

Histology of Nervous System

Central Nervous System (CNS)

- Consists of the brain and spinal cord
- The brain is part of the CNS that is located in the skull and the spinal cord is connected to the brain through the foramen magnum of the occipital bone and is encircled by the bones of the vertebral column
- Source of thoughts, emotions and memories
- Most signals that stimulate muscles to contract and glands to secrete originate in the CNS

Peripheral Nervous System (PNS)

- Consists of all nervous tissue outside the CNS

Components of PNS

- Nerves
- Ganglia
- Enteric plexus
- Sensory receptors

PNS is divided into

- Somatic Nervous System (SNS)
- Autonomic Nervous System (ANS)
- Enteric Nervous System (ENS)

Receptors

sensory structures that detect changes in the internal or external environment

Effectors

are target organs whose activities change in response to neural commands

Somatic Sensory Receptors

provide position, touch, pressure, pain, and temperature sensations

Special Sensory Receptors

provide sensations of smell, taste, vision, balance, and hearing

Information Processing

includes the integration and distribution of information in the CNS

Nerves

is a bundle of hundreds and thousands of axons plus associated connective tissue and blood vessels

Ganglia

are small masses of nervous tissue, consisting primarily of neuron cell bodies, that are located outside of the brain and spinal cord

Enteric plexuses

are extensive networks of neurons located in the walls of organs of the gastrointestinal tract. The neurons of these plexuses help regulate the digestive system

Sensory receptors

refers to a structure of the nervous system that monitors change in the external or internal environment

Somatic Nervous System (SNS)

the part of the peripheral nervous system that controls voluntary movement of skeletal muscles

SNS consists of

- Sensory neurons that convey information to the CNS from somatic receptors in the head, body wall, and limbs and from receptors for the special senses of vision, hearing, taste and smell
- Motor neurons that conduct impulses from the CNS to skeletal muscles only. Because of these motor responses can be consciously controlled the action of this part of the PNS is voluntary

Autonomic Nervous System (ANS)

the part of the peripheral nervous system that controls the glands and the muscles of the internal organs (such as the heart). Its sympathetic division arouses; its parasympathetic division calms.

ANS consists of

- sensory neurons that convey information to the CNS from autonomic sensory receptors, located primarily in visceral organs e.g. stomach and lungs
- motor neurons that conduct nerve impulses from the CNS to smooth muscle, cardiac muscle and glands. Motor responses are not normally under conscious control - action is involuntary.

The motor part of the ANS consists of 2 branches

- Sympathetic Division
- Parasympathetic Division

Sympathetic Division

helps support exercise or emergency actions - the 'fight or flight' response

Parasympathetic Division

takes care of 'rest-and-digest' activities

Enteric Nervous System (ENS)

neural tissue associated with the digestive system that is responsible for nervous control through autonomic connections

Operation of ENS is involuntary

ENS

- many of the neurons function independently of the ANS and SNS to some extent - they also communicate with the CNS via sympathetic and parasympathetic neurons.
- sensory neurons monitor chemical changes within the GI tract smooth muscle to propel food through the GI tract, secretions of GI organs and activities of GI tract endocrine cells, which secrete hormones.

Functions of the Nervous System

- Sensory (input)
- Integrative (process)
- Motor (output)

Sensory (input)

sensory receptors detect internal stimuli or external stimuli. This information is then carried into the brain and spinal cord through cranial and spinal nerves.

- Millions of receptors **monitor** things.
- Externally they monitor things such as temperature, sound, and light, including that from the "special senses" of touch, smell, taste, hearing, and sight from the external environment.
- Inside the body, receptors detect variations of pressure, pH, carbon dioxide concentration, and the levels of various electrolytes and including pain, body position (proprioception).



- All of this information gathered is called sensory input.



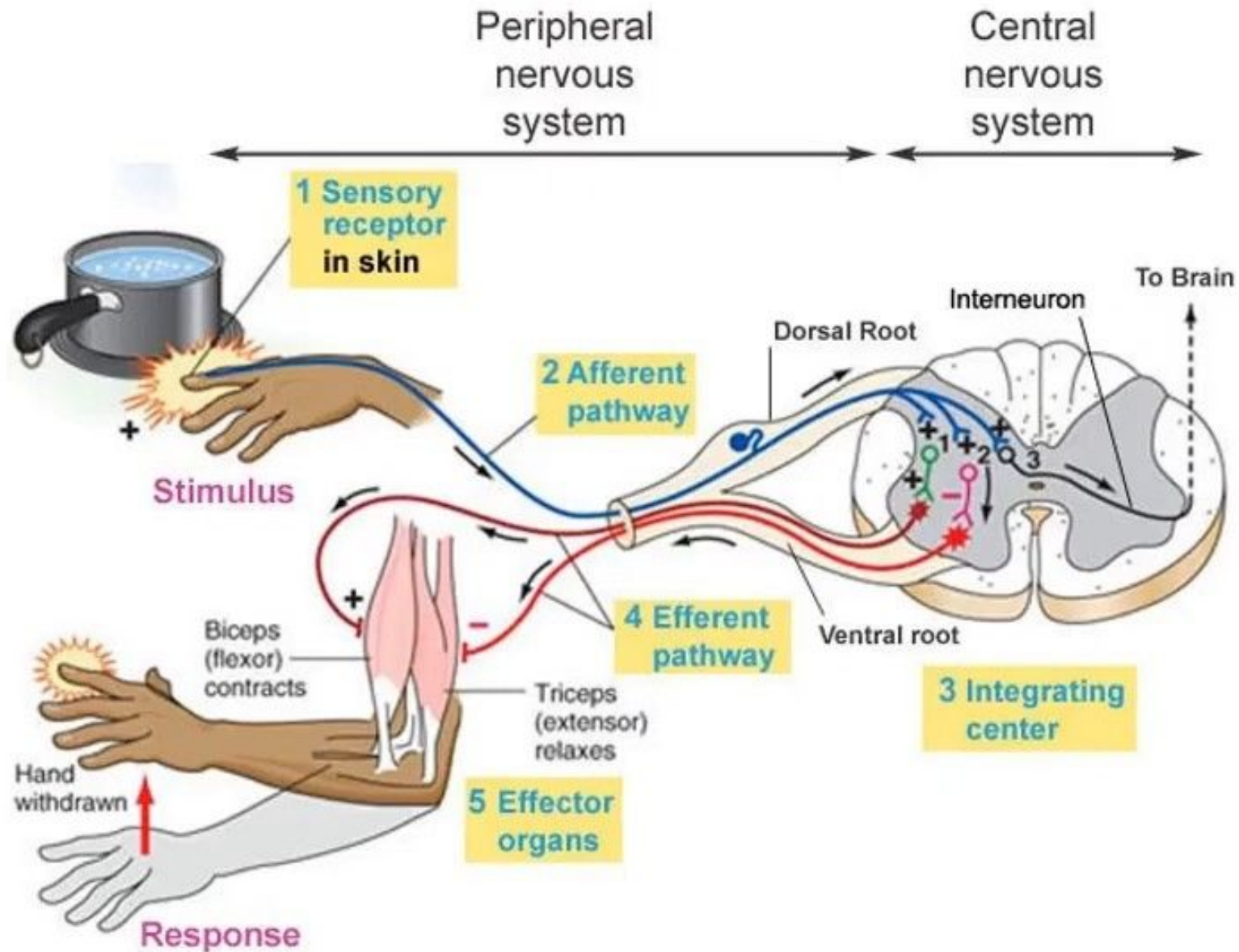
Integrative (process)

the nervous system processes sensory information by analysing it and making decisions for appropriate response - an activity known as integration

Motor (output)

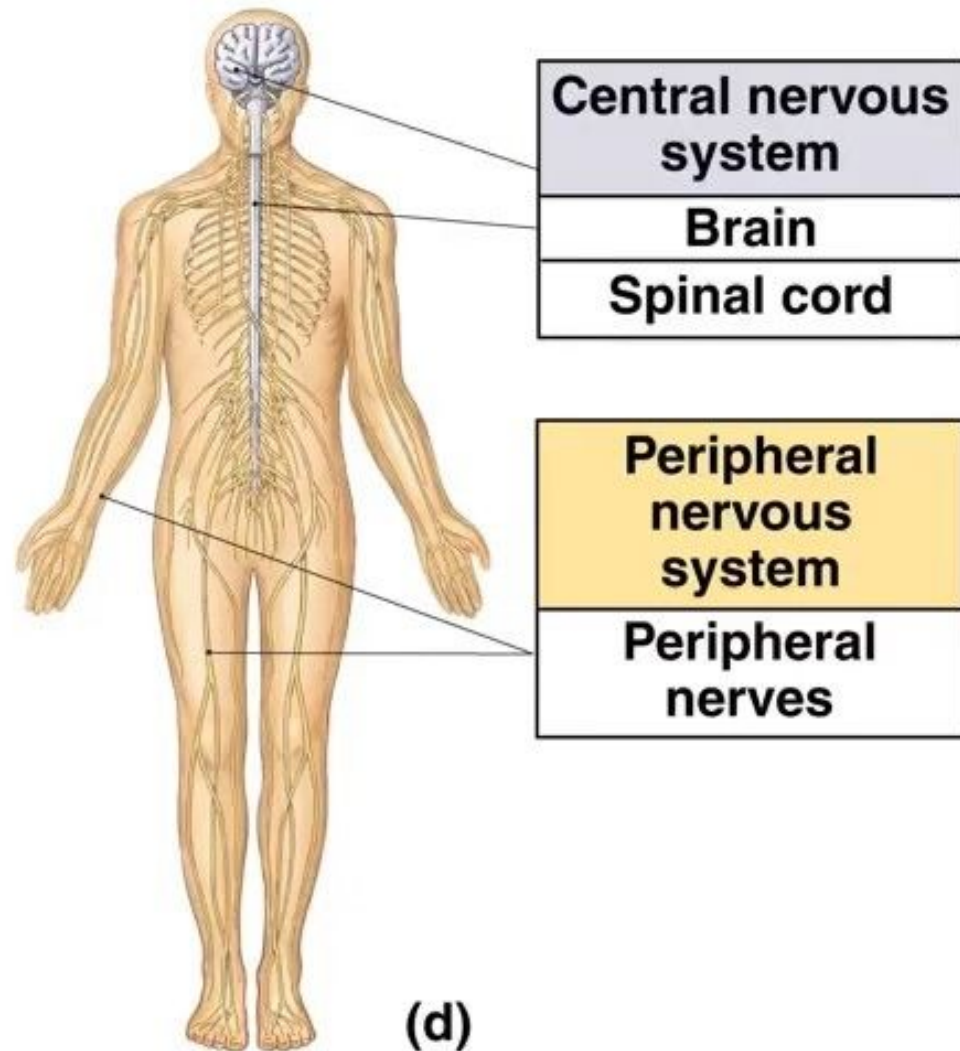
once sensory information is integrated, the nervous system may elicit an appropriate motor response by activating effectors to secrete.

