Neurophysiology
part two

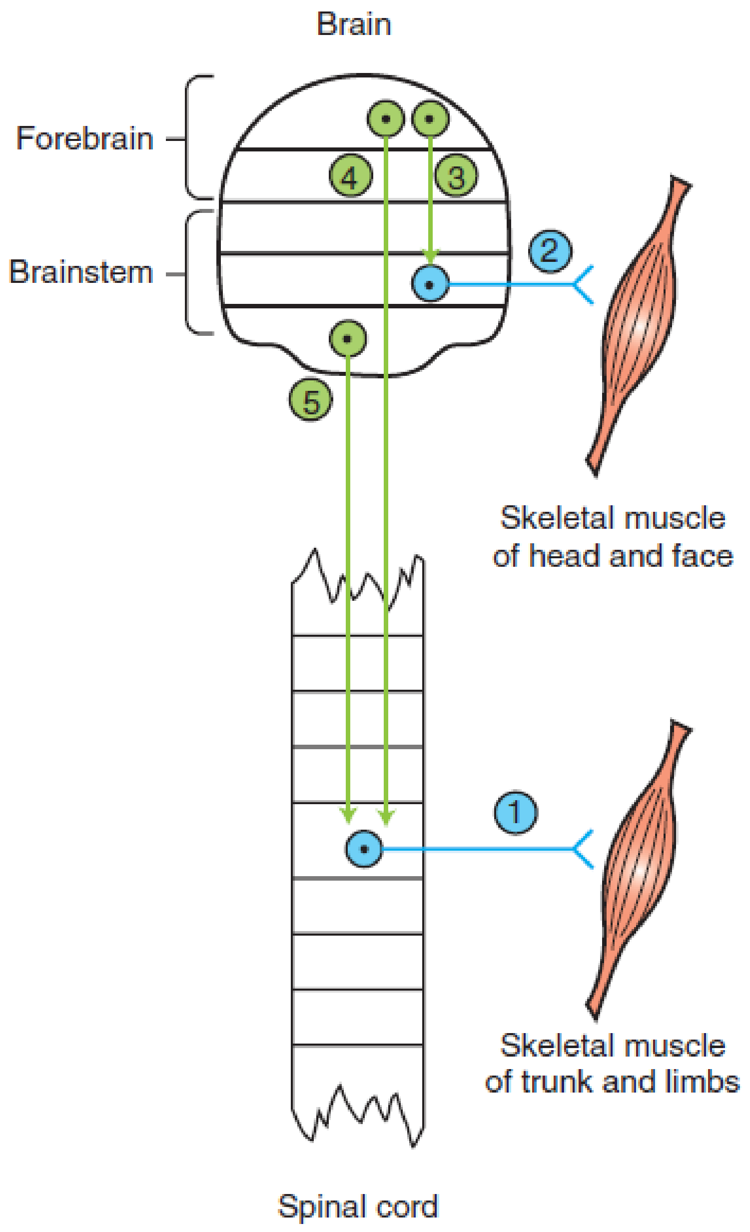
Dr. A. K.Goudarzi, D.V.M. Ph.D
Department of Basic Sciences
Faculty of Veterinary Medicine
I.A. University, Karaj Branch

The Concept of Lower and Upper Motor Neurons

- The majority of veterinary patients with neurological disease display some abnormality of posture and locomotion.
  - Weakness, paralysis, spasticity, rigidity, and convulsions.
- The goal of the diagnostic process for such patients is to determine whether the patient's lesion is located in the lower motor neurons or the upper motor neurons.
- There are two other possible locations of lesions causing movement disorders: the neuromuscular junction and skeletal muscle.

The Lower Motor Neuron

- The Lower Motor Neuron Is Classically Defined as the Alpha (ɑ) Motor Neuron
- The alpha (ɑ) motor neuron is classically defined as a neuron whose cell body and dendrites are located in the central nervous system (CNS) and whose axon extends out through the peripheral nerves to synapse with the extrafusal skeletal muscle fibers.
- The cell bodies of these neurons are located either in the ventral horn of spinal cord gray matter or in cranial nerve nuclei of the brainstem



Disease of Lower Motor Neurons

Regardless of the pathological basis for disease of lower motor neurons, a stereotypical set of clinical signs results in the skeletal muscles they innervate.

- **Paralysis or paresis.** Disease of the α motor neurons usually prevents the neurons' action potentials from reaching the neuromuscular junction. Therefore, despite the brain's command to the muscle to contract, the message cannot reach the muscle, and paralysis is the result.

In fact, such paralysis can be so complete that the adjective flaccid is used to describe the paralysis in which no muscle contraction occurs.

Because not all the α motor neuron axons of a peripheral nerve may be affected by an insult, and because muscles can be supplied by axons of more than one spinal nerve, paralysis may be incomplete. This symptom is referred to as paresis.

Disease of Lower Motor Neurons

- **Atrophy**. Atrophy is the shrinking or wasting of skeletal muscle mass distal to the lower motor neuron. This occurs within days of the injury to a nerve.

The exact origins of this atrophy are controversial. However, evidence indicates that the reduced frequency of muscle stimulation caused by α motor neuron insult, and the resulting reduced use of the muscle, trigger reductions in muscle protein synthesis and increases in muscle proteolysis.

The magnitude of this denervation atrophy can be reduced by direct electrical stimulation of the muscle itself.

There is also some recent evidence that manually imposed repetitive stretching may reduce denervation atrophy; a molecular signaling pathway suspected to underlie this atrophy reduction has been identified.

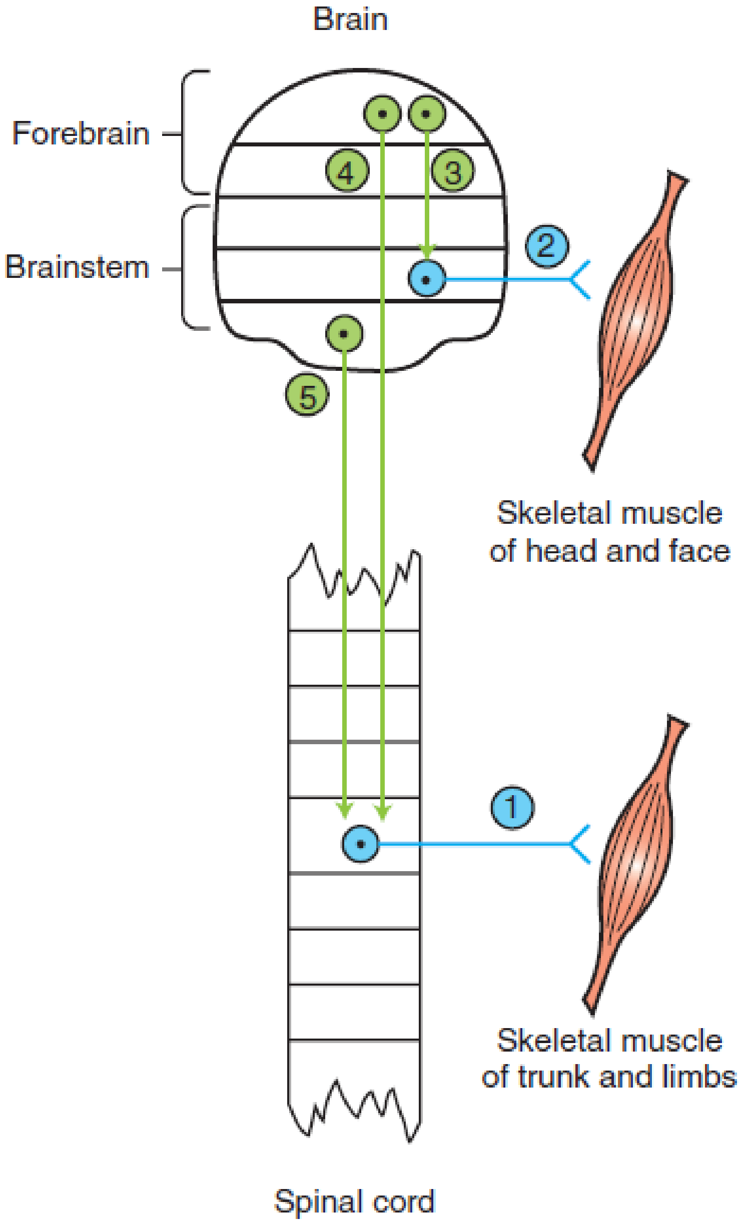
Disease of Lower Motor Neurons

- **Loss of segmental and intersegmental reflexes.** Segmental and intersegmental reflexes require a viable ɑ motor neuron in the reflex arc for the reflex response to occur Therefore, such reflexes as the muscle stretch (knee jerk) reflex and the toe-pinch withdrawal (nociceptive) reflex, as well as the proprioceptive positioning reaction, fail to occur because the motor neuron portion of the arc that activates the skeletal muscle is gone.

- **Electromyographic changes.** Within a few days of damage to ɑ motor neurons, abnormal electrical activity of the muscle can be observed on an electromyogram

Upper Motor Neurons

- Upper motor neurons are the neurons of the CNS that influence the lower motor neurons.
- They are typically considered the neurons of origin of the corticospinal (cerebral cortex to spinal cord), corticobulbar (cerebral cortex to brainstem), and descending brainstem motor (brainstem to spinal cord; also called bulbospinal) pathways
- Upper motor neurons send axons down to the spinal cord or into the brainstem to control the lower motor neurons



Upper Motor Neuron Disease

Lesions of upper motor neurons cause clinical signs that differ significantly from those produced by lower motor neuron disease, although paralysis/paresis may be seen in both scenarios.

- **Inappropriate movement**. Lesions of upper motor neurons can cause a variety of movement disorders, depending on the location of the lesion.

  Spinal cord disease, affecting portions of upper motor neurons projecting to the cord, often causes various degrees of weakness below the lesion.

  Disease of the brain that affects upper motor neurons may cause rigidity, seizures, circling gaits, and other inappropriate movements.

- **No atrophy.** Because the lower motor neuron is intact, the muscle does not atrophy. (Modest disuse atrophy may develop much later.)

Upper Motor Neuron Disease

- **Retained but exaggerated segmental reflexes.** Because the neuronal circuitry of the segmental reflex arc is not interrupted in upper motor neuron disease, reflexes such as the muscle stretch and toe-pinch withdrawal are retained, whereas in lower motor neuron disease, reflexes are depressed or lost.

Because upper motor neurons are normally capable of exerting significant inhibitory control over spinal reflexes, however, damage to these neurons can decrease this inhibition, resulting in exaggeration of the reflex response (hyperreflexia).

- **Normal electromyogram.** Because the muscle is not atrophied and the lower motor neurons are intact, the electrical activity of the muscle appears normal.

Upper Motor Neuron

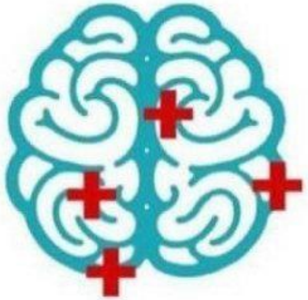
vs.

Lower Motor Neuron

UMNL VS LMNL

Upper motor neuron lesion (also known as pyramidal insufficiency) occurs in the neural pathway above the anterior horn cell of the spinal cord or motor nuclei of the cranial nerves.

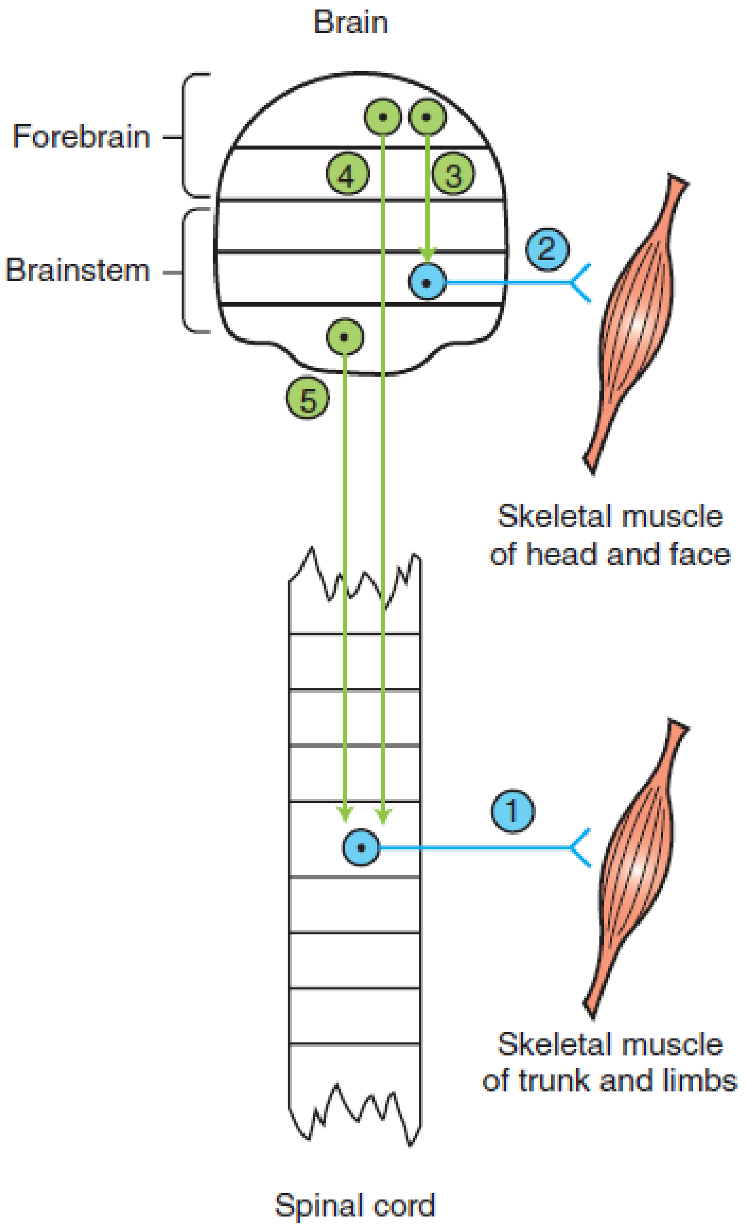
Conversely, lower motor neuron lesion affects nerve fibers traveling from the anterior horn of the spinal cord or the cranial motor nuclei to the relevant muscle.



SIGNS	UPPER MOTOR NEURON LESION	LOWER MOTOR NEURON LESION
Types of Paralysis	Spastic Paresis	Flaccid Paralysis
Atrophy	No (disuse) Atrophy	Severe Atrophy
Deep Tendon Reflex	Increase	Absent
Pathological Reflex	+ve Babinski Sign	Absent
Superficial Reflex	Absent	Present
Fasciculation and Fibrillation	Absent	Could be Present

The Central Control of Movement

- Sensory neurons transform physical energy into neural information, while the motor neurons transforms neural information into physical energy.
- Movement is the result of the contraction of varying numbers of extrafusal skeletal muscle fibers.
- Extrafusal muscle fibers contract by the command of alpha (ɑ) lower motor neurons.
- The ɑ motor neurons send action potential commands by descending upper motor neurons activity or from incoming sensory neurons (or interneurons) in a reflex arc.

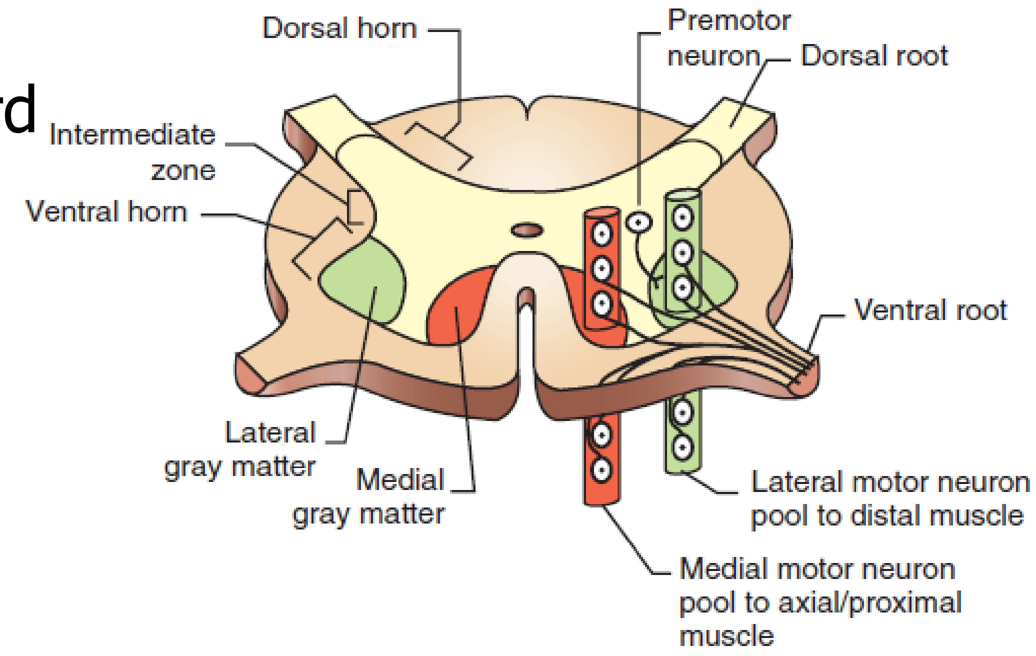


The Central Control of Movement

- Movement can be divided into two general forms.
  - The first is a largely learned, voluntary, conscious, and skilled form, often dominated by flexor muscle activation.
  - The second form is characterized by postural, antigravity muscle activity that is generally subconscious, involuntary, and dominated by extensor muscle contraction.
- The skilled movement results from fairly discrete contraction of a few muscle groups, many of which are distal to the spinal column.
- The maintenance of posture often includes longer-term contraction of larger groups of muscles, many of which are located closer (proximal) to the spinal column.

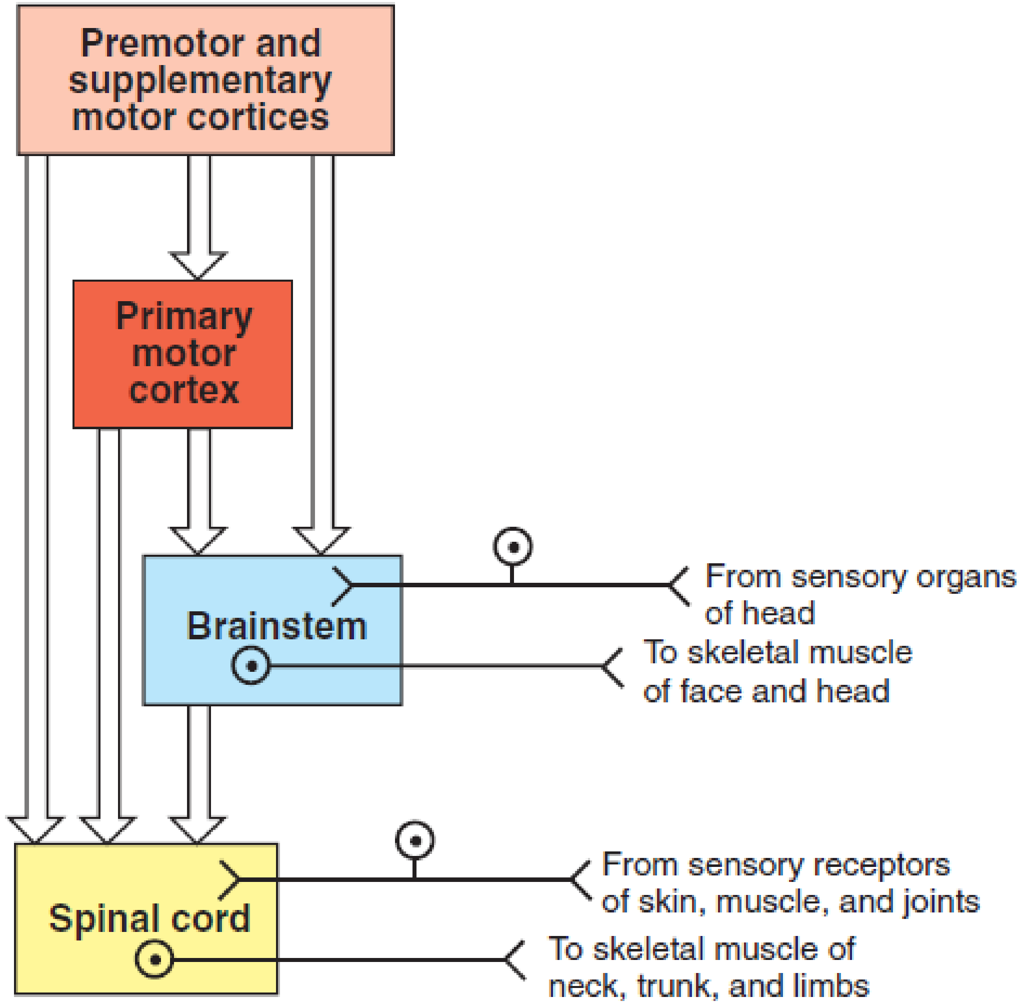
The Central Control of Movement

- Initiating the learned, skilled, voluntary movement of the distal musculature is largely the responsibility of a subgroup of upper motor neuron tracts that project through more lateral regions of the spinal cord white matter and terminate in lateral regions of the spinal cord gray matter.
- Initiating antigravity and postural muscle activity is the responsibility of upper motor neuron tracts that are associated with more medial regions of the spinal cord white and gray matter, respectively.

