NEUROSCIENCE

LECTURE 03: THE BRAIN STEM

A. Medulla Oblongata
   1. The *medulla oblongata*, or just *medulla*, is continuous with the upper part of the spinal cord and contains portions of both motor and sensory tracts
   2. It also contains the nuclei of origin for cranial nerves VIII (cochlear and vestibular branches) through XII
   3. Structural regions of the medulla include the *pyramids*and the *inferior olivarynucleus*.
      a. Decussation of pyramids results in neurons in the left cerebral cortex controlling skeletal muscles on the right side of the body and neurons in the right cerebral cortex controlling skeletal muscles on the left side.
      b. Inferior olivary neurons relay impulses from proprioceptors to the cerebellum.
   4. Functional regions include nuclei that are reflex centers for regulation of heart rate, respiratory rate, vasoconstriction, swallowing, coughing, vomiting, sneezing, and hiccuping; the first three are considered vital reflexes.
   5. The medulla contains nuclei associated with five pairs of carnial nerves: VIII vestibulochoclear, IX glossopharyngeal, X vagus, XI accessory, and XII hypoglossal.
   4. Injury to the medulla can be fatal or lead to serious problems.

B. Pons
   1. The *pons* is located superior to the medulla. It connects the spinal cord with the brain and links parts of the brain with one another by way of tracts .
   2. It relays nerve impulses related to voluntary skeletal movements from the cerebral cortex to the cerebellum.
   3. The pons also contains the pneumotaxic and apneustic areas, which help control respiration along with the respiratory center in the medulla.
   4. It contains nuclei for cranial nerves V trigeminal, VI abducens, VII facial, and VIII vestibulocochlear (vestibular branch).

C. Midbrain
   1. The *midbrain* connects the pons and diencephalon. It conveys motor impulses from the cerebrum to the cerebellum and spinal cord, sends sensory impulses from the spinal cord to the thalamus, and regulates auditory and visual reflexes
   2. Structures within the midbrain include the *cerebral peduncles*, the *corpora quadrigemina*, the left and right *substantianigra*, the left and right *red nucleus*, and the *medial lemniscus*.
   3. It also contains nuclei of origin for cranial nerves III oculomotor and IV trochlear.

D. A large portion of the brain stem is called the *reticular formation*.
   1. It consists of small areas of gray matter interspersed among fibers of white matter and has both sensory and motor functions.

2. It helps regulate muscle tone, alerts the cortex to incoming sensory signals (*reticular activating system*, or *RAS*) and is responsible for maintaining consciousness and awakening from sleep.

THE CEREBELLUM

Motor part of the brain

- Coordination of movement
- Regulation of muscle tone
- Maintenance of equilibrium
- Ensures that there is contraction of the proper muscle at the appropriate time and with the correct force

•Posterior cranial fossa

- Separated from the occipital lobes by the tentorium cerebellum
- Falxcerebelli placed deeply in the posterior cerebellar fissure

•Fastigium constitutes the roof of the 4th ventricle

•Longitudinally: 2 large bilateral hemispheres with vermis between them

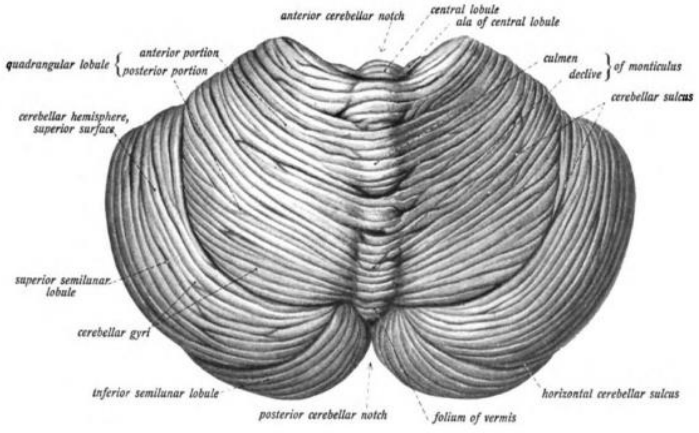
•Transversally:

•Floccolonodular: at the edge of inferior surface; composed of paired irregular-shaped masses –
flocula- joined medially by the nodulus (part of the vermis)

•Anterior: rostral to the primary fissure.

•posterior lobe: between primary and posterolateral fissures

•Posterolateral fissure – between flocculonodular and posterior lobes. 1st fissure to develop



•Gray matter: cortex + 4 types of nuclei in each side

•White matter: medullary center + paired inferior, middle and superior cerebellar peduncles composed of afferent and efferent nerve fibers which connect the cerebellum with the medulla, pons and midbrain respectively