Nervous System



Nervous System

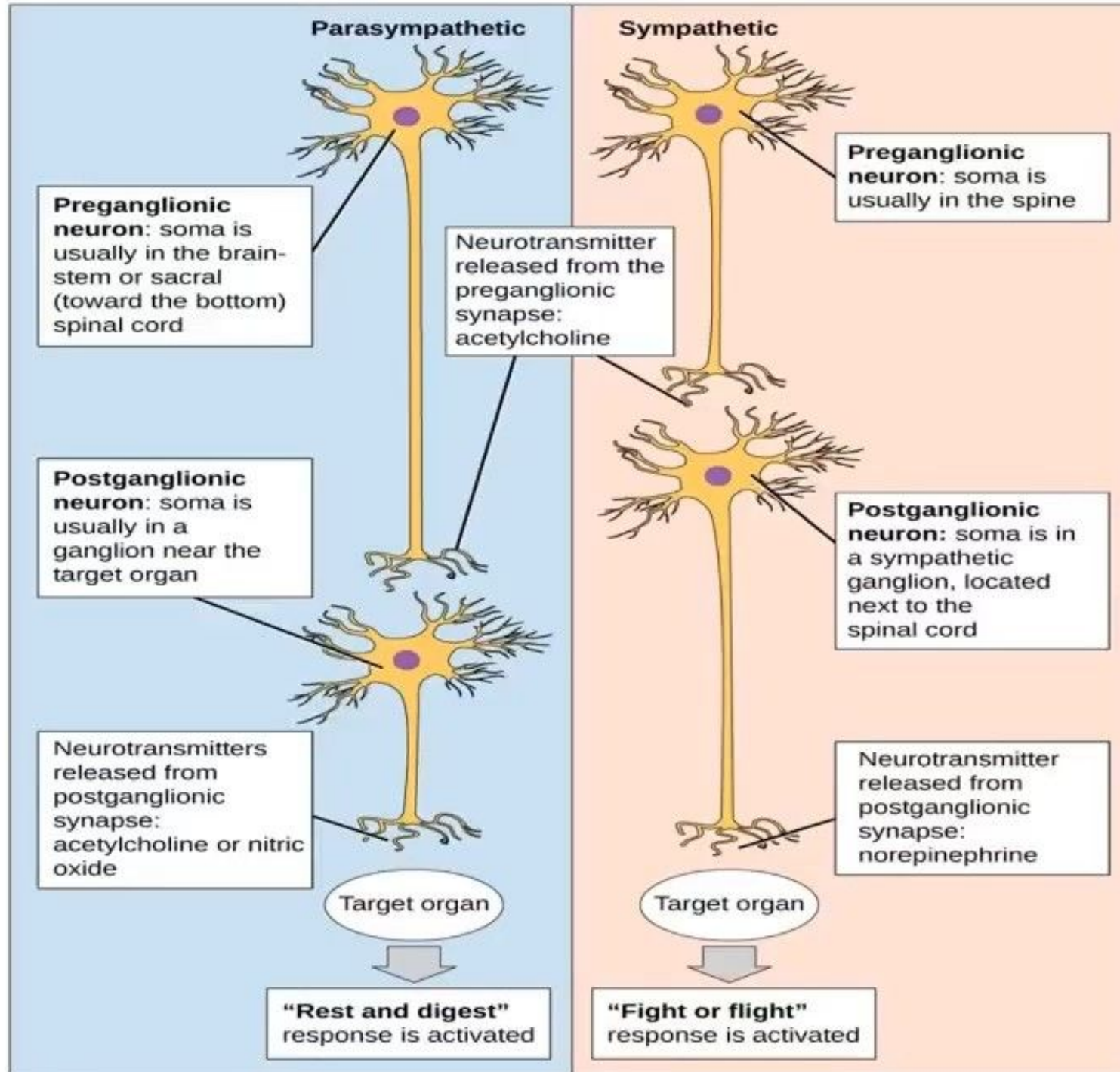
- The three major organs are:
 - Central nervous system
 - The **brain**
 - The **spinal cord**
 - Peripheral nervous system
 - The **nerves**



Copyright © 2007 Pearson Education, Inc., publishing as Benjamin Cummings

Nervous System

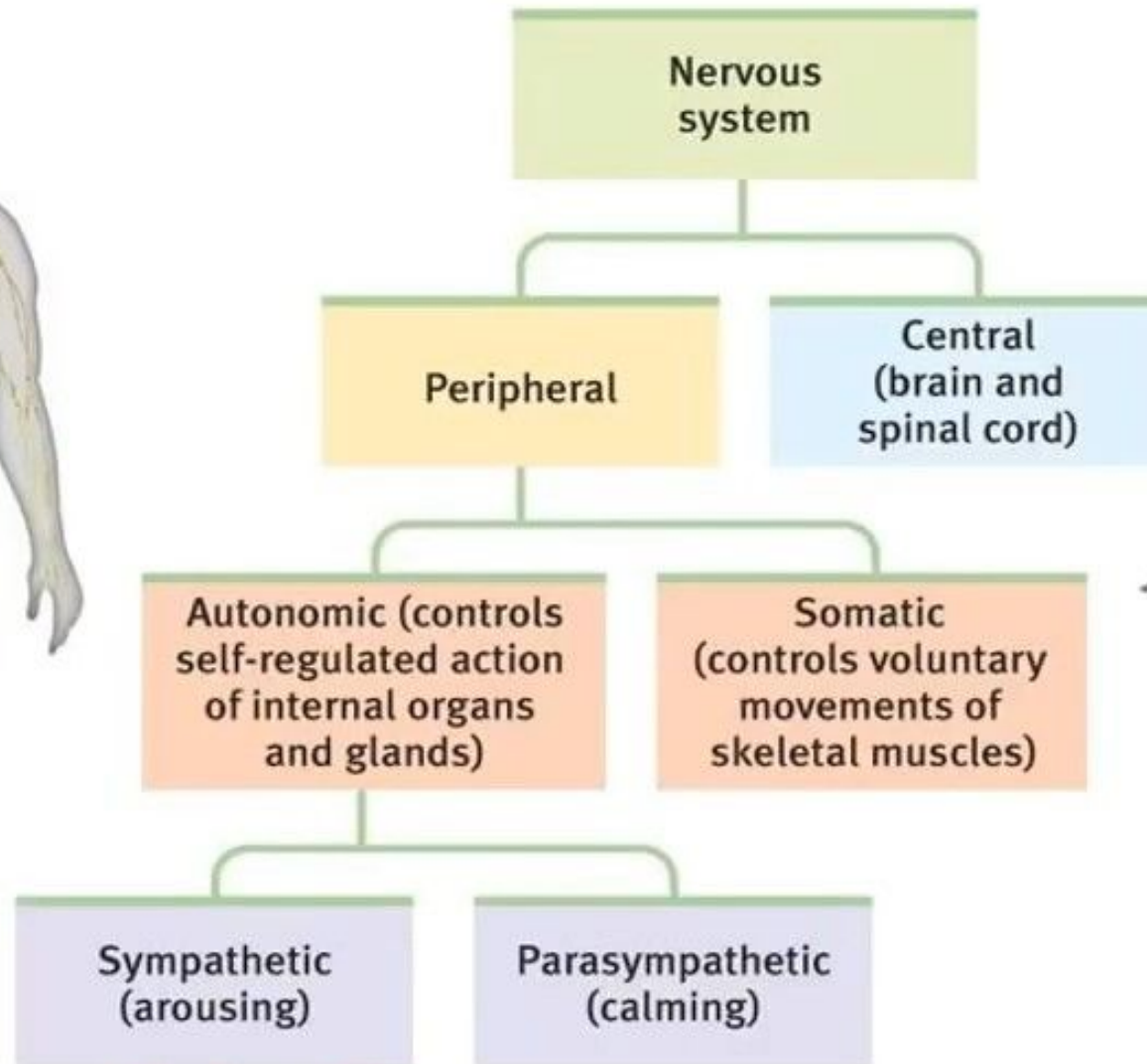
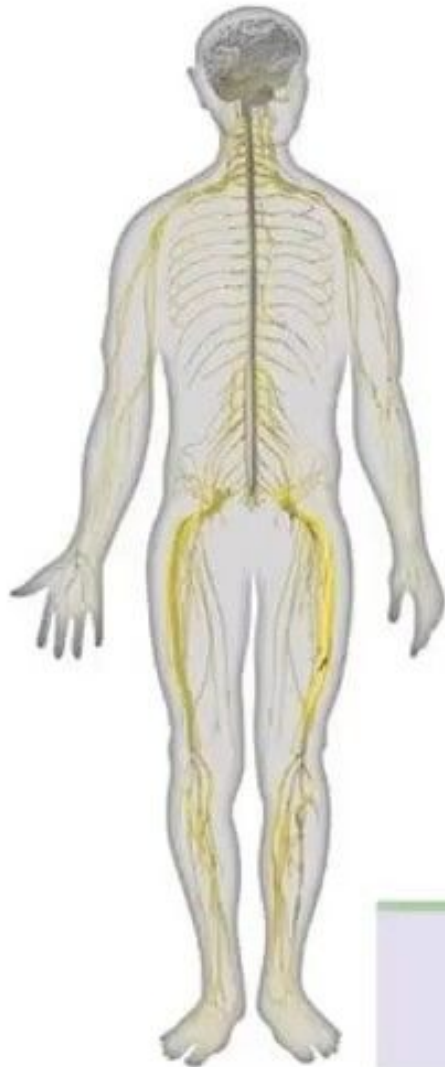
Autonomic Nervous System



Nervous System

Peripheral nervous system

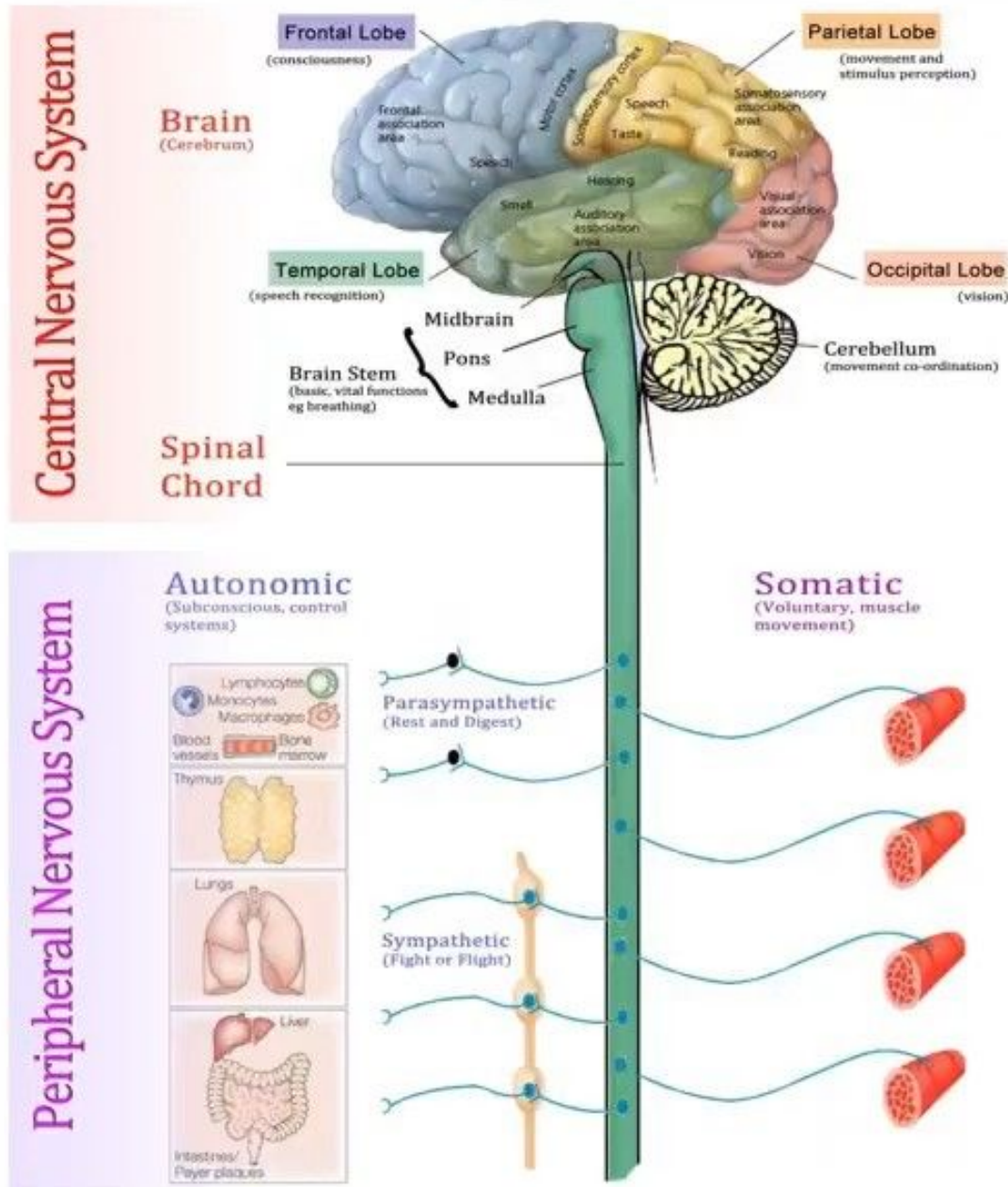
Central nervous system



Referred to as "fight or flight"