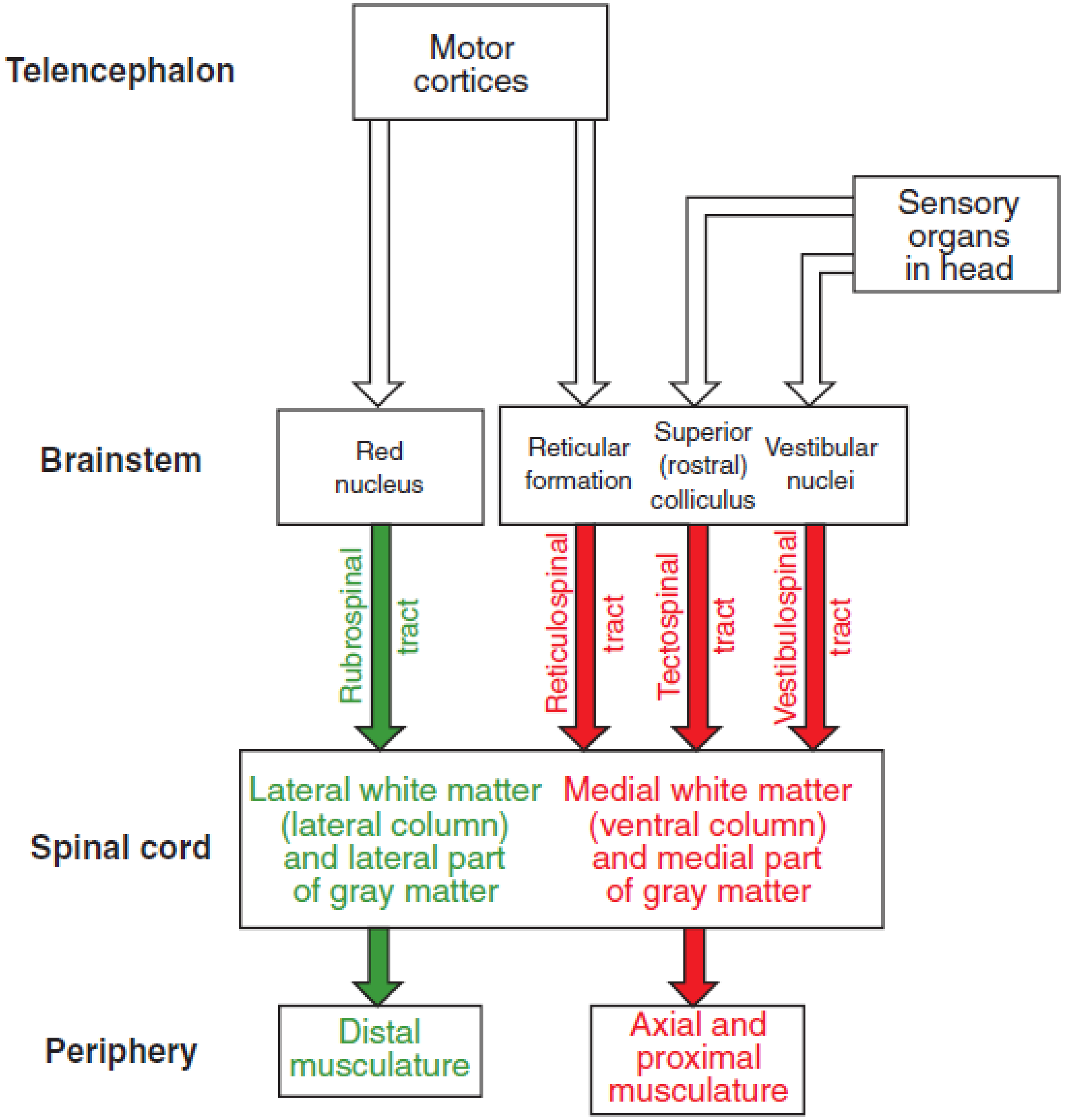


The Central Control of Movement

- Another organizational principle of the neural control of movement is that it consists of a hierarchy.
- Generally, simpler movements or movement patterns are organized by more caudal parts of the CNS (bottom portions)
- More complex and skilled patterns are organized by progressively more rostral regions (top portions).



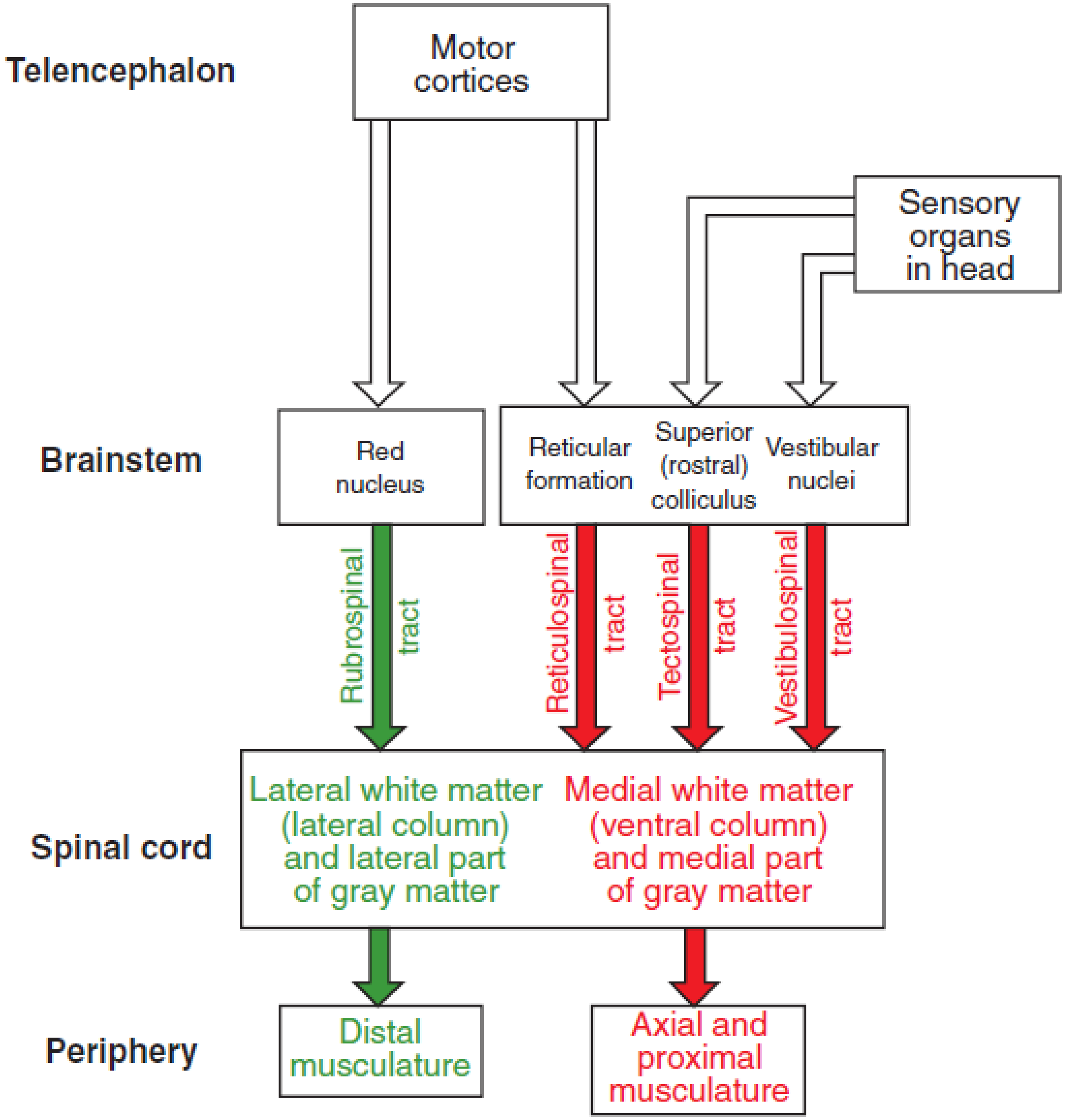
The Central Control of Movement



Organization of the descending brainstem motor pathways to the spinal cord.

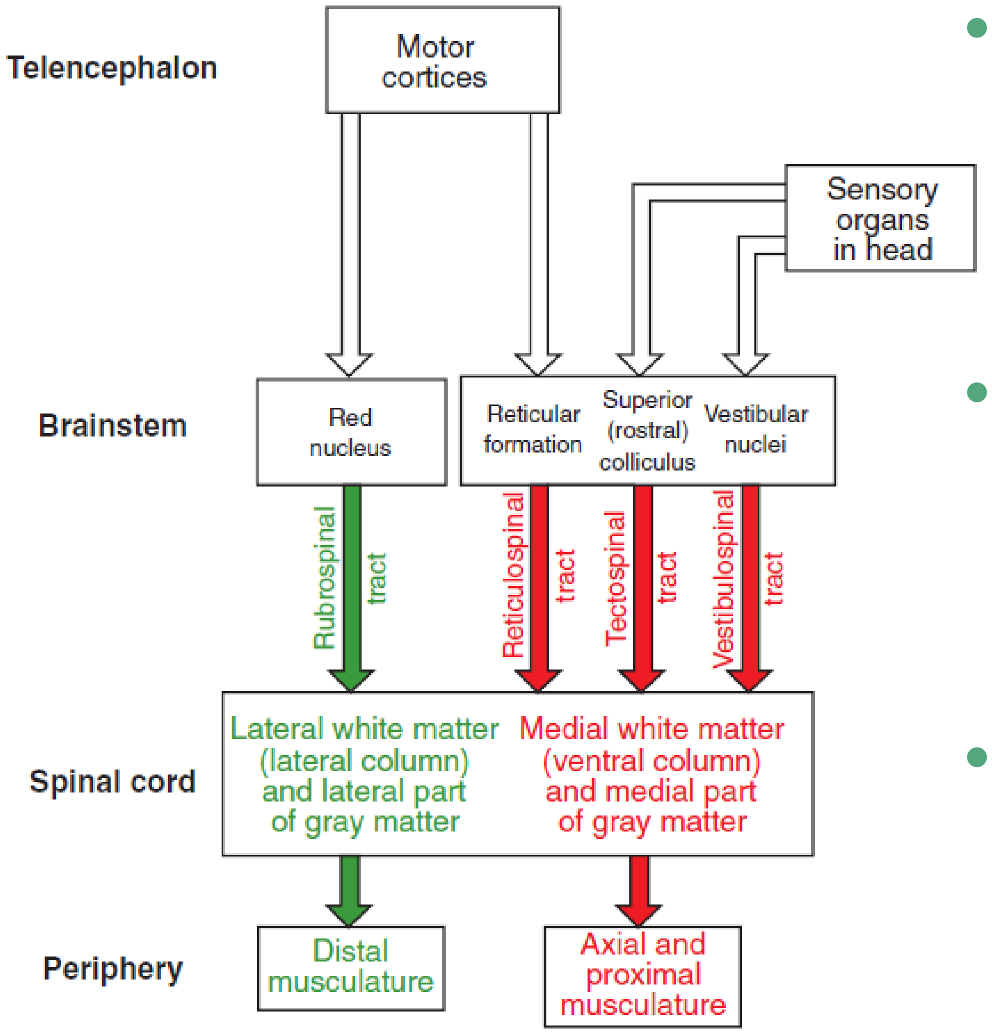
- The medial brainstem motor pathways are the reticulospinal, vestibulospinal, and tectospinal tracts (labeled red arrows).
  - They travel in more medial regions of the spinal cord white matter and synapse within more medial regions of the spinal cord gray matter controlling the axial and proximal musculature.
- The rubrospinal tract (labeled green arrow) is a lateral brainstem motor pathway that travels in more lateral regions of the spinal white matter and synapses within more lateral regions of the spinal gray matter controlling the distal limb musculature

The Central Control of Movement



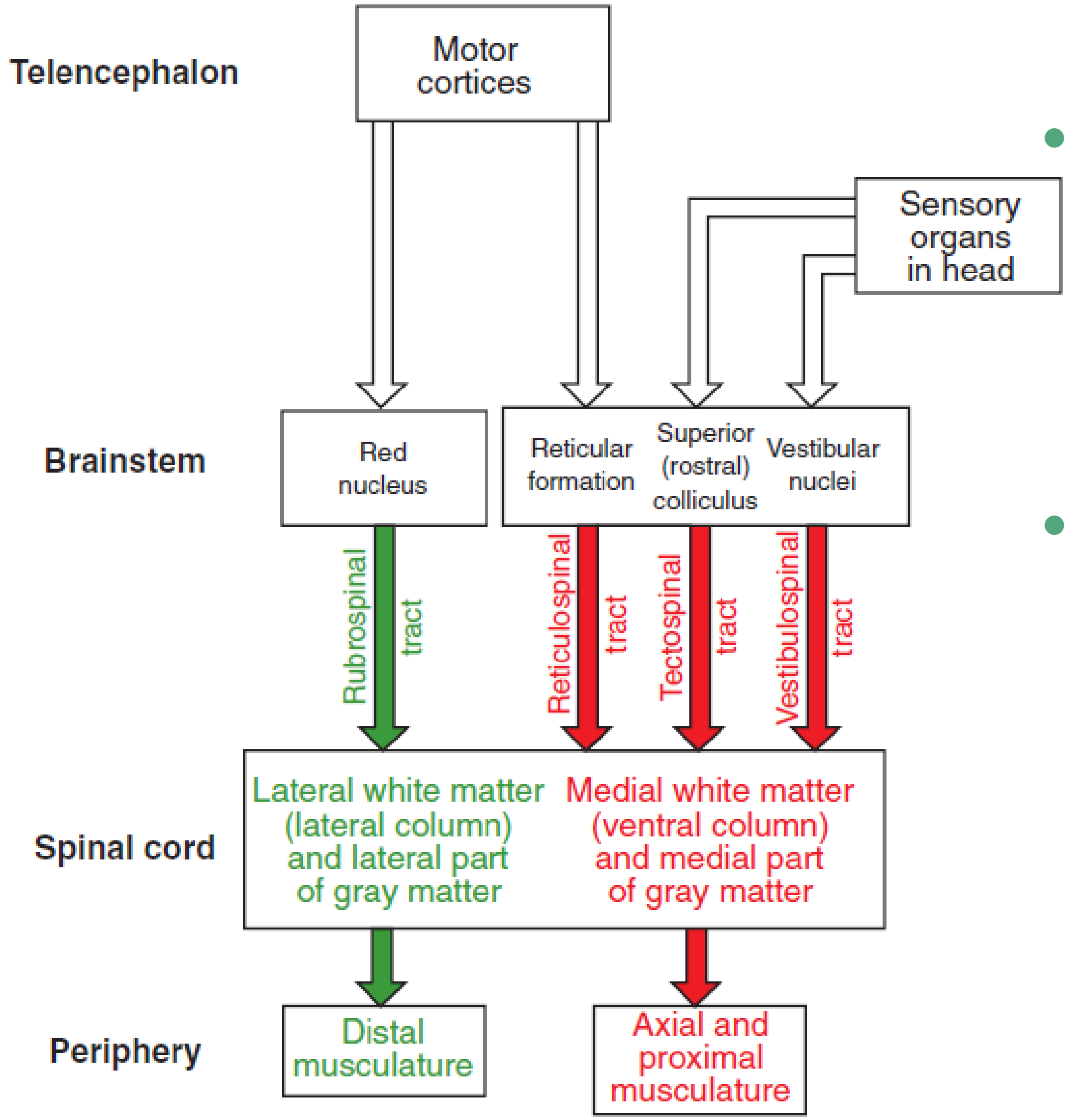
- These four tracts (often along with components of the basal ganglia and cerebellum) are sometimes referred to as the extrapyramidal motor system.
- This is in contrast to the pyramidal motor system that originates in the cerebral cortex, the other major descending motor pathway to the spinal cord
- The four tracts from brainstem to spinal cord are collectively referred to here as the descending brainstem motor pathways.

