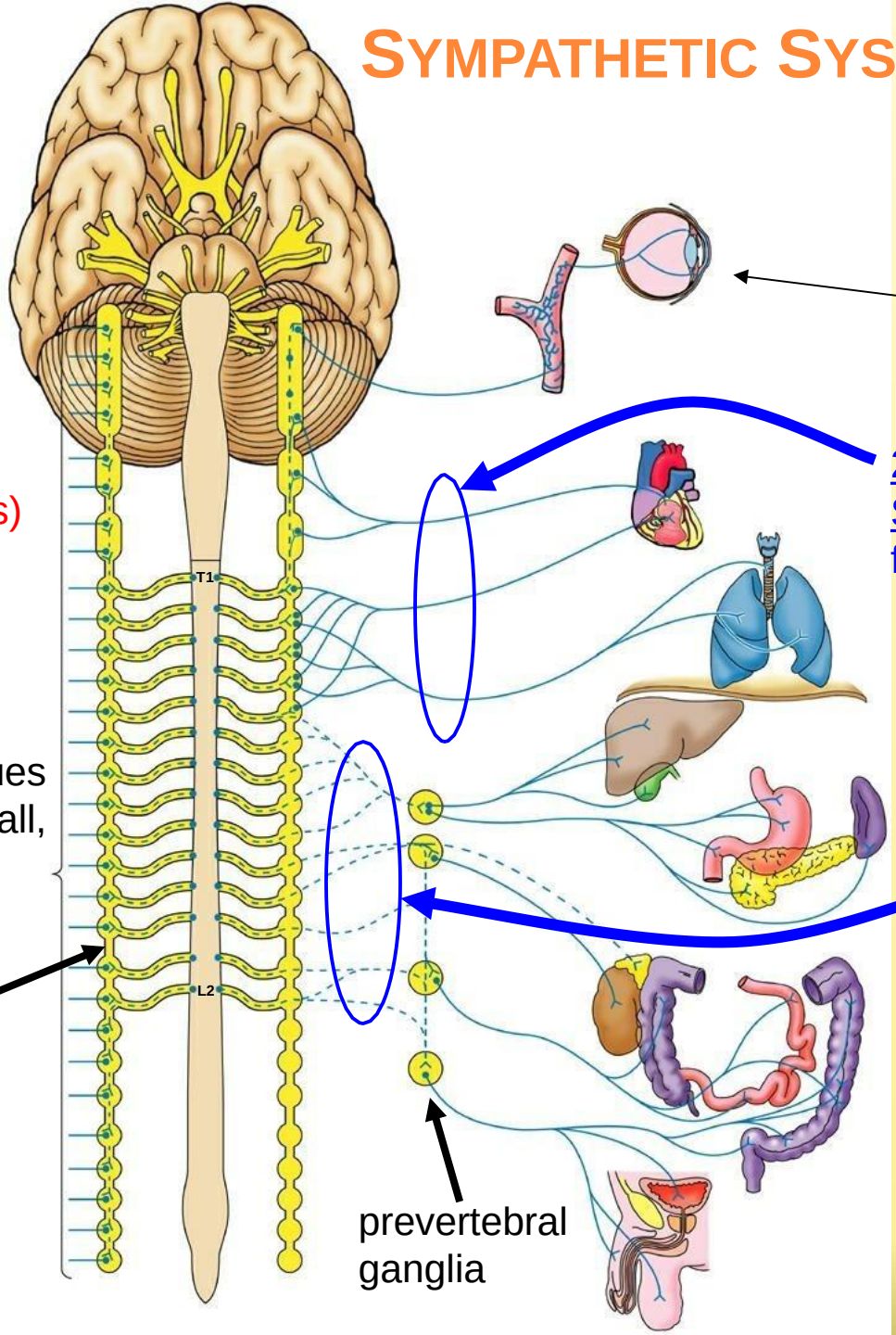
Sympathetic N.S.	Parasympathetic N.S.
Like the accelerator of your car	Like the brakes in your car
Mobilized the body for action	Slows the body down to keep its rhythm
Preganglionic: short, synapse within the lateral & collateral ganglia	Enables the body to conserve and store energy
Postganglionic: long	**Preganglionic**: long, synapse within the terminal ganglia
Has a wide distributions	**Postganglionic**: short
	Has a restricted distributions



SYMPATHETIC NERVOUS SYSTEM

drsherwanshal@gmail.com

Sympathetic System: Summary



visceral tissues
(organs)

