NEUROPHYSIOLOGY

PHSL2101, PHSL2121, PHSL2501

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References:
Germann & Stanfield: *Principles of Human Physiology*
Bear, Connors & Paradiso: *Neuroscience: Exploring the Brain*

Neurophysiology – Lecture structure

1. We will use the Echo360 Active Learning Platform. Notes are also available as .pdfs in Moodle
2. If you bring a device to class you will be able to engage in interactive questions.
3. At the start of each lecture I will answer the 2 most popular questions from the previous lecture. We'll break for an illusion/demo in the middle.
4. I will answer all questions from the lectures online in the ALP within a day or two of the lecture.
5. The notes have coloured sidebars to show which learning outcome they are linked to.

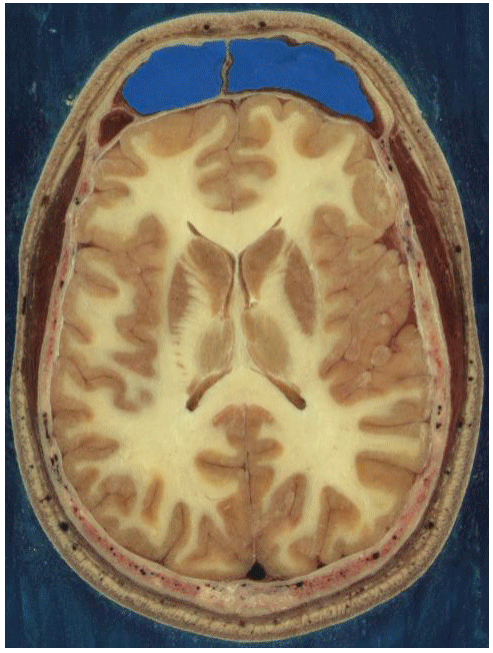
Neurophysiology 1 – Overview of the nervous system

Objectives

- Describe the arrangement of grey and white matter in the spinal cord and the brain.
- Describe the major divisions and functional organization of the brain.
- Describe the dermatomal organization of spinal cord, and differentiate between efferent and afferent fibres.
- Describe the blood-brain barrier and the role of cerebro-spinal fluid (CSF).

Grey and white matter

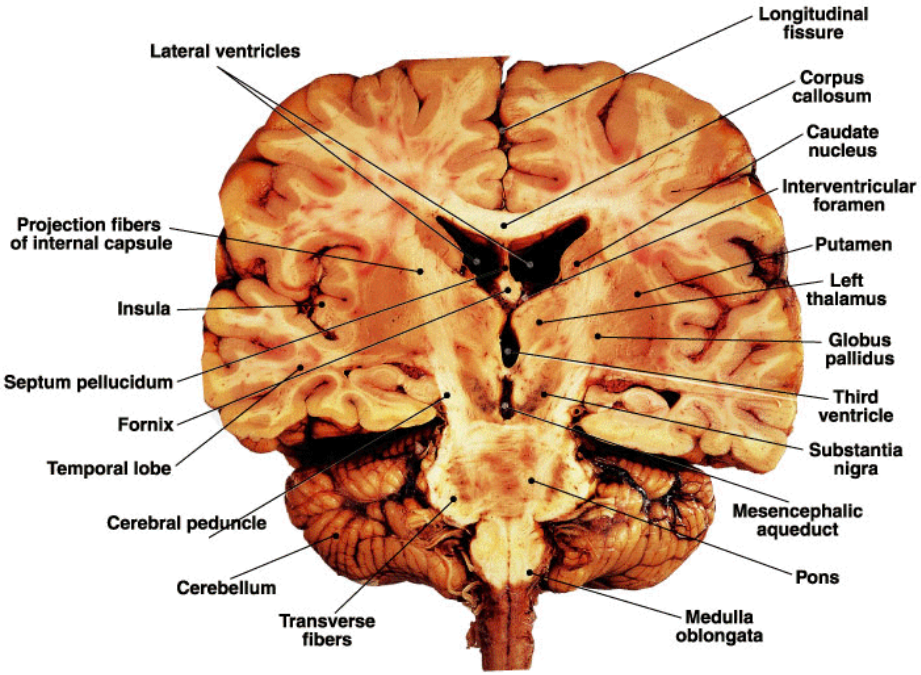
Horizontal section through the skull



- the brain fills most of the space inside the skull
- the brain is not directly attached to the skull, and floats in the cerebrospinal fluid
- the brain is bilaterally symmetrical