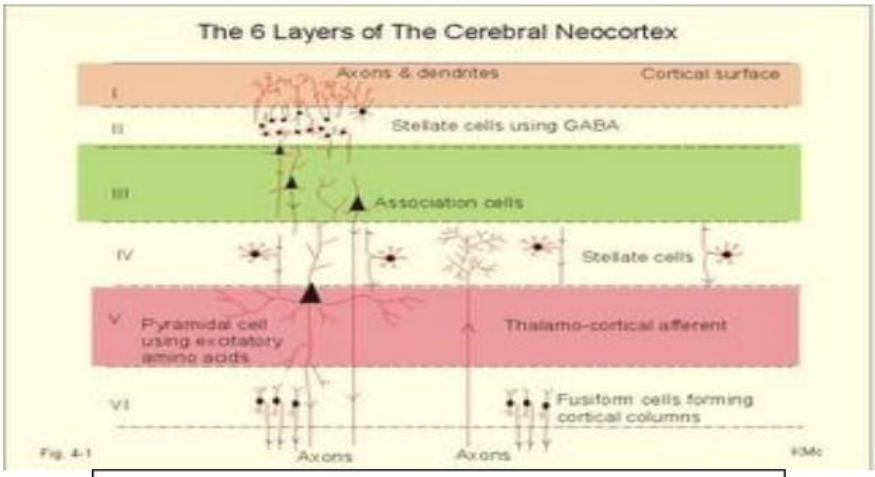
Cerebellar cortex

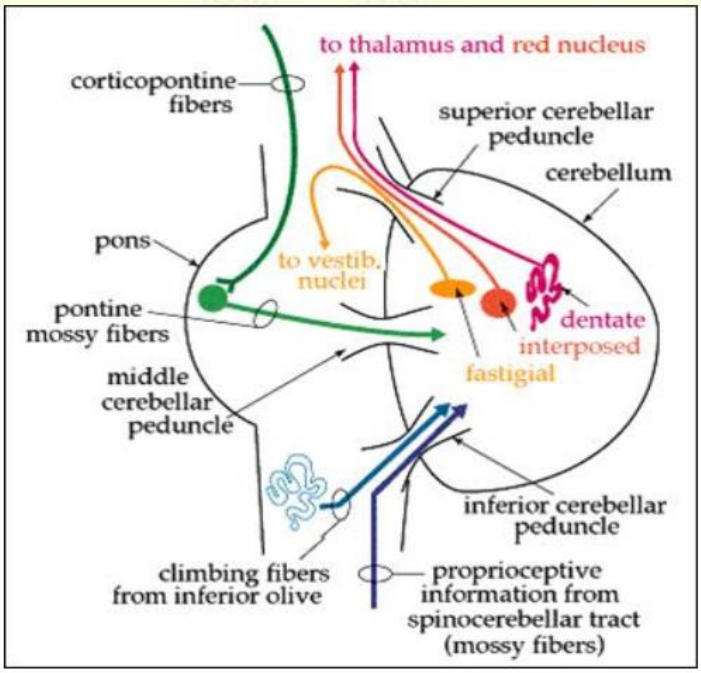
•Folia cerebelli

•3 layers:

•Molecular (stellate +basket)

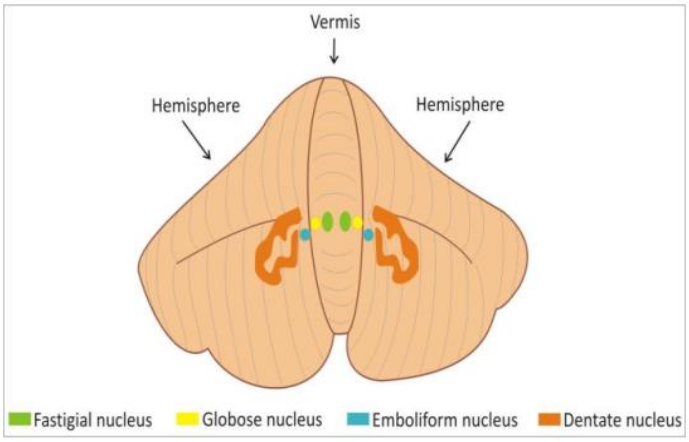
•Ganglionar (purkyne)
•Granular (golgi cells + granular cells)
•Layers have 5 types of cells:
•Stellate
•Basket
•Purkyne
•Golgi
•granule



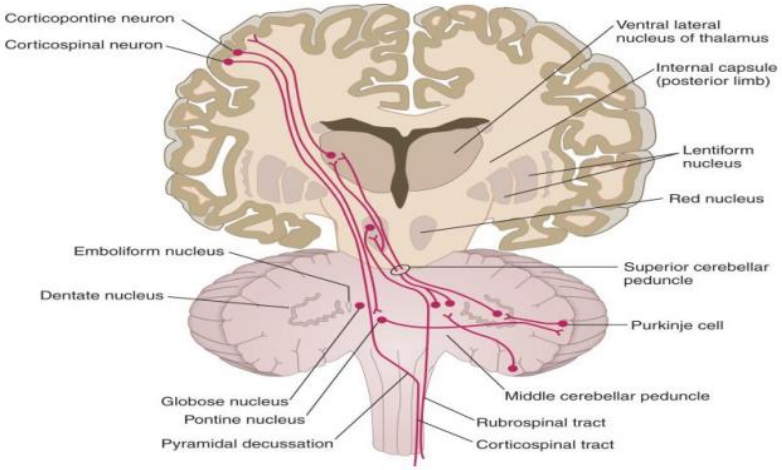


Cerebellar nuclei
•Transmit all output from the cerebellum
•Fastigial: close to the midline in contact with the fastigium
•globulose: 2 or 3 masses in each side
•Emboliform: oval shape
•Dentate: most proeminent

NEUROSCIENCE



White matter
•All the afferent (sensory) and efferent (motor) pathways pass through the peduncles.
•Inferior cerebellar peduncle
•Fibers entering the cerebellum with predominant origin in the inferior olivary complex – olivocerebelar tract;
•Middle cerebellar peduncle
•Fibers originating in the nuclei pontis / ponto cerebellar tract
•Superior cerebellar peduncles
•Fibers from globulose, emboliform and dentate nuclei.
•Afferent fibers: superior spinocerebellar + rubrocerebellar tracts



Phylogenetical development
•Archicerebellum – flocculonodular lobe: vestibular nuclei (major connection); function: posture and eye movement
•Paleocerebellum – superior vermis in the anterior lobe + part of inferior vermis in the posterior lobe; spinal cord (major connection); function: progressive movement
•Neocerebellum – ceberellar hemispheres + vermis in posterior lobe; cerebral cortex via nclpontis (major connection); funtion: manipulative movement and speech

damage to the cerebellum disrupts muscle coordination resulting in ataxia.

