**Brain Overview  
Dr. Gary Mumaugh – Campbellsville University**

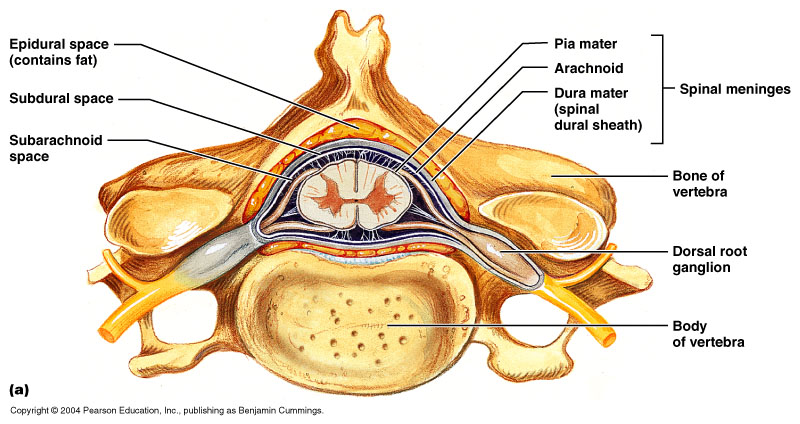
**Coverings of the Brain and Spinal Cord**

* Two protective coverings
  + Outer covering is bone; cranial bones encase the brain and vertebrae encase the spinal cord
  + **Diagram

    Description automatically generated**Inner covering is the meninges; the meninges of the cord continue inside the spinal cavity beyond the end of the spinal cord

**Protection of the Brain**

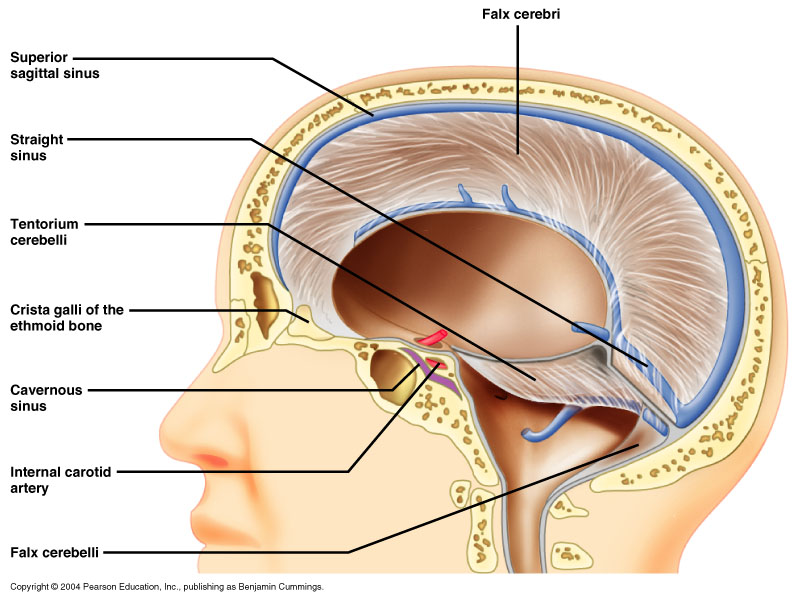
* Scalp - 5 layers
* Skull - Encloses and protects the brain and special senses
* Meningeal Protection - CSF provides cushion for brain and is a shock absorber

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**Protection of the Spinal** Cord - Vertebral Column

* + - Protects spinal cord
    - Articulates with the head, rib, pectoral and pelvic girdles
    - Points of attachment for muscles
    - Avenue for vertebral arteries

**Meninges of Vertebra and Spinal Cord – Dura Mater**

* The outermost layer of the meninges, directly underneath the bones of the skull
* Thick, tough and does not stretch
* ****Dura has two connective tissue sheets:
* Periosteal layer – lines the inner surface of the bones of the cranium.
* Meningeal layer – deep to the periosteal layer inside the cranial cavity. It is the only layer present in the vertebral column.
* Between the two layers are dural venous sinuses which will drain the blood from the brain into the jugular veins.
* In some areas within the skull, the dura mater folds inwards as separates the parts of the brain and anchors it.
  + Falx cerebri separates the two hemispheres and anchors to the crista galli
  + Falx cerebelli separates the two parts of cerebellum
  + Tentorium cerebelli separates the cerebellum from the cerebrum.