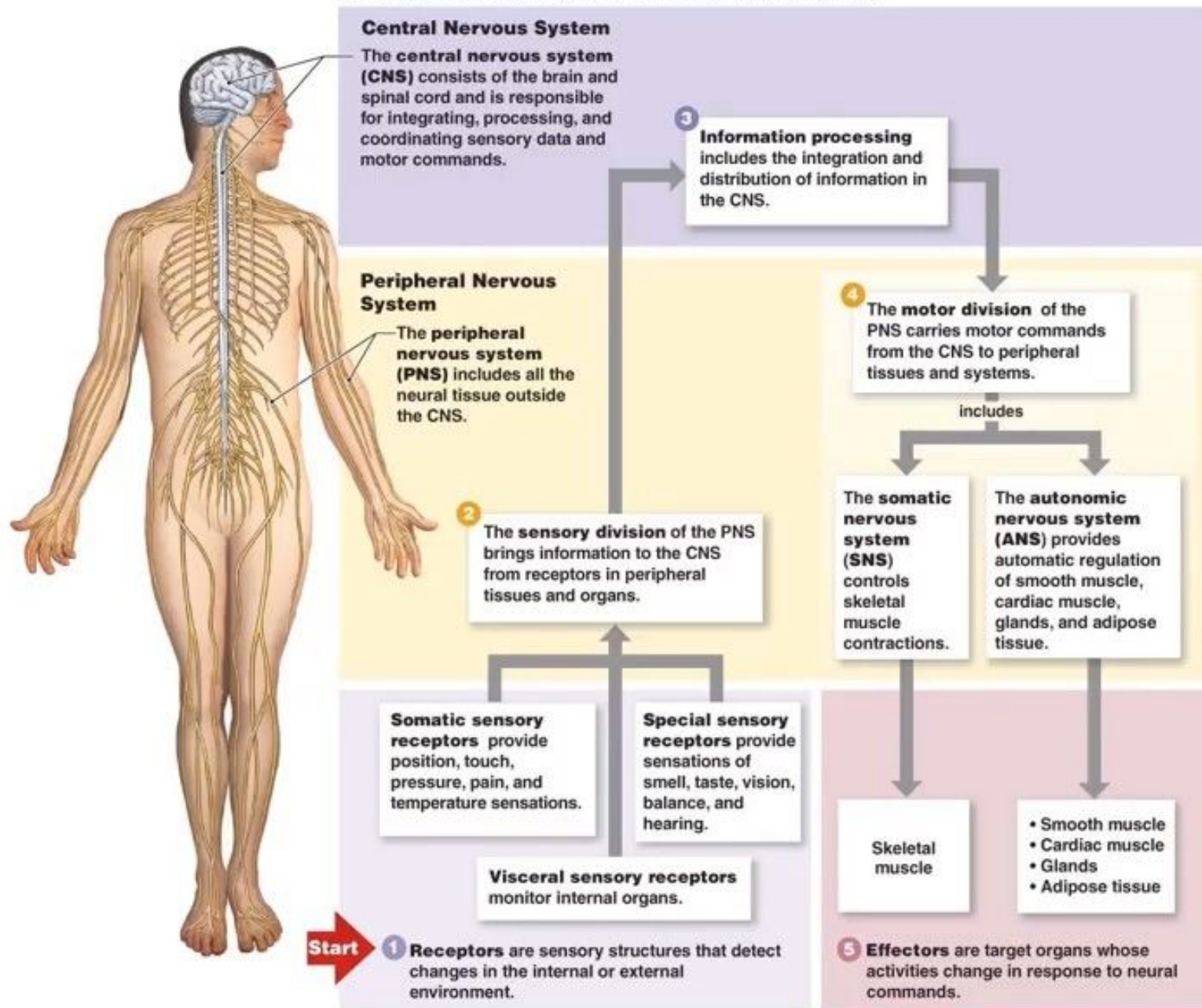
Nervous System

The Nervous System



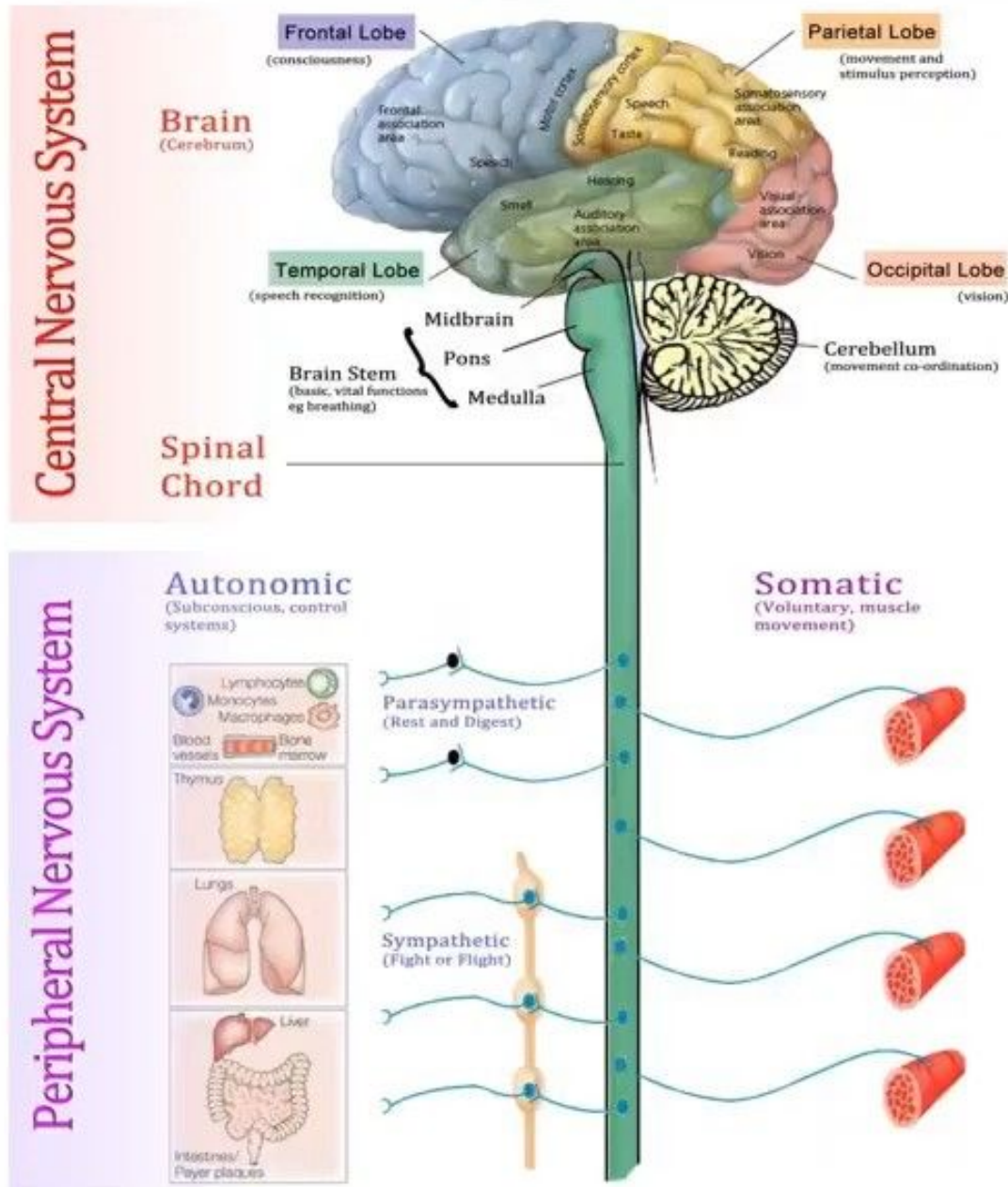
Nervous System

The major components and functions of the nervous system



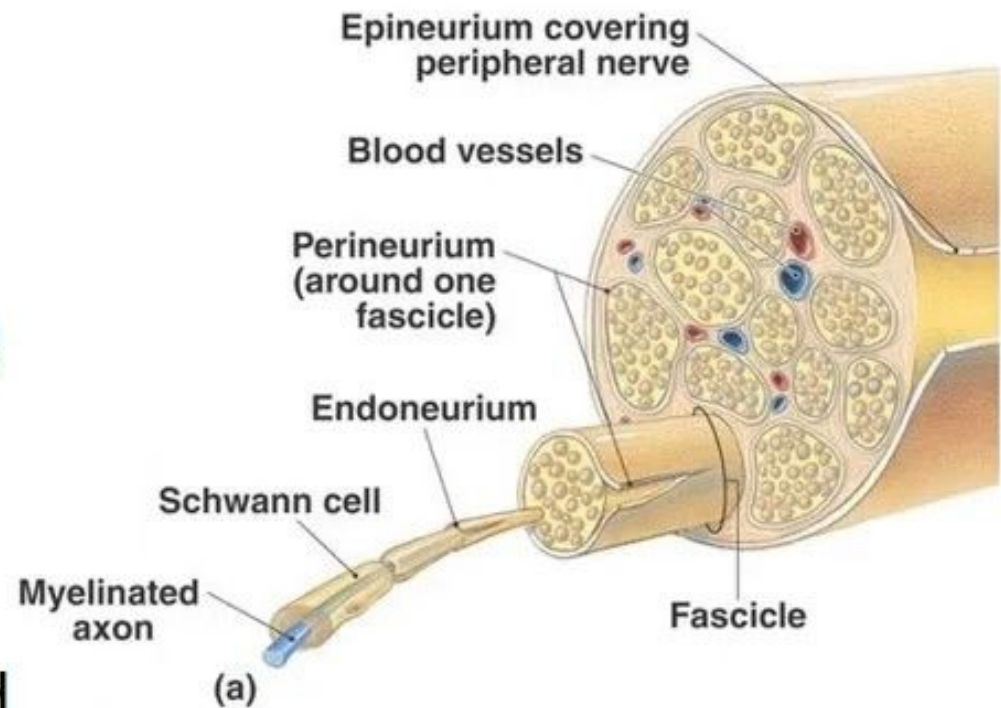
Nervous System

The Nervous System



Nerves

- A **nerve** is the primary structure of the peripheral nervous system (PNS) that encloses the axons of peripheral neurons.
- The axons are bundled together into groups called **fascicles**, and each fascicle is wrapped in a layer of connective tissue called the **perineurium**



Nerve Fiber:

A nerve fiber consists of an axon. The axon is covered by axolemma and contains cytoplasm called axoplasm. It arises from a conical extension of the cell body called axon hillock.

Types of nerve fibers:

Unmyelinated nerve fibers: have no myelin sheath. It is subdivided into;

1. Unmyelinated fibers without sheath of Schwann cells (neurolemma) as in gray matter (naked)
2. Unmyelinated nerve fibers with sheath of Schwann cells as in sympathetic post ganglionic fibers.

Myelinated nerve fibers: have myelin sheath. It is subdivided into;

1. Myelinated nerve fibers without sheath of Schwann cells as in white matter .
2. Myelinated nerve fibers with sheath of Schwann cells as in peripheral nerve fibers .

NOTE:

Myelin is a large lipoprotein complex, composed mainly of lipid bilayers and membrane proteins.

Myelin is an insulating layer, or sheath that forms around nerves, including those in the brain and spinal cord.

