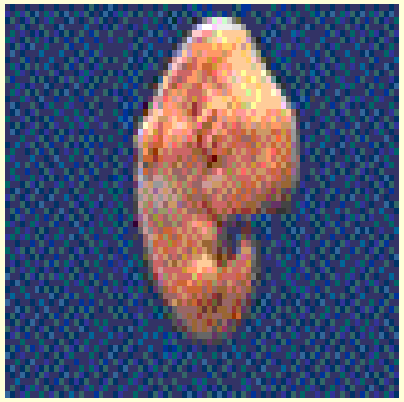


Embryology /organogenesis/

Development and teratology of nervous system.

Repetition: nervous tissue.

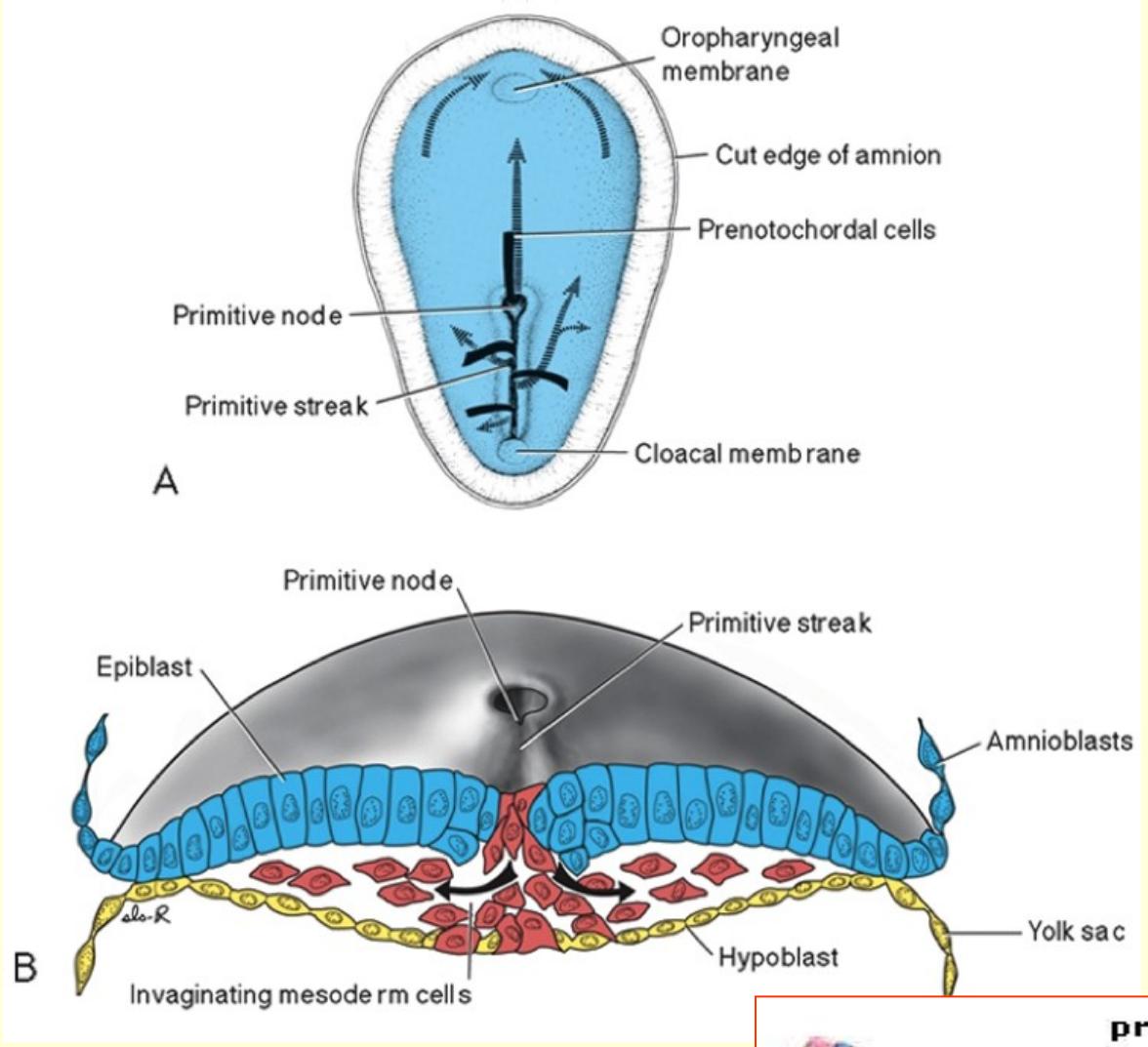
Special embryology - questions

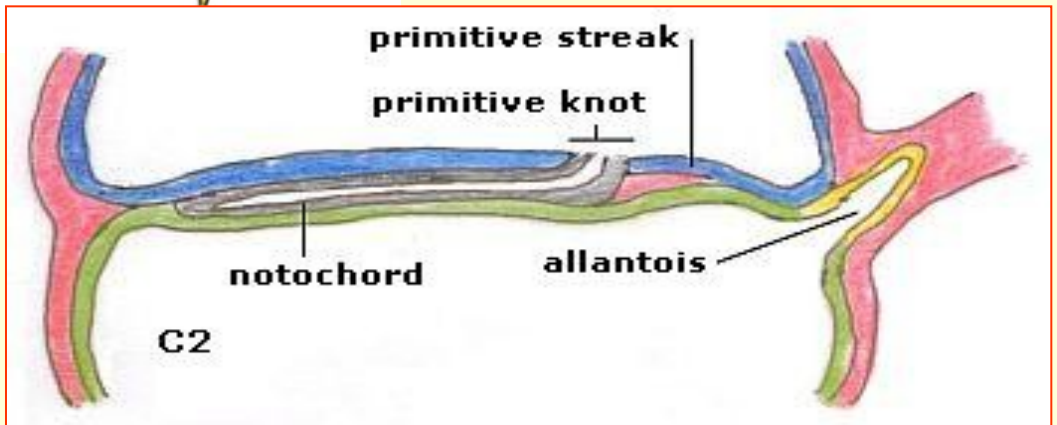
- Development of neural (ganglionic) crest and its differentiation.
- Development of spinal cord.
- Development of the brain – differentiation of secondary brain vesicles; brain chambers.
- Developmental abnormities of central nerve system.