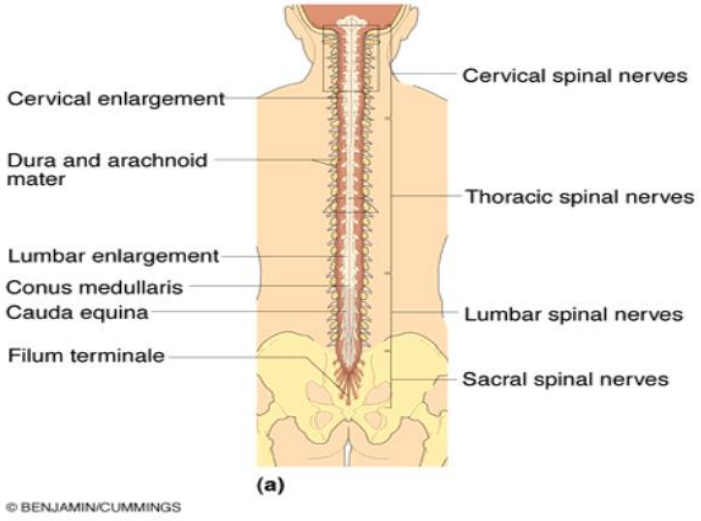
NEUROSCIENCE

Spinal Cord & Nerves, Autonomics

I. General Structure of Spinal Cord

A. Principal Parts

1. 42-45 cm in length; 2.5 cm wide
2. cervical enlargement - C4:T1 supply upper limbs
3. lumbar enlargement - T9:T12 supply lower limbs
4. conusmedullaris - tapers off to end at L1-L2
5. filumterminale - pia mater anchors cord to coccyx
6. caudaequina - (horse tail) nerves below L2

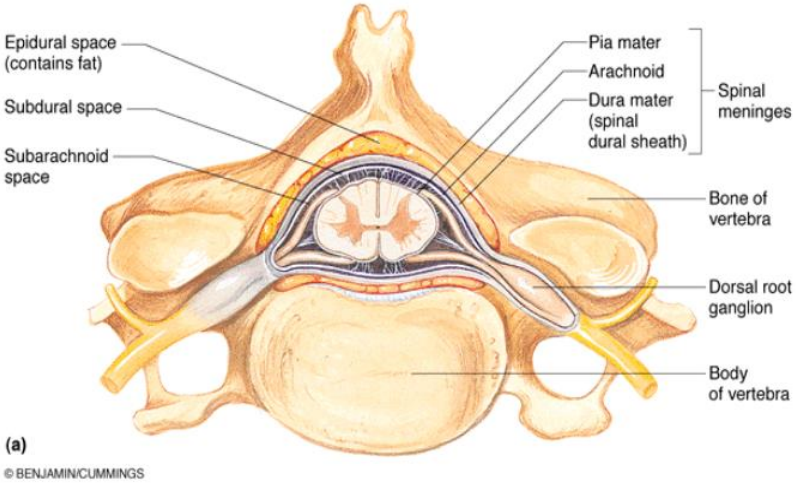


B. Things to Note

1. Cord itself ends at L1-L2 vertebrae
2. Lower nerves dangle down in the caudaequina
3. There are 31 pairs of spinal nerves
4. spinal segment - gives rise to one spinal nerve
5. C1-C7 spinal nerves project **ABOVE** C1-C7 vertebrae

6. C8 spinal nerve projects below C7 vertebra

7. T1-S5 spinal nerves project **BELOW** T1-S5 vertebrae



II. Spinal Cord Structure - Cross Section

A. Grey vs. White Matter

1. grey matter - nerve cell bodies motor & interneurons

2. white matter - myelinated axons of motor & sensory

B. Regions in the Grey Matter - **H** shaped center

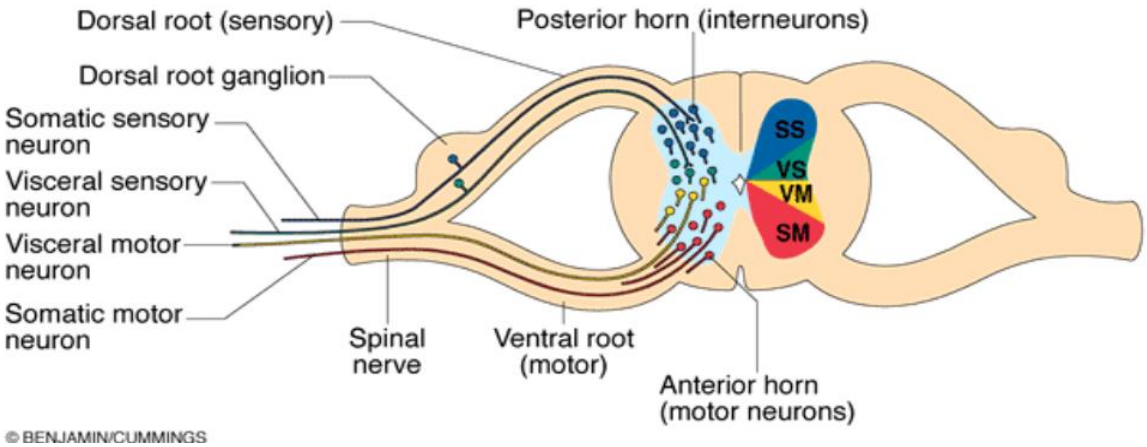
1. grey commissure - cross bar of the H

2. central canal - hole in the center

3. anterior (ventral) horns

4. posterior (dorsal) horns

5. lateral (intermediate) horns (T, L, S only)