from the Visible Human Project

Cross-section of brain



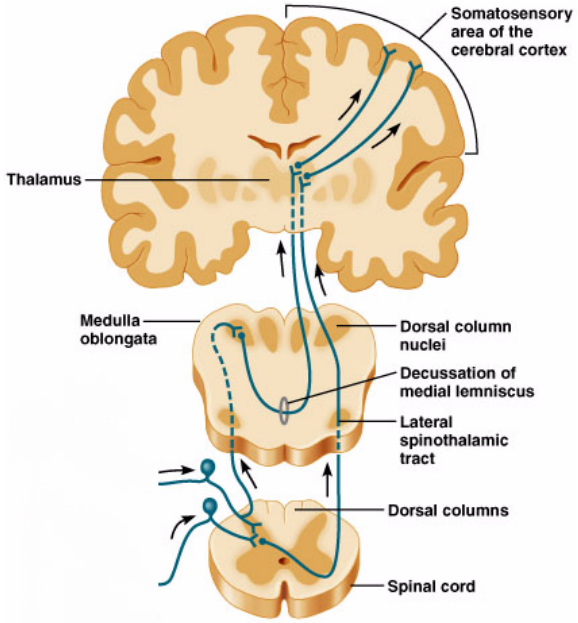
from Sherwood, Human Physiology

Grey and white matter

Grey on the inside for spinal cord, on the outside for brain

white matter = axons

grey matter = somas & dendrites



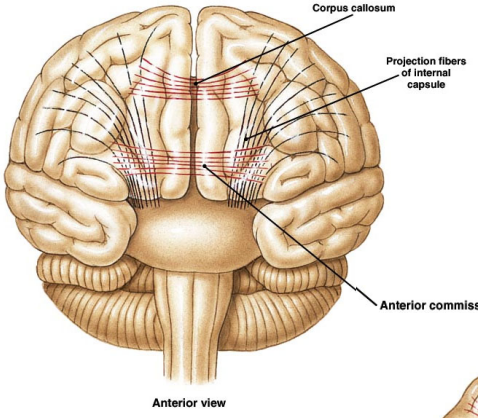
from Germann & Stanfield, Principles of Human Physiology

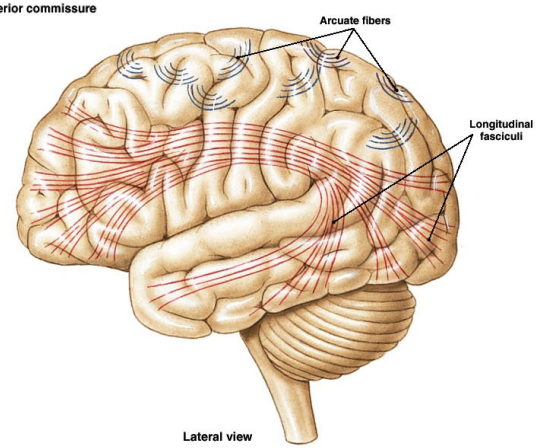
Grey and white matter

- The two cerebral hemispheres are effectively separate from each other, with only a major linking white matter tract, the *corpus callosum*, and some minor ones including the *anterior commissure*.
- The folds are called *sulci,* and the 'bumps' are called *gyri.*
- The ventricles are fluid-filled spaces inside the brain. They make up only a small part of the total volume in a healthy brain.
- Spinal cord is the body's major pathway for ascending and descending information. **What is the benefit in having the white matter on the outside?**
- Cortex has the grey matter on the outside surface. **What is the benefit of this structure.**
- Note that much of the organization of the nervous system is crossed: the sensory inputs from the right side of the body are processed by the left cerebral hemisphere.