The Reticulospinal and Vestibulospinal Tracts



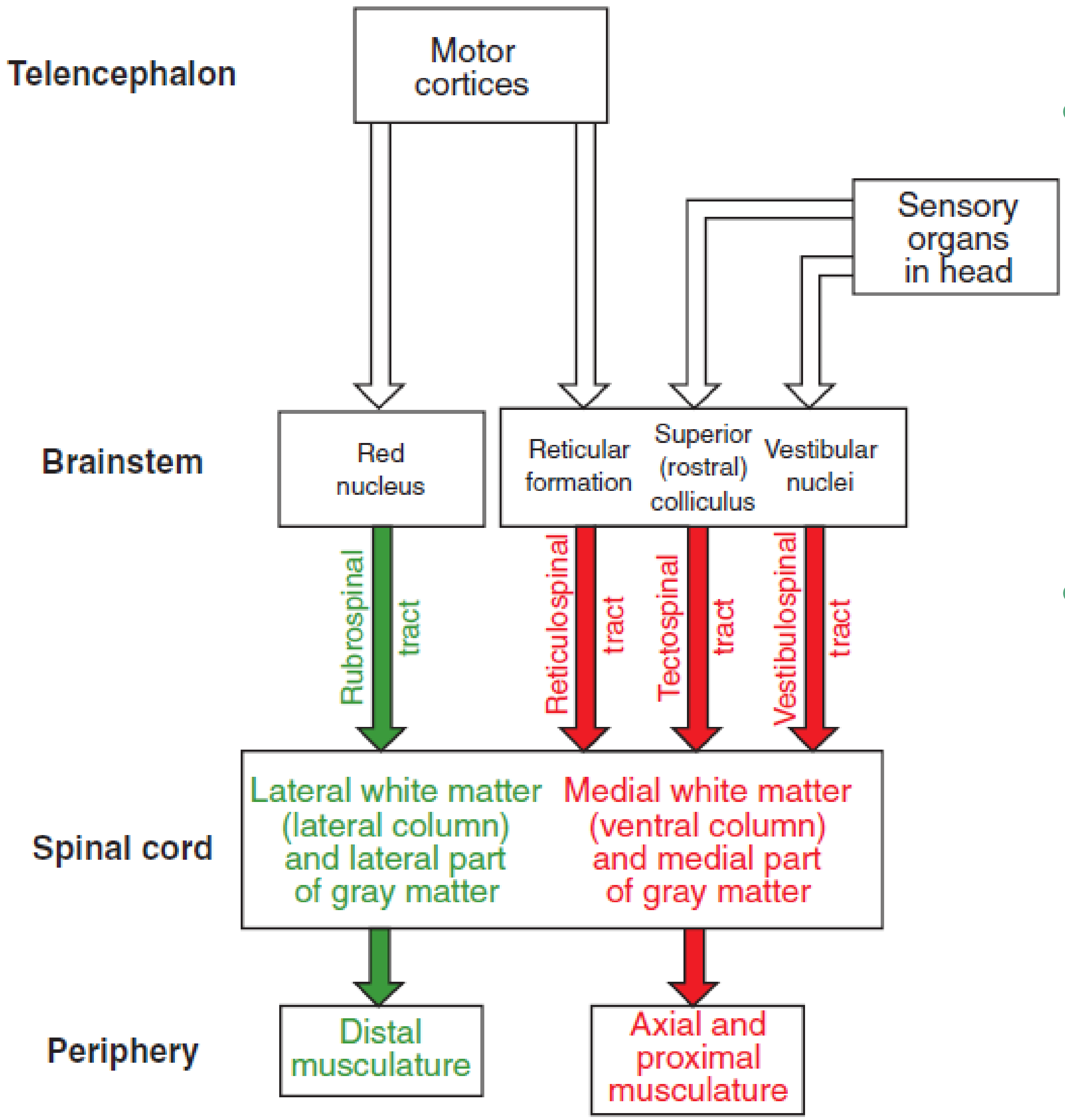
- The reticulospinal tract is particularly important in controlling the magnitude of the steadystate contraction level, or muscle tone, of these antigravity muscles.
- The vestibulospinal tract plays an essential role in activating the antigravity muscles in response to destabilization of the body with respect to gravity.
- Subconscious control of the postural musculature is an integral part of the ability to execute skilled voluntary movement of the distal musculature successfully

The Tectospinal Tract



- The tectospinal tract is a medial brainstem motor pathway that is principally involved in reflex orientation of the head toward environmental stimuli.
- The tectospinal tract is involved in producing a movement of the head toward the stimulus that corresponds with the rapid eye movement so that the animal's gaze is fixated directly on the stimulus.

The Rubrospinal Tract



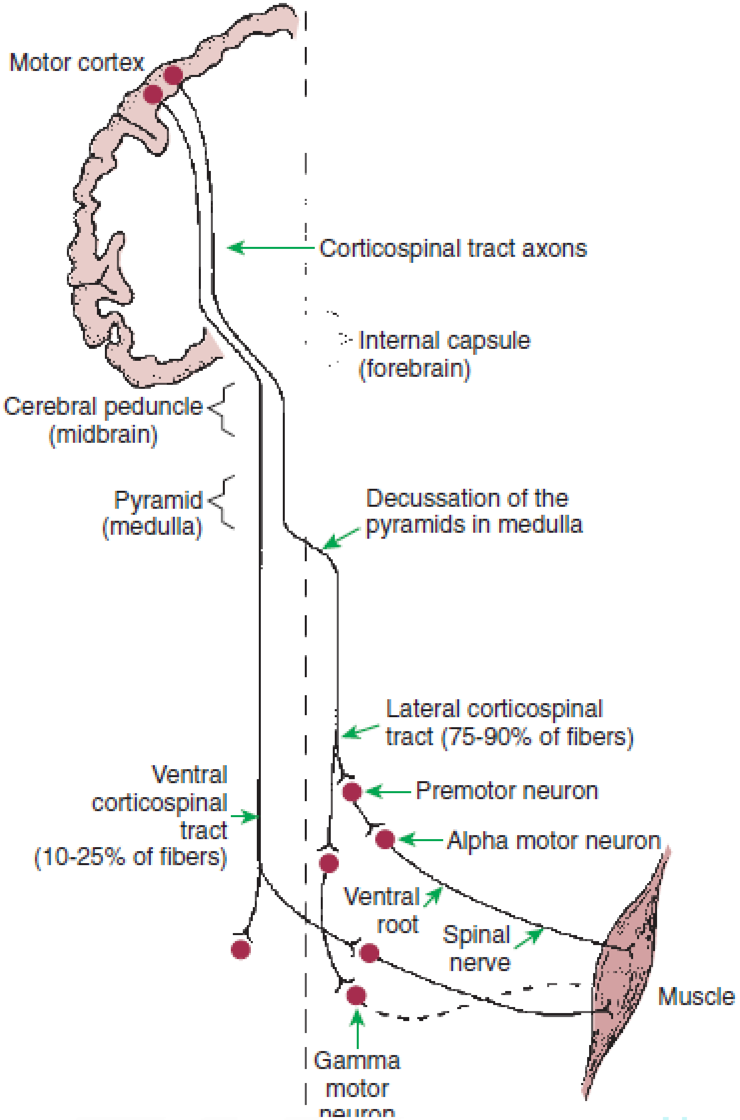
- The rubrospinal tract is a lateral descending brainstem motor pathway whose axons course within more lateral regions of the spinal white matter and synapse in more lateral portions of the spinal gray matter.
- This region of the spinal gray matter exerts unilateral control over a limited complement of muscles of the distal limbs, often flexors, associated with skilled movements of the extremities.

The Corticospinal (Pyramidal) Tract

- The motor cortices of the forebrain locates above the brainstem and represent the most complex level of movements.
- These cortical regions can operate on spinal lower motor neurons indirectly through some of the descending brainstem motor pathways to the spinal cord (e.g., cortico reticulospinal route, cortico-rubrospinal route).
- In mammals a more efficient system exists for the cortical control of spinal lower motor neurons
- This direct corticospinal tract, also referred to as the pyramidal tract, is responsible for the most elaborate and dexterous voluntary movements.

The Corticospinal (Pyramidal) Tract

- The corticospinal tract is a direct route primarily from the motor cortices to the contralateral spinal cord gray matter.
- Most axons of the tract synapse on premotor neurons of the intermediate zone, but some, synapse directly on α and γ lower motor neurons.
- About 75% to 90% of the axons of the tract cross the midline at the spinomedullary border to form the lateral corticospinal tract, and about 10% to 25% remain on the same side to form the ventral corticospinal tract.



The Corticospinal (Pyramidal) Tract

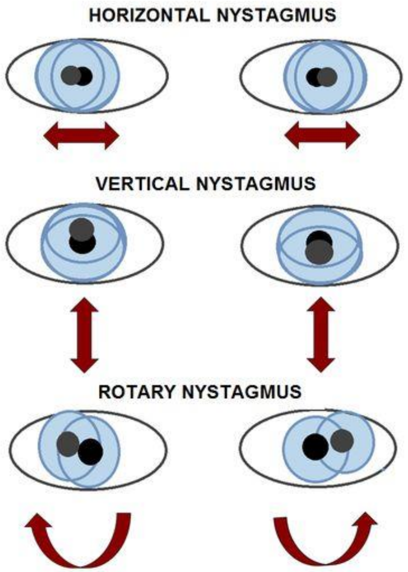
- The corticospinal tract can be divided into components that respectively travel in more lateral or more medial regions of the spinal cord white matter.
- The massive and laterally located lateral corticospinal tract synapses in more lateral regions of the spinal cord gray matter that control the distal limb musculature. The axons of this tract originate from the contralateral motor cortices.
- The much smaller ventral corticospinal tract, whose axons originate from the ipsilateral motor cortices, travels in more medial regions of the spinal white matter and synapses in more medial regions of the spinal gray matter that control the axial and proximal musculature.

The Vestibular System

- To coordinate posture and locomotion, the brain needs to know:
  - what movement it intends to command,
  - the orientation of the body
  - what movement the body is actually performing
- The vestibular system supplies information about the body's orientation or tilt with respect to gravity and about acceleration of the body through space by detecting:
  - static tilt of the head (e.g., the head is held stationary at 5 degrees from vertical),
  - linear acceleration of the head (e.g., the head accelerates in a straight line as an organism begins to run or as your elevator begins to rise),
  - rotary acceleration of the head (e.g., the head accelerates in a circular fashion as an organism begins to turn its head toward a target or as someone begins to spin you in an office chair).

The Vestibular System

- The vestibular system is a common site of pathological lesions.
- In most veterinary species, lesions of the vestibular system cause a syndrome characterized by head tilt, compulsive rotary movements such as circling or rolling, and spontaneous nystagmus, which is an oscillating movement of the eyes.
- The Vestibular System Is a Bilateral Receptor System Located In the Inner Ear

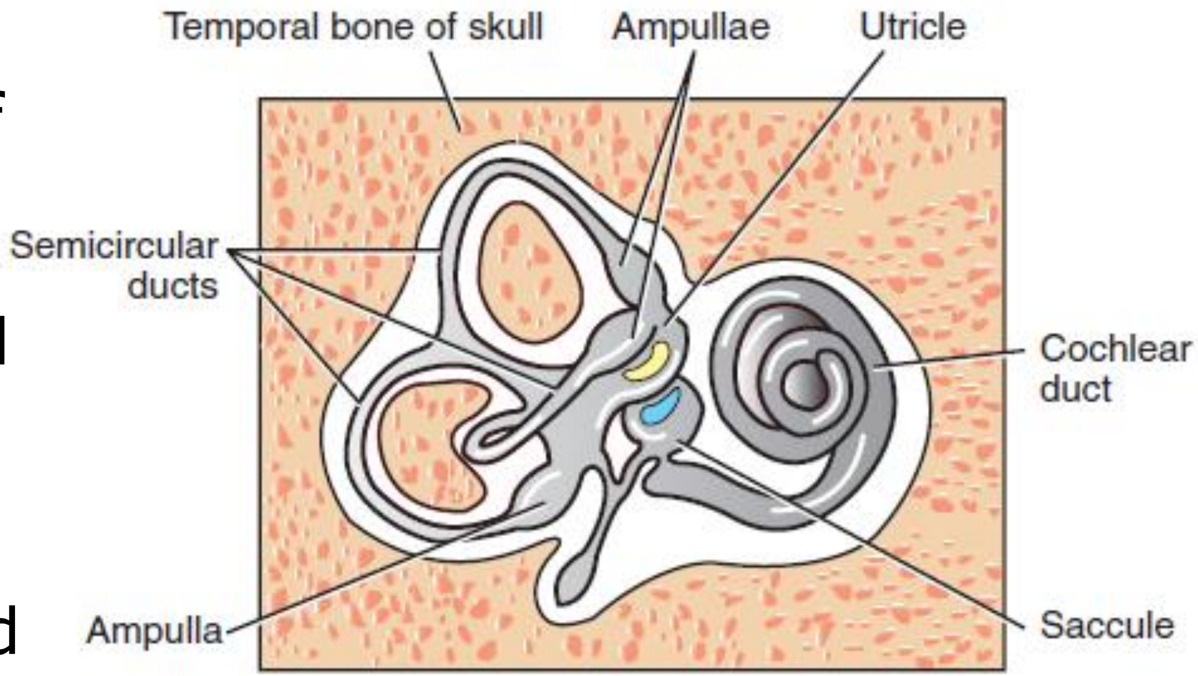


The Vestibular System

- The inner ear, or labyrinth, is made up of two parts:
  - The bony labyrinth
    - a system of caverns and tunnels through the petrous temporal bone of the skull
    - houses the receptor organs of the vestibular system as well as the receptor organ for hearing, the cochlea
  - The membranous labyrinth
    - consists of thin membranes of epithelium and lies within the bony labyrinth.
    - The membranous labyrinth is filled with a fluid called endolymph and is separated from the bony labyrinth by a fluid called perilymph.

The Vestibular System

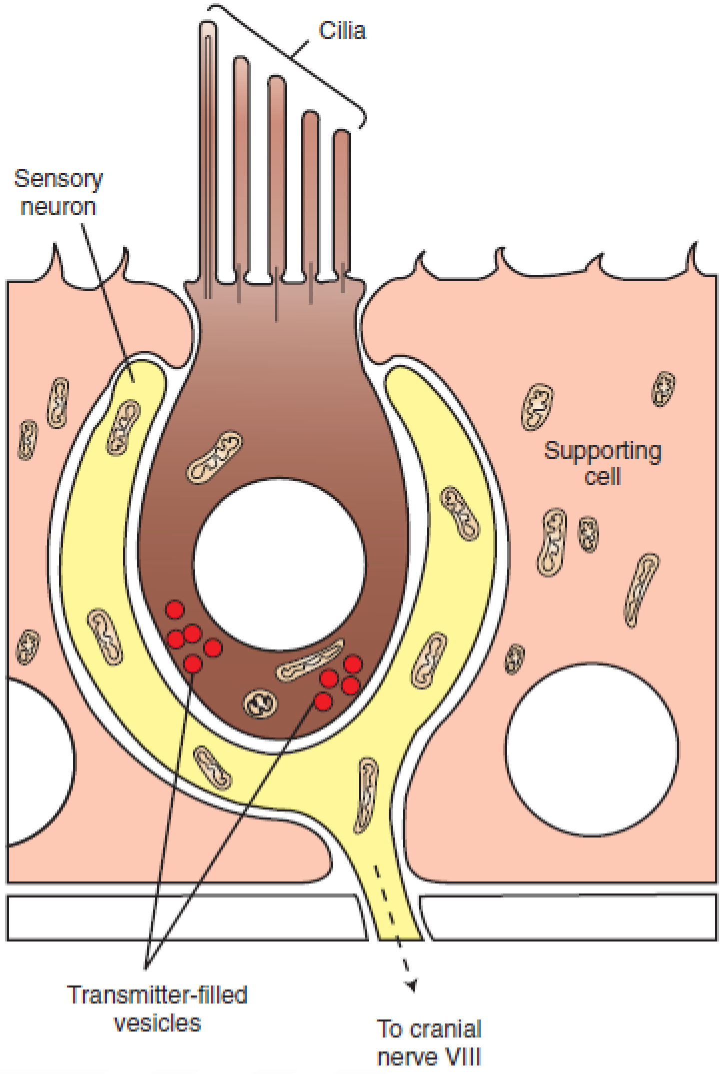
- The vestibular portion of the membranous labyrinth consists of two major sets of structures:
  - (1) three semicircular ducts, located at approximately right angles to each other
  - (2) a pair of saclike structures called the utricle and saccule, sometimes called the otolith organs.



Receptor Organs of the Vestibular System

- Each structure of the peripheral vestibular apparatus contains a region of hair cells that form the basis of a sensory receptor organ.

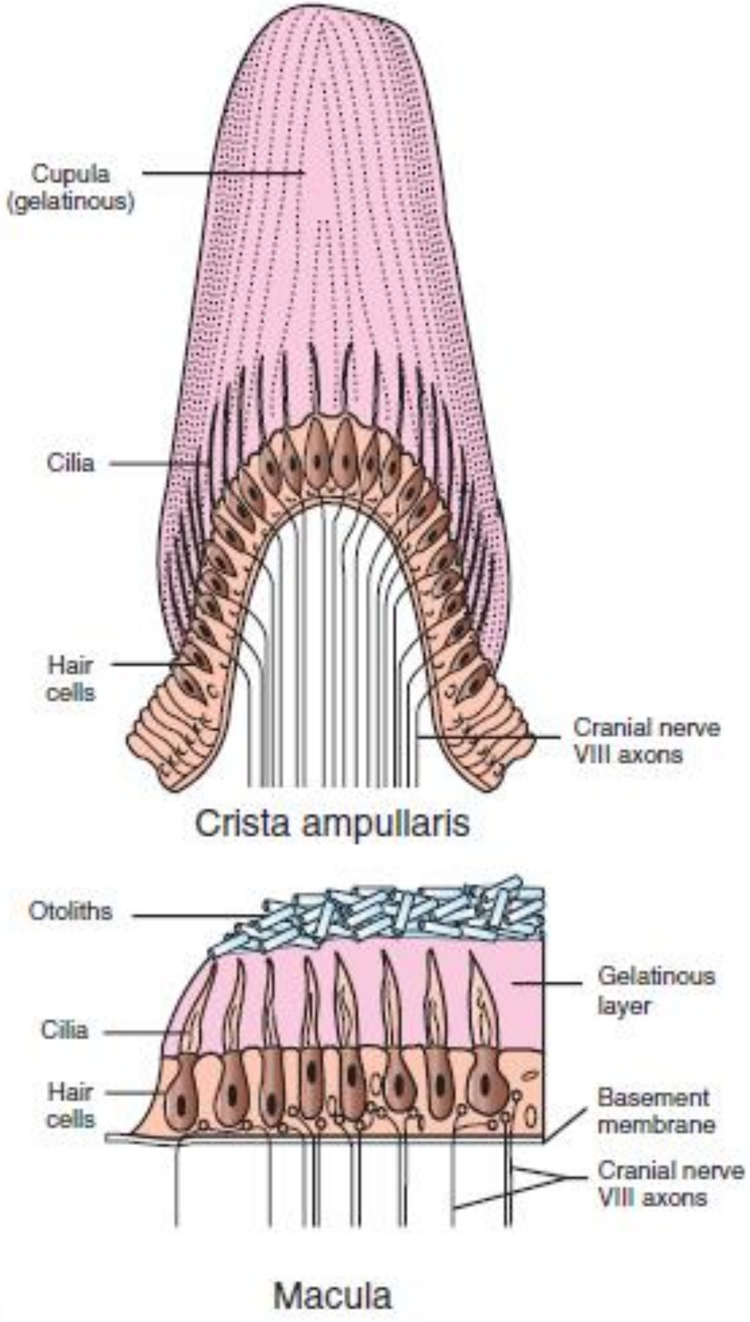
- Each hair cell has several cilia at its apex, arranged in size order, and synapses on a sensory neuron of cranial nerve VIII at its base.



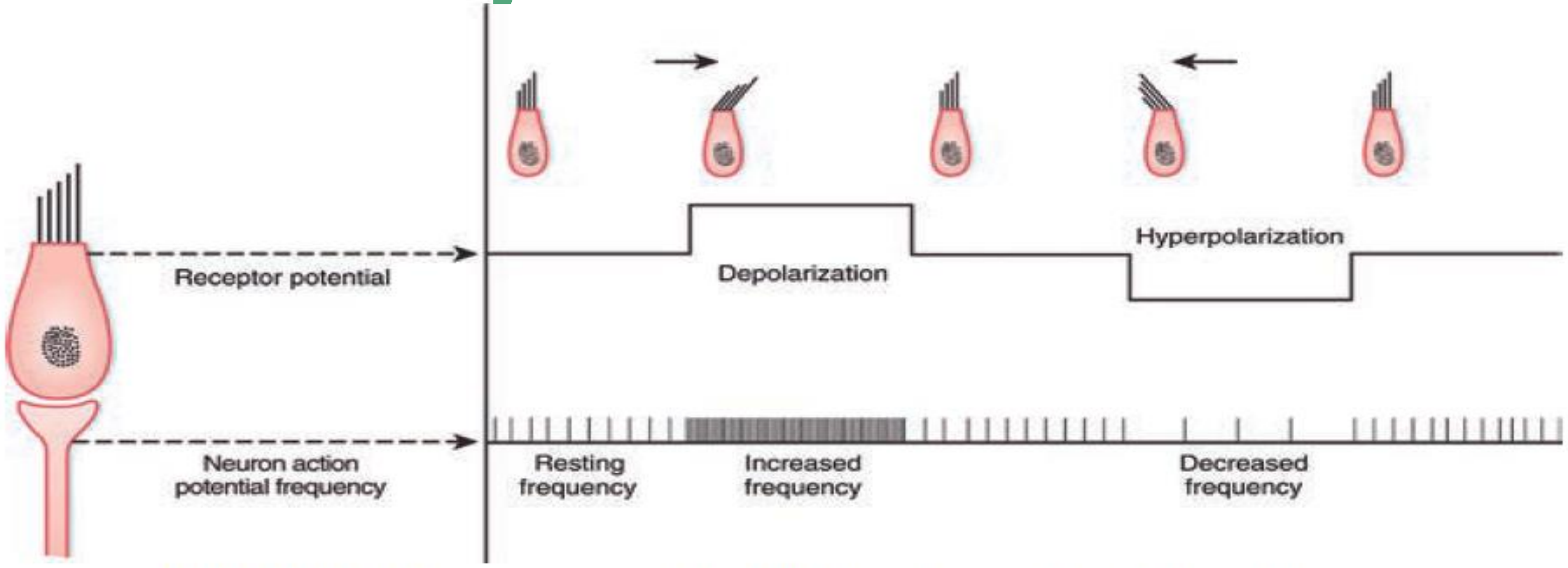
Receptor Organs of the Vestibular System

- In each ampulla of the semicircular ducts, there is a crest of hair cells whose cilia project into a gelatinous mass called the cupula, forming a receptor organ called the crista ampullaris.

