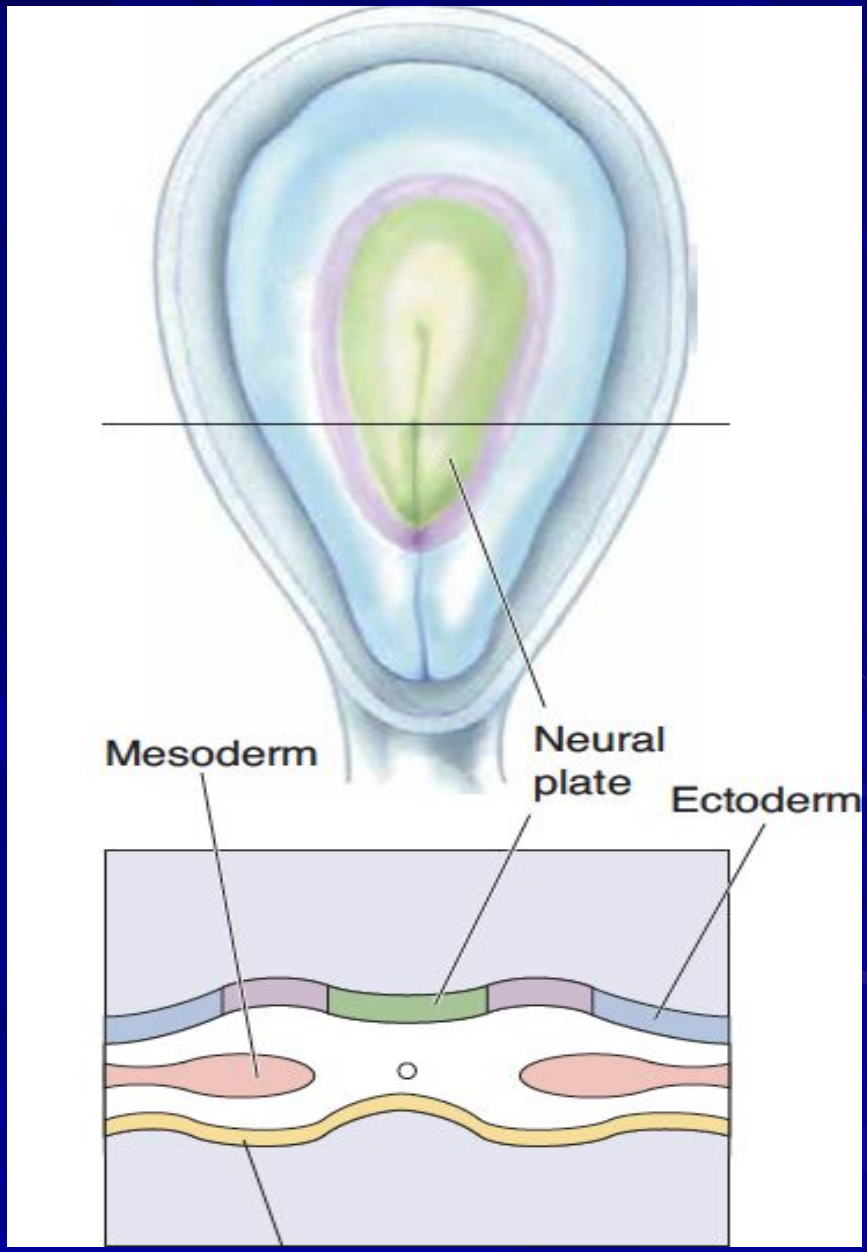
Brain development

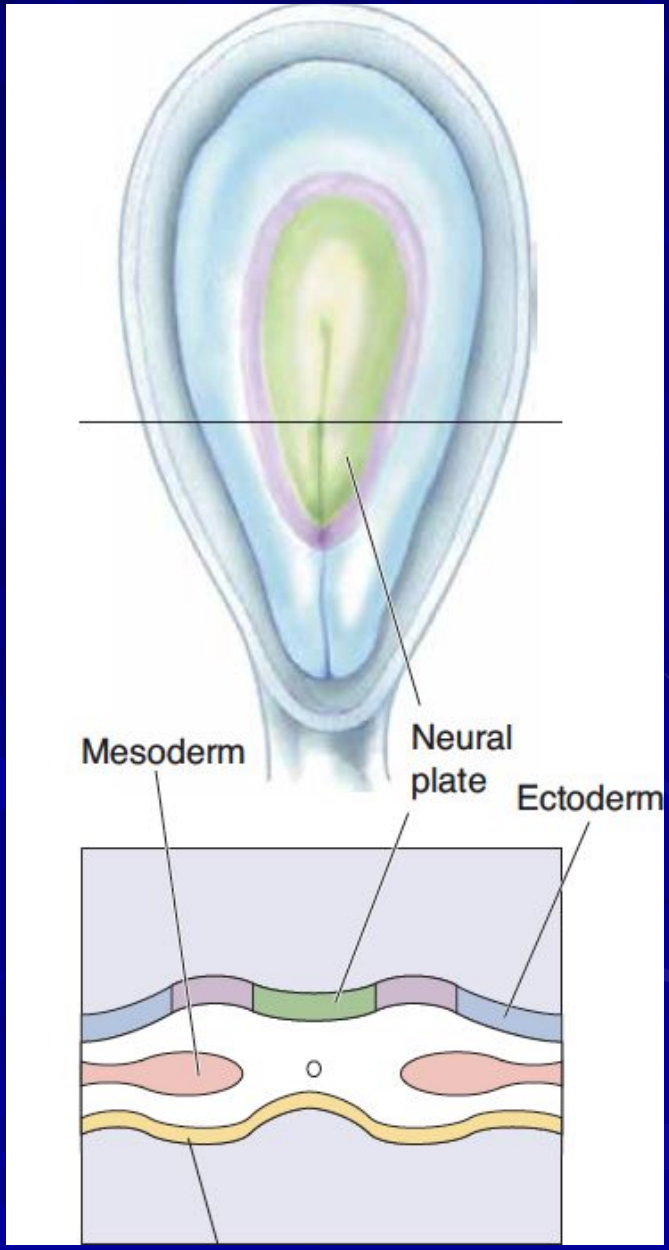
The embryo begins as a flat disk with three distinct layers of cells

1. endoderm
2. mesoderm
3. ectoderm



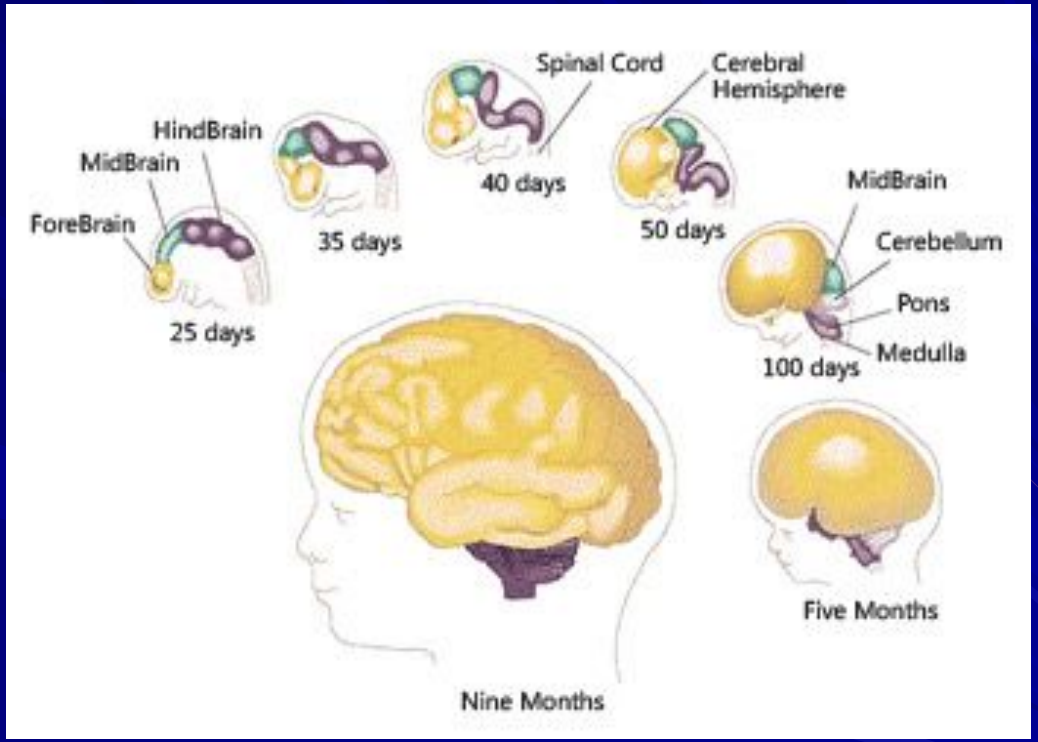
Brain development

- The endoderm gives rise to the lining of many of the internal organs
- From the mesoderm arise the bones of the skeleton and the muscles.
- The nervous system and the skin derive entirely from the ectoderm.



The stages of nerves system development

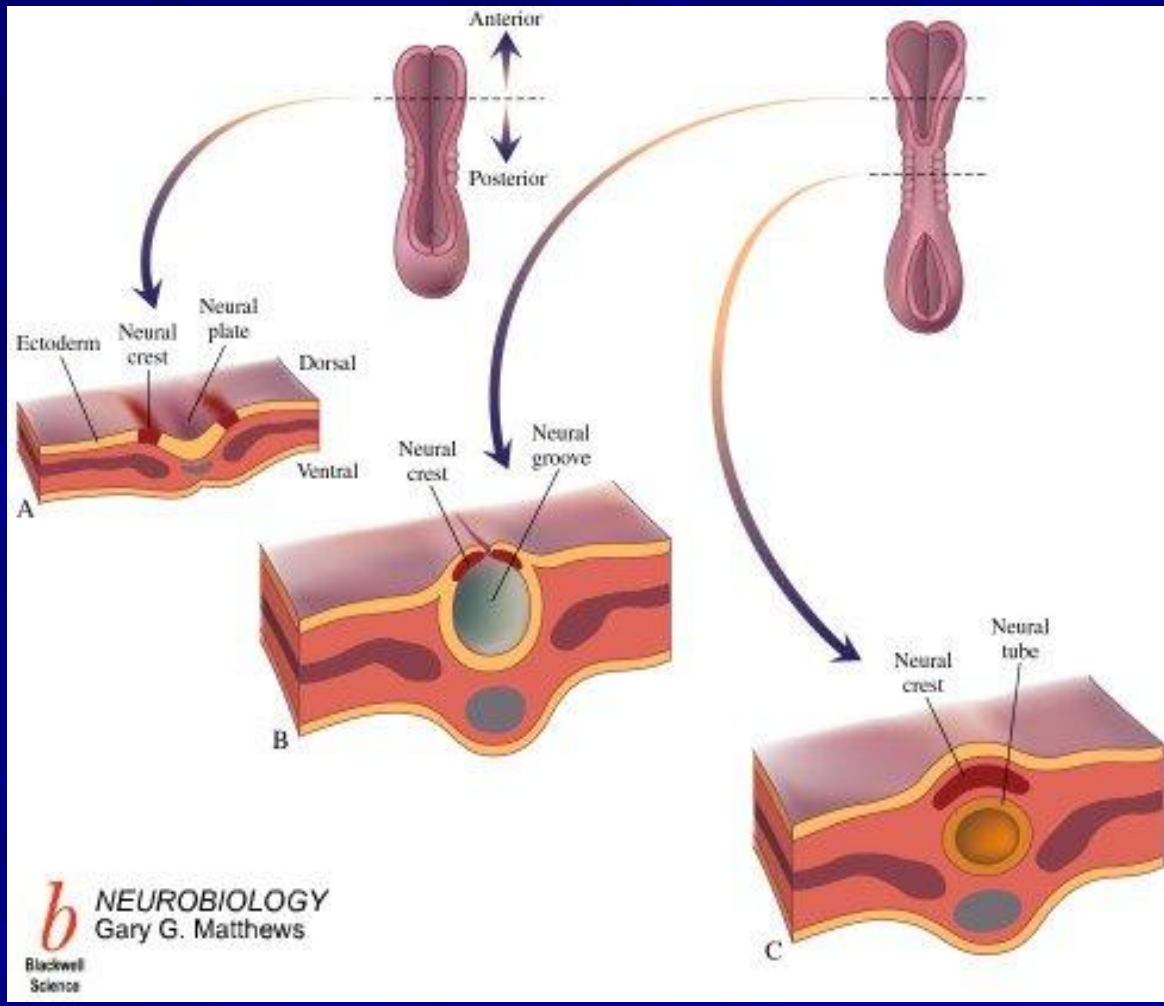
1. Formation of the Neural Tube
2. Formation and differentiation of three primary Brain Vesicles