Grey and white matter

White matter tracts connect cortical areas





- myelinated axons provide communication between cortical areas

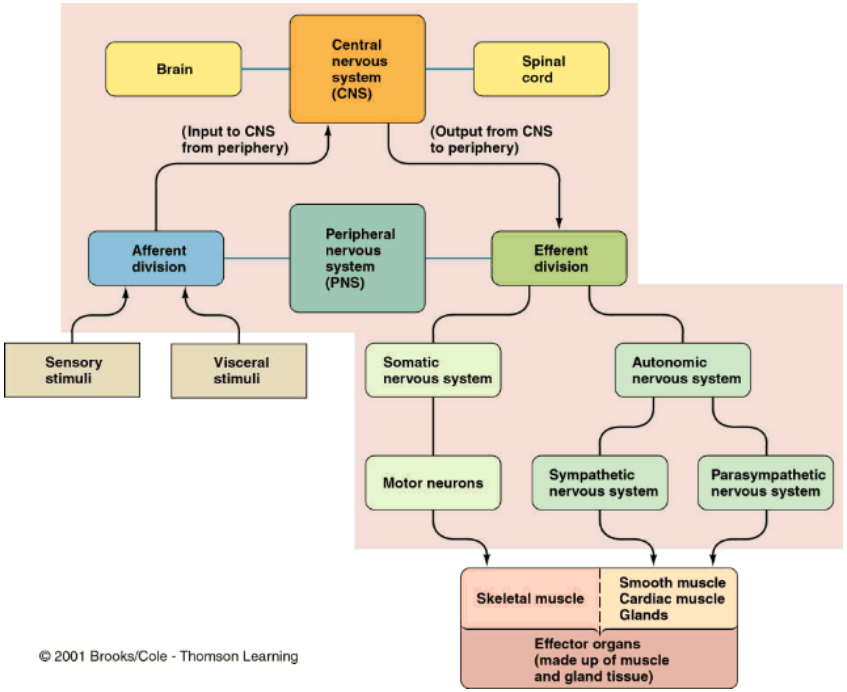
from Sherwood, Human Physiology

Grey and white matter

- Cerebral cortex is structured as a thin sheet about 2.5 mm thick. To fit the maximum surface area of cortex in the brain, it is 'crumpled up' which gives rise to the gyri and sulci.
- Cortex has many specialised areas. These need to be inter-connected so that the information can be integrated.
  - Connections between the hemispheres (corpus callosum and anterior commissure) - usually between matching areas.
  - Long-range connections within a hemisphere that enable fast passage of neural information
  - Local connections (arcuate fibres) for selective sharing of information to neighbouring areas.
  - Within an area, axons branch and selectively synapse with the dendrites of particular neurons, rather than just with every neighbour.