- The hair cell receptor organ in the utricle and saccule is the macula, a layer of hair cells whose cilia project up into a gelatinous layer, on top of which lies a layer of calcium carbonate crystals called otoliths.



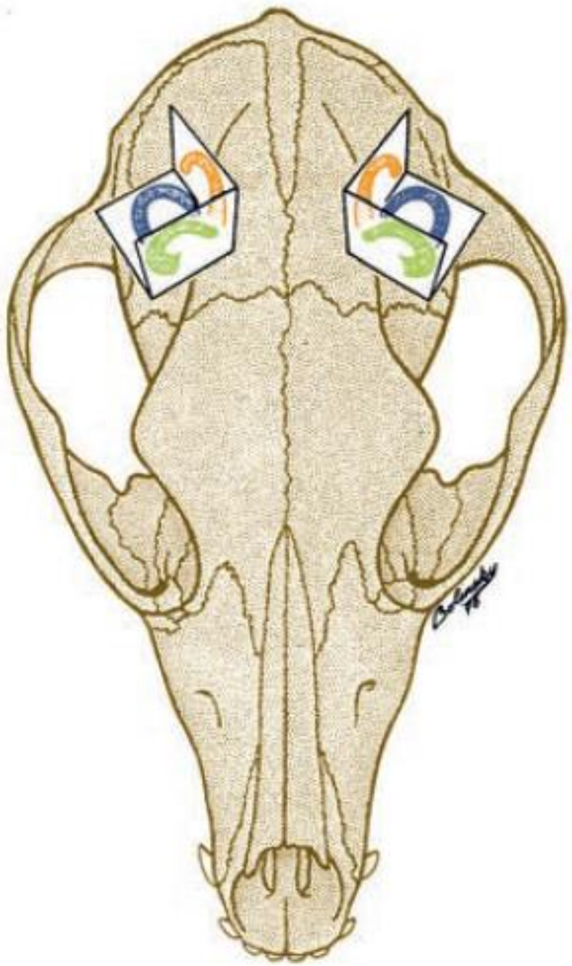
Receptor Organs of the Vestibular System



- At rest, sensory neurons on which vestibular hair cells synapse transmit action potentials spontaneously at a rate of about 100 per second.
- When hair cell cilia are deflected in one direction toward the largest cilium, the action potential frequency increases; when cilia are deflected in the opposite direction, the frequency decreases.

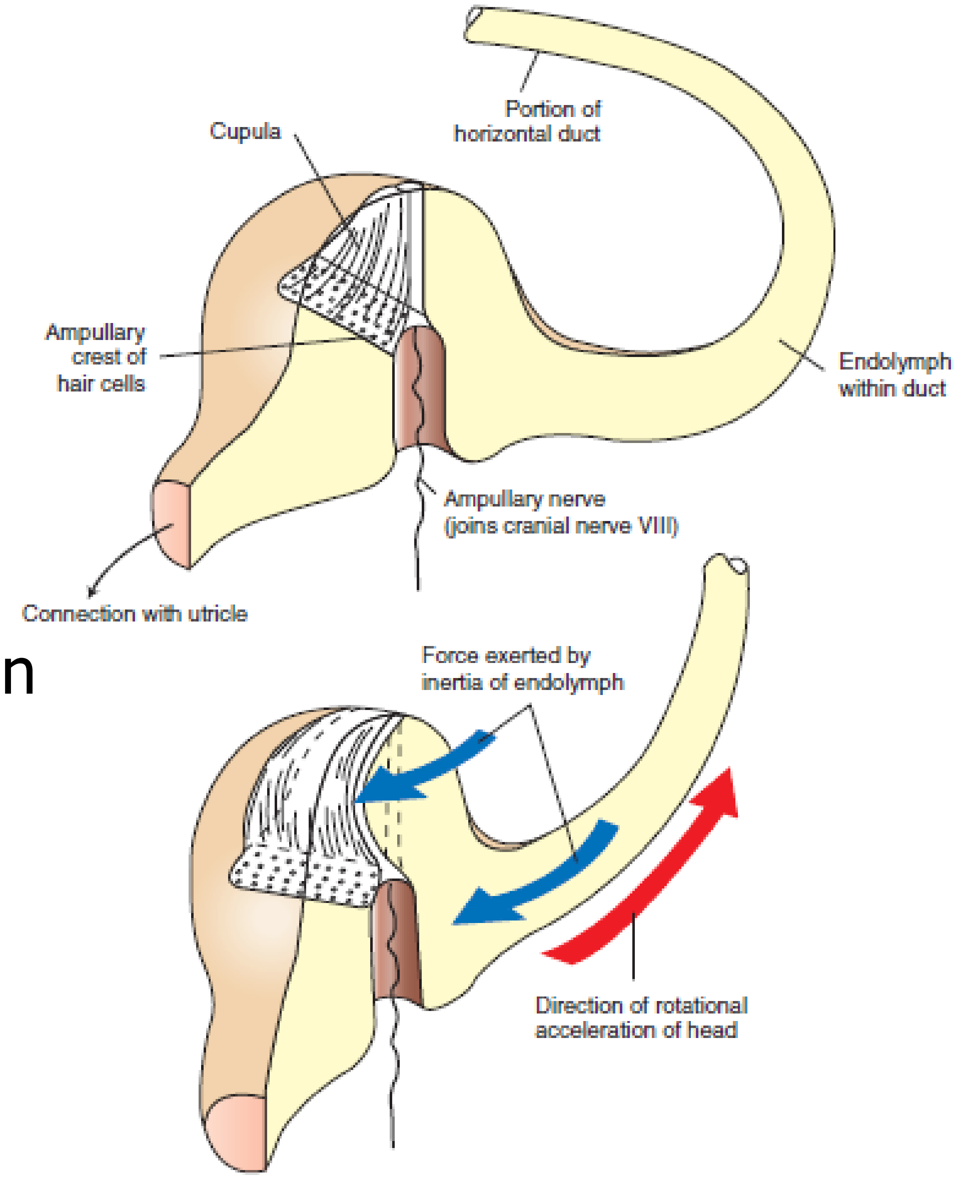
Receptor Organs of the Vestibular System

- Three membranous semicircular ducts are located within corresponding semicircular canals of each bony labyrinth
- They are positioned at approximately right angles to each other, and both ends of each fluid-filled duct terminate in the utricle.
- Each semicircular duct has an enlargement at one end, called the ampulla, near its junction with the utricle.
- The ampulla contains a hair cell receptor organ called the crista ampullaris.



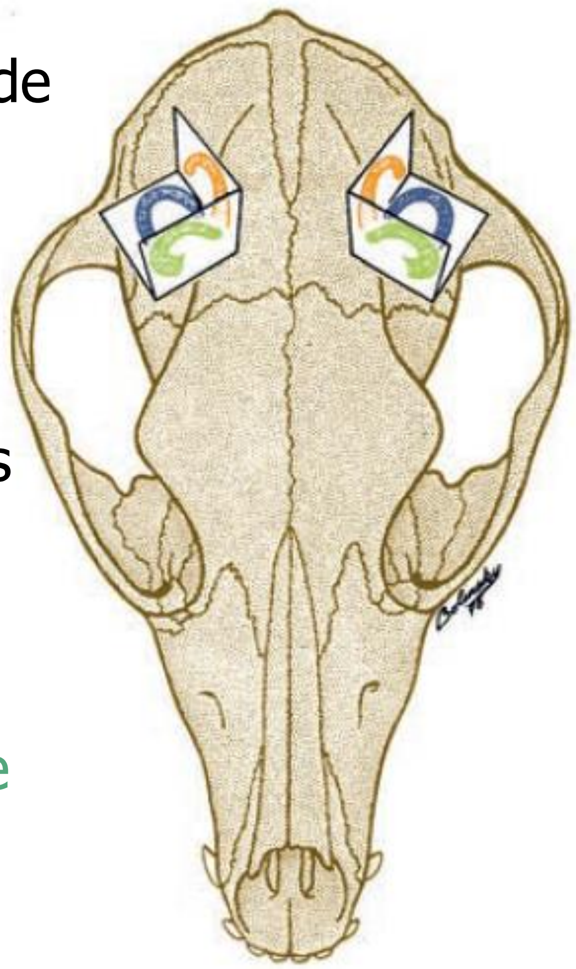
Receptor Organs of the Vestibular System

- Ampullae of the semicircular ducts contain a crista ampullaris which transduces rotational acceleration/ deceleration of the head. The ducts are filled with endolymph.
- A, Crista ampullaris of the horizontal canal when the head is at rest.
- B, On rotational acceleration of the head in the indicated direction, the relative inertia of the endolymphatic fluid displaces the cupula, and thus the hair cell cilia, in the opposite direction



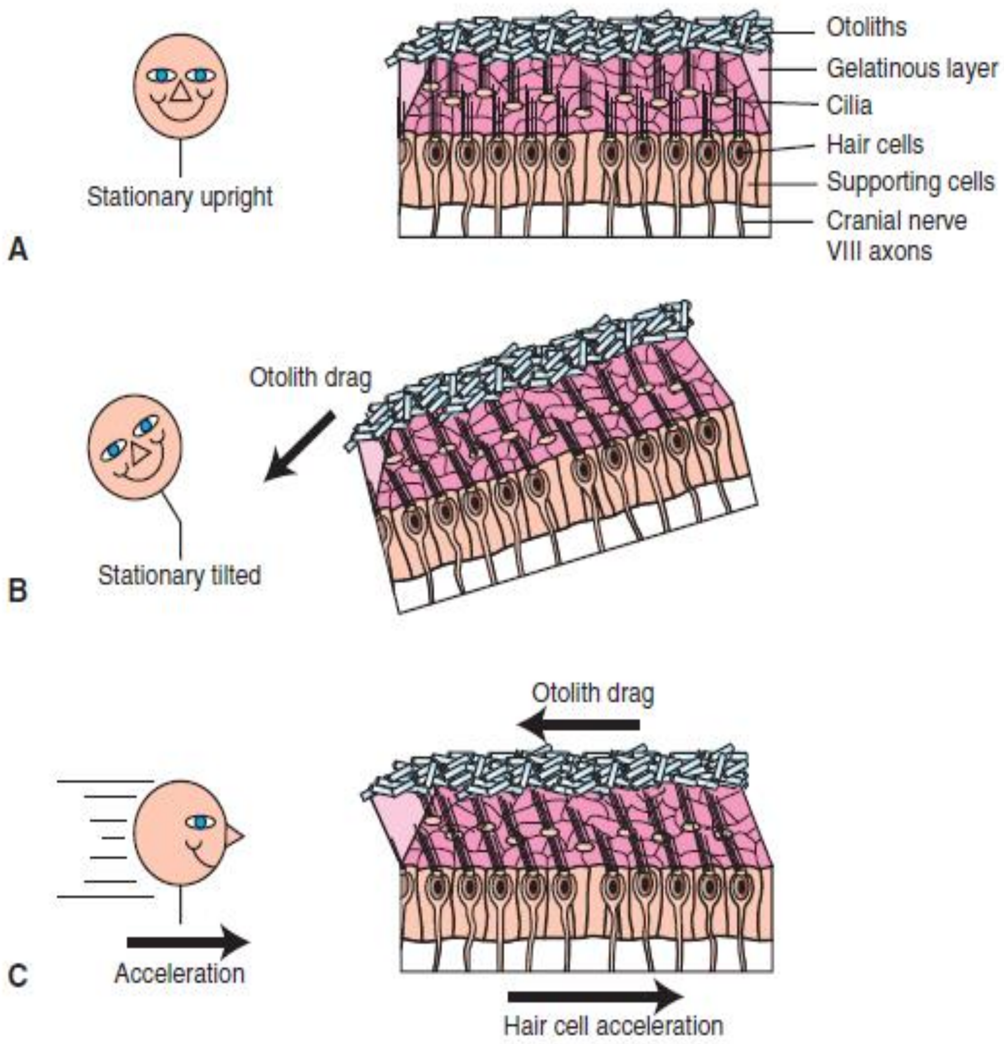
The Vestibular System

- Semicircular ducts located on opposite sides of the head, but in approximately the same plane (co-planar), work as a pair to provide the brain with information about the direction and nature of head movement.
- For instance, a clockwise rotary acceleration of the head would cause bending of the directionally sensitive hair cell cilia in each member of a co-planar pair of semicircular ducts on opposite sides of the head.
- However, the sensory axons leaving the crista ampullaris from the duct on one side of the head would carry an increased action potential frequency, whereas those from the duct of the other side would carry a decreased action potential frequency.
- The brain interprets such reciprocal changes in sensory action potential frequency as resulting from clockwise or counterclockwise acceleration or deceleration in a given plane of movement.

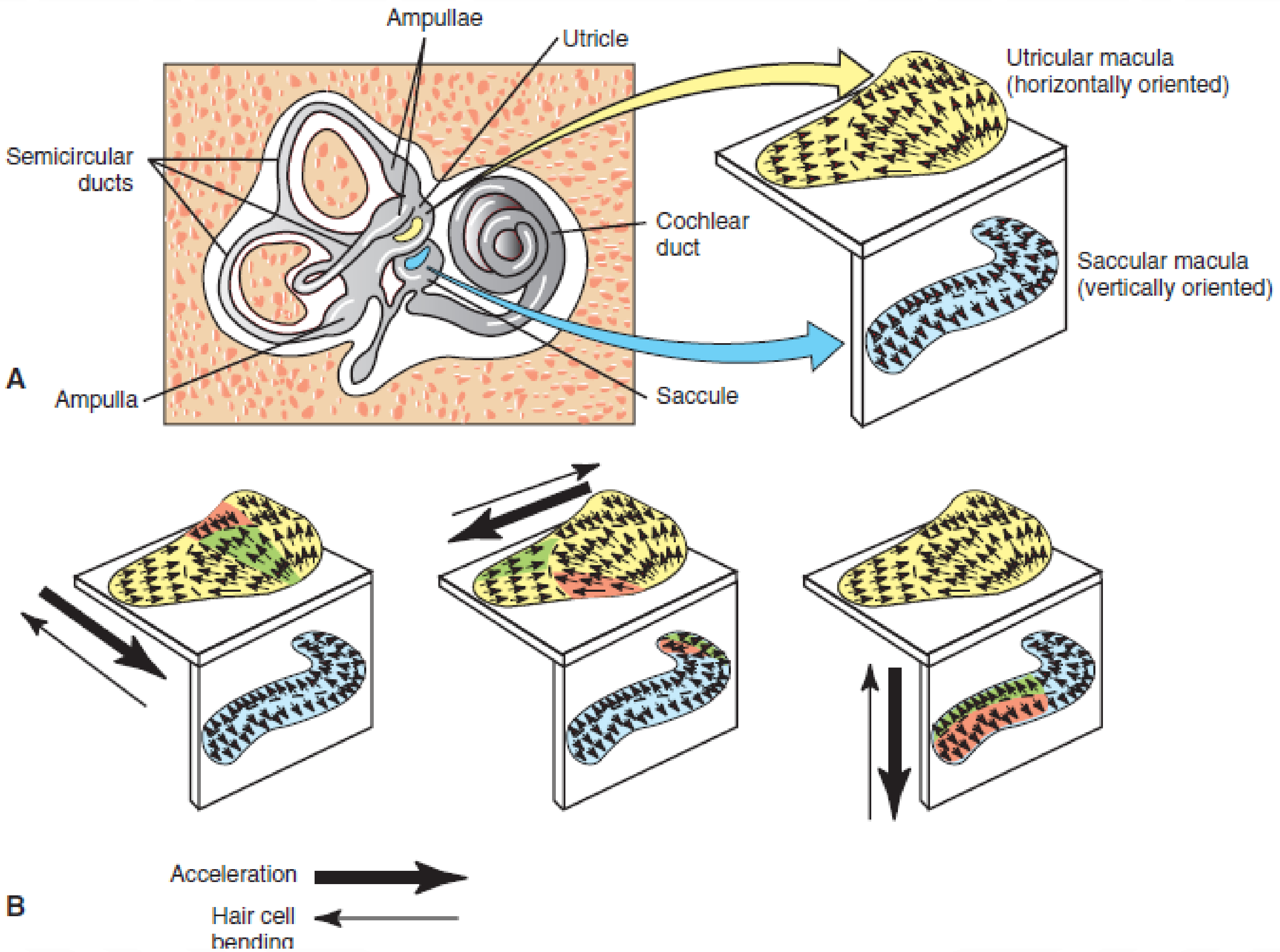


Receptor Organs of the Vestibular System

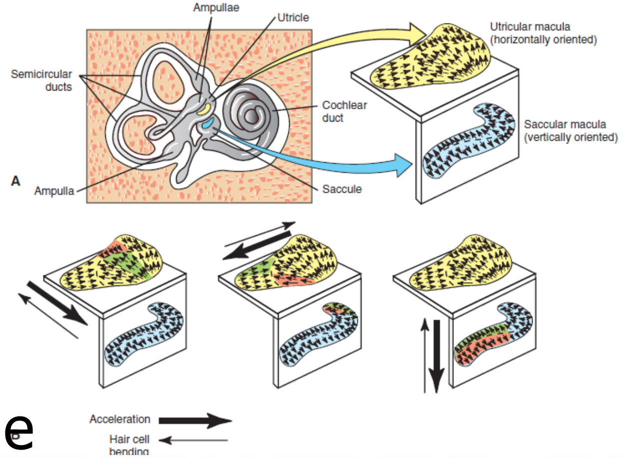
- Utricle and saccule each contain a macula, which transduces static head tilt and linear acceleration/deceleration of the head.
- Macula of the utricle is horizontally oriented.
- A, When the head is stationary and upright, there is little or no bending of the hair cell cilia.
- B, When the head tilts and remains tilted, the heavy otolith layer "falls over," producing a drag. This bends the hair cell cilia, by way of the interposed gelatinous layer, in the direction of the tilt.
- C, When the head accelerates in a straight line, the hair cells accelerate in the same direction, but the heavy otolith layer lags behind, producing a drag in the opposite direction. This bends the hair cell cilia, by way of the interposed gelatinous layer, in the direction opposite the acceleration.