**Meninges of Vertebra and Spinal Cord – Arachnoid Membrane**

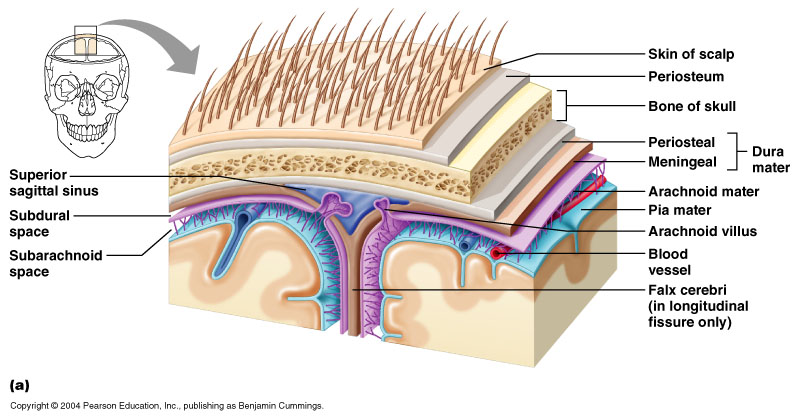
* Delicate, cobweblike layer between the dura mater and pia mater and is avascular
* Underneath the arachnoid is a space known as the sub-arachnoid space.
* It contains cerebral spinal fluid, which acts to cushion the brain.
* Small projections of arachnoid mater into the dura (known as arachnoid granulations) allow CSF to re-enter the circulation via the dural venous sinuses

**Meninges of Vertebra and Spinal Cord – Pia Mater**

* Innermost, transparent layer; adheres to the outer surface of the brain and spinal cord
* It is very thin, and tightly adhered to the surface of the brain and spinal cord. It is the only covering to follow the contours of the brain (the gyri and fissures).
* Like the dura mater, it is highly vascularized, with blood vessels perforating through the membrane to supply the underlying neural tissue.

**Diagram

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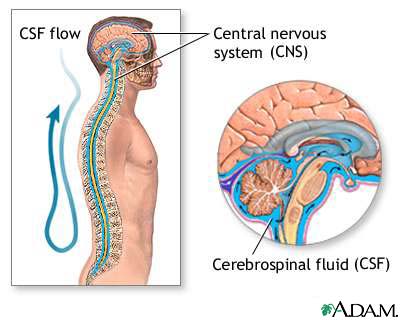
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**Spaces between the meninges**

* Epidural space
  + Between the dura mater and inside the bony covering of the spinal cord; contains a supporting cushion of fat and other connective tissues
* Subdural space
  + Between the dura and arachnoid; contains lubricating serous fluid
* Subarachnoid space
  + Between the arachnoid and pia mater; contains a significant amount of cerebrospinal fluid (CSF)

**Cerebral Spinal Fluid**

* CSF continually flows through and around the CNS
  + driven by its own pressure, beating of ependymal cilia, and pulsations of the brain produced by each heartbeat
* cerebrospinal fluid (CSF) – clear, colorless liquid that fills the ventricles and canals of CNS - small amount of CSF fills the central canal of the spinal cord
* brain produces and absorbs 500 mL/day
  + 100 – 160 mL normally present at one time
* production begins with the filtration of blood plasma through brain capillaries
* Functions of CSF
  + buoyancy
    - allows brain to attain considerable size without being impaired by its own weight
    - if it rested heavily on floor of cranium, the pressure would kill the nervous tissue
  + protection
    - protects the brain from striking the cranium when the head is jolted
    - shaken child syndrome and concussions do occur from severe jolting
  + chemical stability
    - flow of CSF rinses away metabolic wastes from nervous tissue and homeostatically regulates its chemical environment
  + nutrition to the cord

**Diagram

Description automatically generated**

**Hydrocephalus**

* Excess fluid within the cranial vault, subarachnoid space, or both
* 3 mechanisms for hydrocephalus
  + Over secretion of CSF: rare
  + Impaired absorption of CSF: many ways, anything that raises venous pressure
  + Obstruction of CSF pathways: due to tumor of fibrosis

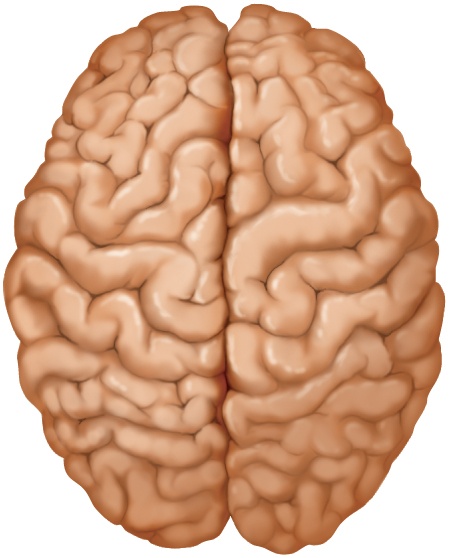
**Brain Directional Terms and Landmarks**