Divisions of the nervous system

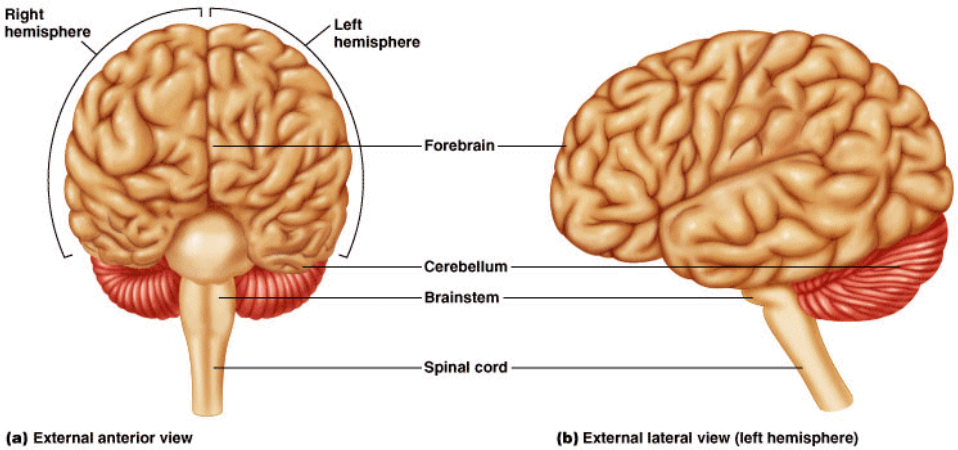
Divisions of the nervous system



from Sherwood, Human Physiology

Divisions of the nervous system

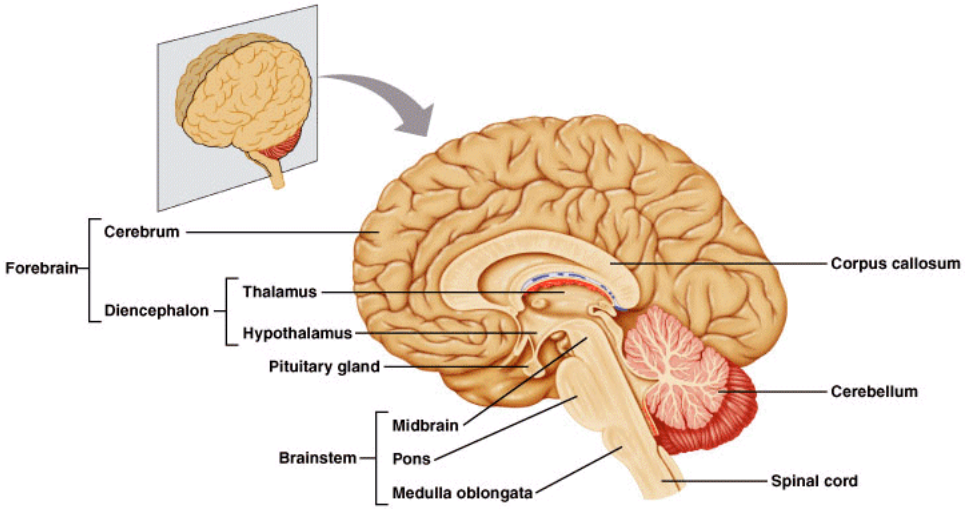
Main brain divisions – lateral view



from Germann & Stanfield, Principles of Human Physiology

Divisions of the nervous system

Main brain divisions – medial view



from Germann & Stanfield, Principles of Human Physiology

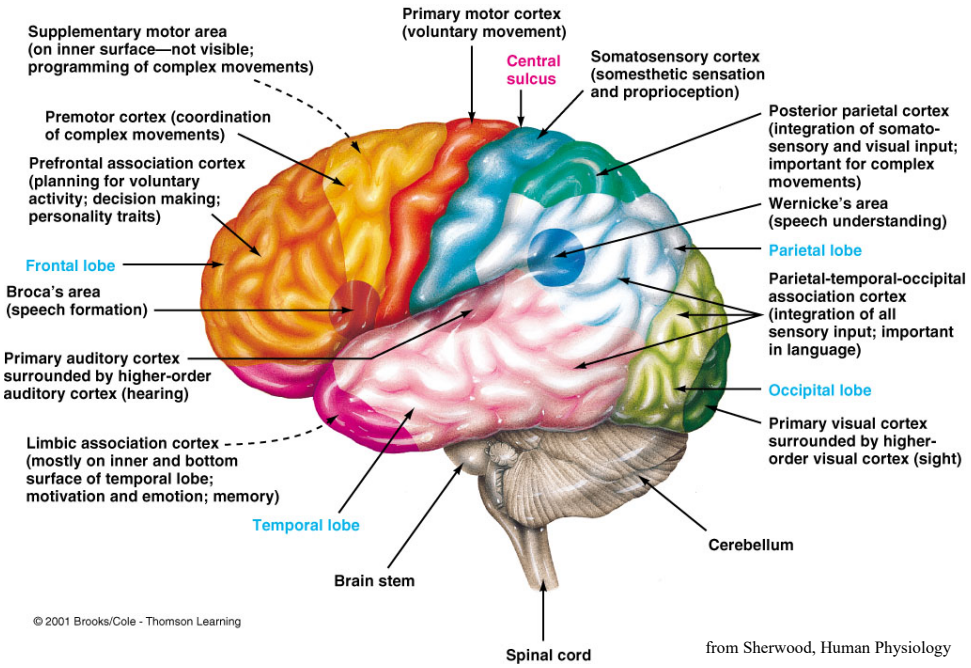
- The divisions on the previous slides are mainly anatomical.
- Any functional system of the brain is likely to span many anatomical areas. For example, touch information arises in the peripheral nervous system, ascends to the medulla oblongata, then goes to thalamus, and finally to somatosensory cortex.

(You don't need to remember details of these structures: they are to orient you in later lectures.)

- The *brain stem* has many regulatory nuclei for control of autonomic functions. *Medulla oblongata* links spinal cord neurons with the rest of the brain. *Pons* connects with the cerebellum. *Mid-brain* connects these brainstem structures with the forebrain.
- *Cerebellum* is a key structure for motor control and learning, and receives direct sensory input.
- *Hypothalamus* links the autonomic and somatic nervous systems. It controls endocrine system through the *pituitary gland*.
- *Thalamus* is the sensory and motor gateway. Every sense has to pass through the thalamus on the way to its cortical area.

