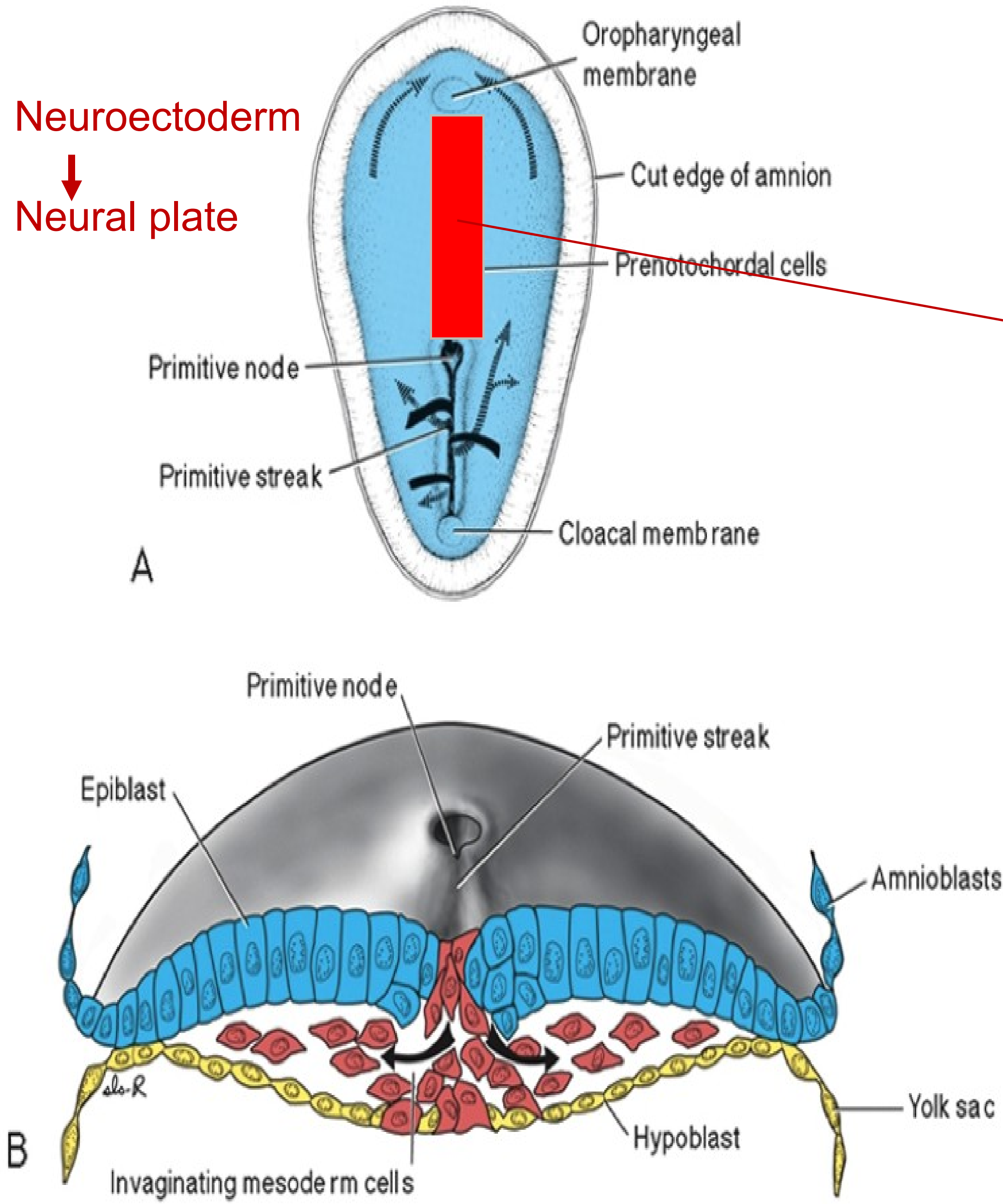
Embryology /organogenesis/

Development and teratology of nervous system.