This myelin sheath allows electrical impulses to transmit quickly and efficiently along the nerve cells. If myelin is damaged, these impulses slow down. This can cause diseases such as multiple

Schwann cells

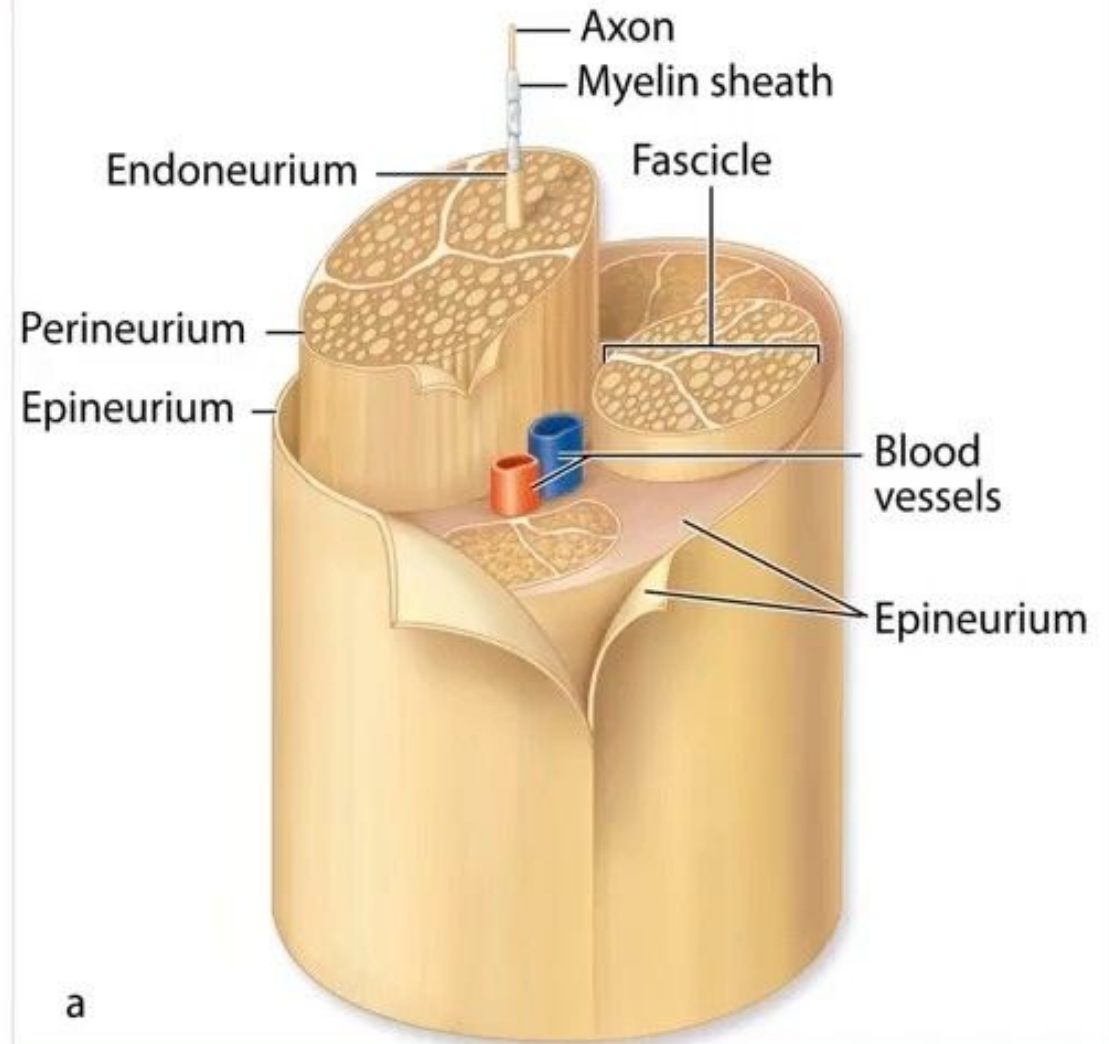
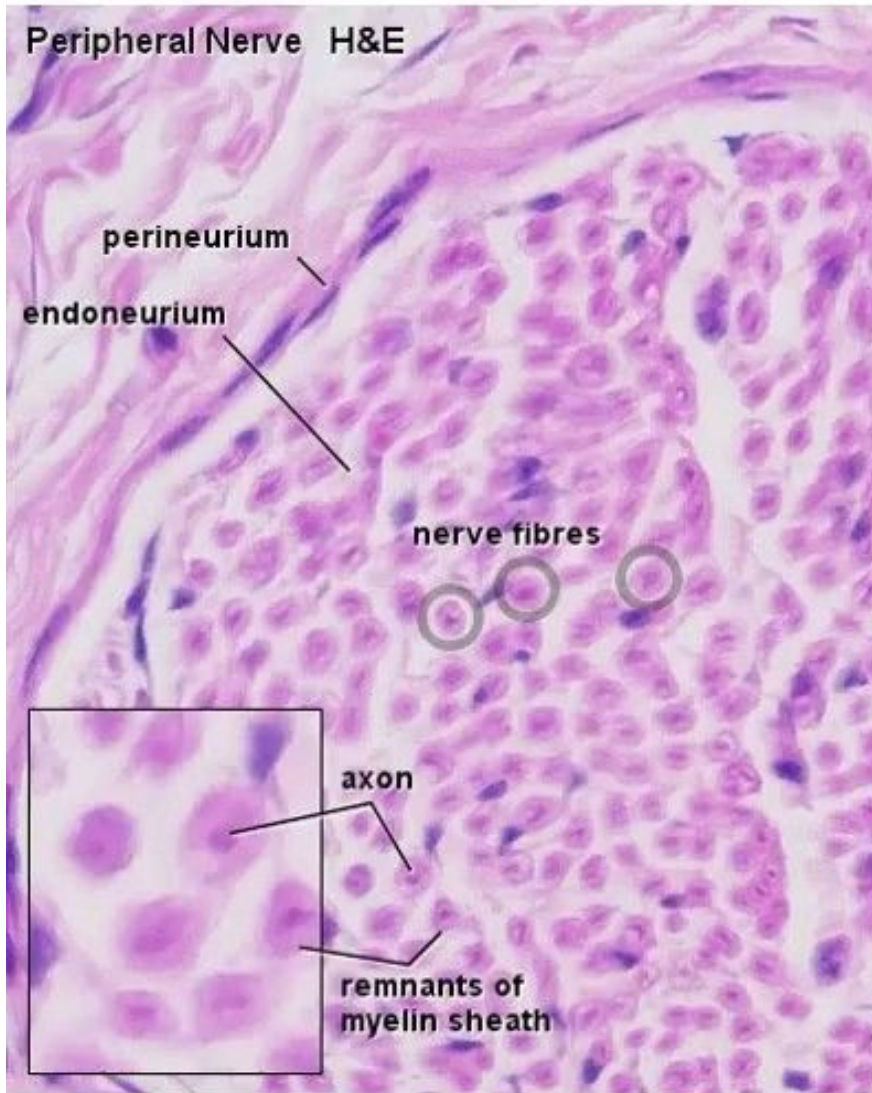
- ◉ Schwann cells (named for 19th century German histologist Theodor Schwann), are sometimes called **neurolemmocytes**.
- ◉ They are found only in the PNS and differentiate from precursors in the neural crest.
- ◉ Schwann cells are important for myelination of peripheral axons, like the oligodendrocytes of the CNS.
- ◉ **One Schwann cell forms myelin around a segment of one axon.**

Ganglia

They are collections of nerve cells outside the central nervous system.

They are of 2 types sensory (spinal) and autonomic (sympathetic and parasympathetic).

