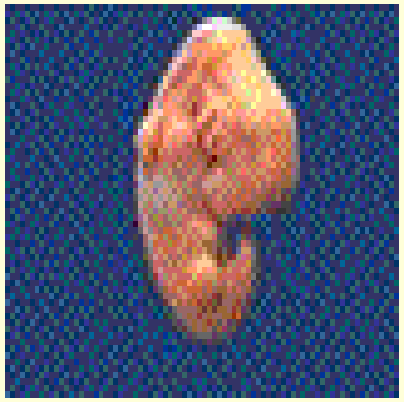


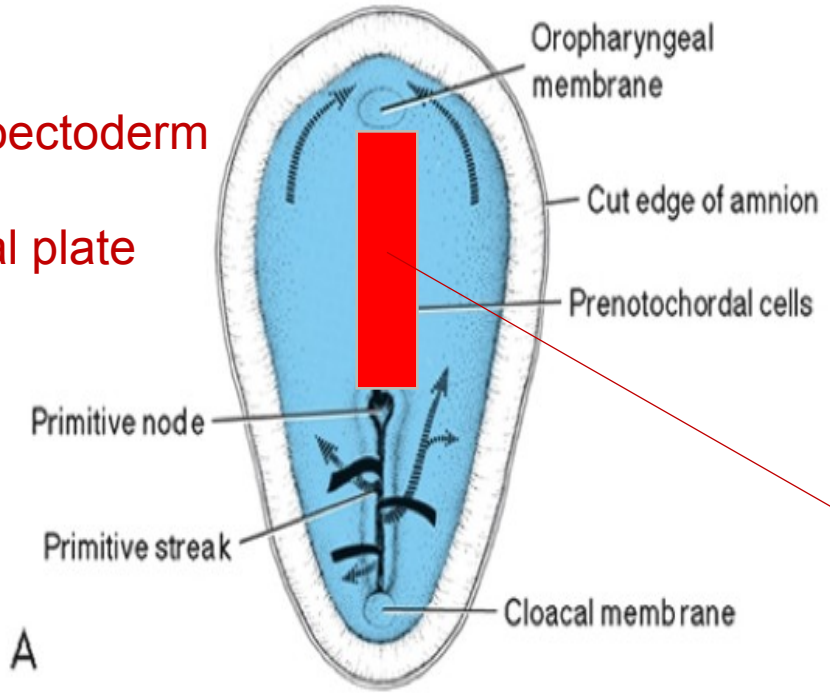
Embryology /organogenesis/

Development and teratology of nervous system.

Neuroectoderm

↓

Neural plate

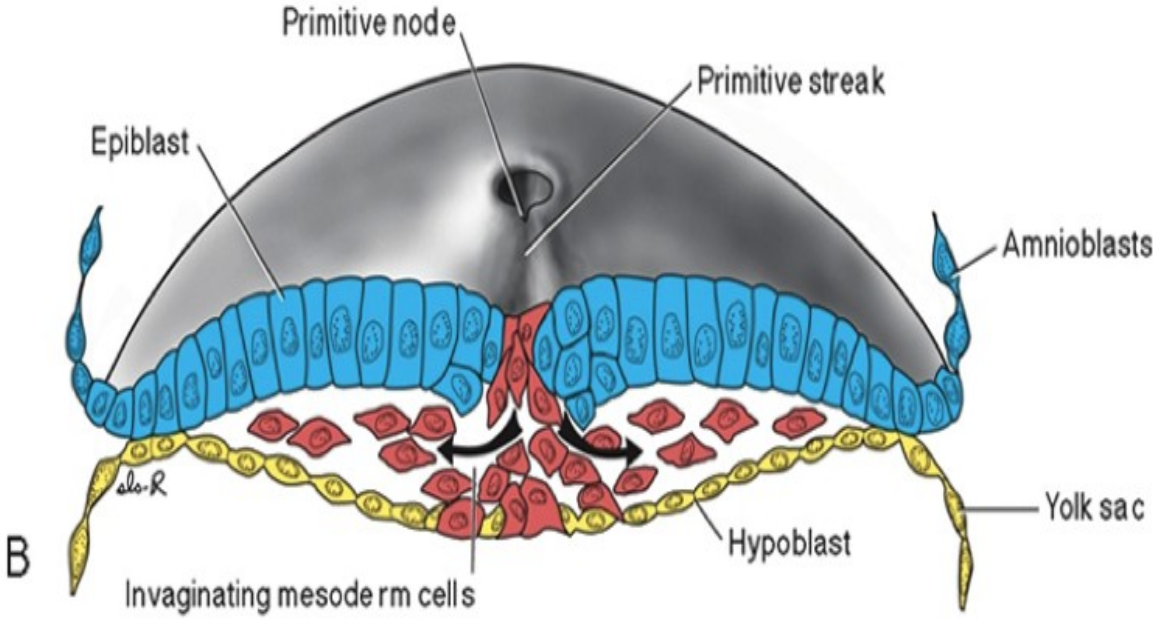


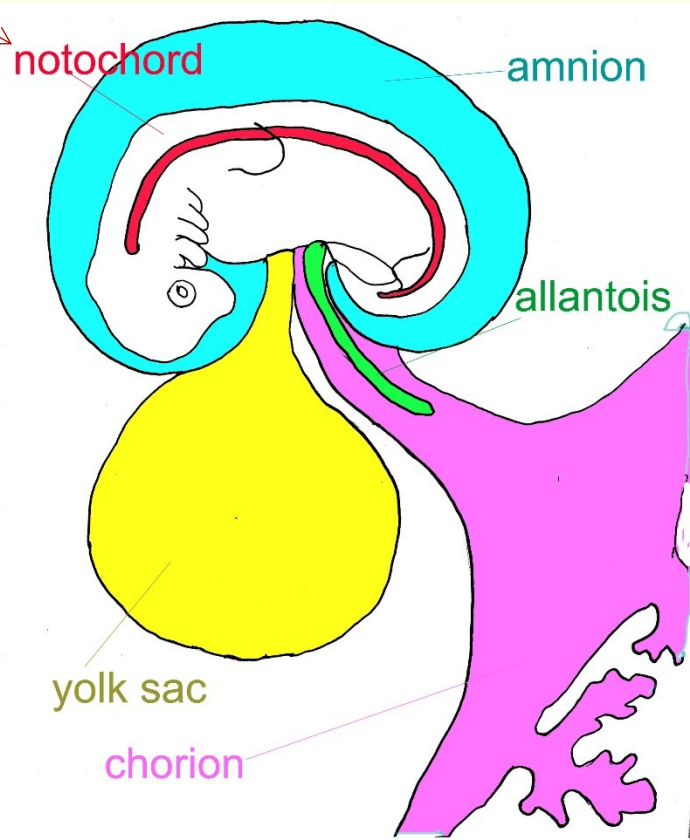
NOTOCHORD DEVELOPMENT

↓

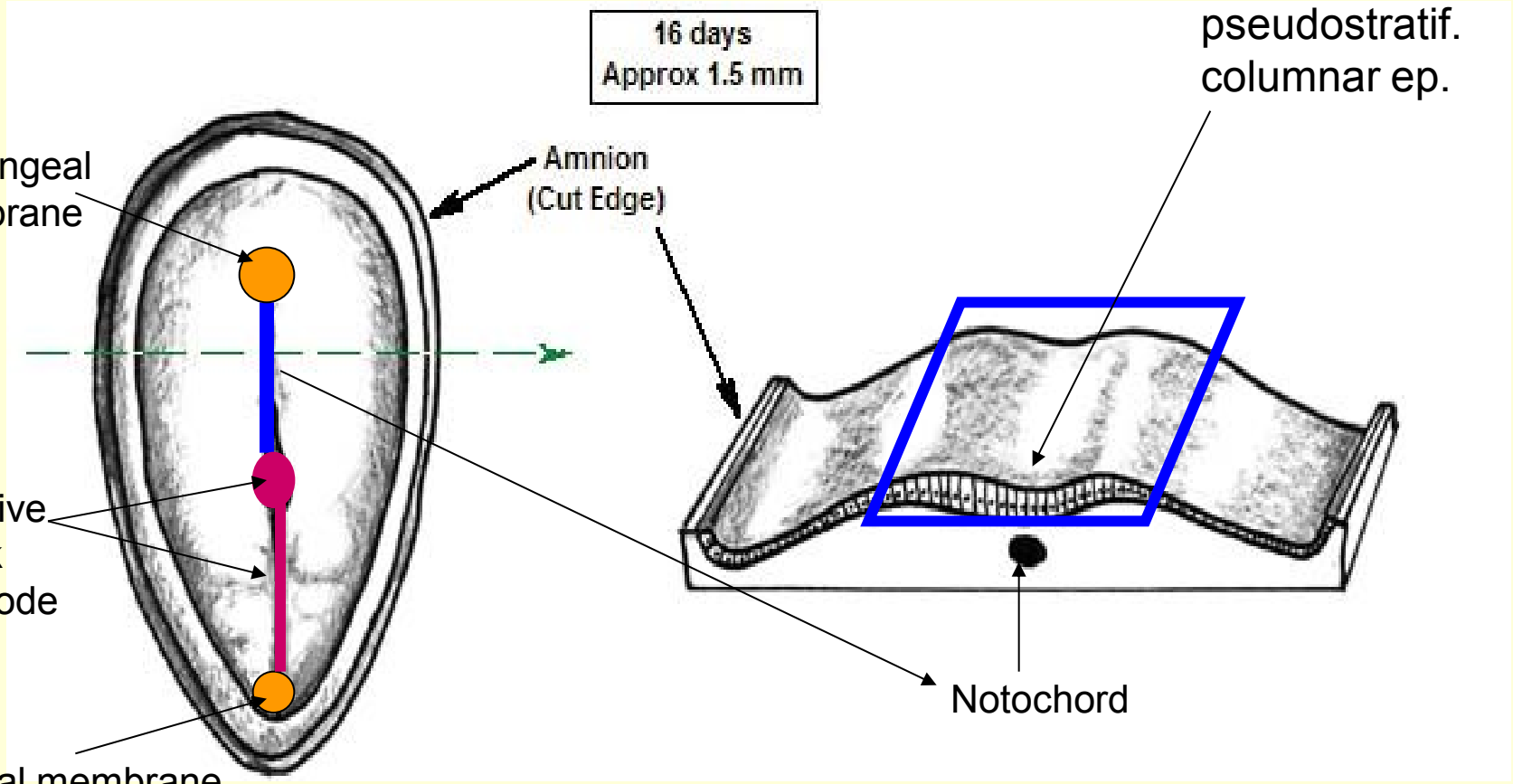
NOTOCHORD

- induces neural plate development

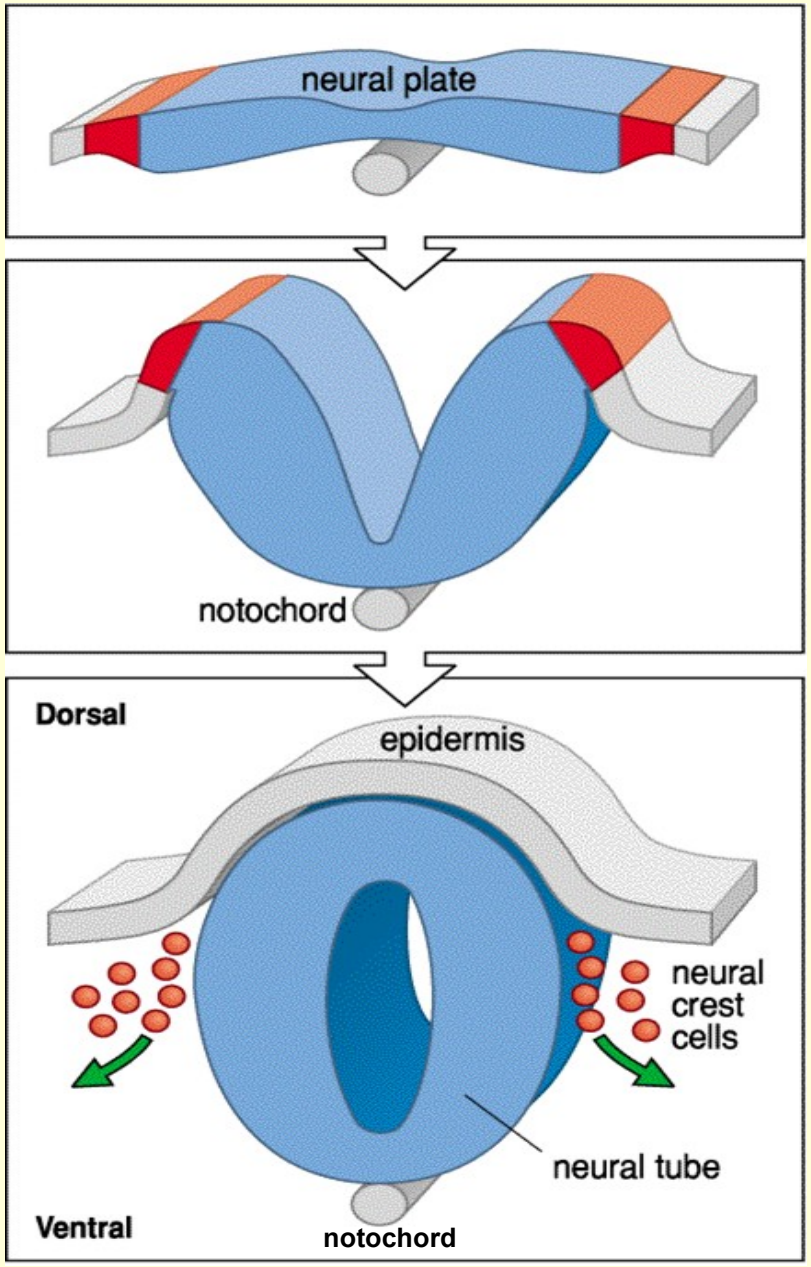




Neural plate – thickened area of embryonic ectoderm ⇨ **neuroectoderm**



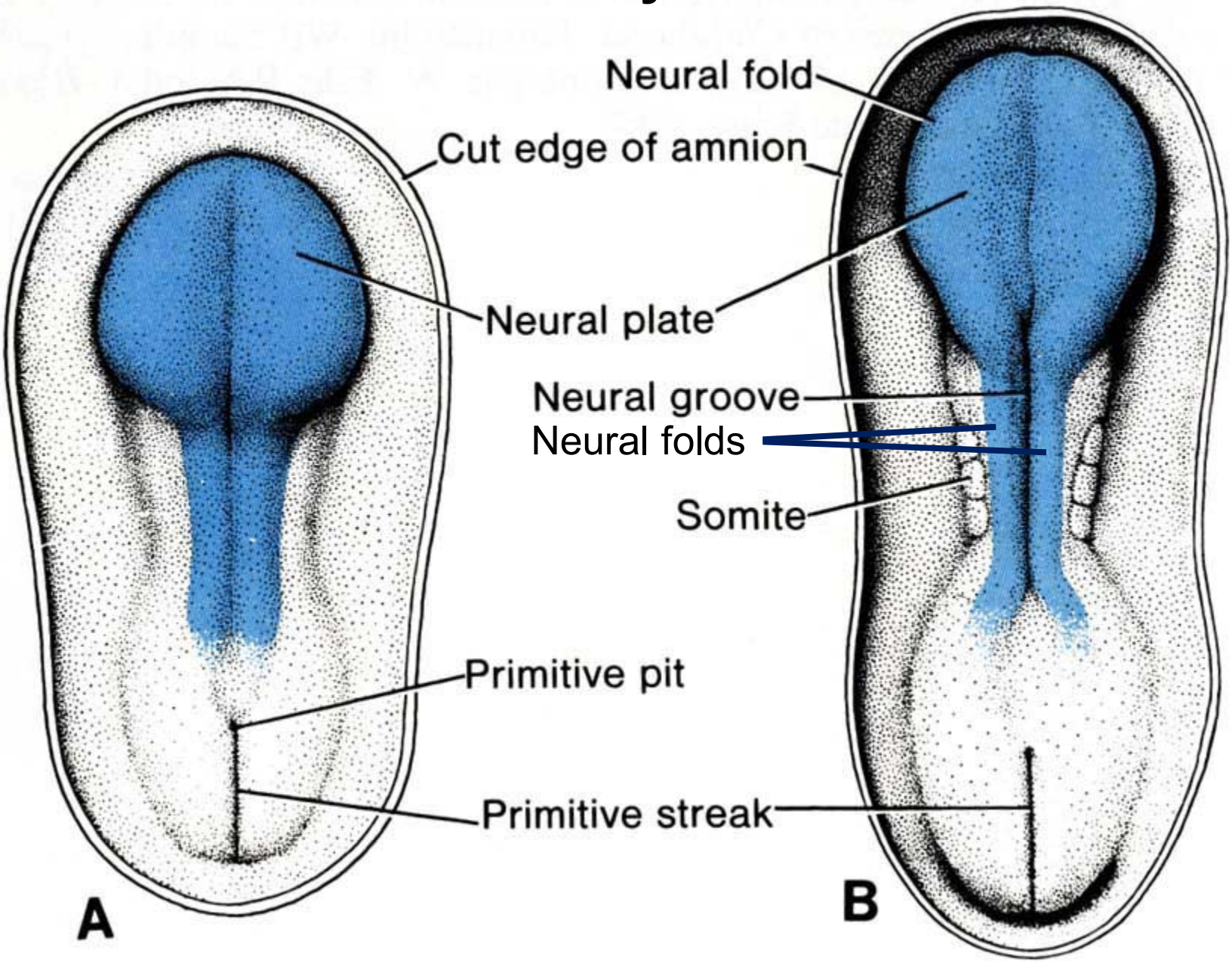
NEURULATION – invagination of neural plate (day 16 - 24)