Development of endocrine glands (pp. 35-44)

NOTOCHORD DEVELOPMENT

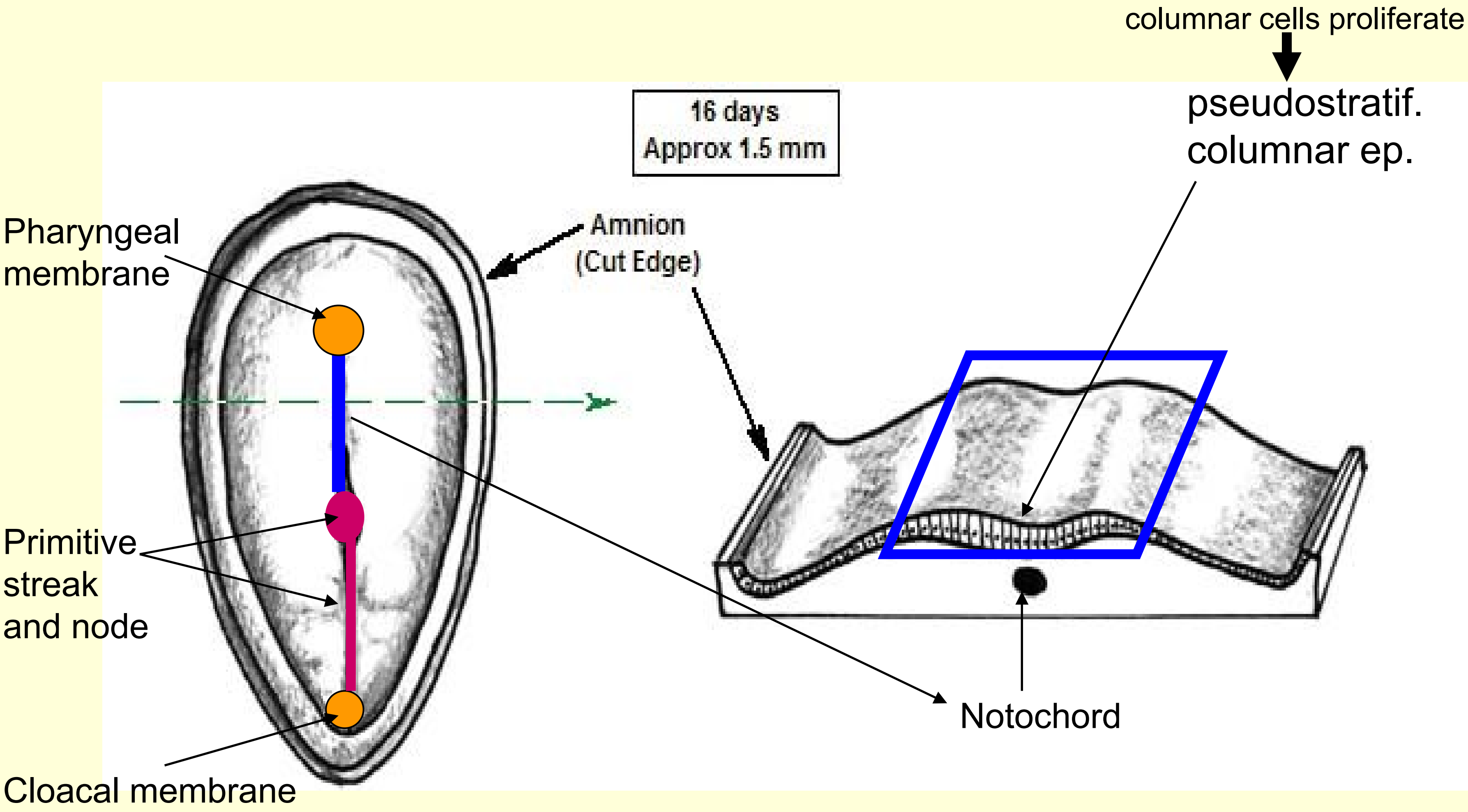
Neuroectoderm
↓
Neural plate