The Vestibular System

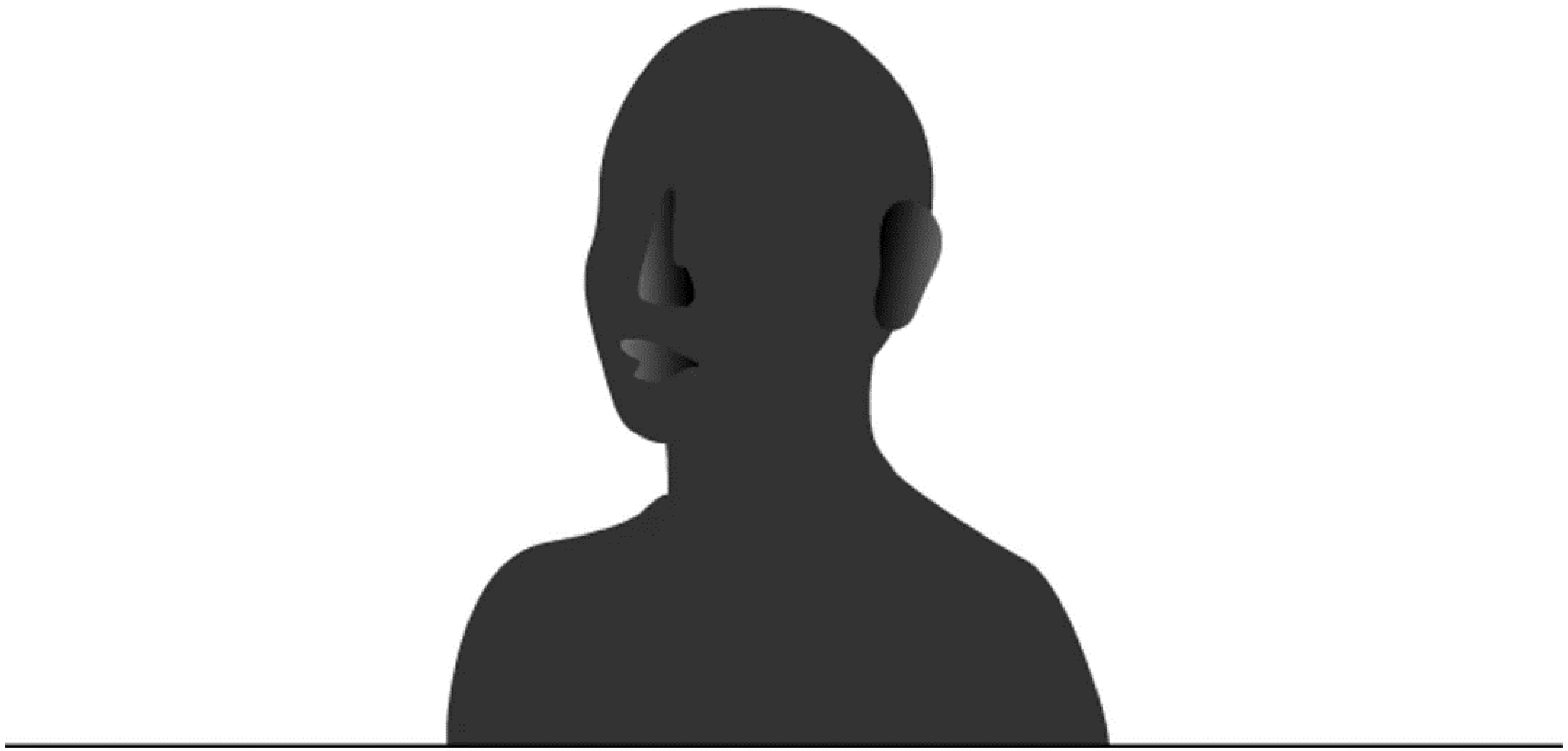


The Vestibular System



- A, Macula of the utricle is horizontally oriented, and macula of the saccule is vertically oriented. Small arrows in a macula represent the approximate orientation of the hair cells in that region, with respect to their cilia. For a given hair cell, the arrow tip represents the position of the largest cilium, and the arrow tail represents the shortest cilium.
- B, Acceleration in a given direction (large thick arrows) results in bending of hair cell cilia in the opposite direction (large thin arrows) caused by otolith drag. Hair cells whose cilia are bent directly toward the largest cilium (green regions) will be depolarized the most and will produce the greatest increase in action potential frequency in their associated sensory neurons. Conversely, hair cells whose cilia are bent directly away from the largest cilium (red regions) will be hyperpolarized the most and will produce the greatest decrease in action potential frequency in their associated sensory neurons. Hair cells whose cilia are bent along other axes will be less significantly affected

The Vestibular System



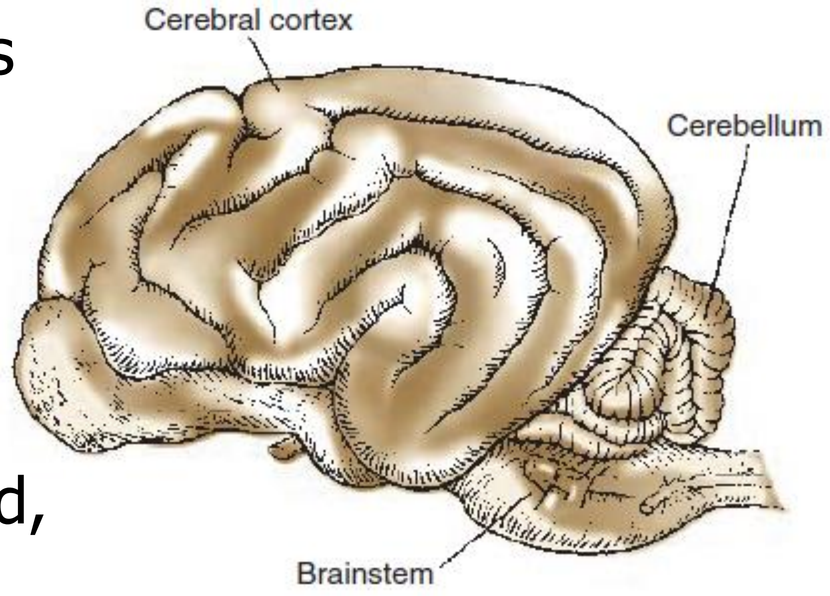
The Vestibular System Disease

The Cerebellum

- The corticospinal system and the descending brainstem motor system are major subgroups of upper motor neurons that influence the lower motor neurons.
  - More medial portions of those systems coursing through the spinal cord are primarily responsible for the control of axial and proximal antigravity extensor muscles.
  - The more lateral portions primarily control more skilled, learned, voluntary movements caused by contraction of distal flexor muscles.
- The Cerebellum is a part of another subgrouping of upper motor neurons which is critical for proper movement.

The Cerebellum

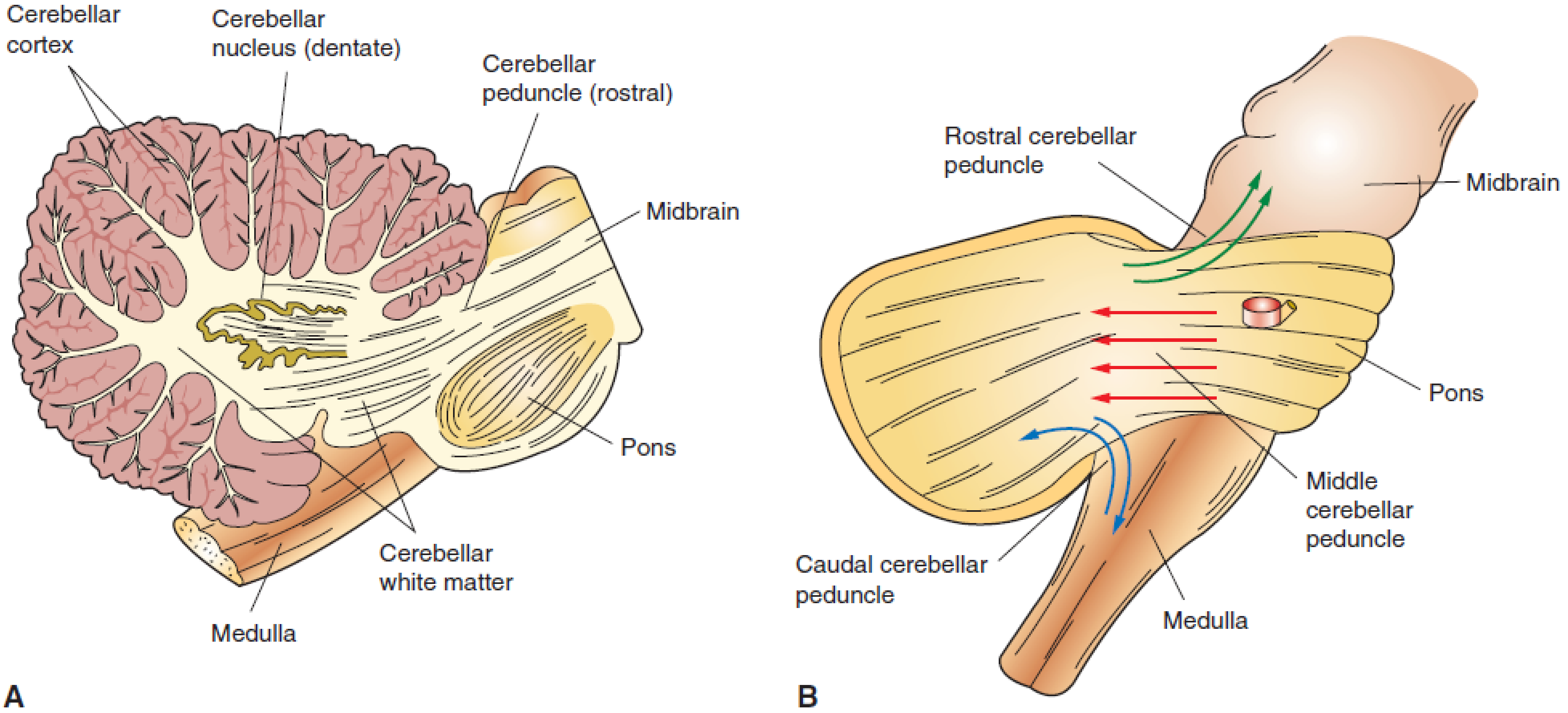
- The cerebellum (Latin, “little brain”) is caudal to the cerebral cortex and dorsal to the brainstem
- Although it constitutes only about 10% of the gross brain volume because of its highly folded structure, the cerebellum contains more than half of all CNS neurons.
- The outer layer of cerebellar gray matter, the cerebellar cortex, has a highly regular, three-layered, histological appearance, which suggests that all cerebellar regions may perform a common underlying task.



The Cerebellum

- The Cerebellum Constantly Compares the Intended Movement with the Actual Movement and Makes Appropriate Adjustments.
- It first receives information from components of the motor system hierarchy about the movement it has commanded.
- It also receives information from muscle spindles, the vestibular and visual systems, and other sensory receptors about the movement the body is actually performing.
- When the intended movement and the actual movement are not the same, the cerebellum's job is to perform the adjustments necessary to make them the same.

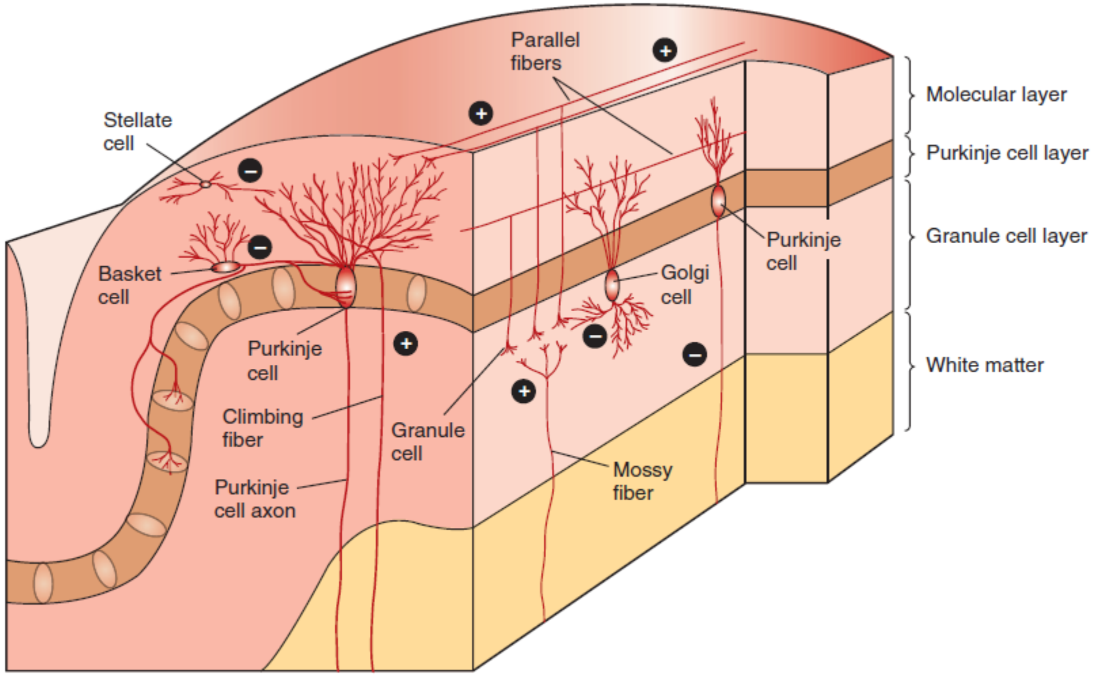
The Cerebellum



- A, Mid-sagittal section through the brainstem region showing the internal organization of the cerebellum.
- B, A lateral view of the brainstem region emphasizing the cerebellar peduncles and the principal directions that axons travel within them.

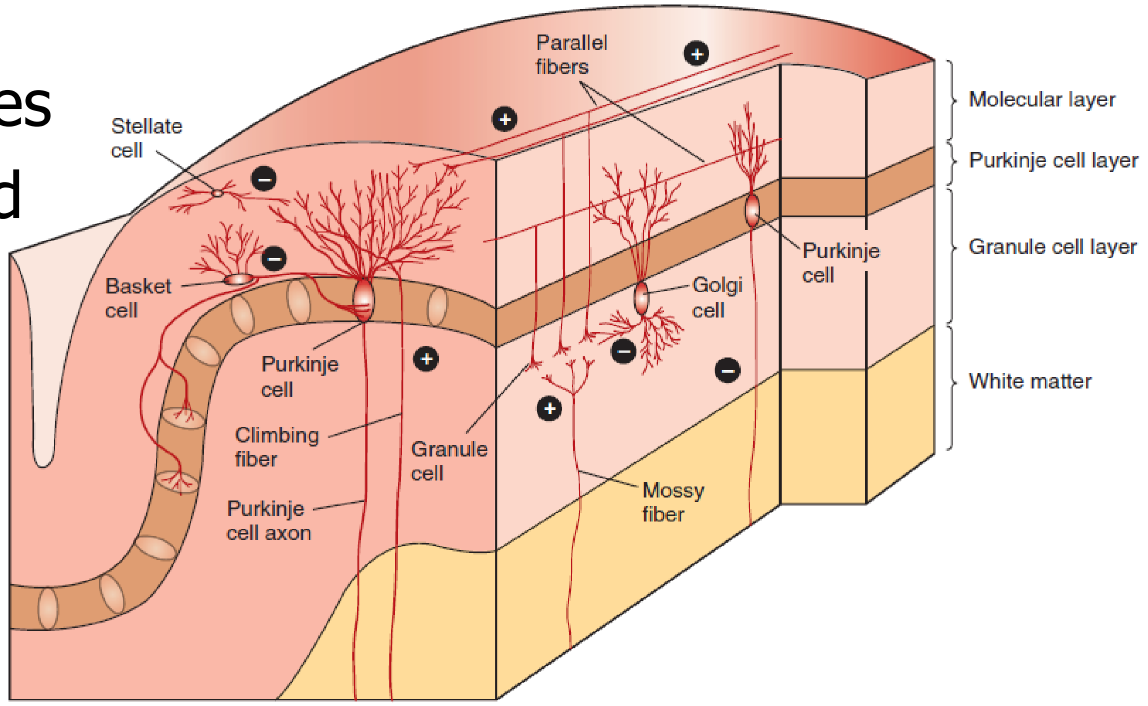
Cerebellar Cortex Histology

- Five types of neurons are organized into three layers in the cerebellar cortex.
- A single cerebellar folium is sectioned vertically, in both sagittal and transverse planes, to illustrate the general organization of the cerebellar cortex.
- A positive sign denotes an excitatory effect of a neural element on its postsynaptic target.
- A negative sign denotes an inhibitory effect of a neural element on its postsynaptic target.



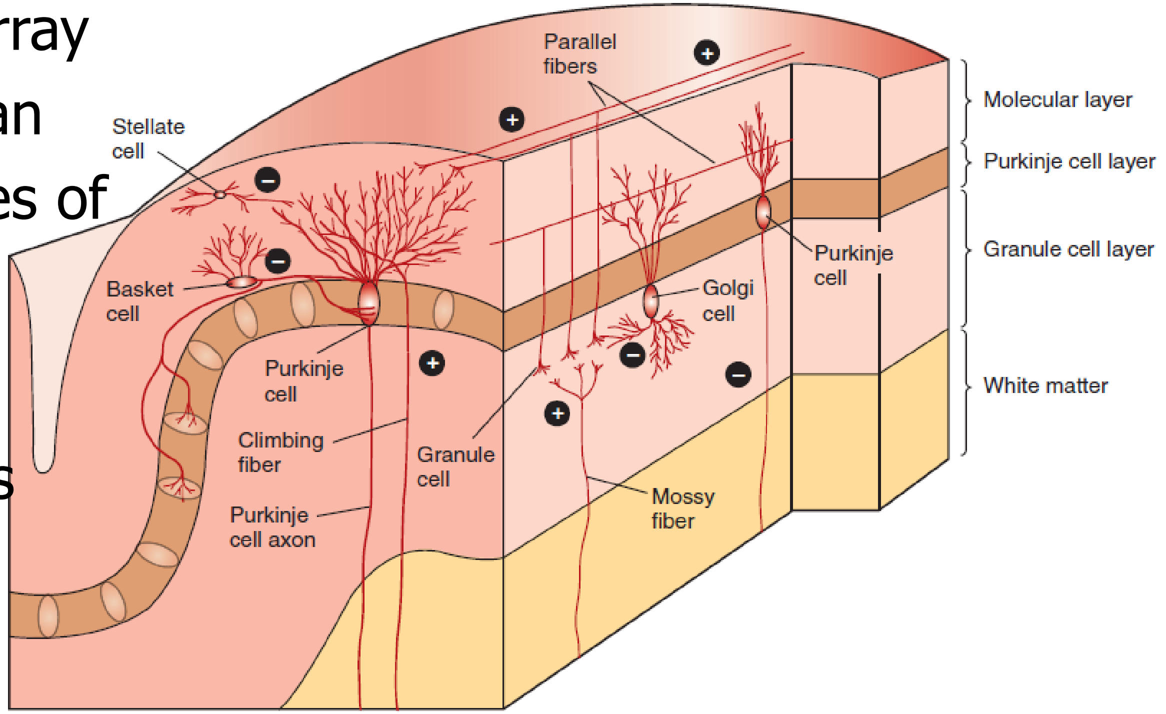
Cerebellar Cortex Histology

- The molecular layer: is the outermost layer, consists primarily of granule cell axons, known as parallel fibers, dendrites of neurons located in deeper layers; and scattered inhibitory interneurons, the stellate and basket cells.
- The middle layer: Purkinje cell layer, consists of the large cell bodies of Purkinje neurons, which have a flat but extremely expansive dendritic field that extends into the molecular layer