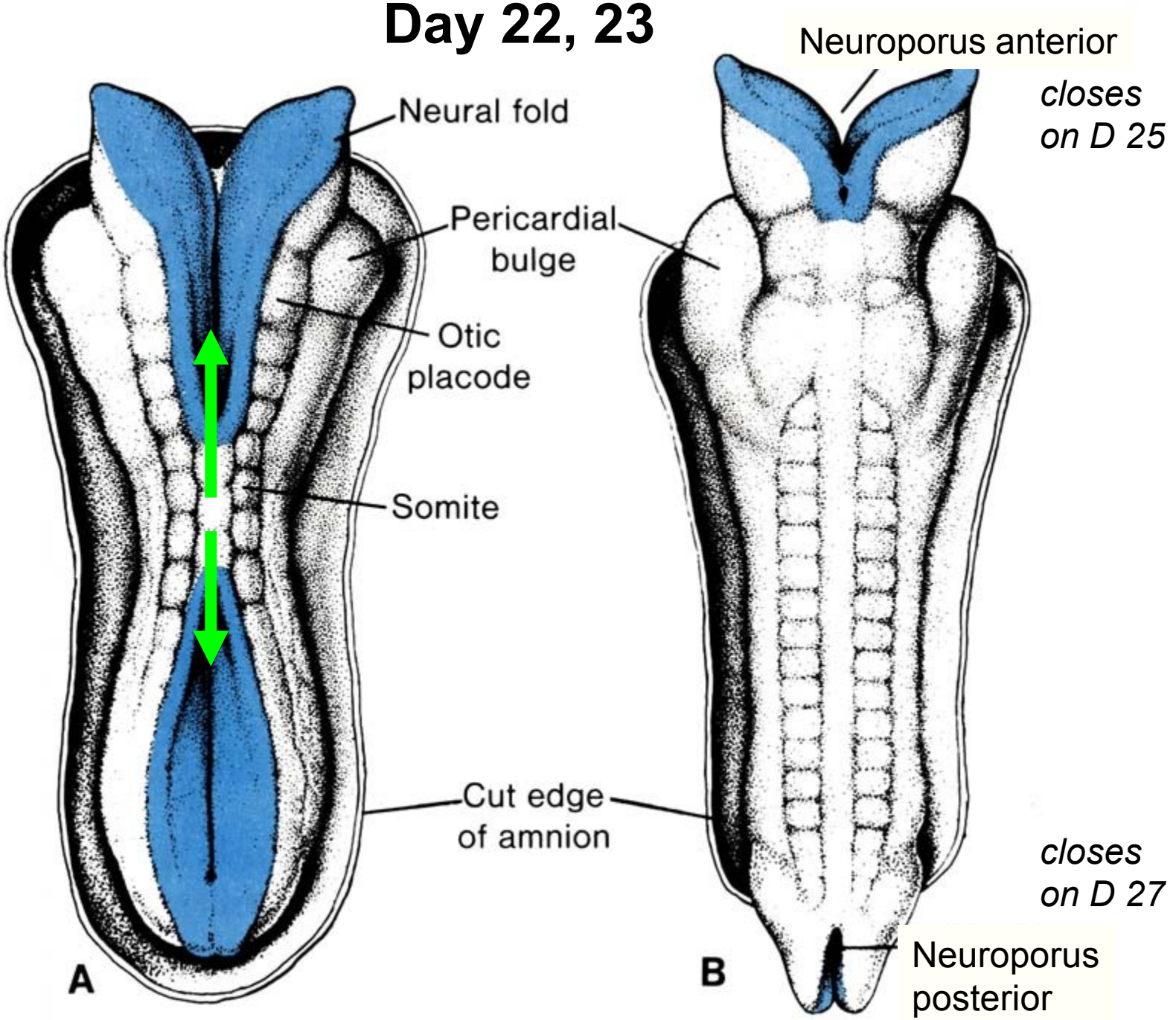
- neural folds
- neural groove

- neural tube
- neural crest

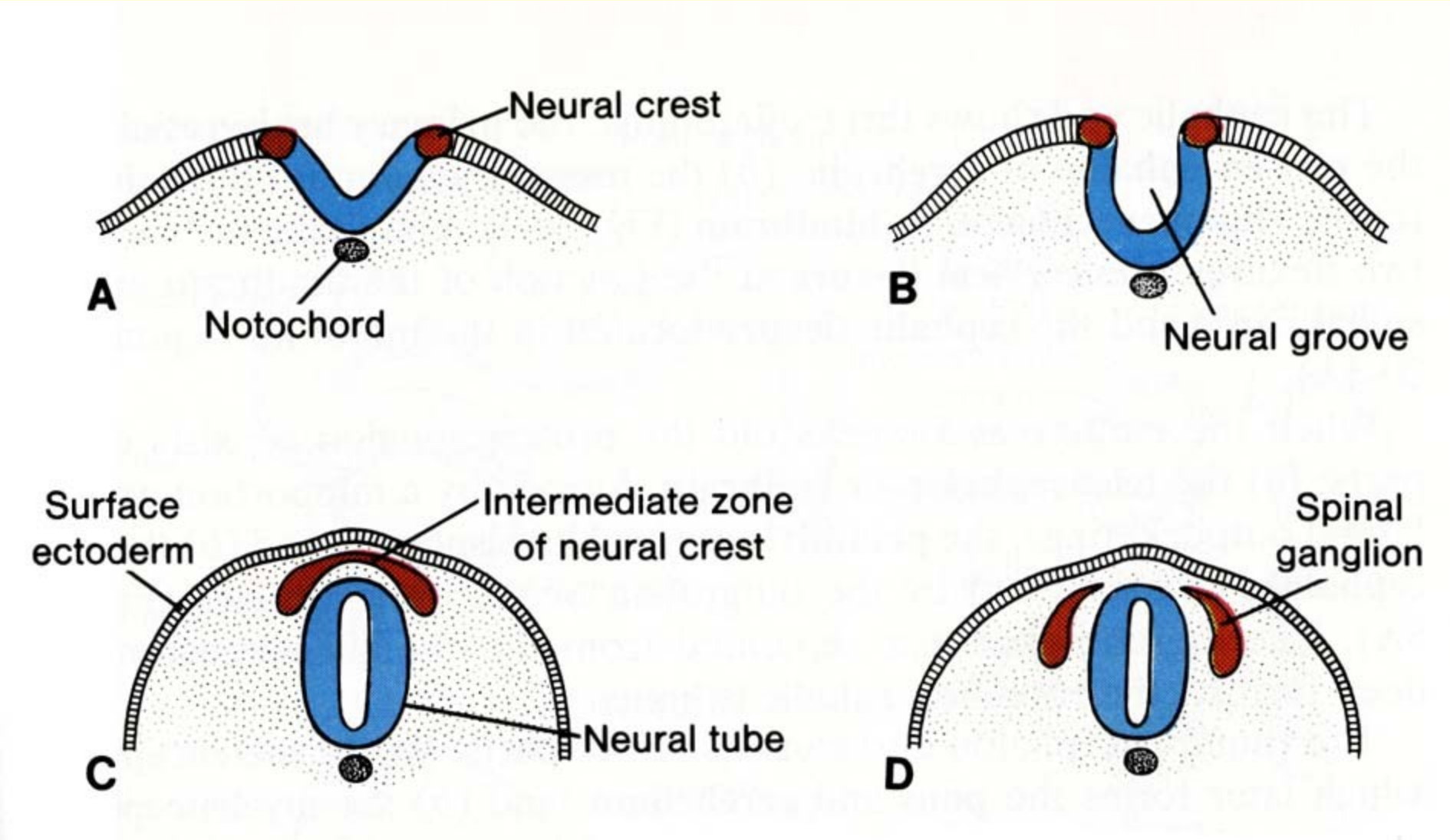
Day 20

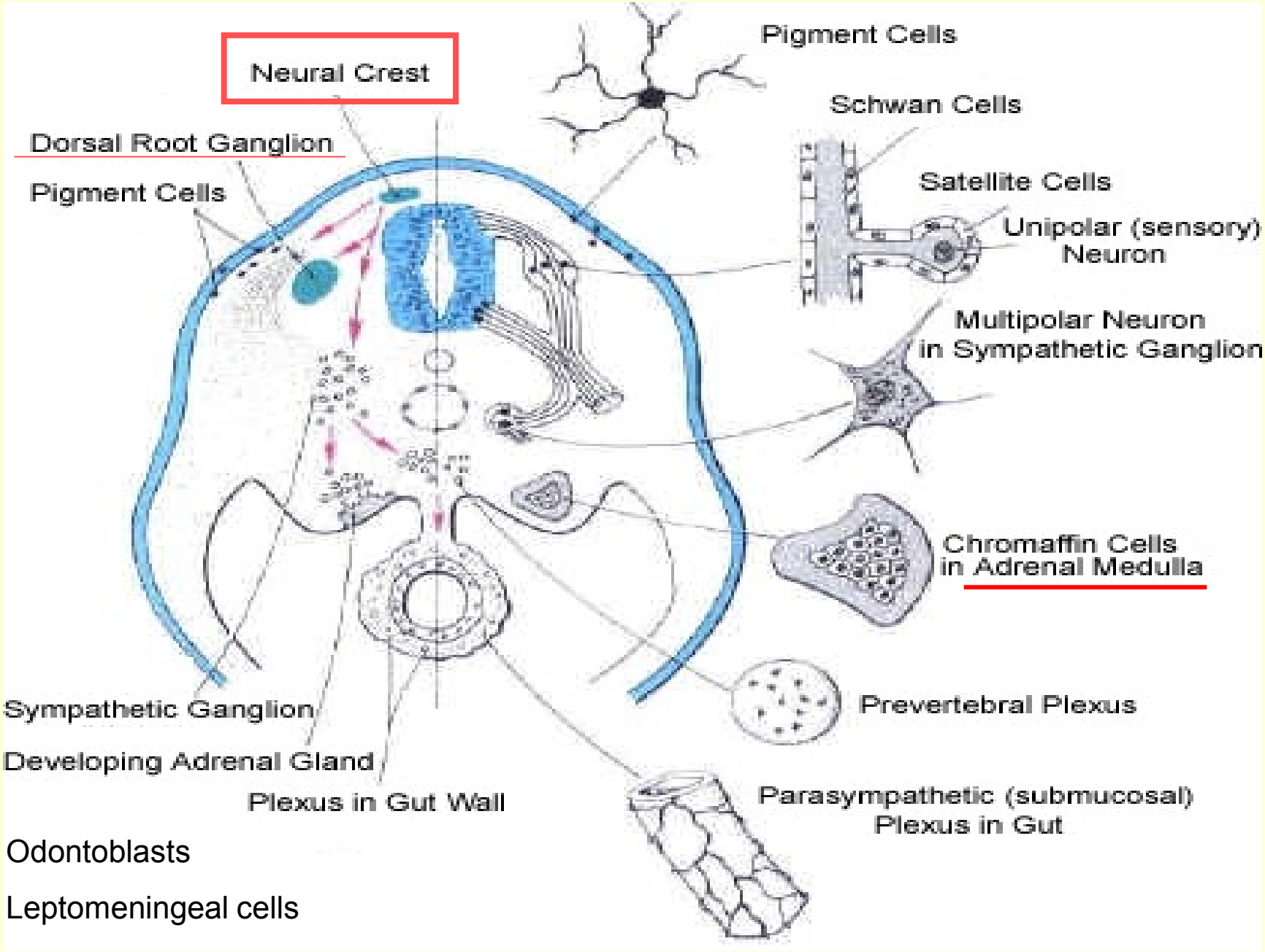

Neural fold
Cut edge of amnion
Neural plate
Neural groove
Neural folds
Somite
Primitive pit
Primitive streak
A
B

Day 22, 23


Neural fold
Pericardial bulge
Otic placode
Somite
Cut edge of amnion
A
Neuroporus anterior
closes on D 25
B
closes on D 27
Neuroporus posterior

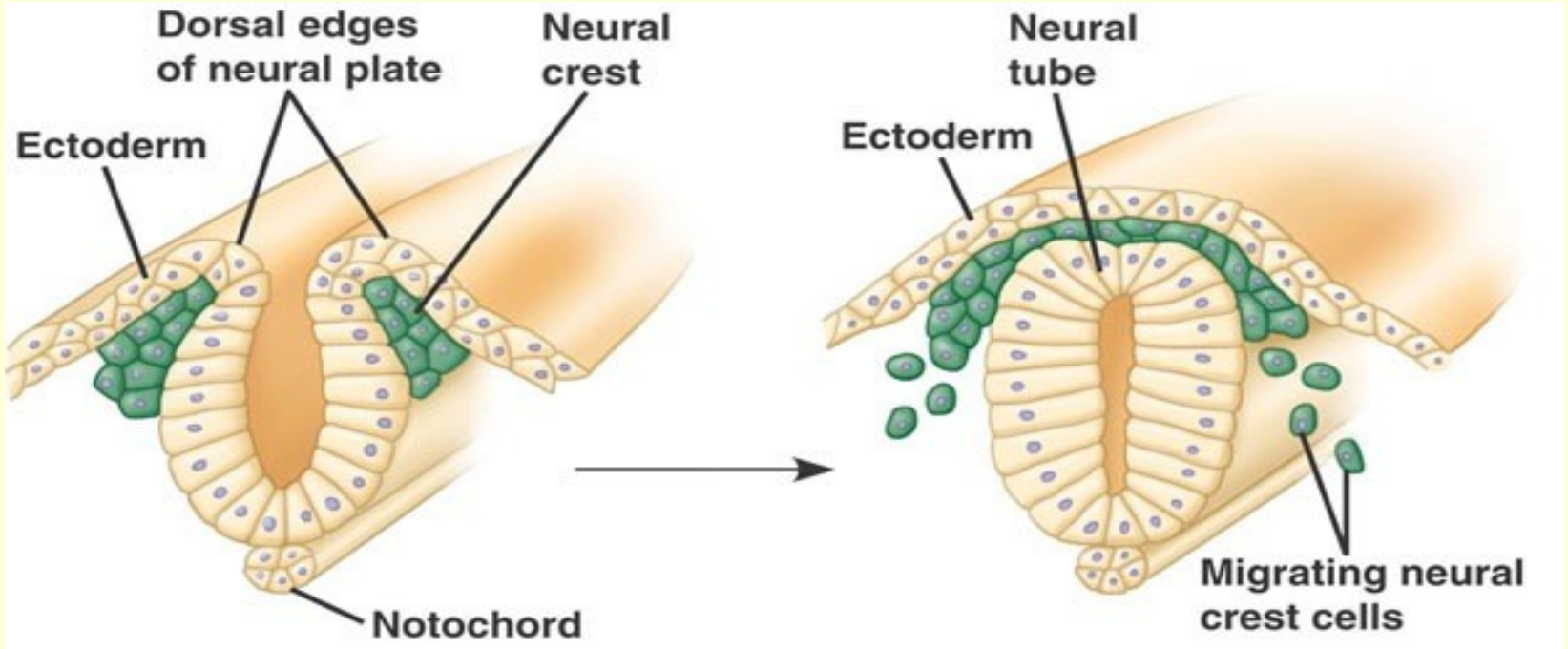
NEURAL CREST





Odontoblasts

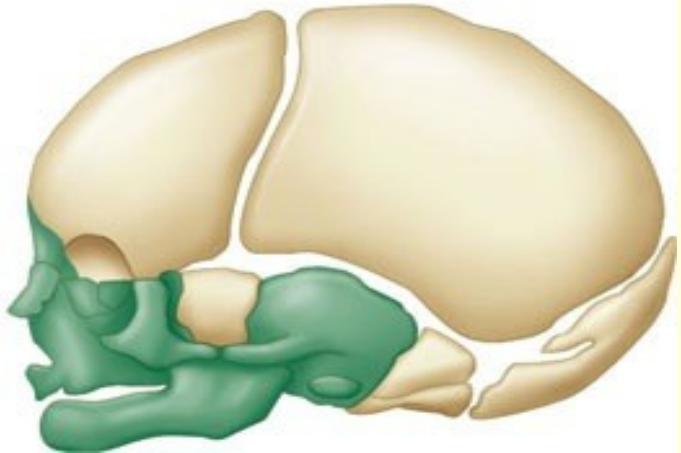
Leptomeningeal cells



(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.

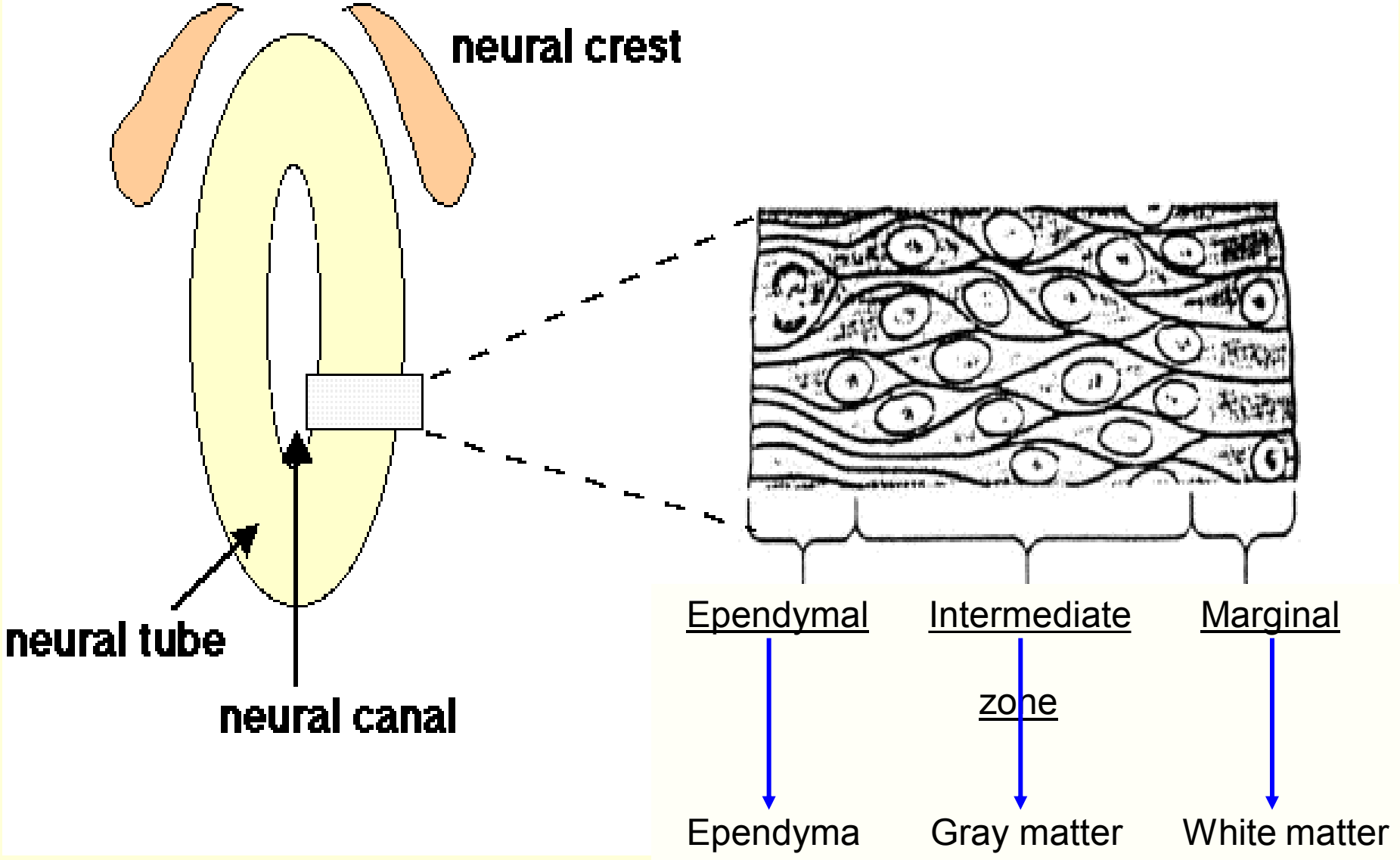
(c) The cells give rise to some of the anatomical structures unique to vertebrates, including some of the bones and cartilage of the skull.



EKTOMESENCHYME

Histogenesis of neural tube

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



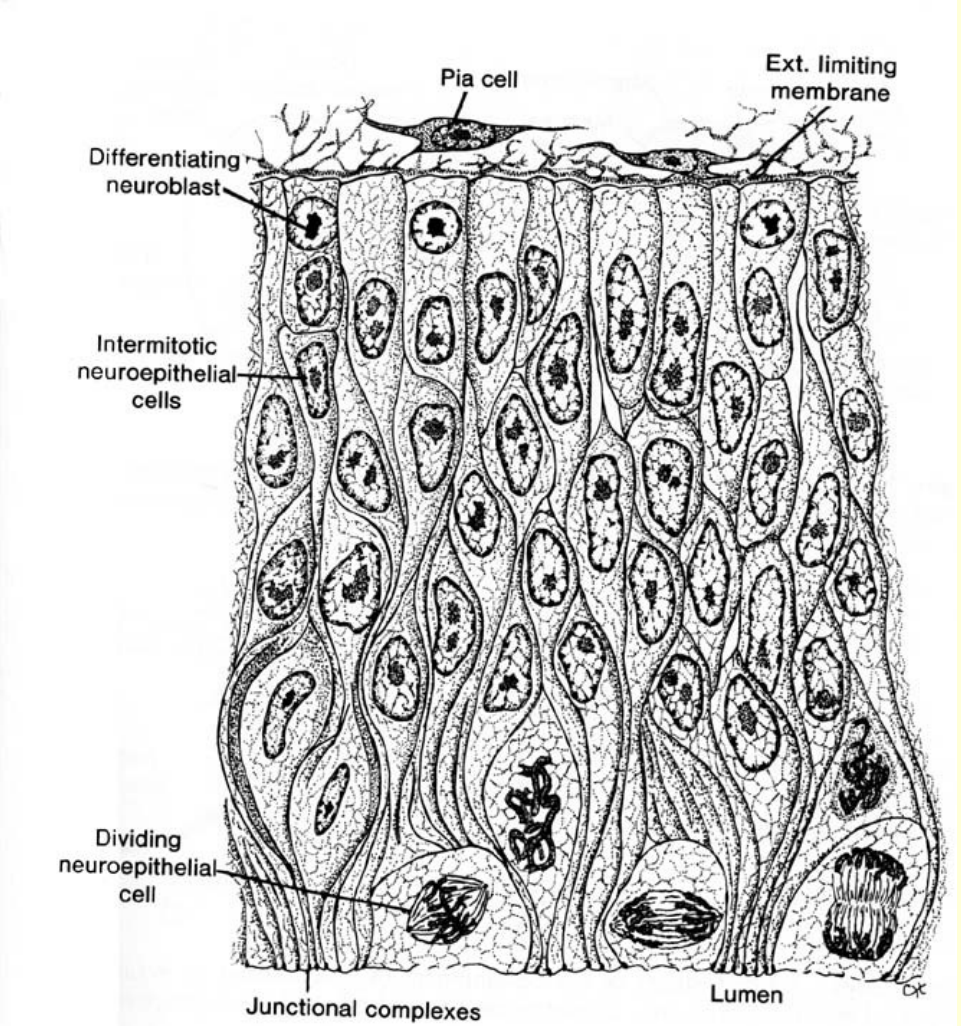
(in medulla spinalis)

HISTOGENESIS of NEURAL TUBE

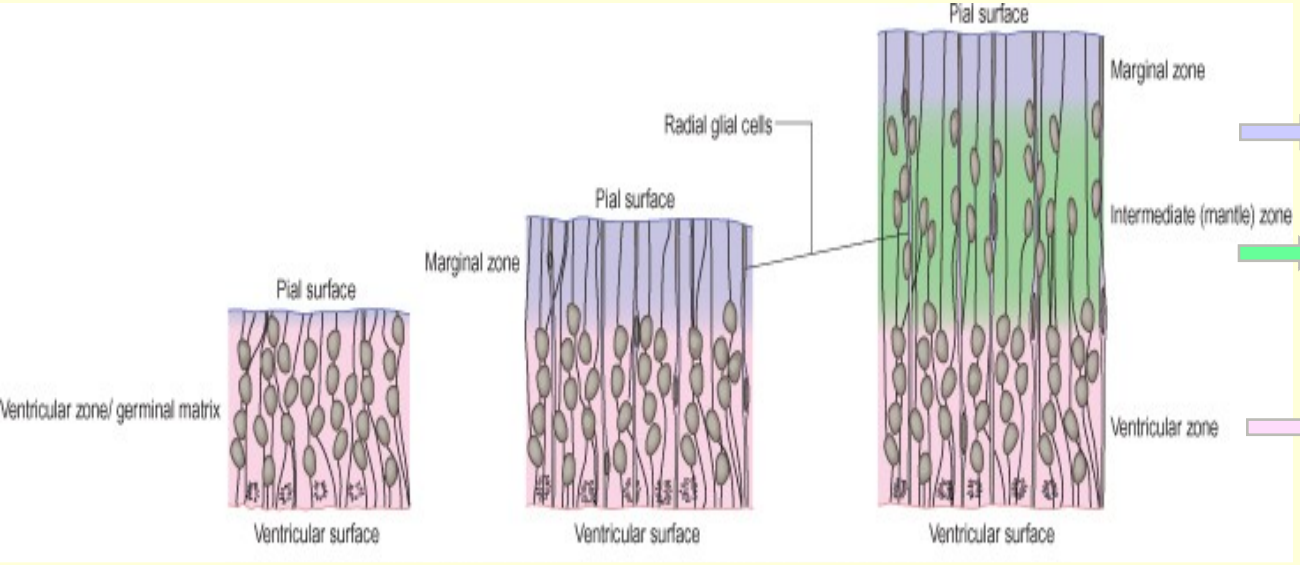
Marginal zone (white matter)

Intermediate zone (gray matter) (mantle zone)

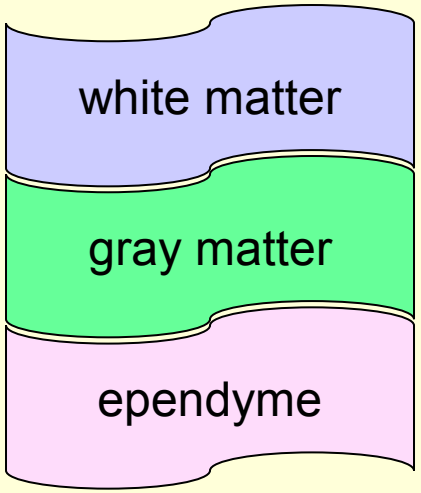
Ependymal zone (germinal)



Histogenesis of neural tissue



In spinal cord



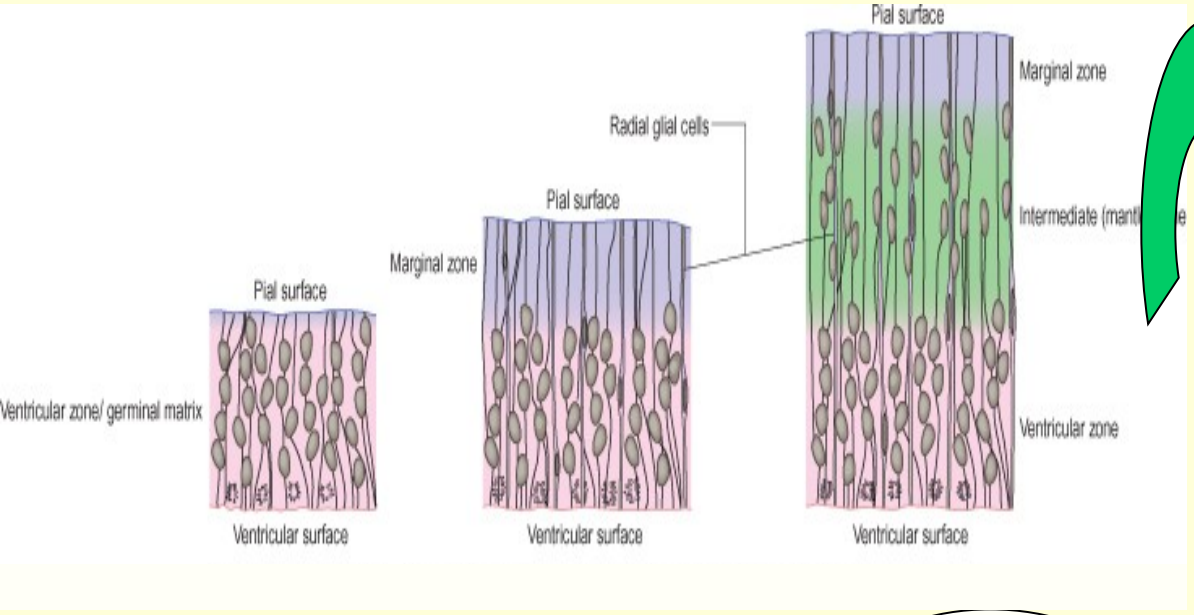
Three zones line neural tube (the spinal cord and brain stem).