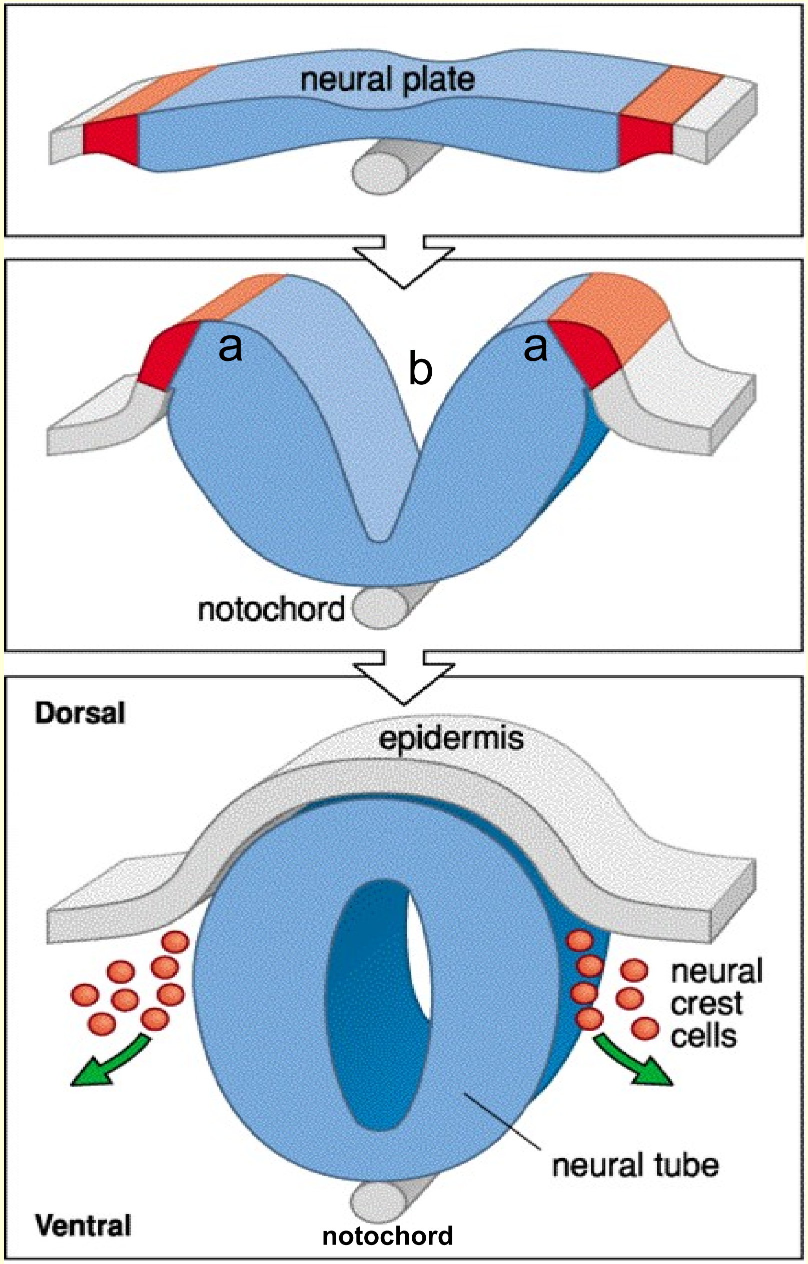
NOTOCHORD

- induces neural plate development in neuroectoderm

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