NOTOCHORD DEVELOPMENT

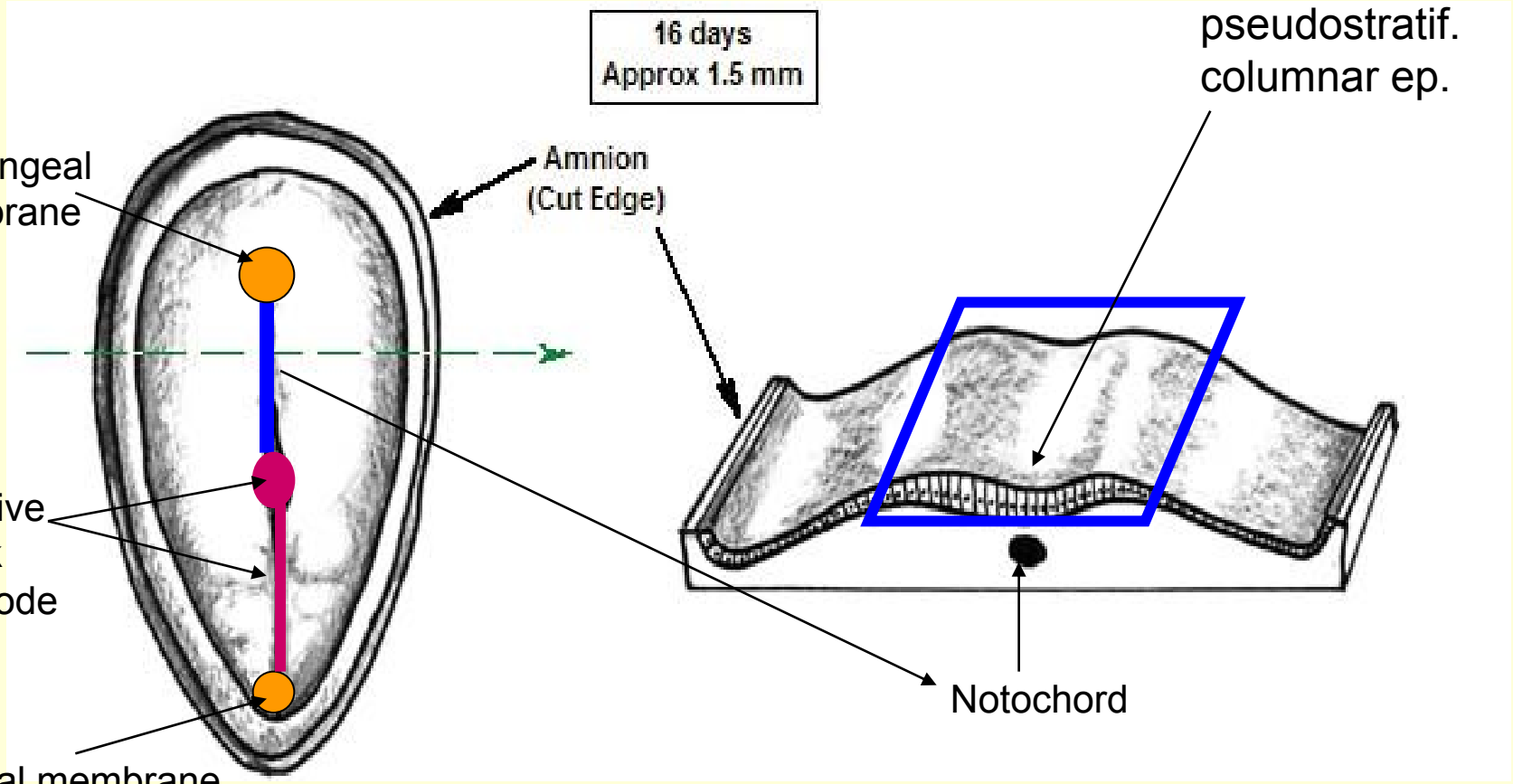
NOTOCHORD

- induction of neural plate development

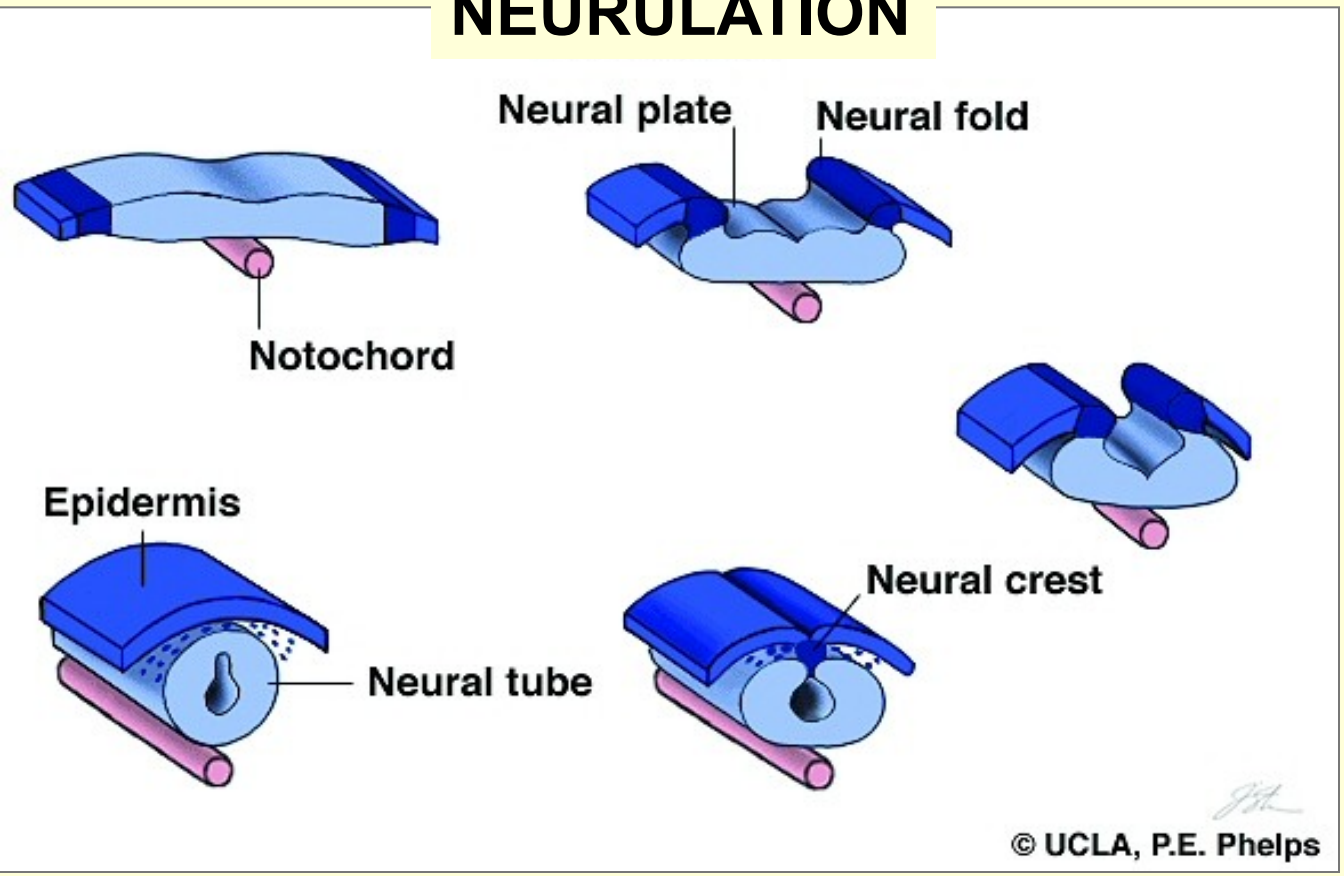


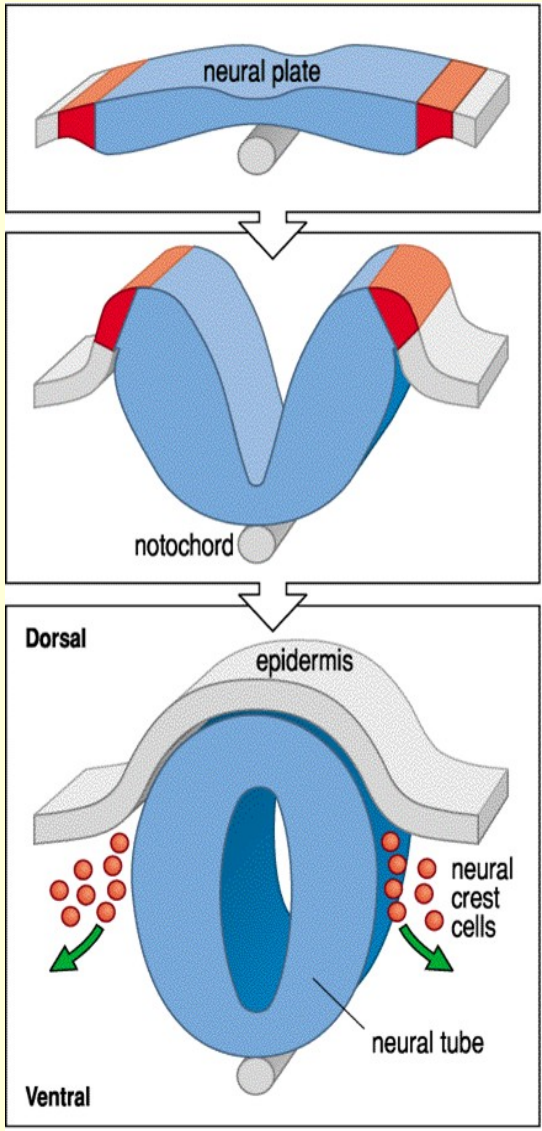


Neural plate – thickened area of embryonic ectoderm ⇨ **neuroectoderm**

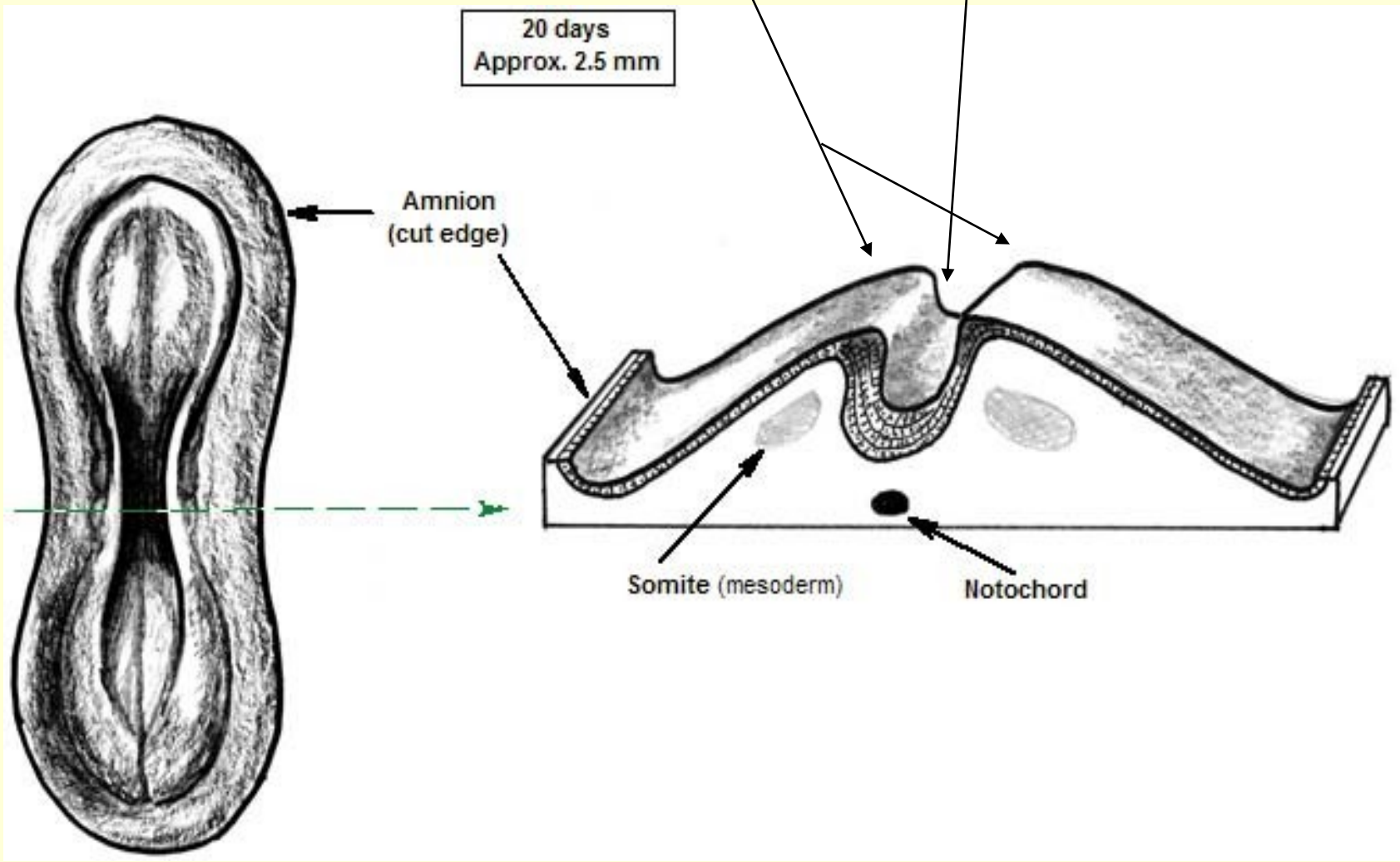


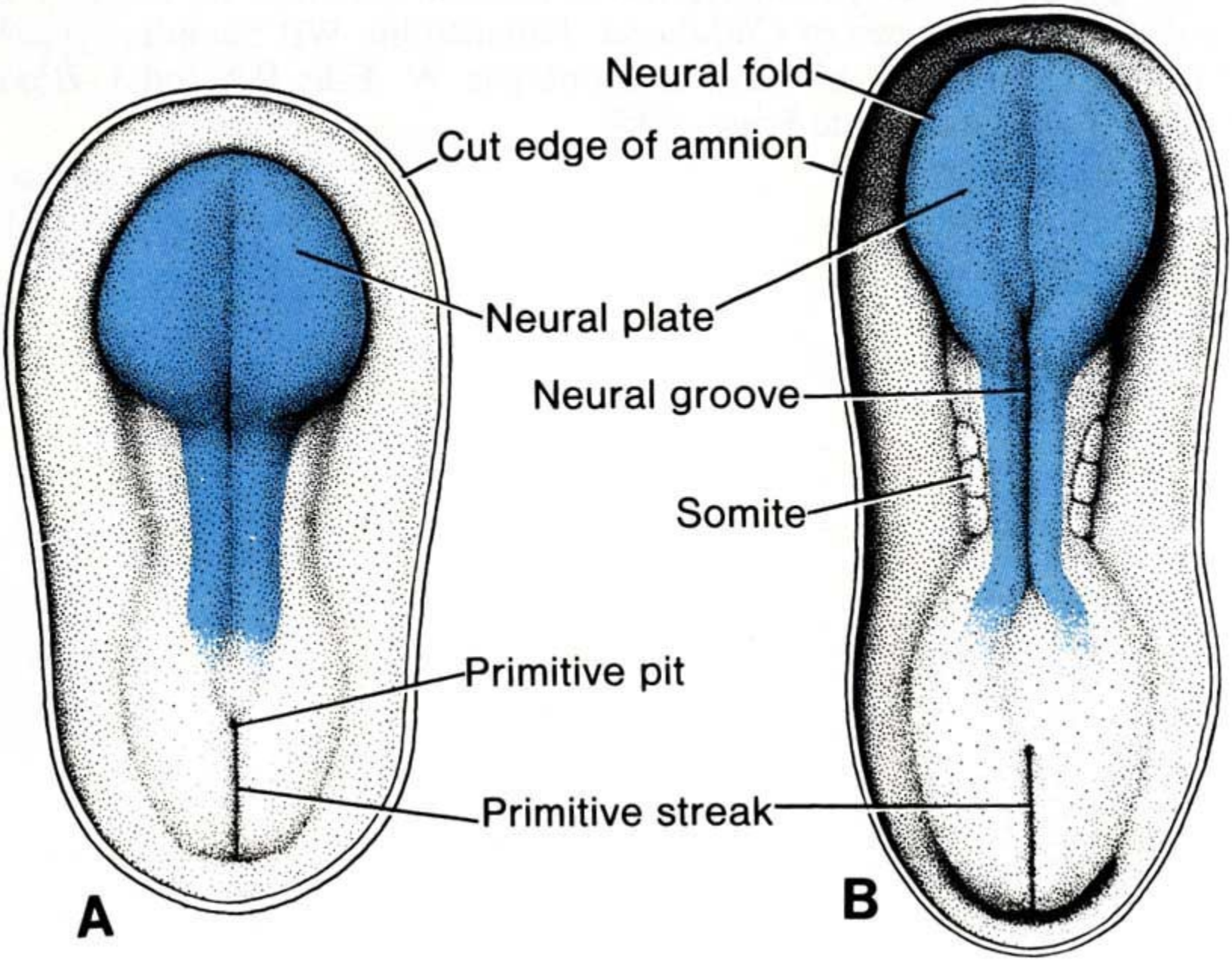
NEURULATION

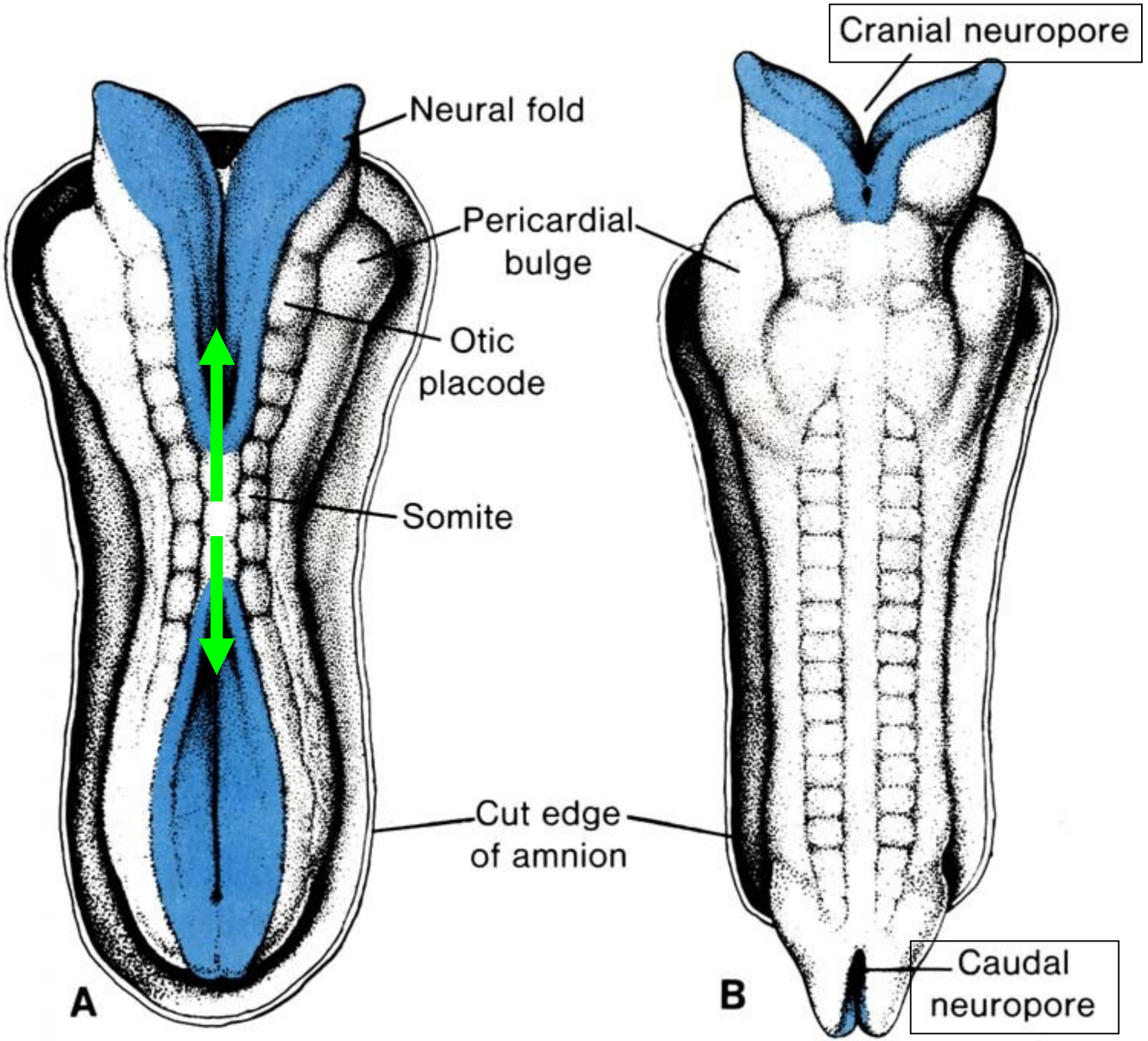




Invagination of neural plate ⇨ neural folds + neural groove

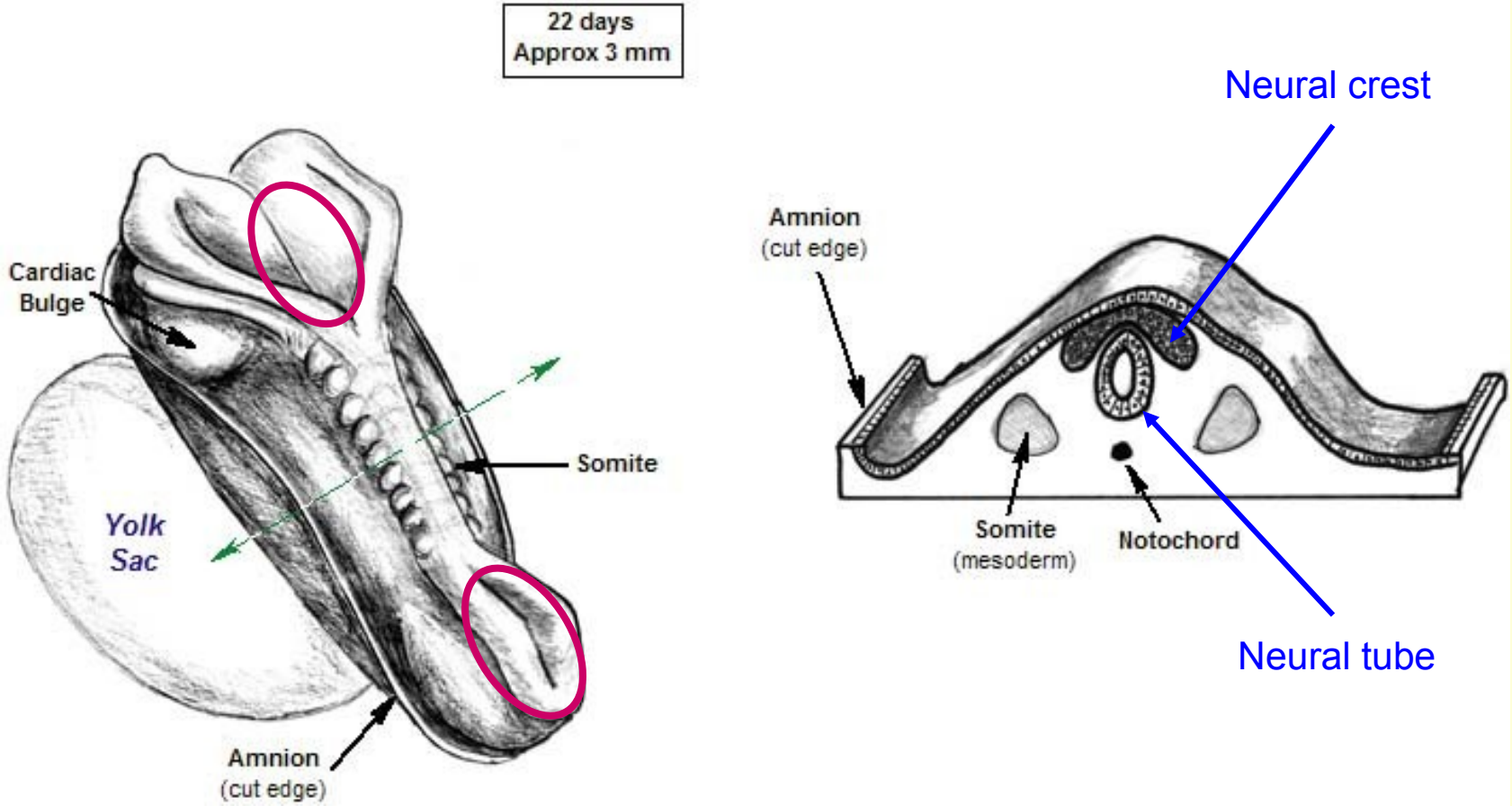


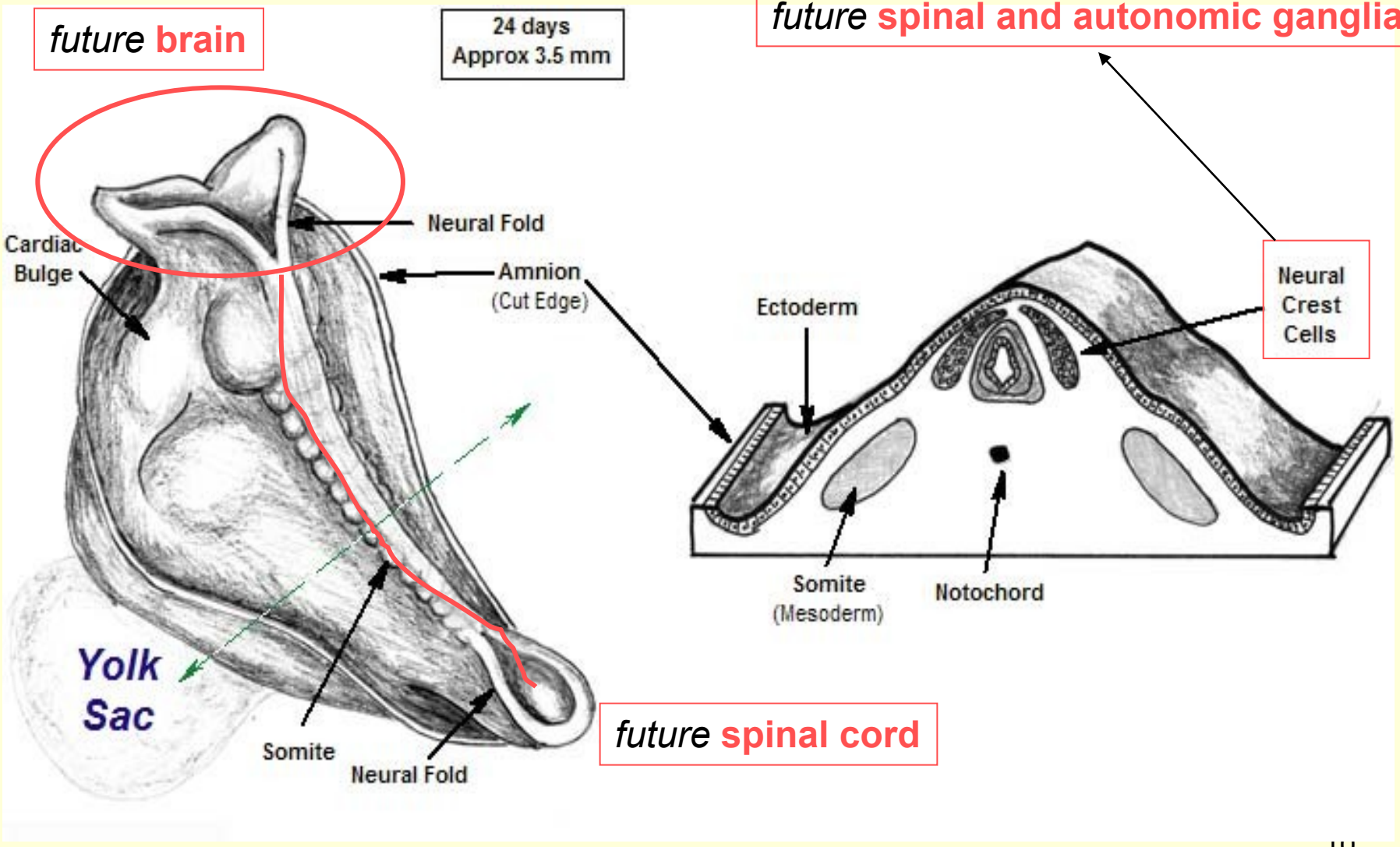

Neural fold
Cut edge of amnion
Neural plate
Neural groove
Somite
Primitive pit
Primitive streak
A
B


Cranial neuropore
Neural fold
Pericardial bulge
Otic placode
Somite
Cut edge of amnion
Caudal neuropore
A
B

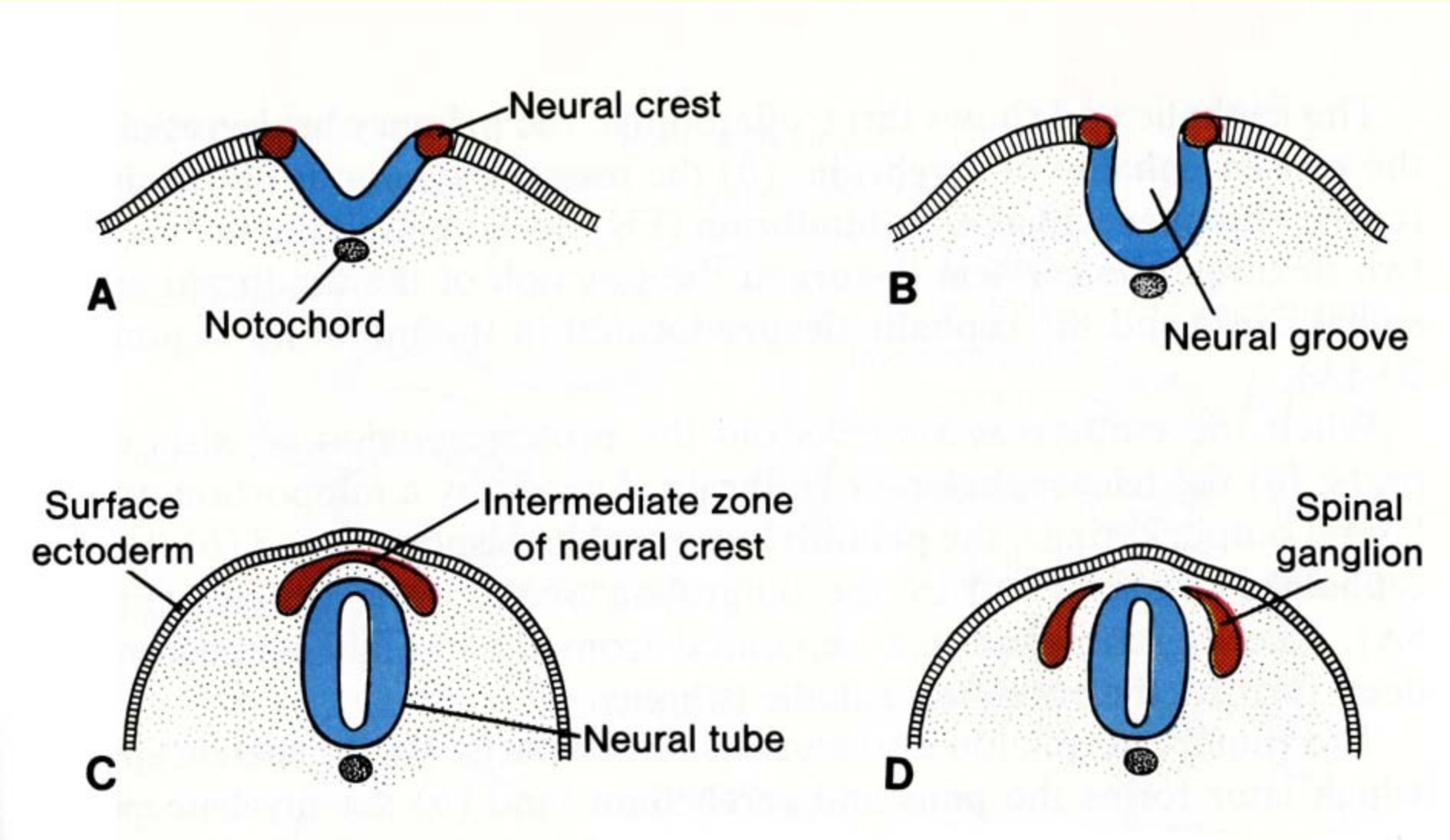
Neural tube and neural crest

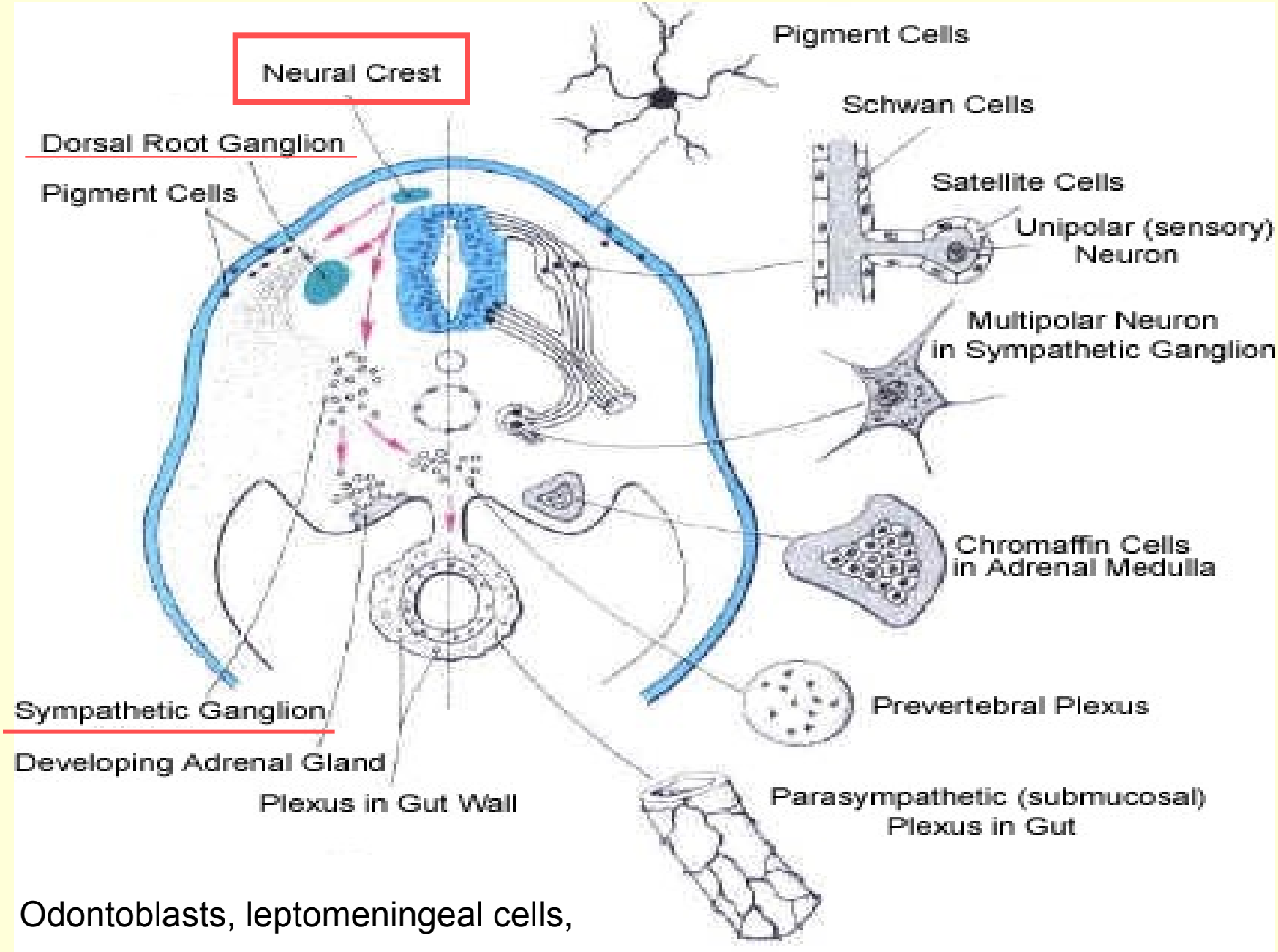
Neuroporus ant., post.