C. Regions in the White Matter - fiber tracts

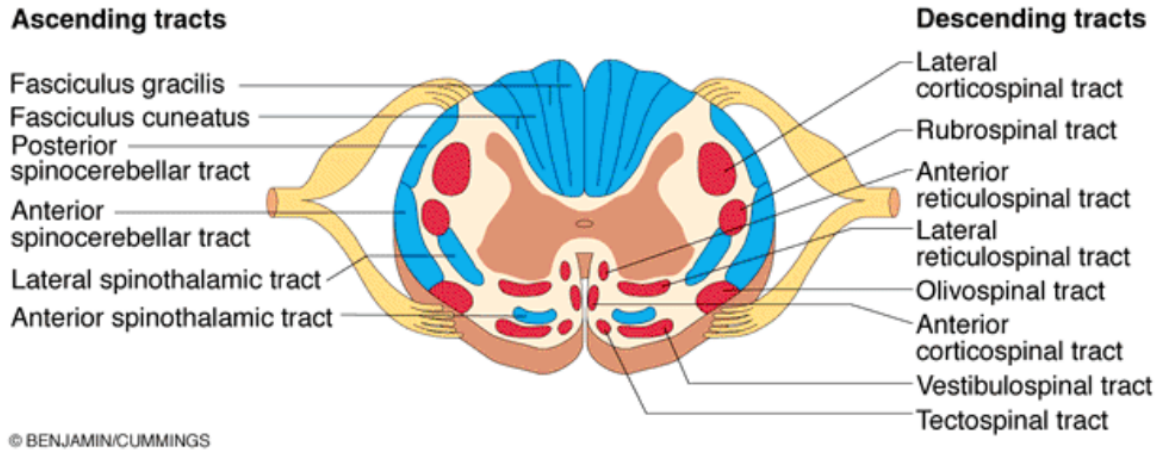
1. anterior (ventral) column
2. posterior (dorsal) column
3. lateral (intermediate) column
4. fasciculi/tracts - axon bundles w/ common function
    a. ascending tracts - sensory to the brain
    b. descending tracts - brain->motor neurons

III. The Ascending/Descending Tracts of the Cord

Tract	**Function**
ASCENDING TRACTS (SENSORY)	
anterior (ventral) spinothalamic	touch and pressure to thalamus
lateralspinothalamic tract	pain & temperature to thalamus
fasciculusgracilis	touch, 2-pt. discrimination, fasciculus cuneatus conscious proprioception, stereognosis, weight discrimination, vibration
posteriorspinocerebellar	subconscious proprioception
anteriorspinocerebellar	
DESCENDING TRACTS (MOTOR)	
lateralcorticospinal	motor output from cortex to anterior corticospinal motor cells of ant. horn
rubrospinal	motor from midbrain to ant. horn for precise movement

tectospinal	motor from midbrain to ant. horn; movements in response to audiovisual/cutaneous stimuli
vestibulospinal	motor from medulla to ant. horn; coordination/balance
lateralreticulospinal	motor from medulla to ant. horn; inhibit ext. reflexes
medialreticulospinal	motor from pons to ant. horn; facilitate ext. reflexes

***NOTE:** These descending tracts terminate on the motor cells of the ANTERIOR GREY HORN. It is here that the cell bodies of the motor neurons to the skeletal muscles reside. The efferent skeletal motor fibers (axons) originate in the ANTERIOR HORN !!!!!!!!! These motor fibers get to the muscles via the 31 pairs of spinal nerves. This is how all motion is controlled.



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IV. Anatomy of a Reflex

A. Structures Involved

1. dorsal (posterior,sensory) root
    a. all afferent (sensory) fibers from periphery
2. dorsal (sensory) root ganglion
    a. contains sensory nerve cell bodies (bipolar)
3. ventral (anterior,motor) root
    a. motor nerve AXONS only
        i. skeletal motor neurons (ant. horn)
        ii. smooth/cardiac/gland neurons (lat. horn)

B. The Simple Reflex Arc

1. A special type of conduction pathway
2. Receptor - responds to internal/external stimulus
3. Sensory Neuron - passes impulse to CNS
    a. impulse sent along nerve from that organ
    b. eventually reaches DORSAL ramus of spinal nerve
    c. synapses on neuron somewhere in grey matter
4. Center - point in the CNS where message is accepted
    a. sometimes directly to the effector motor neuron
    b. most times on an INTERNEURON of dorsal horn
    c. passes message to motor neuron in VENTRAL HORN
    d. or passes message to brain via specific tract
5. Motor neuron - sends signal to appropriate effector
    a. resides in anterior horn - skeletal muscle
    b. resides in lateral horn - smooth/cardiac/gland
6. Effector Organ - organ effected by motor neuron
    a. simple reflexes and motion - skeletal muscle
    b. general physiological - other organs

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C. Different Reflexes

1. Spinal reflexes - spinal cord controlled (posture)
2. Somatic reflexes - skeletal muscles
3. Cranial reflexes - brain and cranial nerves
4. Visceral (autonomic) r. - smooth/cardiac/glands
5. stretch reflex - monosynaptic
    a. muscle spindle organ (sense stretch)
    b. sensory neuron -> motor neuron
    c. ipsilateral (same side) reflex arc
    d. patellar tendon reflex
    e. reciprocal innervation - excitatory/inhibitory
6. tendon reflex - polysynaptic
    a. Golgi tendon organs (sense tension)
    b. sensory neuron -> interneuron -> motor neuron
    c. ipsilateral reflex arc
    d. also reciprocal innervation
7. flexor (withdrawal) reflex polysynaptic
    a. pain receptors
    b. sensory -> interneurons -> many motor neurons
    c. intersegmental reflex arc
        i. many spinal segments involved in response
        ii. complex movement is coordinated
    d. crossed-extensor reflex
        i. sensory message crosses to opposite side
        ii. allowscontralateral muscle response
        iii. maintain body balance during reflex

D. Major Clinical Reflexes

1. patellar reflex (knee jerk)
2. Achilles reflex (ankle jerk)

3. Babinski sign - positive (under 1 1/2 years old)
   negative (after 1 1/2 years old)
4. abdominal reflex

V. The Spinal Nerves

A. Named - according to vertebral level (as above)

B. Coverings

1. endoneurium - around individual axon (myel. or not)
2. perineurium - around axon bundles (fascicles)
3. epineurium - around the entire nerve
4. meninges of cord fuse with epineurium on exit

C. Branches of a Spinal Nerve

1. dorsal ramus - deep muscles and skin of back
2. ventral ramus - extremities, ventrolateral trunk
3. meningeal branch - back into the spinal column
4. ramicommunicantes - for autonomic nerve fibers

D. The Four Nerve Plexuses

1. cervical plexus - ventral rami of C1-C4 with some C5
   a. muscles/skin of head, neck, some shoulder
   b. phrenic nerve - diaphragm muscle (breathing)
2. brachial plexus - ventral rami of C5-C8 and T1
   a. nervous supply to entire arm and shoulder

NEUROSCIENCE

The Brachial Plexus

Roots →**Trunks**→ **Divisions** →**Cords**→**Nerve**→ muscles

E.g.