Divisions of the nervous system

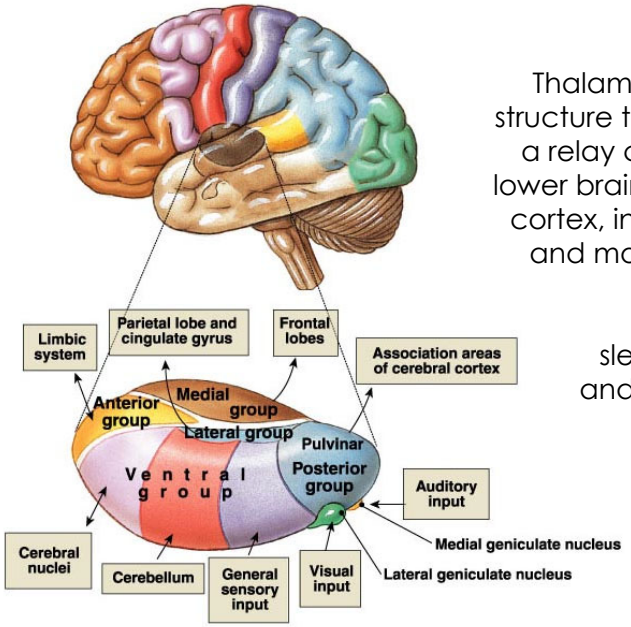
Functionally defined areas of cortex



from Sherwood, Human Physiology

Divisions of the nervous system

Thalamus is sub-divided into nuclei with connections to particular parts of cortex



Thalamus is deep brain structure that functions as a relay centre between lower brain structures and cortex, including sensory and motor information.

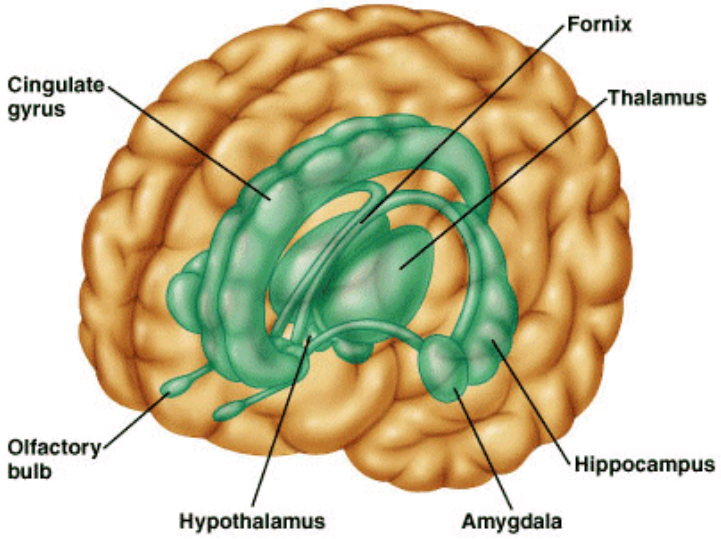
It is involved in sleep/wake states and is implicated in consciousness.

from Sherwood, Human Physiology

Divisions of the nervous system

Limbic System - emotions

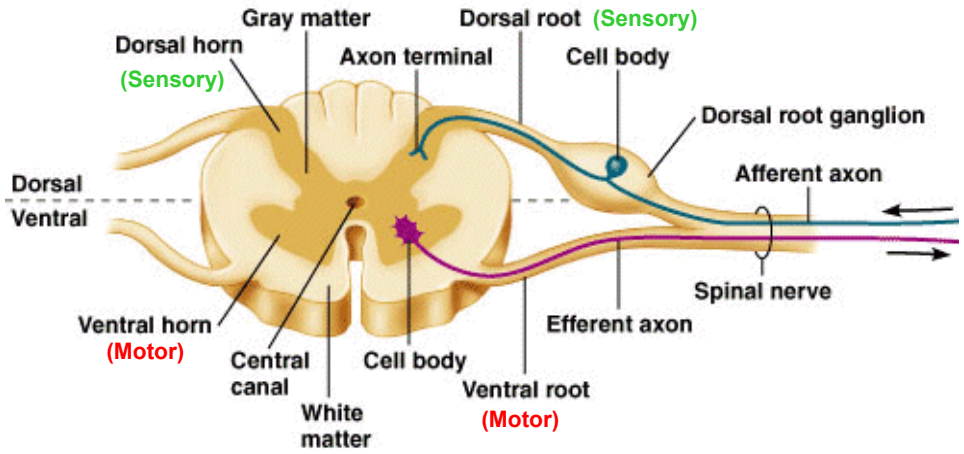
Hypothalamus: *autonomic integration;* **Amygdala**: *fear;* **Hippocampus**: *memory;* **Cingulum**: *cortical interface*