1- Cervical division

4- somatic tissues
(body wall, limbs)

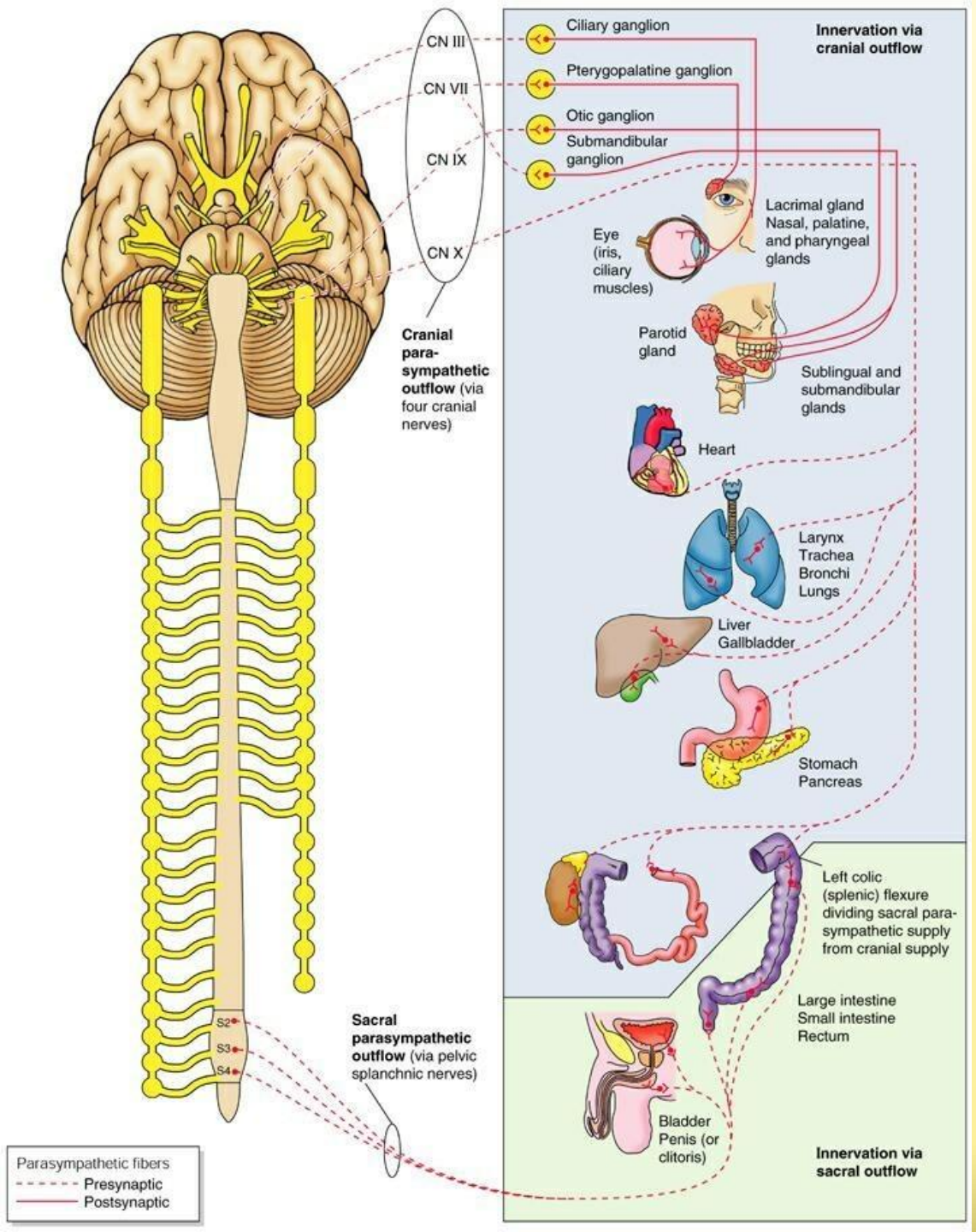
postganglionics via 31 spinal nerves to somatic tissues of neck, body wall, and limbs

sympathetic trunk

2- Cardiopulmonary Splanchnics: postganglionic fibers to thoracic viscera

3- Abdominopelvic Splanchnics: preganglionic fibers to prevertebral ganglia, postganglionic fibers to abdominopelvic viscera

prevertebral ganglia



Parasympathetic Pathways

Cranial outflow

- CN III, VII, IX, X
- Four ganglia in head
- Vagus nerve (CN X) is major preganglionic parasymp. supply to thorax & abdomen
- Synapse in ganglia within wall of the target organs (e.g., enteric plexus of GI tract)