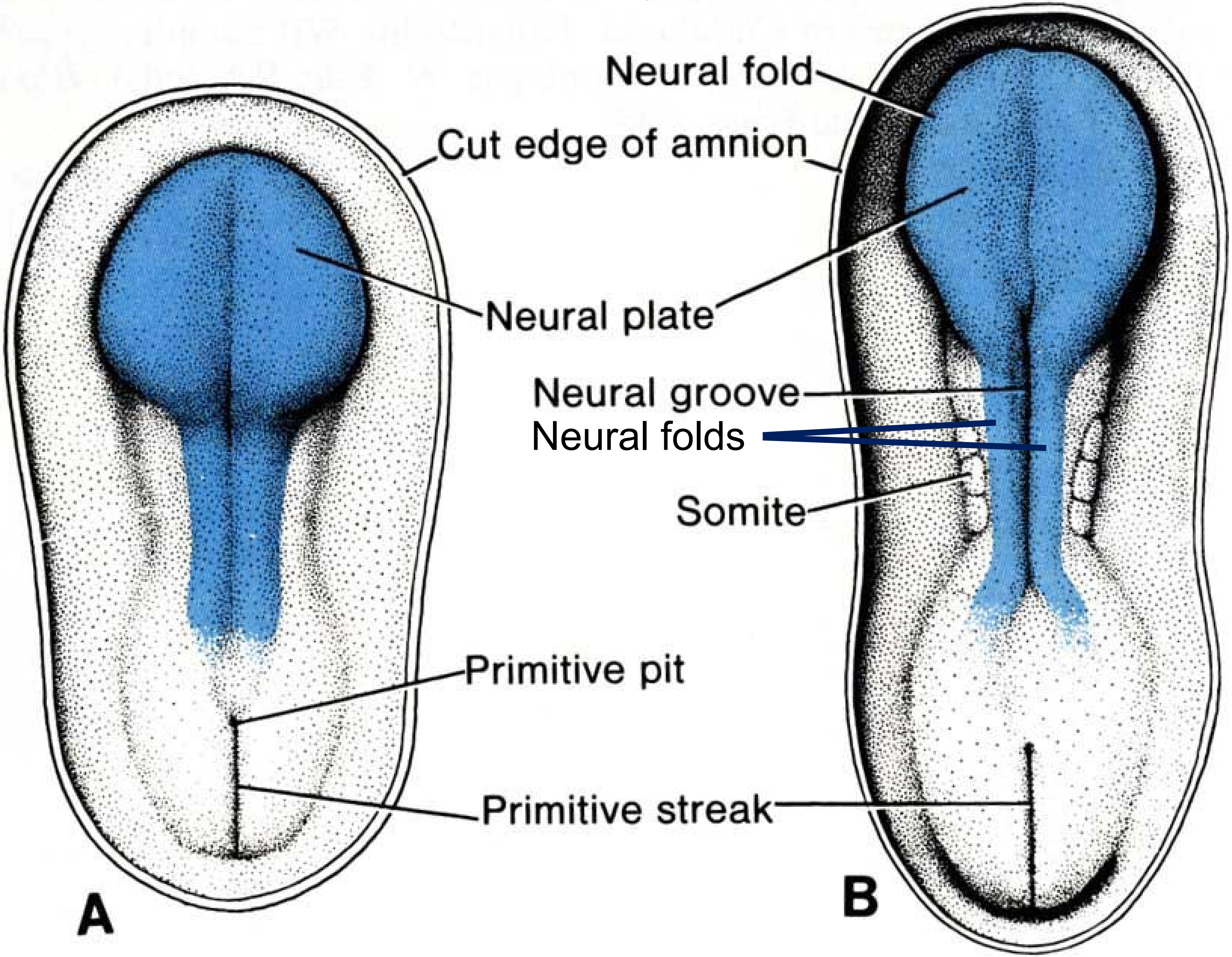
NEURULATION – invagination of neural plate (day 16 - 24)



- neural folds (a)
- neural groove (b)