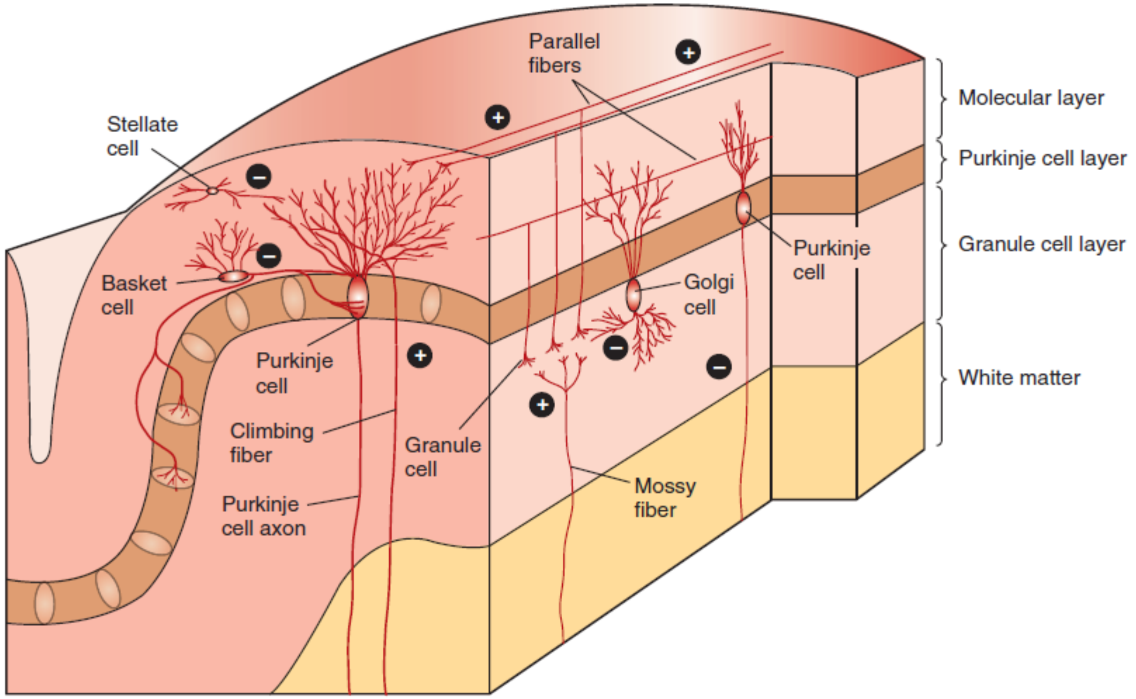
Cerebellar Cortex Histology

- Dendritic field of Purkinje neuron is oriented at right angles to the parallel fibers. Therefore, a Purkinje cell is contacted by an expansive array of parallel fiber axons of granule cells, and an individual parallel fiber contacts the dendrites of many Purkinje cells.
- The stellate and basket cell inhibitory interneurons can act to refine, or prune, this extensive spatial pattern of Purkinje cell activation by parallel fibers.
- The Purkinje cells are the only output neurons of the cerebellar cortex and are all inhibitory.



Cerebellar Cortex Histology

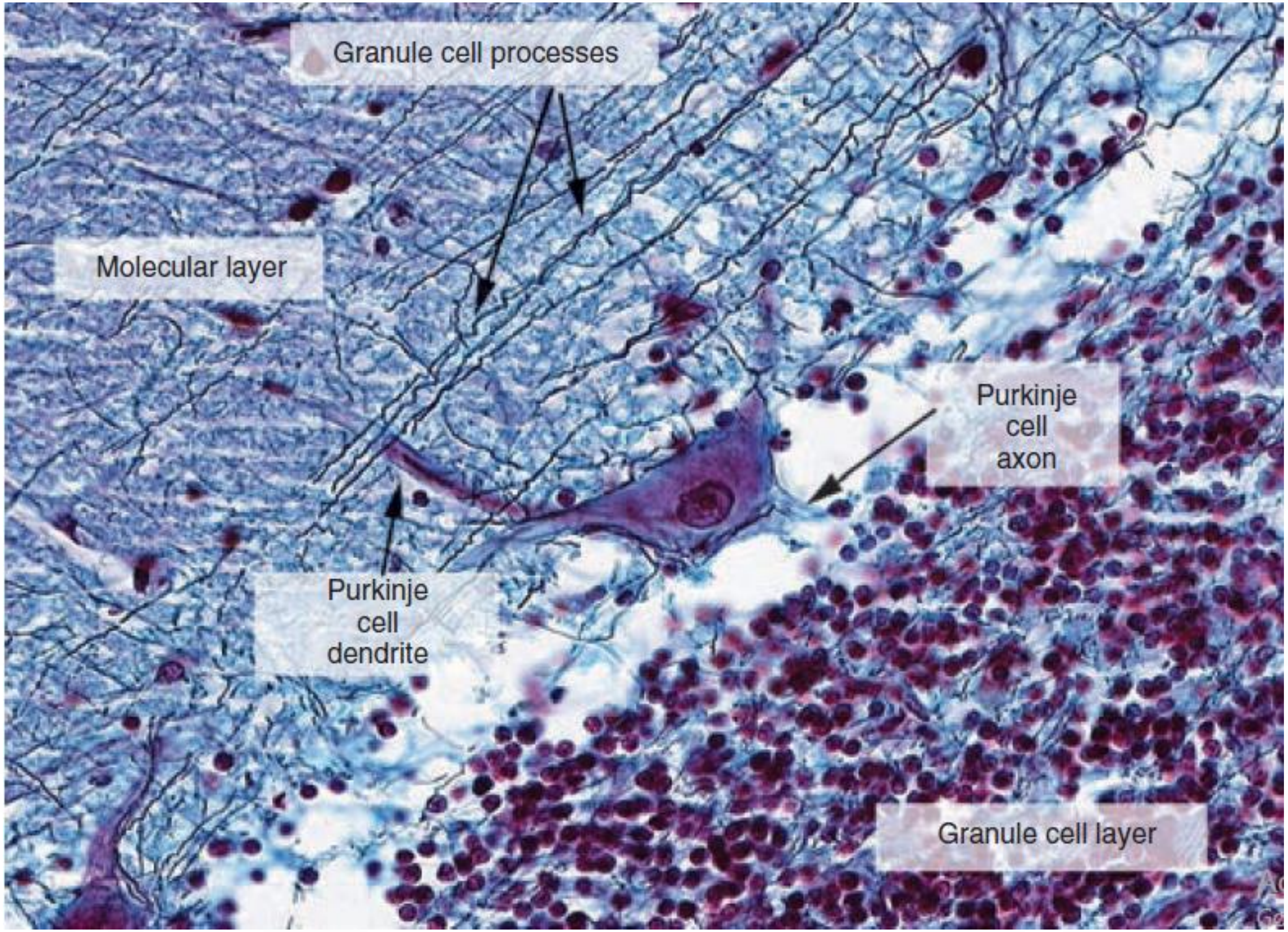
- The granule cell layer: is the innermost layer contains the vast number of granule cell somas that give rise to the parallel fibers.
- This layer also contains occasional Golgi cell bodies.
- These are inhibitory interneurons that can regulate the overall level of excitation of the Purkinje cells by the granule cell parallel fibers.



Cerebellar Cortex Histology

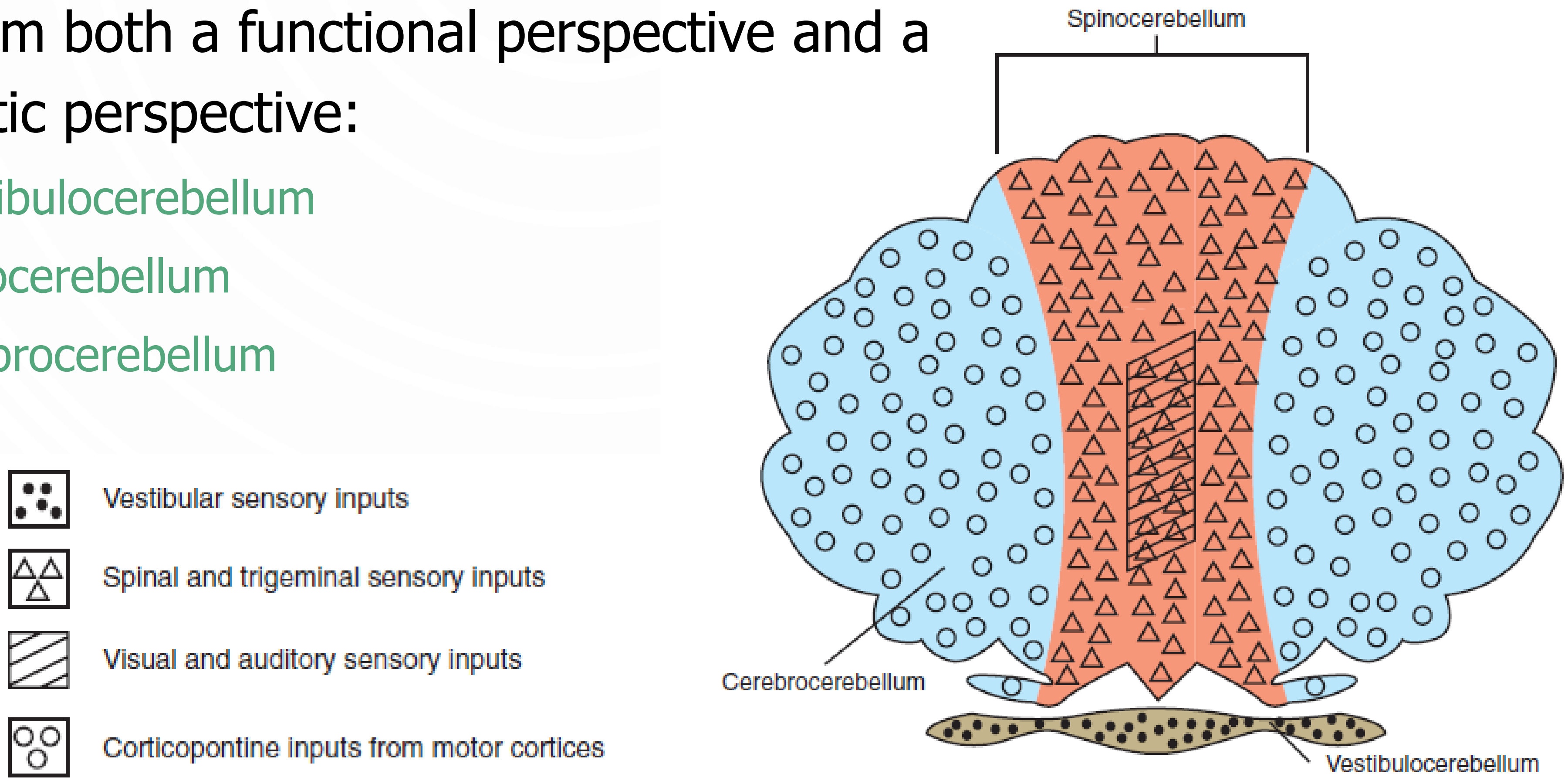
- The Purkinje cells can inhibit the spontaneously active neurons of the deep cerebellar nuclei, whose axons leave the cerebellum. This selective inhibition represents a sensitive temporal refinement of cerebellar processing that supplements the spatial refinement, and the excitation level control.
- The cerebellar output neurons participate in regulating the activity of brainstem motor pathways and motor cortices involved in the execution and planning of movement.
- The two primary groups of input axons to the cerebellum are the mossy fiber and climbing fiber axons. Both are excitatory; they cause excitatory postsynaptic potentials (EPSPs) within the cerebellar cortex and, through collateral axons, within the deep cerebellar nuclei

Cerebellar Cortex Histology

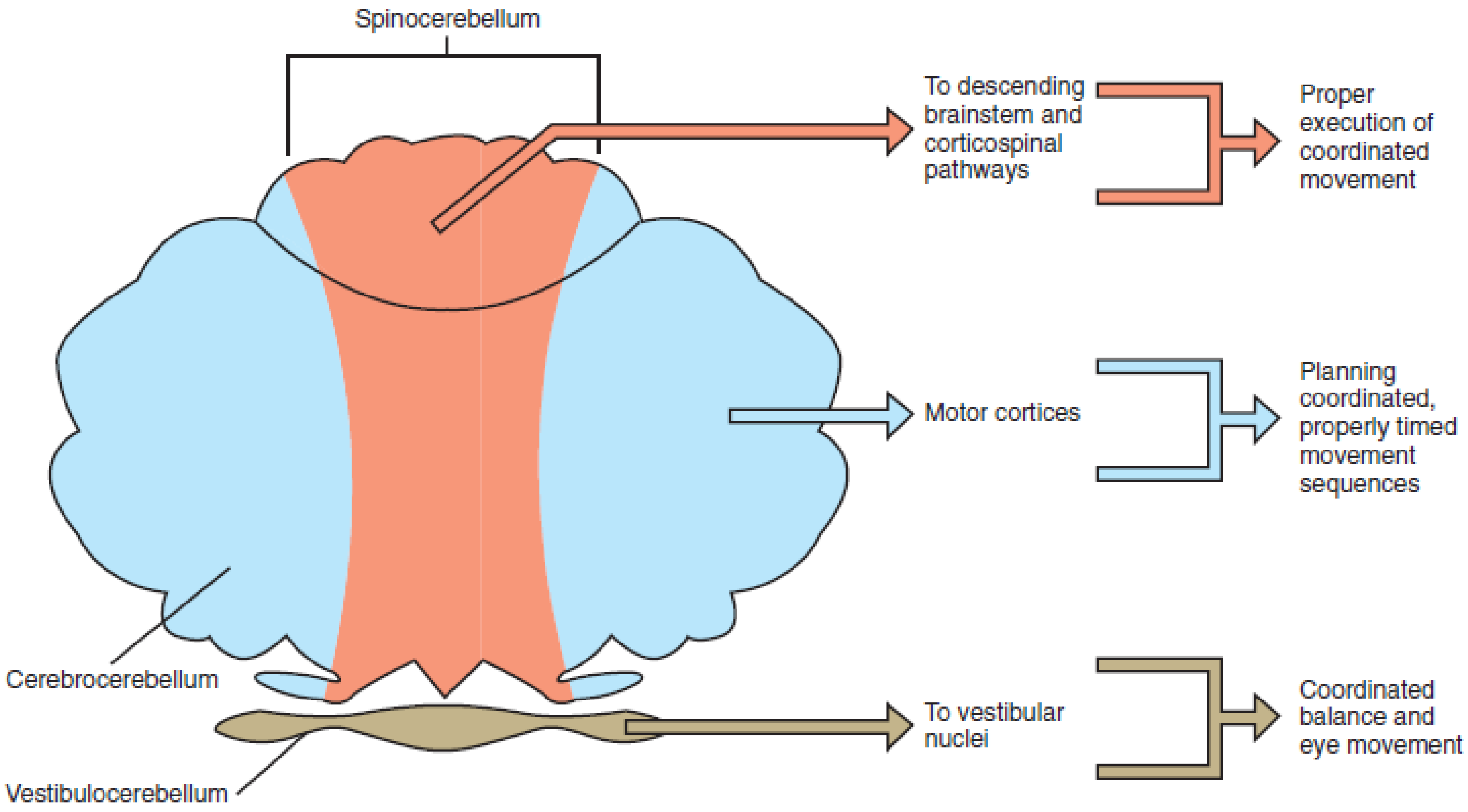


Functional Regions of The Cerebellum

- The cerebellum can be divided into three distinct regions from both a functional perspective and a phylogenetic perspective:
  - The vestibulocerebellum
  - the spinocerebellum
  - the cerebrocerebellum



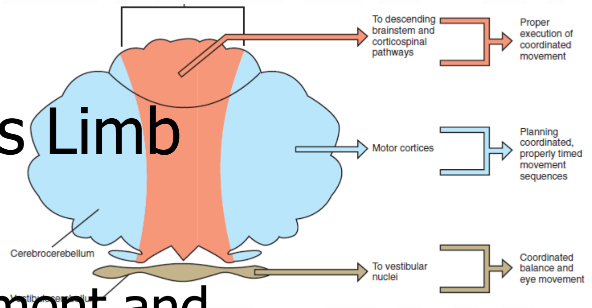
Functional Regions of The Cerebellum



Major output targets and general roles of the three functional regions of the cerebellum.

Functional Regions of The Cerebellum

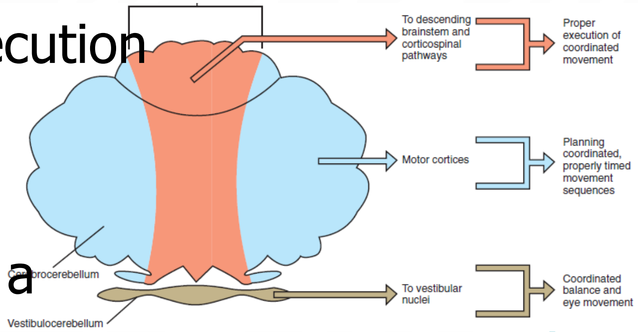
- The Vestibulocerebellum Helps Coordinate Balance and Eye Movements
  - The cerebellar output to the vestibular nuclei helps to coordinate the axial and proximal muscles controlling balance, by way of the vestibulospinal tract, and helps to coordinate head and eye movements by way of the medial longitudinal fasciculus
  - Because this part of the cerebellum was the first to appear in vertebrate evolution, it is sometimes called the *archicerebellum*.



- The Spinocerebellum Helps Coordinate Muscle Tone as Well as Limb Movement
  - The spinocerebellum receives information about commands for movement and significant feedback information about the execution of the movement itself.
  - the spinocerebellum can adjust the timing and coordination of "in progress" movement and muscle tone.
  - Because this portion of the cerebellum appeared next in evolution, it is sometimes called the *paleocerebellum*.

Functional Regions of The Cerebellum

- The Cerebrocerebellum Helps with Planning Coordinated, Properly Timed Movement Sequences
  - the cerebrocerebellum is part of a communication loop with regions of motor cortex that are involved in the planning of, and preparation for, movement.
  - Whereas the spinocerebellum helps coordinate the “in progress” execution of movement, the cerebrocerebellum helps the motor cortices with planning ahead for the next appropriate movement so there will be smooth and appropriately timed transitions between components of a movement sequence.
  - The dramatic growth of the cerebrocerebellum and cerebral cortex was the major phylogenetic addition to the brain during primate evolution, and thus it is often called the *neocerebellum*.



The Cerebellum and Motor Learning

- Functional magnetic resonance imaging (fMRI) studies have shown that the cerebellum is very active when learning a new sequence of movements, but it is not as active when the movement becomes relatively automatic.
- Structural and functional changes in cerebellar circuitry have also been observed during motor learning. For example, increases in the number of parallel fiber and climbing fiber synaptic contacts on Purkinje cells have been observed following the learning of complex motor behavior.