Formation of the Neural Tube

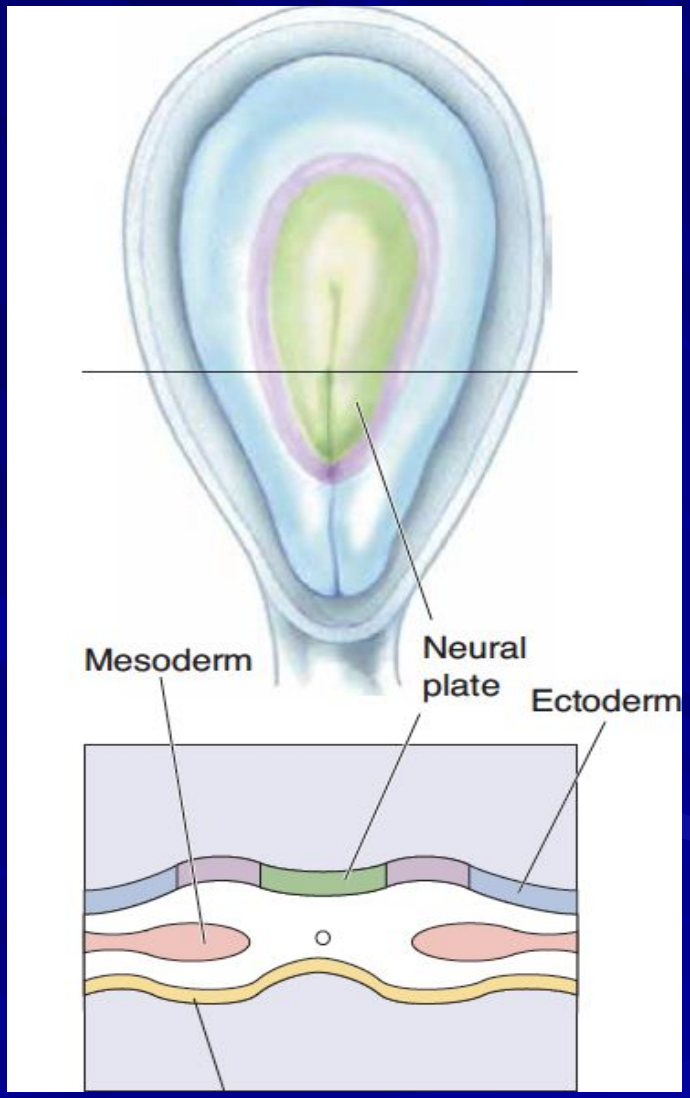
Neurulation

is the formation of neural tube from neural plate



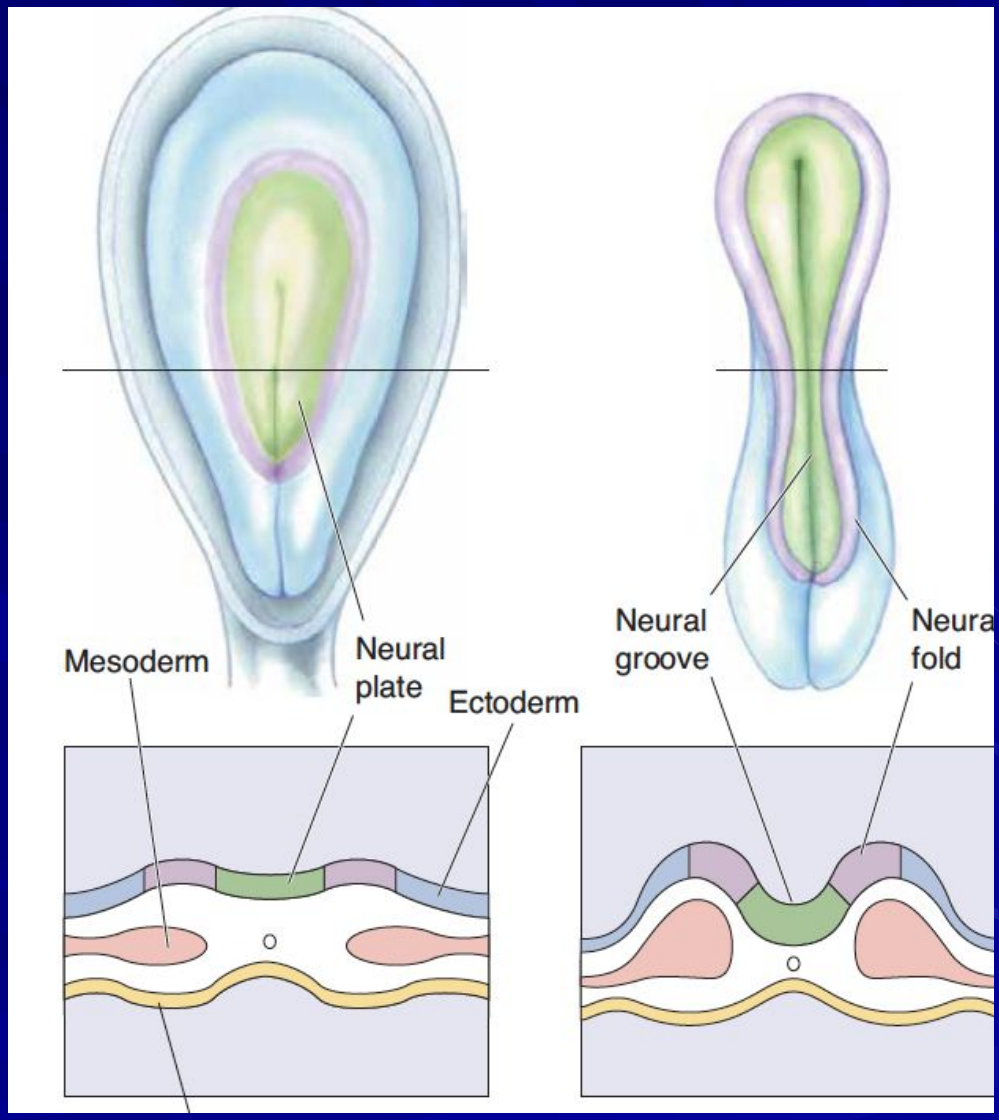
Formation of the Neural Tube

- At early stage the brain consists only of a flat sheet of cells - neural plate



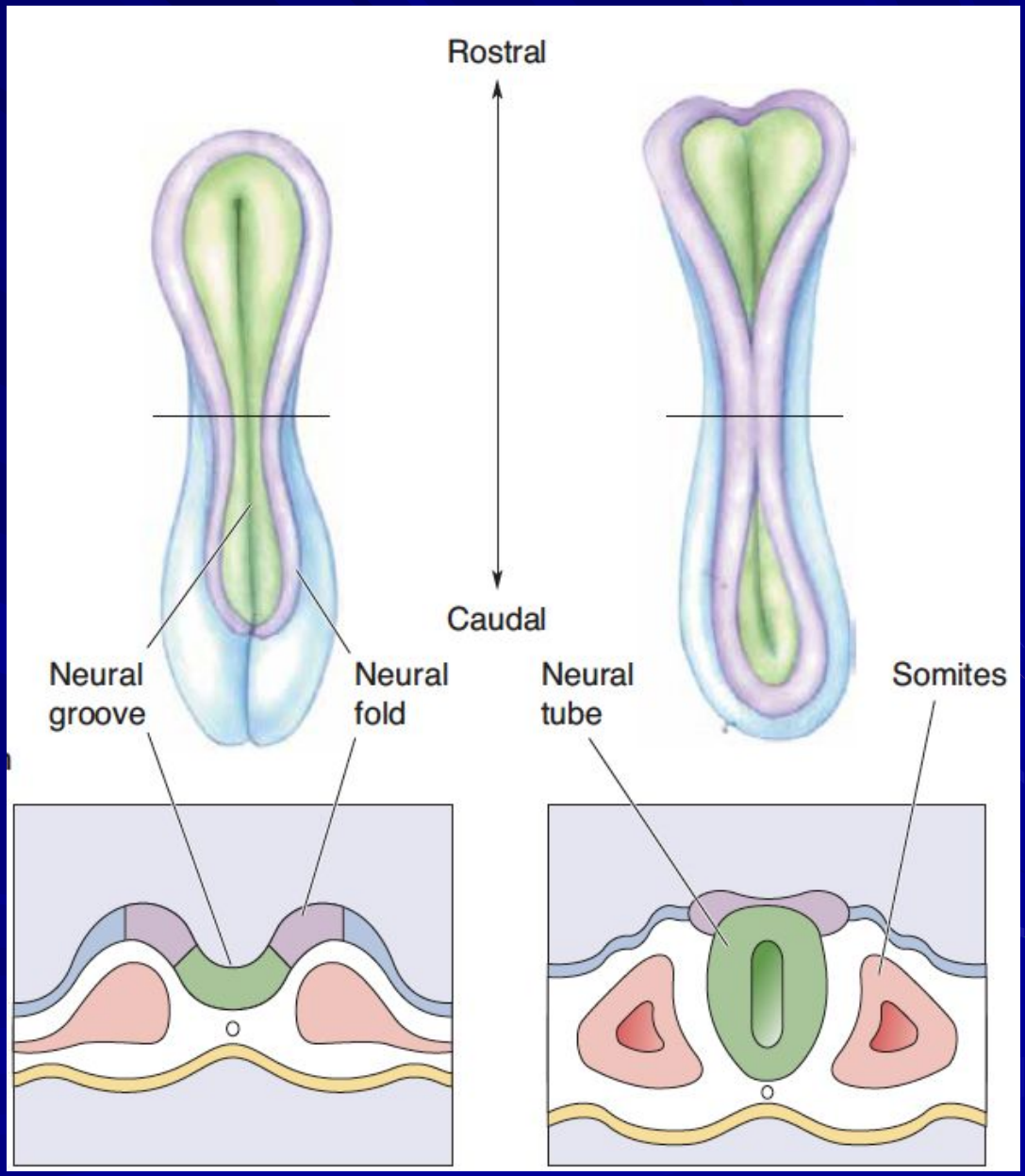
Formation of the Neural Tube

- The next event is the formation of a groove in the neural plate – neural groove