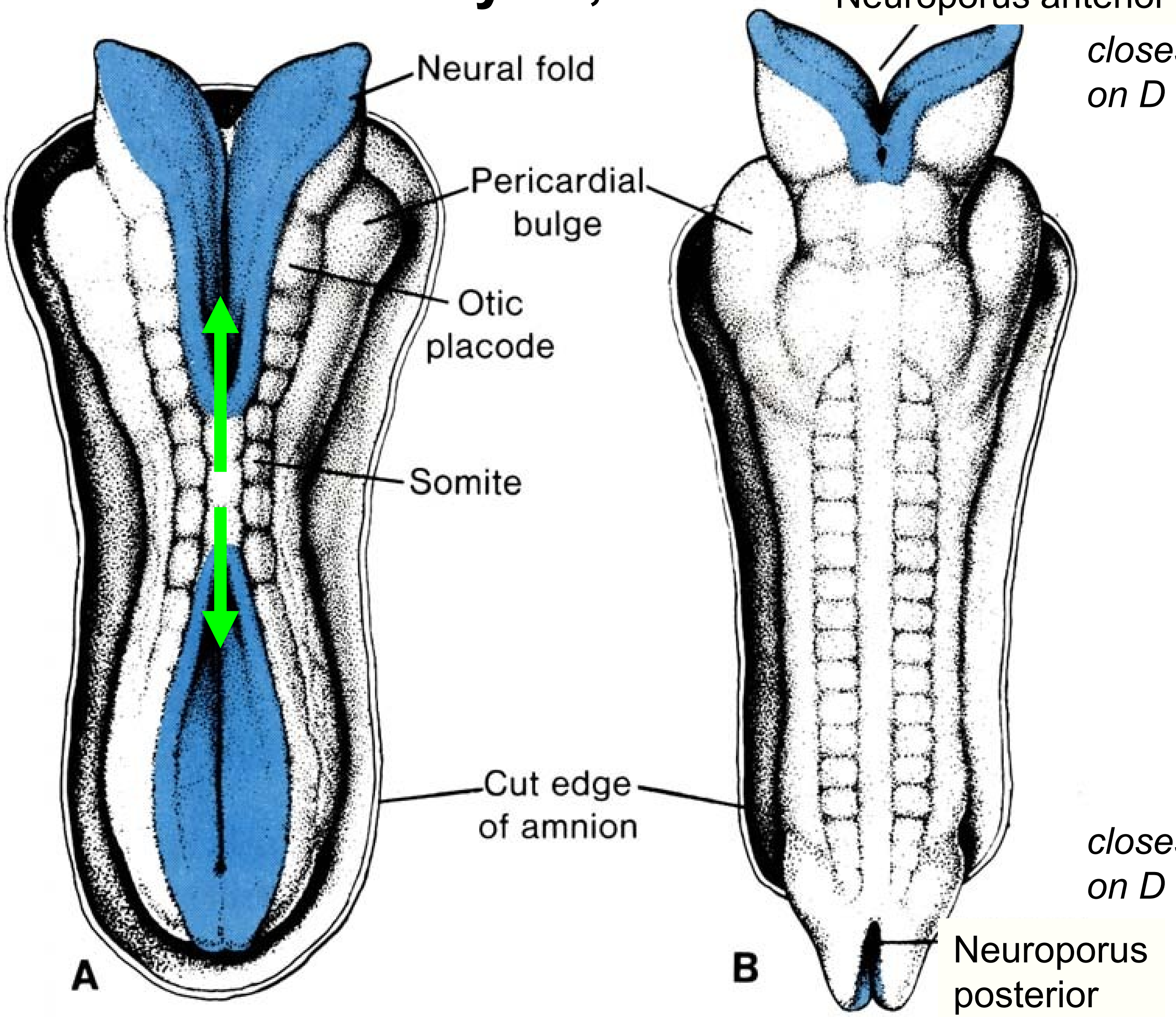
- neural tube
- neural crest

Day 20