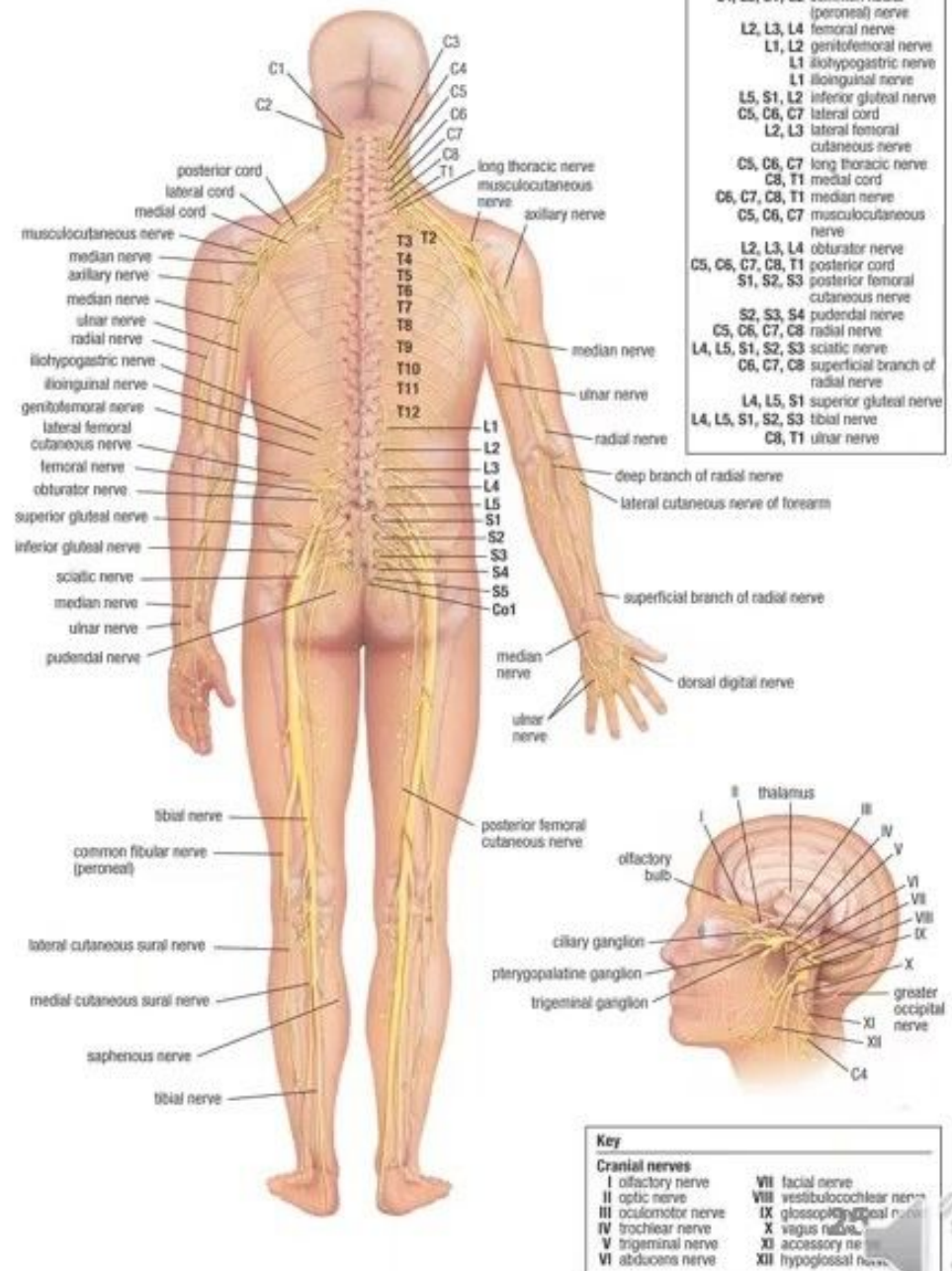
Nerves



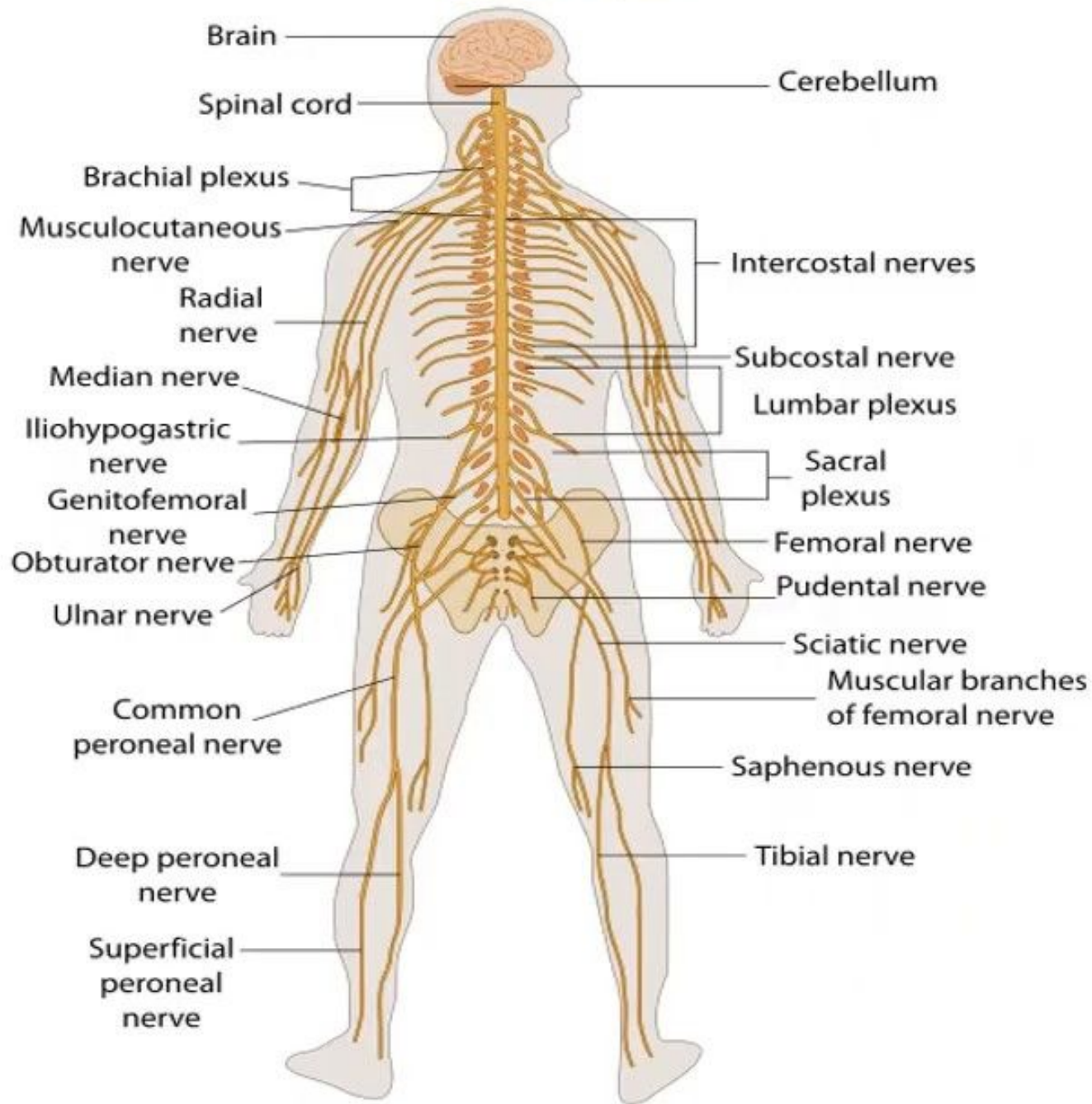
Nerves

SPINAL AND CRANIAL NERVES

- There are:
 - 12 pairs of cranial nerves and their branches
 - 31 pairs of spinal nerves and their branches



Nerves



Brain

- The brain has three major parts:

- **Forebrain** or **Prosencephalon**

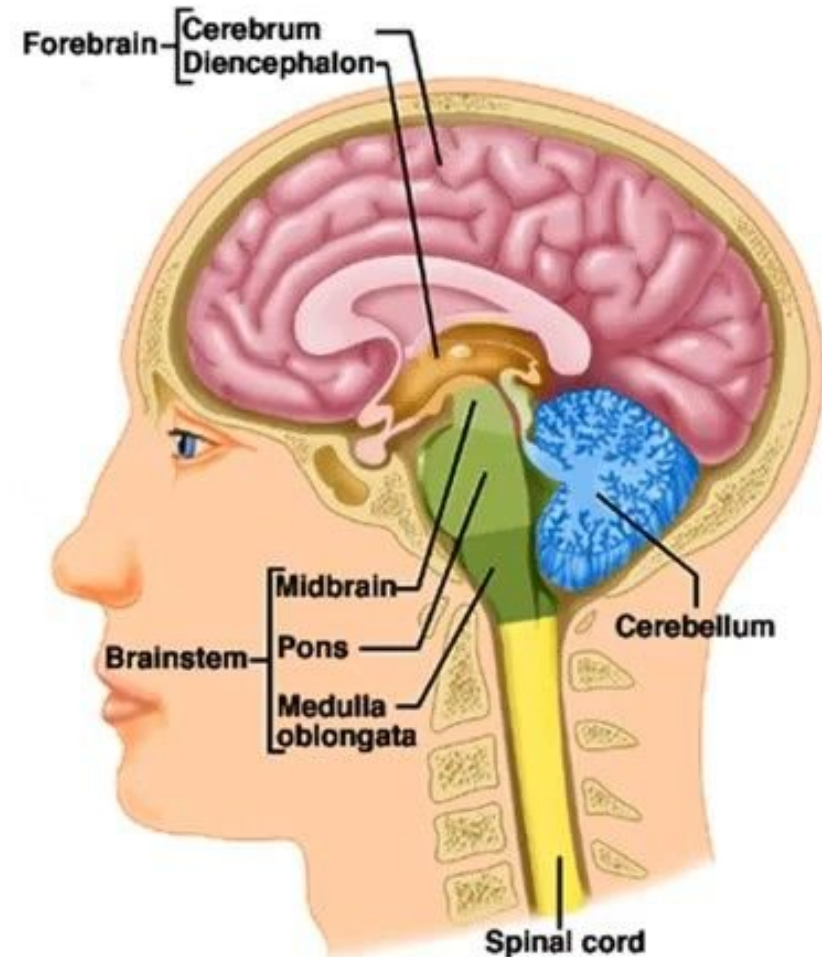
- Cerebrum or telencephalon
- Diencephalon

- **Cerebellum**

- **Brainstem***

- Midbrain or mesencephalon
- Pons
- Medulla oblongata

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



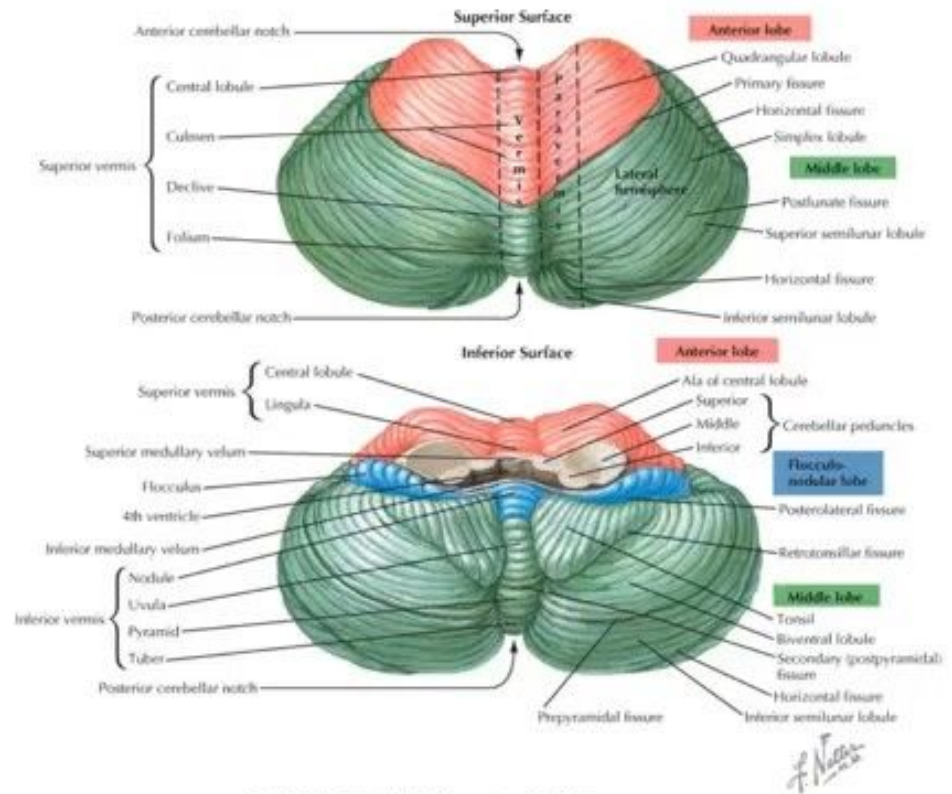
Brain

■ Cerebellum

- The cerebellum is divided into hemispheres with three lobes in each.
 - The section between hemispheres is called the vermis.

■ Functions

- Coordinates somatic motor function
- Fine muscle control (adjusts output of somatic motor centers resulting in smooth operation)
- Balance and coordination



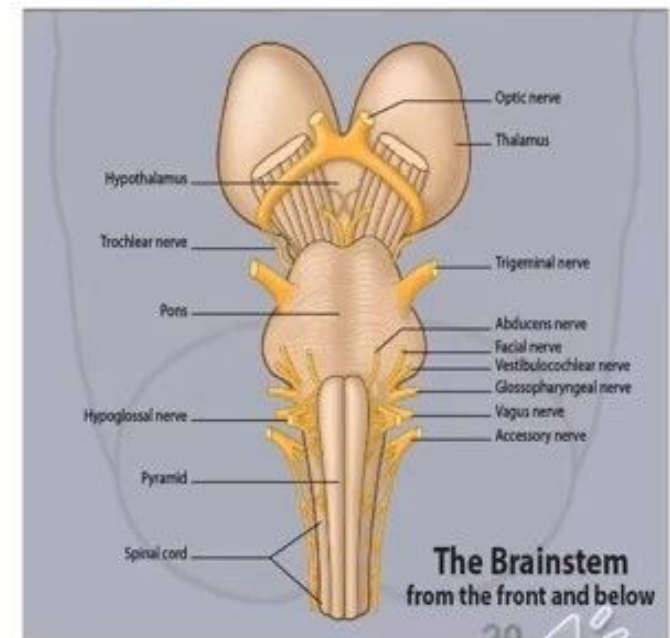
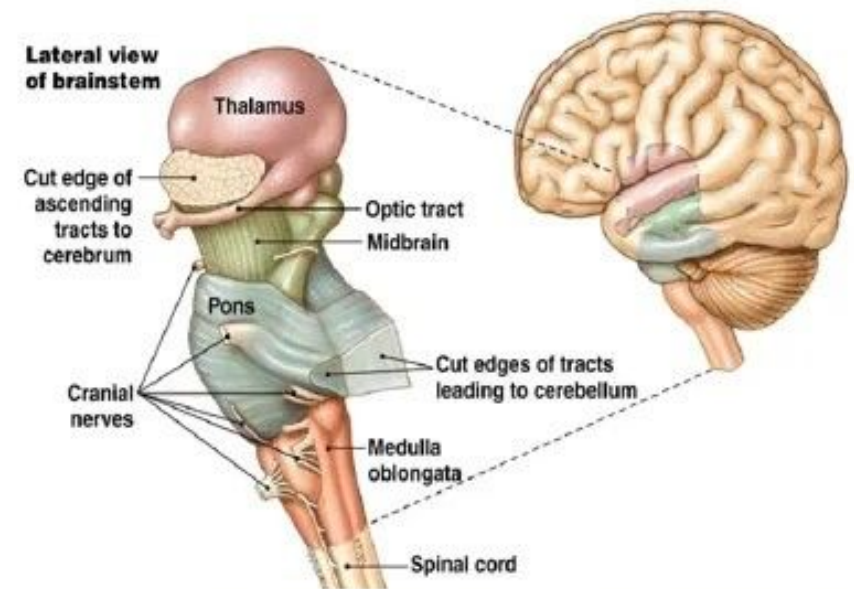
Felten & Shetty: Netter's Atlas of Neuroscience, 2nd Edition.
Copyright © 2009 by Saunders, an imprint of Elsevier, Inc. All rights reserved.