* rostral - toward the forehead
* caudal - toward the spinal cord
* brain weighs about 1600 g (3.5 lb) in men, and 1450 g in women
* three major portions of the brain - cerebrum, cerebellum, brainstem

Diagram

Description automatically generated

**Brain Functions**

* Interprets sensations
* ****Determines perception
* Stores memory
* Reasoning
* Makes decisions
* Coordinates muscular movements
* Regulates visceral activities
* Determines personalities

**Cerebrum**

* 80-85% of brain volume
* longitudinal fissure – deep groove that separates cerebral hemispheres
* gyri - thick folds
* sulci - shallow grooves
* corpus callosum – thick nerve bundle at bottom of longitudinal fissure that connects hemispheres
* Two cerebral hemispheres divided by longitudinal fissure
  + connected by white fibrous tract the corpus callosum
  + gyri and sulci – increases amount of cortex in the cranial cavity
  + gyri increases surface area for information processing capability
  + some sulci divide each hemisphere into lobes named for the cranial bones that overly them

**General Functions of the Cerebrum**

* Interpreting impulses
* Initiating voluntary movements
* Storing information as memory
* Retrieving stored information
* Reasoning
* Seat of intelligence and personality

**Functions of Cerebrum - Lobes**

* frontal lobe
  + voluntary motor functions
  + motivation, foresight, planning, memory, mood, emotion, social judgment, and aggression
* parietal lobe
  + receives and integrates general sensory information, taste and some visual processing
* occipital lobe
  + primary visual center of brain
* temporal lobe
  + areas for hearing, smell, learning, memory, and some aspects of vision and emotion
* insula (hidden by other regions)
  + **Diagram

    Description automatically generated**understanding spoken language, taste and sensory information from visceral receptors

**Brain – Cerebral Cortex**

* Sensory functions of the cortex
  + Somatic senses: sensations of touch, pressure, temperature, proprioception, and similar perceptions that require complex sensory organs
  + Cortex contains a somatic sensory map of the body
  + Information sent to primary sensory areas is relayed to sensory association areas and other parts of the brain
  + The sensory information is compared and evaluated, and the cortex integrates separate bits of information into whole perceptions
* Motor functions of the cortex
  + For normal movements to occur, many parts of the nervous system must function
  + Is the region of the cerebral cortex involved in the planning, control, and execution of voluntary movements.
  + Classically, the motor cortex is an area of the frontal lobe located in the posterior precentral gyrus immediately anterior to the central sulcus.

Diagram

Description automatically generated

**Cerebral Lateralization**

* cerebral lateralization – the difference in the structure and function of the cerebral hemispheres
* left hemisphere - *categorical hemisphere*
  + specialized for spoken and written language
  + sequential and analytical reasoning (math and science)
* right hemisphere - *representational hemisphere*
  + perceives information in a more integrated holistic way
  + musical and artistic skill
  + comparison of sights, sounds, smells, and taste
* lateralization develops with age
  + males exhibit more lateralization than females and suffer more functional loss when one hemisphere is damaged

|  |  |
| --- | --- |
| **Male Brain** | **Female Brain** |
| Better at single tasks | Better at multitasking |
| Shorter attention span | Better attention span |
| Better at spatial processing and sensorimotor speed | Better with word memory and verbal abilities |
| Better memory of things | Better memory of faces |
| When getting lost, tends to use N,S,E, W | When getting lost, tends to use landmarks |