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

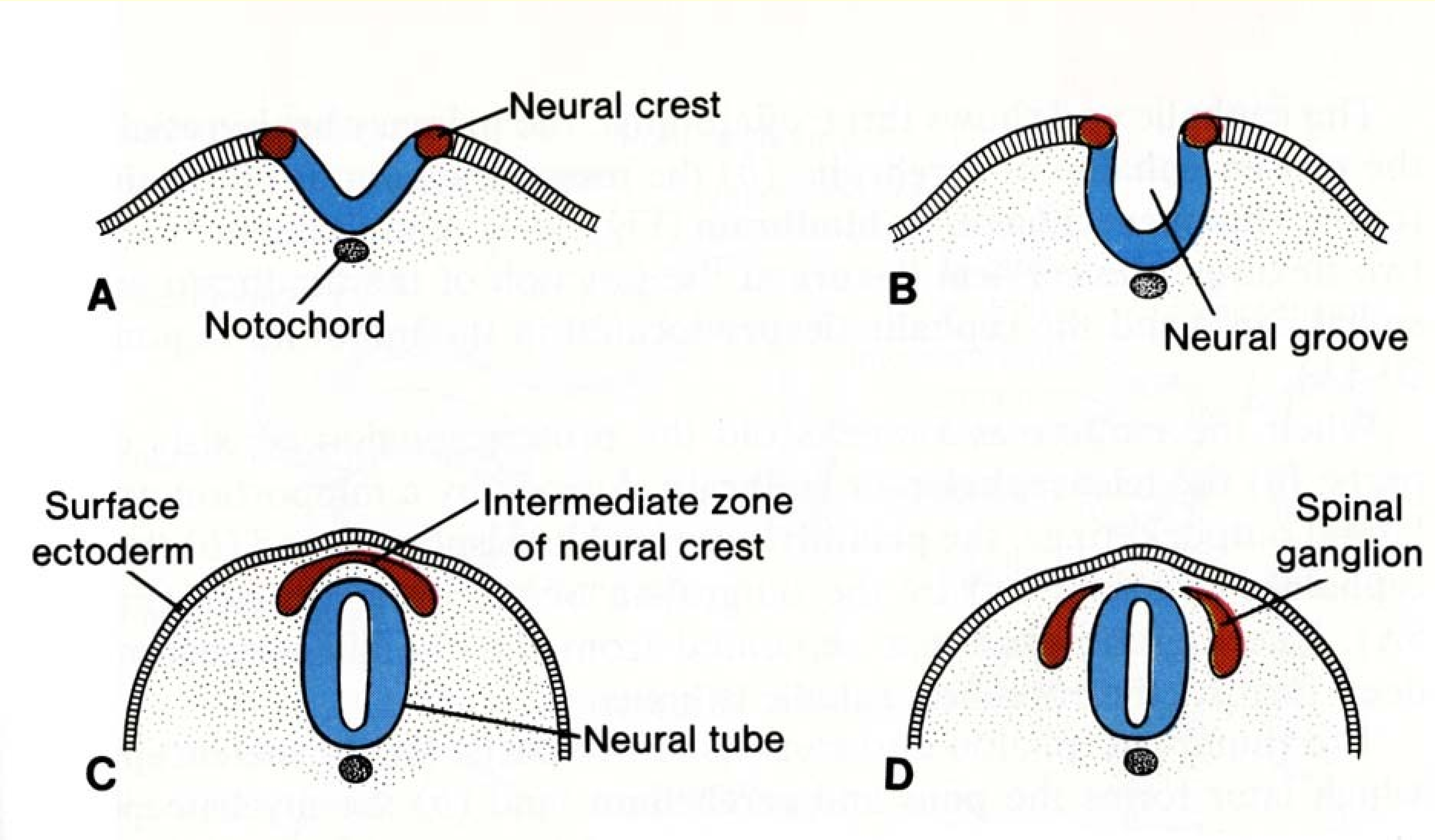
Day 22, 23