Brain

■ Brainstem

- Connects the spinal cord to the brain, and in turn contains 3 parts:
 - Midbrain or mesencephalon
 - Pons
 - Medulla Oblongata
- Functions:
 - Midbrain:
 - Processes visual and auditory data
 - Control of consciousness and awareness
 - Pons
 - Relays information to the thalamus and cerebellum
 - Regulates subconscious somatic and visceral motor centers
 - Medulla oblongata
 - Relays information to the thalamus and brain stem
 - Regulates visceral function
 - Houses the reflex centers e.g. those associated with respiratory (breathing) and cardiovascular system (blood pressure, heartbeat), swallowing, digestion, body temperature, sleep
 - Channels the ascending and descending tracts between the spinal cord and brain
 - Contains the nuclei of all the cranial nerves except the first 2



Brain

- **Forebrain**

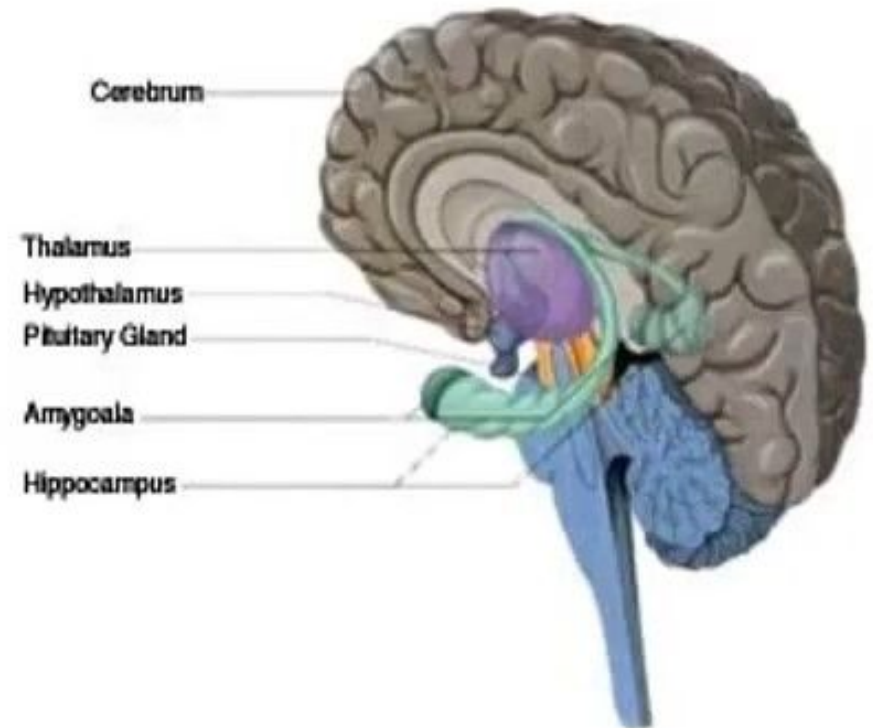
- Functions

- Cerebrum:

- Conscious thought processes
 - Memory storage
 - Conscious regulation of skeletal muscle contractions

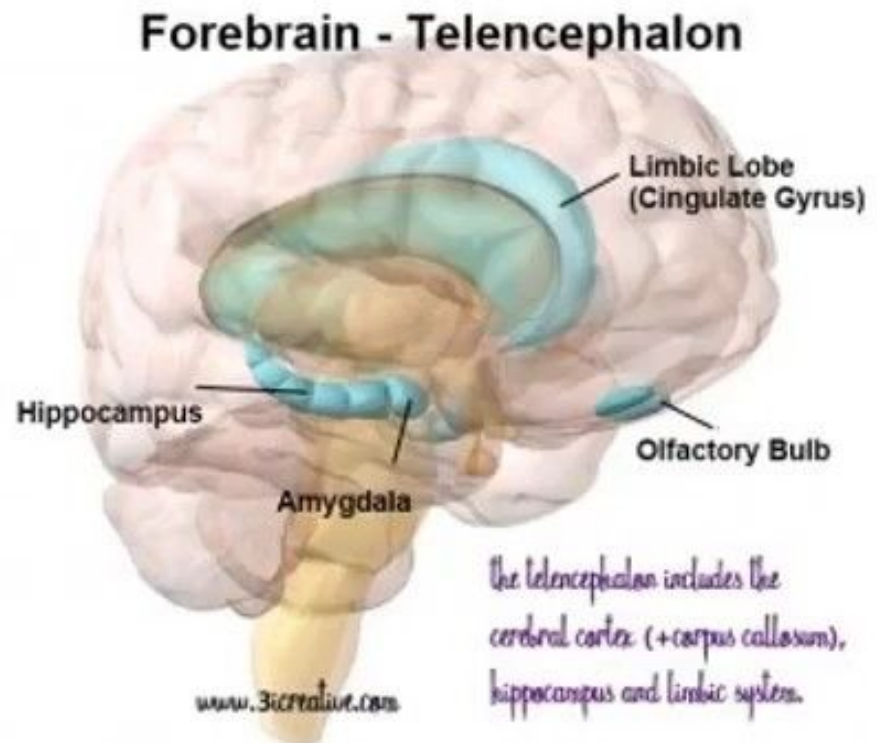
- Diencephalon

- Control of internal organs (viscera)
 - Directing Sense Impulses Throughout the Body
 - Autonomic Function Control
 - Endocrine Function Control
 - Motor Function Control
 - Homeostasis
 - Hearing, Vision, Smell, Taste and Touch Perception



Brain

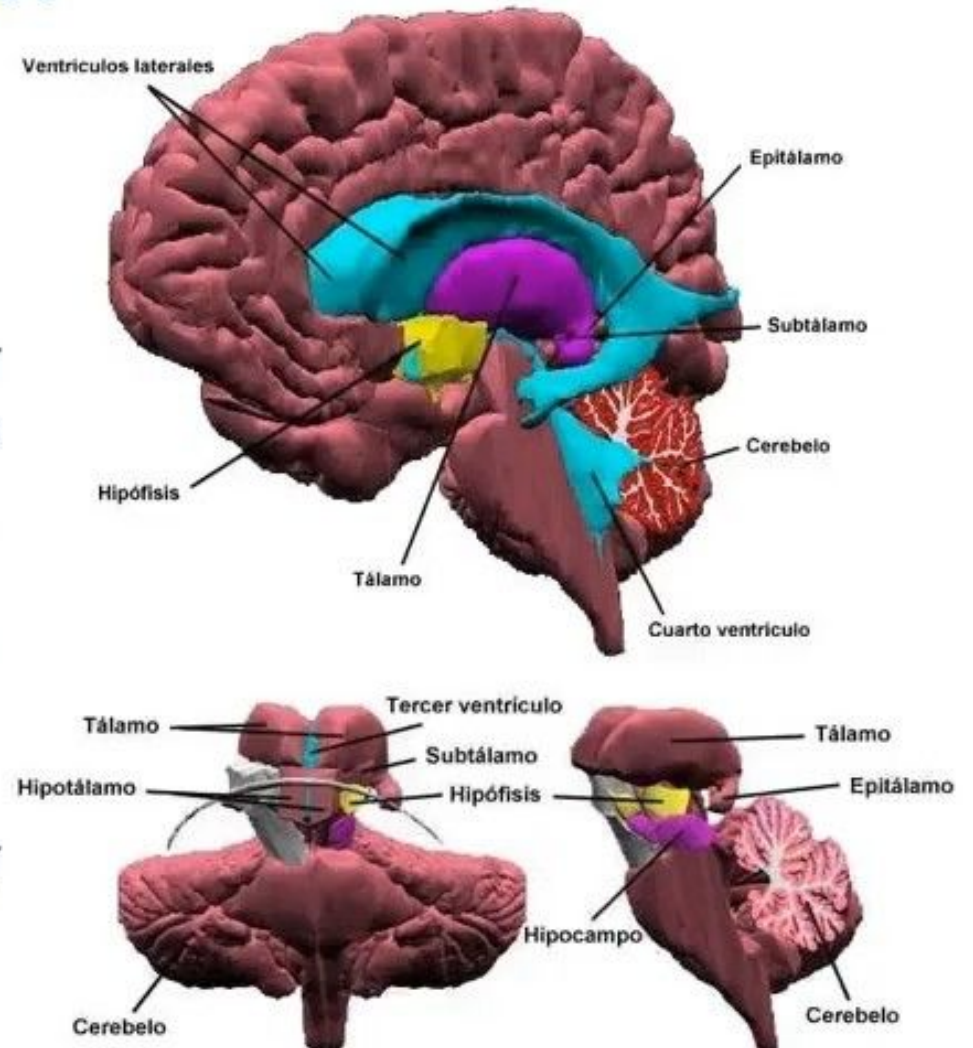
- **Cerebrum** or **telencephalon**
 - In turn it contains:
- **Cerebral Cortex** responsible for information processing, thought and planning, spoken and written language
- **Corpus callosum** responsible for connecting brain hemispheres
- **Hippocampus** responsible for short and long term memory
 - NOTE: Sometimes you'll see the hippocampus mentioned as part of the limbic system
- **Limbic system** responsible for controlling emotions (fear, anger, rage, etc) and motivation



Brain

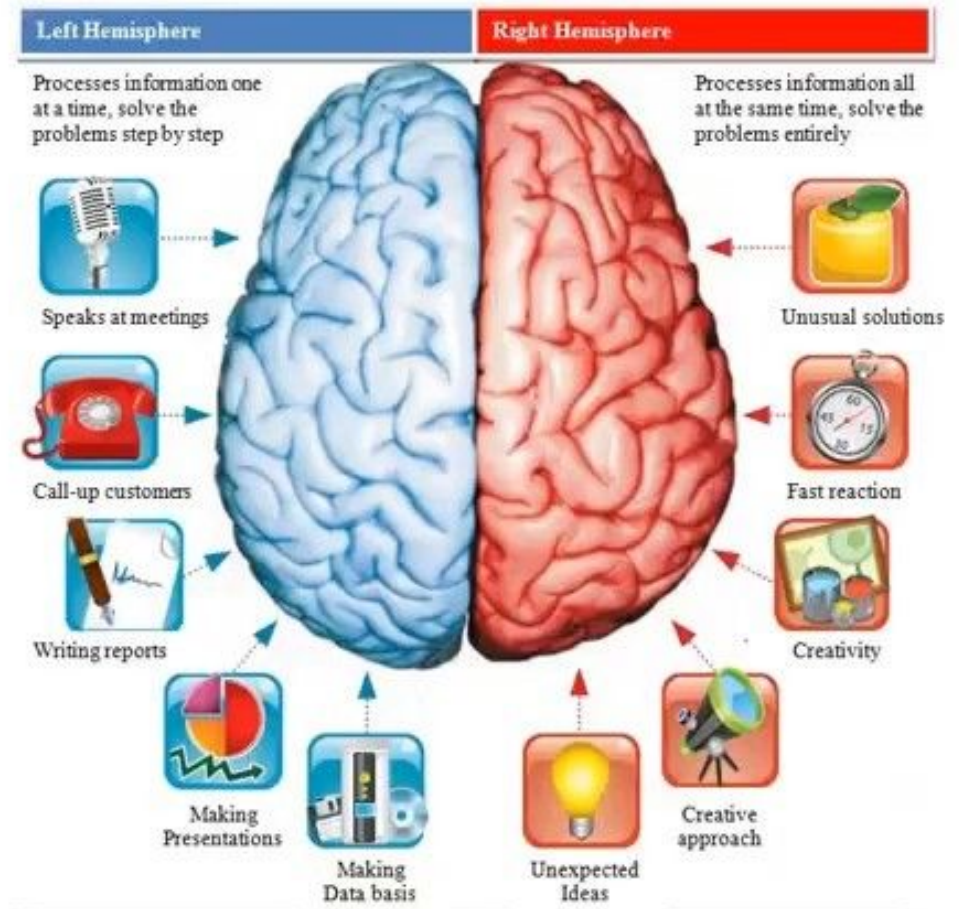
■ Diencephalon

- In turn has 4 divisions
 - **Thalamus**, responsible for traffic of information (it is a repetition station)
 - **Subthalamus**, function is mostly unknown but might be responsible for check of muscular responses
 - **Hypothalamus** responsible for hormone regulation, “flight and fight”, feeding and sex, and body function in general
 - **Epithalamus** (including the **pineal gland**), responsible for melatonin and the circadian rhythm