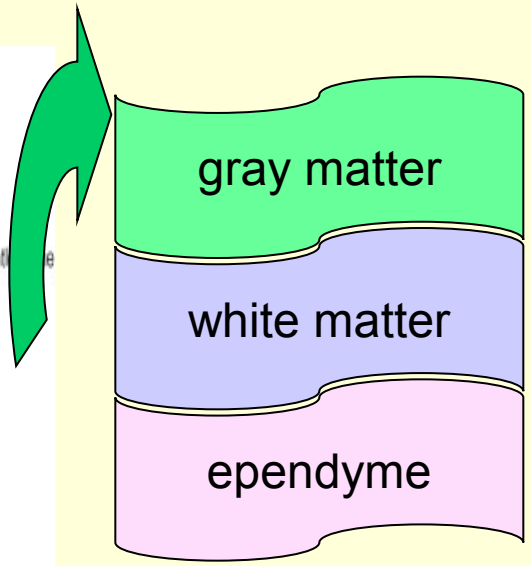
Marginal zone (white matter) – without neurons, but with axons of neurons and glial cells

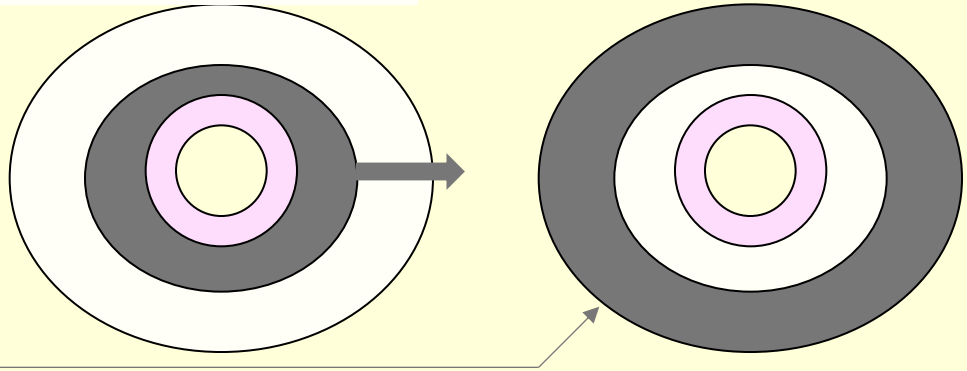
Mantle zone (gray matter) – neuroblasts + spongioblasts give rise to bodies of neurons and glial cells

Ependymal zone (germinal) – lining of central canal

→ **In brain and cerebellum**



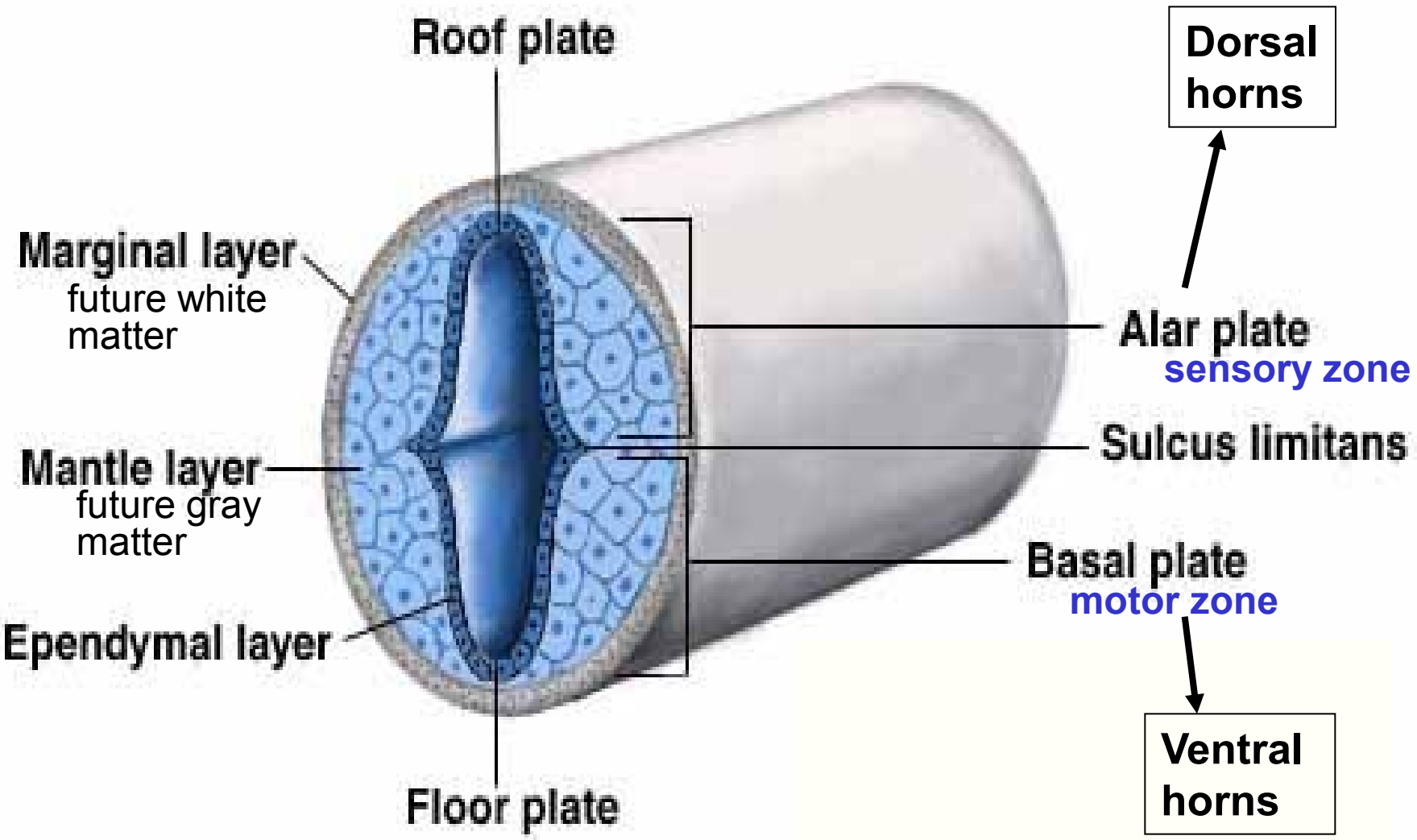




In brain and cerbellum:

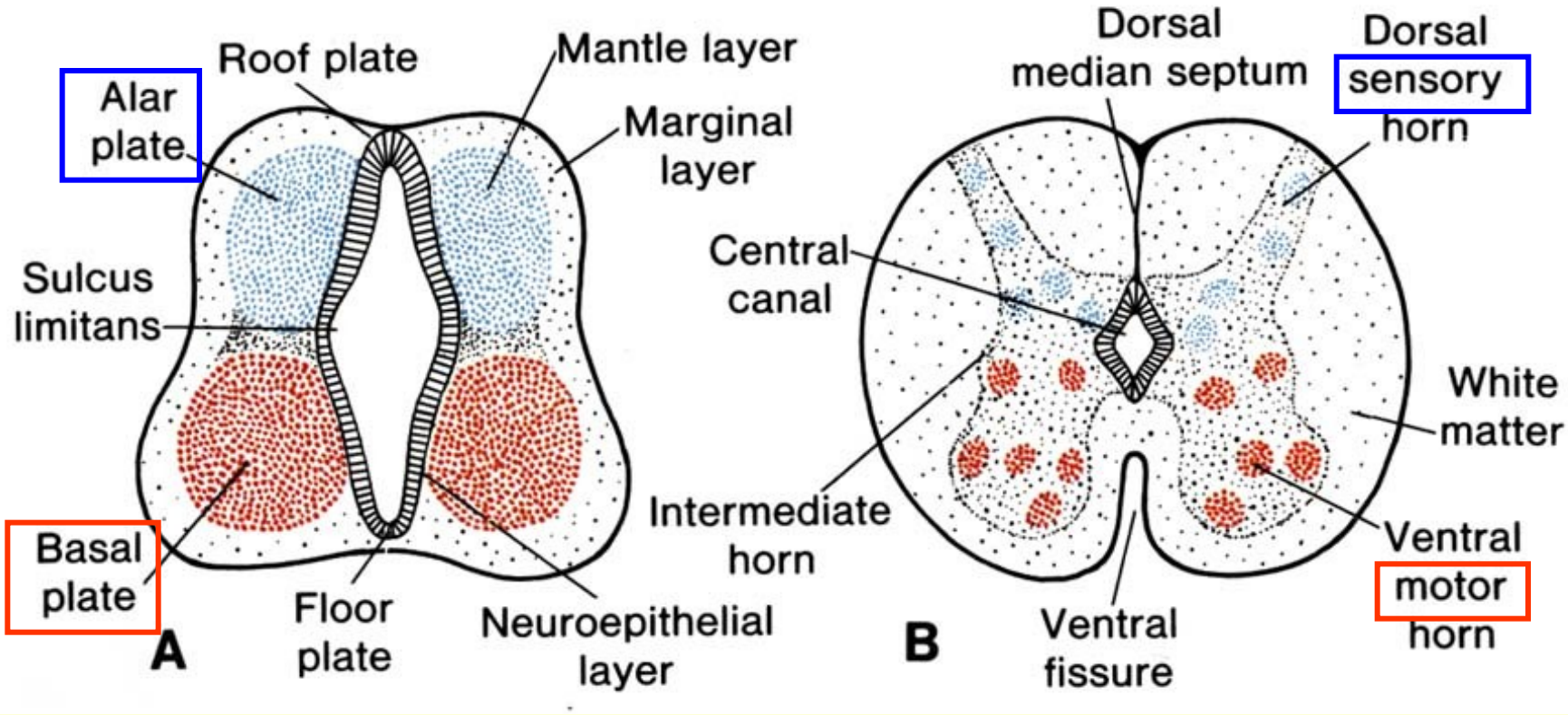
mantle zone cells migrate through marginal layer and the gray matter coveres white matter. Some neurons stay in white matter ⇨ nuclei.

Spinal cord development



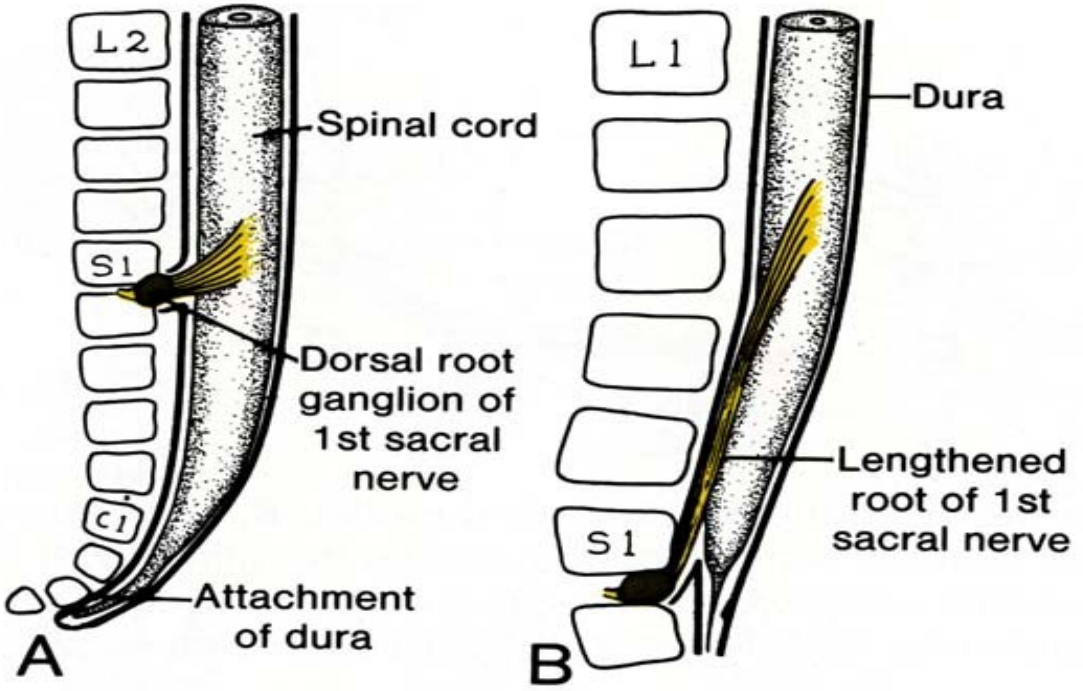
SPINAL CORD:

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

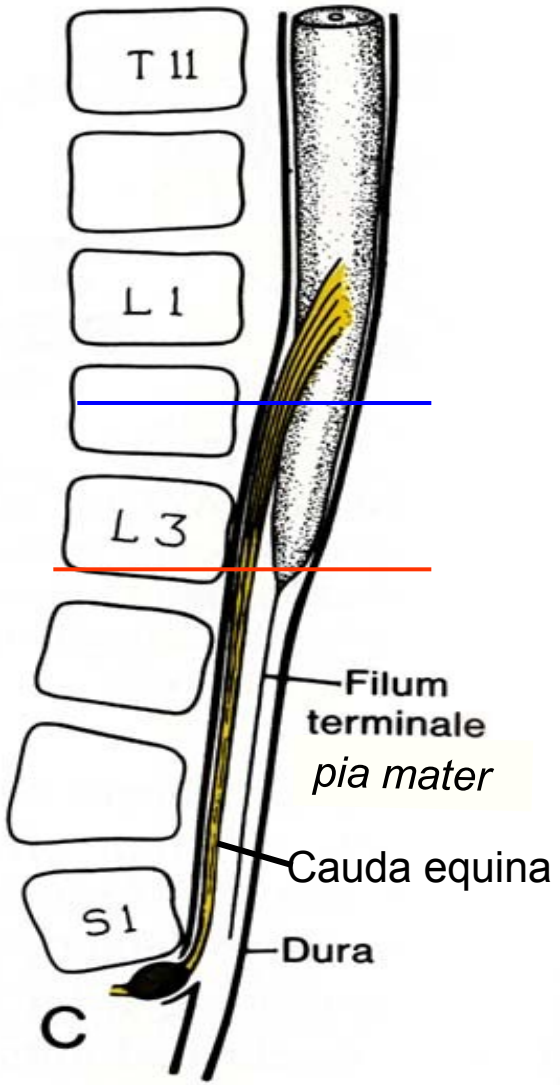


Positional changes of spinal cord

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 L2 in adults # .



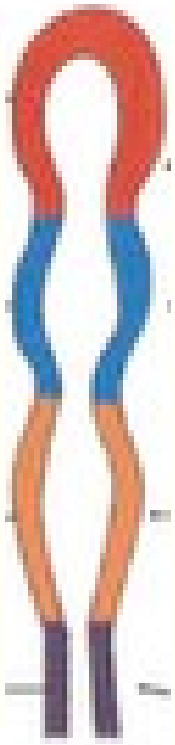
Brain development

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

3 primary → 5 secondary vesicles:

week 5

week 4



Prosencephalon

Telencephalon

1

Diencephalon

Optic vesicle
Neurohypophysis
Epiphysis

Mesencephalon

4

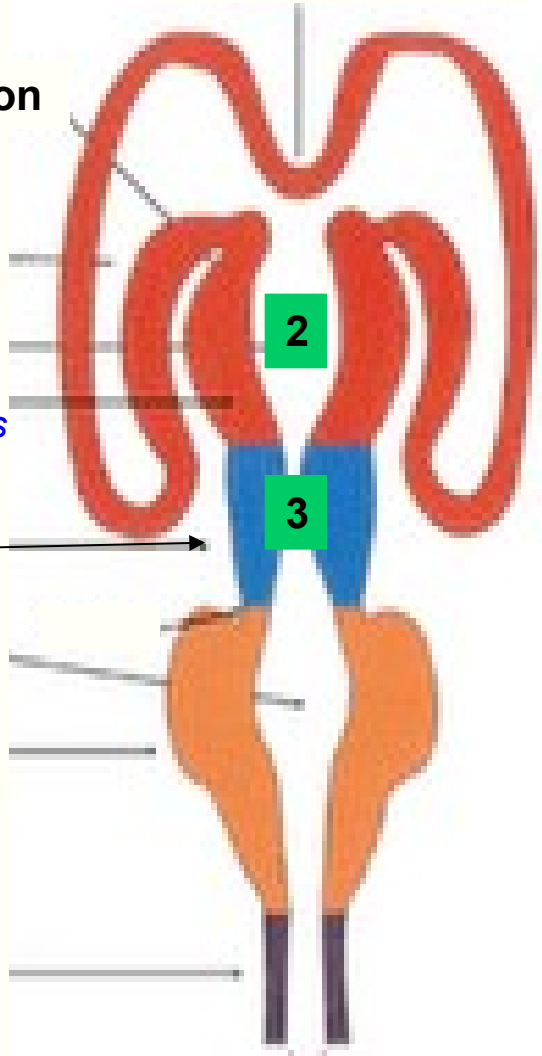
Rhombencephalon

Metencephalon

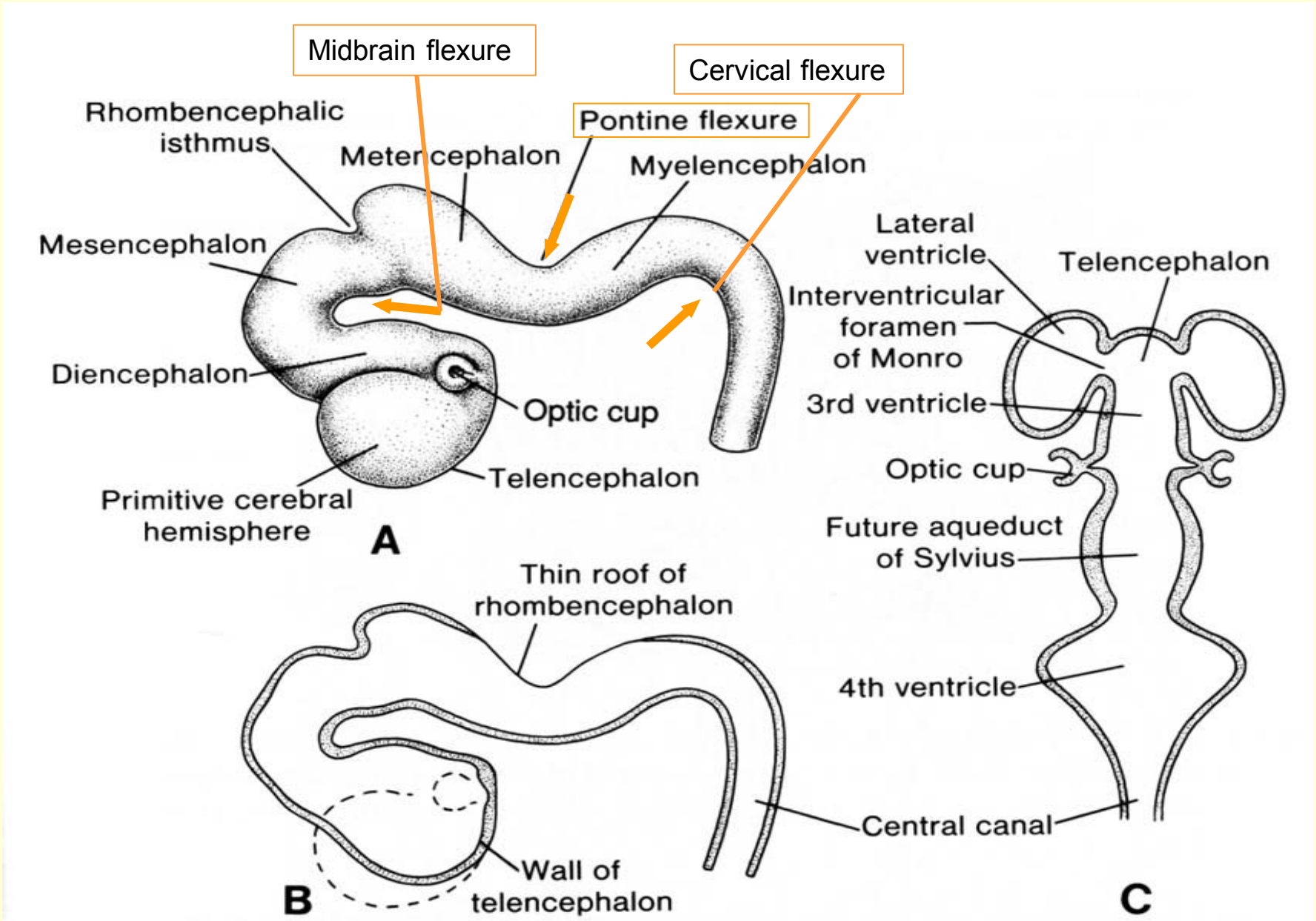
Cerebellum
Pons

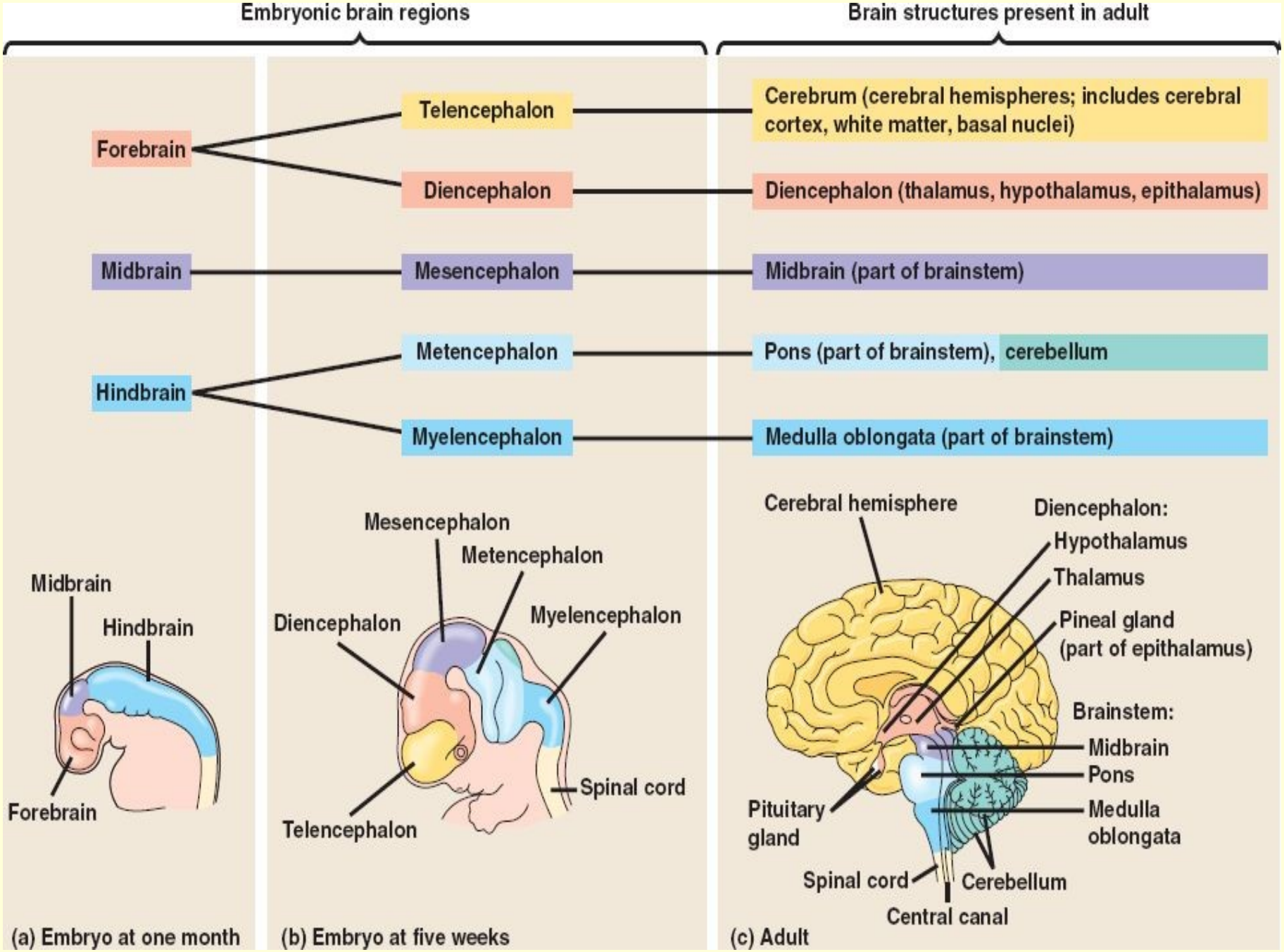
Myelencephalon

Lamina terminalis

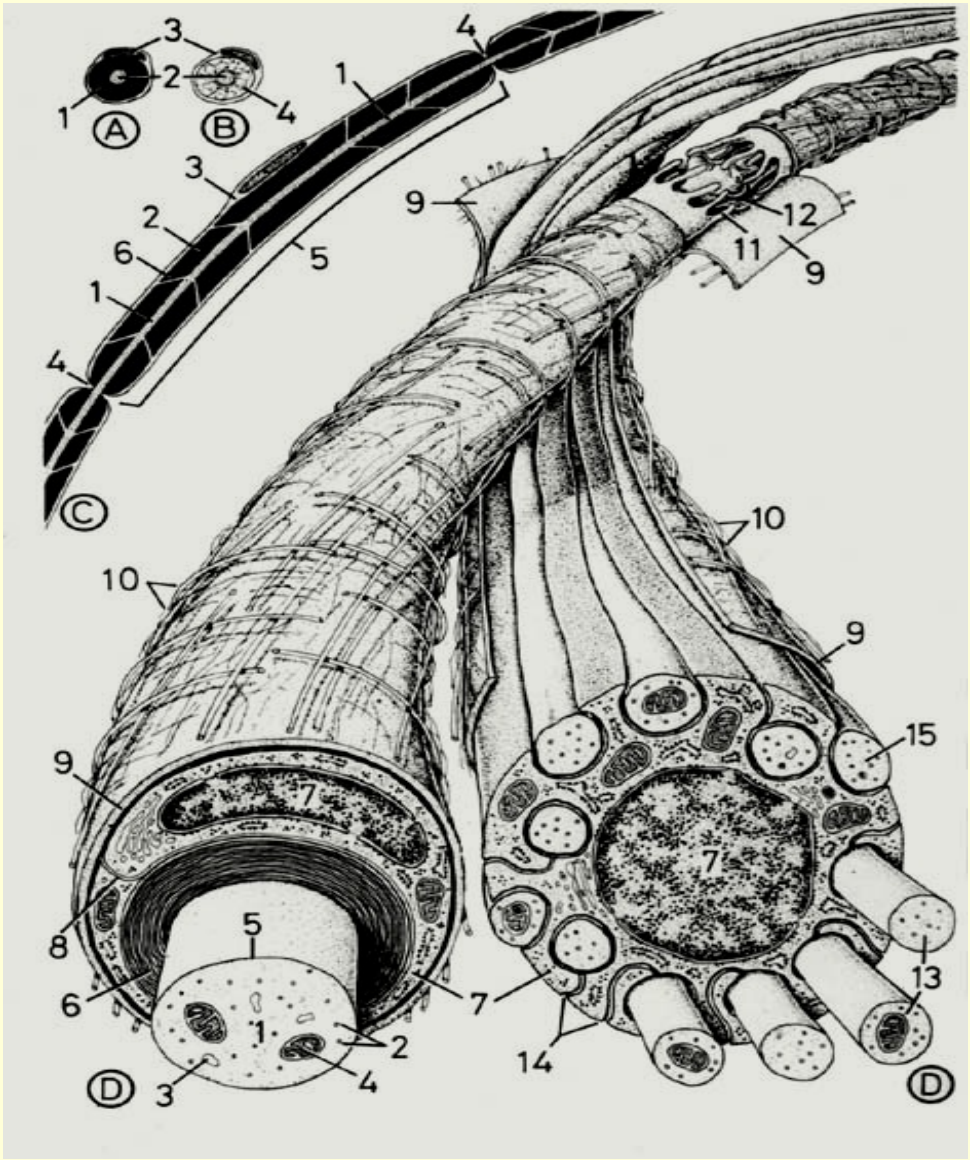


1 – ventriculi lat., 2 – ventriculus tertius, 3 – aqueductus cerebri, 4 – ventriculus quartus


Midbrain flexure
Cervical flexure
Pontine flexure
Rhombencephalic isthmus
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

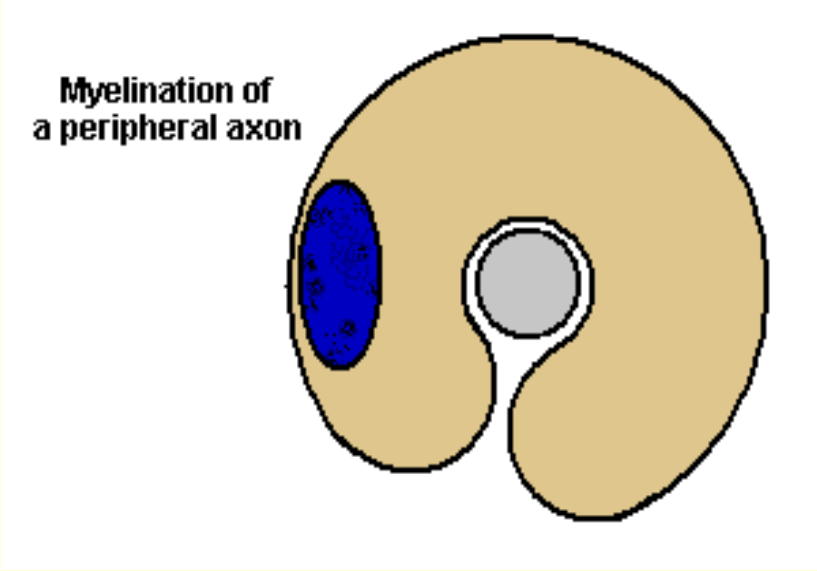

Embryonic brain regions
Brain structures present in adult
Forebrain
Midbrain
Hindbrain
Telencephalon
Diencephalon
Mesencephalon
Metencephalon
Myelencephalon
Cerebrum (cerebral hemispheres; includes cerebral cortex, white matter, basal nuclei)
Diencephalon (thalamus, hypothalamus, epithalamus)
Midbrain (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 end of 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.

Etiology: usually multifactorial (fever, drugs during gravidity, hypervit. A etc.) or hereditary disposition.

Folic acid use influence normal development of CNS.

Sonography detects anomalies.

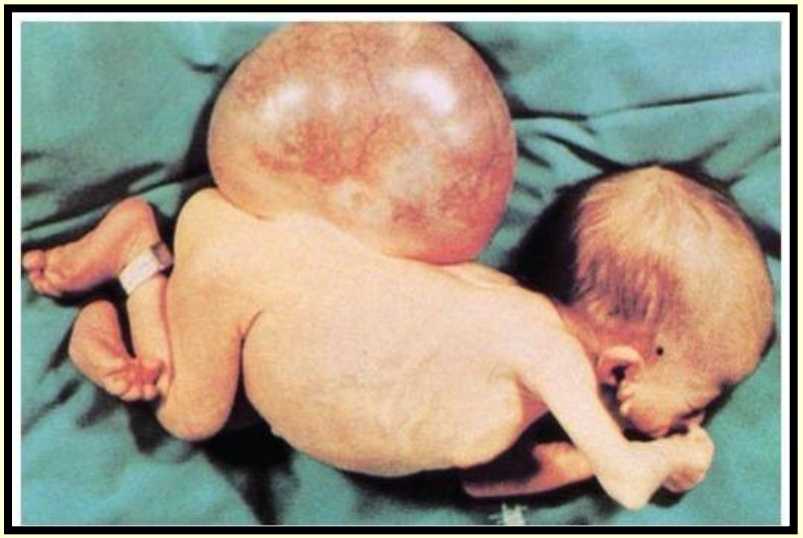
Spinal cord malformations

Defects (clefts) of vertebral arches

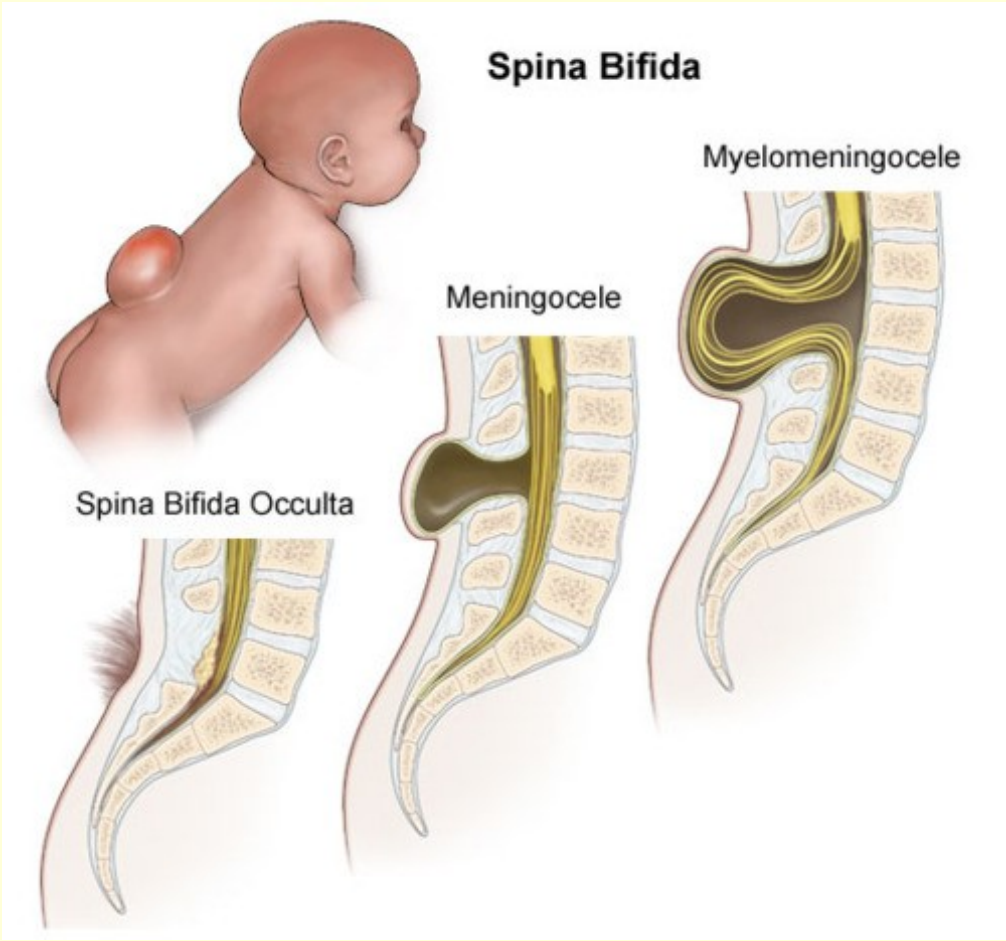
- Menigocele
- Menigomyelocele
- Menigohydromyelocele

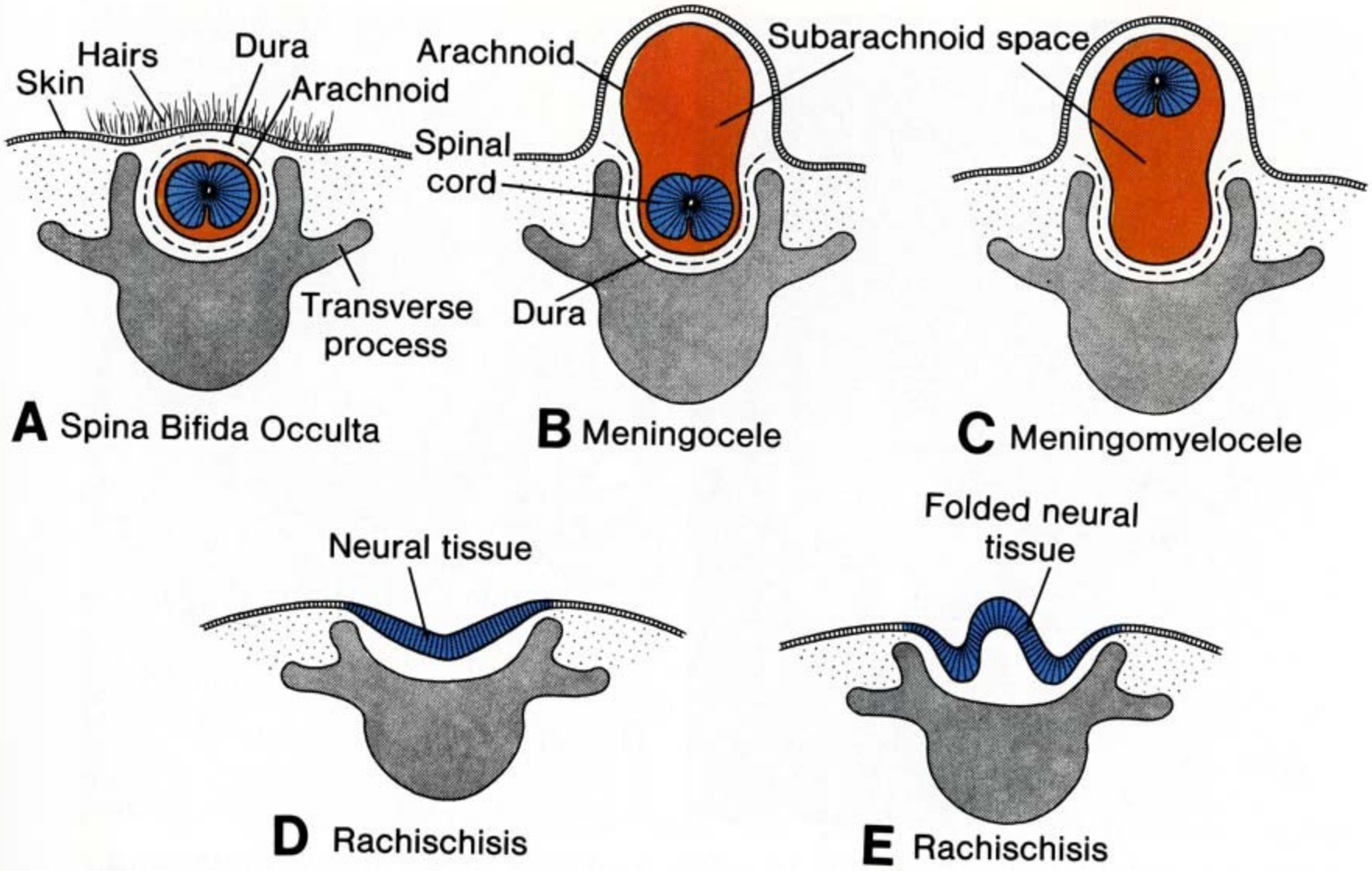
} **spina bifida cystica**

- 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

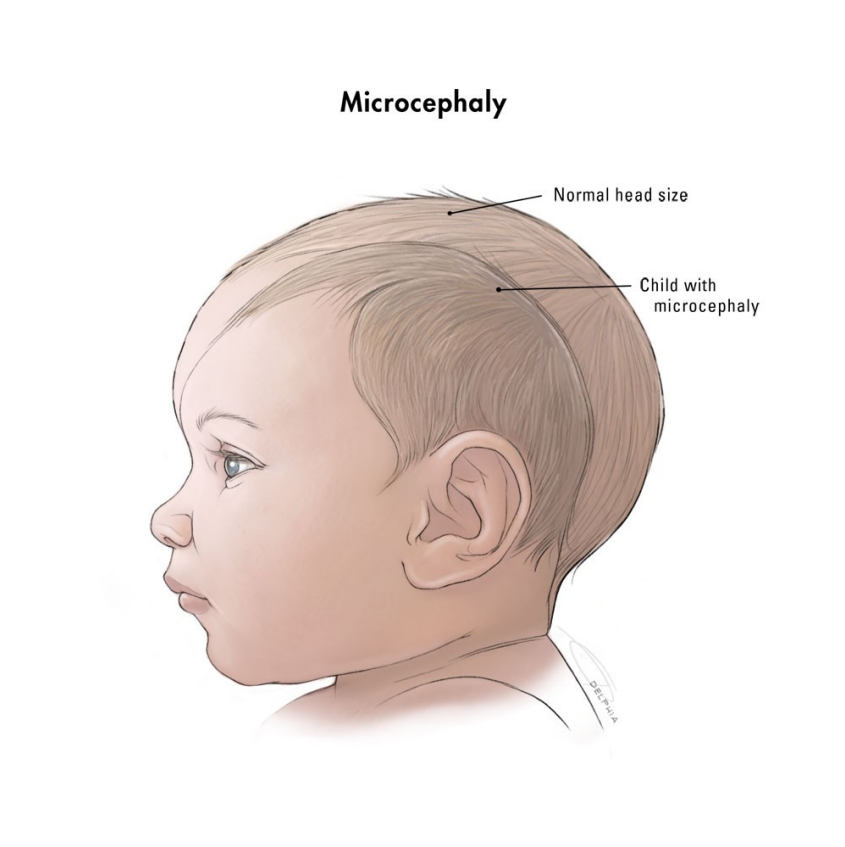
4) lipomatous mass

Brain malformations

- Anencephalia (†) (with myeloschisis)

Brain malformations

MICROCEPHALIA



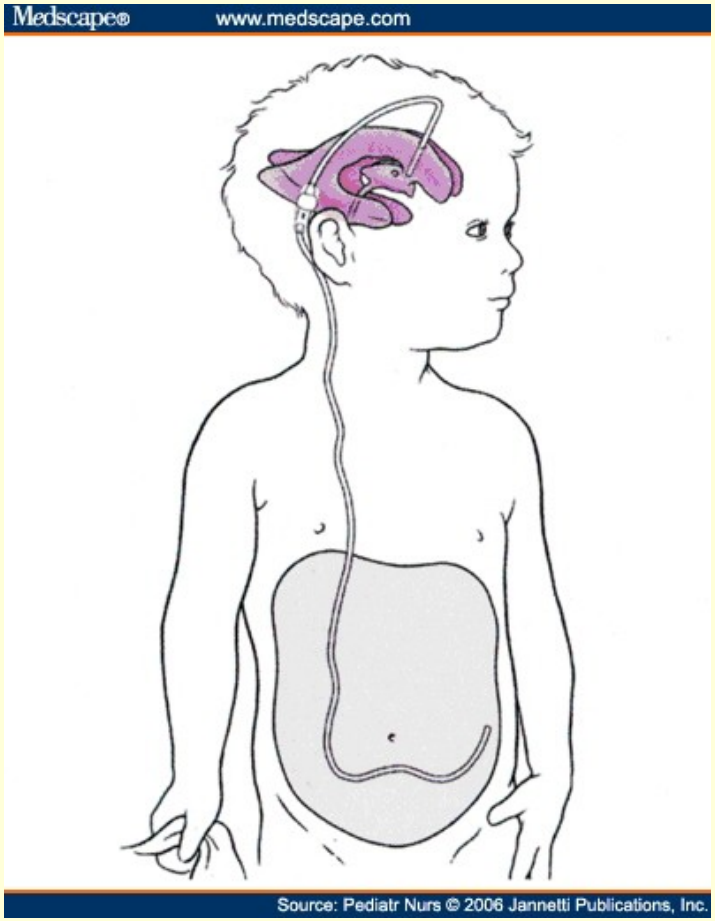
ANENCEPHALIA

Hydrocephalus

- accumulation of abundant cerebrospinal fluid in brain ventricular system,
- etiology: stenosis or obliteration of aqueductus cerebri between 3rd and 4th ventricles ➡ fluid is accumulated in lateral ventricles ➡ pushes on the brain tissue (is thinned); internal pressure complicates drenage of fluid insubarachnoid space;
- until skull suture don‘t ossify – skull can grows extremely .

HYDROCEPHALUS

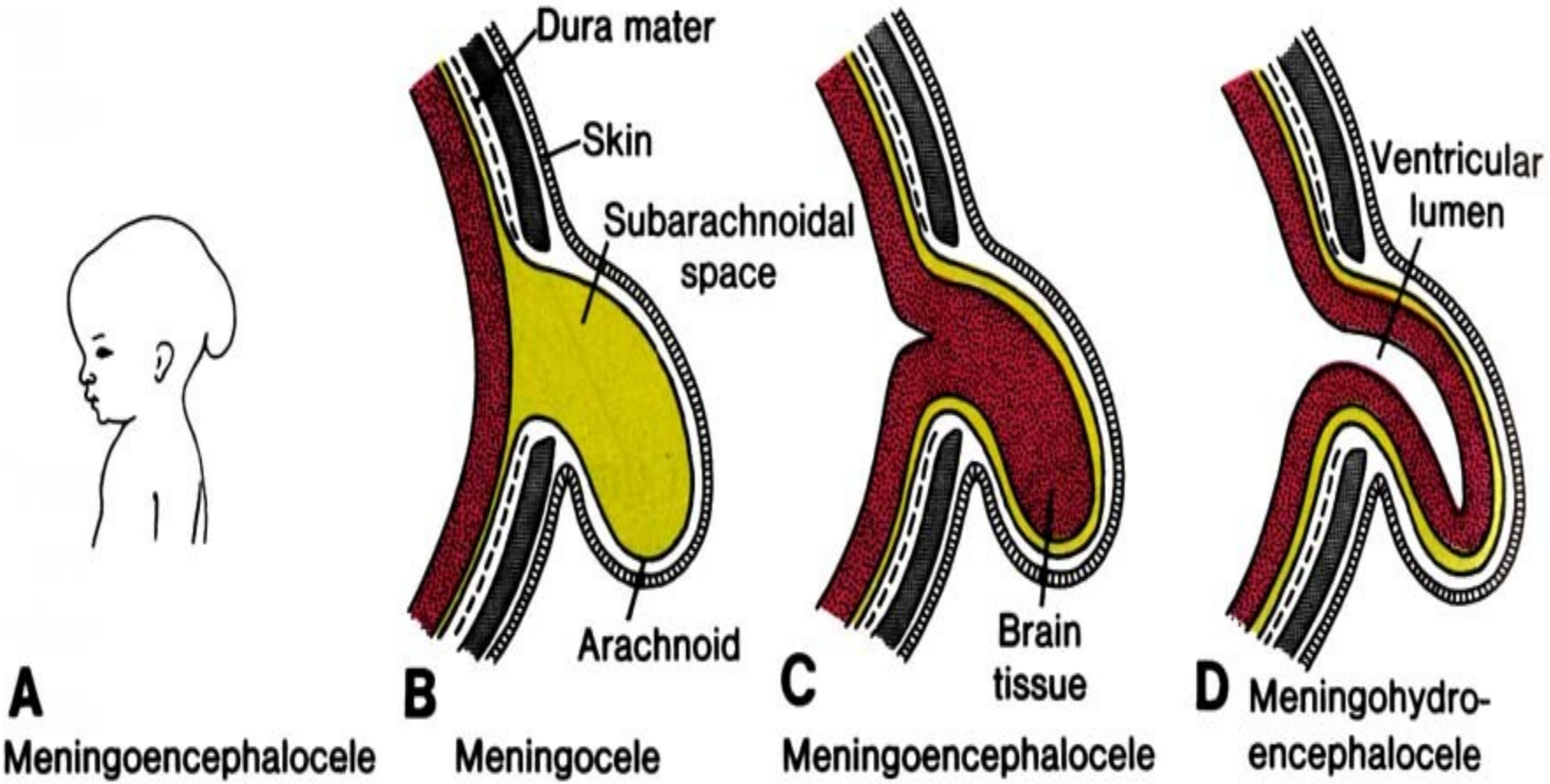
ventriculoperitoneal shunt



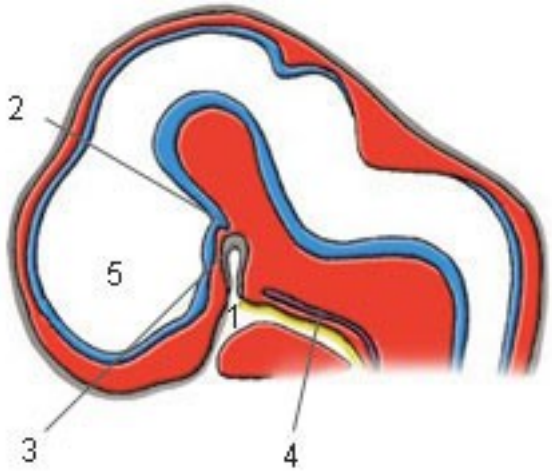
CASE A. [CASE B. MICROCEPHALUS.] CASE B.