Formation of the Neural Tube

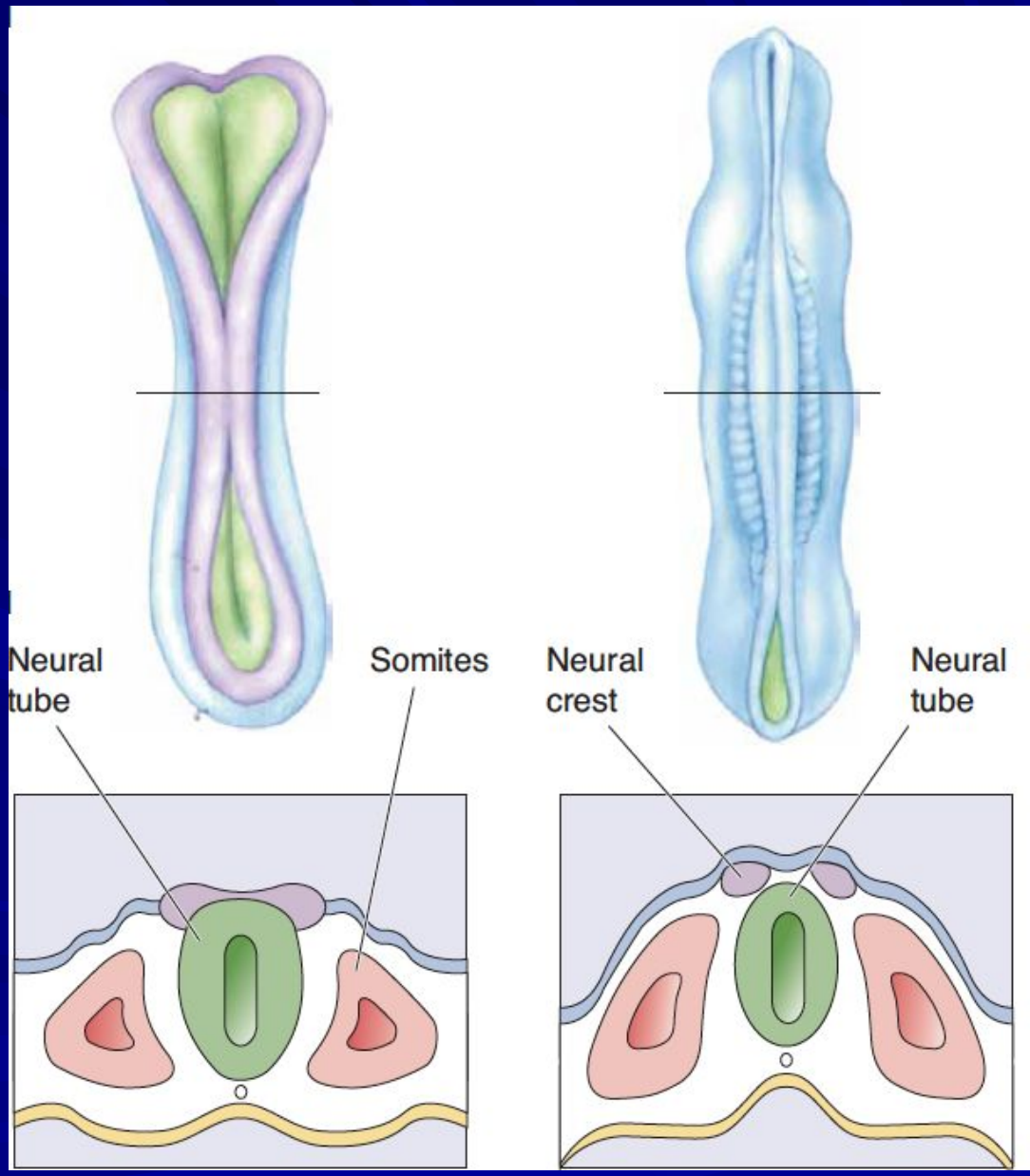
- The walls of the groove (neural folds) subsequently move together and fuse dorsally, forming the neural tube
- The fusion occurs first in the middle, then anteriorly and posteriorly
- *!!! The entire central nervous system develops from the walls of the neural tube*



Formation of the Neural Tube

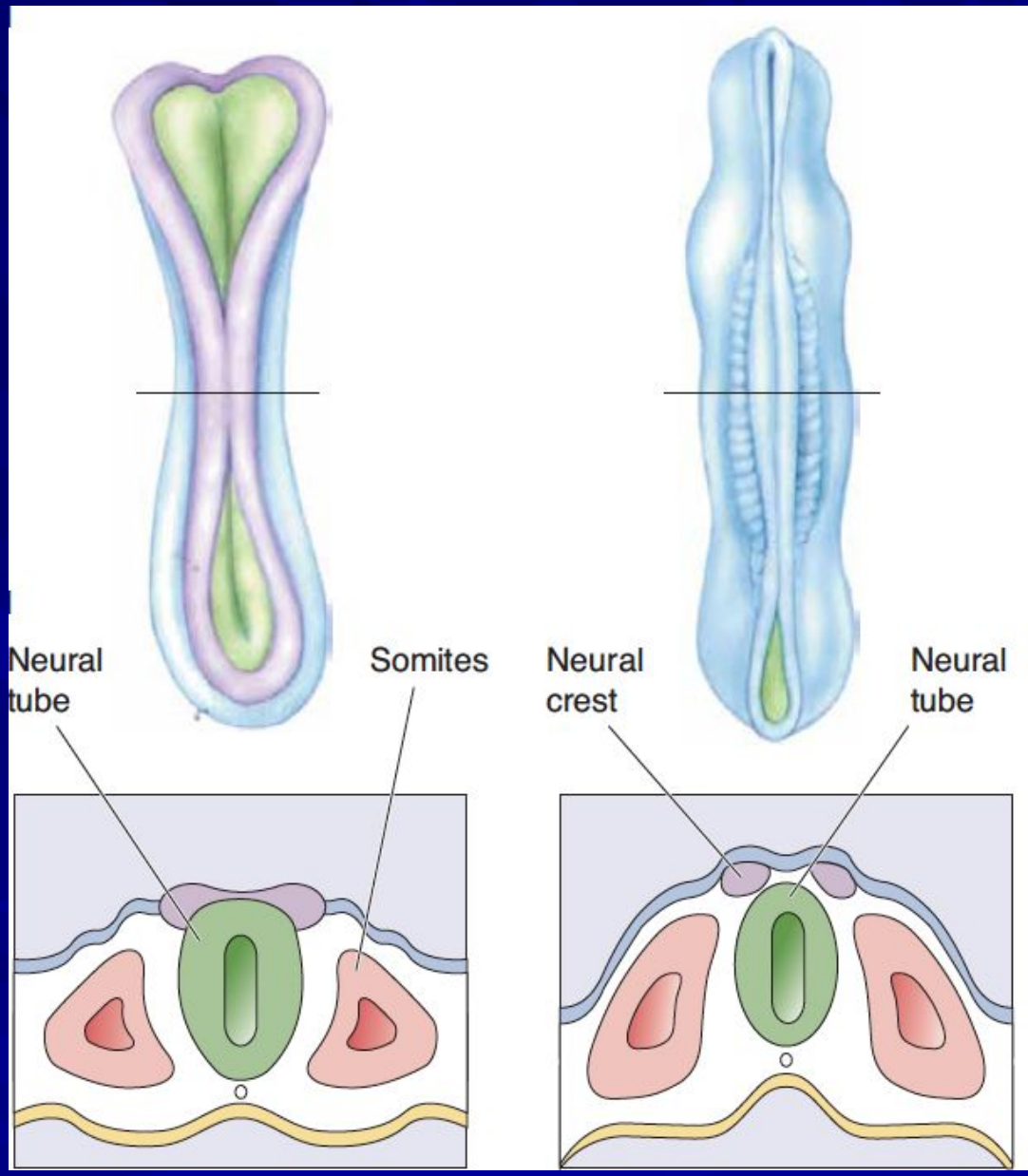
- Some neural ectoderm is pinched off and comes to lie just lateral to the neural tube.
- This tissue is called the neural crest

- !!! All neurons in the peripheral nervous system derive from the neural crest.



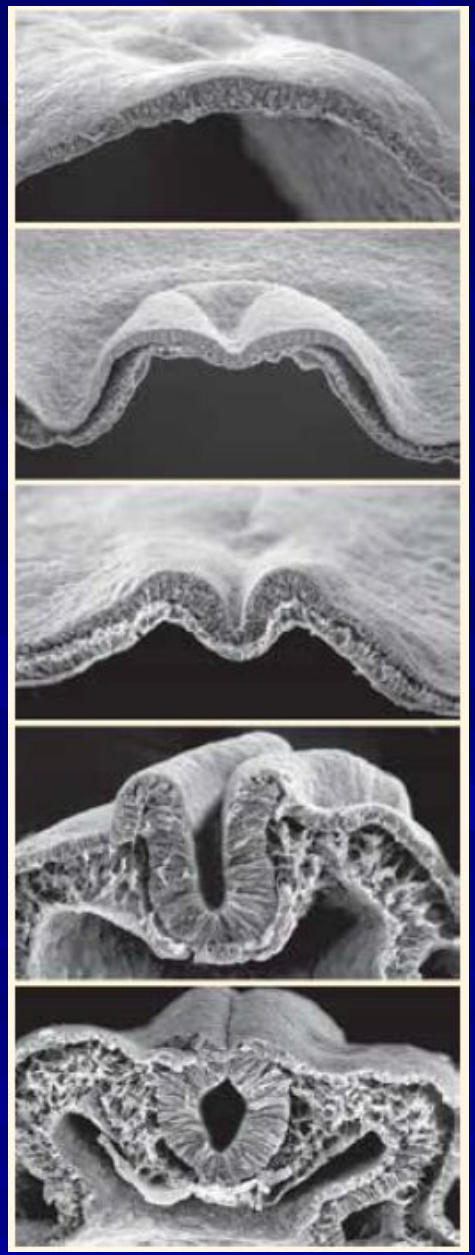
Formation of the Neural Tube

- The mesoderm at this stage in development forms somites on either side of the neural tube.
- From these somites, the 33 individual vertebrae of the spinal column and the related skeletal muscles will develop.



Formation of the Neural Tube

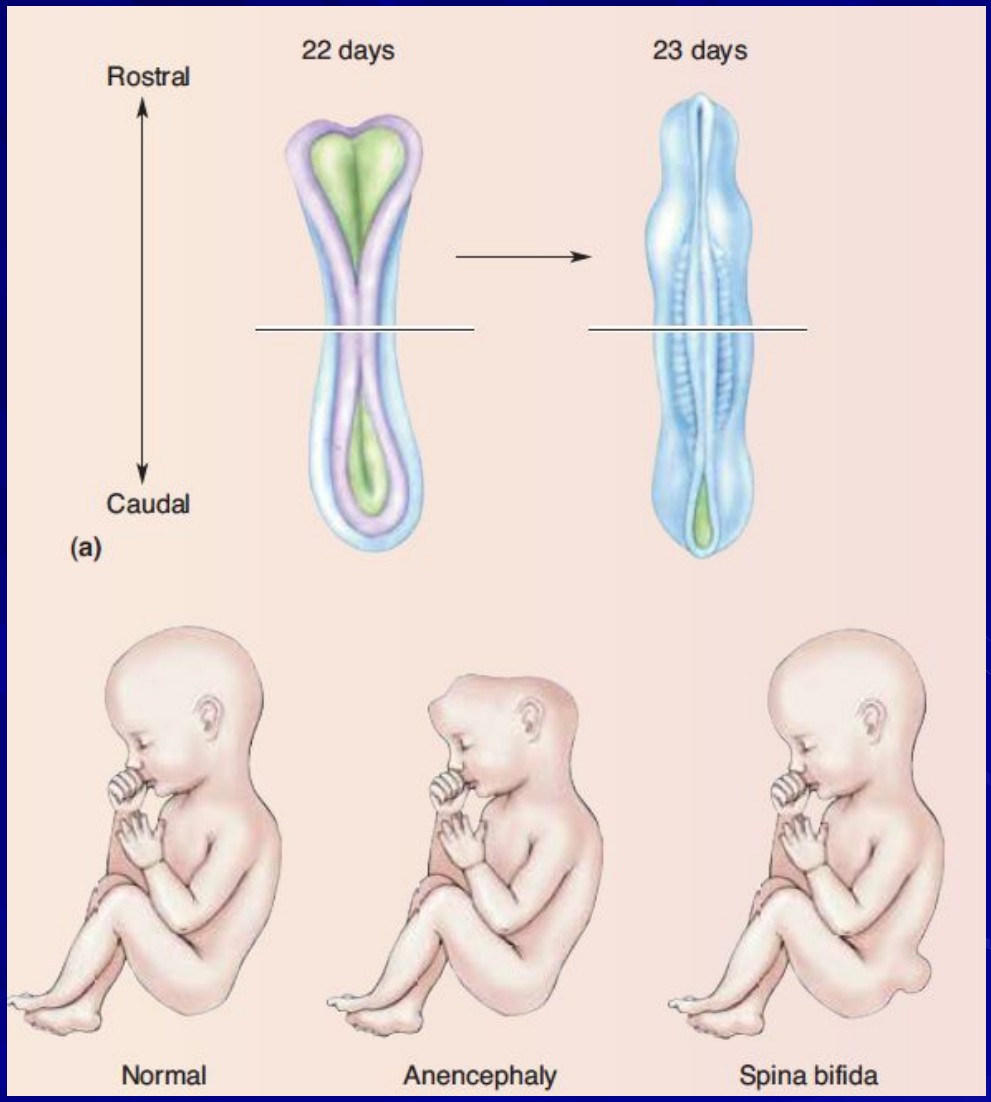
- Neurulation occurs very early in embryonic development, about 22 days after conception in humans.