Sacral outflow

- S2–S4 via pelvic splanchnics
- Hindgut, pelvic viscera, and external genitalia

Clinical Relevance

» Surgery for colorectal cancer puts pelvic splanchnics at risk

» Damage causes bladder & sexual dysfunction

The Parasympathetic Division

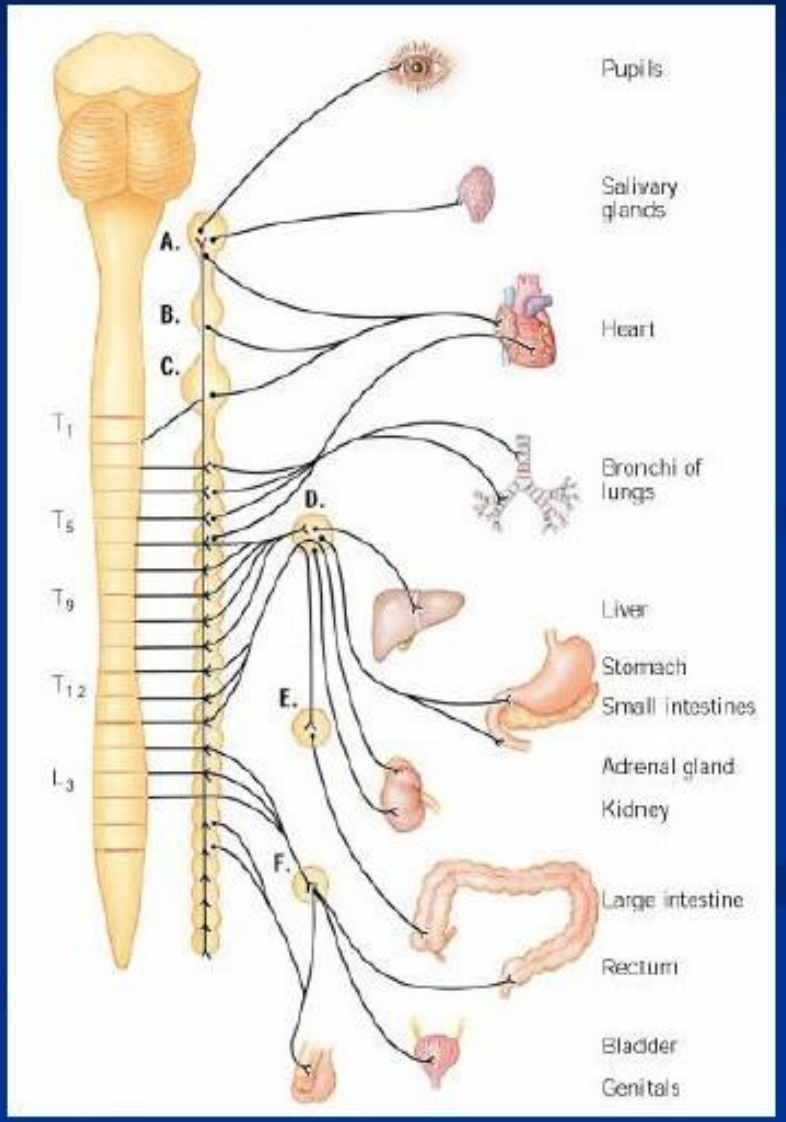
- Cranial outflow
  - Comes from the brain
  - Innervates organs of the head, neck, thorax, and abdomen
- Sacral outflow
  - Supplies remaining abdominal and pelvic organs