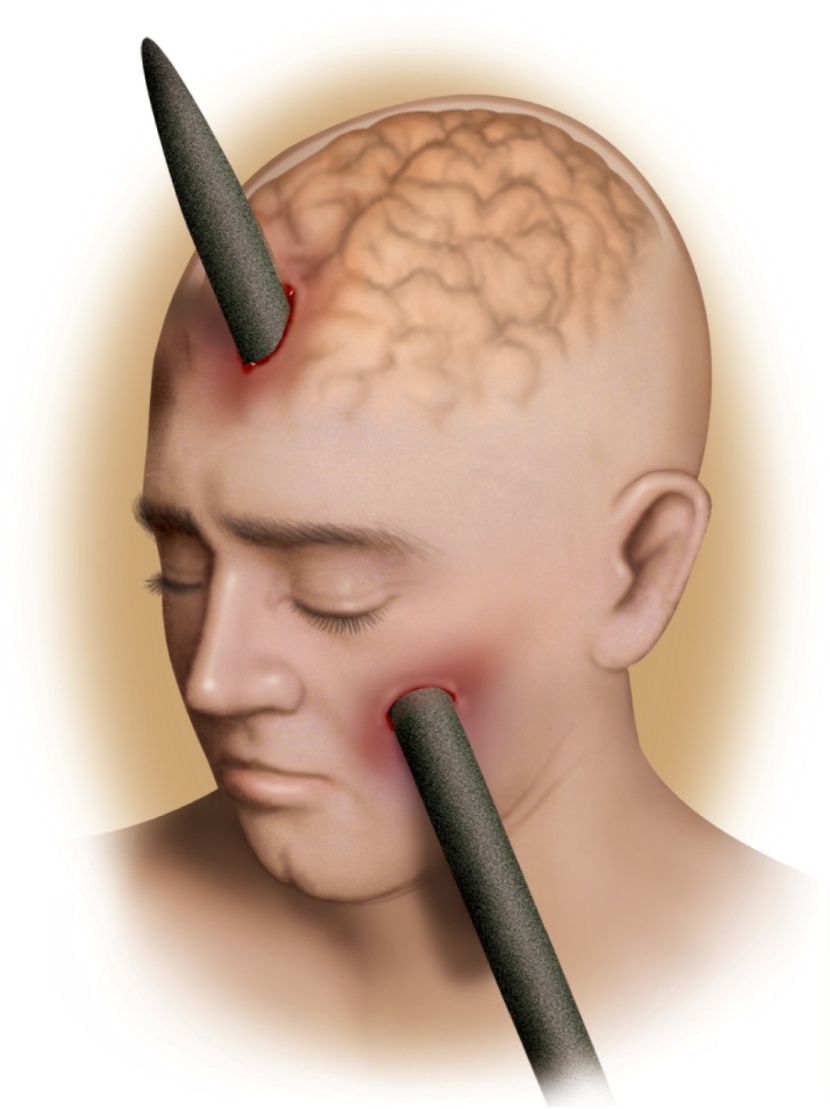
**Consciousness**

* State of awareness of one’s self, one’s environment, and other human beings
* Depends on excitation of cortical neurons by impulses conducted to them by the reticular activating system
* Two current concepts about the reticular activating system
  + Functions as arousal system for the cerebral cortex
  + Functioning is crucial for maintaining consciousness

**Cognition**

* cognition – the range of mental processes by which we acquire and use knowledge
  + such as sensory perception, thought, reasoning, judgment, memory, imagination, and intuition
* association areas of cerebral cortex constitutes about 75% of all brain tissue
* studies of patients with brain lesions, cancer, stroke, and trauma yield information on cognition
  + parietal lobe association area – perceiving stimuli
  + temporal lobe association area – identifying stimuli
    - agnosia – inability to recognize, identify, and name familiar objects
    - prosopagnosia – person cannot remember familiar faces

**Memory**

* information management requires
  + learning – acquiring new information
  + memory – information storage and retrieval
  + forgetting – eliminating trivial information; as important as remembering
* amnesia – defects in declarative memory – inability to describe past events
  + procedural memory – ability to tie your shoes
  + anterograde amnesia – unable to store new information
  + retrograde amnesia – cannot recall things they knew before the injury
* hippocampus – important memory-forming center
  + does not store memories
  + memory consolidation – the process of “teaching the cerebral cortex” until a long-term memory is established
  + long-term memories are stored in various areas of the cerebral cortex
* cerebellum – helps learn motor skills
* amygdala - emotional memory

**Lobotomy of Phineas Gage**

* severe injury with metal rod
* injury to the ventromedial region of both frontal lobes
* extreme personality change
  + fitful, irreverent, grossly profane, opposite of previous personality
* prefrontal cortex functions
  + planning, moral judgment, and emotional control

**Emotion**

* prefrontal cortex - seat of judgment, intent, and control over expression of emotions
* feelings come from hypothalamus and amygdala
* amygdala receives input from sensory systems
  + role in food intake, sexual behavior, and drawing attention to stimuli
  + **Diagram