Scanning electron micrographs of neurulation.

Formation of the Neural Tube

- Failure of the anterior neural tube to close results in anencephaly, a condition characterized by degeneration of the forebrain and skull. It is always fatal.
- Failure of the posterior neural tube to close results in a condition called spina bifida.
- Spina bifida, while usually not fatal, does require extensive medical care.
- Folic acid plays an essential role in the formation of the neural tube



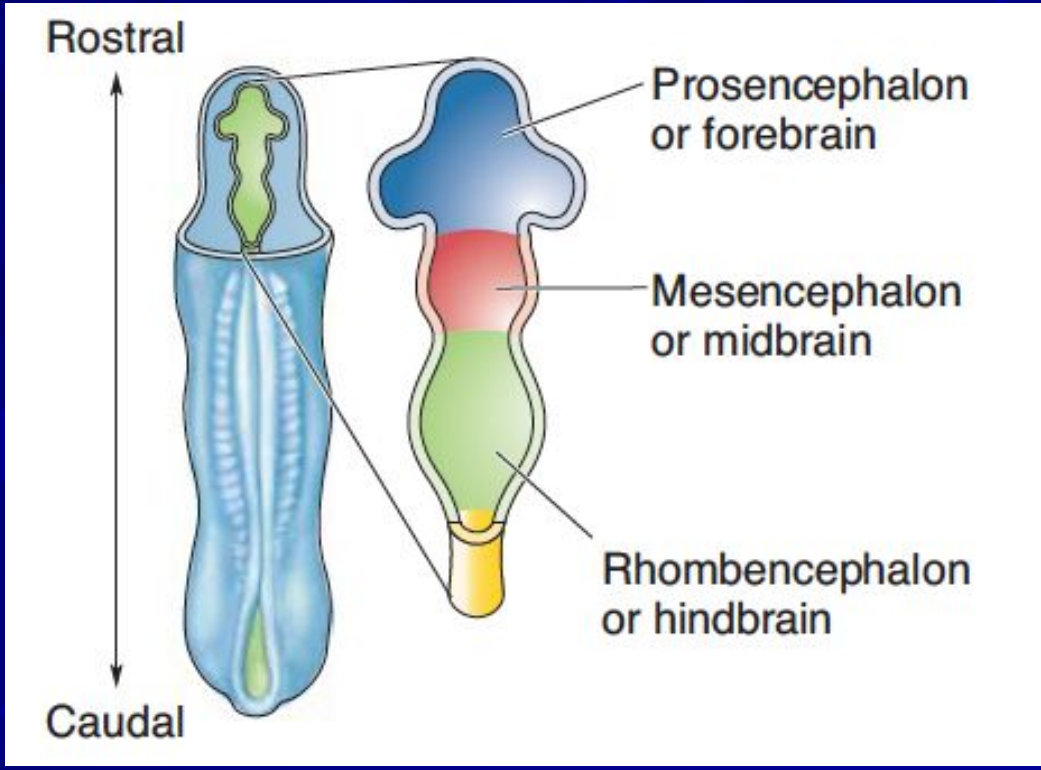
Development of three primary Brain Vesicles

- The first step in the differentiation of the brain is the development of three swellings called the primary vesicles

1. Prosencephalon (forebrain)
2. Mesencephalon (midbrain)
3. Rhombencephalon (hindbrain)

- !!! The entire brain derives from the three primary vesicles of the neural tube

- The rhombencephalon connects with the caudal neural tube, which gives rise to the spinal cord.

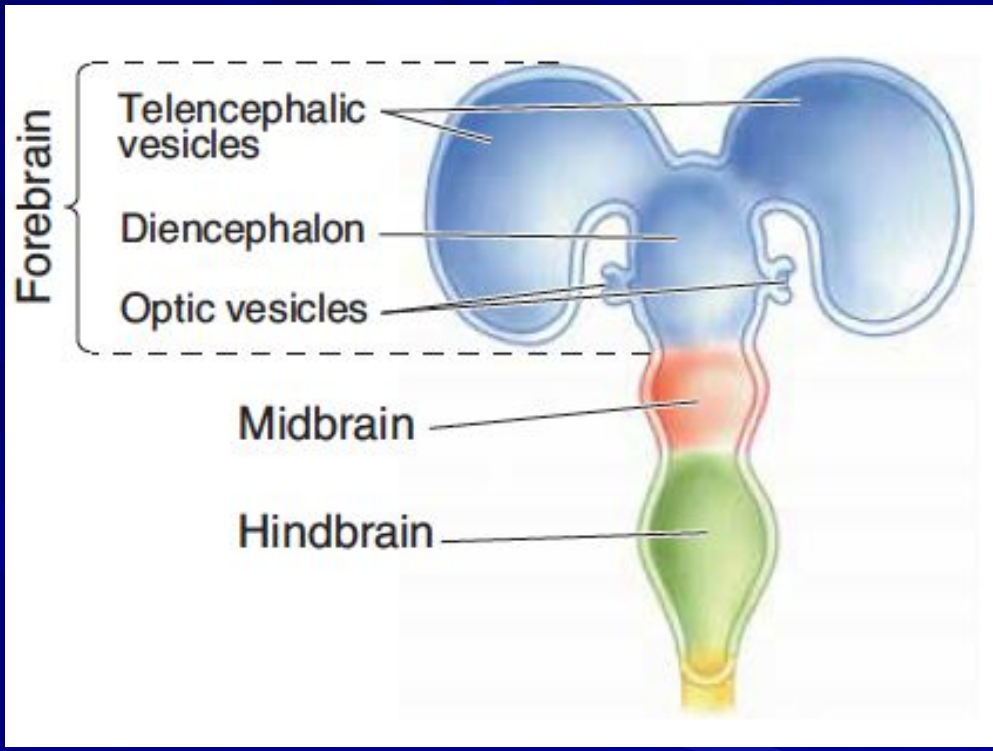


Differentiation of the Forebrain

- Secondary vesicles sprout off on both sides of the forebrain

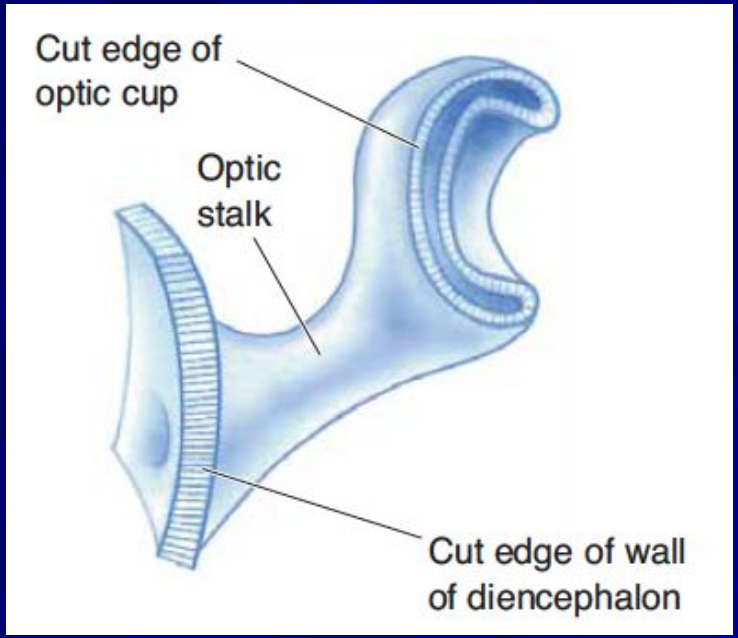
1. optic vesicles
2. telencephalic vesicles

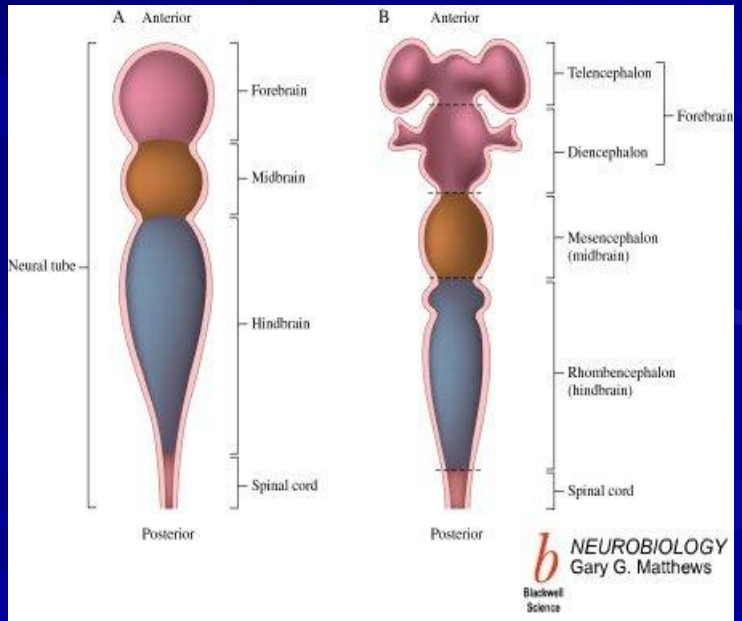
- The central structure is called the diencephalon



Differentiation of the Forebrain

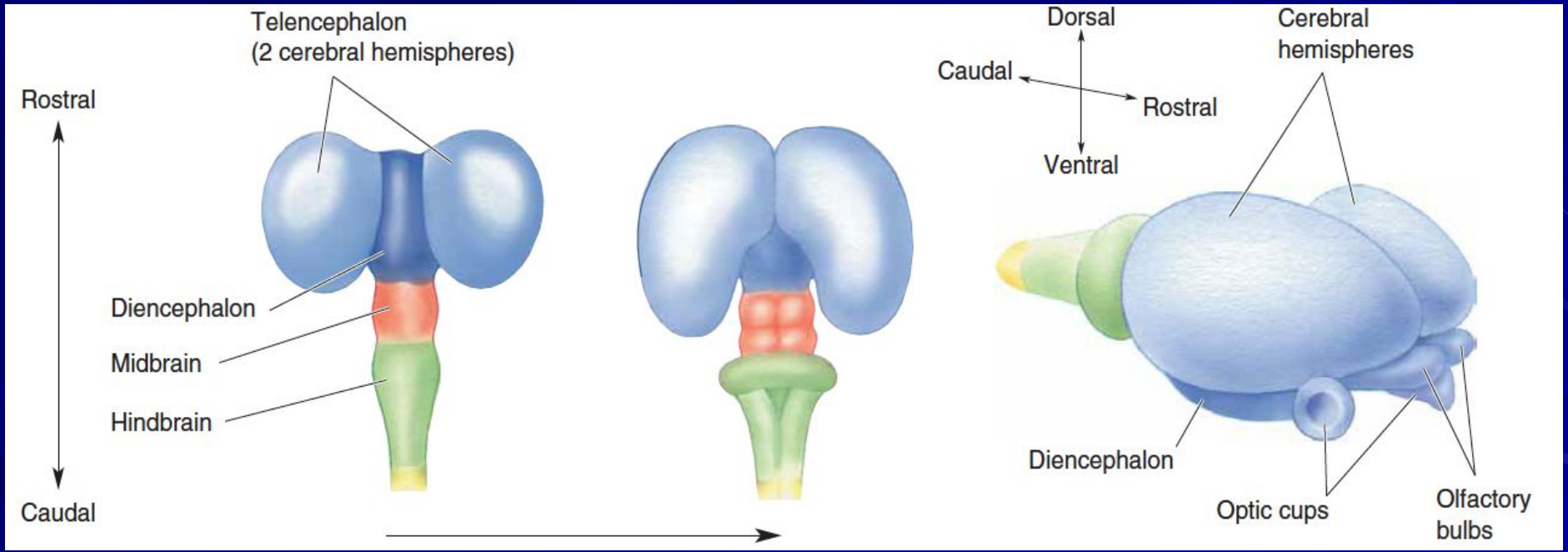
- The optic vesicles grow and invaginate to form the optic stalks and the optic cups, which will ultimately become the optic nerves and the two retinas in the adult





Differentiation of the Telencephalon and Diencephalon

- The telencephalic vesicles together form the telencephalon, consisting of the two cerebral hemispheres.