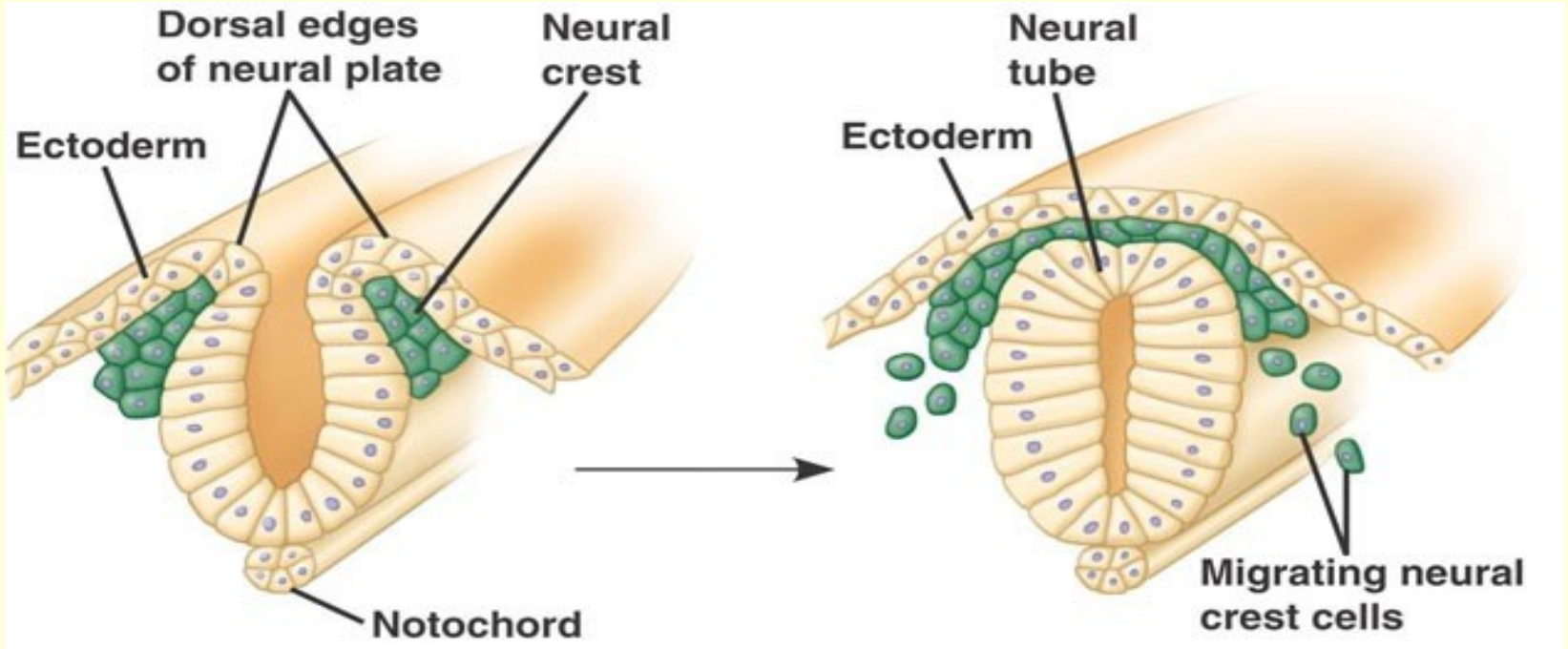

future brain
24 days
Approx 3.5 mm
future spinal and autonomic ganglia
Neural Fold
Cardiac Bulge
Amnion
(Cut Edge)
Ectoderm
Neural Crest Cells
Somite
(Mesoderm)
Notochord
Yolk Sac
Somite
Neural Fold
future spinal cord

NEURAL CREST





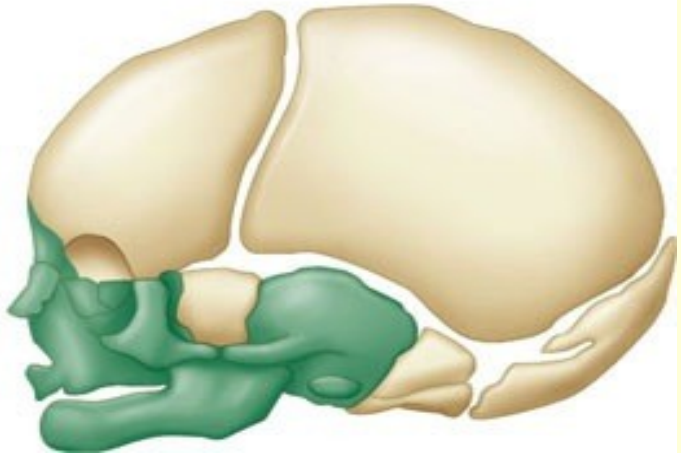
Odontoblasts, leptomeningeal cells,



(a) The neural crest consists of bilateral bands of cells near the margins of the embryonic folds that form the neural tube.

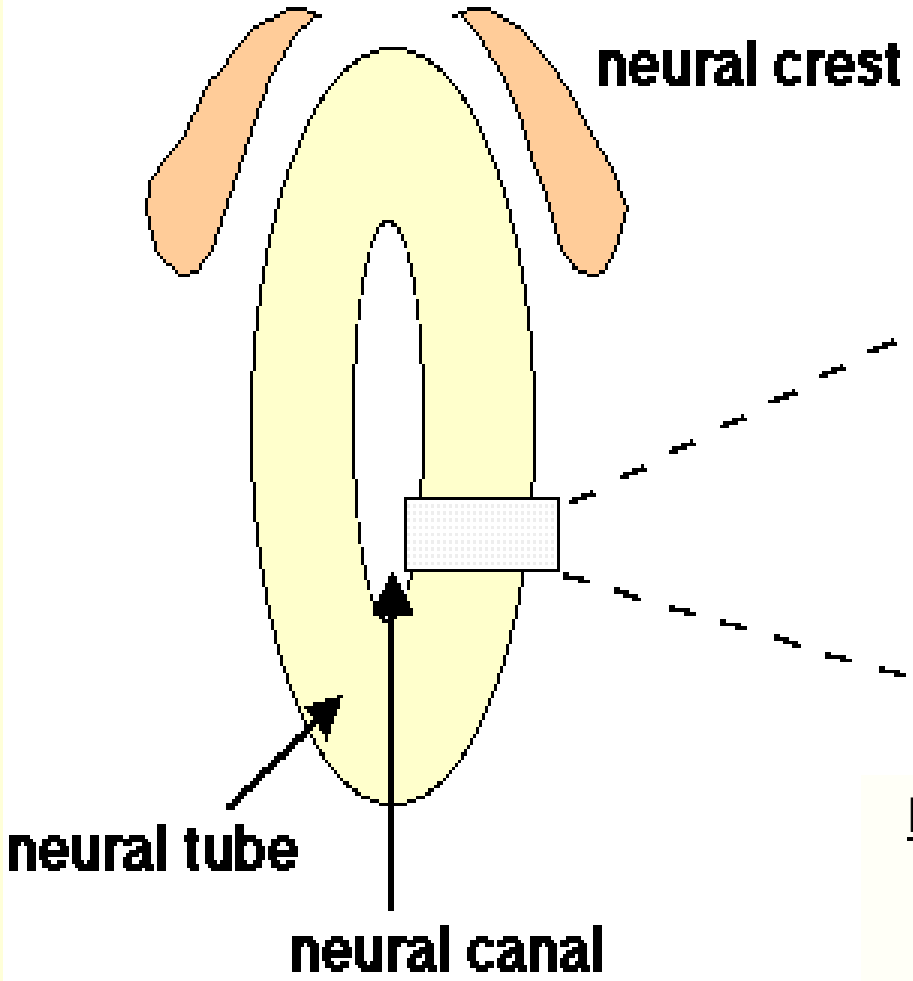
(b) Neural crest cells migrate to distant sites in the embryo.

(c) The cells give rise to some of the anatomical structures unique to vertebrates, including some of the bones and cartilage of the skull.

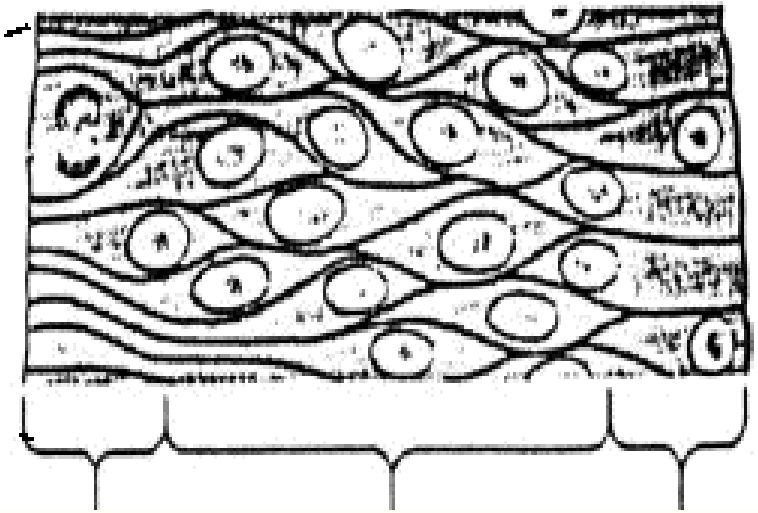


Histogenesis of neural tube

The wall of neural tube – several cell layers
(simple → pseudostratified neural epithelium)
Cell proliferation ⇨ 3 layers (zones):



(in brain and cerebellum: cells from mantle zone migrate through marginal zone; gray matter coveres white matter)



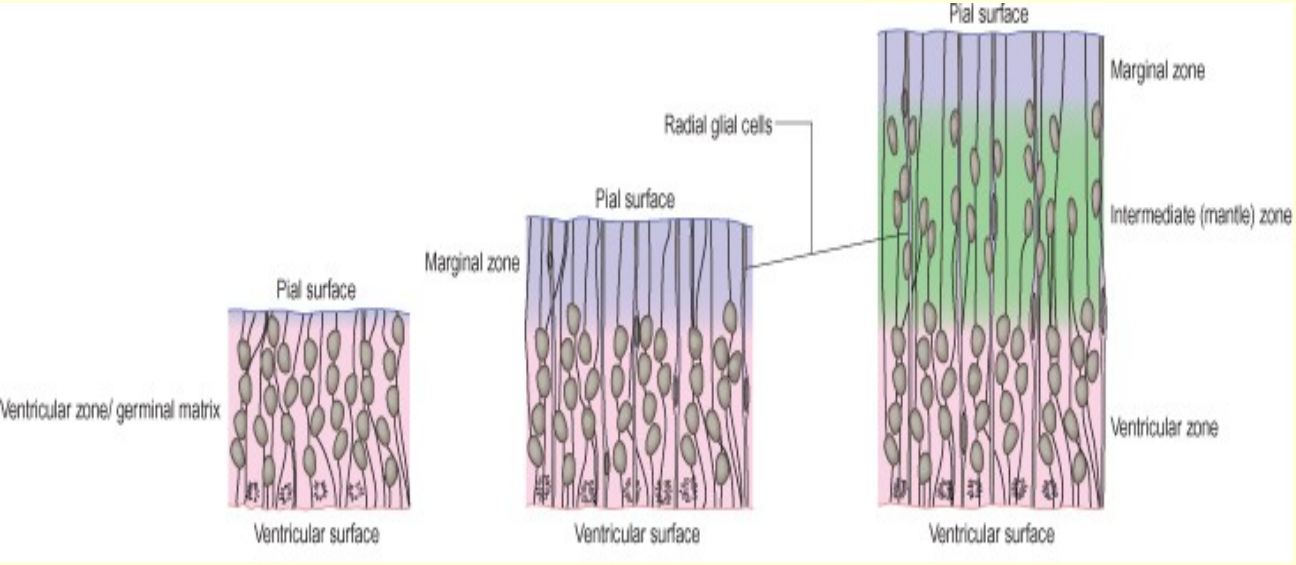
Ependymal — Mantle — Marginal

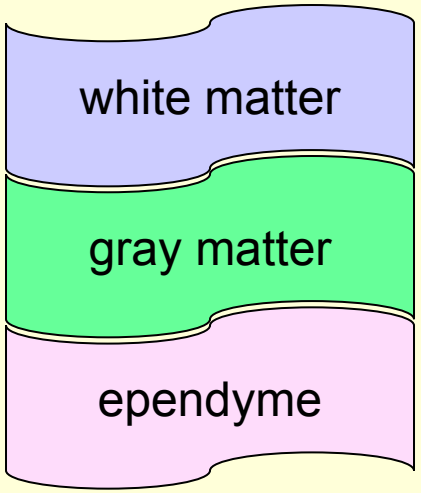
layer (zone)

Ependyma — Gray matter — White matter

(in medulla spinalis)

Histogenesis of neural tissue

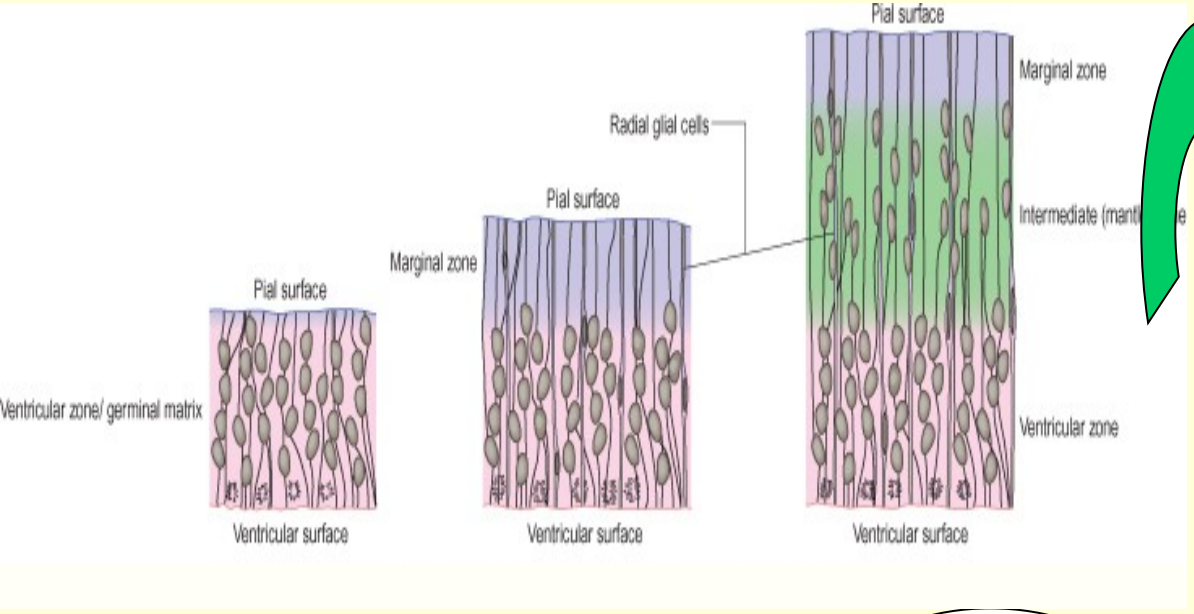


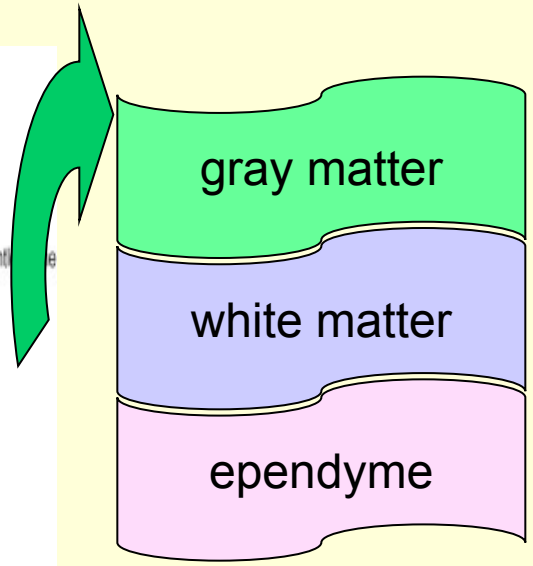


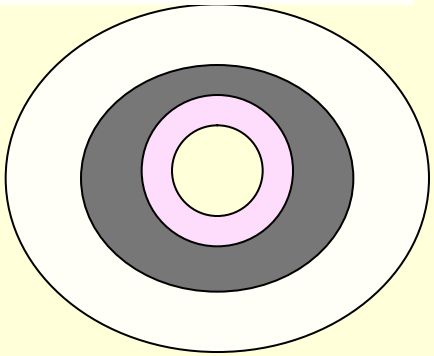
Three layers can lines neural tube (the spinal cord and brain stem).