Comparison of some effects of sympathetic & parasympathetic branches

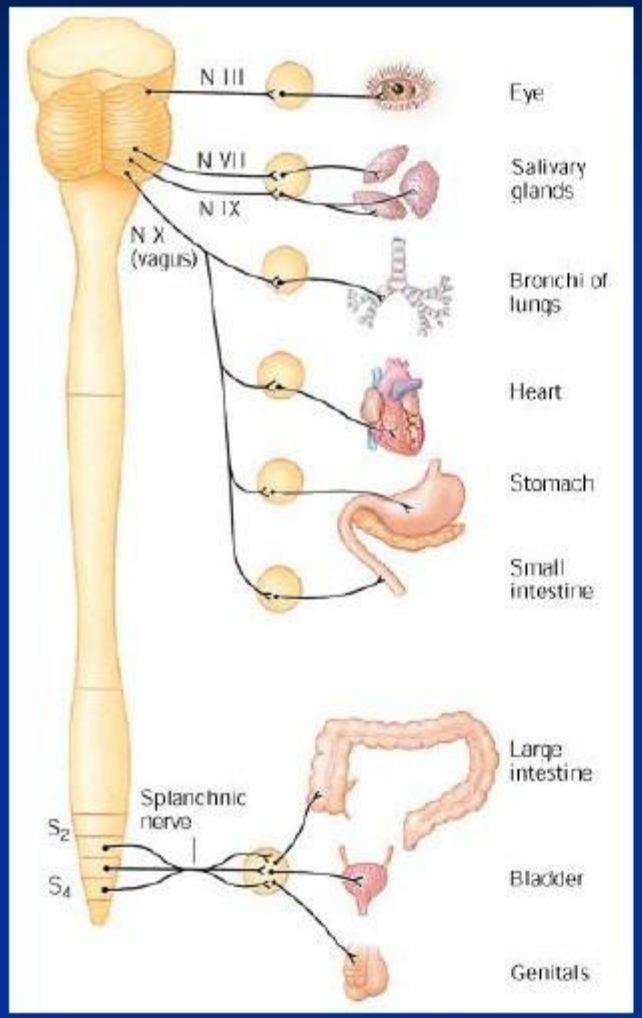
Sympathetic nervous system	Parasympathetic nervous system
contracts anal & bladder sphincters	relaxes anal & bladder sphincters
contracts erector pili muscles	no comparable effect
increases sweat production	no comparable effect
no comparable effect	increases secretion of tears

Sympathetic Stimulation

- stimulate sweat glands
- constrict peripheral vessels
- increase blood to skeletal muscles
- increase chronotropic and inotropic effects
- bronchodilation
- stimulation of NRG production
- reduce blood flow to abdomen
- decrease digestive activity
- relax smooth muscle in wall of bladder
- release glucose stores from liver