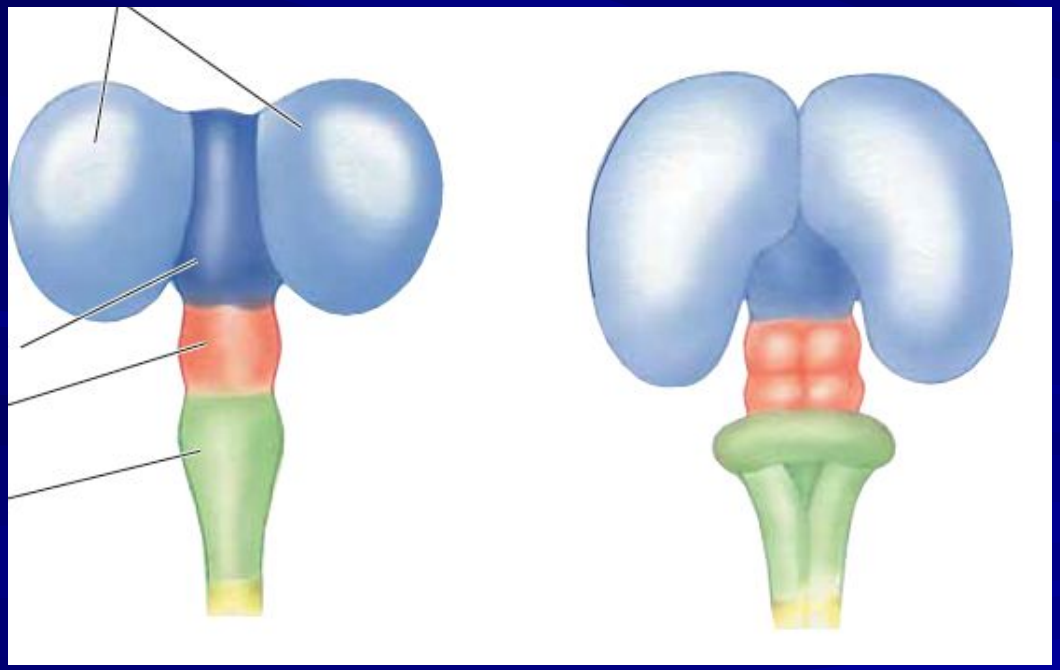


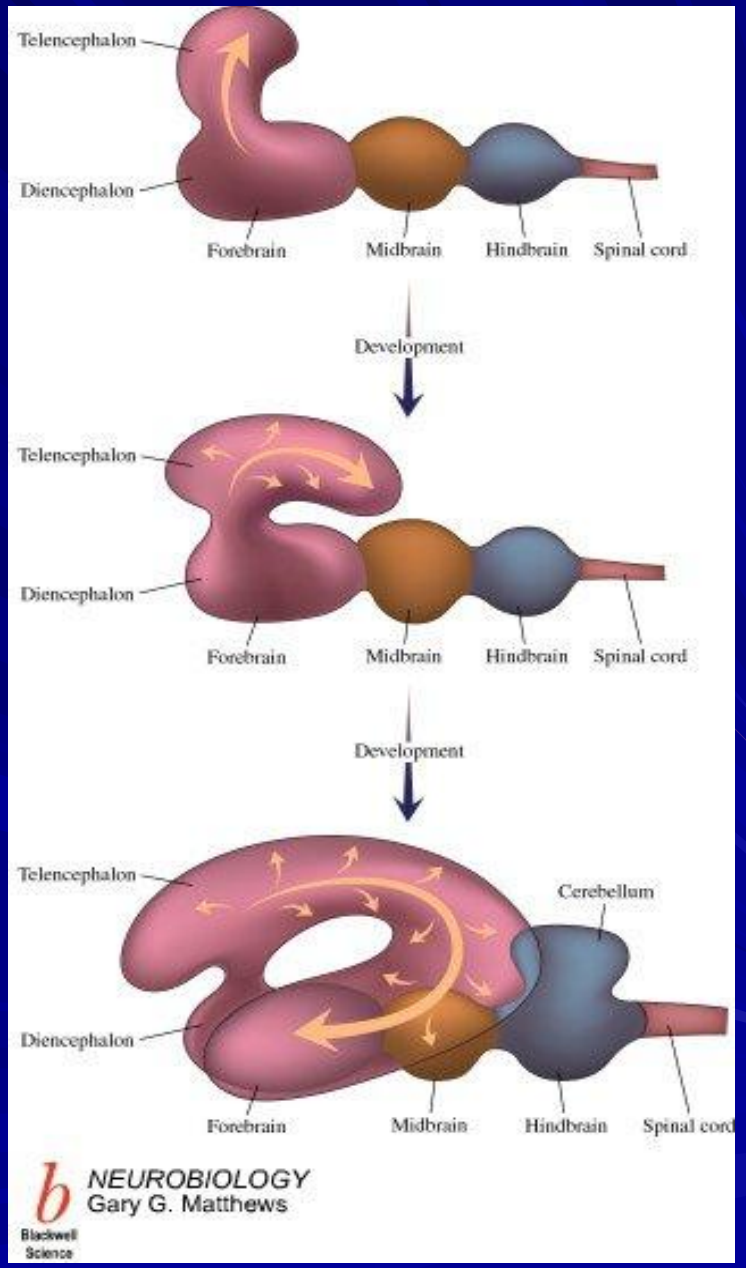
Differentiation of the Telencephalon and Diencephalon

The telencephalon continues to develop in four ways.

First way

The telencephalic vesicles grow posteriorly so that they lie over and lateral to the diencephalon.

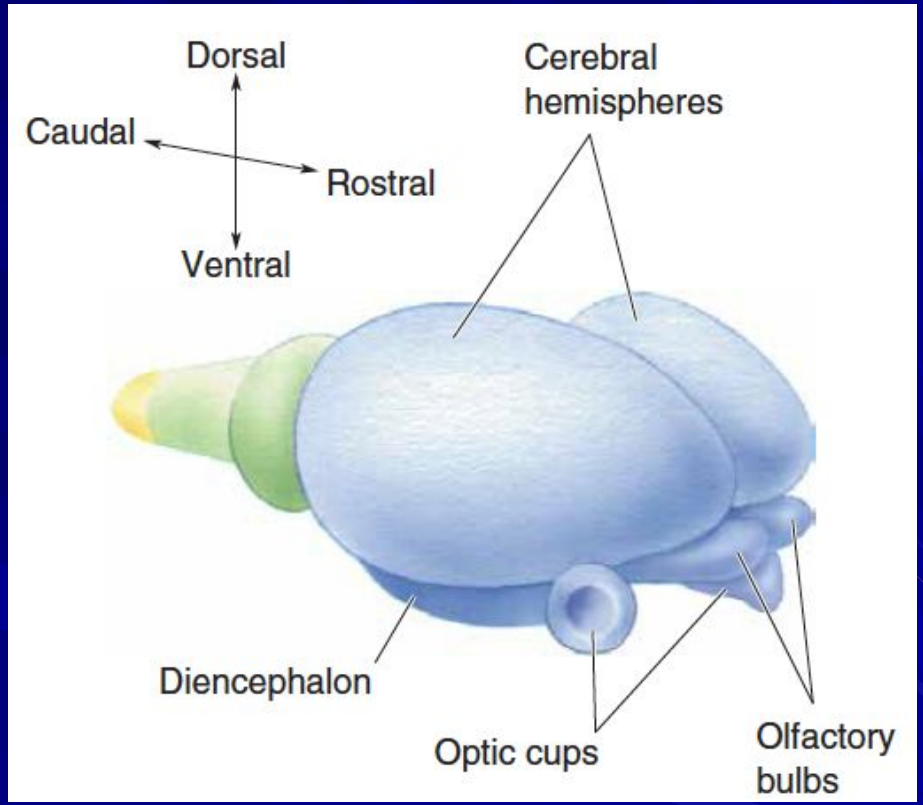




Differentiation of the Telencephalon and Diencephalon

Second way

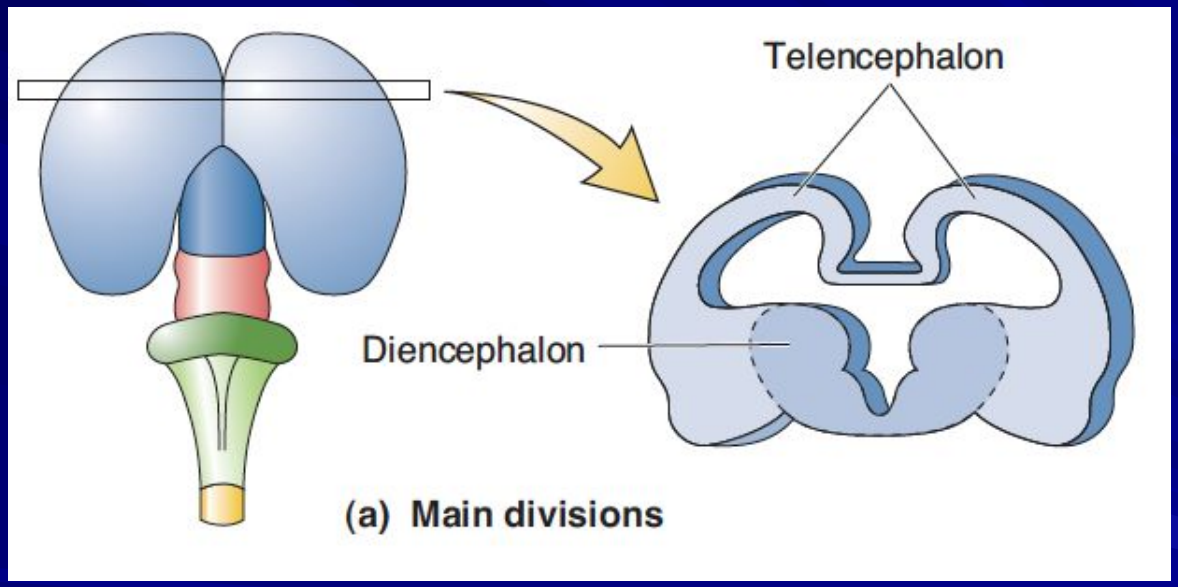
- Another pair of vesicles sprout off the ventral surfaces of the cerebral hemispheres, giving rise to the olfactory bulbs and related structures that participate in the sense of smell



Differentiation of the Telencephalon and Diencephalon

Third way

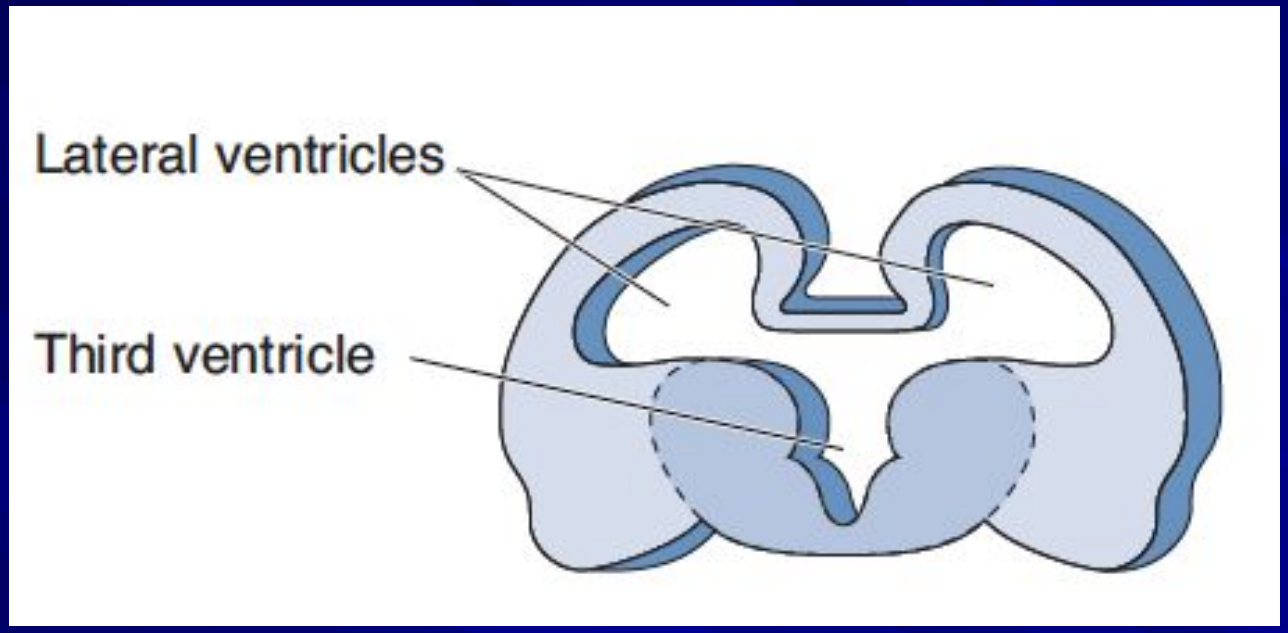
- The cells of the walls of the telencephalon divide and differentiate into various structures.