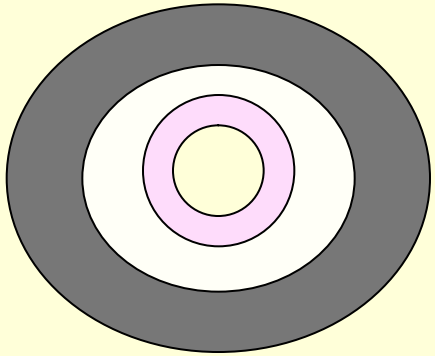
Ependymal layer (germinal) – lining of central canal
Mantle layer (gray matter) – neuroblasts + spongioblasts give rise to perikarya of neurons and glial cells
Marginal layer (white matter) – without neurons, but with axons of neurons and glial cells

In spinal cord → In brain and cerebellum





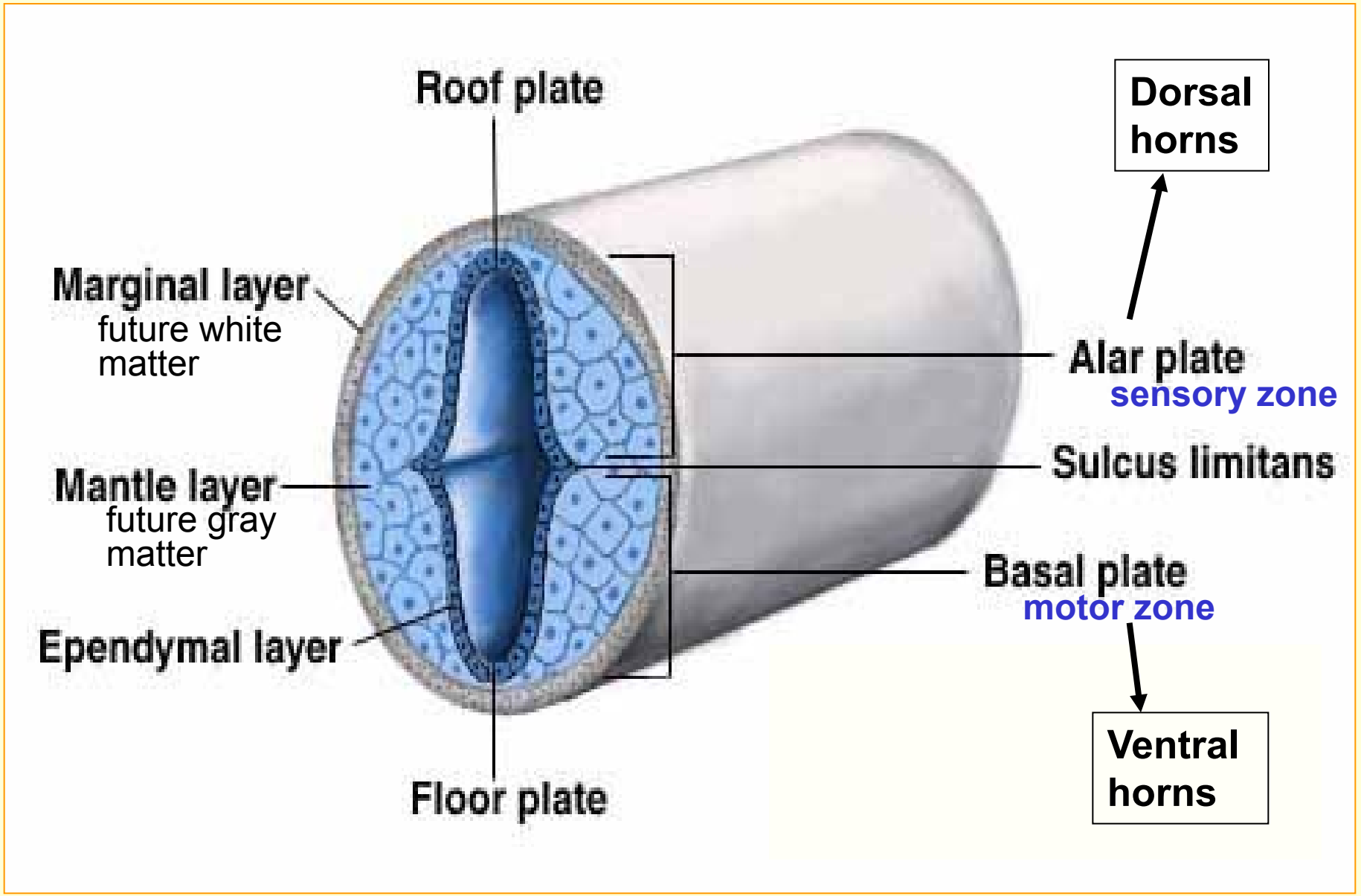




In brain and cerbellum:

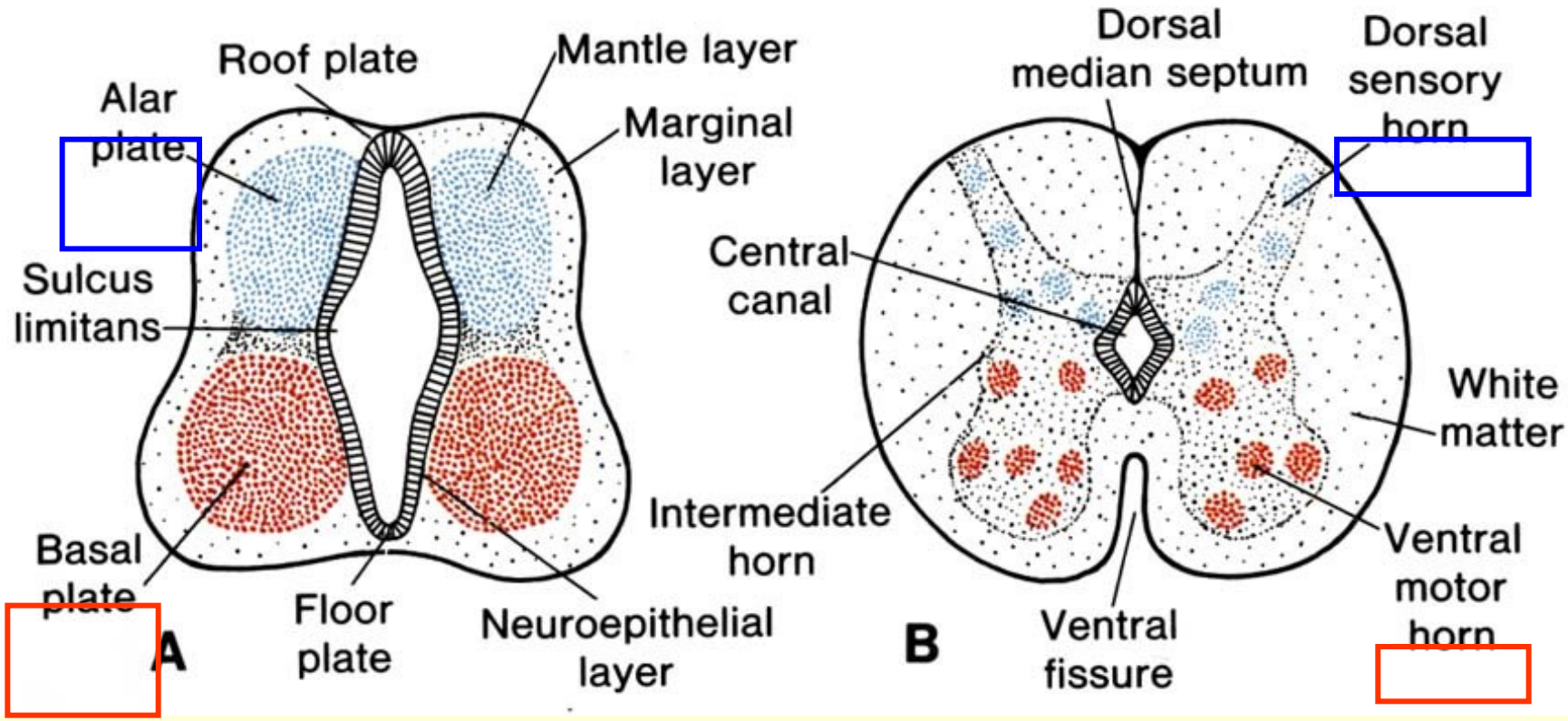
mantle layer cells migrate through marginal layer and the gray matter coveres white matter. Some neurons stay in white matter ⇨ nuclei.

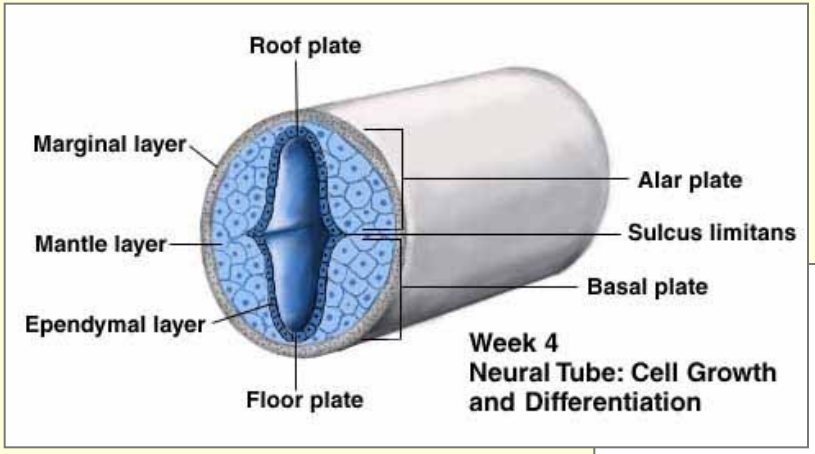
Spinal cord development

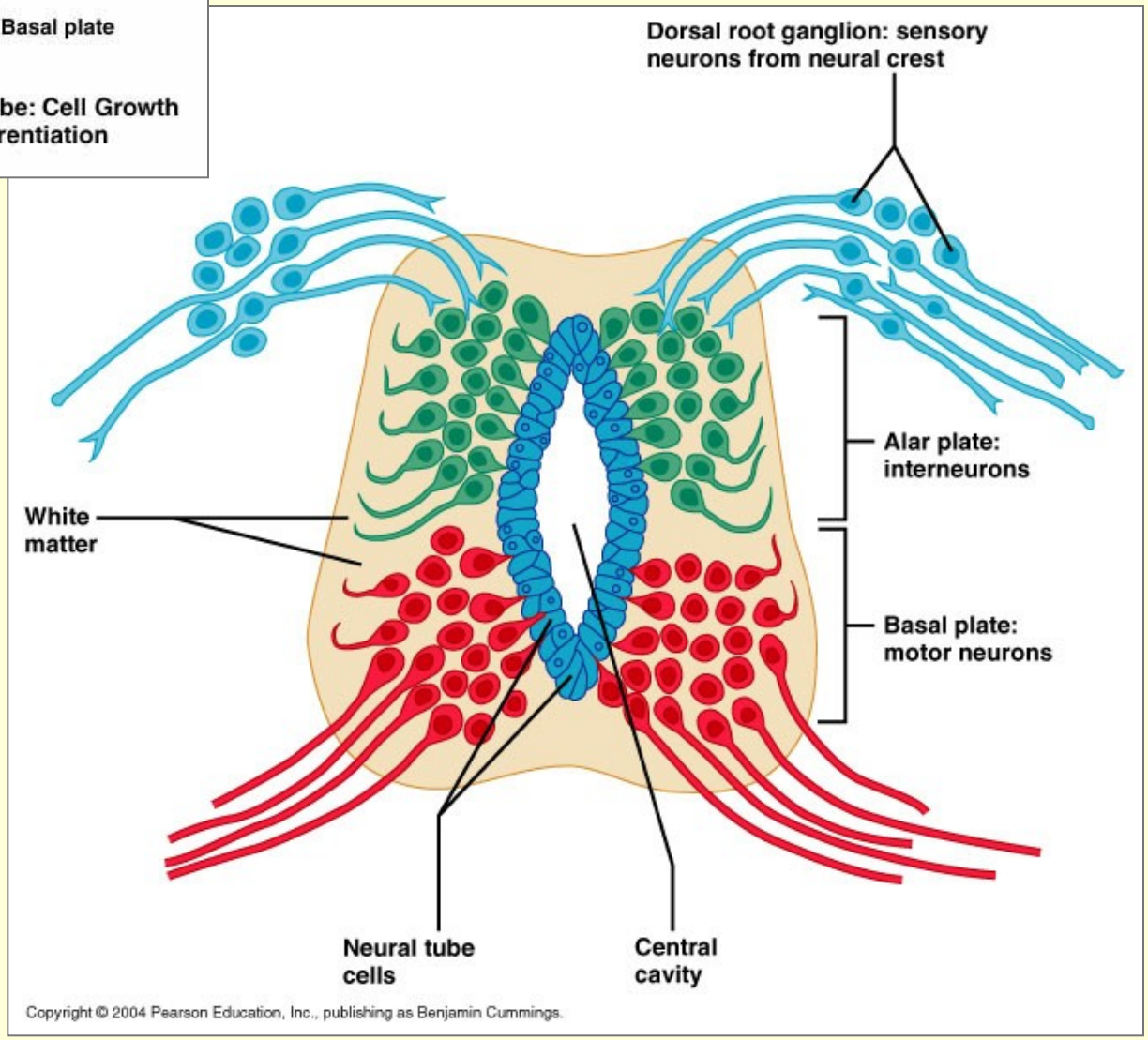


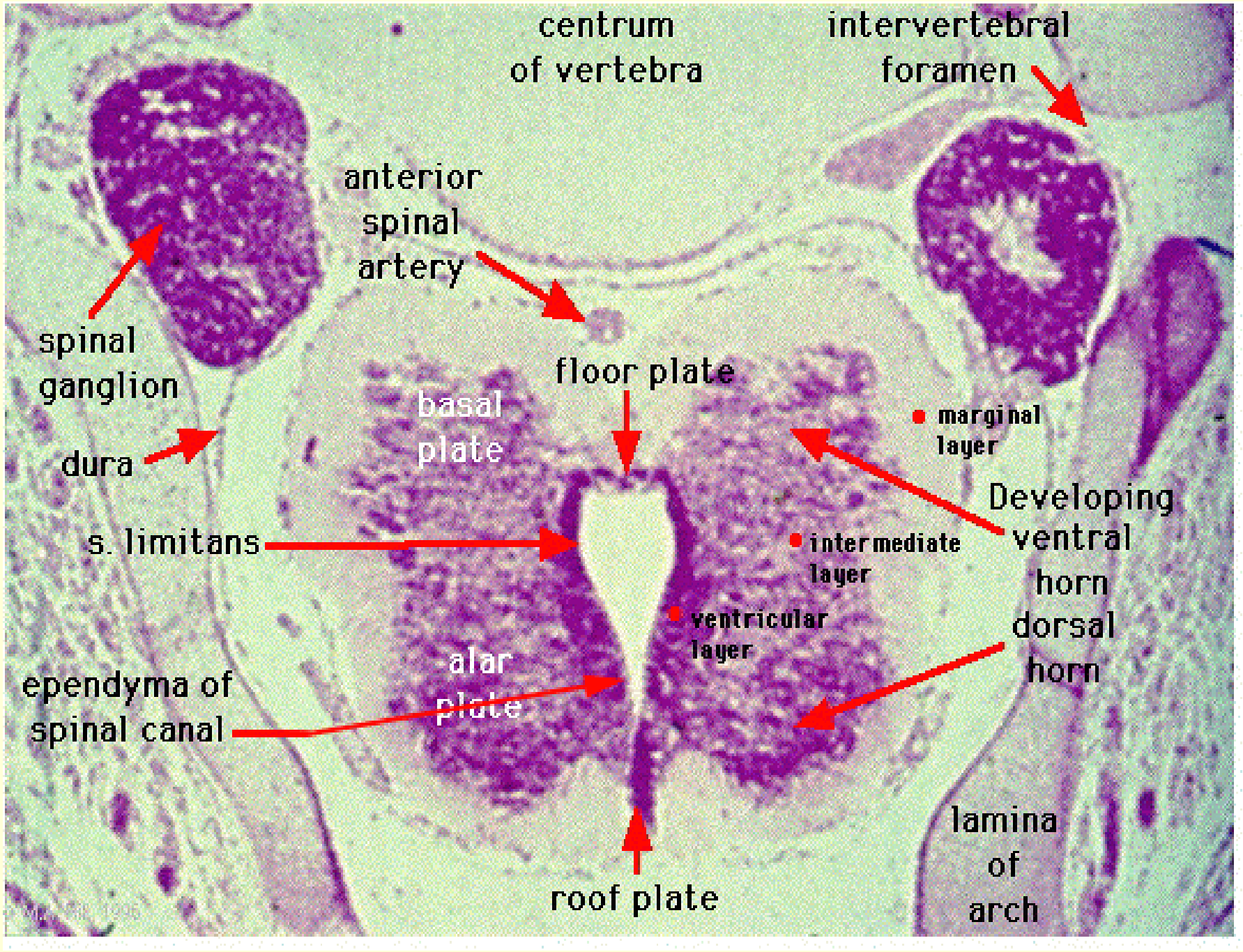
SPINAL CORD:

1. **Ependymal layer (germinal)**
2. **Mantle layer (gray matter)**
3. **Marginal layer (white matter)**



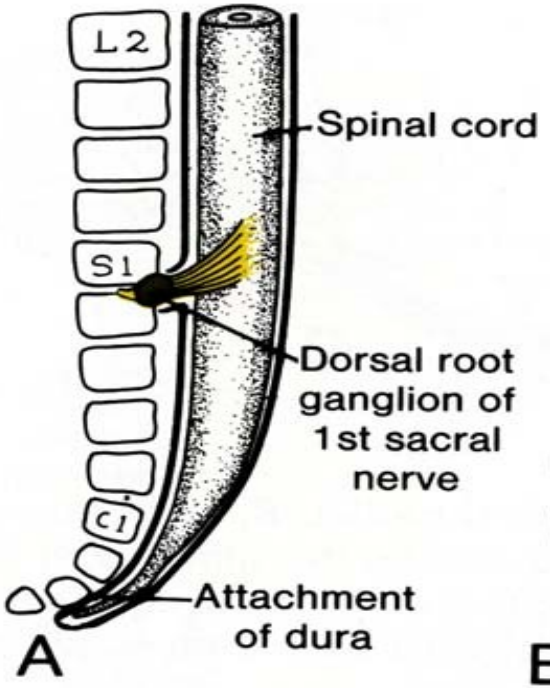

Roof plate
Marginal layer
Alar plate
Sulcus limitans
Mantle layer
Basal plate
Ependymal layer
Floor plate
Week 4
Neural Tube: Cell Growth
and Differentiation

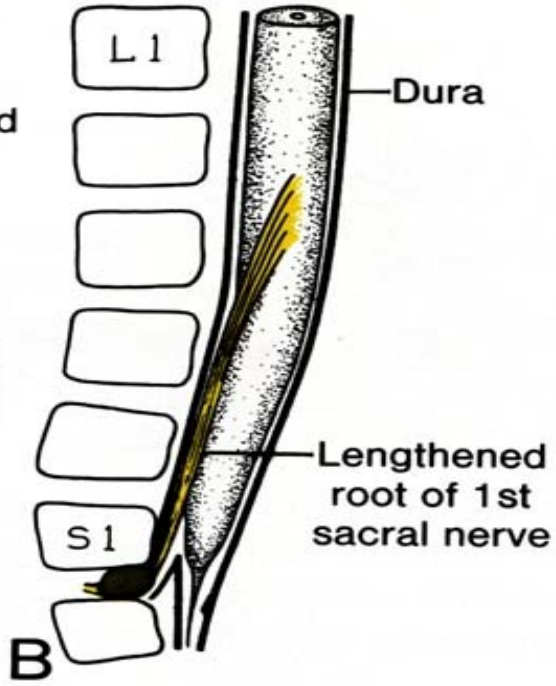

Dorsal root ganglion: sensory neurons from neural crest
Alar plate: interneurons
White matter
Basal plate: motor neurons
Neural tube cells
Central cavity
Copyright © 2004 Pearson Education, Inc., publishing as Benjamin Cummings.