    Description automatically generated**one output goes to hypothalamus influencing somatic and visceral motor systems
  + other output to prefrontal cortex important in controlling expression of emotions
* behavior shaped by learned associations between stimuli, our responses to them, and the reward or punishment that results

**Cerebellum**

* marked by gyri, sulci, and fissures
* about 10% of brain volume
* contains over 50% of brain neurons

**Structure of the Cerebellum**

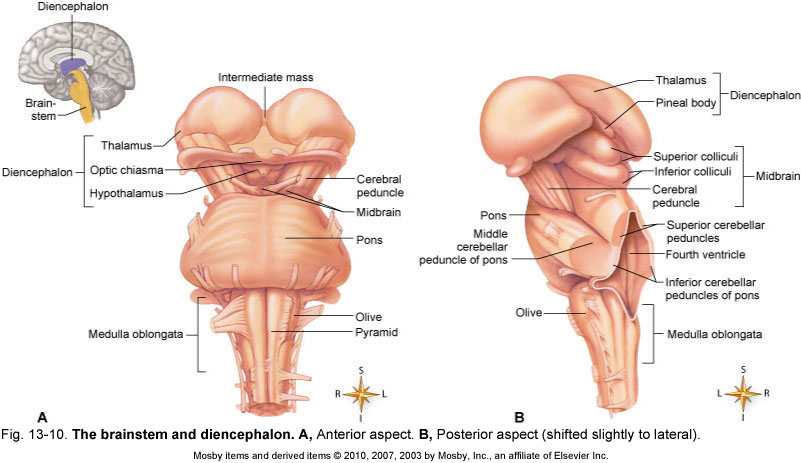
* Second largest part of the brain; contains more neurons than the rest of the nervous system
* Located just below the posterior portion of the cerebrum
* Gray matter makes in cortex & white matter interior
* Internal white matter: composed of short and long tracts
  + Shorter tracts conduct impulses from cerebellar cortex to interior of the cerebellum
  + Longer tracts conduct impulses to and from the cerebellum
* Dentate nuclei
  + Important pair of cerebellar nuclei, one in each hemisphere
  + Nuclei connected with thalamus and motor areas of the cerebral cortex by tracts

**Diagram

Description automatically generated**

**Brainstem**

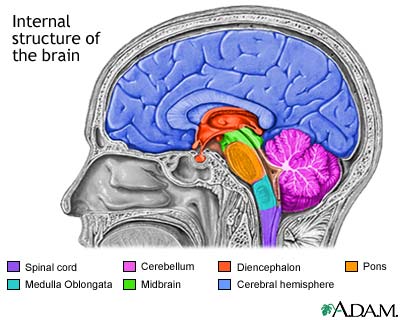
* major components
  + diencephalon
  + midbrain
  + pons
  + medulla oblongata

**Structures of the Brainstem**

* Medulla oblongata
  + Lowest part of the brainstem
  + Part of the brain that attaches to spinal cord; located just above the foramen magnum
  + Composed of white matter and a network of gray and white matter called the *reticular formation network*
* Pons
  + Located above the medulla and below the midbrain
  + Composed of white matter and reticular formation
* Midbrain
  + Located above the pons and below the cerebrum
  + Composed of white tracts and reticular formation

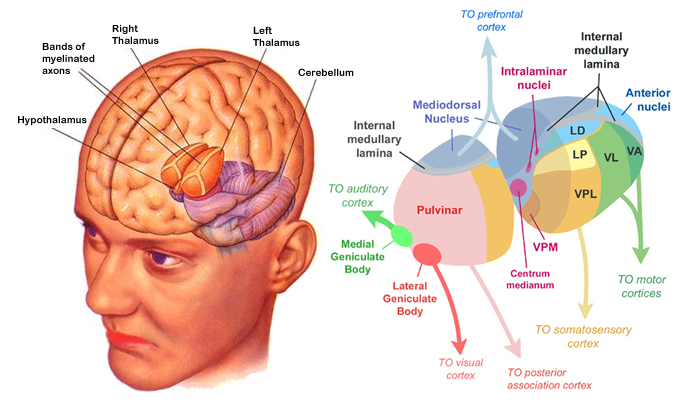
**Functions of the Brainstem**

* Performs sensory, motor, and reflex functions
* Important sensory tracts that pass through the brainstem
* Sensory tracts terminate in the brainstem
* Nuclei in medulla contain reflex centers
  + Vital importance: cardiac, vasomotor, and respiratory centers
  + Nonvital reflexes: vomiting, coughing, sneezing, etc.
* Pons contains reflexes mediated by fifth, sixth, seventh, and eighth cranial nerves and pneumotaxic centers that help regulate respiration