Fourth way

- White matter systems develop, carrying axons to and from the neurons of the telencephalon.

Differentiation of the Telencephalon and Diencephalon



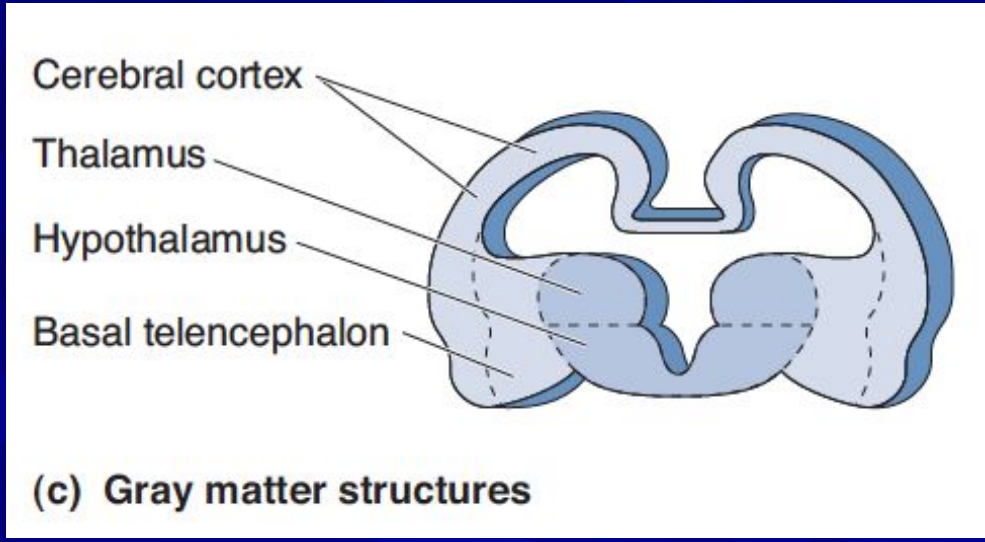
- The fluid-filled spaces within the cerebral hemispheres are called the lateral ventricles
- The space at the center of the diencephalon is called the third ventricle

Differentiation of the Telencephalon and Diencephalon

- The walls of the telencephalic vesicles appear swollen due to the proliferation of neurons.

- These neurons form two different types of gray matter in the telencephalon:

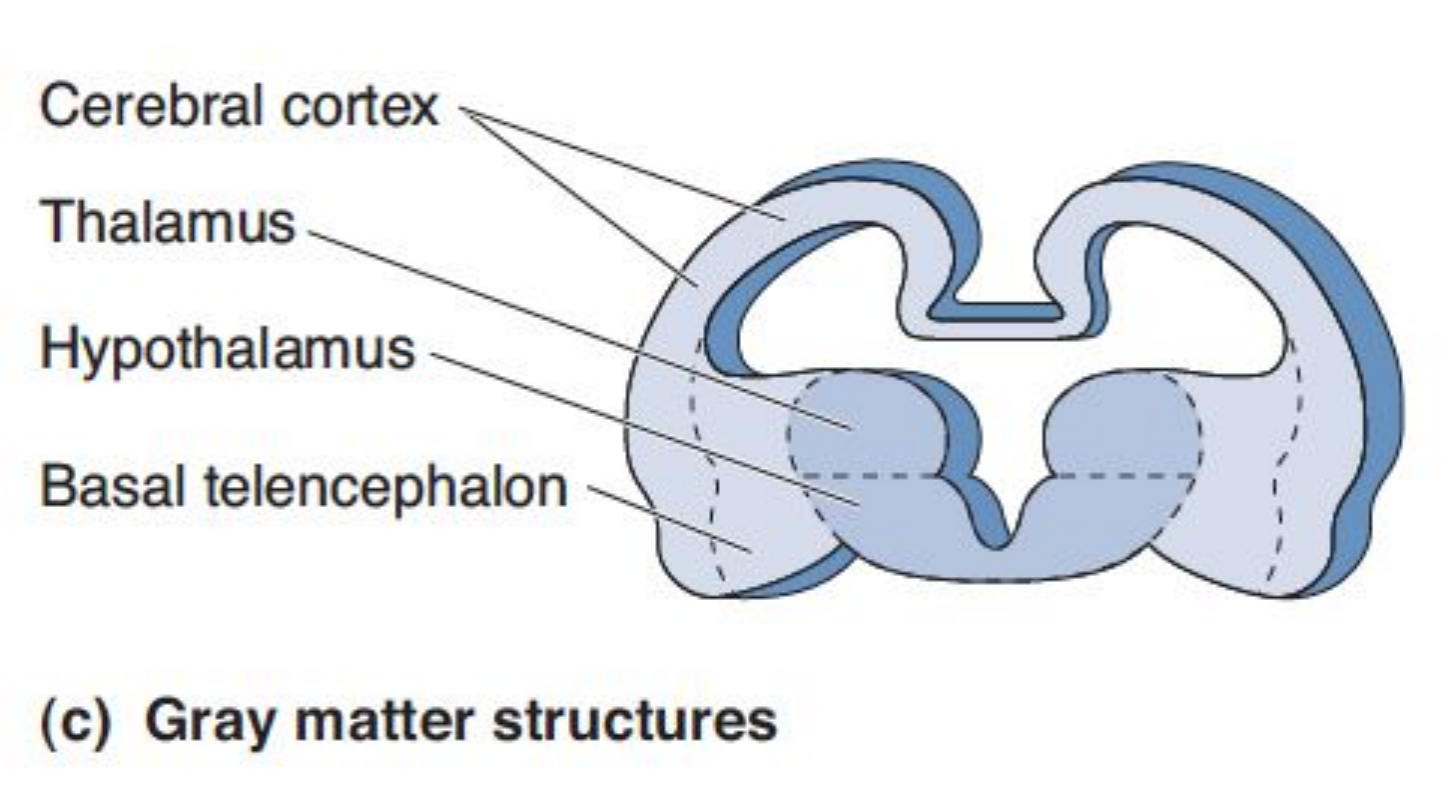
1. the cerebral cortex
2. the basal telencephalon



Differentiation of the Telencephalon and Diencephalon

- The diencephalon differentiates into two structures:

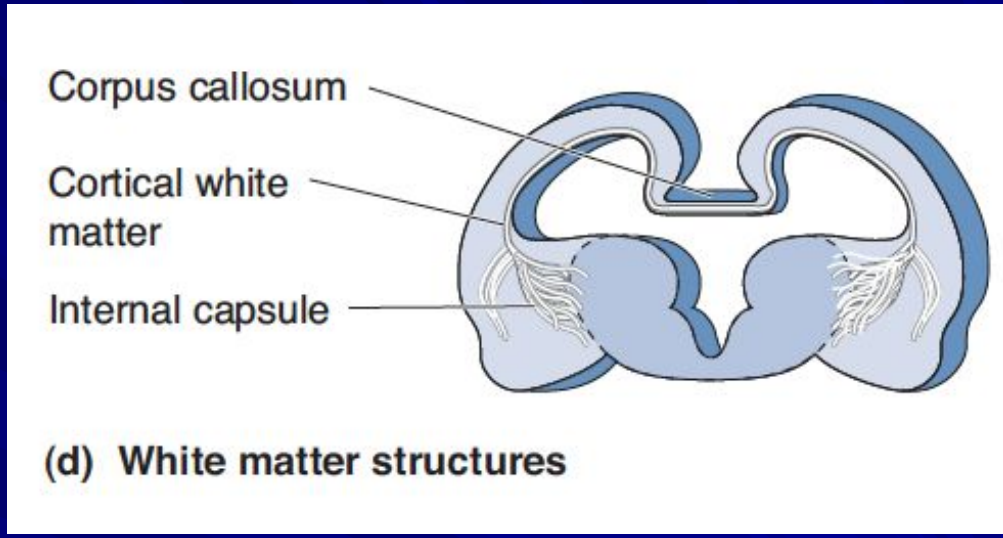
1. the thalamus
2. the hypothalamus



Differentiation of the Telencephalon and Diencephalon

- The neurons of the developing forebrain extend axons to communicate with other parts of the nervous system. These axons bundle together to form three major white matter systems:

1. the cortical white matter
2. the corpus callosum
3. the internal capsule



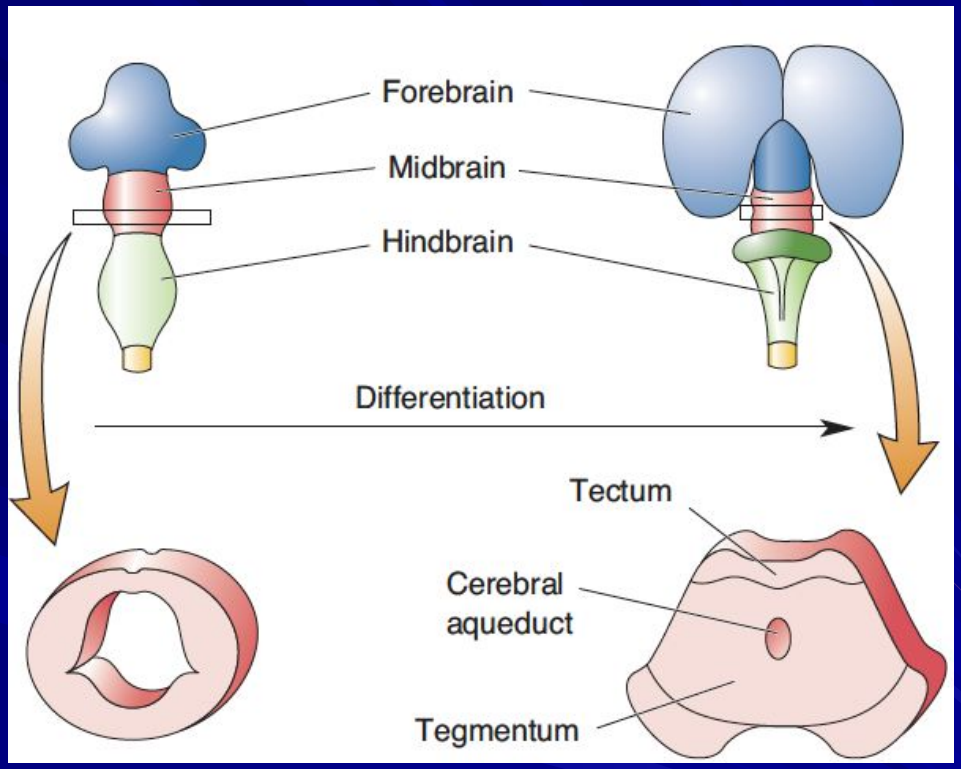
(d) White matter structures

- The cortical white matter contains all the axons that run to and from the neurons in the cerebral cortex.
- The corpus callosum forms an axonal bridge that links cortical neurons of the two cerebral hemispheres.

The internal capsule links the cortex with the brain stem, particularly the thalamus.

Differentiation of the Midbrain

- The midbrain differentiates relatively little during subsequent brain development
- The dorsal surface of the mesencephalic vesicle becomes a structure called the tectum
- The floor of the midbrain becomes the tegmentum.
- The CSF-filled space in between constricts into a narrow channel called the cerebral aqueduct .
- The aqueduct connects rostrally with the third ventricle of the diencephalon.