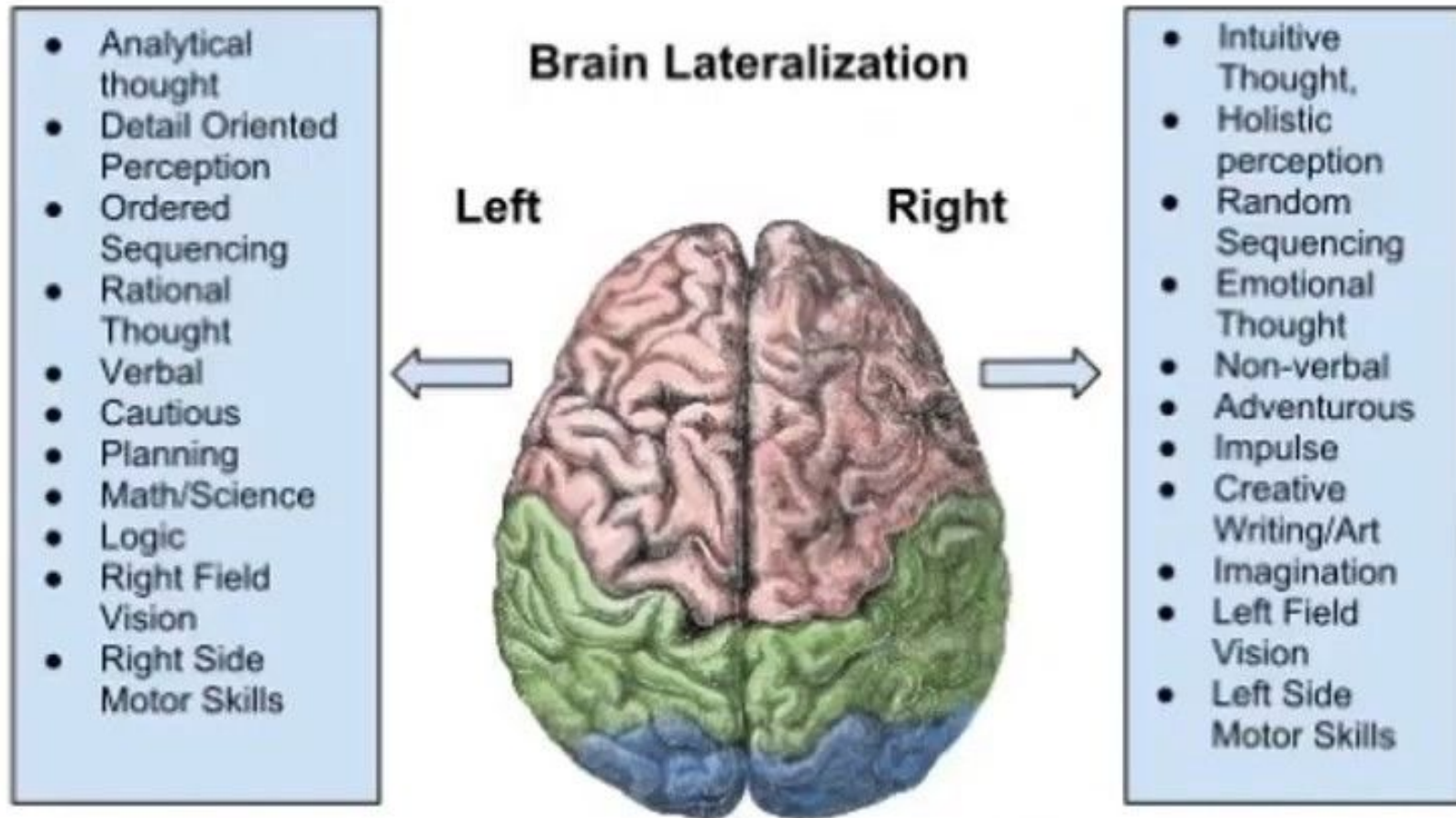


Brain

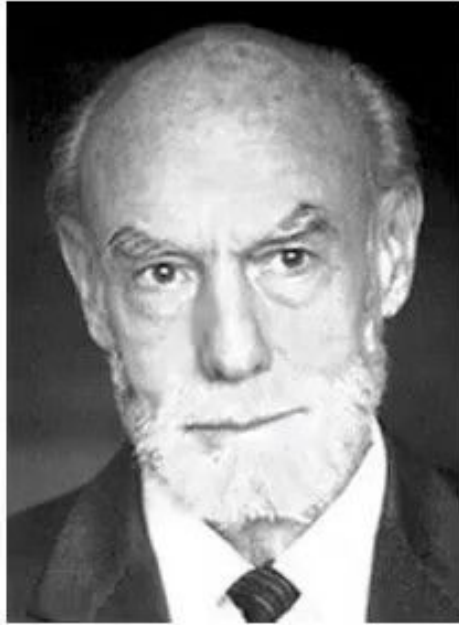
- Brain
 - Divided into 2 hemispheres
 - The **left hemisphere** is dominant with regard to language and and speech, as well as logical processing, writing, and arithmetic
 - the **right hemisphere** concerned with imagination, art, symbols and spatial perception, and your personality in general



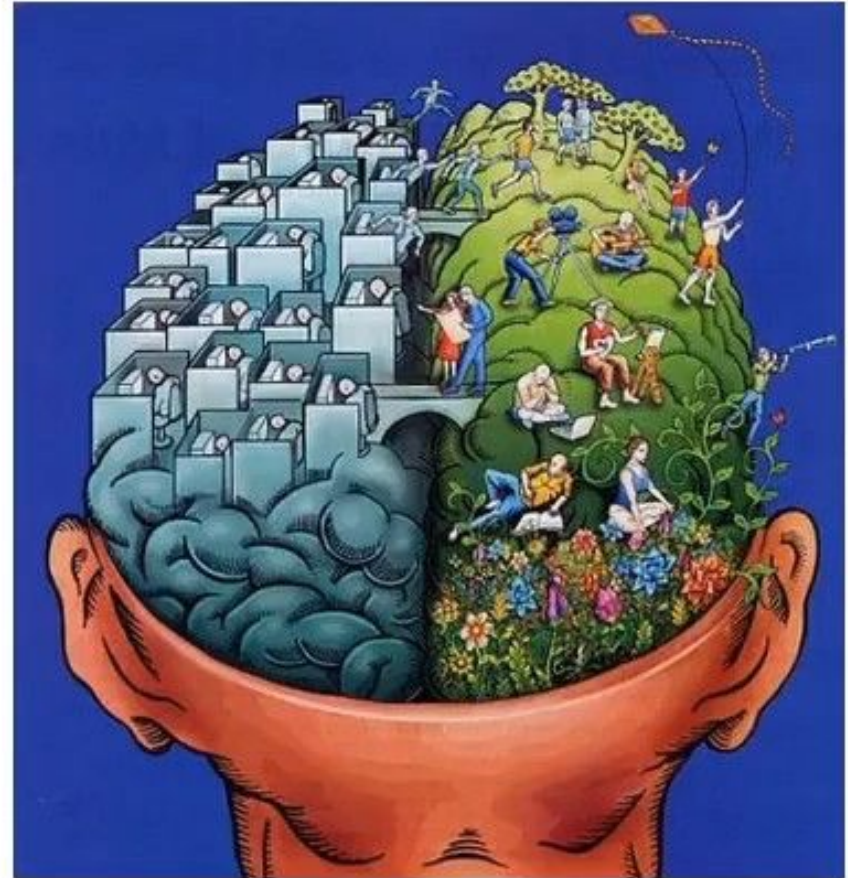
Brain



Brain



- Roger W. Sperry, USA (1913-)
- 1981 Nobel Prize in Physiology or Medicine “for his discoveries concerning the functional specialization of the cerebral hemispheres.”