**Thalamus**

* ovoid mass on each side of the brain perched at the superior end of the brainstem beneath the cerebral hemisphere
* composed of at least 23 nuclei
* the “gateway to the cerebral cortex” – nearly all input to the cerebrum passes by way of synapses in the thalamic nuclei, filters information on its way to cerebral cortex
* plays key role in motor control by relaying signals from cerebellum to cerebrum
* involved in the memory and emotional functions of the limbic system

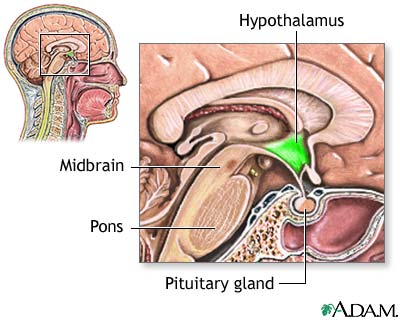


**Hypothalamus**

* extends anteriorly to optic chiasm and posteriorly to the paired mammillary bodies
* infundibulum – a stalk that attaches the pituitary gland to the hypothalamus
* major control center of autonomic nervous system and endocrine system
  + plays essential roll in homeostatic regulation of all body systems
* Functions of Hypothalamic Nuclei
  + hormone secretion
    - controls anterior pituitary
    - regulates growth, metabolism, reproduction ,and stress responses
  + autonomic effects
    - major integrating center for the autonomic nervous system
    - influences heart rate, blood pressure, gastrointestinal secretions and motility, and others

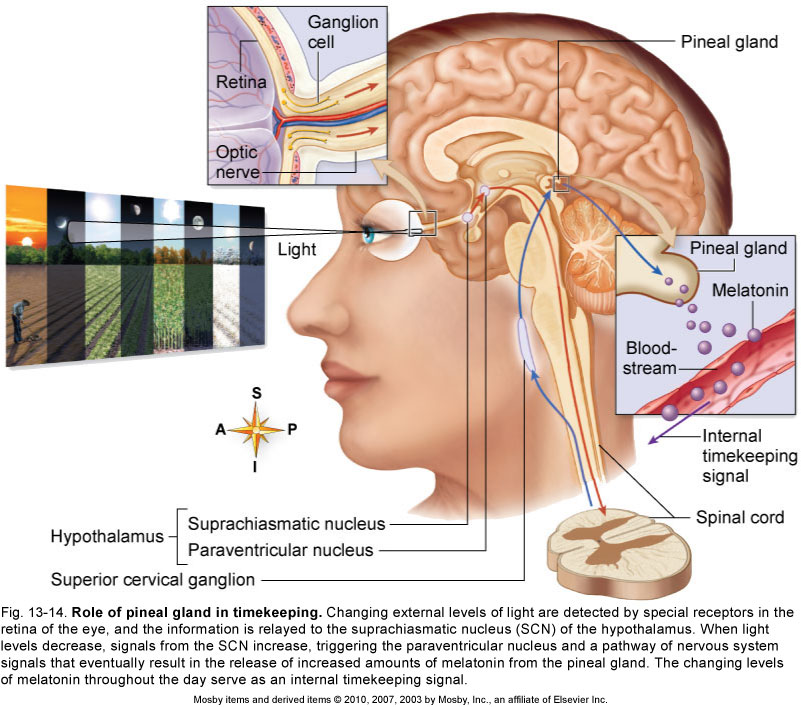
**Hypothalamus**

* Functions of Hypothalamic Nuclei
  + thermoregulation
    - hypothalamic thermostat monitors body temperature
    - activates heat-loss center when temp is too high
    - activates heat-promoting center when temp is too low
  + food and water intake
    - hunger and satiety centers monitor blood glucose and amino acid levels
      * produce sensations of hunger and satiety
    - thirst center monitors osmolarity of the blood
  + rhythm of sleep and waking
    - controls 24 hour circadian rhythm of activity
  + memory
  + emotional behavior
    - anger, aggression, fear, pleasure, and contentment



**Pineal gland**

* Located just above the corpora quadrigemina of the midbrain
* Involved in regulating the body’s biological clock
* Produces melatonin as a “timekeeping” hormone
  + Melatonin is made from the neurotransmitter serotonin
  + Levels increase when sunlight is absent and decrease when sunlight is present, thus regulating the circadian (daily) biologic clock
  + Melatonin is the “sleep hormone”

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