C5-T1 → Superior trunk, Inferior trunk →Anterior division → lateral cord, medial cord → median nerve → flexors of forearm

3. lumbar plexus - ventral rami of L1-L4
    a. abdominal wall, genitals, part of lower limb
    b. femoral nerve
4. sacral plexus - ventral rami of L4-L5 and S1-S4
    a. buttocks, perineum, part of lower limb
    b. sciatic nerve - largest nerve of body

VI. Dermatomes

A. Dermatome - skin innervated by dorsal root of a spinal n.

VII. Overview of the Autonomic Nervous System (ANS)

A. General Functions

1. efferent control of everything except skeletal m.
2. pupil size, accommodation for near/far vision
3. dilation/constriction of blood vasculature
4. rate and force of heart contractions
5. gastrointestinal movements
6. secretion of most glands

B. General Differences from Somatic Nervous System

1. allfibers are efferent (motor)
2. two different types of efferent fibers
    i. two neurotransmitters (ACh and Norepinephrine)
3. must synapse on ganglion before effecting target
4. has two primary divisions
    a. sympathetic

b. parasympathetic

5. can act in both inhibitory and excitatory fashion

VIII. Structure of Autonomic Pathway

A. preganglionic neurons - spinal cord -> ganglion

1. sympathetic (thoracolumbar)

a. lateral grey horn of T1-L3

2. parasympathetic

a. lateral grey horn of S2-S4

b. nuclei of cranial nerves III, VII, IX, X

B. autonomic ganglia - house cell bodies of effector n.

1. sympathetic

a. vertebral ganglia - along the spine

b. prevertebral ganglia - near arteries

2. parasypathetic

a. terminal ganglion - near effected organ

C. postganglionic neurons - motor to effected organ

IX. The Autonomic Ganglia

A. Sympathetic System

1. superior cervical ganglion

a. sweat glands, eye, face vessels and glands

2. middle cervical ganglion

a. heart

3. inferior cervical ganglion

a. heart

4. thoracic ganglia

a. heart, lungs, bronchi, thoracic viscera

5. lumbar and sacral ganglia

a. viscera of abdominopelvic cavity

B. Parasympathetic Ganglia

1. ciliary ganglion

a. smooth muscle of the eye

2. pterygopalantine ganglion

a. nasal mucosa, palate, pharynx, lacrimal gland

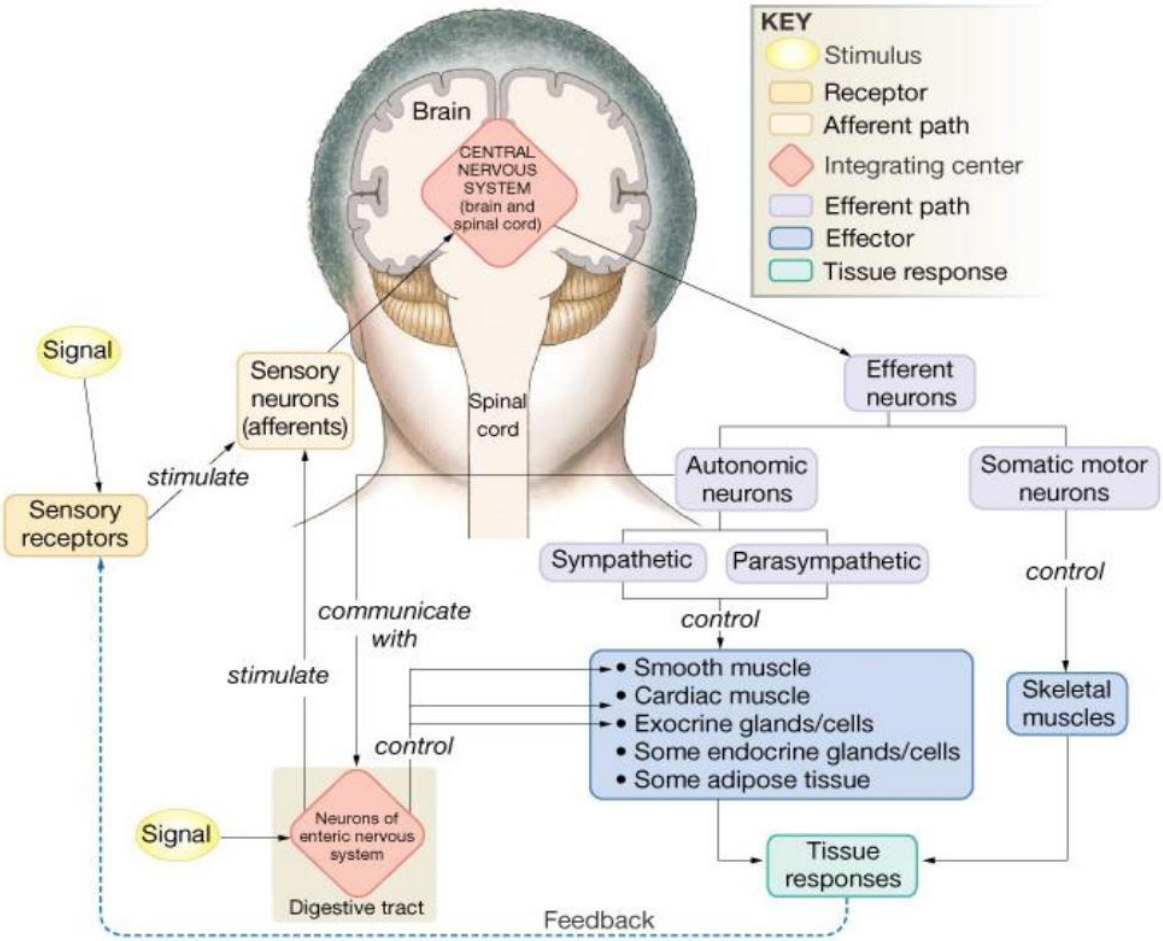
3. submandibular and otic ganglia

a. salivary glands

4. cardiac and pulmonary plexuses

a. to the heart and lungs

PERIPHERAL NERVOUS SYSTEM



- Nervous structures outside the brain and spinal cord
- Nerves allow the CNS to receive information and take action