HYDROCEPHALUS.

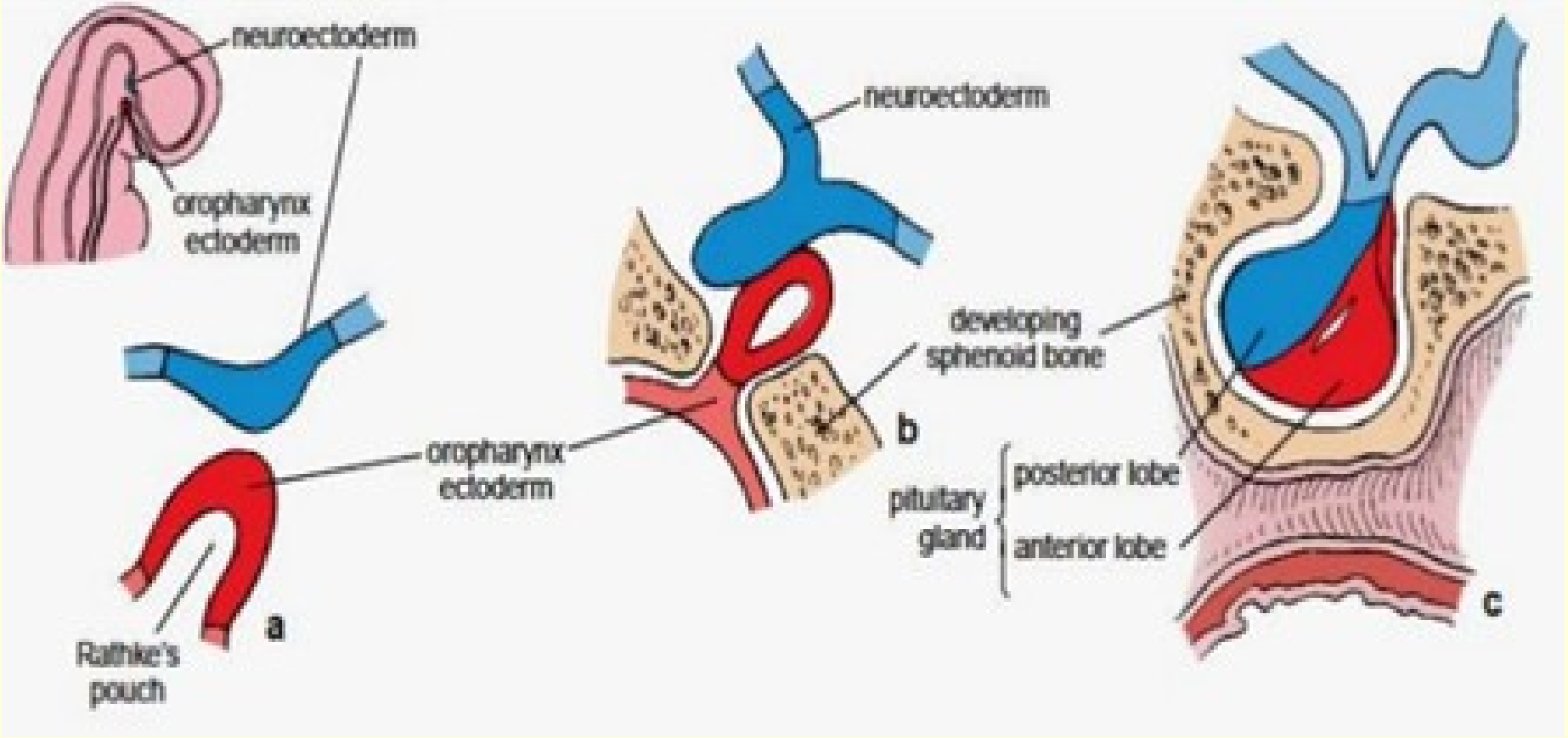
Brain and meninges hernia(tion)




End



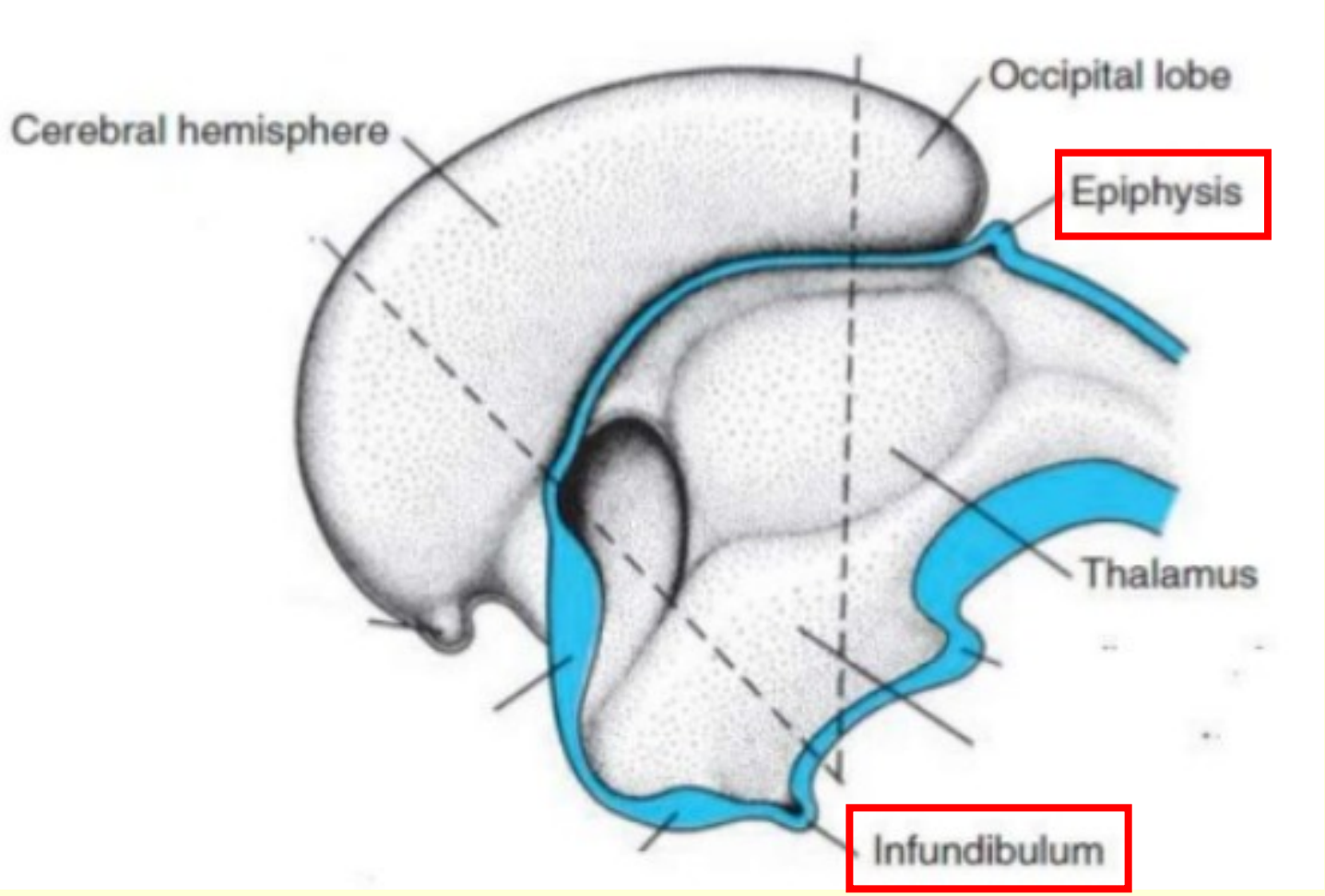
Neurohypophyseal diverticle
of diencephalon floor
+
Rathke‘s pouch
of stomodeum roof



Possible congenital anomalies

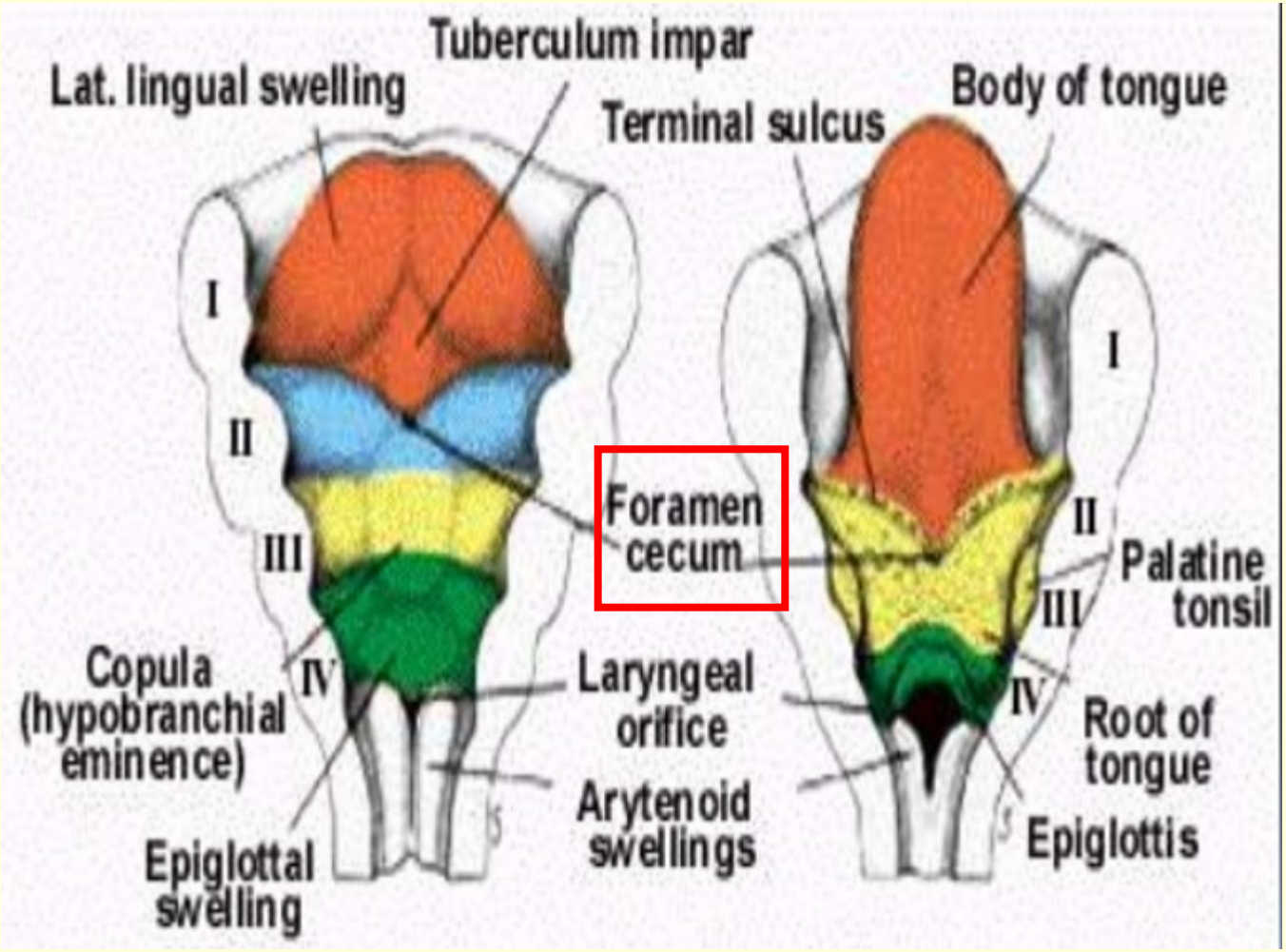
- Pharyngeal hypophysis
- Agenesis/Hypogenesis of pituitary gland
- Duplication of pituitary gland
- Congenital tumor of the gland (Craniopharyngioma)