from Germann & Stanfield, Principles of Human Physiology

Organization of spinal cord

Spinal cord has a precise organization

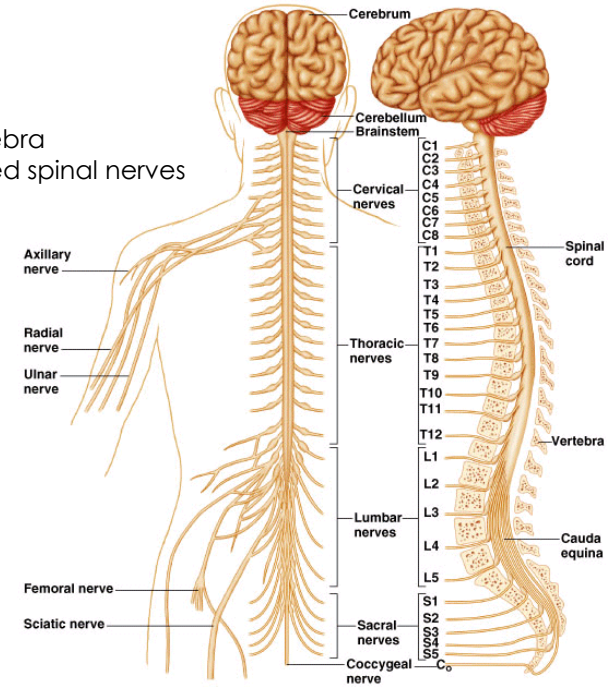


from Germann & Stanfield, Principles of Human Physiology

Organization of spinal cord

Spinal nerves exit between each vertebra

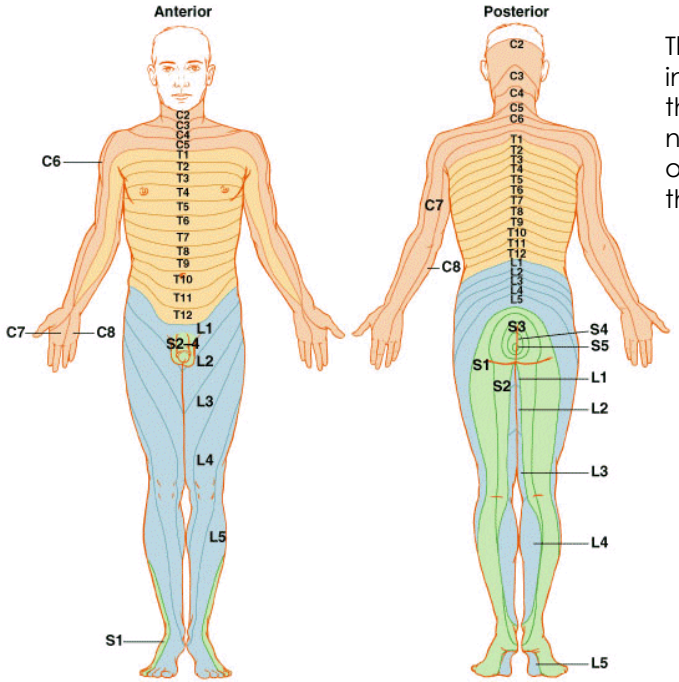
- 30 vertebra
- 31 paired spinal nerves



from Germann & Stanfield, Principles of Human Physiology

Organization of spinal cord

Each spinal nerve innervates a dermatome



The face is innervated by the cranial nerves, originating in the brain stem.