- *Functional components of the PNS*
  - Sensory inputs and motor outputs categorized as somatic or visceral
  - Sensory inputs also classified as *general* or *special*

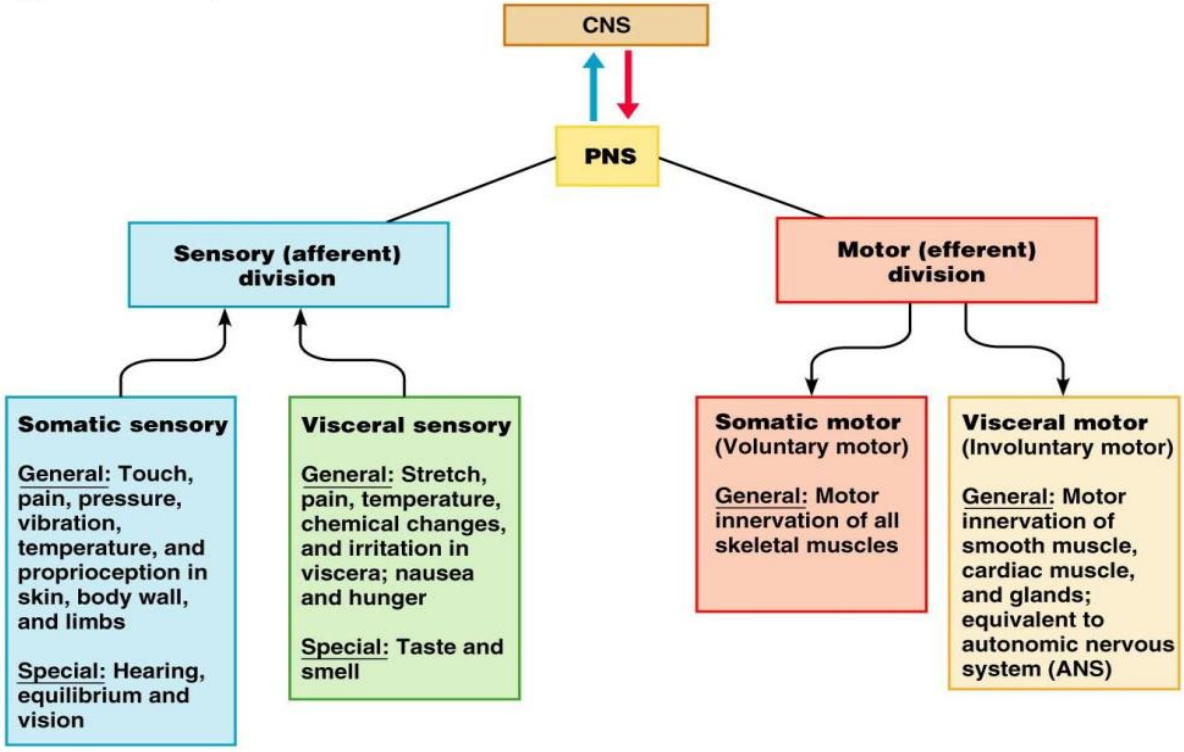
Sensory Input and Motor Output

- Sensory (afferent) signals picked up by sensor receptors, carried by nerve fibers of PNS to the CNS
- Motor (efferent) signals are carried away from the CNS, innervate muscles and glands
- Divided according to region they serve
  - Somatic body region
  - Visceral body region
- Results in four main subdivisions
  - Somatic sensory
  - Visceral sensory
  - Somatic motor
  - Visceral motor

PNS 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

Types of Sensory and Motor Information



Sensory

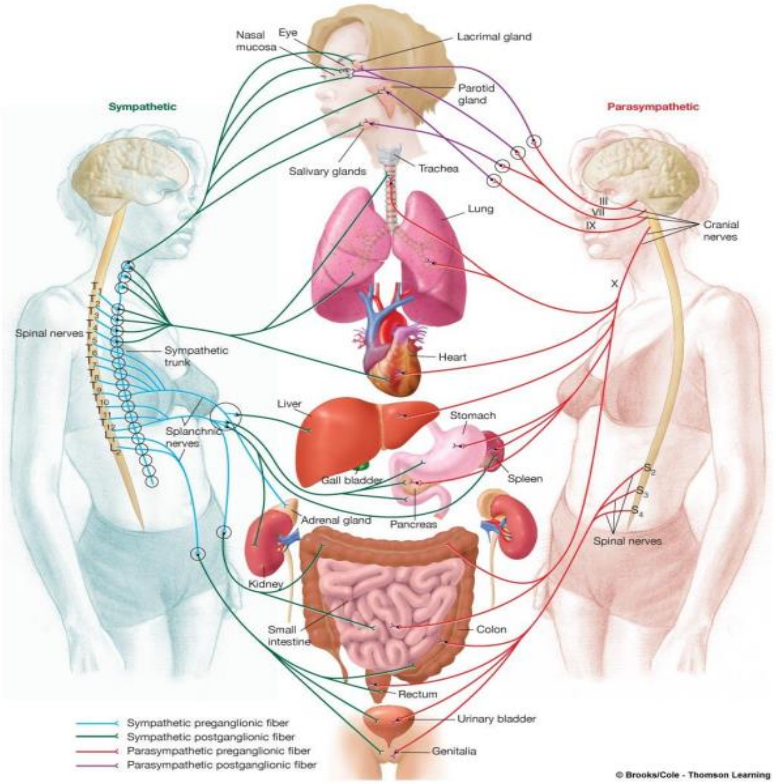
- General somatic senses – include touch, pain, vibration, pressure, temperature