Pineal gland (epiphysis) – diverticulum of the roof of diencephalon

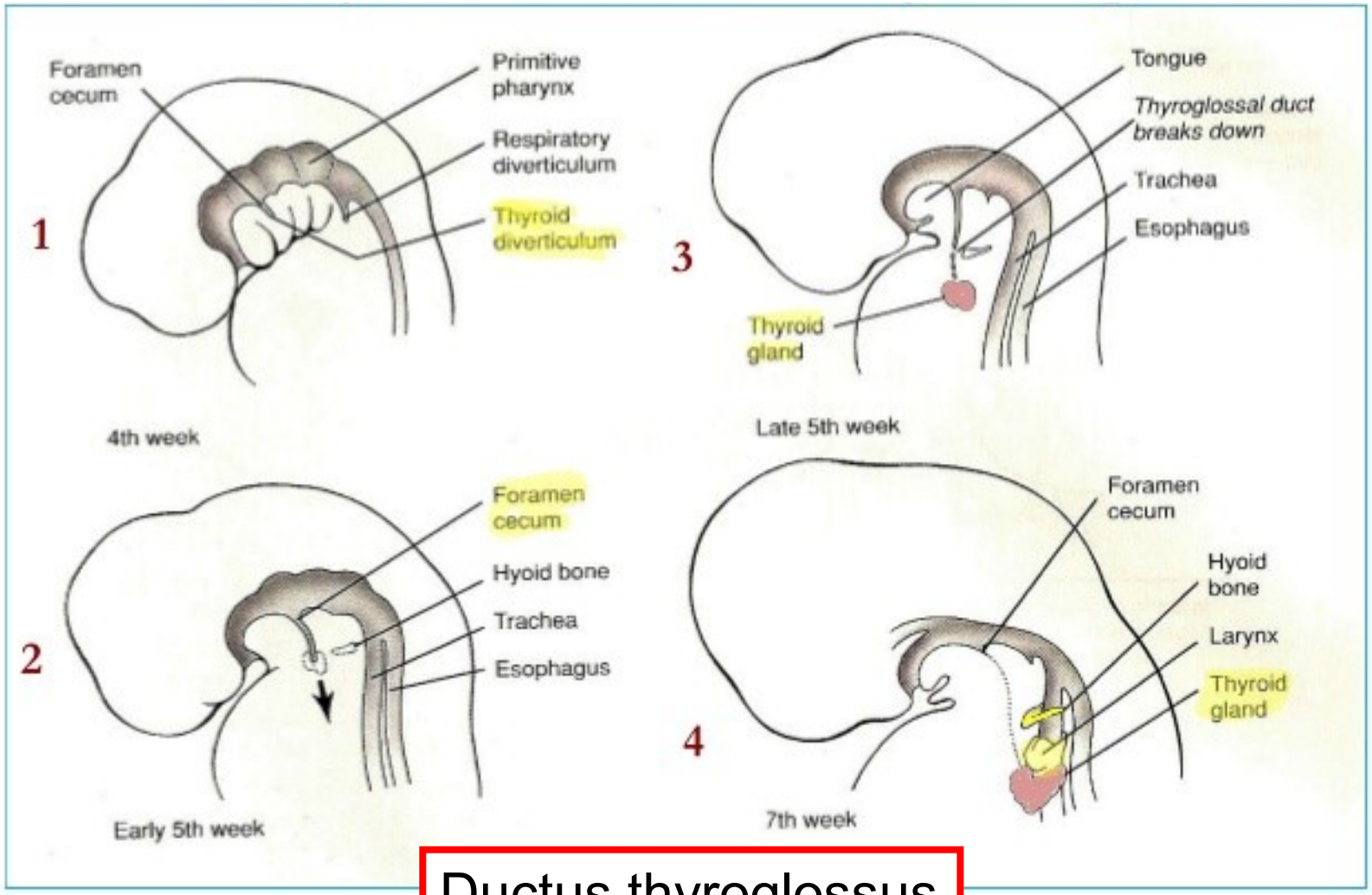


the floor of diencephalon

Thyroid gland

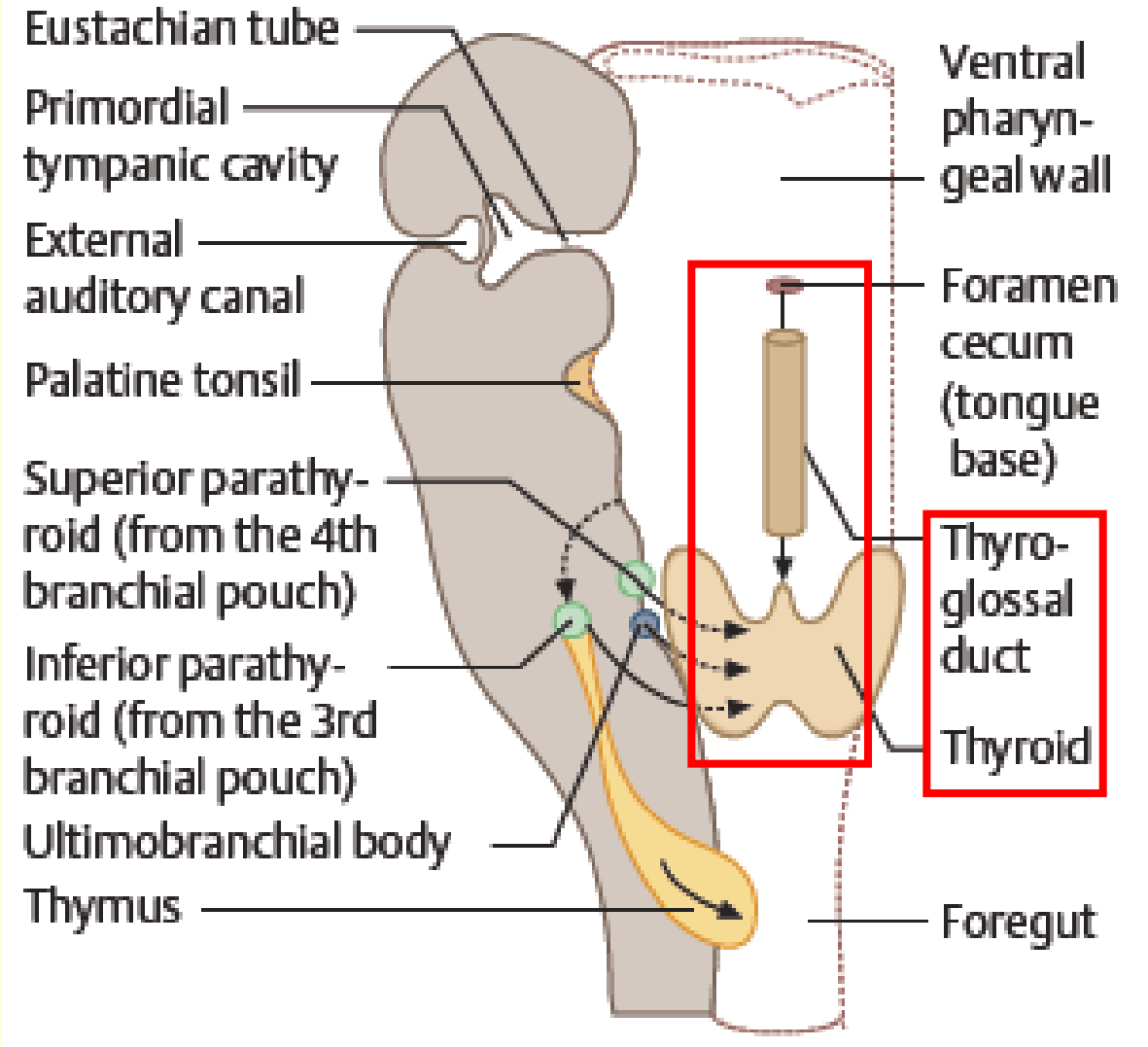


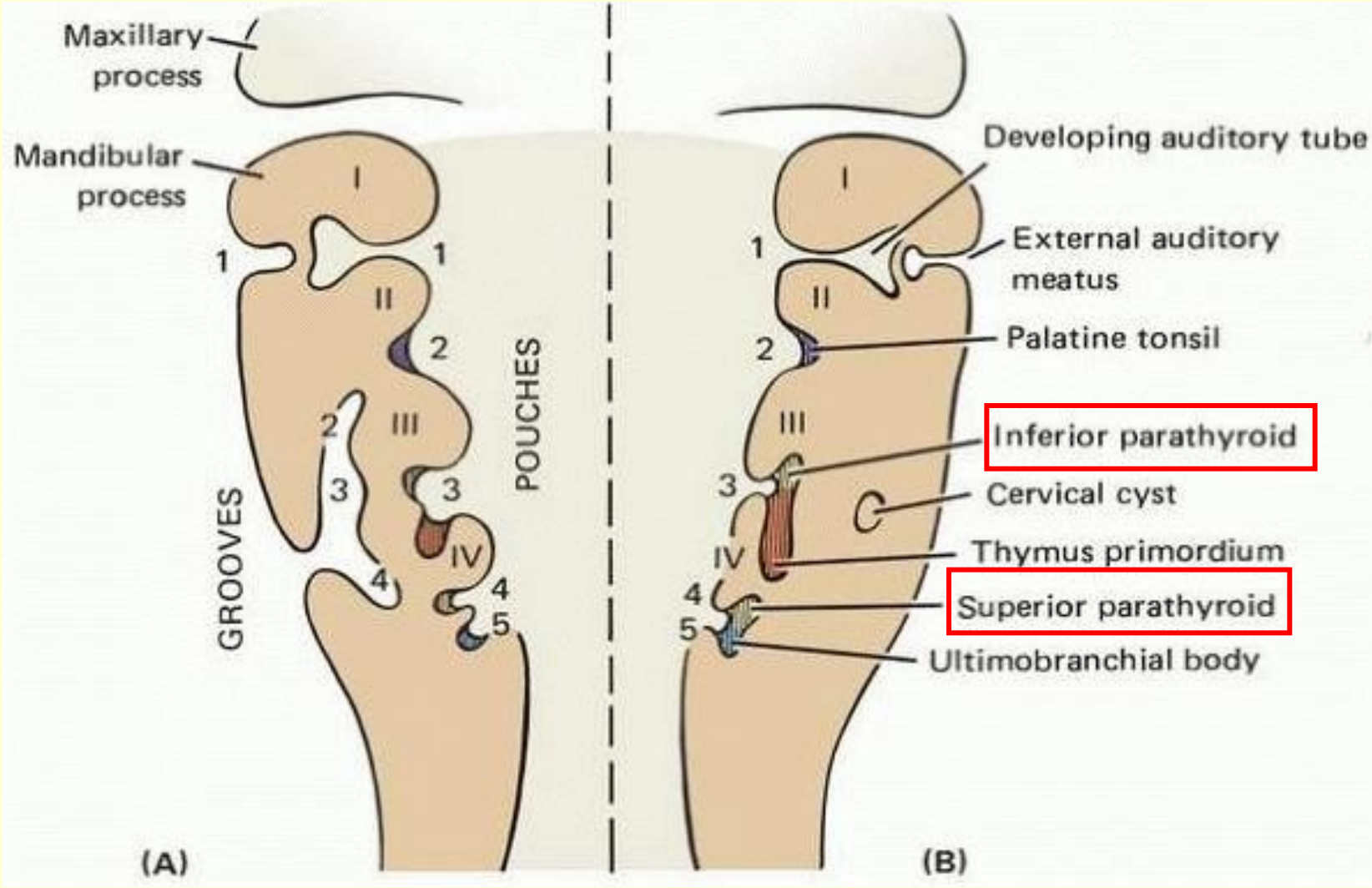
Descensus of thyroid gland

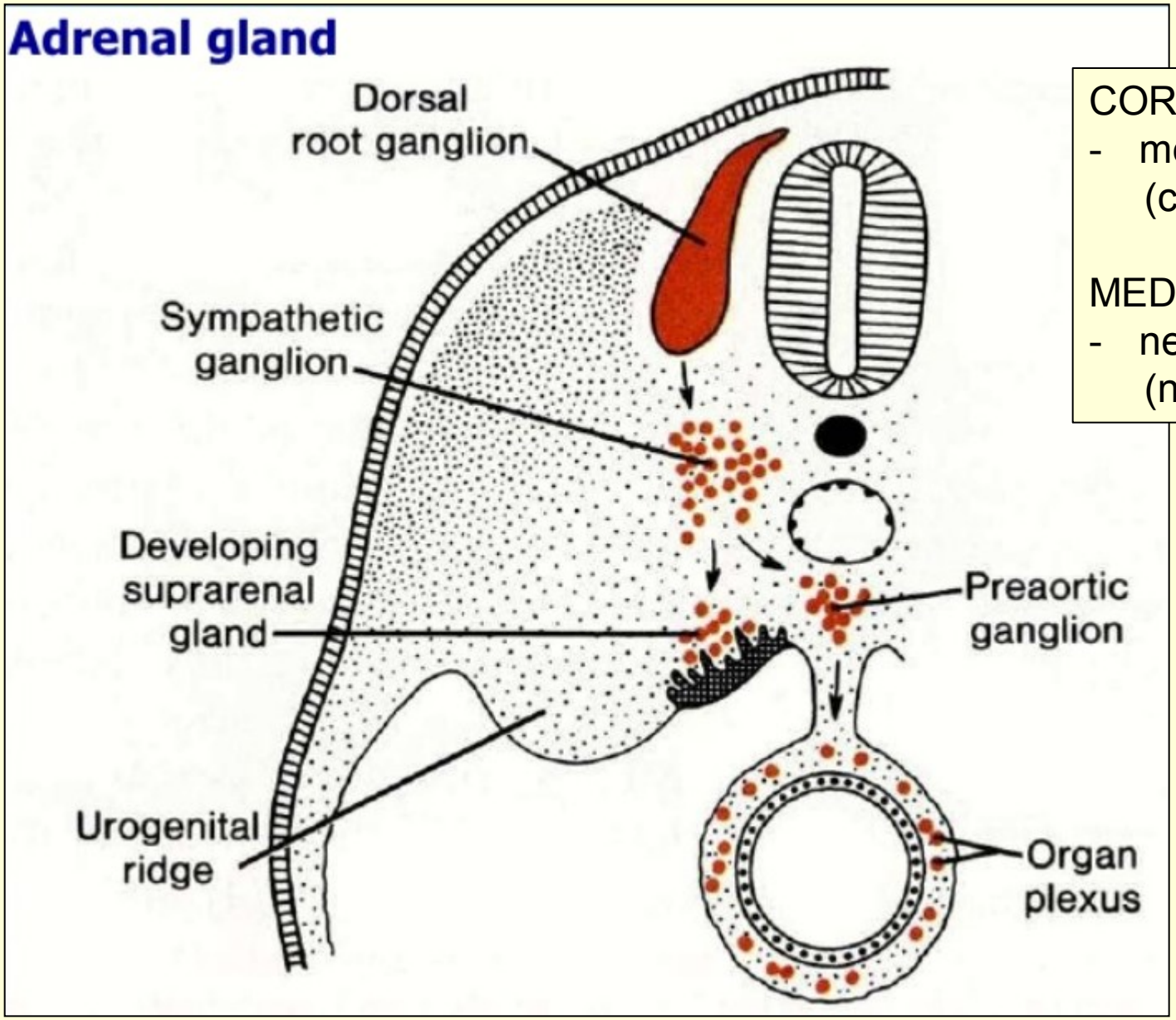


Ductus thyroglossus

Ultimobranchial body – the 4th endodermal pouch – parafollicular cells


Eustachian tube
Primordial tympanic cavity
External auditory canal
Palatine tonsil
Superior parathyroid (from the 4th branchial pouch)
Inferior parathyroid (from the 3rd branchial pouch)
Ultimobranchial body
Thymus
Ventral pharyngeal wall
Foramen cecum (tongue base)
Thyroglossal duct
Thyroid
Foregut

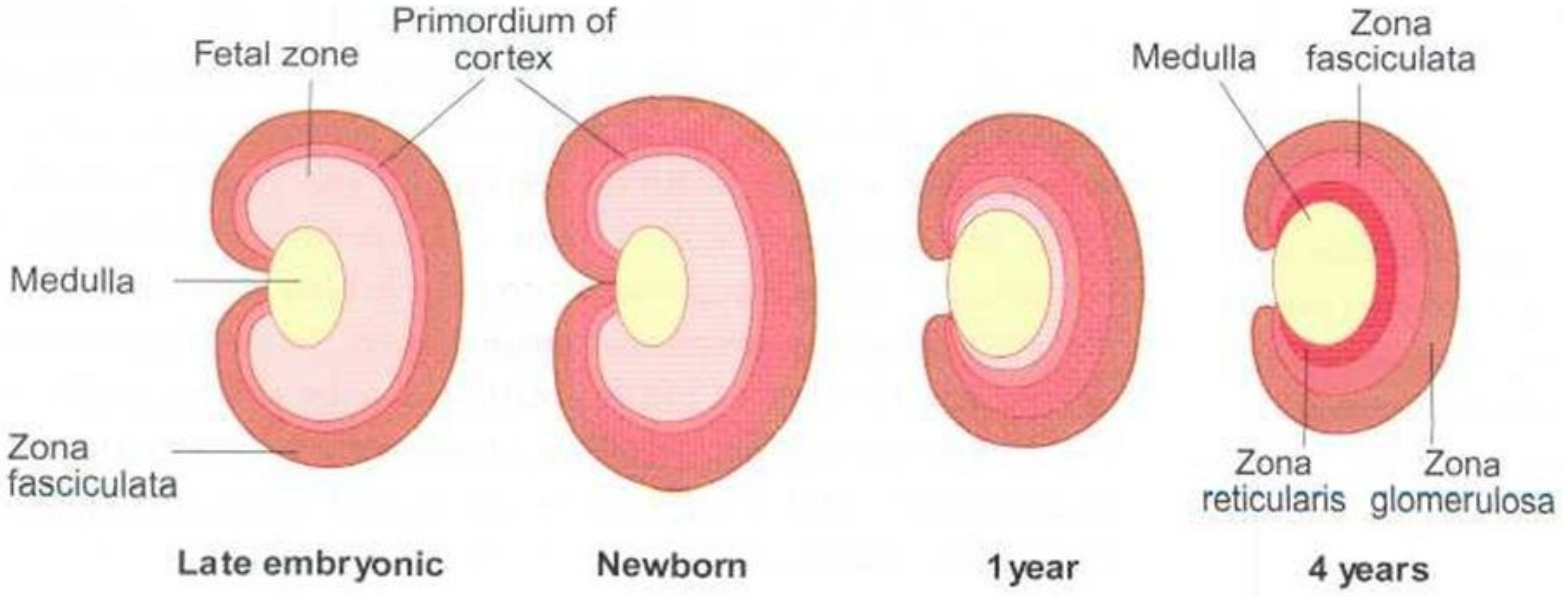

Maxillary process
Mandibular process
I
1
1
II
2
2
III
3
3
IV
4
4
5
GROOVES
POUCHES
(A)
Developing auditory tube
External auditory meatus
Palatine tonsil
Inferior parathyroid
Cervical cyst
Thymus primordium
Superior parathyroid
Ultimobranchial body
(B)



CORTEX
- mesoderm (coelomic epithelium)

MEDULLA
- neuroectoderm (neural crest)

Schematic diagram showing the changes in the adrenal gland during development.



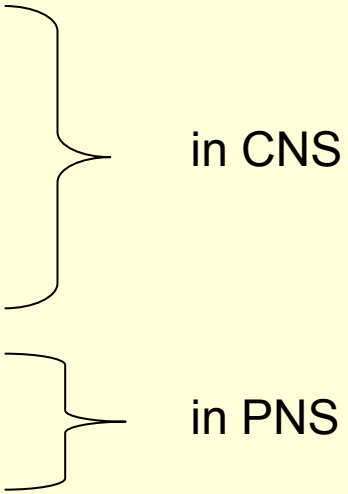

End

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



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

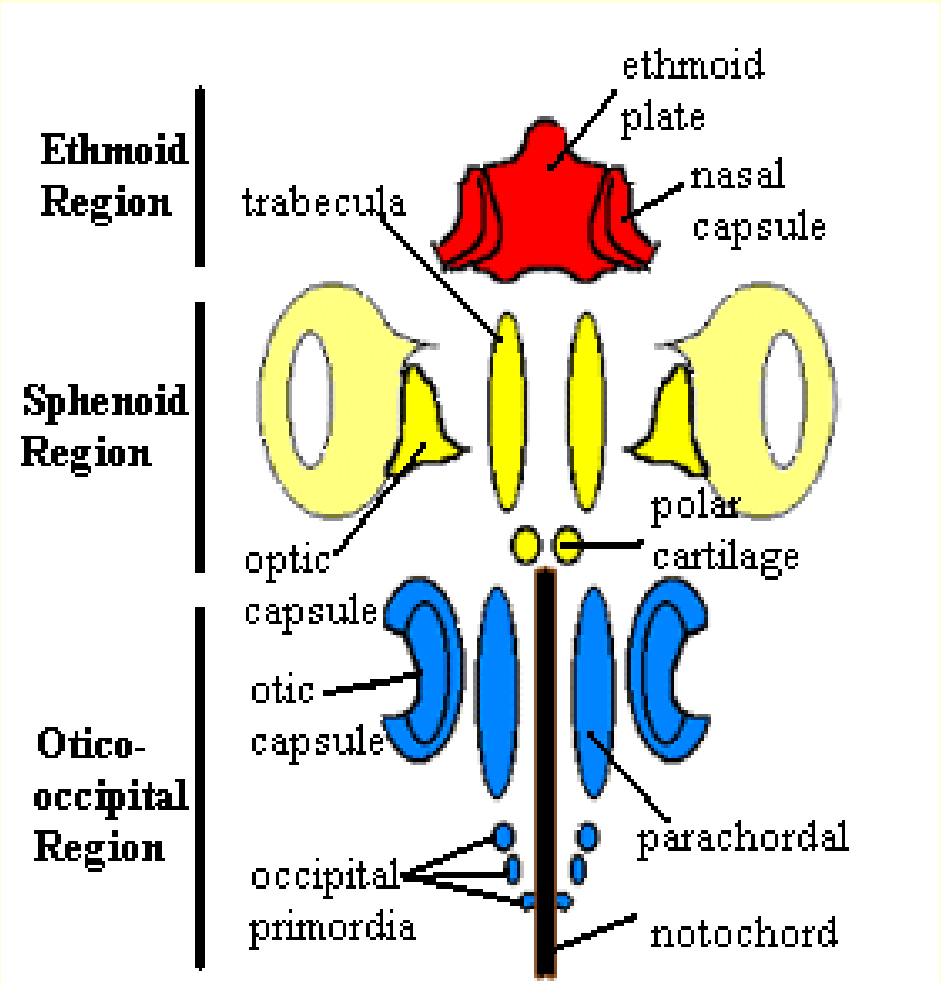


Figure 3. Schematic view of vertebrate braincase development

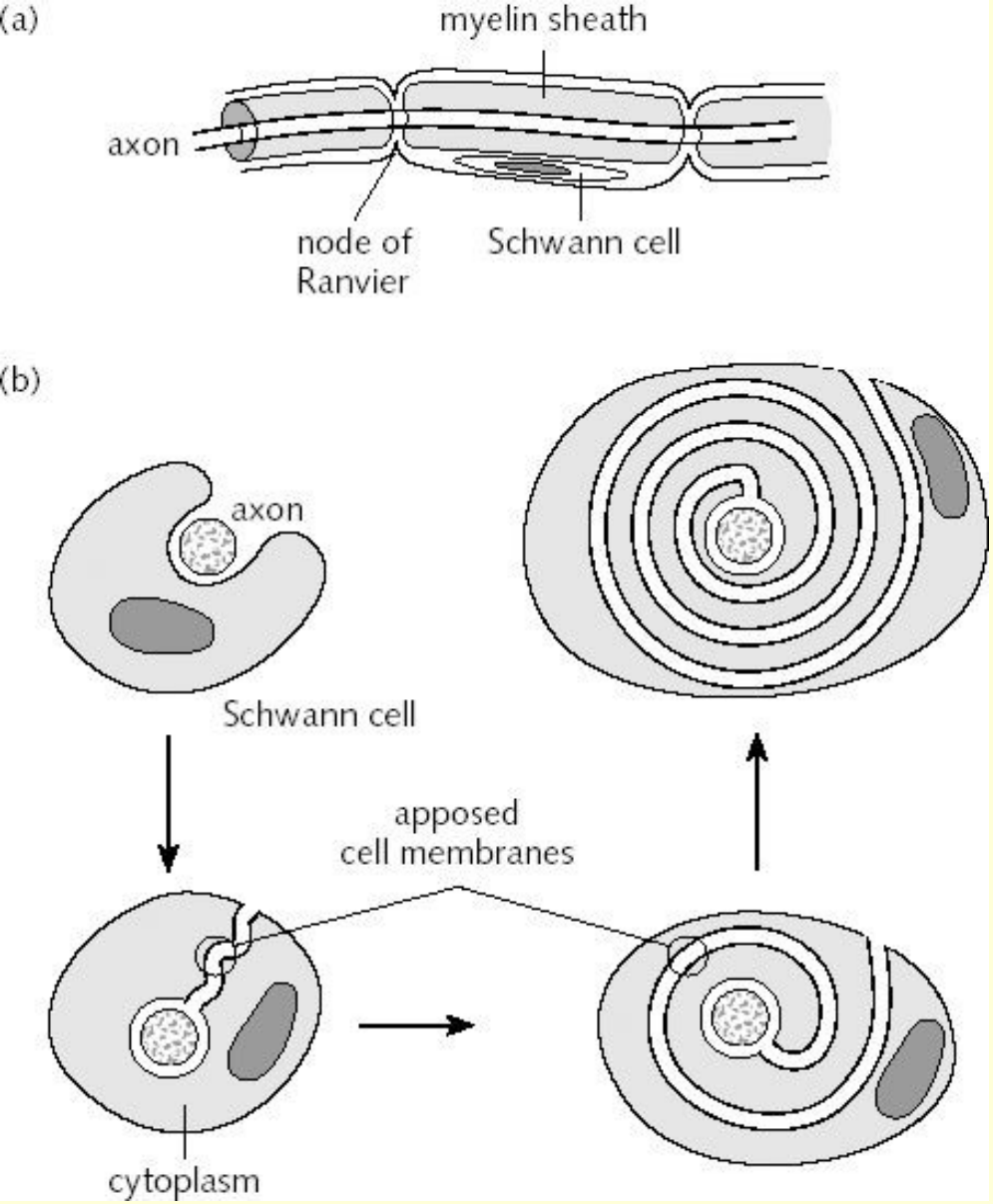


Fig. 1 (a) A myelinated axon in the peripheral nervous system and (b) its development. Each Schwann cell myelinates a single axon, to which it is directly apposed. During development (anticlockwise) Schwann cells loosely ensheath axons and the myelin sheath grows around the axon to form concentric layers,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