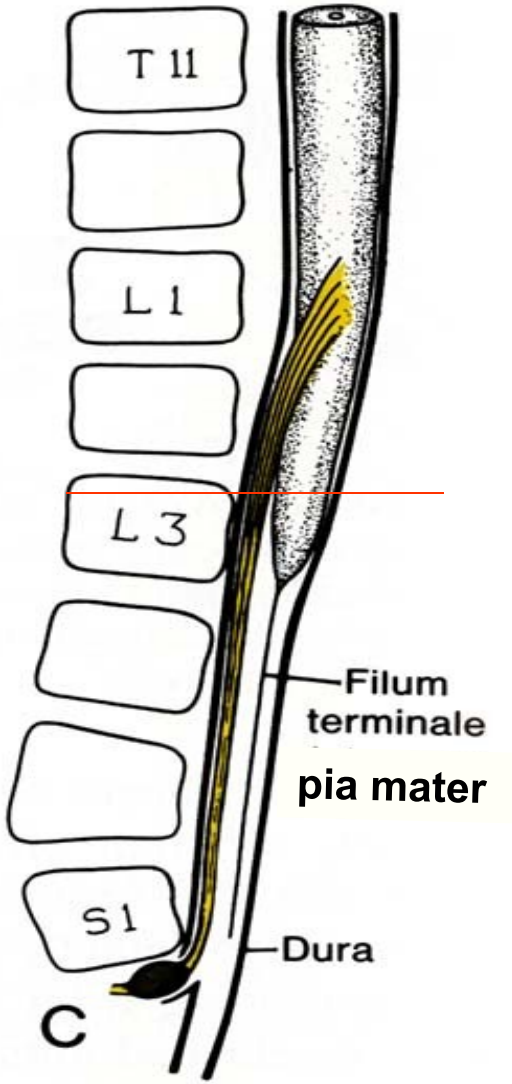

centrum
of vertebra
intervertebral
foramen
anterior
spinal
artery
spinal
ganglion
floor plate
basal
plate
marginal
layer
dura
Developing
ventral
horn
s. limitans
intermediate
layer
ventricular
layer
dorsal
horn
alar
plate
ependyma of
spinal canal
lamina
of
arch
roof plate

Positional changes of spinal cord

the end fo the 2nd month the 5th month new-born child #



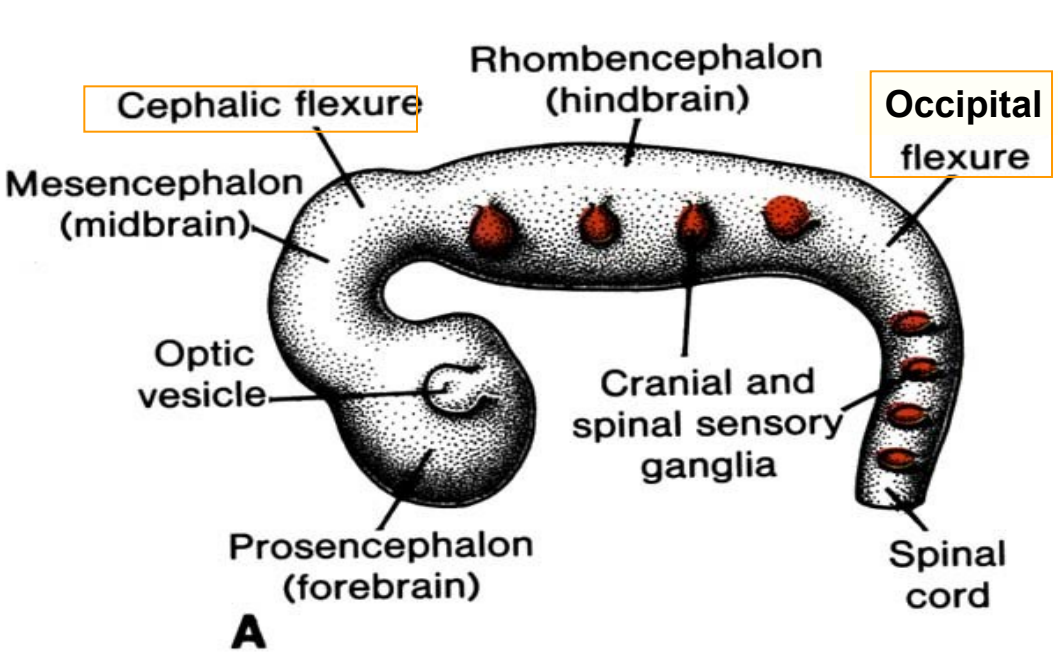


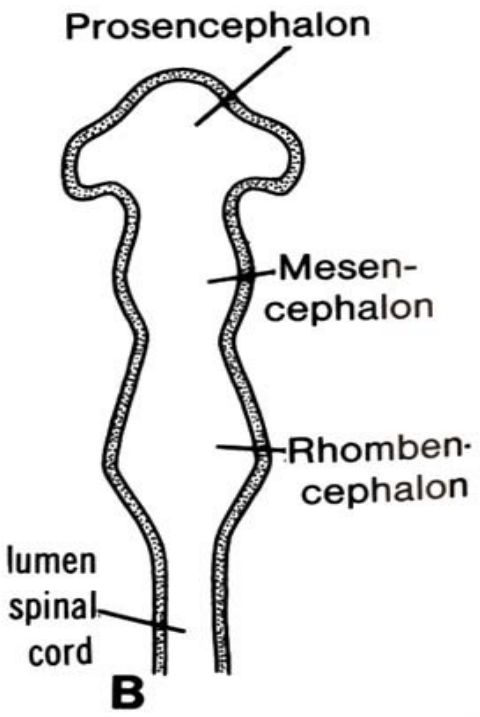


Vertebrate canal grows more rapidly than spinal cord and caudal end of spinal cord doesn‘t extend the entire length of canal in adult; it terminates at L1 in adults # .

Brain development

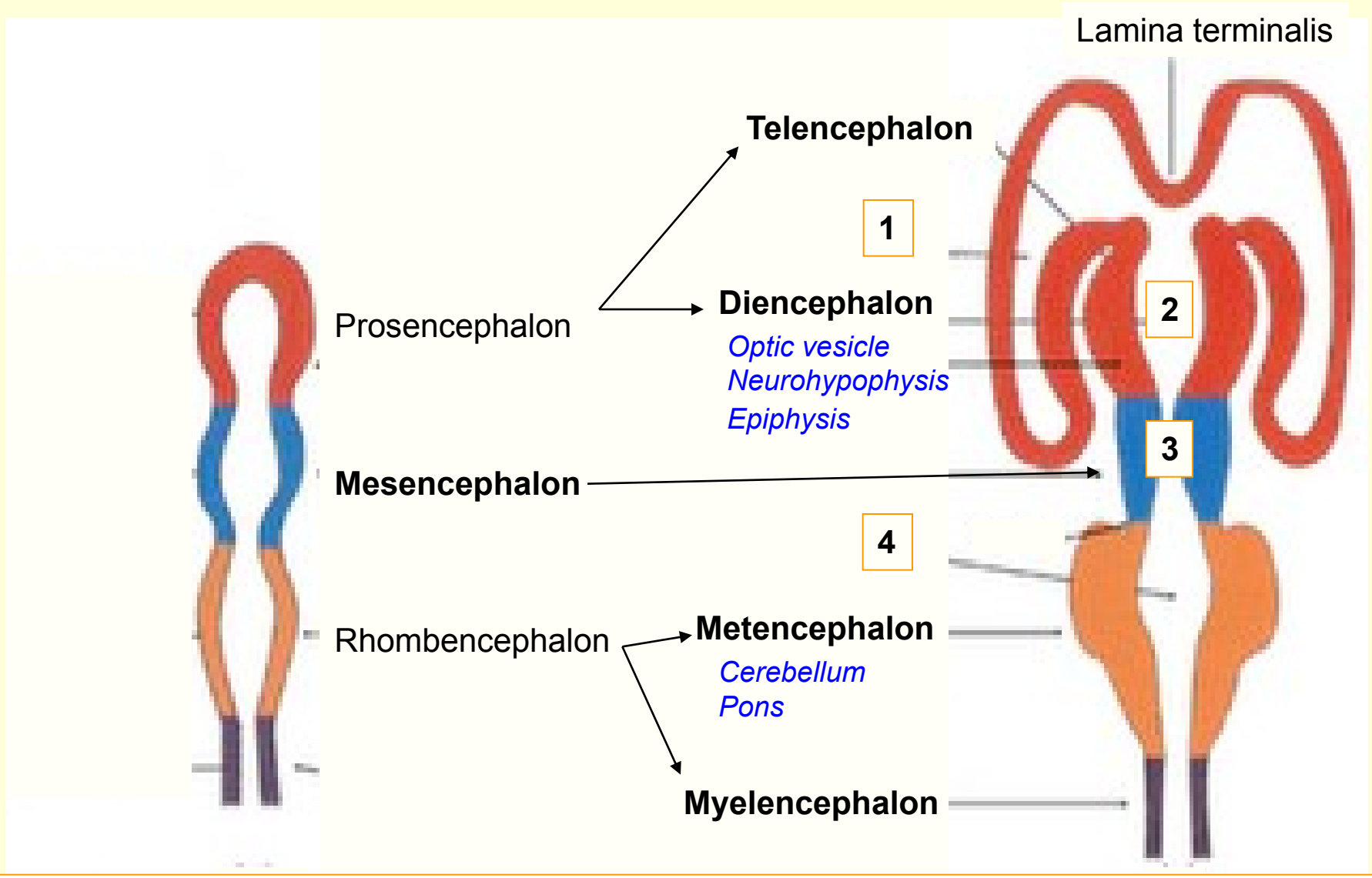
- Brain develops from cranial part of neural tube
- Week 4 – three primary brain vesicles:
  prosencephalon (forebrain)
  mesencephalon (midbrain)
  rhombencephalon (hindbrain)



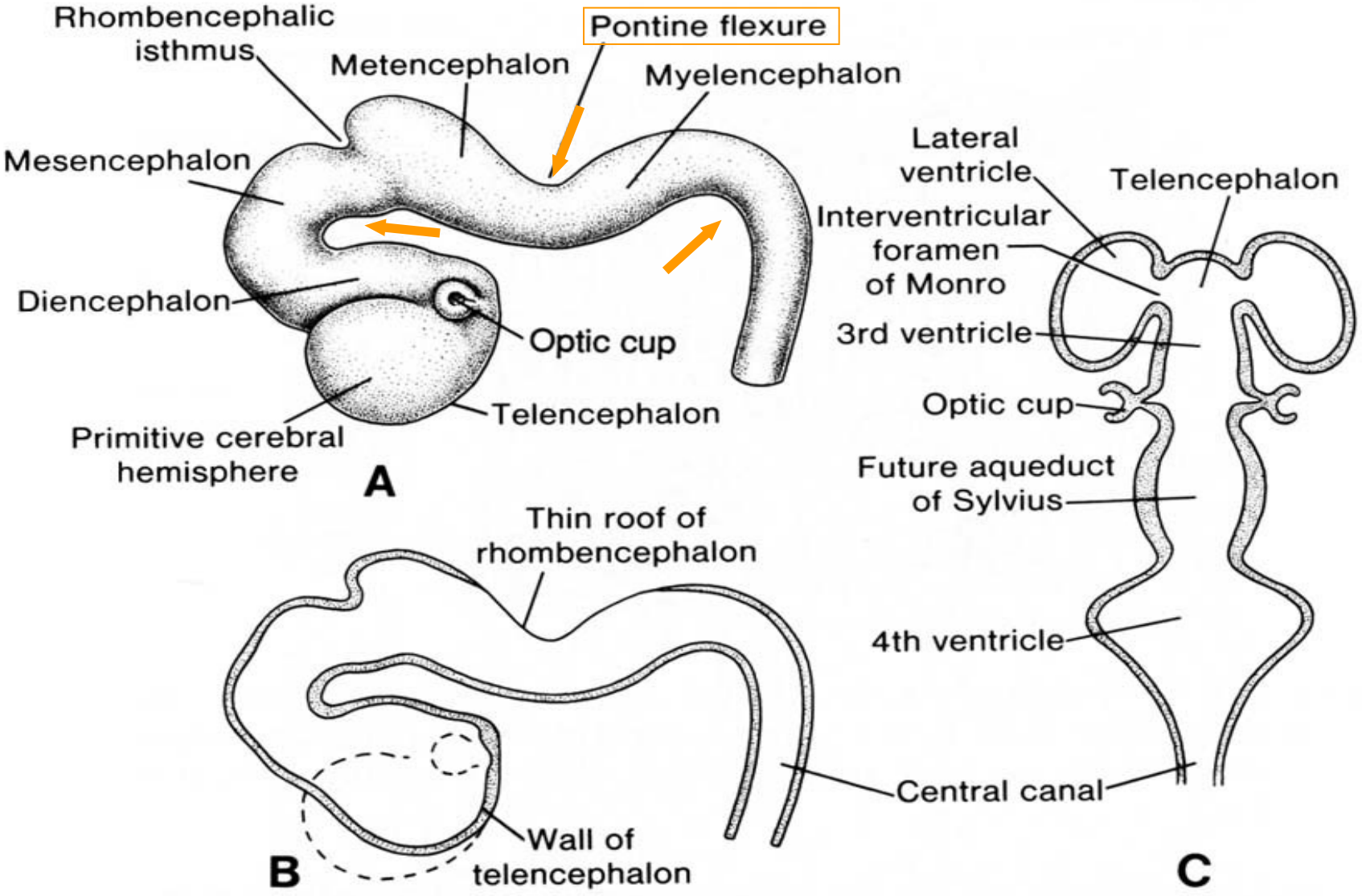


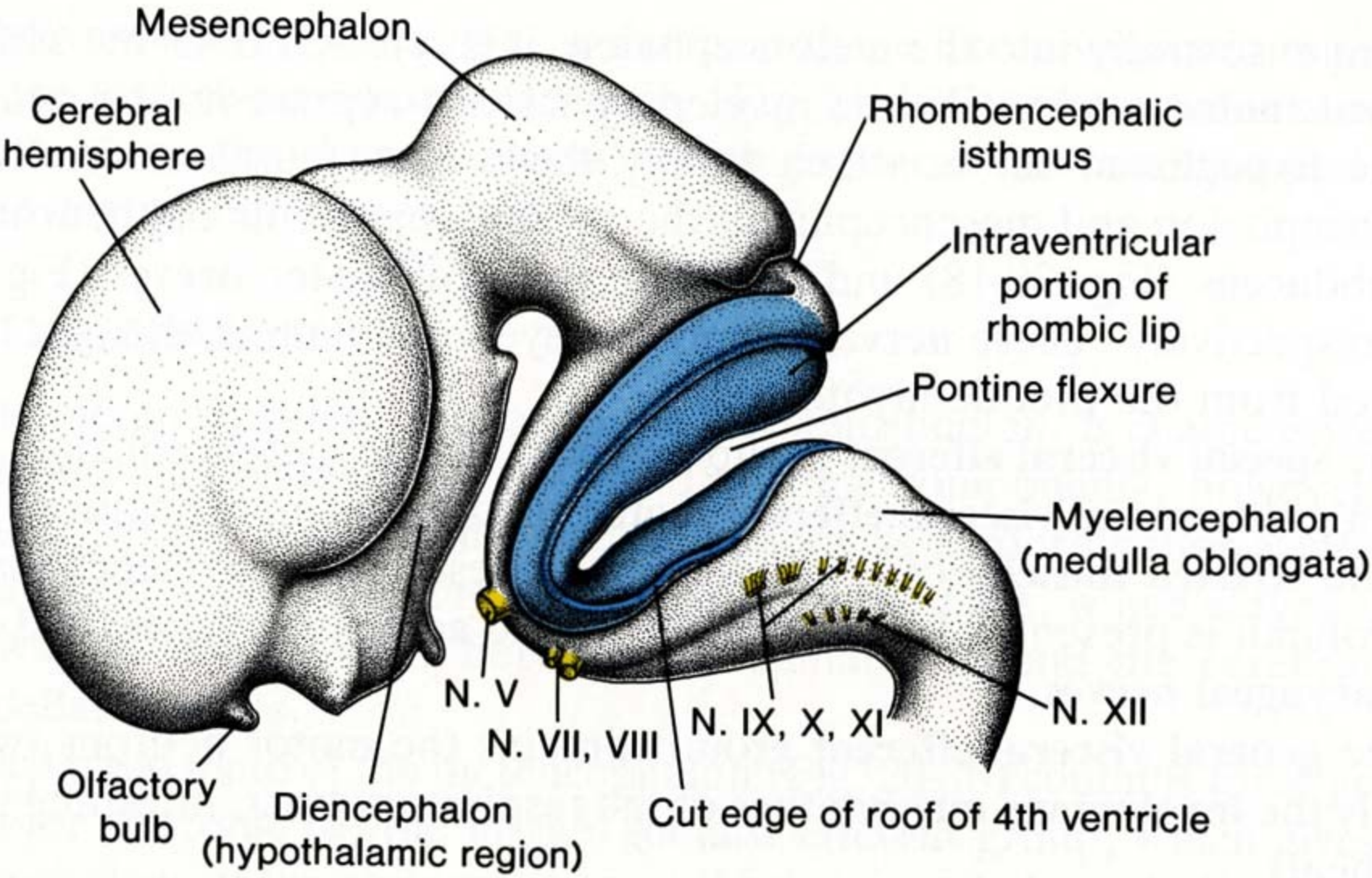
5 secondary vesicles:

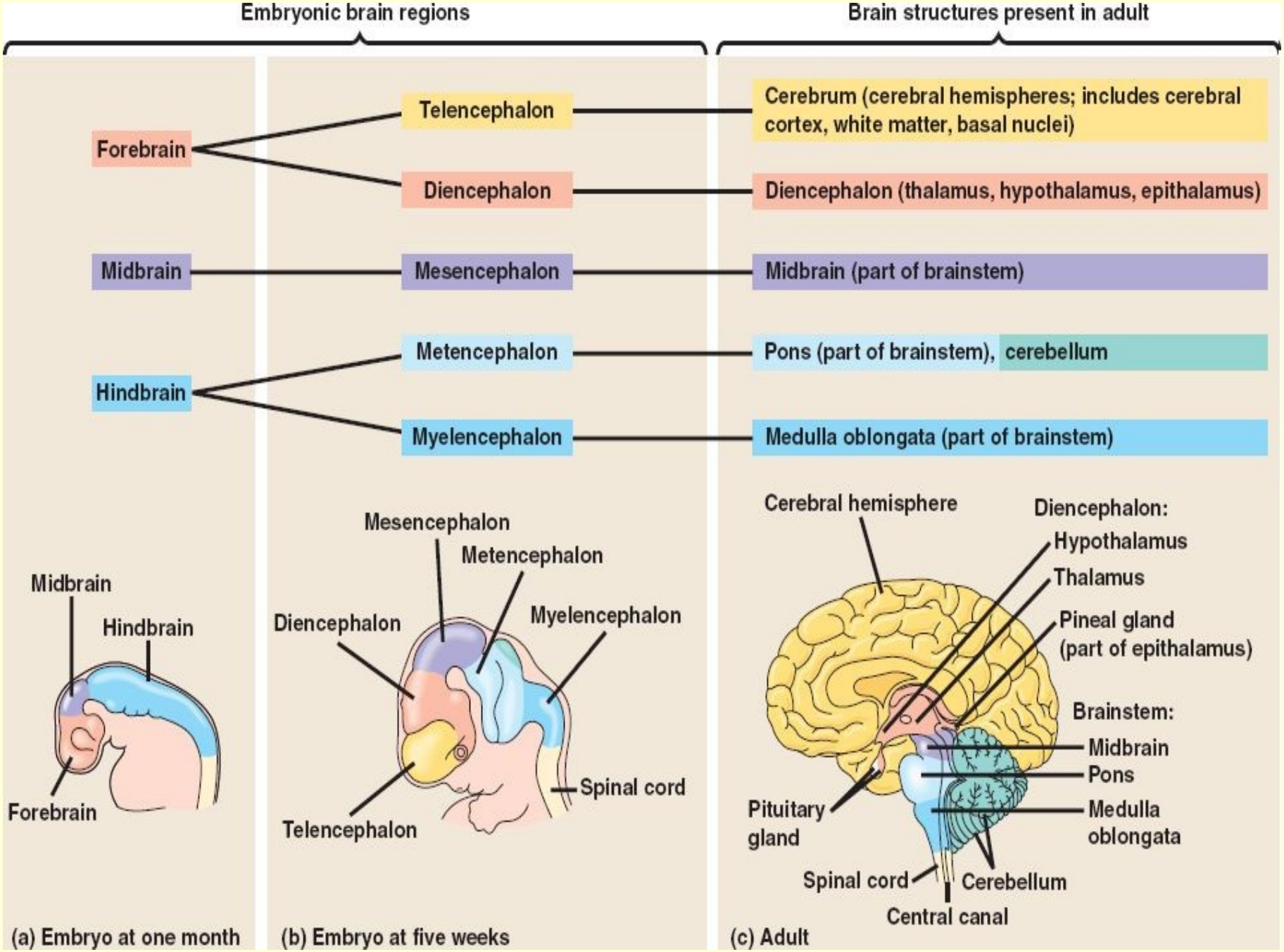
week 5



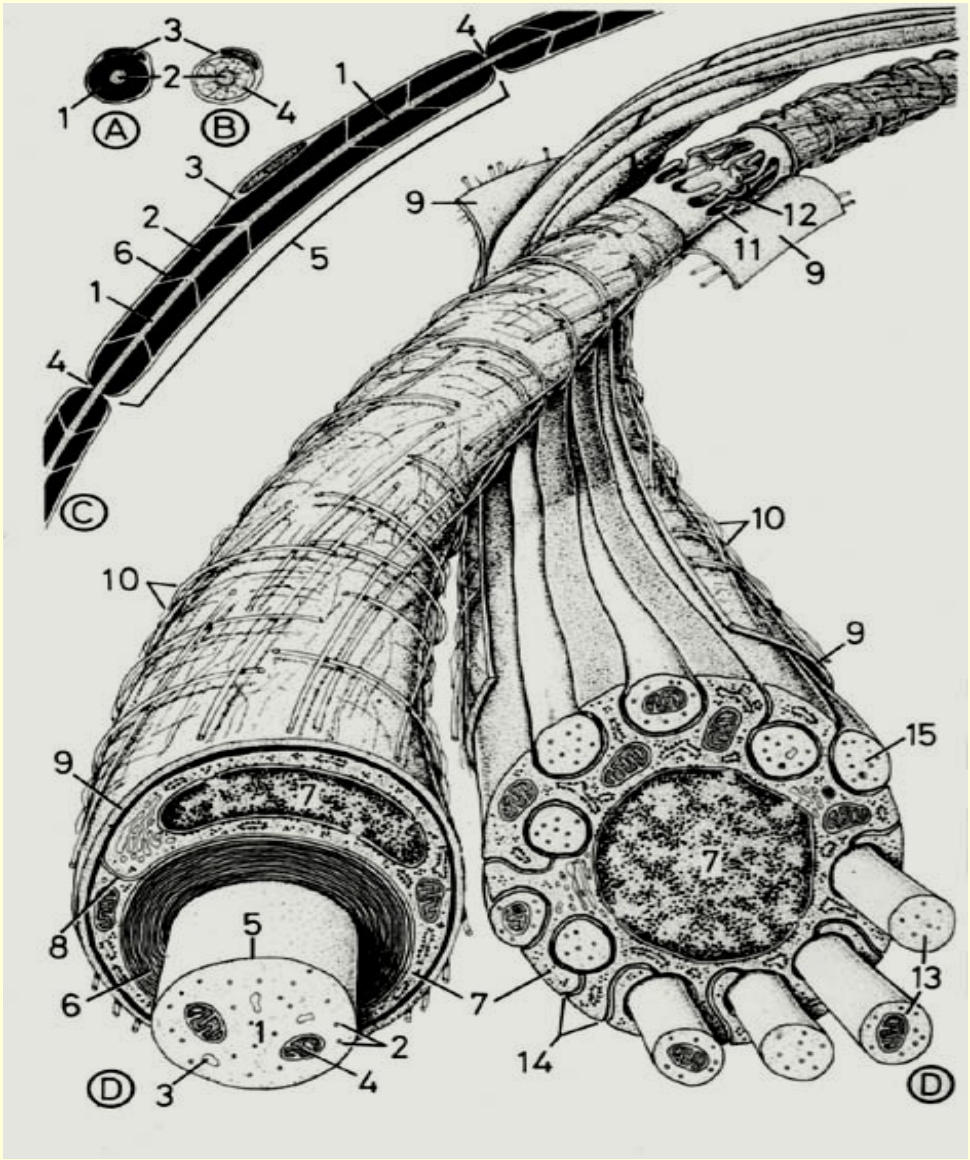
1 – ventriculi lat., 2 – ventriculus tertius, 3 – aqueductus cerebri, 4 – ventriculus quartus