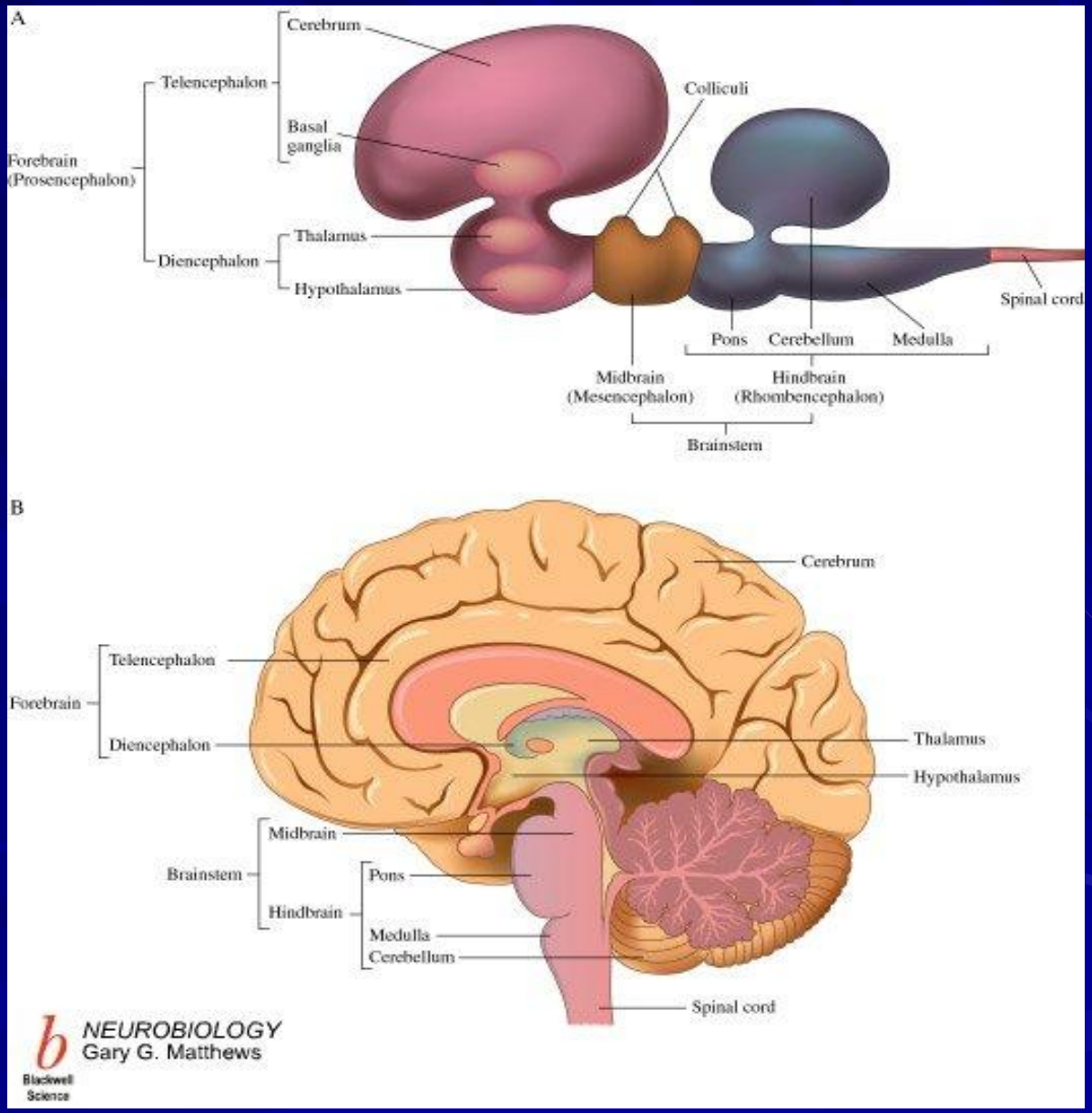


Differentiation of the Hindbrain

- The hindbrain differentiates into three structures:

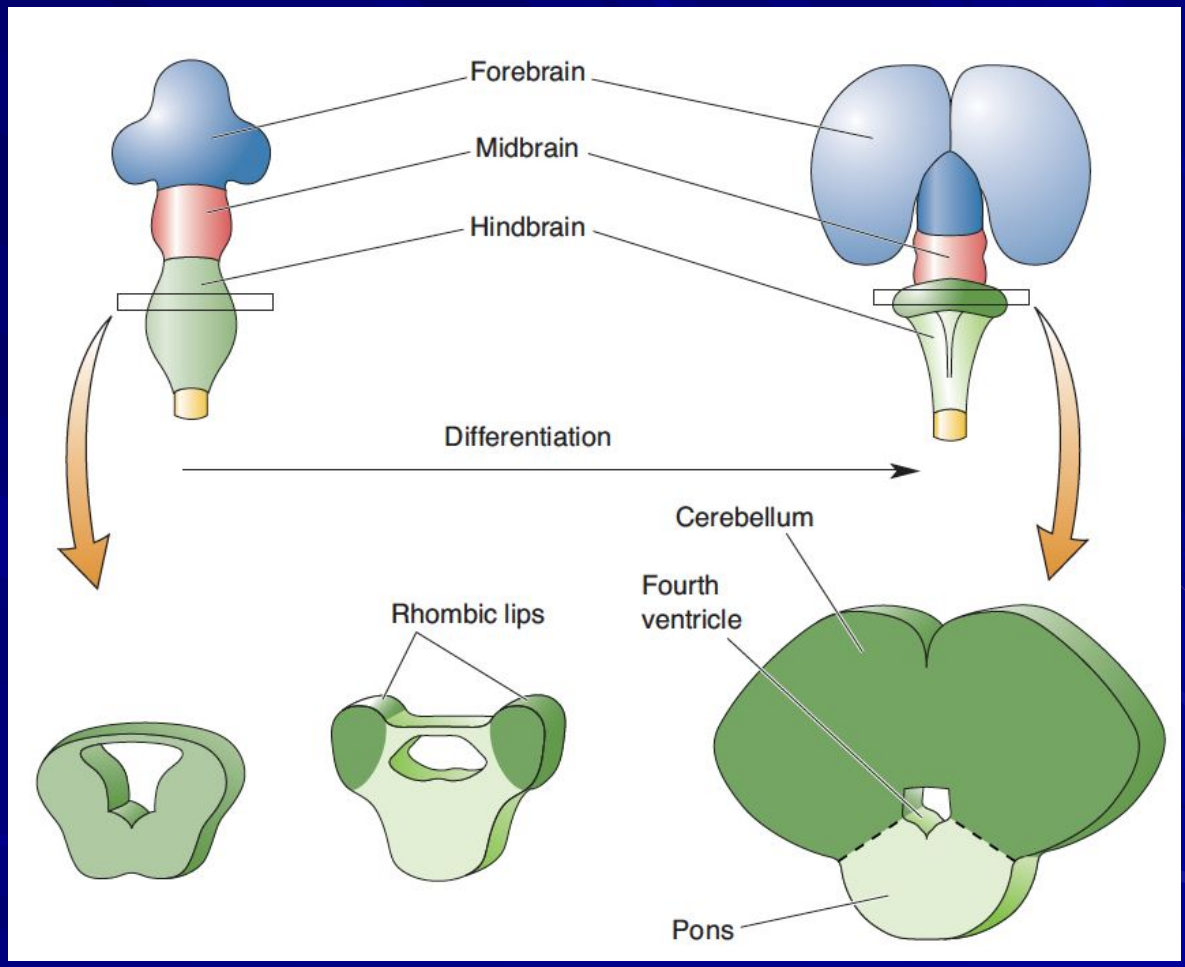
1. cerebellum
2. pons
3. medulla

- The CSF-filled tube becomes the fourth ventricle, which is continuous with the cerebral aqueduct of the midbrain.



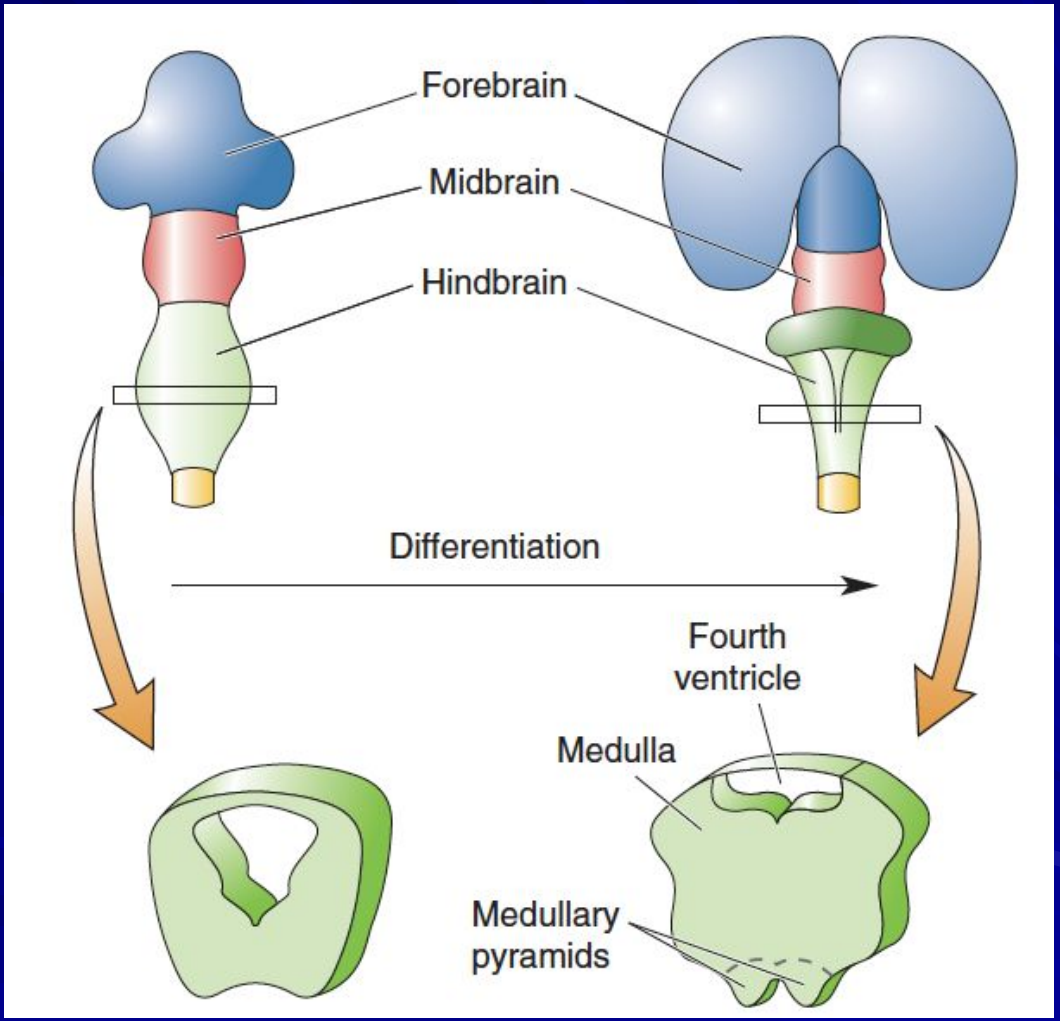
Differentiation of the Hindbrain

- The tissue along the dorsal–lateral wall of the tube (rhombic lips), grows dorsally and medially until it fuses with its twin on the other side.
- The resulting flap of brain tissue grows into the cerebellum.
- The ventral wall of the tube differentiates and swells to form the pons