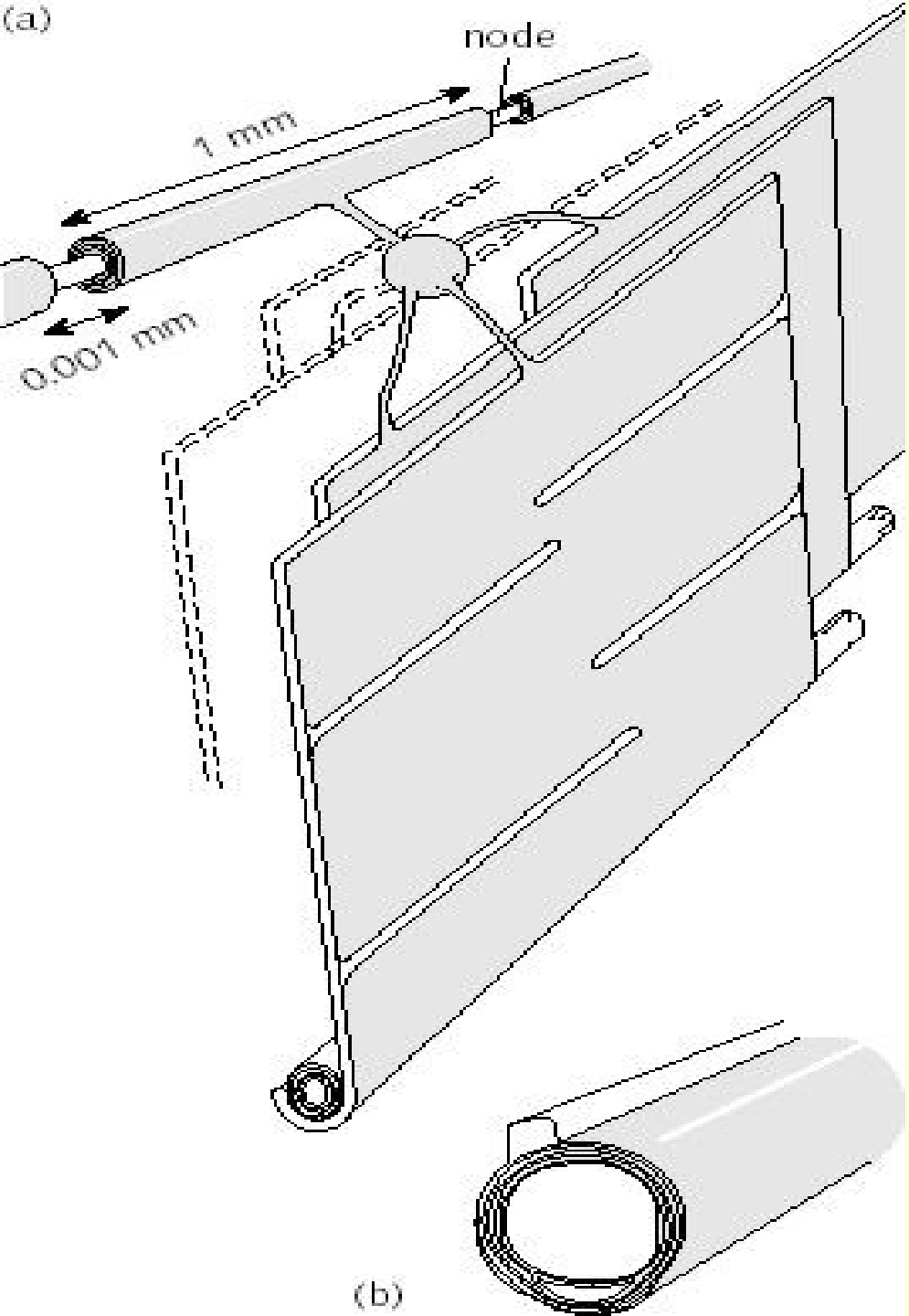
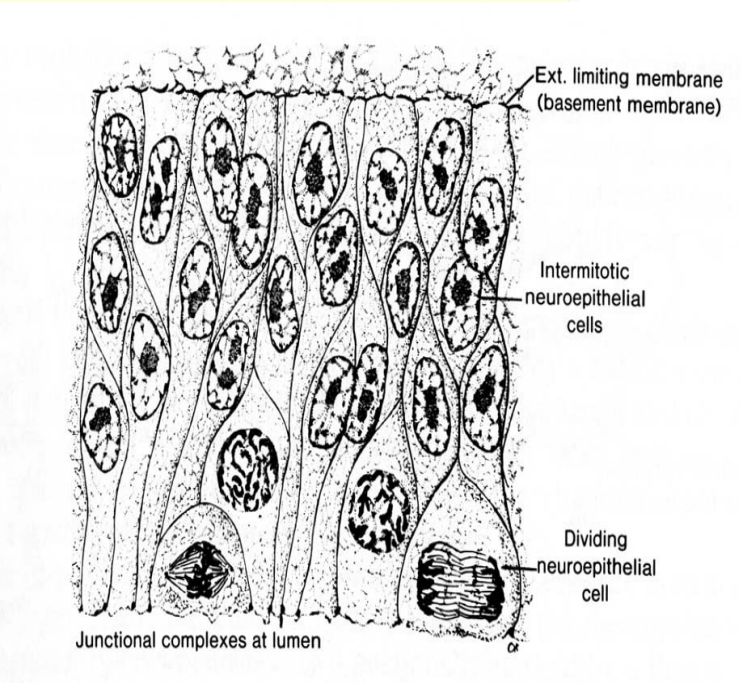
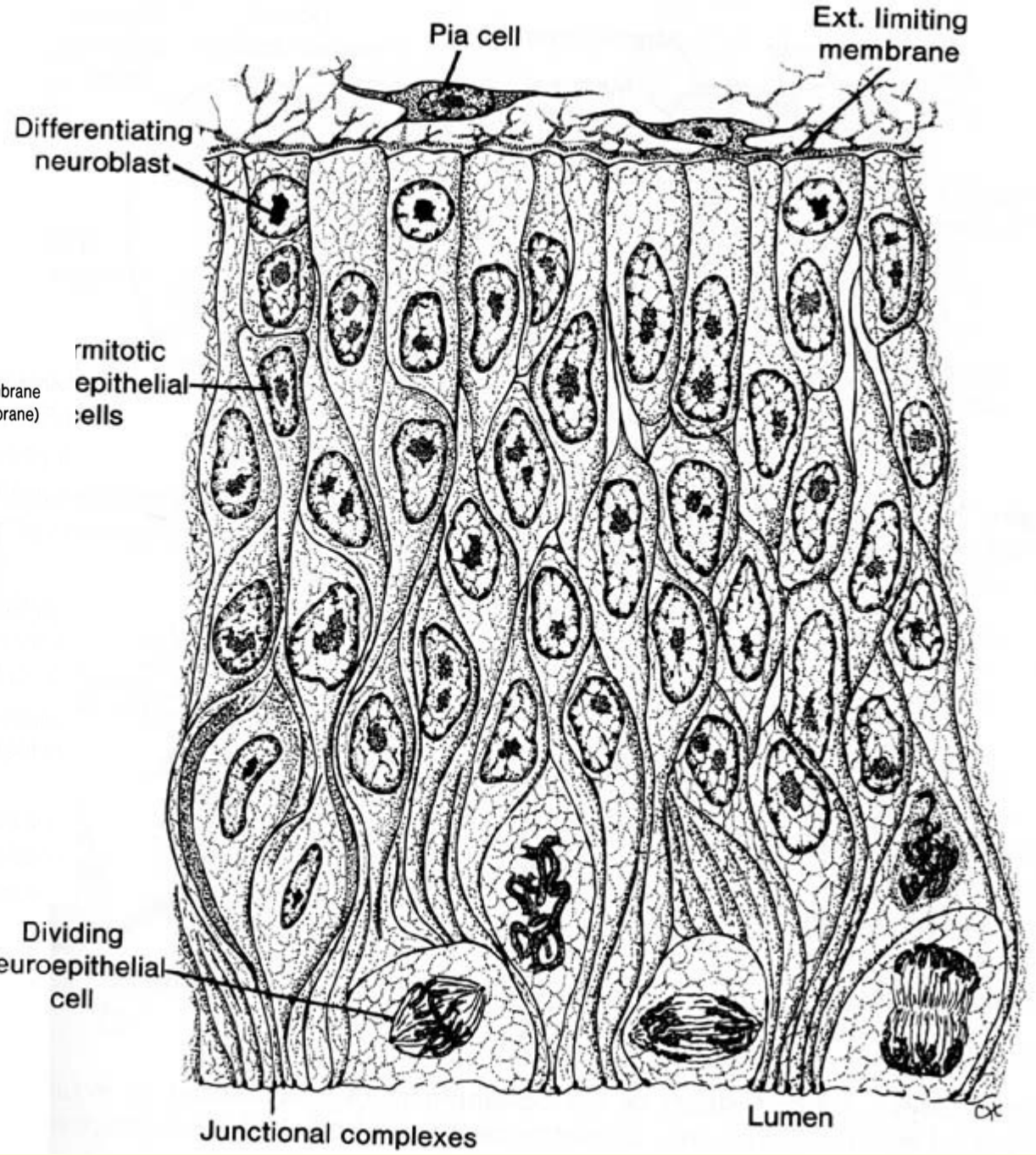
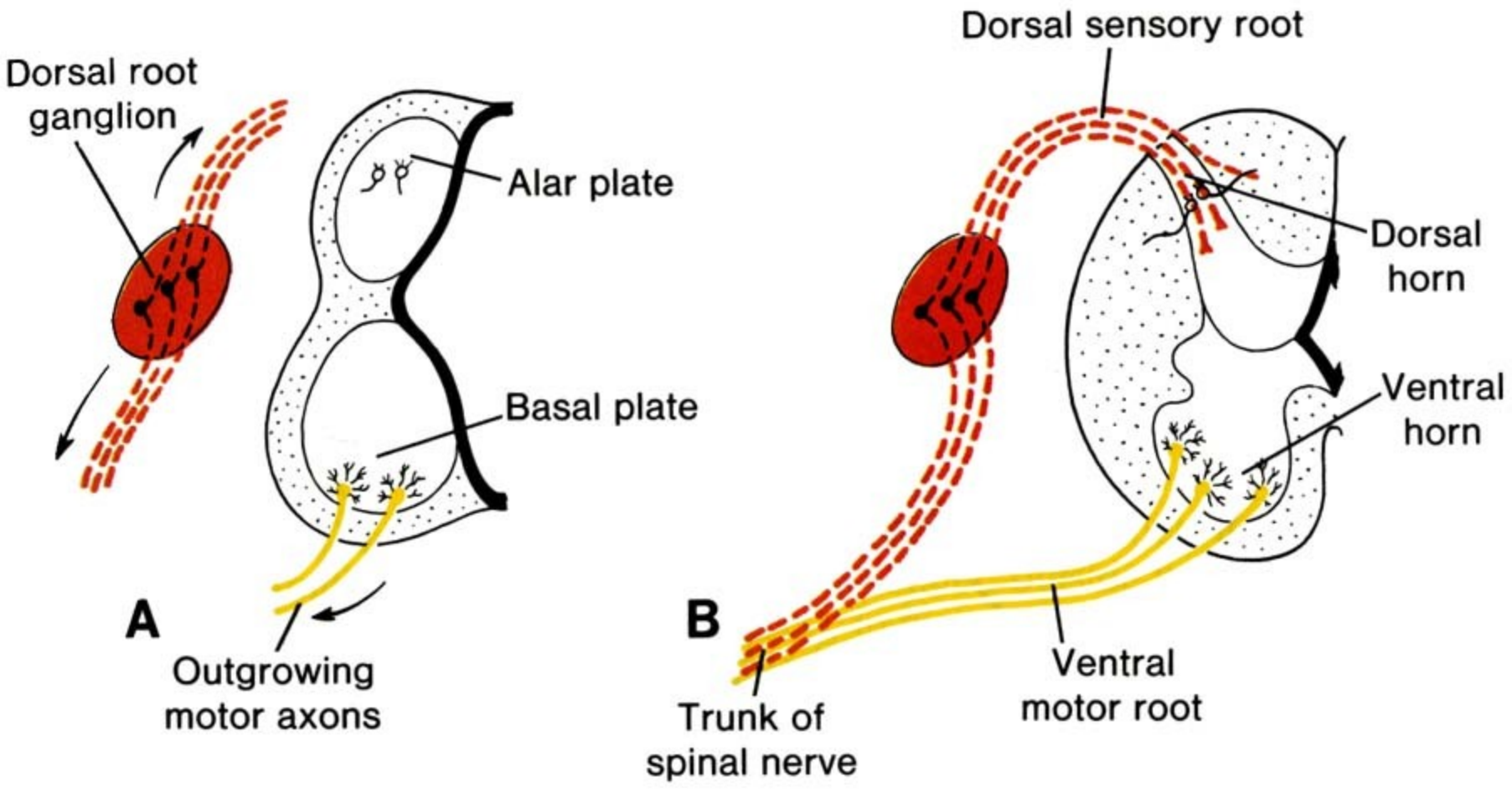
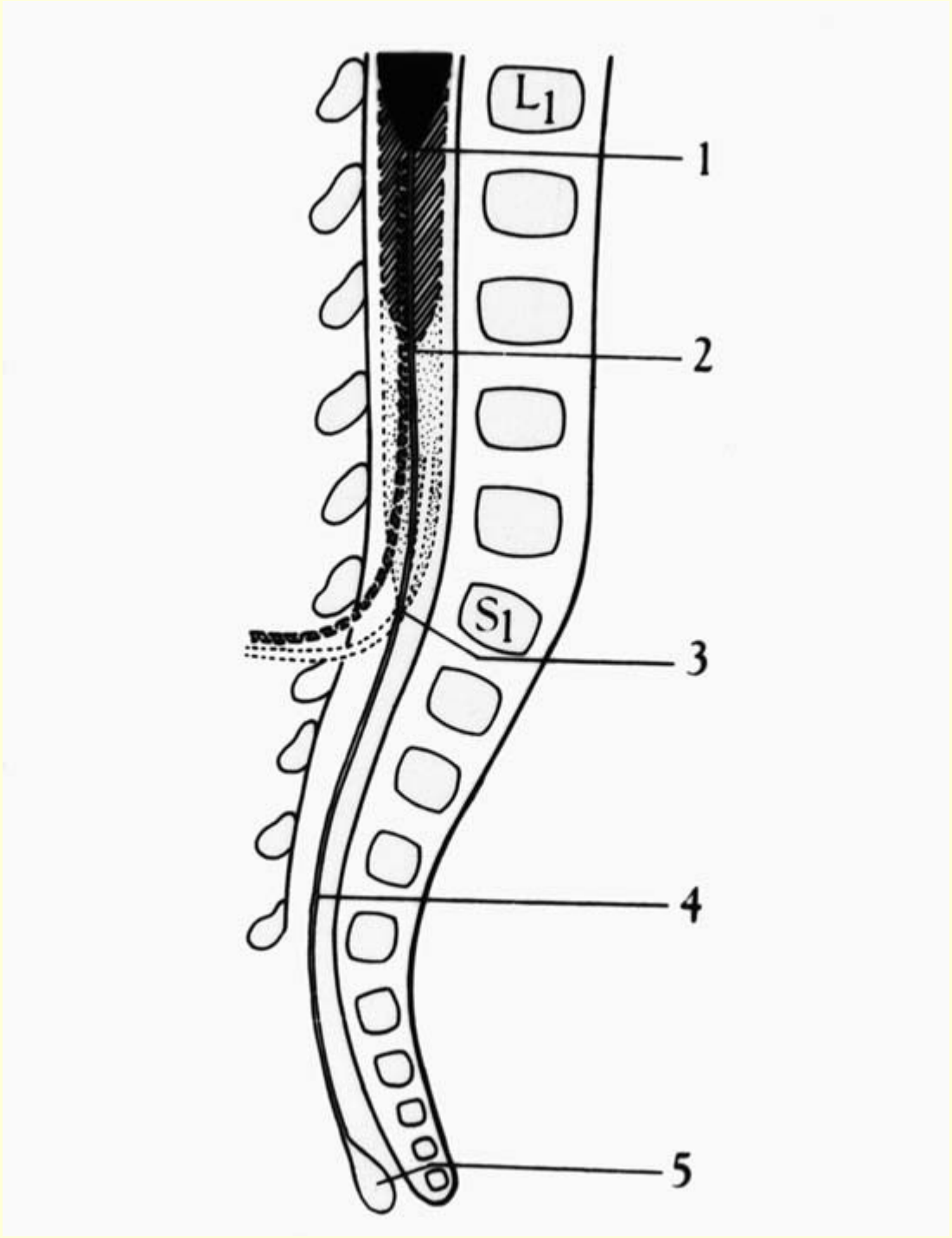


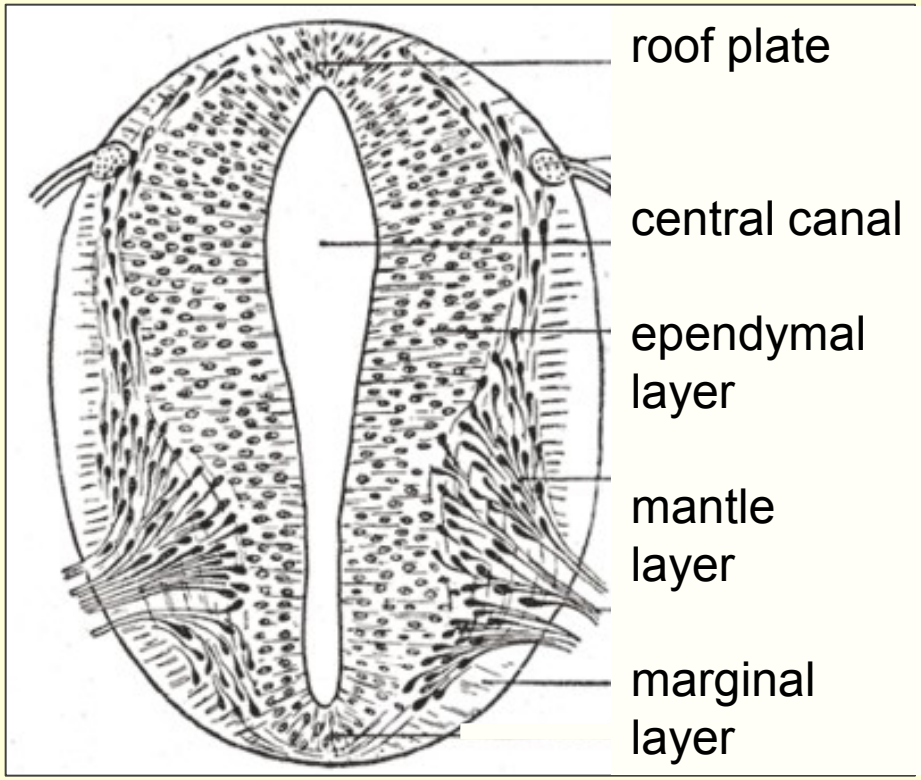
Fig. 3 Myelination in the central nervous system. A single oligodendrocyte myelinates numerous axons (a) and, in section, concentric layers of myelin are seen to spiral around the axon (b). Myelin sheaths are arranged along axons in segments 1 mm long separated by short nodes, and would appear as large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

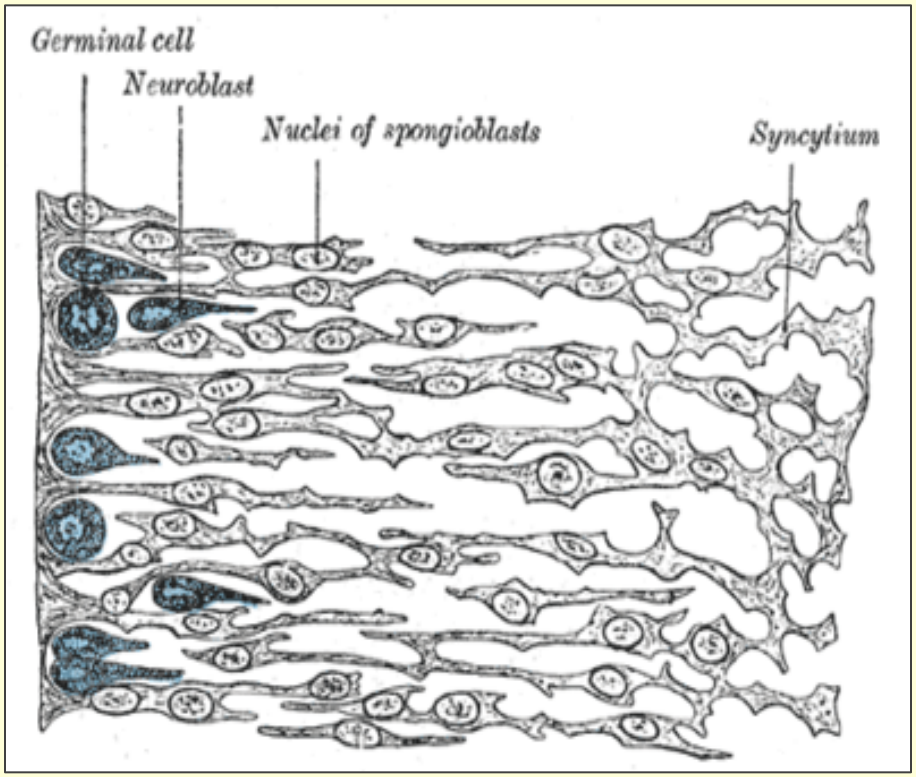

Ext. limiting membrane
(basement membrane)
Intermitotic
neuroepithelial
cells
Dividing
neuroepithelial
cell
Junctional complexes at lumen

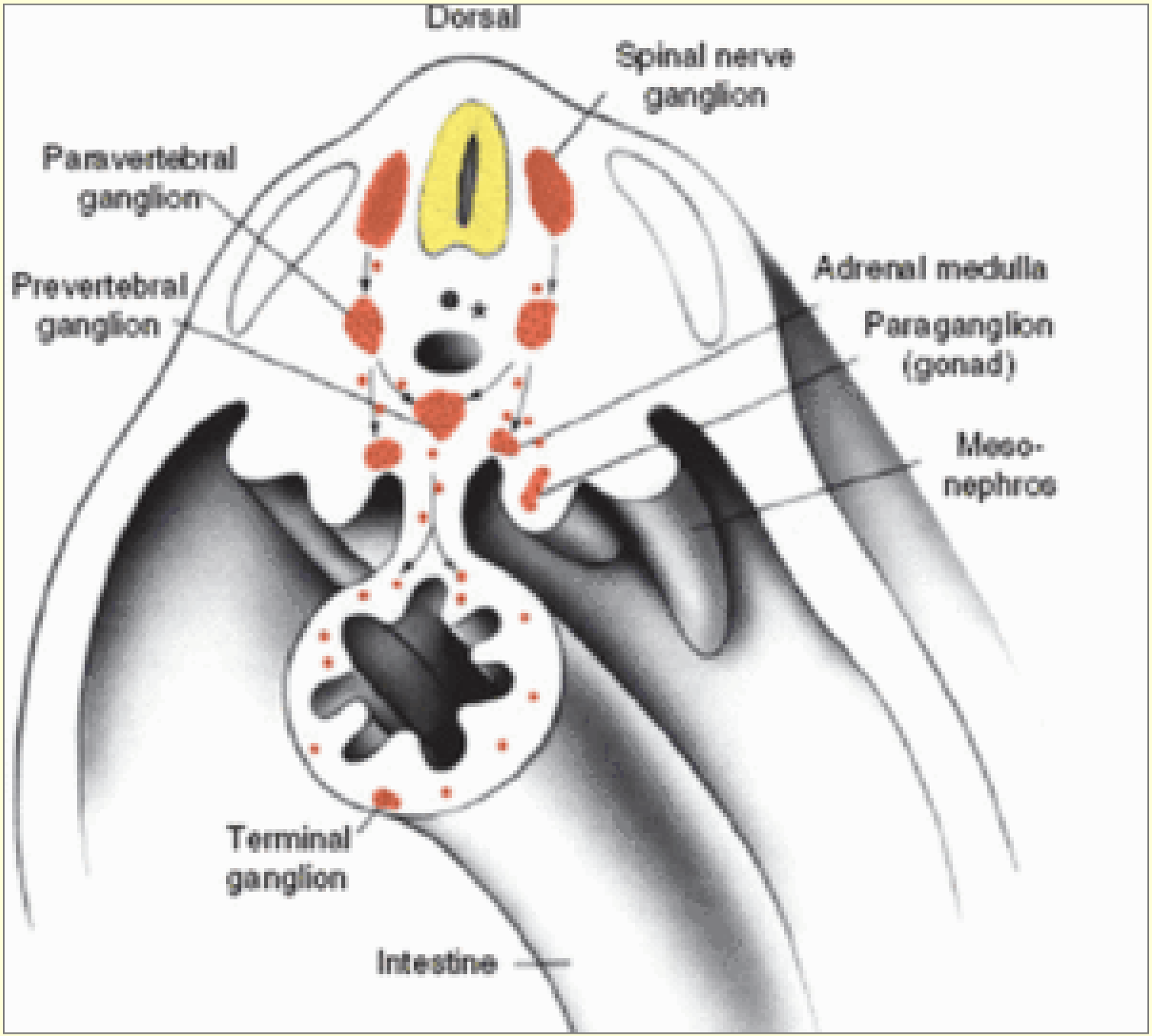

Pia cell
Ext. limiting
membrane
Differentiating
neuroblast
rmitotic
epithelial
cells
Dividing
neuroepithelial
cell
Junctional complexes
Lumen

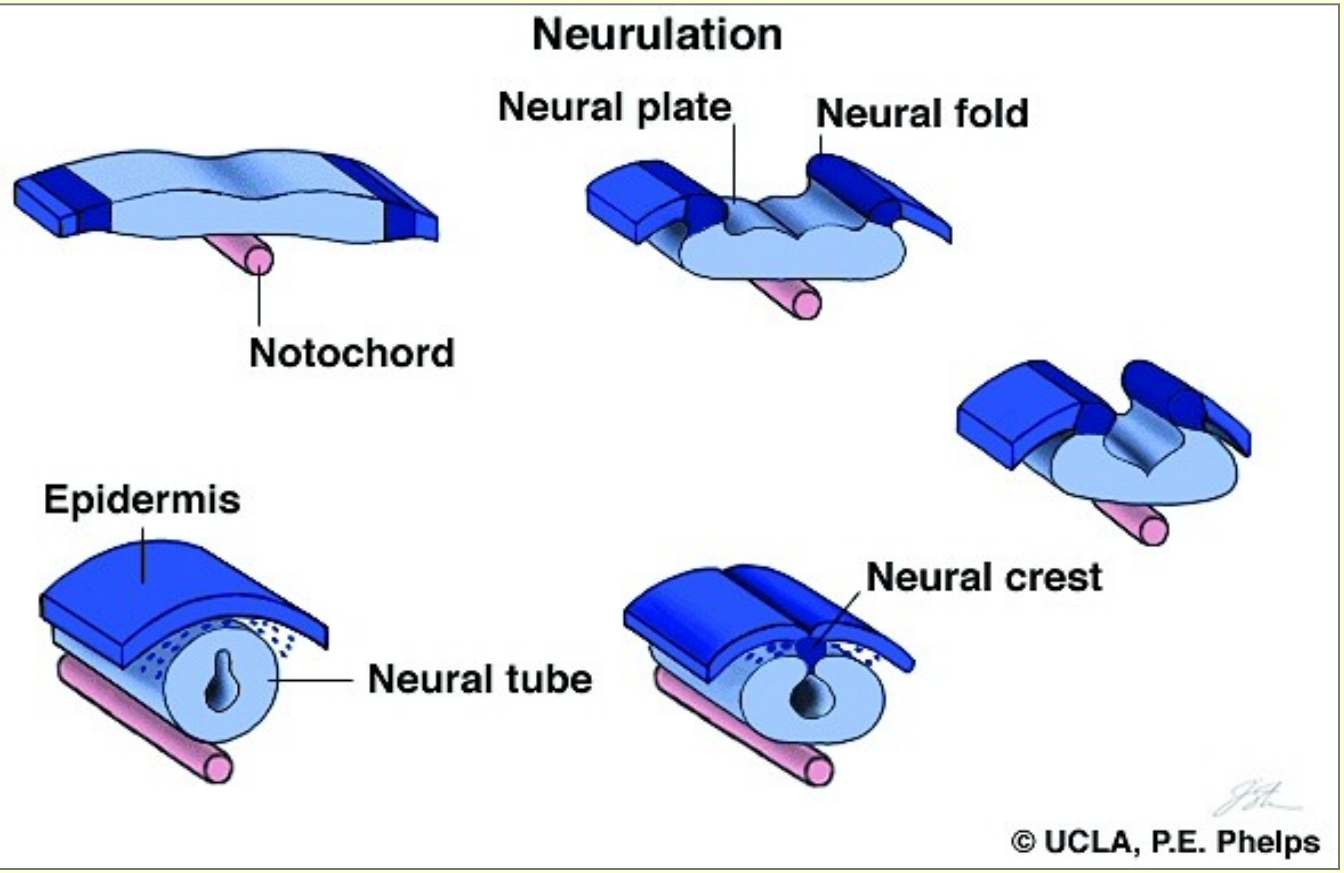

Dorsal root ganglion
Alar plate
Basal plate
A
Outgrowing motor axons
Dorsal sensory root
Dorsal horn
Ventral horn
B
Trunk of spinal nerve
Ventral motor root