Rhombencephalic isthmus
Pontine flexure
Metencephalon
Myelencephalon
Mesencephalon
Diencephalon
Optic cup
Telencephalon
Primitive cerebral hemisphere
A
Lateral ventricle
Telencephalon
Interventricular foramen of Monro
3rd ventricle
Optic cup
Future aqueduct of Sylvius
4th ventricle
Central canal
C
Thin roof of rhombencephalon
Wall of telencephalon
B


Mesencephalon
Cerebral hemisphere
Rhombencephalic isthmus
Intraventricular portion of rhombic lip
Pontine flexure
Myelencephalon (medulla oblongata)
N. V
N. VII, VIII
N. IX, X, XI
N. XII
Olfactory bulb
Diencephalon (hypothalamic region)
Cut edge of roof of 4th ventricle

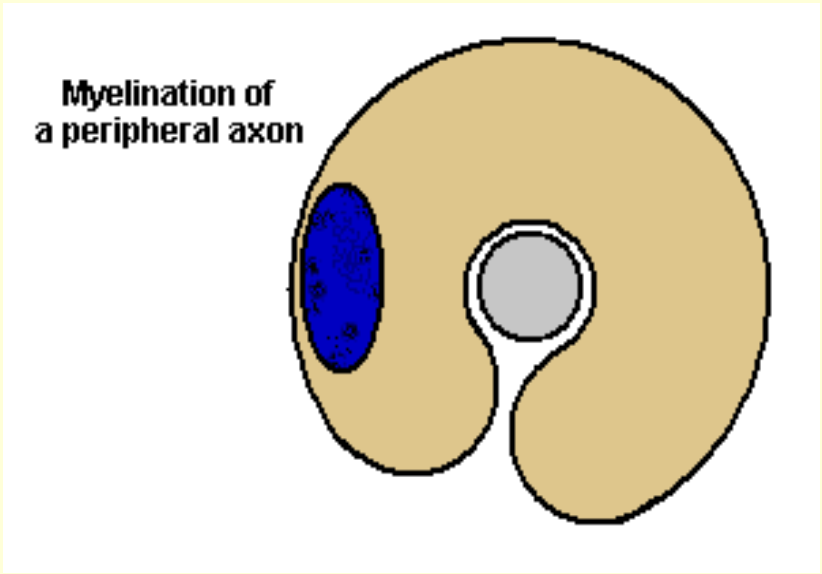

Embryonic brain regions
Brain structures present in adult
Forebrain
Midbrain
Hindbrain
Telencephalon
Diencephalon
Mesencephalon
Metencephalon
Myelencephalon
Cerebrum (cerebral hemispheres; includes cerebral cortex, white matter, basal nuclei)
Diencephalon (thalamus, hypothalamus, epithalamus)
Midbrain (part of brainstem)
Pons (part of brainstem), cerebellum
Medulla oblongata (part of brainstem)
Midbrain
Hindbrain
Forebrain
(a) Embryo at one month
Mesencephalon
Metencephalon
Diencephalon
Myelencephalon
Spinal cord
Telencephalon
(b) Embryo at five weeks
Cerebral hemisphere
Diencephalon:
Hypothalamus
Thalamus
Pineal gland
(part of epithalamus)
Brainstem:
Midbrain
Pons
Medulla
oblongata
Pituitary
gland
Spinal cord
Cerebellum
Central canal
(c) Adult

Myelination of nerve fibers



from the 4th prenatal month

to the 2nd postnatal year



CNS malformations

- failure neurulation (absence of notochord inductive influence or teratogen influence on neuroectodermal cells)
- defects of spinal cord
- defects of brain
- difficult malformations of CNS are usually connected with skull or spinal column (vertebral) defects.

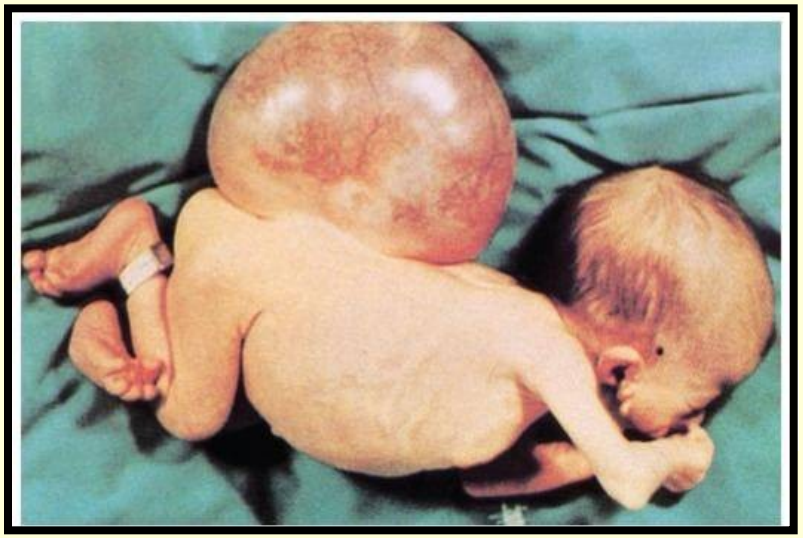
Spinal cord malformations

Defects - clefts of vertebral arches (rarelly bodies)

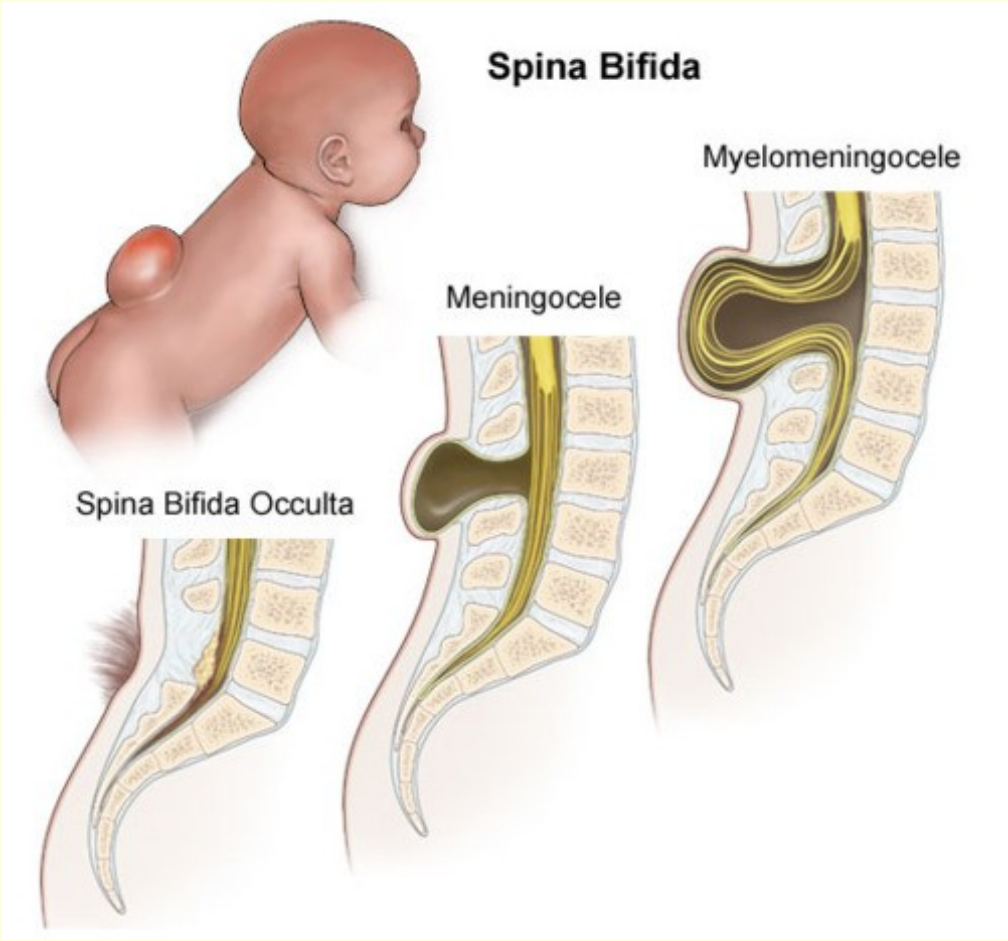
- Menigocele
- Menigomyelocele
- Menigohydromyelocele

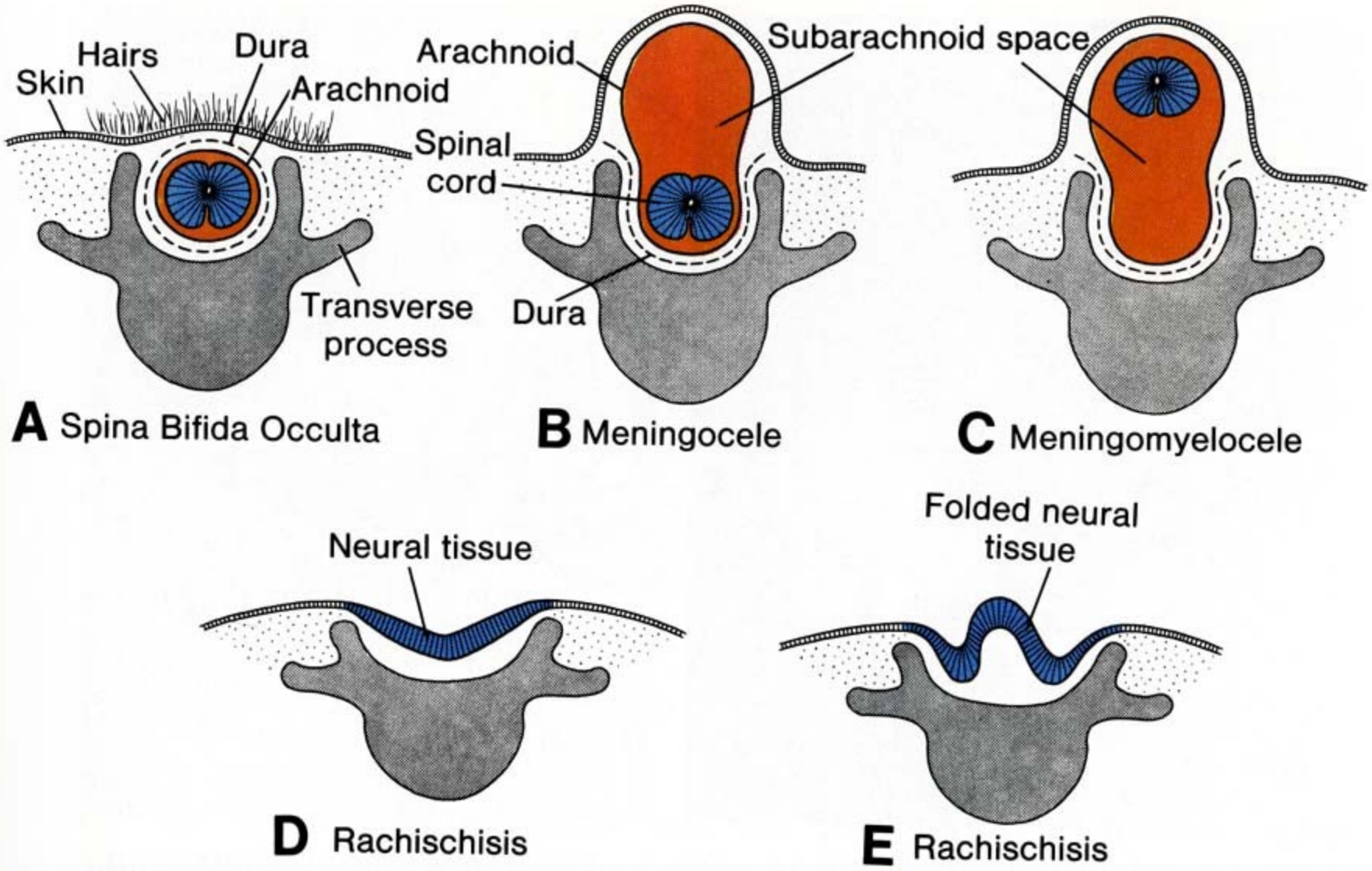
} **spina bifida cystica**

- Myeloschisis – complete cleft of spinal column in the whole length




Meningomyelocele


Spina Bifida
Myelomeningocele
Meningocele
Spina Bifida Occulta


Hairs
Skin
Dura
Arachnoid
Transverse process
A Spina Bifida Occulta
Arachnoid
Subarachnoid space
Spinal cord
Dura
B Meningocele
C Meningomyelocele
Neural tissue
D Rachischisis
Folded neural tissue
E Rachischisis

Examples of external signs of **spina bifida**:

1) hairy patch, 2) hemangioma, 3) skin appendage,
4) lipomatous mass.

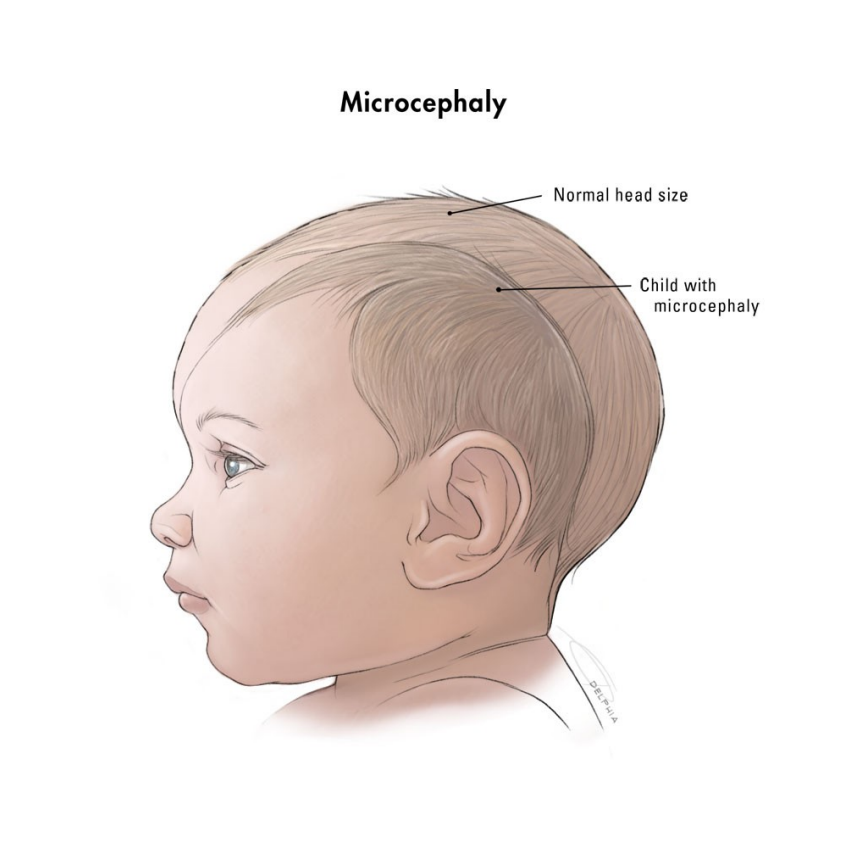
1	2
3	4

Brain malformations

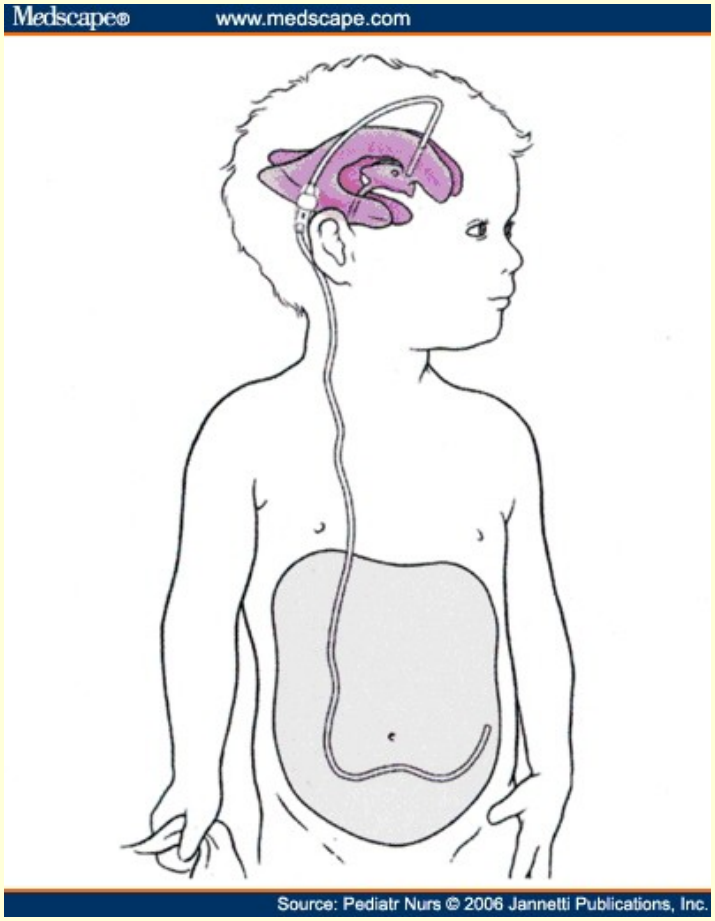
- Anencephalia (†) (+ myeloschisis)