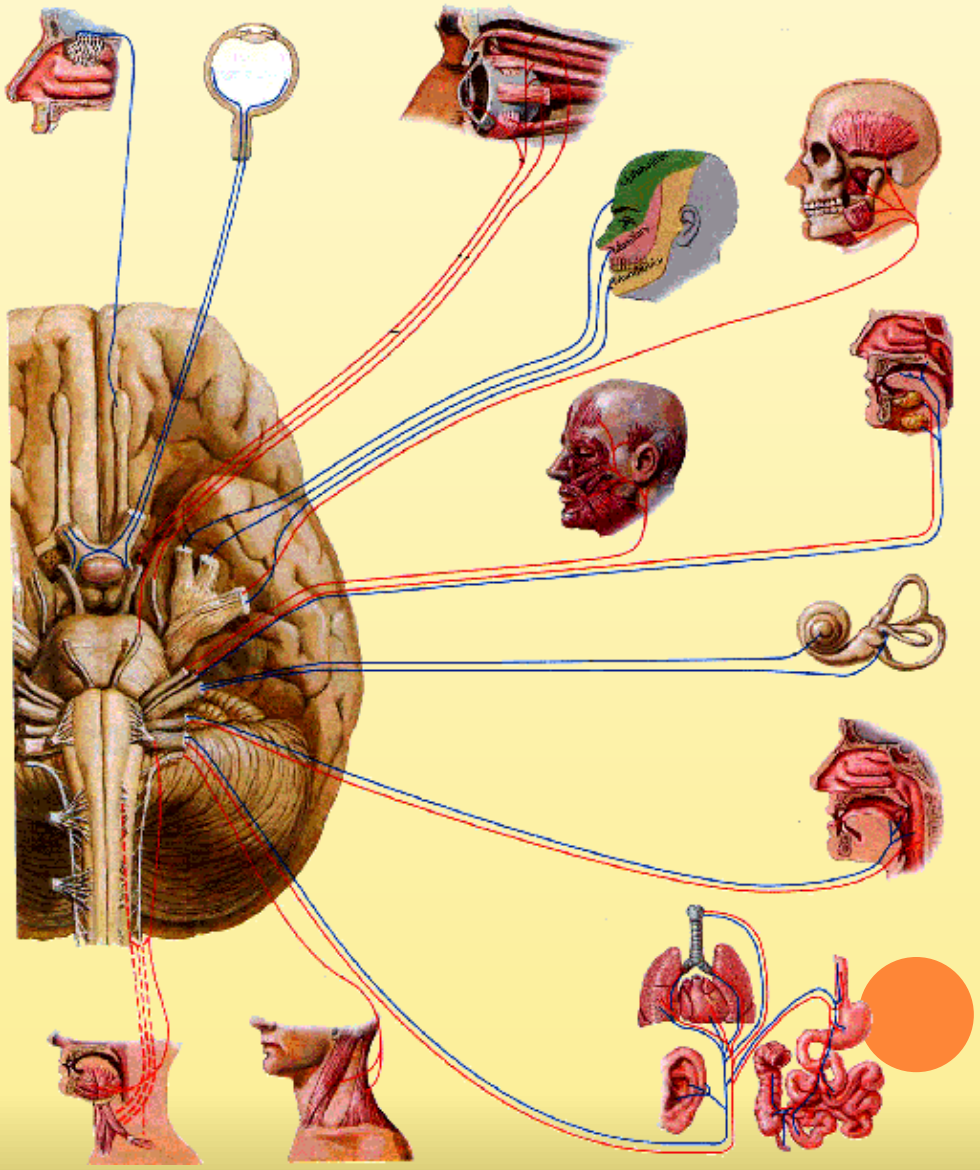
Parasympathetic Nervous System



- **Stimulation Results in:**
  - pupillary constriction
  - secretion by digestive glands
  - increased smooth muscle activity along GI tract
  - bronchoconstriction
  - reduced HR & negative Inotropic effects

Cranial Nerves

1. Olfactory nerve
2. Optic nerve
3. Oculomotor nerve
4. Trochlear nerve
5. Trigeminal nerve
6. Abducent nerve
7. Facial nerve
8. Vestibulocochlear nerve
9. Glossopharyngeal nerve
10. Vagus nerve
11. Accessory nerve
12. Hypoglossal nerve



Cranial Nerves

Table 9-1: The Cranial Nerves

NUMBER	NAME	TYPE	FUNCTION
I	Olfactory	Sensory	Olfactory (smell) information from nose
II	Optic	Sensory	Visual information from eyes
III	Oculomotor	Motor	Eye movement, pupil constriction, lens shape
IV	Trochlear	Motor	Eye movement
V	Trigeminal	Mixed	Sensory information from face, mouth; motor signals for chewing
VI	Abducens	Motor	Eye movement
VII	Facial	Mixed	Sensory for taste; efferent signals for tear and salivary glands, facial expression
VIII	Vestibulocochlear	Sensory	Hearing and equilibrium
IX	Glossopharyngeal	Mixed	Sensory from oral cavity, baro- and chemoreceptors in blood vessels; efferent for swallowing, parotid salivary gland secretion
X	Vagus	Mixed	Sensory and efferents to many internal organs, muscles, and glands
XI	Spinal accessory	Motor	Muscles of oral cavity, some muscles in neck and shoulder
XII	Hypoglossal	Motor	Tongue muscles

Summary of Function of Cranial Nerves

Cranial nerves I - VI	Sensory function	Motor function	PS* fibers
I Olfactory	Yes (smell)	No	No
II Optic	Yes (vision)	No	No
III Oculomotor	No	Yes	Yes
IV Trochlear	No	Yes	No
V Trigeminal	Yes (general sensation)	Yes	No
VI Abducens	No	Yes	No

Cranial nerves VII - XII	Sensory function	Motor function	PS* fibers
VII Facial	Yes (taste)	Yes	Yes
VIII Vestibulocochlear	Yes (hearing and balance)	No	No
IX Glossopharyngeal	Yes (taste)	Yes	Yes
X Vagus	Yes (taste)	Yes	Yes
XI Accessory	No	Yes	No
XII Hypoglossal	No	Yes	No

(b) *PS = parasympathetic

Classification of cranial nerves

- **Sensory cranial nerves**: contain only afferent (sensory) fibers
  - **Ⅰ Olfactory nerve**
  - **Ⅱ Optic nerve**
  - **Ⅷ Vestibulocochlear nerve**
- **Motor cranial nerves**: contain only efferent (motor) fibers
  - **Ⅲ Oculomotor nerve**
  - **Ⅳ Trochlear nerve**
  - **Ⅵ Abducent nerve**
  - **Ⅺ Accessory nerv**
  - **Ⅻ Hypoglossal nerve**
- **Mixed nerves**: contain both sensory and motor fibers---
  - **Ⅴ Trigeminal nerve,**
  - **Ⅶ Facial nerve,**
  - **Ⅸ Glossopharyngeal nerve**
  - **Ⅹ Vagus nerve**

THANK YOU