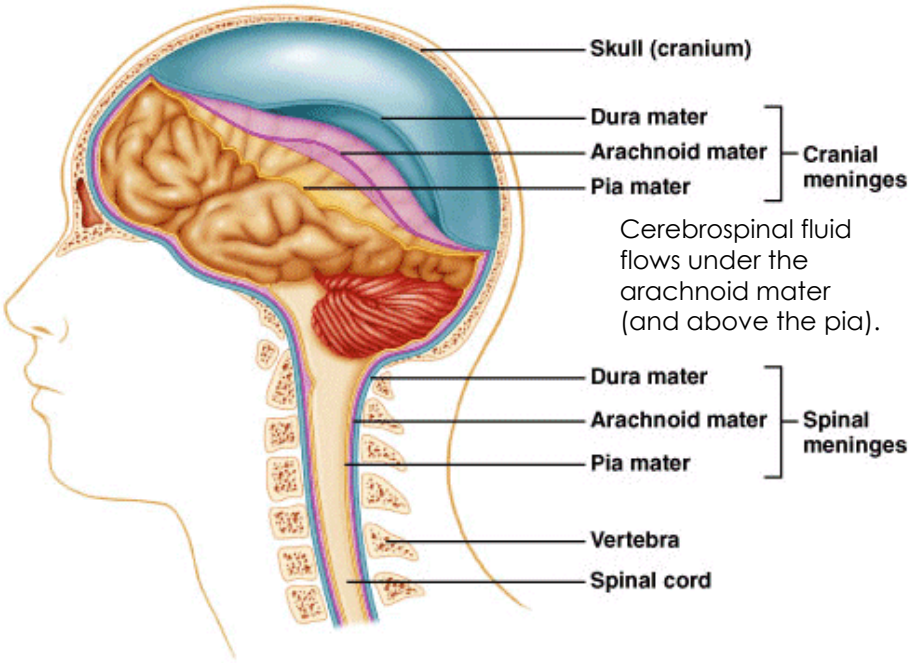
from Germann & Stanfield, Principles of Human Physiology

Organization of spinal cord

- The white matter in the spinal cord is on the outside, so that axons can enter and leave without disrupting the grey matter.
- The dorsal part of the spinal cord is related to afferent (incoming) sensory function, the ventral to efferent (outgoing) motor function.
- The spinal cord is divided into four levels: cervical, thoracic, lumbar and sacral: C, T, L, S.
- There are 30 vertebra, and 31 paired spinal nerves that exit between the vertebra.
- The spinal nerves innervate particular regions of the body, using a plan that is consistent across individuals. Each region innervated by a spinal nerve is called a dermatome.
- The level at which sensation is lost in a paraplegic relates to the where the spinal cord injury occurred.

Glia and CSF

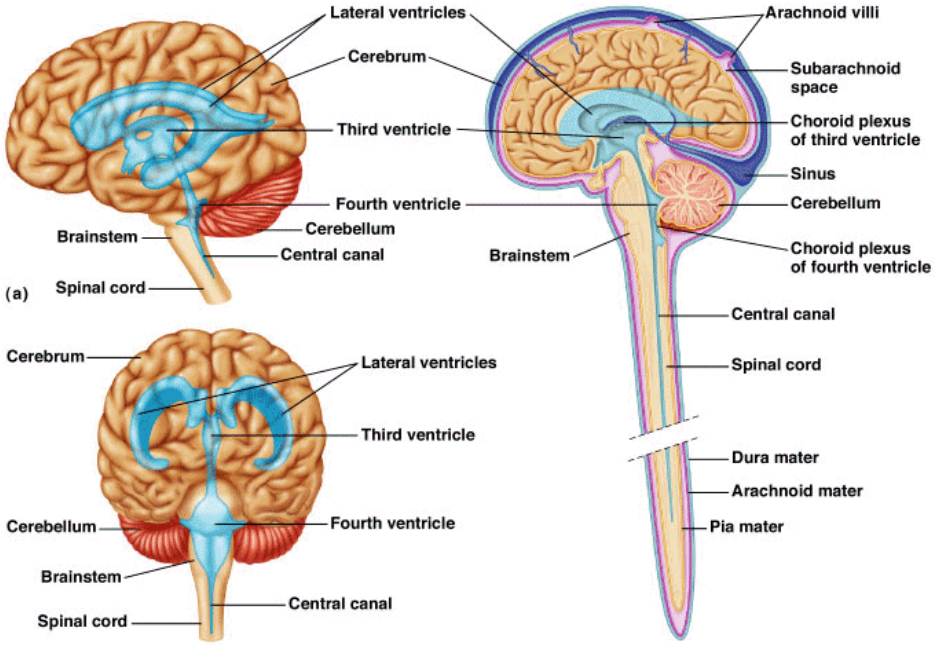
Membranes around the brain: *meninges*



from Germann & Stanfield, Principles of Human Physiology

Glia and CSF

Ventricles & cerebrospinal fluid (CSF)