Brain malformations

MICROCEPHALIA



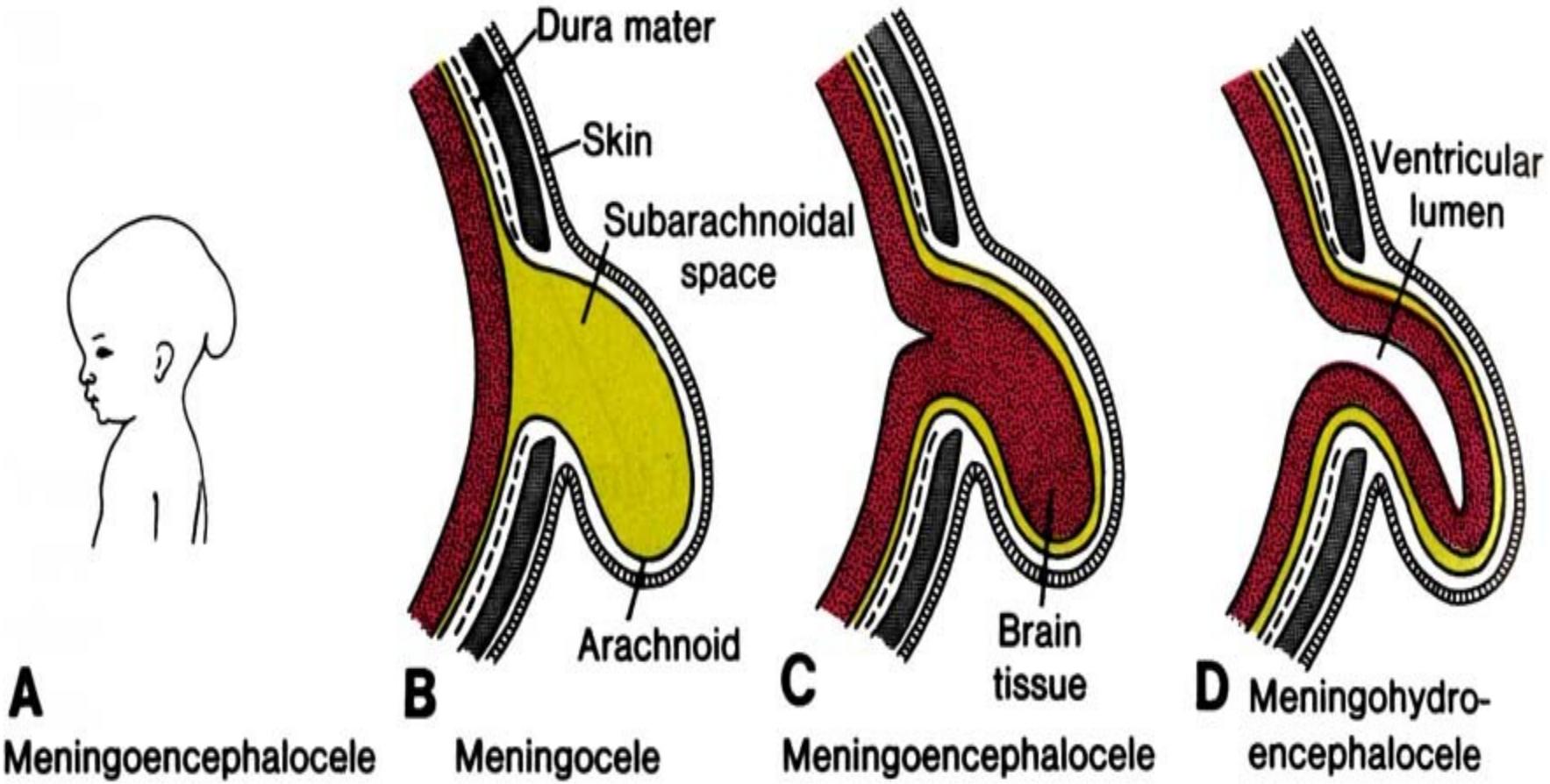
HYDROCEPHALUS



CASE A. [CASE B. MICROCEPHALUS.] CASE B.

HYDROCEPHALUS.

Brain and meninges hernia(tion)




End

General histology - questions

- Nerve tissue – definition, structure, function and origin.
- Microscopic structure of nerve cell, types of neurons. The sheaths of nerve processes.
- Synapses – their structure and function. Nerve mediators (neurotransmiters).
- Central and peripheral nerve endings.
- Neuroglia – classification, cytological character and function.

Terms

- Neuron – perikaryon – axon (= neurite) – dendrite(s)
- Nissl bodies = rough ER
- Axon hillock
- Myeline sheath
- Schwann sheath
- Mesaxon
- Internodium
- Node of Ranvier
- Neuron – classification
- Synapse (presynaptic knobe, synaptic cleft, postsynaptic memrane)
- Neurotransmitters

Terms

- Neuroglia - classification
- Oligodendroglia
- Astrocytes
- Microglia (of Horteg)
- Ependyma - tanycytes
- Schwann cells
- Satelite cells

in CNS

in PNS

Special histology - questions

- Structure of the brain cortex. Cyto- and myeloarchitecture.
- Structure of the cerebellum. Synapses of the cerebellum.
- Microscopic structure of the spinal cord.
- Microscopic structure of ganglia and peripheral nerves.
- Ependyma, plexus chorioideus and meninges.

Terms

- Brain cortex – 6 layers (lamina)
- Cajal cells, Martinotti cells, granular and pyramidal cells
- Membrana limitans gliae superficialis et profunda (seu perivascularis)
- Brain barrier
- Cerebellum – 3 layers of cortex (stratum)
- Purkinje cells, basket cells, granular cells
- Glomeruli cerebellares
- Mossy and climbing fibers

Terms

- Dura mater – arachnoidea – pia mater
- Endoneurium – perineurium – epineurium
- Plexus chorioideus


End

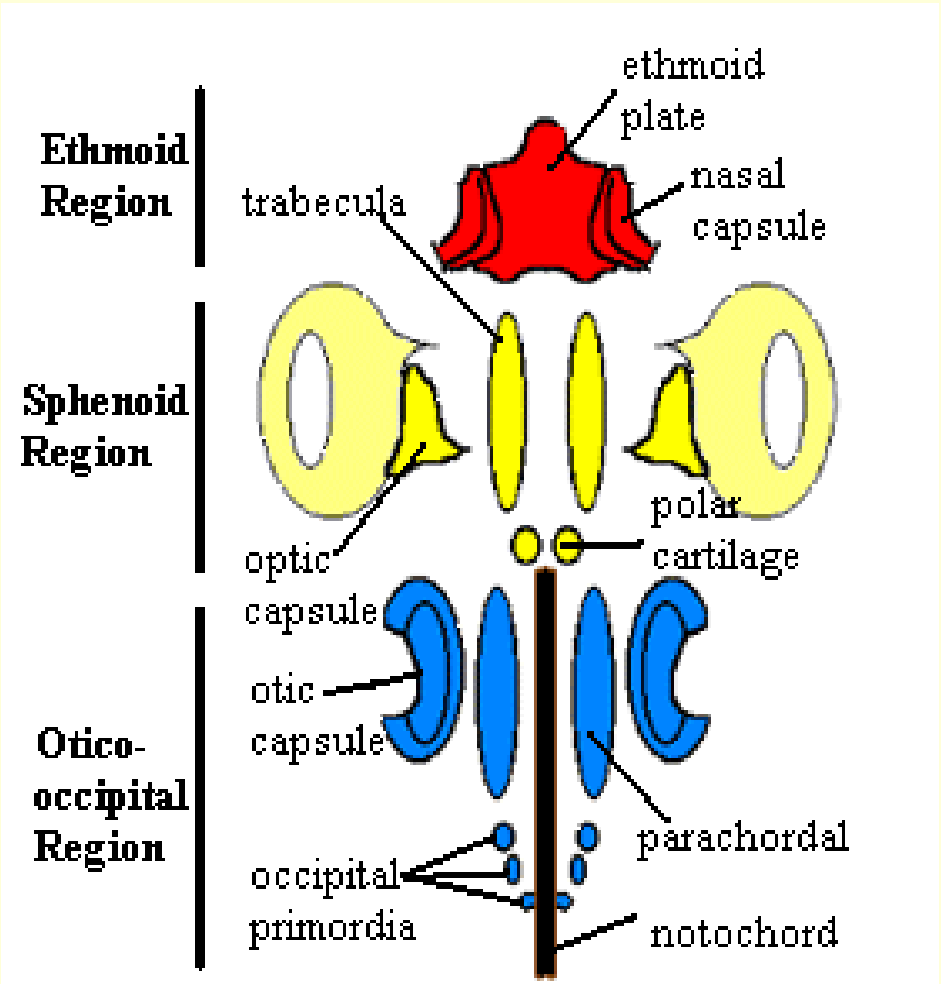


Figure 3. Schematic view of vertebrate braincase development

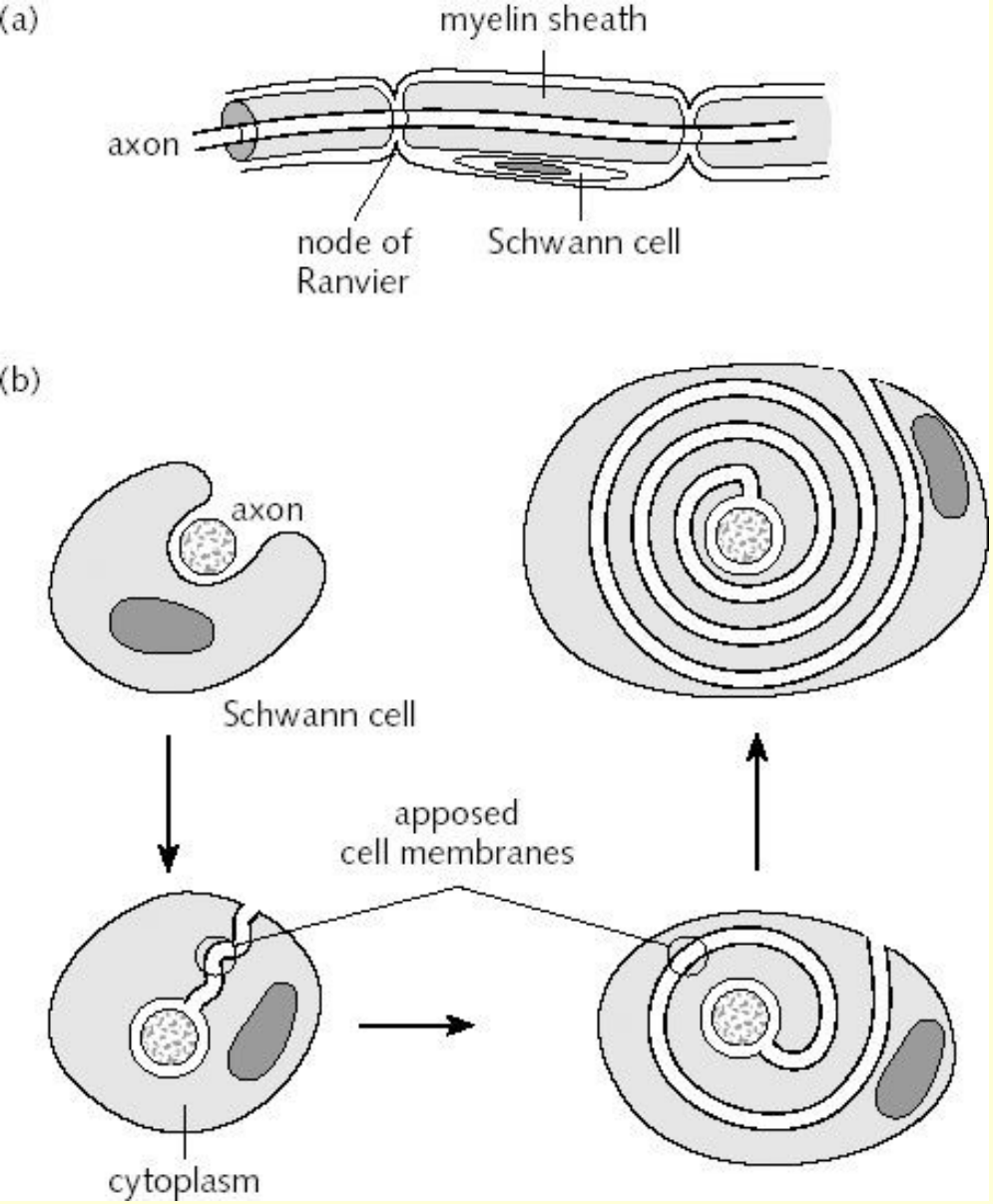


Fig. 1 (a) A myelinated axon in the peripheral nervous system and (b) its development. Each Schwann cell myelinates a single axon, to which it is directly apposed. During development (anticlockwise) Schwann cells loosely ensheath axons and the myelin sheath grows around the axon to form concentric layers, which become tightly apposed

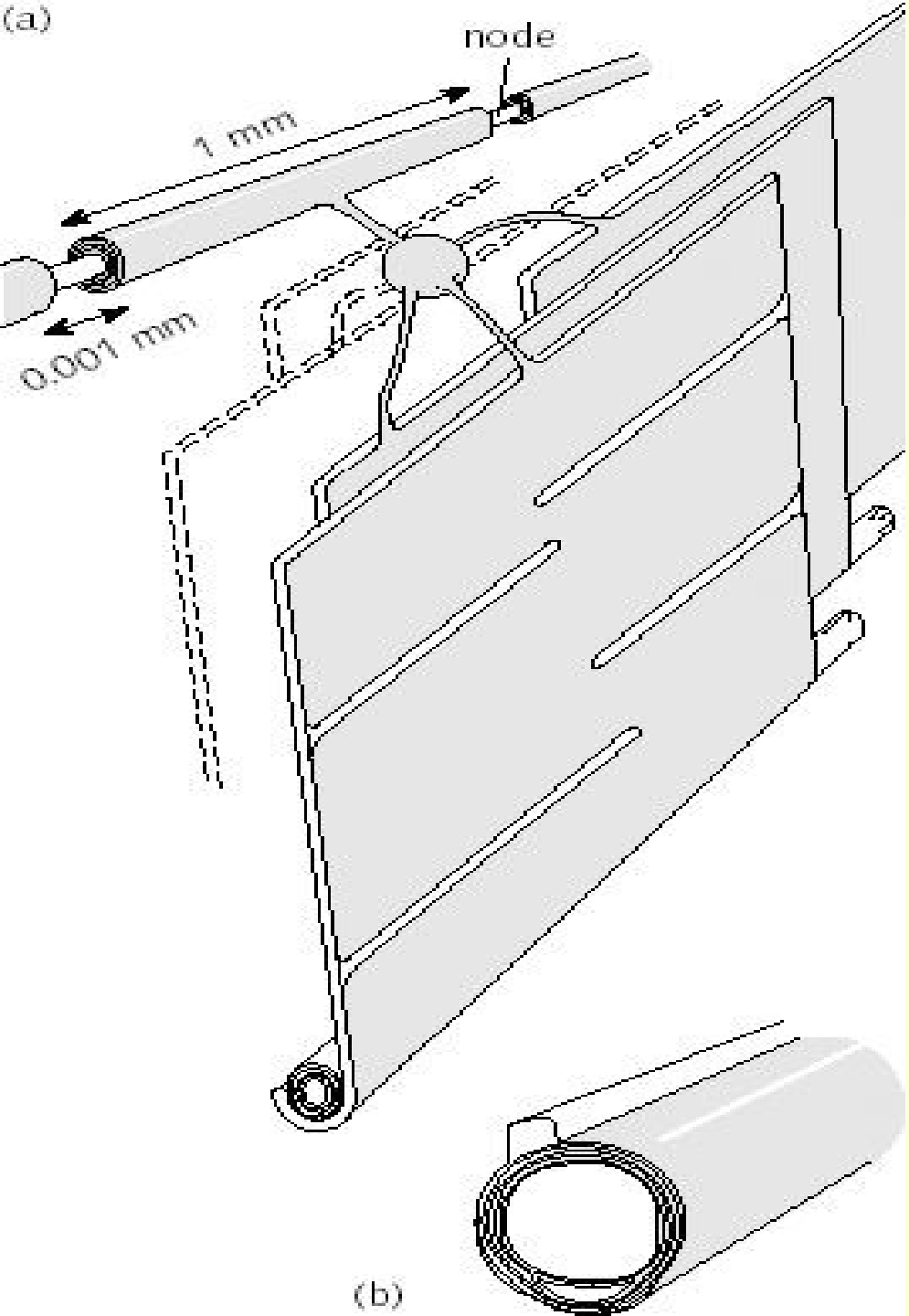
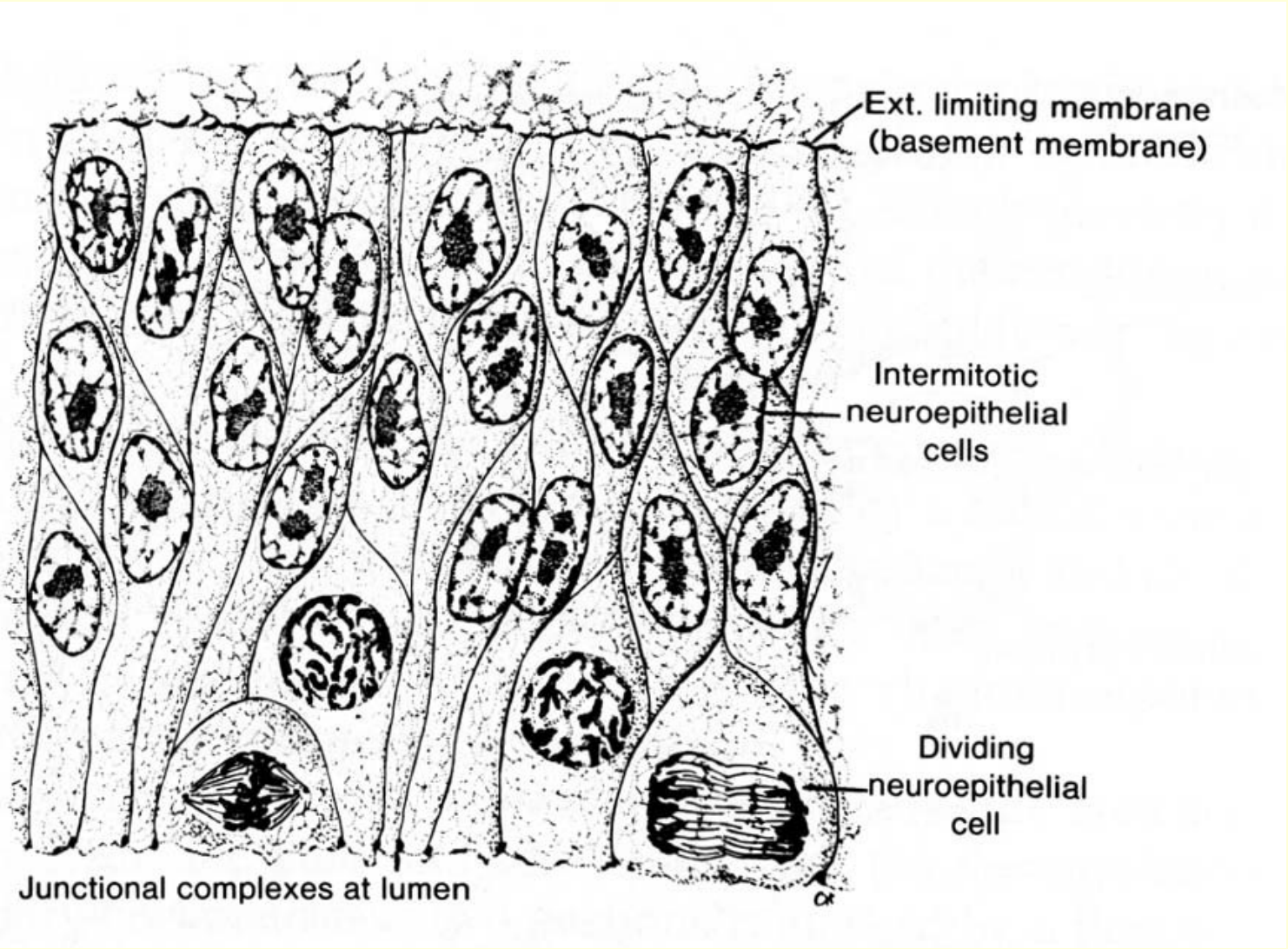
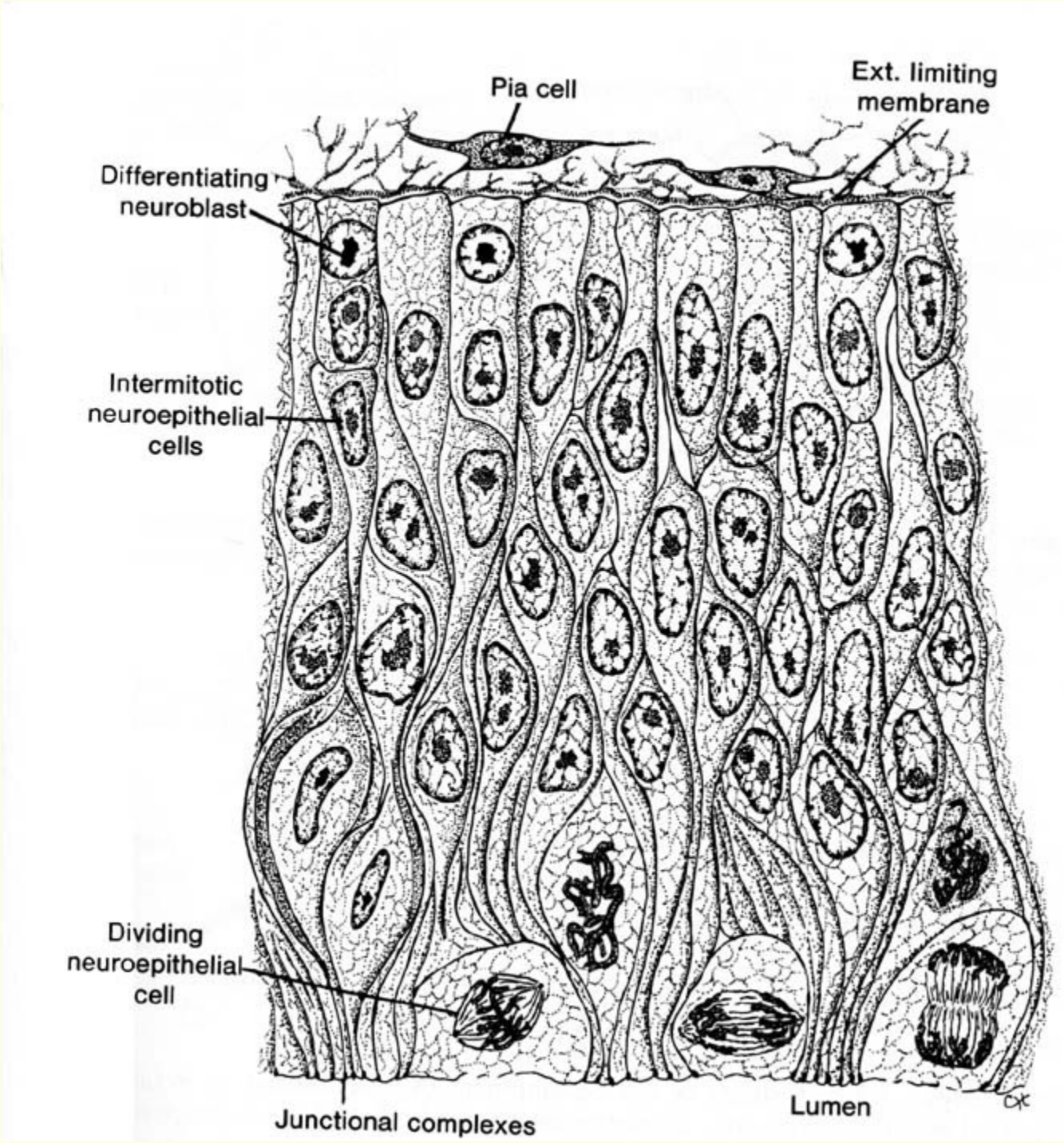
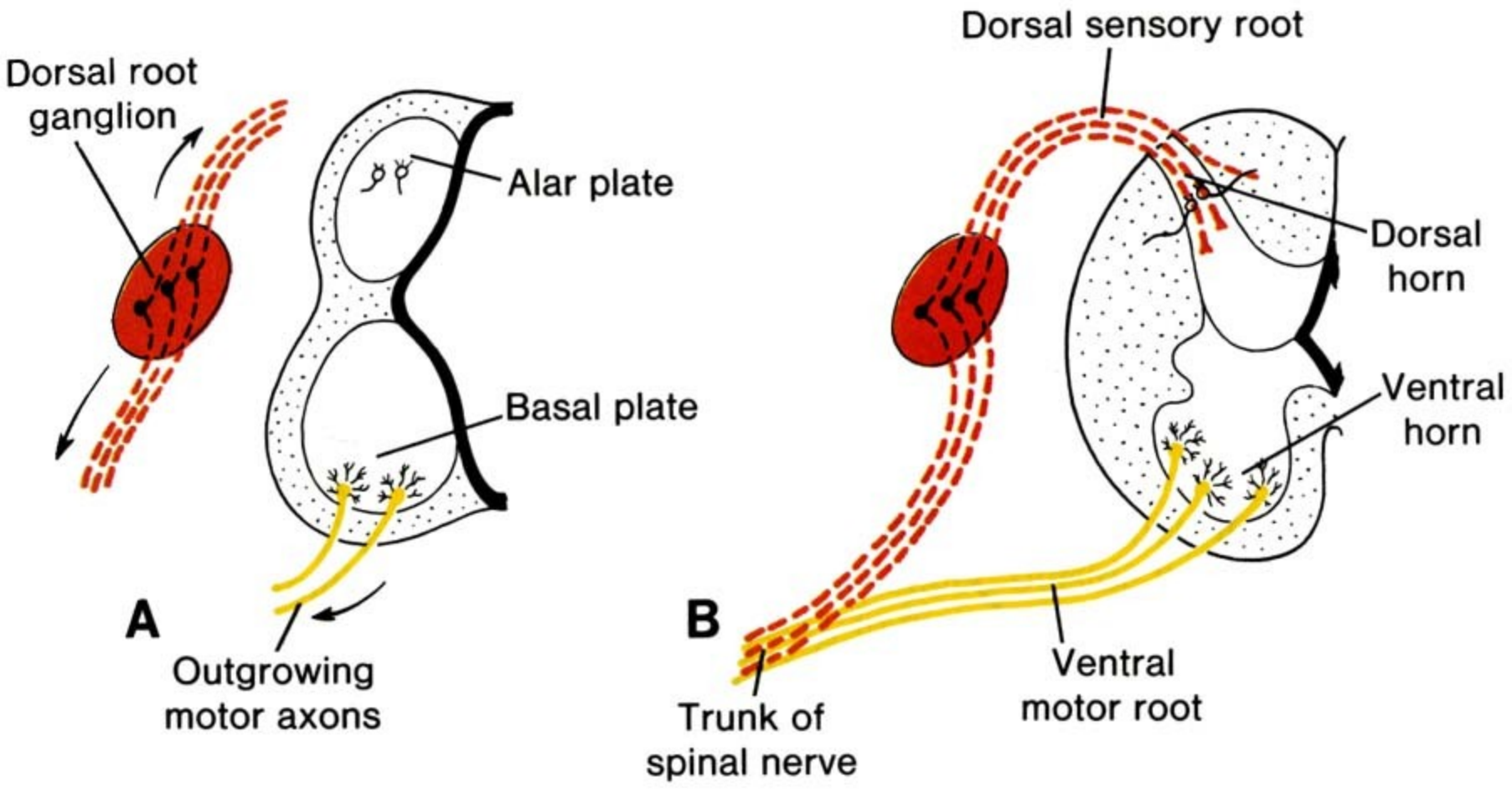