- Proprioceptive senses – detect stretch in tendons and muscle provide information on body position, orientation and movement of body in space
- Special Senses - hearing, balance, vision, olfaction (smell), gustation (taste)

Motor

- General somatic motor
  - Signals contraction of skeletal muscles
  - Under our voluntary control
- Visceral motor
  - Makes up autonomic nervous system (ANS)
  - Regulates the contraction of smooth and cardiac muscle, controls function of visceral organs
  - ANS has two divisions
    - Parasympathetic
    - Sympathetic

Divisions of ANS

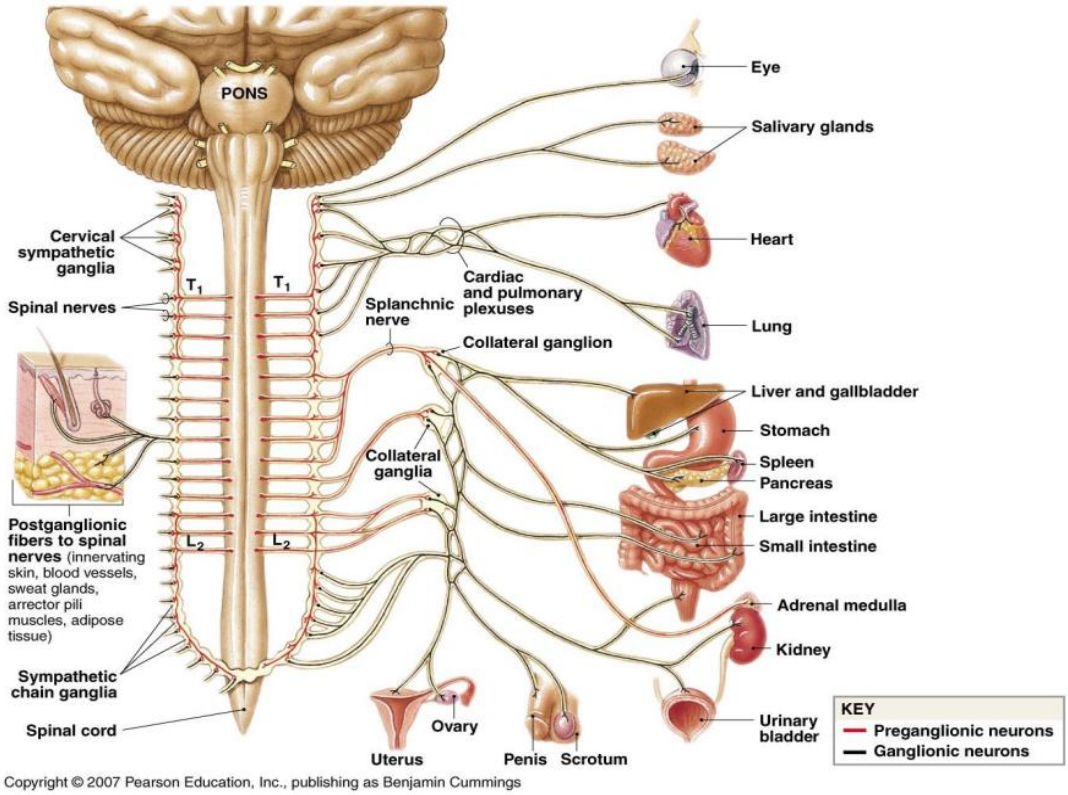


- Sympathetic - "fight or flight"
  - Catabolic (expend energy)
  - Mass activation prepares for intense activity.
    - Heart rate (HR) increases.
    - Bronchioles dilate.
    - Blood [glucose] increases.
- Parasympathetic - "feed & breed", "rest & digest"
  - Maintain homeostasis

- Normally not activated as a whole, stimulation of separate parasympathetic nerves.
- Relaxing effects:
  - Decreases HR.
  - Dilates visceral blood vessels.
  - Increases digestive activity.

- Dual innervation of many organs — having a brake and an accelerator provides more control

Sympathetic Division Organization



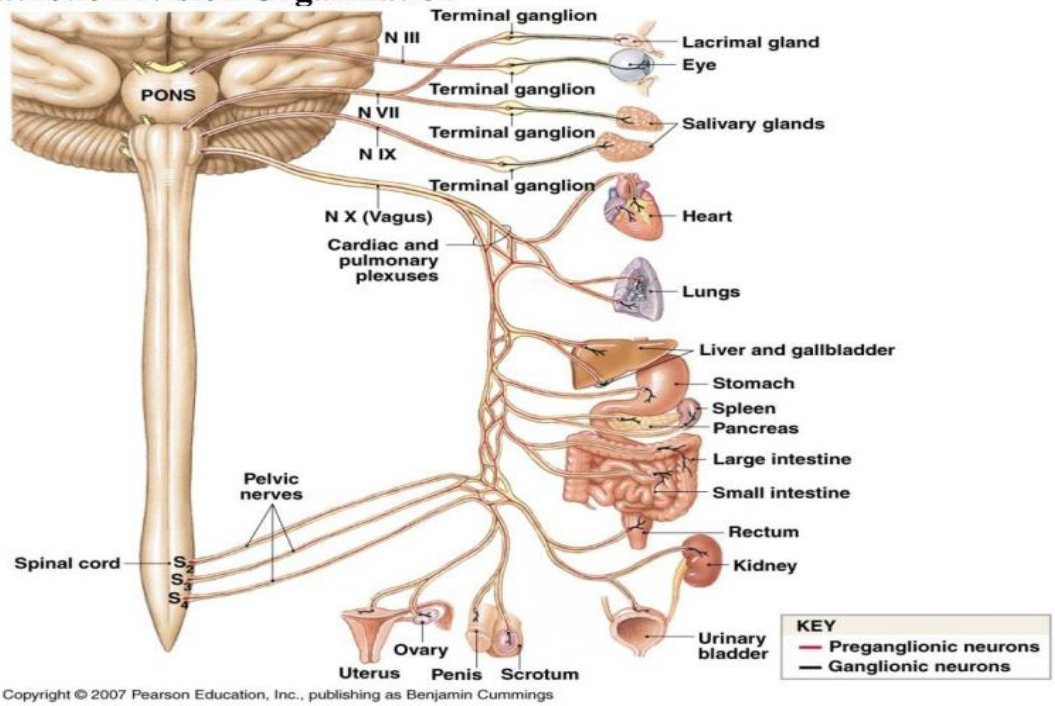
- Preganglionic neurons in segments T_1 to L_2
- Ganglia near the vertebral column
- Sympathetic ganglia
  - Paired sympathetic chain ganglia
  - Unpaired collateral ganglia
- Preganglionic fibers to adrenal medullae
  - *Epinephrine* (adrenalin)into blood stream