Cerebellar Disease and Movement Abnormalities

- The cerebellum constantly compares the intended movement with the actual movement and makes appropriate adjustments.
- Movement disorders:
  - Place the paws far apart (wide-based gait)
  - Walk in an uncoordinated manner (ataxia), which reflects the inability of the vestibulocerebellum and spinocerebellum to coordinate balance and movement of the axial skeleton.
  - Dysmetria (inappropriate measure of muscular contraction), in which movements either continue too long or not long enough.
  - Asynergia, a failure of the components of a complex, multiple-joint movement to occur in a coordinated fashion.
  - Intention tremor (action tremor), an oscillating movement disorder that is worse when the animal is moving, especially near the end of the movement

The Cerebellum


3
E
A

Autonomic Nervous System (ANS)

- The autonomic or involuntary nervous system is that portion of the nervous system which regulates the activity of cardiac muscle, smooth muscle, and the glands.
- The ANS has two parts:
  - Sympathetic
  - Parasympathetic

Autonomic Nervous System (ANS)

- Sympathetic – stimulates viscera
  - Prepares the body for emergency situations ("fight or flight" response to stress)
  - Fear, emergency, physical exertion, and embarrassment are responded to by this system
  - This system shifts energy and blood toward the skeletal muscles, cardiac muscles, and respiration

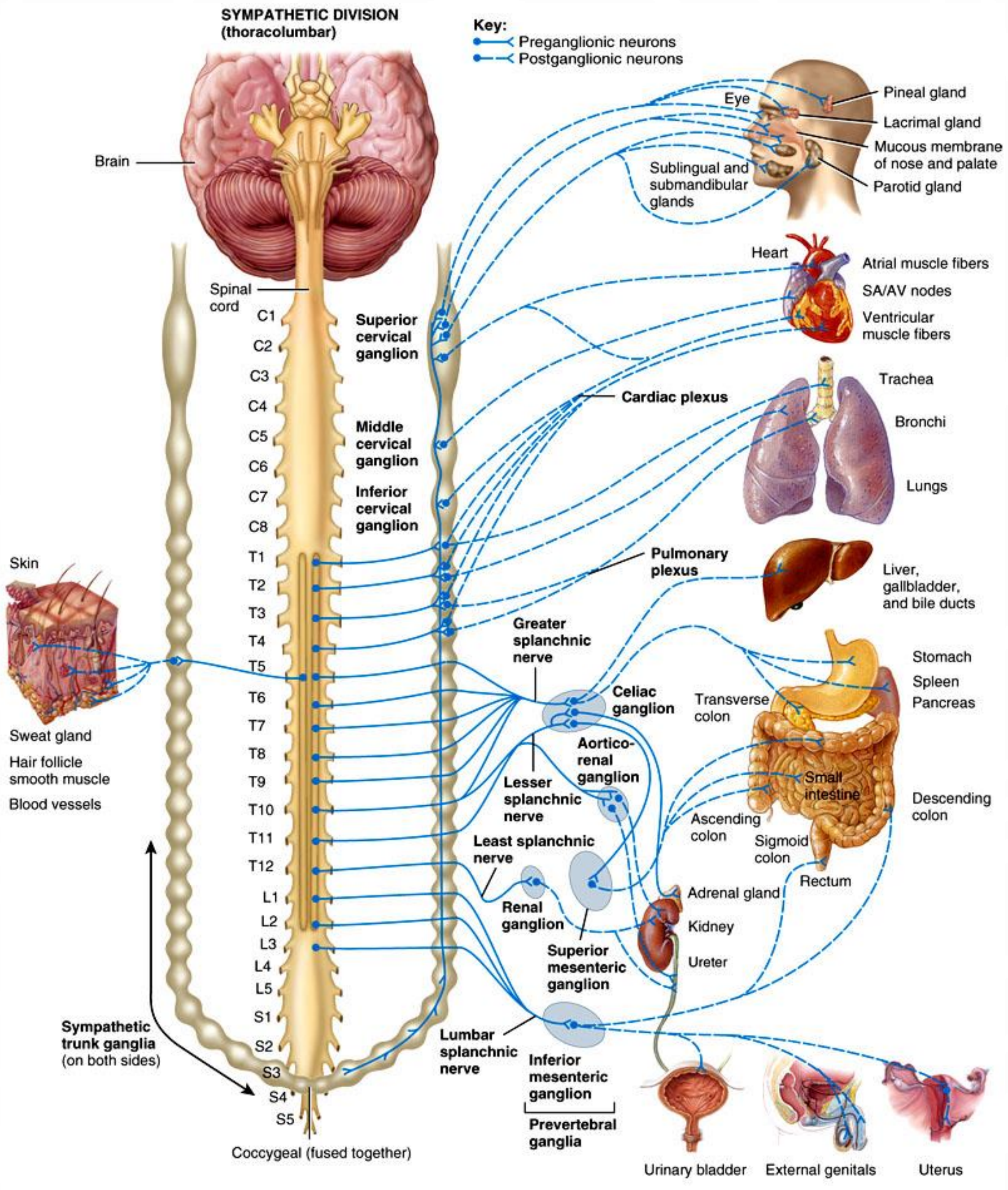


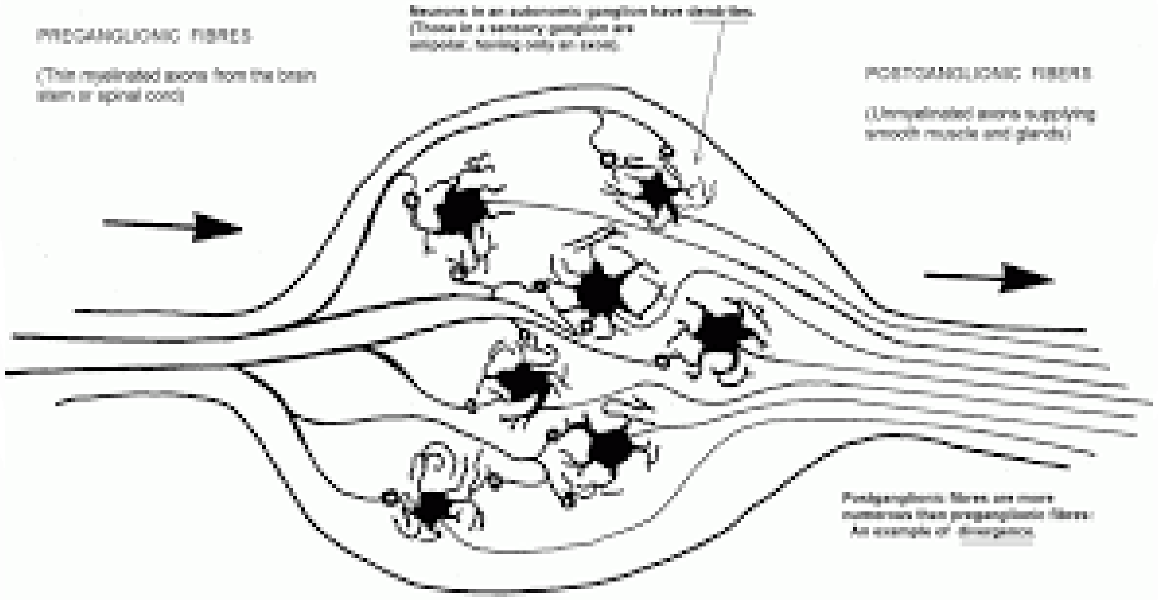
Figure 15.02 Tortora - PAP 12/e

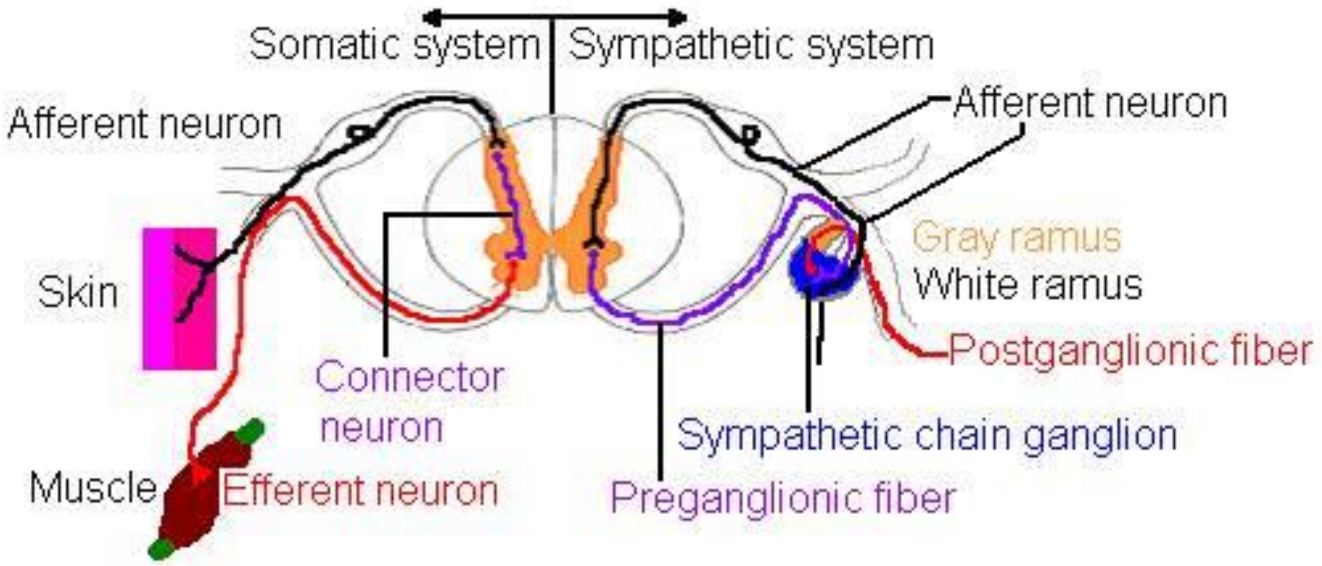
GANGLION

In anatomy, a ganglion is a nerve cell cluster or a group of nerve cell bodies located in the autonomic nervous system and sensory system.

Ganglia house the cells bodies of afferent nerves and efferent nerves.

A pseudoganglion looks like a ganglion but only has nerve fibers and has no nerve cell bodies


PREGANGLIONIC FIBRES
(Thin myelinated axons from the brain stem or spinal cord)
Neurons in an autonomic ganglion have dendrites.
(Those in a sensory ganglion are unipolar, having only an axon)
POSTGANGLIONIC FIBERS
(Unmyelinated axons supplying smooth muscle and glands)


Somatic system
Sympathetic system
Afferent neuron
Afferent neuron
Skin
Gray ramus
White ramus
Postganglionic fiber
Connector neuron
Sympathetic chain ganglion
Muscle
Efferent neuron
Preganglionic fiber

Autonomic Nervous System

- Parasympathetic – inhibits viscera
  - Energy conservation system
  - Restores body energy during rest
  - Responses toward digestion, elimination of waste, and decreases heart rate

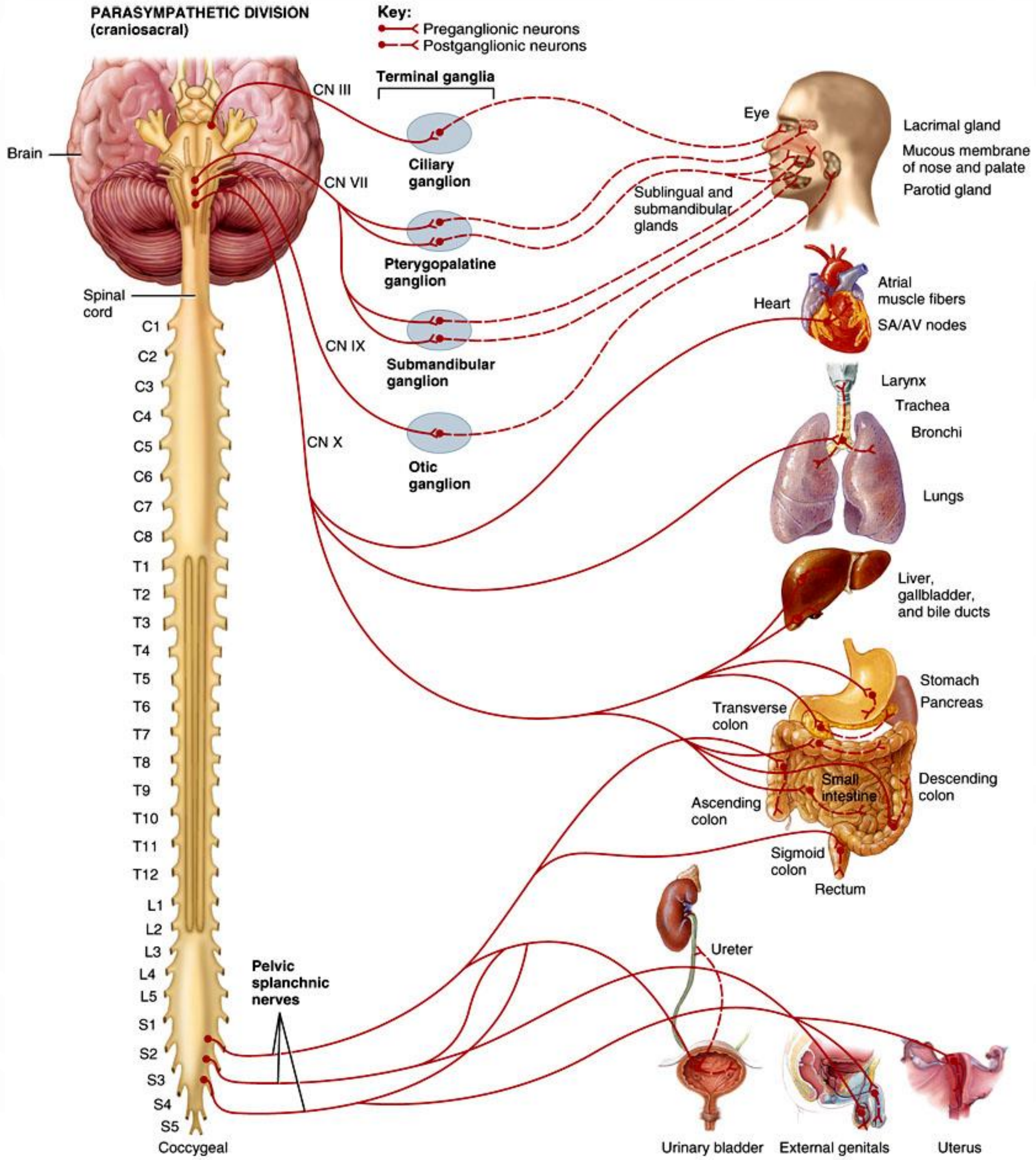


Figure 15.03 Tortora - PAP 12/e

ANS vs. Somatic Nervous System (SNS)

- The ANS differs from the SNS in the following three areas
  - Effectors
  - Efferent pathways
  - Target organ responses
- The effectors of the SNS are skeletal muscles
- The effectors of the ANS are cardiac muscle, smooth muscle, and glands

Efferent Pathways

- Heavily myelinated axons of the somatic motor neurons extend from the CNS to the effector (skeletal muscles)
- Axons of the ANS are a two-neuron chain
  - The preganglionic (first) neuron has a lightly myelinated axon
  - The ganglionic (second) neuron extends to an effector organ

Neurotransmitter Effects

- All somatic motor neurons release Acetylcholine (ACh), which has an excitatory effect
- In the ANS:
  - Preganglionic fibers release ACh
  - Postganglionic fibers release norepinephrine or ACh and the effect is either stimulatory or inhibitory
  - ANS effect on the target organ is dependent upon the neurotransmitter released and the receptor type of the effector

Comparison of Somatic and Autonomic Systems

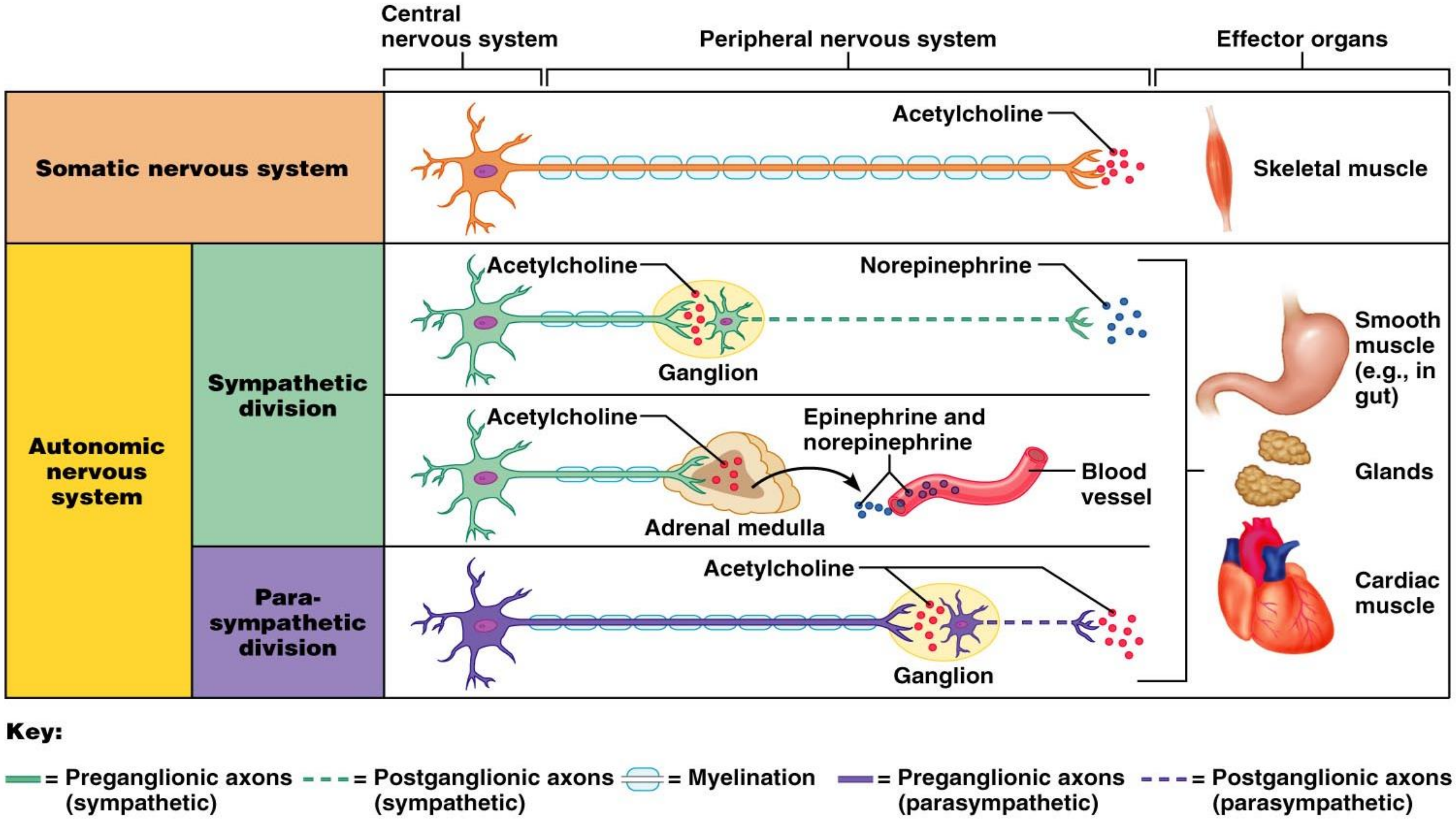


Figure 14.2

Role of the Parasympathetic Division

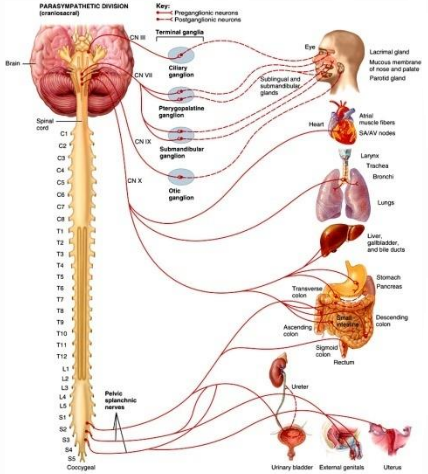


Figure 15.03 Tortora - PAP 12/e

- Concerned with keeping body energy use low
- Involves the **D** activities – digestion, defecation, and diuresis
- Its activity is illustrated in a person who relaxes after a meal
  - Blood pressure, heart rate, and respiratory rates are low
  - Gastrointestinal tract activity is high
  - The skin is warm and the pupils are constricted

Parasympathetic Responses

- Rest-and-digest response.
- Conserve and restore body energy.
- ↑ digestive and urinary function.
- ↓ body functions that support physical activity.