from Germann & Stanfield, Principles of Human Physiology

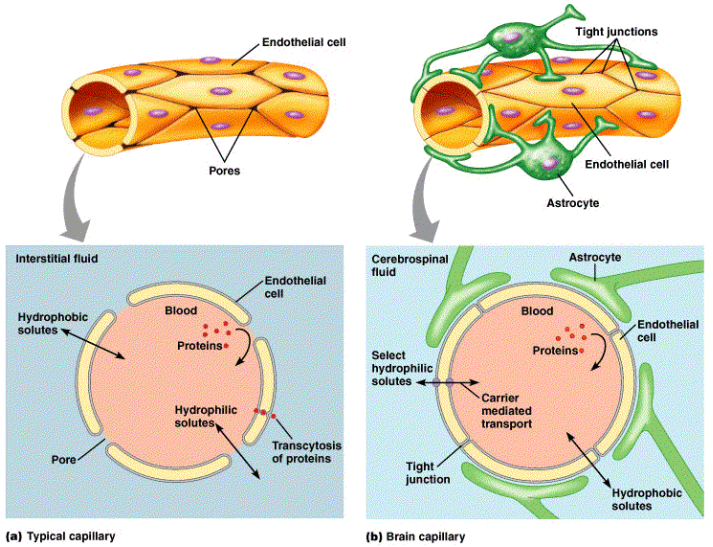
Glia and CSF

Role of cerebrospinal fluid (CSF)

- Supports the brain, allowing it to float inside the skull.
- Provides an appropriate chemical environment for the brain by supplying nutrients and removing waste products.
- Allows for chemical signalling.
- CSF volume ~150 mL, but ~500 mL produced/day. CSF is produced in the third and fourth ventricles by the choroid plexus.
- Composition of CSF is similar to plasma but with less protein.
- The brain does not store energy, so needs a near-continuous supply of blood to deliver oxygen and glucose. An interruption to the cortical blood flow lasting 10 seconds will produce unconsciousness, and one lasting several minutes will cause permanent brain damage.

Glia and CSF

Blood-brain barrier – selectively leaky

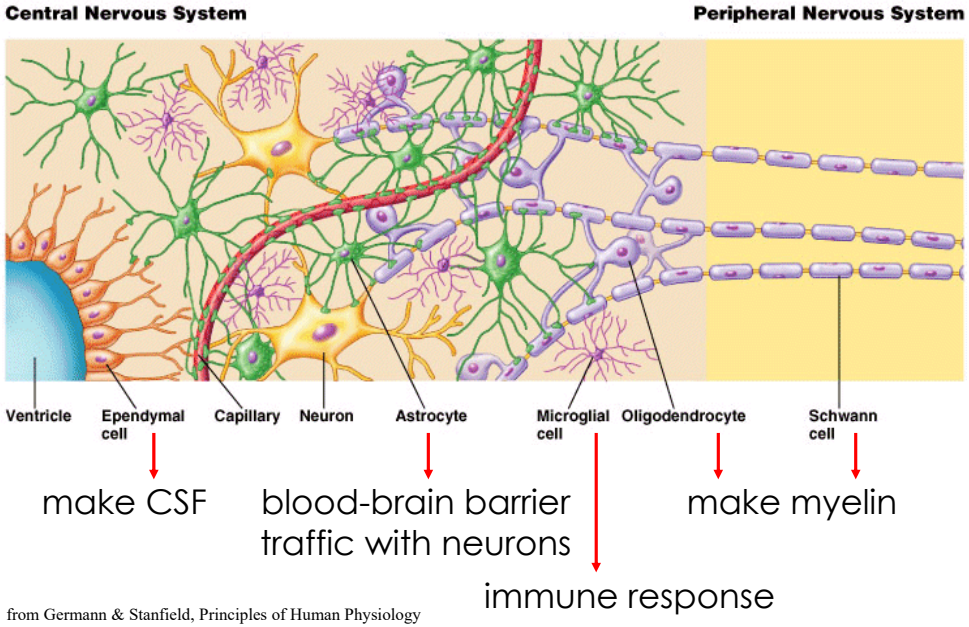


The blood-brain barrier refers to the restricted permeability of brain capillaries. Astrocytes work with the capillary cells to make the tight junctions less leaky. The main purpose is to protect the brain from toxins.

from Germann & Stanfield, Principles of Human Physiology

Glia and CSF

Glial cells are of several sorts and outnumber neurons by 10:1



make CSF

blood-brain barrier
traffic with neurons

immune response

make myelin

from Germann & Stanfield, Principles of Human Physiology