L1
S1
1
2
3
4
5

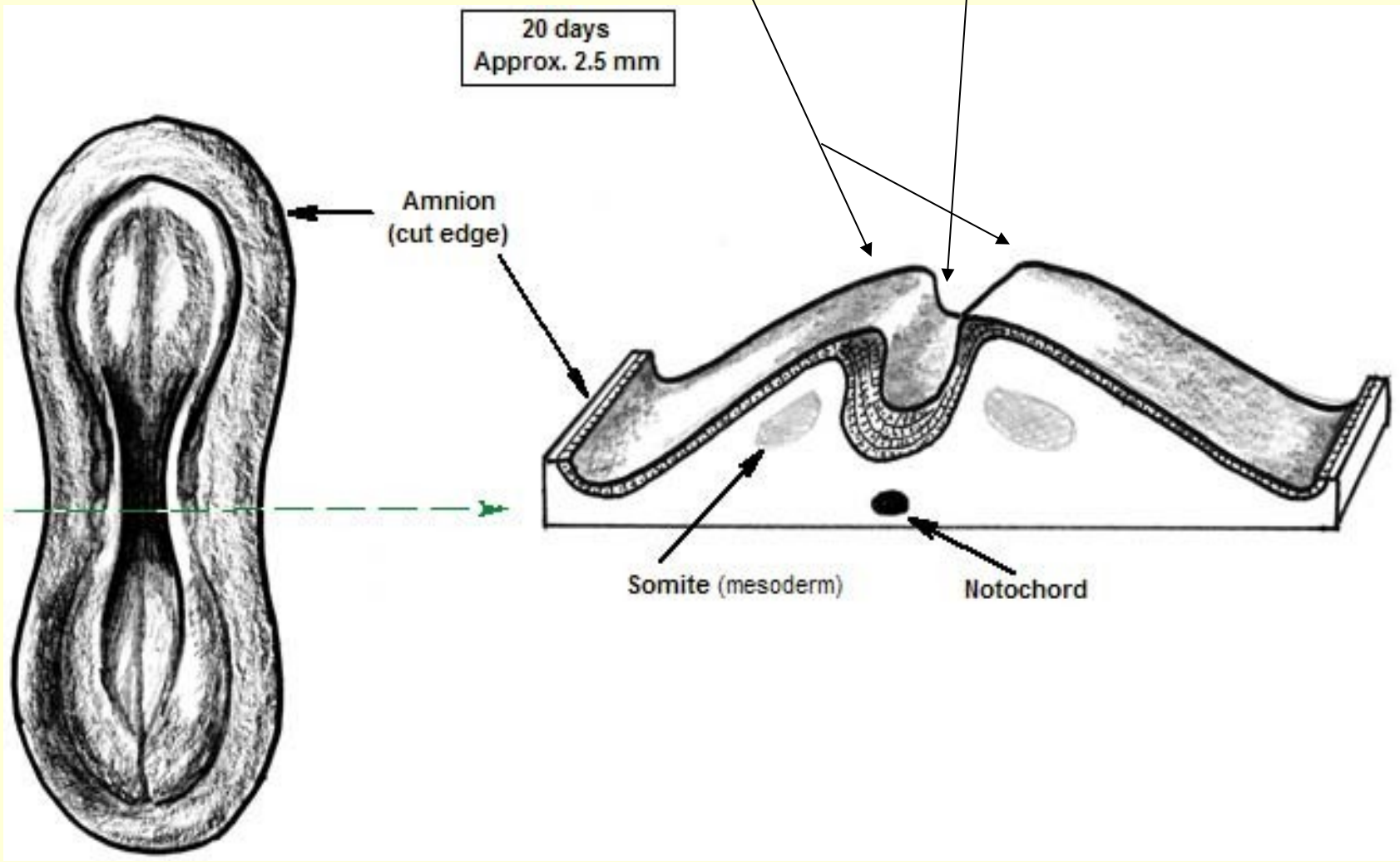

roof plate
central canal
ependymal layer
mantle layer
marginal layer
floor plate


Germinal cell
Neuroblast
Nuclei of spongioblasts
Syncytium


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

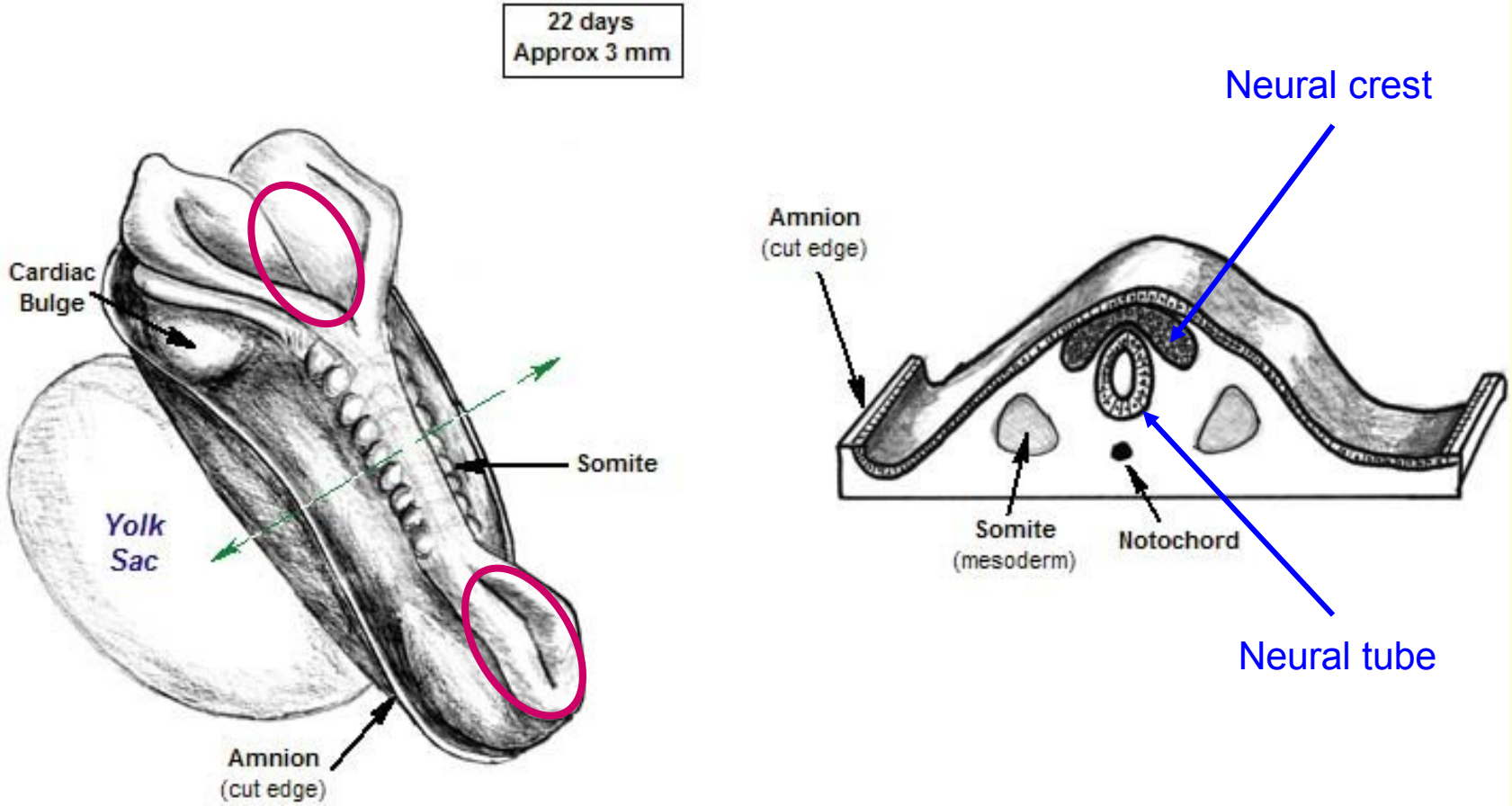

Neurulation
Neural plate
Neural fold
Notochord
Epidermis
Neural tube
Neural crest
© UCLA, P.E. Phelps

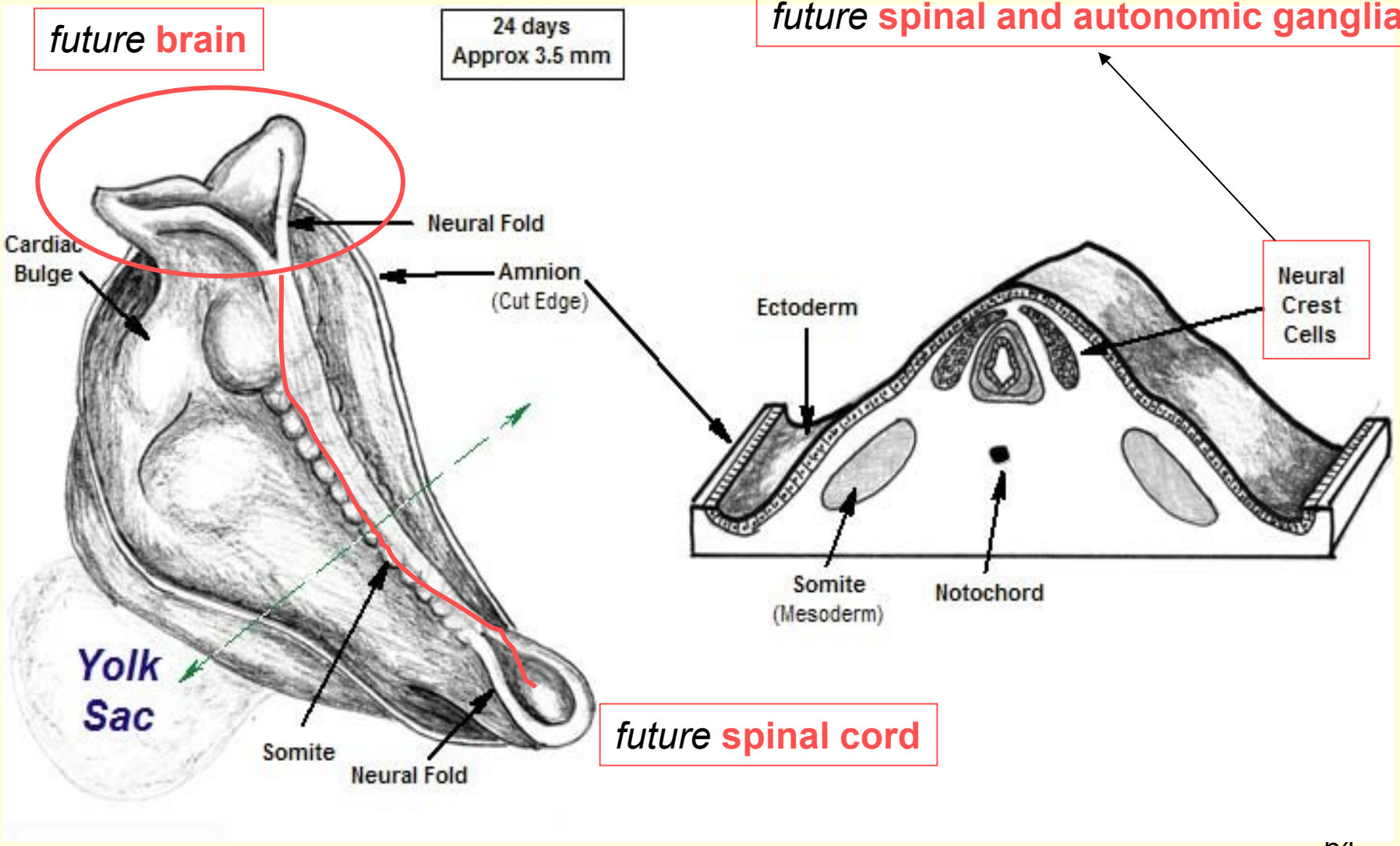
Invagination of neural plate ⇨ neural folds + neural groove

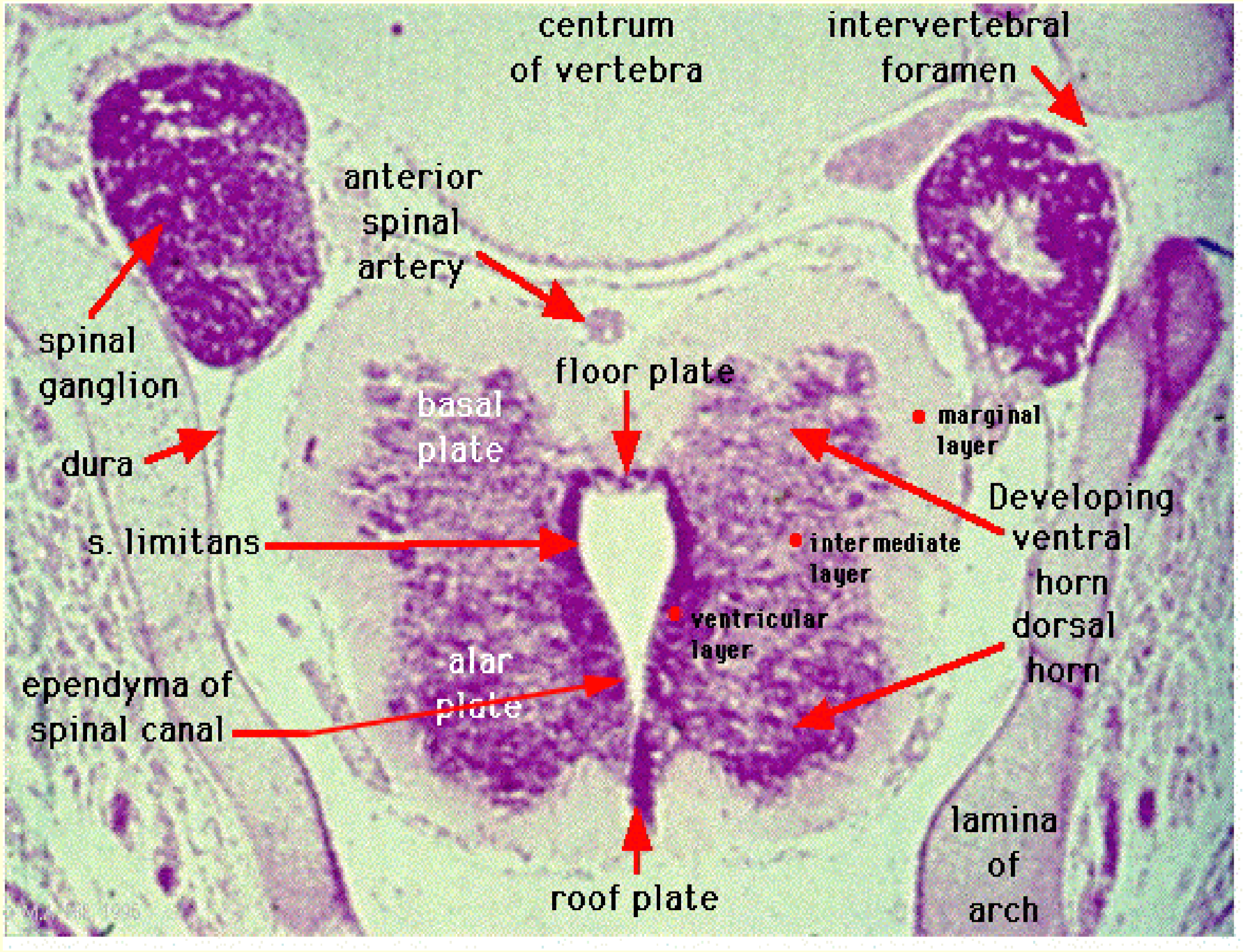


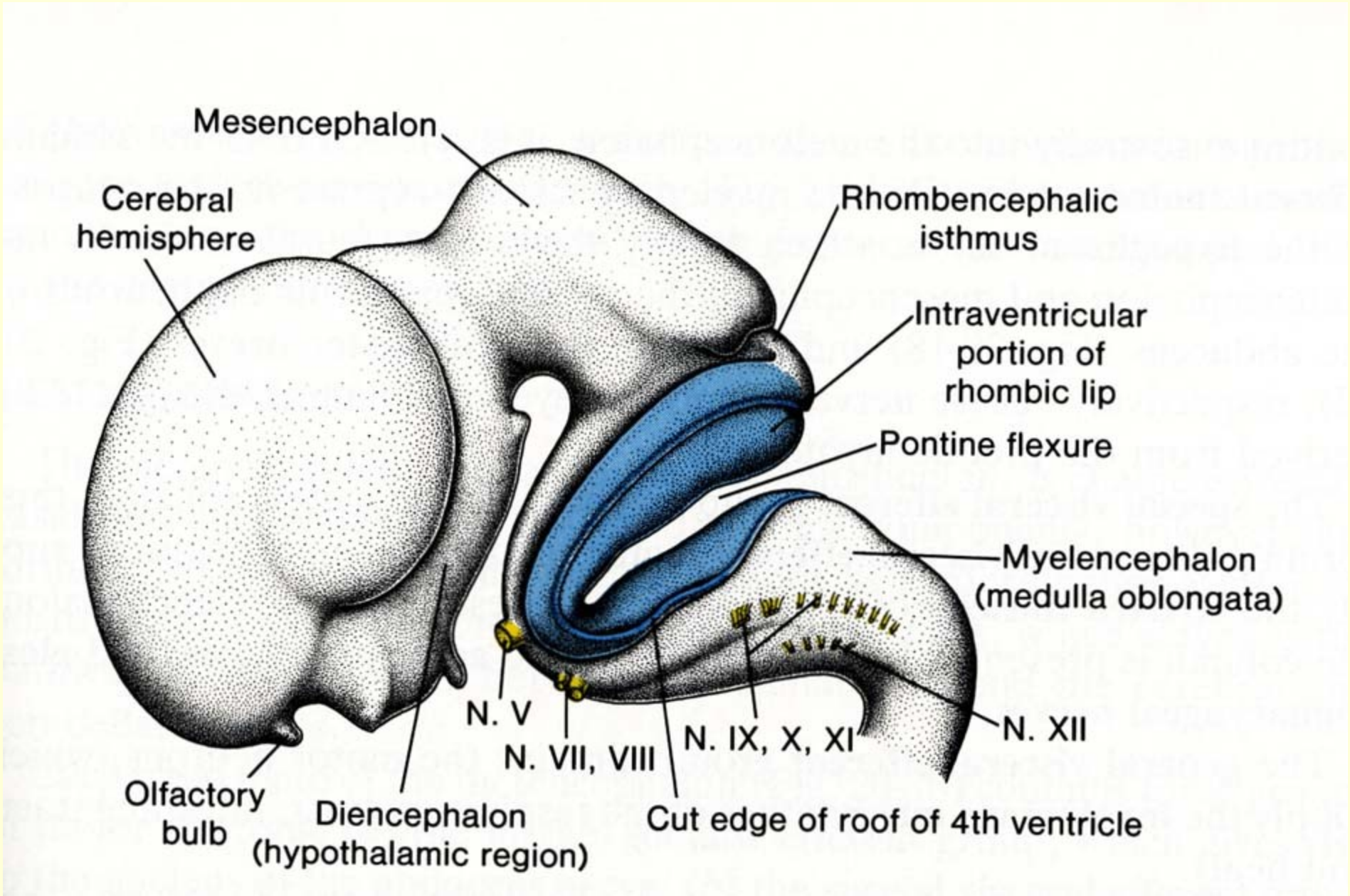
Neural tube and neural crest

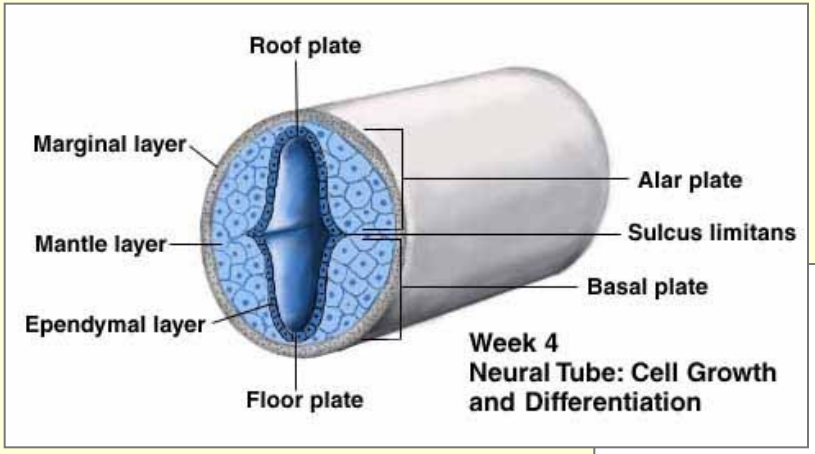
Neuroporus ant., post.

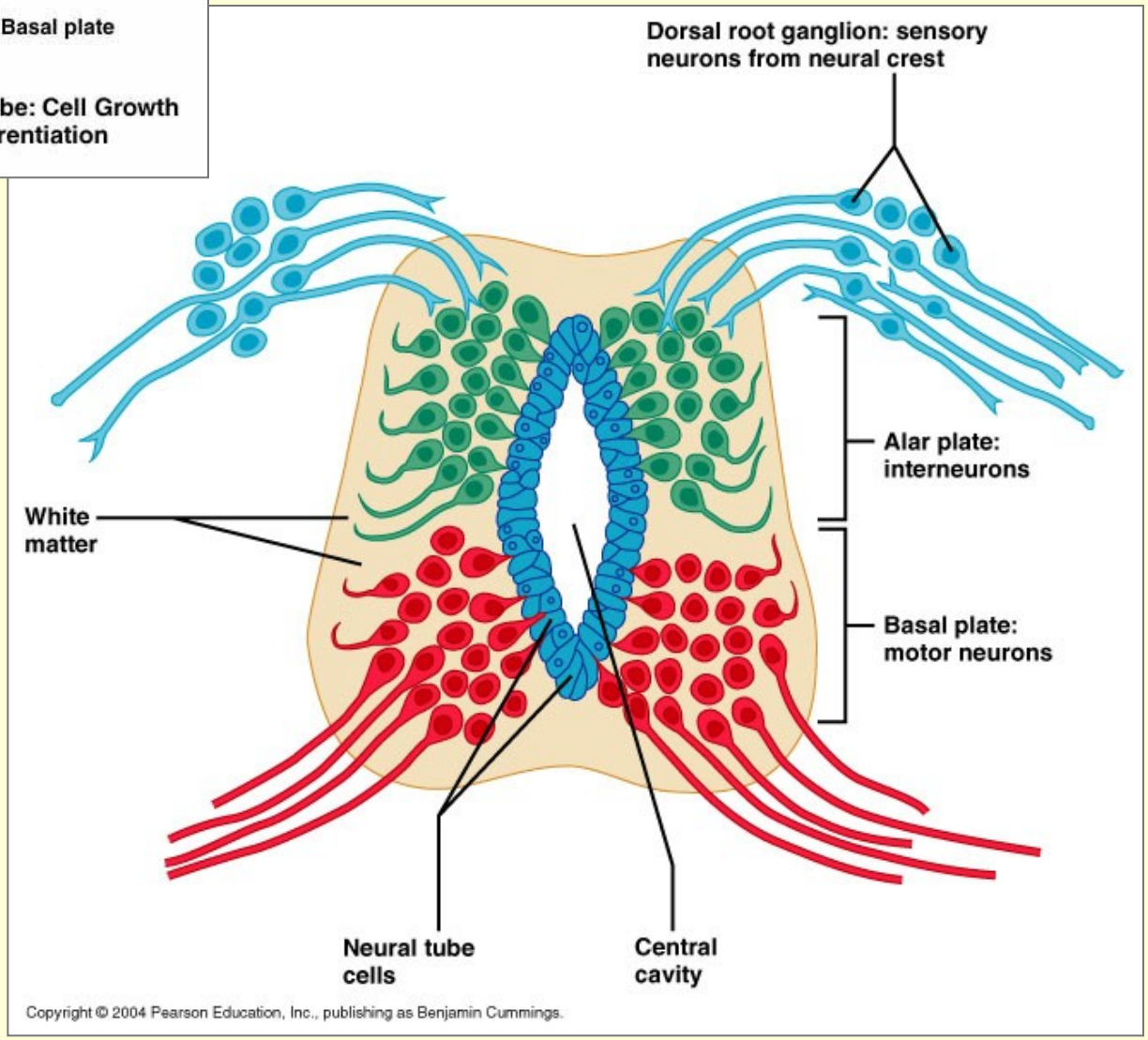



future brain
24 days
Approx 3.5 mm
future spinal and autonomic ganglia
Neural Fold
Cardiac Bulge
Amnion
(Cut Edge)
Ectoderm
Neural Crest Cells
Somite
(Mesoderm)
Notochord
Yolk Sac
Somite
Neural Fold
future spinal cord


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


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


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
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