Role of the Sympathetic Division

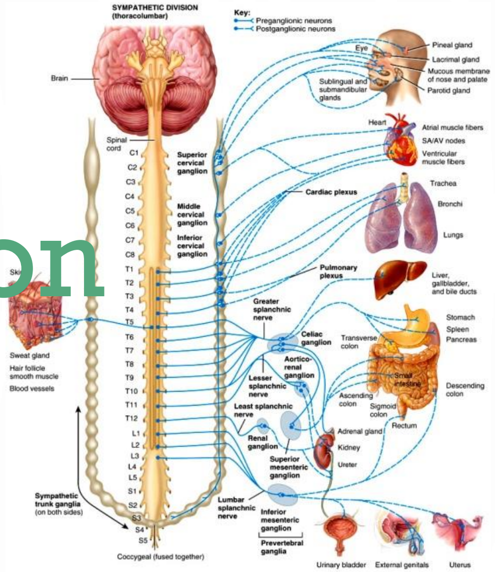


Figure 15.02 Tortora - PAP 12/e

- The sympathetic division is the "fight-or-flight" system
- Involves **E** activities – exercise, excitement, emergency, and embarrassment
- Promotes adjustments during exercise – blood flow to organs is reduced, flow to muscles is increased
- Its activity is illustrated by a person who is threatened

Sympathetic Responses

- Stress ↑ sympathetic system ↑ fight-or-flight response.
- ↑ production of ATP.
- Dilation of the pupils.
- ↑ heart rate and blood pressure.
- Dilation of the airways.
- Constriction of blood vessels that supply the kidneys and gastrointestinal tract.

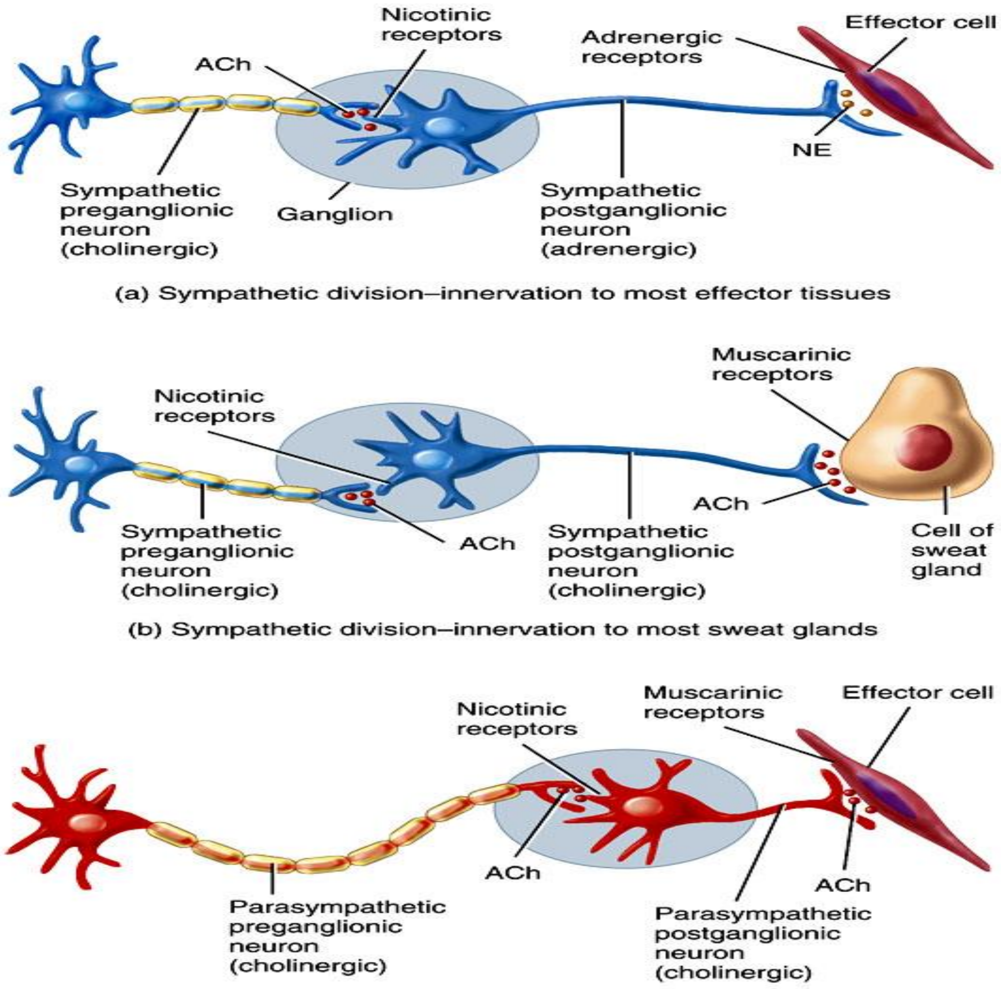
Sympathetic Responses

- ↑ blood supply to the skeletal muscles, cardiac muscle, liver and adipose tissue
- ↑ glycogenolysis ↑ blood glucose.
- ↑ lipolysis.

Anatomy of ANS

Division	Origin of Fibers	Length of Fibers	Location of Ganglia
Sympathetic	Thoracolumbar region of the spinal cord	Short preganglionic and long postganglionic	Close to the spinal cord
Parasympathetic	Brain and sacral spinal cord	Long preganglionic and short postganglionic	In the visceral effector organs

Cholinergic and Adrenergic Neurons in the Autonomic Nervous System

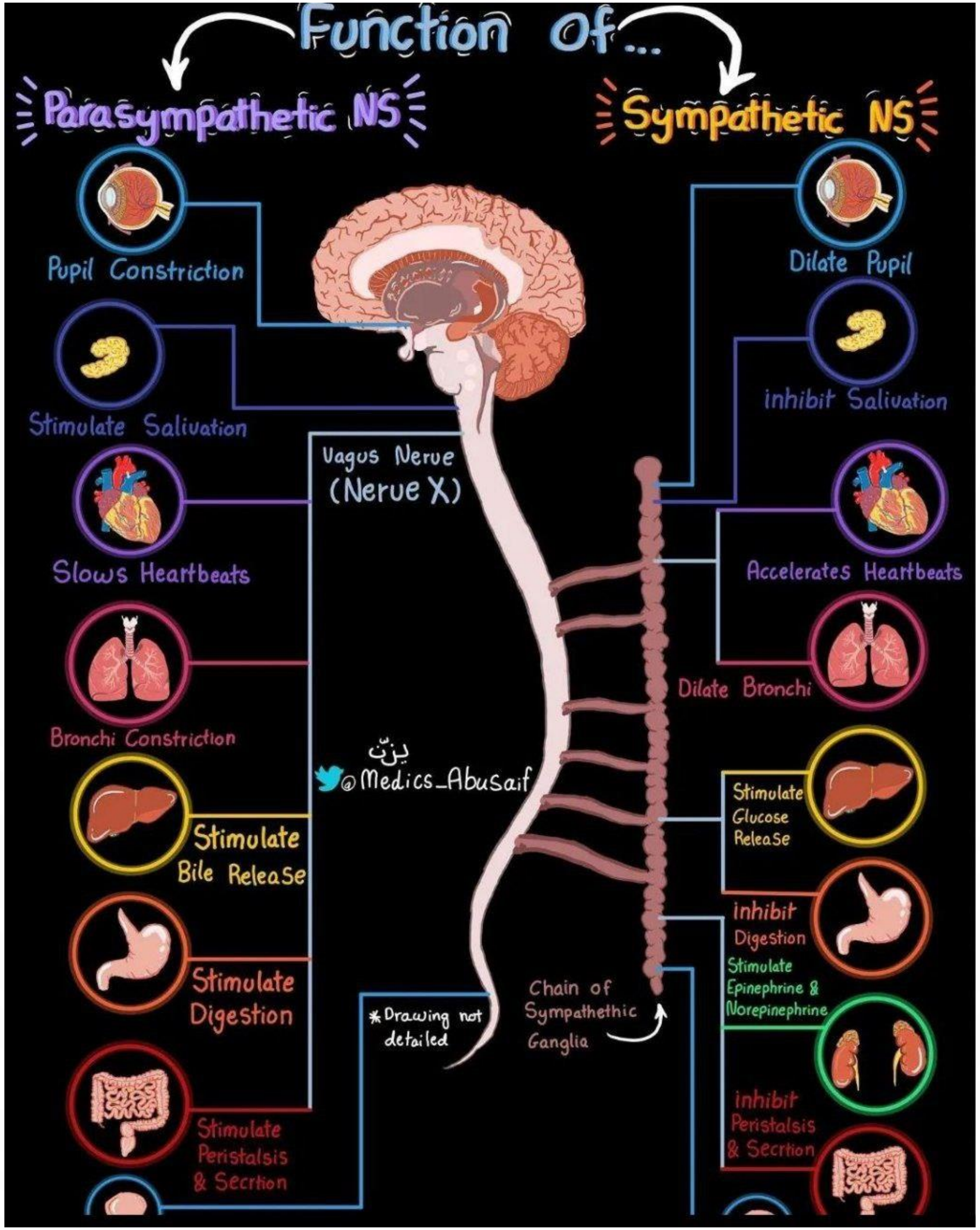


(a) Sympathetic division–innervation to most effector tissues

(b) Sympathetic division–innervation to most sweat glands

(c) Parasympathetic division

Figure 15.07 Tortora - PAP 12/e

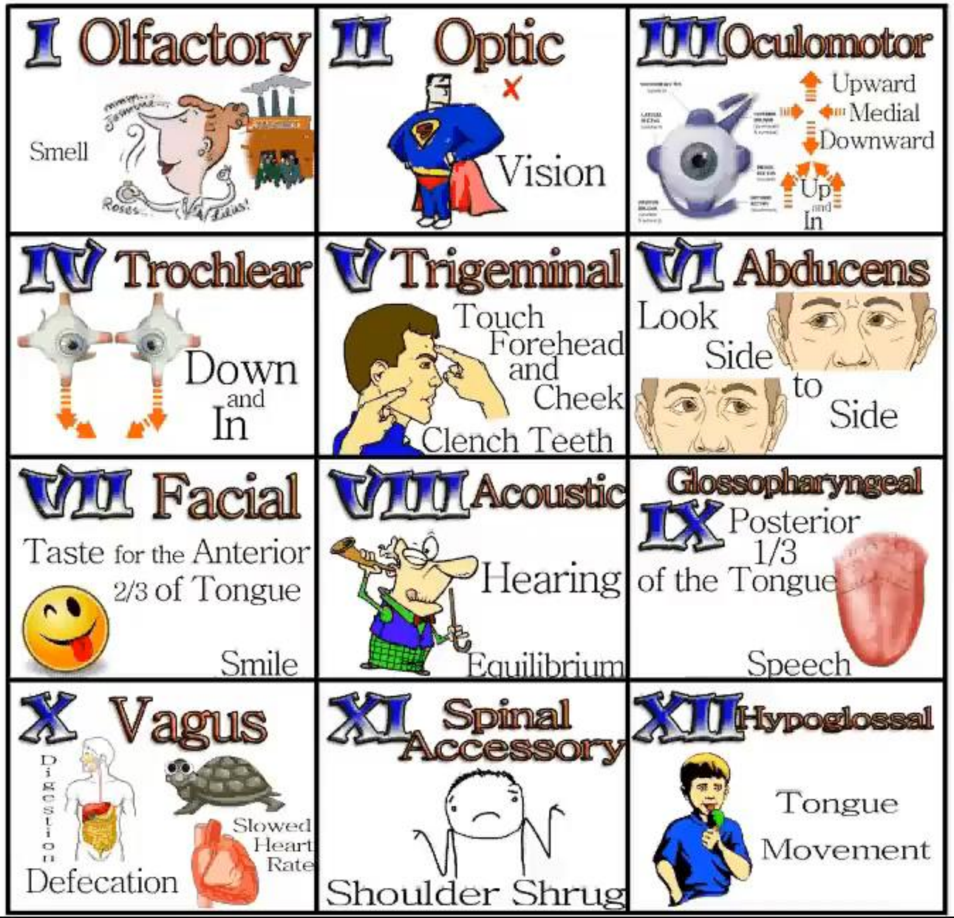


Function of...
Parasympathetic NS
Sympathetic NS
Pupil Constriction
Dilate Pupil
Stimulate Salivation
inhibit Salivation
Vagus Nerve
(Nerve X)
Slows Heartbeats
Accelerates Heartbeats
Dilate Bronchi
Bronchi Constriction
@Medics_Abusaif
Stimulate Glucose Release
Stimulate Bile Release
inhibit Digestion
Stimulate Digestion
Stimulate Epinephrine & Norepinephrine
Chain of Sympathethic Ganglia
*Drawing not detailed
inhibit Peristalsis & Secrtion
Stimulate Peristalsis & Secrtion

PERIPHERAL NERVOUS SYSTEM (PNS)

- Nerves are either motor nerves or sensory nerves.
  - Efferent or motor nerves innervate muscles and glands. In order to accomplish this, they conduct nerve impulses from the CNS to the muscles and glands.
  - Afferent or sensory nerves send sensory information and nerve impulses from sensory receptors in the skin, muscles, and joints to the brain.

CRANIAL NERVES



PERIPHERAL NERVOUS SYSTEM (PNS)

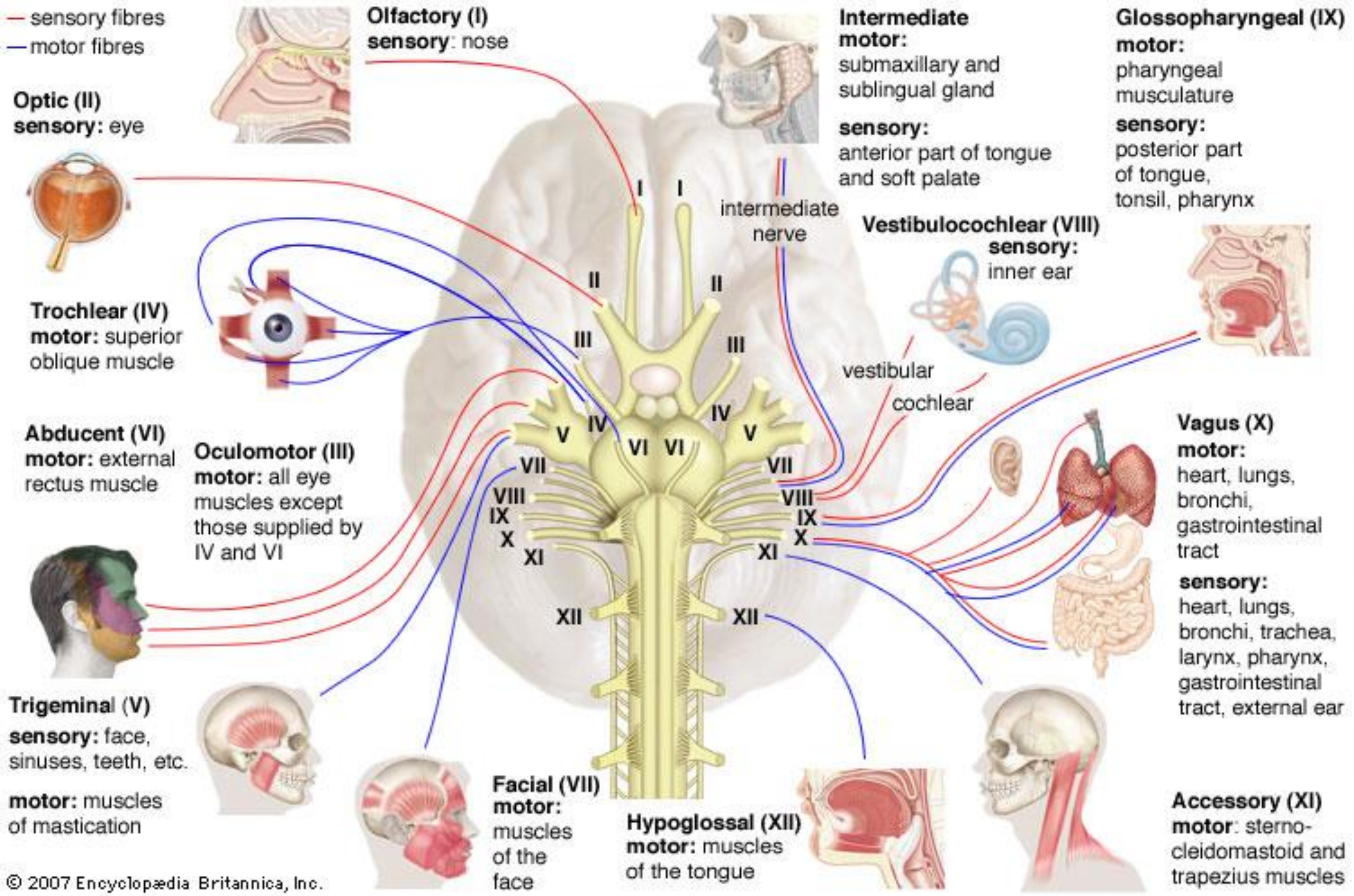
- Cranial Nerves – 12 pairs of cranial nerves which are either sensory or motor nerves. 10 of these nerves originate at the brain stem.
  - Cranial Nerve 1: Olfactory – smell
  - Cranial Nerve 2: Optic – vision
  - Cranial Nerve 3,4&6: Occulomotor, trochlear, and abducens – motor nerves controlling movement of the eyes.

PERIPHERAL NERVOUS SYSTEM (PNS)

- Cranial Nerve 5: Trigeminal – sensation of the head, face, and movements of the jaw
- Cranial Nerve 7: Facial – taste, facial movements, and secretions of tears and saliva
- Cranial Nerve 8: Acoustic (vestibulocochlear) – hearing and equilibrium
- Cranial Nerve 9: Glossopharyngeal – taste, sensation and movement in the pharynx, and secretion of saliva

Peripheral Nervous System (PNS)

- Cranial Nerve 10: Vagus – controls taste, and movements in the pharynx and larynx
- Cranial Nerve 11: Spinal accessory – movements of the pharynx, larynx, head, and shoulders
- Cranial Nerve 12: Hypoglossal – movement of the tongue



sensory fibres
motor fibres
Olfactory (I)
sensory: nose
Optic (II)
sensory: eye
Intermediate
motor:
submaxillary and
sublingual gland
sensory:
anterior part of tongue
and soft palate
intermediate
nerve
Glossopharyngeal (IX)
motor:
pharyngeal
musculature
sensory:
posterior part
of tongue,
tonsil, pharynx
Vestibulocochlear (VIII)
sensory:
inner ear
vestibular
cochlear
Trochlear (IV)
motor: superior
oblique muscle
Abducent (VI)
motor: external
rectus muscle
Oculomotor (III)
motor: all eye
muscles except
those supplied by
IV and VI
Vagus (X)
motor:
heart, lungs,
bronchi,
gastrointestinal
tract
sensory:
heart, lungs,
bronchi, trachea,
larynx, pharynx,
gastrointestinal
tract, external ear
Trigeminal (V)
sensory: face,
sinuses, teeth, etc.
motor: muscles
of mastication
Facial (VII)
motor:
muscles
of the
face
Hypoglossal (XII)
motor: muscles
of the tongue
Accessory (XI)
motor: sterno-
cleidomastoid and
trapezius muscles
I I II II III III IV IV V V VI VI VII VII VIII VIII IX IX X X XI XI XII XII
© 2007 Encyclopædia Britannica, Inc.