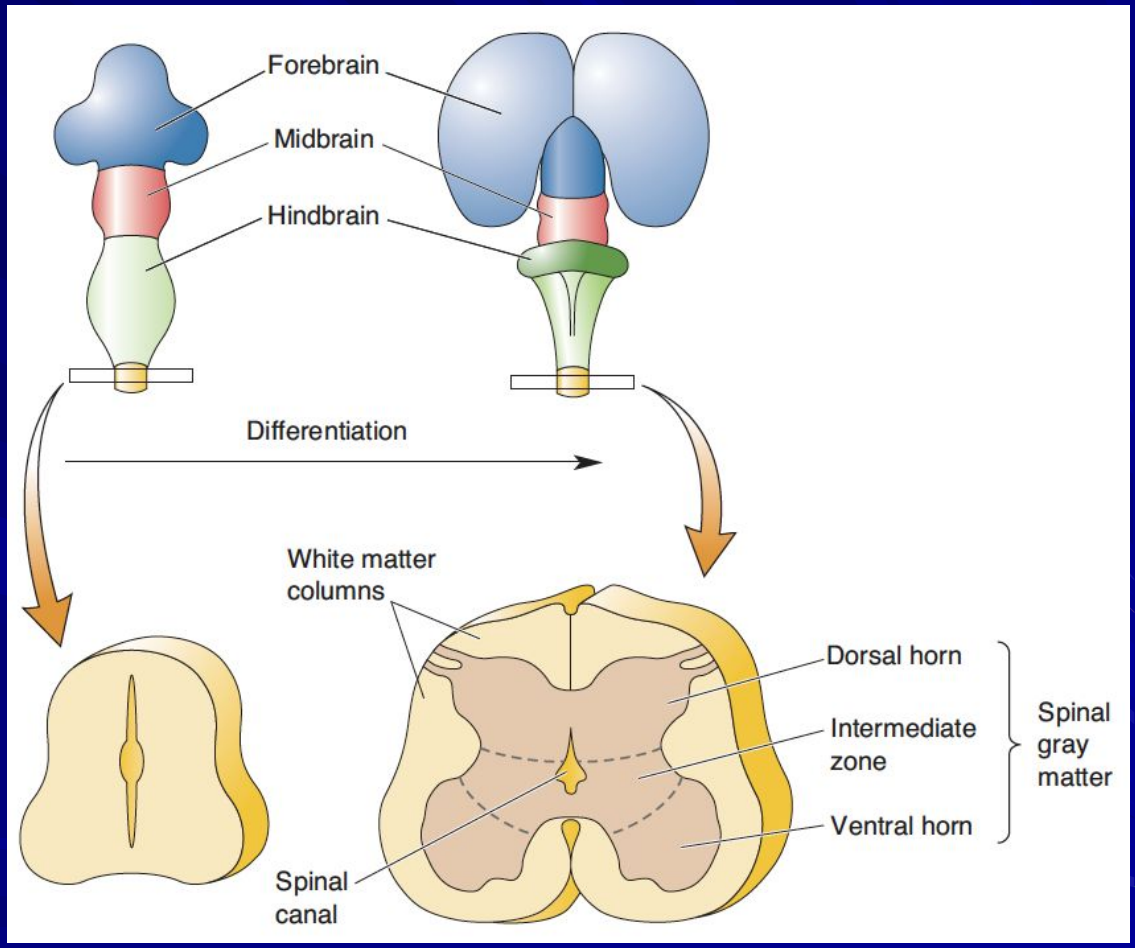
Differentiation of the Hindbrain

- The ventral and lateral walls of caudal half of the hindbrain swell, leaving the roof covered only with a thin layer of nonneuronal ependymal cells.
- Along the ventral surface of each side of the medulla runs a major white matter system - the medullary pyramids



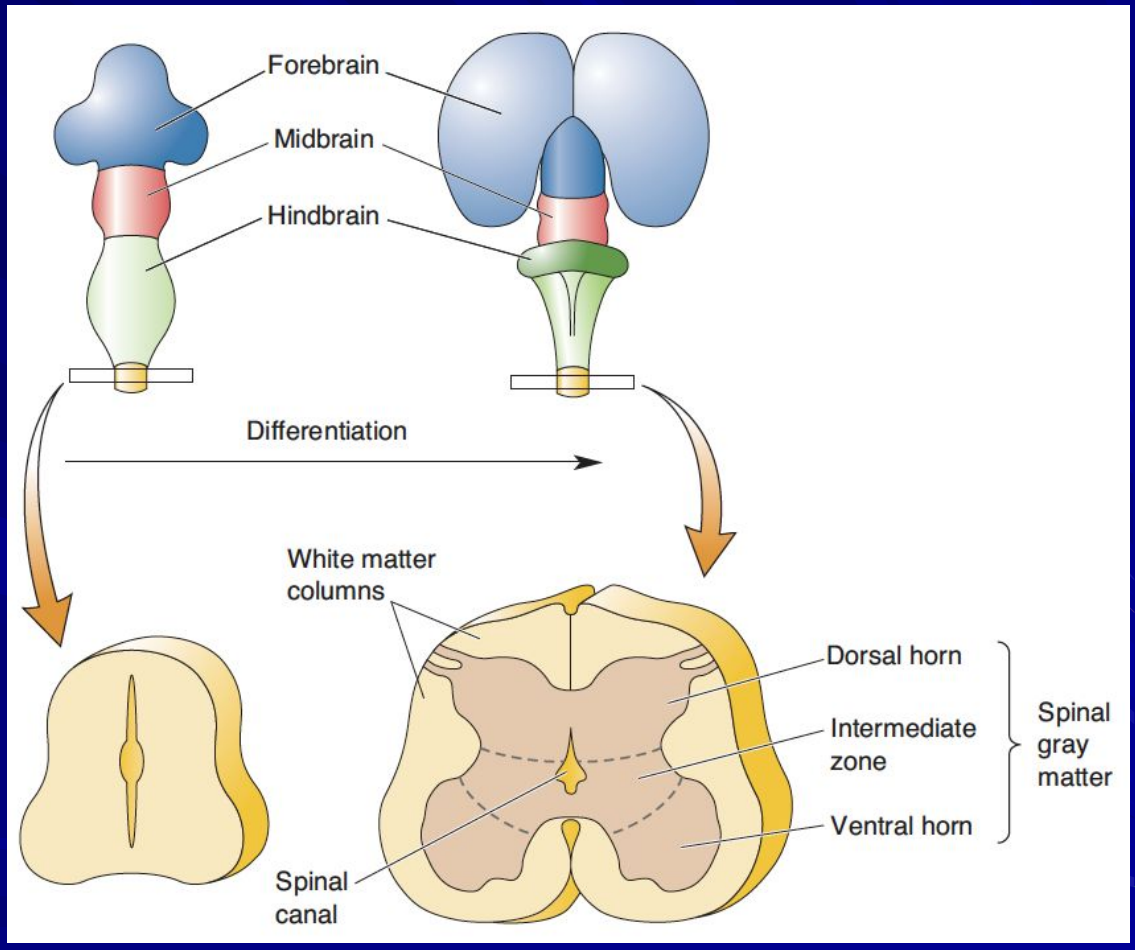
Differentiation of the Spinal Cord

- The cavity of the tube constricts to form the tiny CSF-filled spinal canal
- The gray matter of the spinal cord has the appearance of a butterfly.
- The upper part of the gray matter is the dorsal horn, and the lower part is the ventral horn
- The gray matter between the dorsal and ventral horns is the intermediate zone .

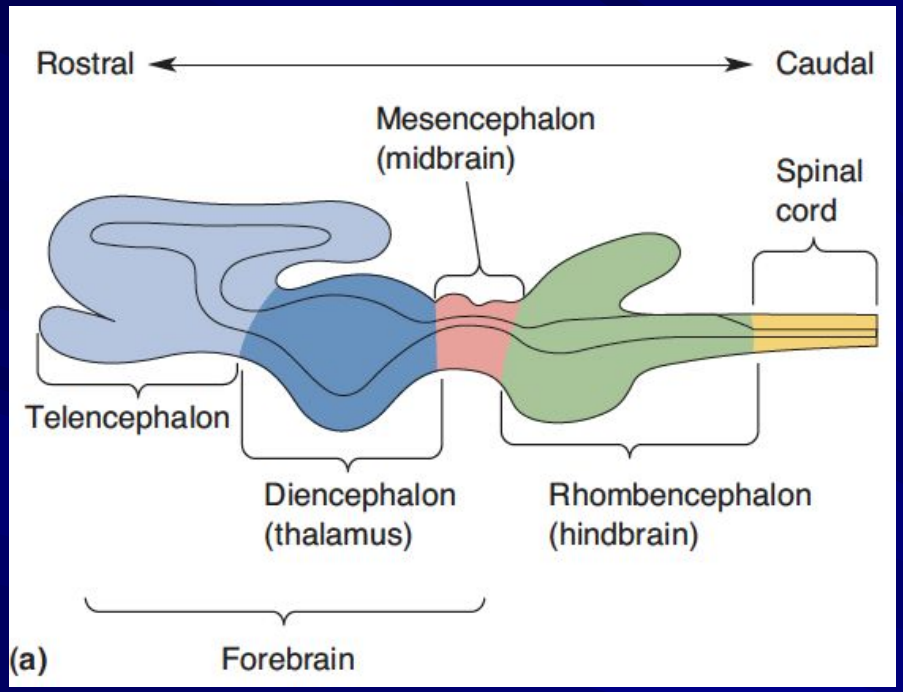


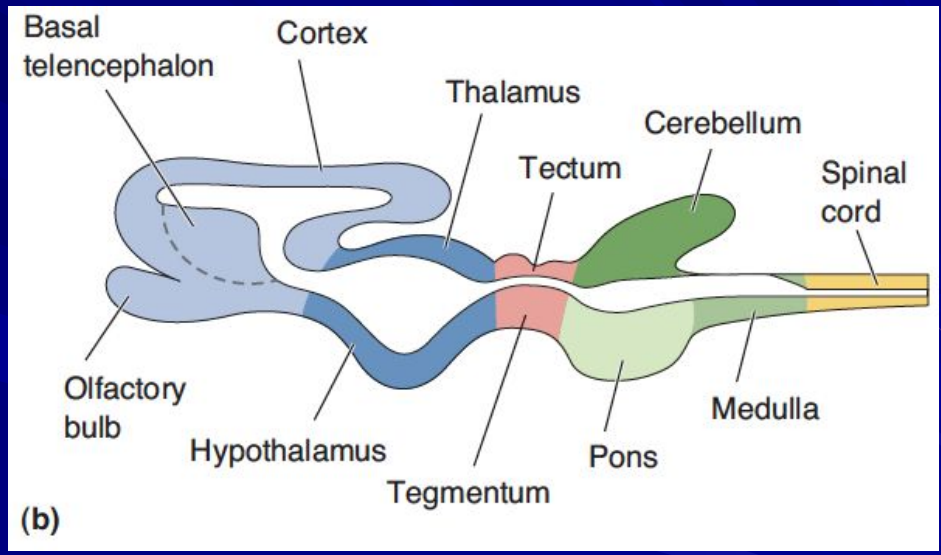
Differentiation of the Spinal Cord

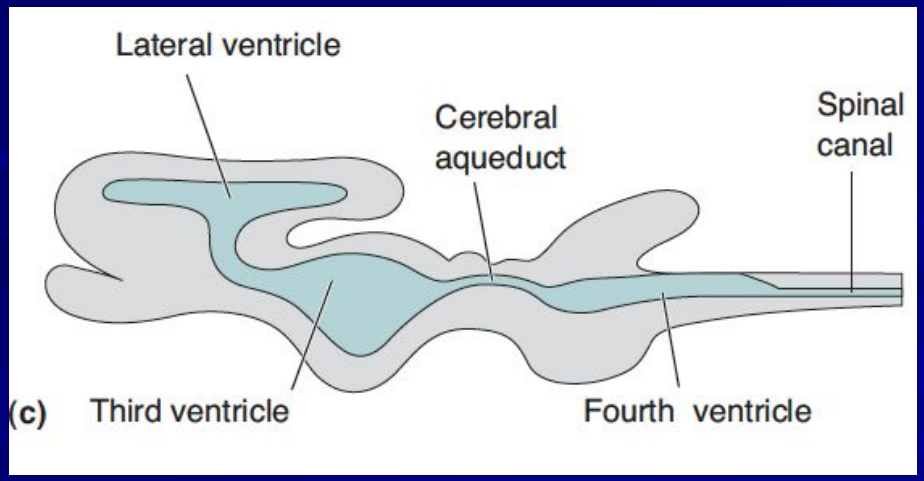
- The white matter consists of columns of axons that run up and down the spinal cord.
- The bundles of axons running along the dorsal surface of the cord are the dorsal columns
- The bundles of axons lateral to the spinal gray matter on each side are the lateral columns
- The bundles on the ventral surface are the ventral columns



Resume of brain development







Resume of brain development

TABLE 7.3 **The Ventricular System of the Brain**

Component	Related Brain Structures
Lateral ventricles	Cerebral cortex Basal telencephalon
Third ventricle	Thalamus Hypothalamus
Cerebral aqueduct	Tectum Midbrain tegmentum
Fourth ventricle	Cerebellum Pons Medulla