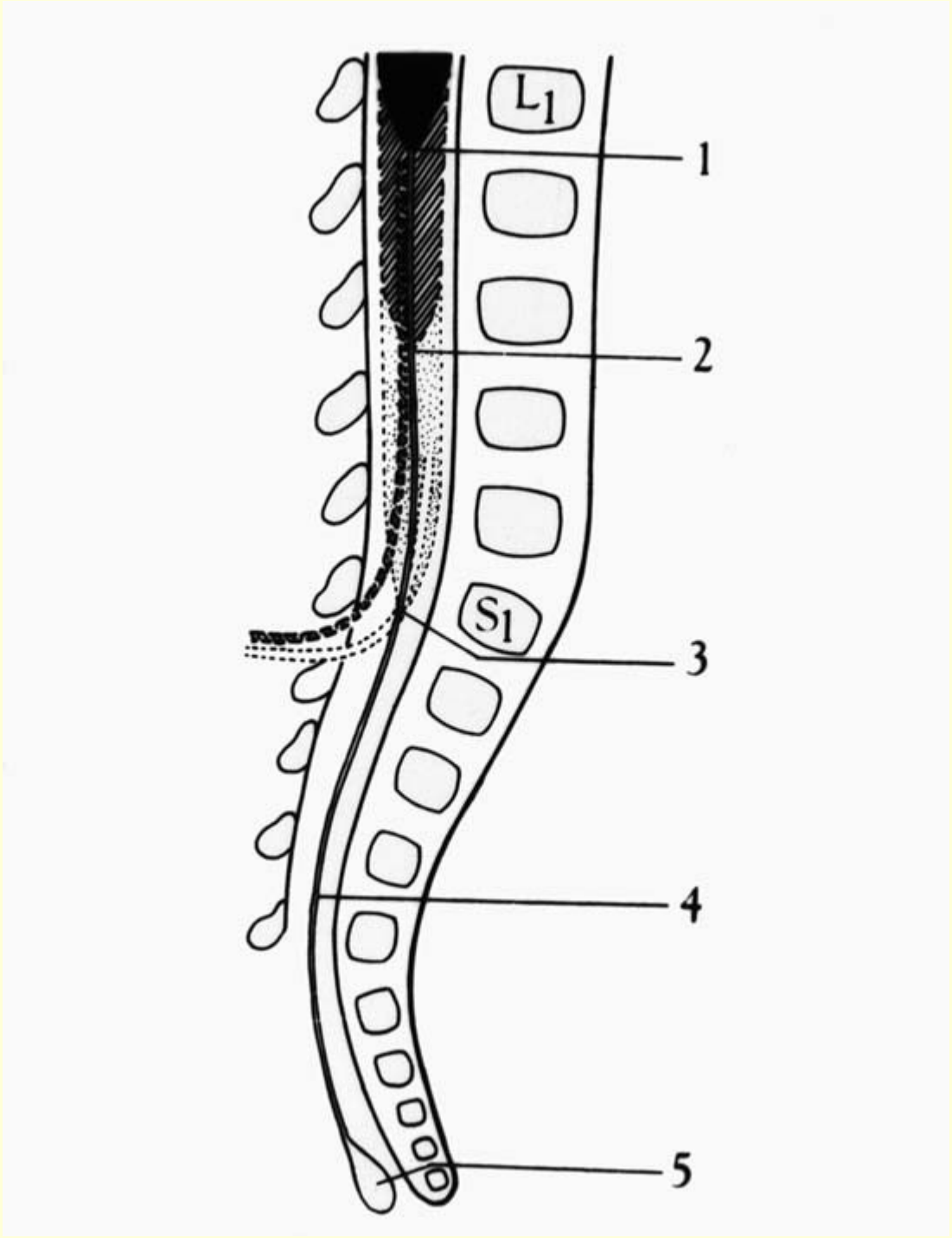
Fig. 3 Myelination in the central nervous system. A single oligodendrocyte myelinates numerous axons (a) and, in section, concentric layers of myelin are seen to spiral around the axon (b). Myelin sheaths are arranged along axons in segments 1 mm long separated by short nodes, and would appear as large sheets if they were unwrapped from around the axon

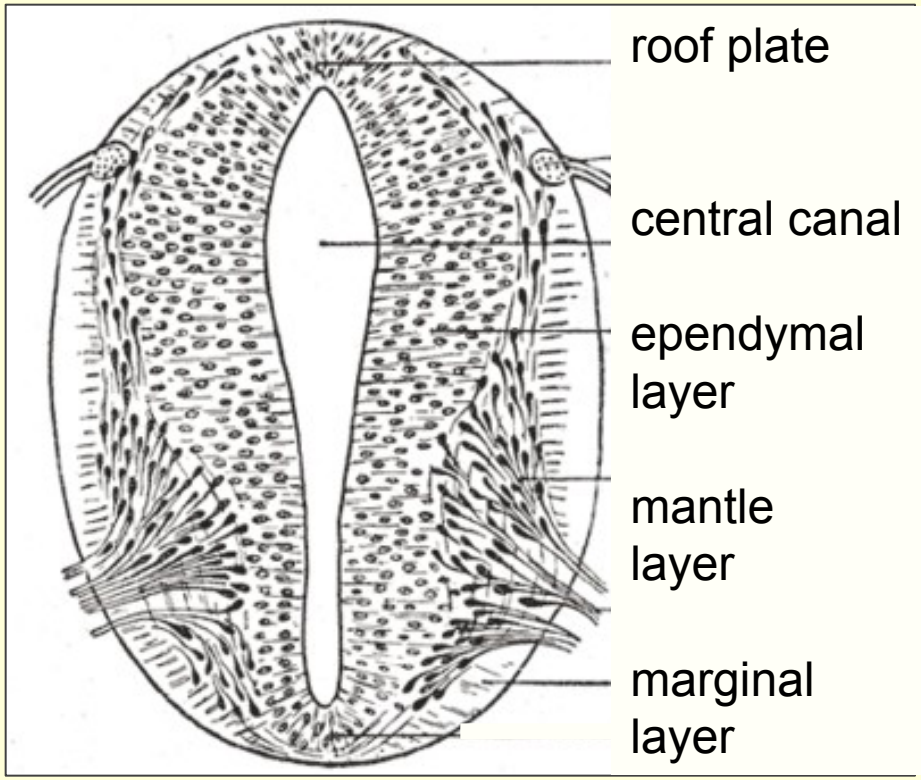
HISTOGENESIS of NEURAL TUBE

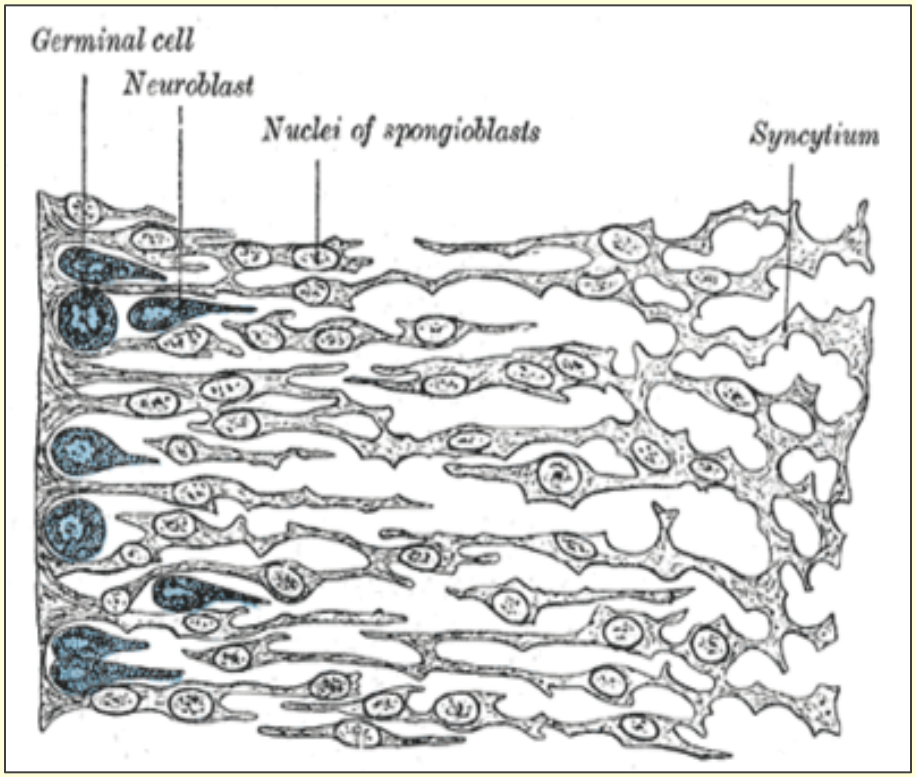


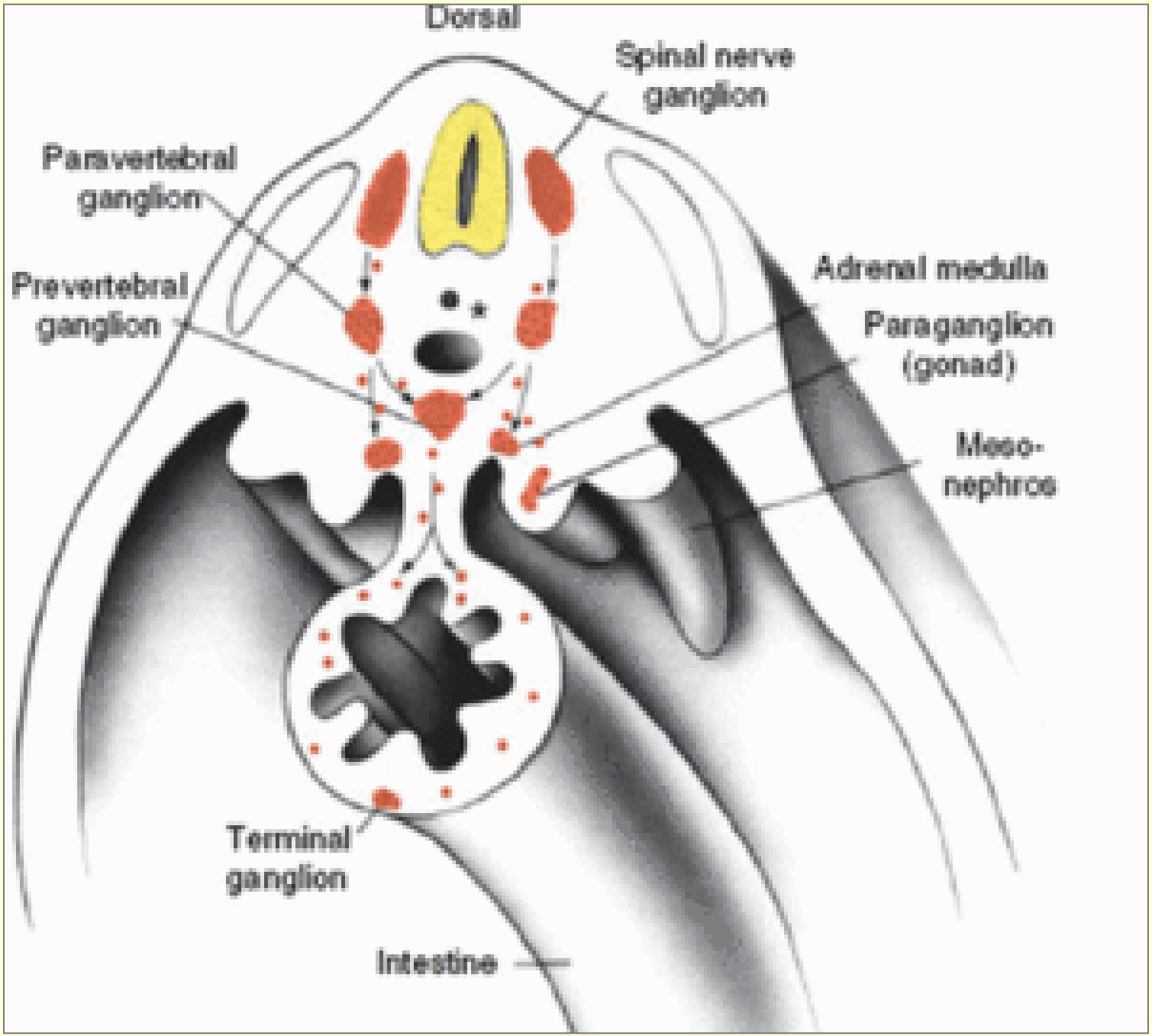

Pia cell
Ext. limiting membrane
Differentiating neuroblast
Intermitotic neuroepithelial cells
Dividing neuroepithelial cell
Junctional complexes
Lumen


Dorsal root ganglion
Alar plate
Basal plate
A
Outgrowing motor axons
Dorsal sensory root
Dorsal horn
Ventral horn
B
Trunk of spinal nerve
Ventral motor root


L1
S1
1
2
3
4
5


roof plate
central canal
ependymal layer
mantle layer
marginal layer
floor plate


Germinal cell
Neuroblast
Nuclei of spongioblasts
Syncytium


Dorsal
Spinal nerve ganglion
Paravertebral ganglion
Prevertebral ganglion
Adrenal medulla
Paraganglion (gonad)
Meso-nephros
Terminal ganglion
Intestine