The Autonomic Nervous System

- Effects of Sympathetic Activation
  - Generalized response in crises
  - Increased alertness/energy
  - Increased cardiovascular activity
  - Increased respiratory activity

- Increased muscle tone

Parasympathetic Division Organization



- Preganglionic neurons in brain stem and sacral spinal segment
- Ganglionic neurons (peripheral ganglia) in or near target organ
- Sacral fibers form *pelvic nerves*

The Autonomic Nervous System

- Effects of Parasympathetic Activation
  - Relaxation
  - Food processing
  - Energy absorption
  - Brief effects at specific sites

Detailed explanation under the spinal cord nerves and autonomic

Cranial Nerves

- Attach to the brain and pass through foramina of the skull
- Numbered from I–XII
- Cranial nerves I and II attach to the forebrain
  - All others attach to the brain stem
- Primarily serve head and neck structures
  - The vagus nerve (X) extends into the abdomen

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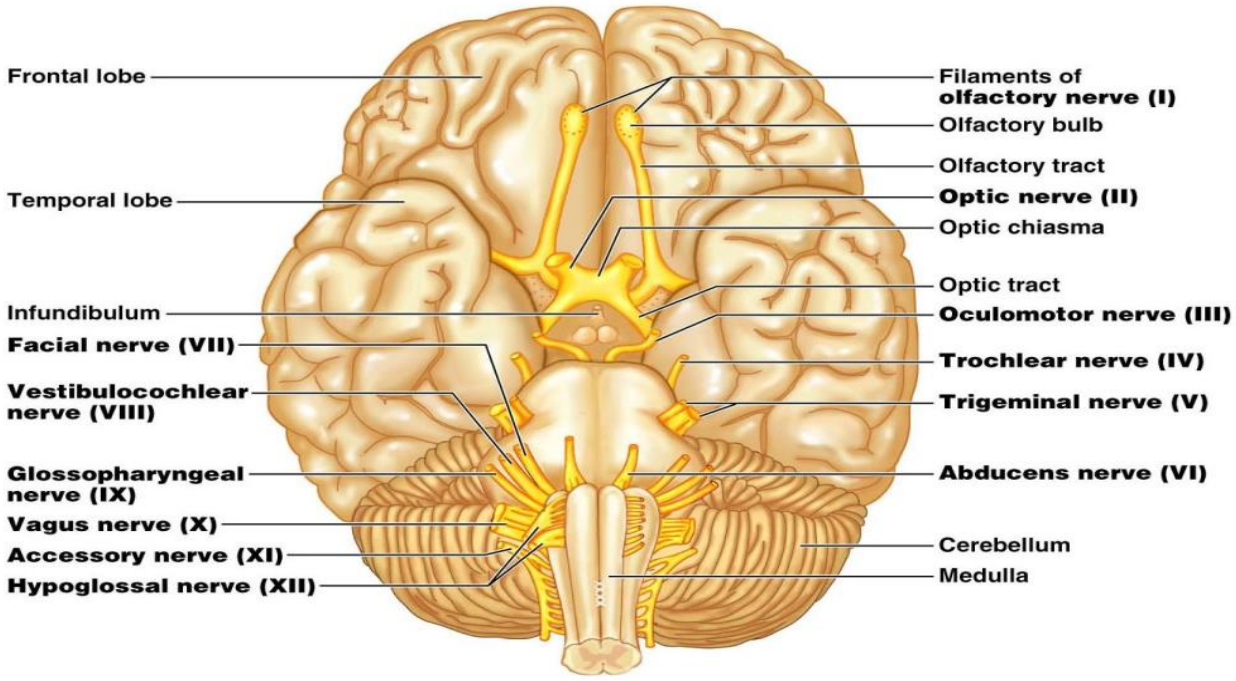

PNS consists of 43 pairs of nerves branching from the

CNS including **12 pairs of cranial nerves,** most cranial nerves arise from the brain stem

functional classification of cranial nerves:

a. **sensory** cranial nerves(no more than a few motor fibers)

I. **Olfactory** [sense of smell]

II. **Optic** [sense of sight]

VIII. **Vestibulocochlear**[senses of hearing and balance]

has a few motor fibers

-injury causes deafness

b. motor cranial nerves

(no more than a few sensory fibers)

III. **Oculomotor**

IV. **Trochlear** [eye movements]

VI. **Abducens**

-injury to VI causes eye to turn inward

c. **mixed** cranial nerves

–contain a large number of both sensory and motor neurons

IX. **Glossopharyngeal** [sense of taste, swallowing]

XII. **Hypoglossal** [tongue]

V. **Trigeminal** [cutaneous senses of head and face,chewing muscles]

VII. **Facial** [sense of taste, facial expression]

X. **Vagus**[sensory and motor to larynx, heart,lungs, digestive system]

XI. **Accessory** [shoulder and head]severe head injury often damages one or more cranial nerves

Spinal Nerves

Detailed explanation under the spinal cord nerves and autonomic