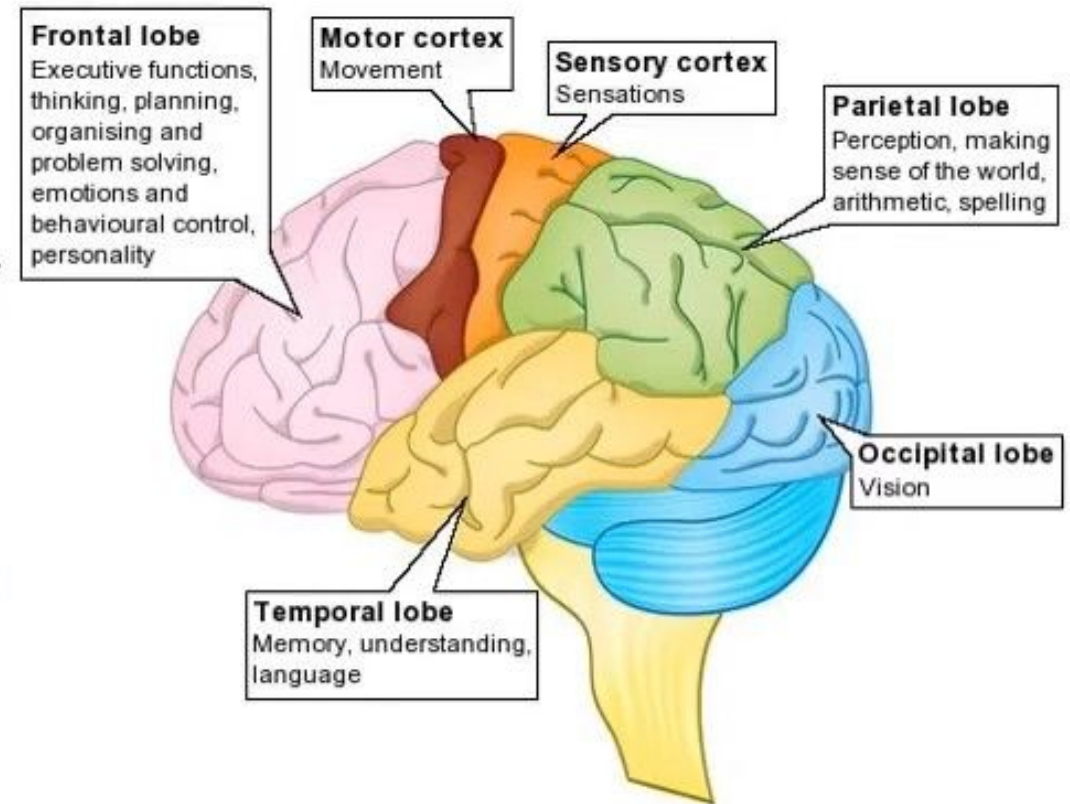


Brain

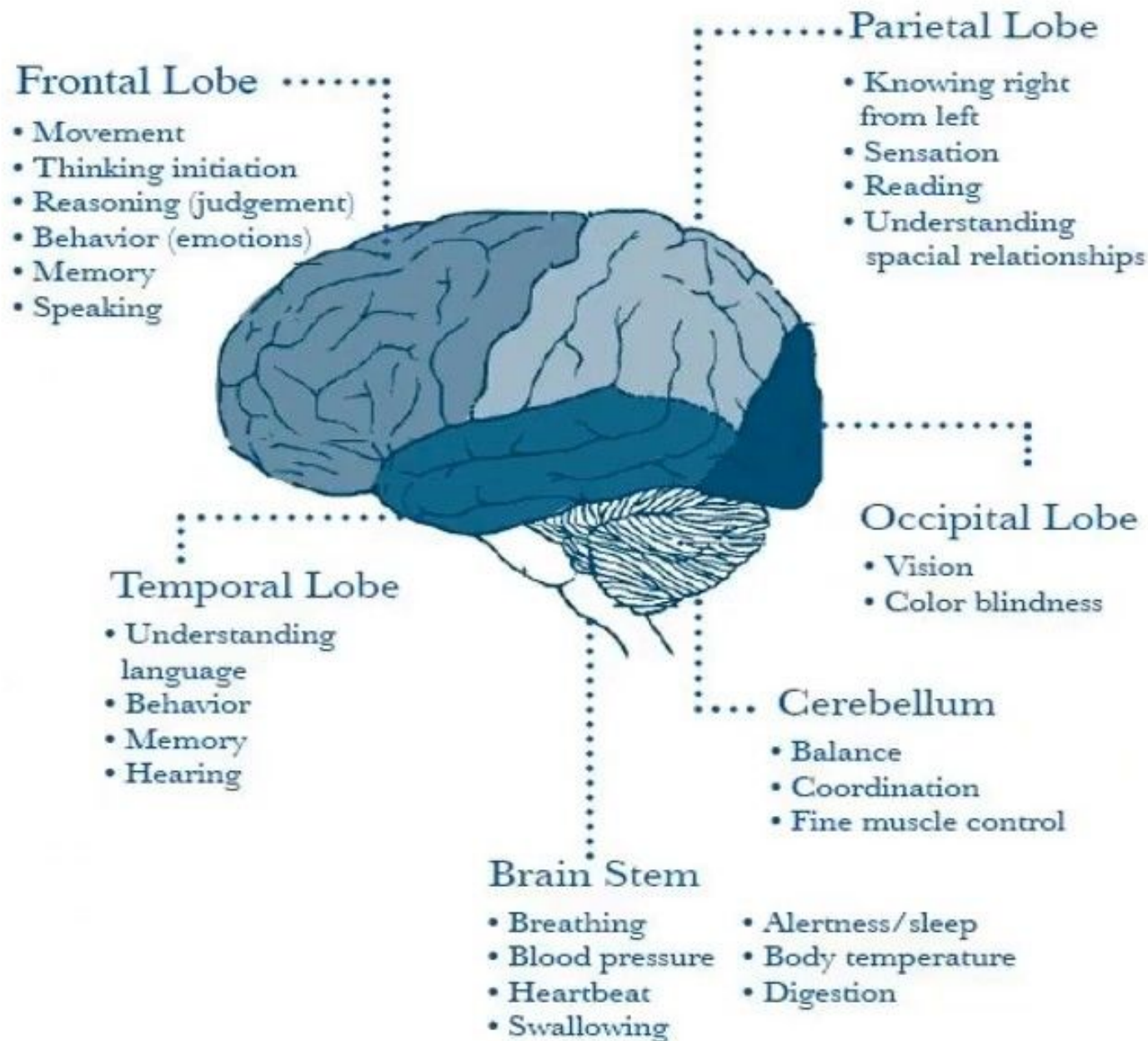
- Brain

- ...and 4 lobes:

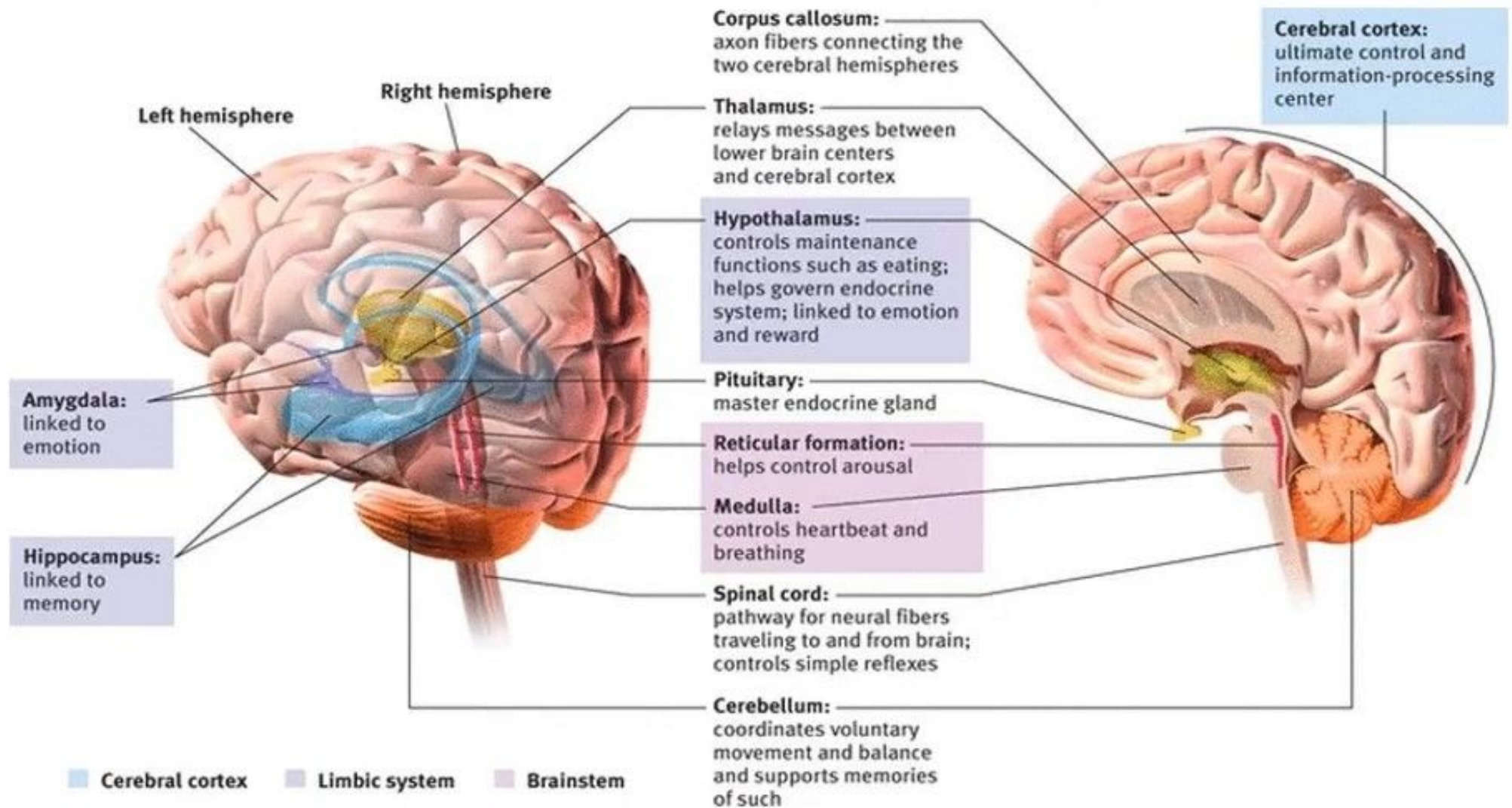
- The **frontal lobe** is associated with executive functions, motivation and inhibition, concentration, judgement and motor performance.
 - NOTE: the motor cortex is part of this lobe
- The **temporal lobe** is associated with the retention of short and long term memories, and processes sensory input including auditory information, language comprehension and naming.
- The **occipital lobe** is the visual processing center of the brain.
- The **parietal lobe** is associated with sensory skills, calculation spelling, body sense and position, object perception.
 - NOTE: the sensory cortex is part of this lobe



Brain



Brain: Other functions



Cortex parcellation

- The cortex is divided into regions or **cortical areas** that facilitate understanding how the brain Works.
- These cortical areas differ from their neighbours in:
 - Microstructural cyto**architecture**
 - Functional specialization or segregational **function**
 - Functional integration or **connectivity**
 - Intra-área **topographic** organization
- The resulting division of the cortex in areas is referred to as **brain parcellation**.

Cortex parcellation

- Parcellation can:
 - Provide a map of where things happen in the brain
 - Enable efficient comparison of results across studies
 - Reduce data complexity for neuroimaging analysis

Cortex parcellation

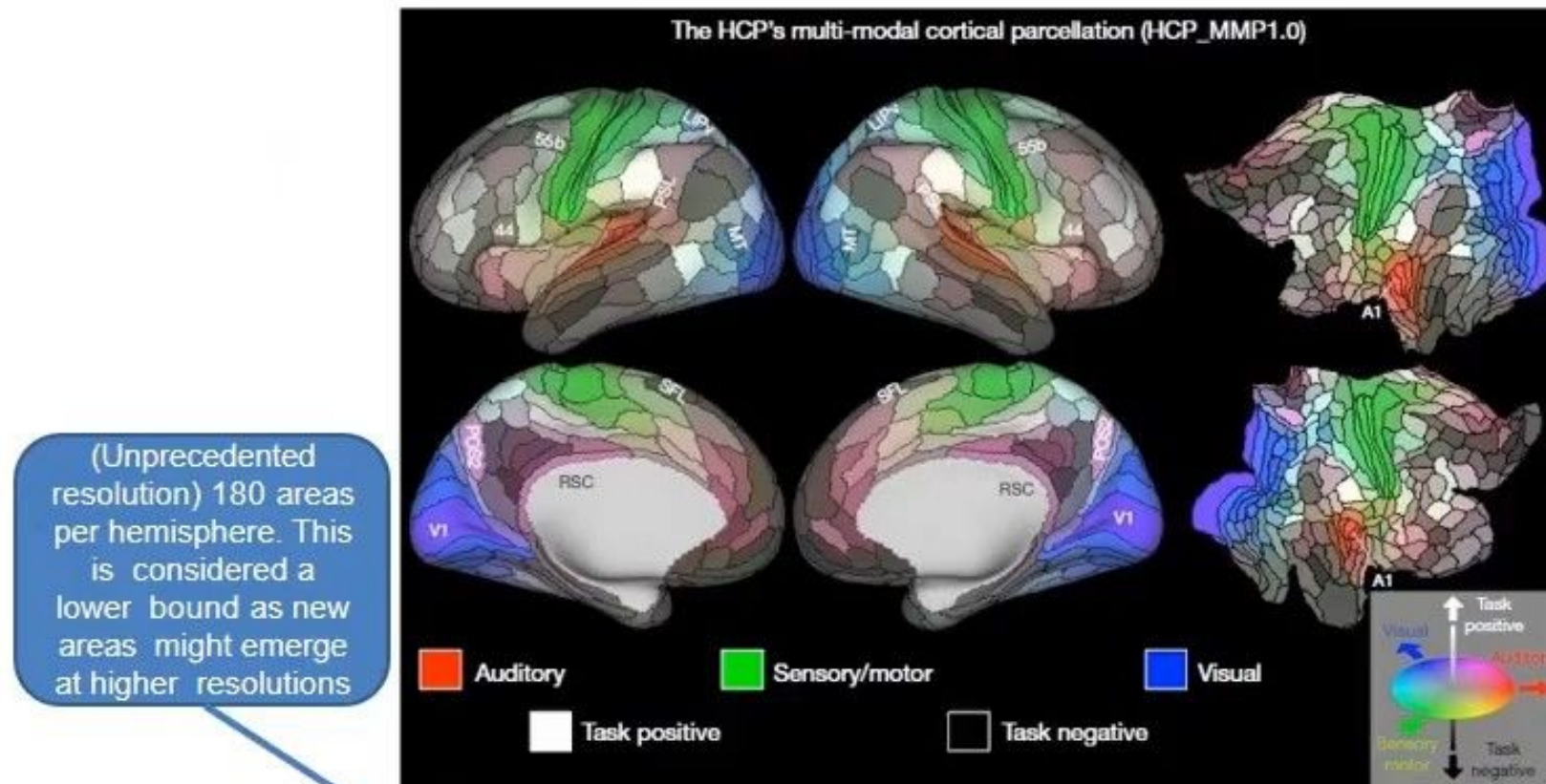


Figure 3 | The HCP's multi-modal parcellation, version 1.0 (HCP_MMP1.0). The 180 areas delineated and identified in both left and right hemispheres are displayed on inflated and flattened cortical surfaces. Black outlines indicate areal borders. Colours indicate the extent to which the areas are associated in the resting state with auditory (red), somatosensory

(green), visual (blue), task positive (towards white), or task negative (towards black) groups of areas (see Supplementary Methods 5.4). The legend on the bottom right illustrates the 3D colour space used in the figure. Data at <http://balsa.wustl.edu/WN56>.

[Glasser MF et al (2016), Nature]

HISTOPHYSIOLOGY (AND BLOOD IRRIGATION)