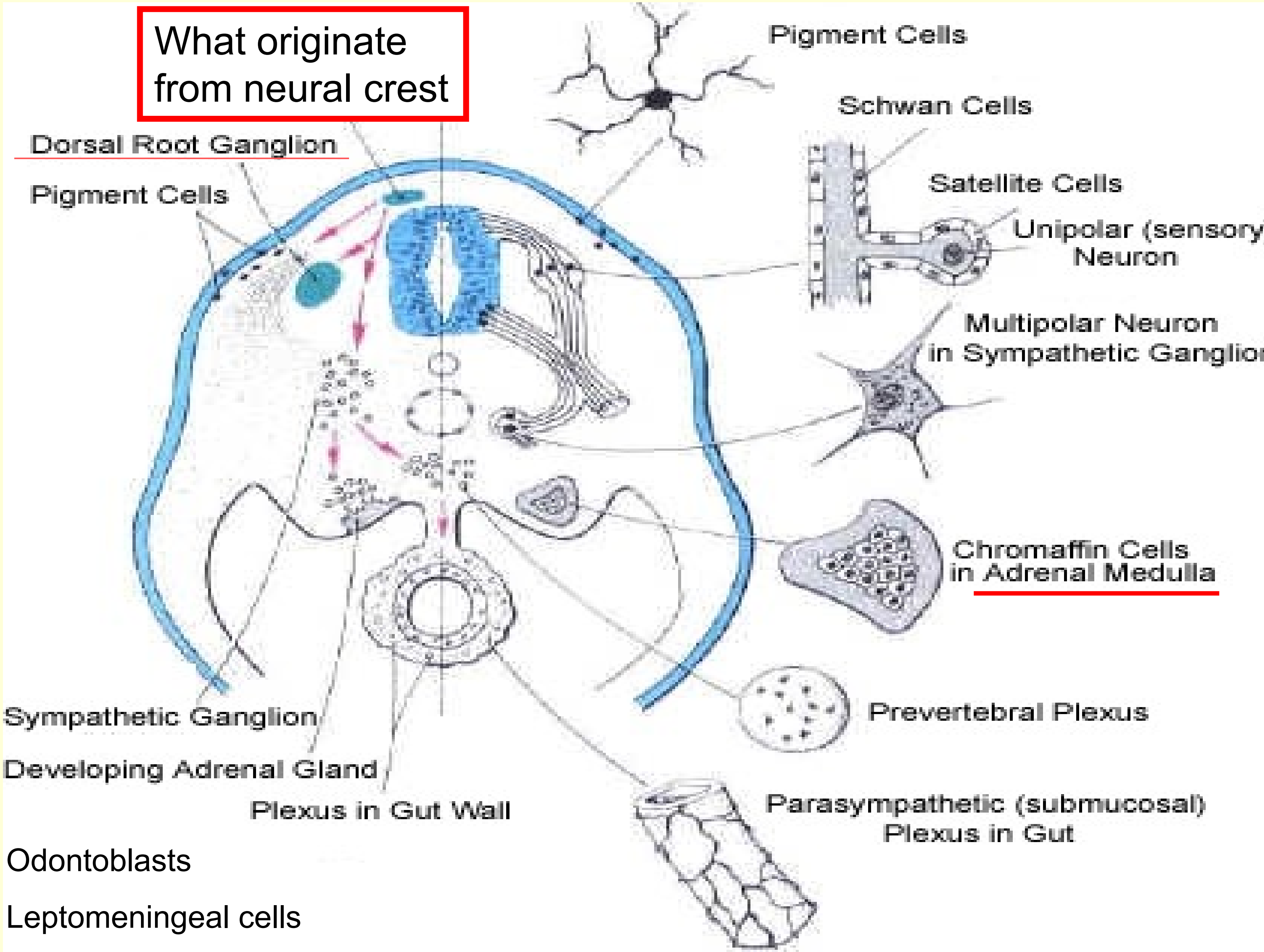
closes on D 25

closes on D 27

NEURAL CREST

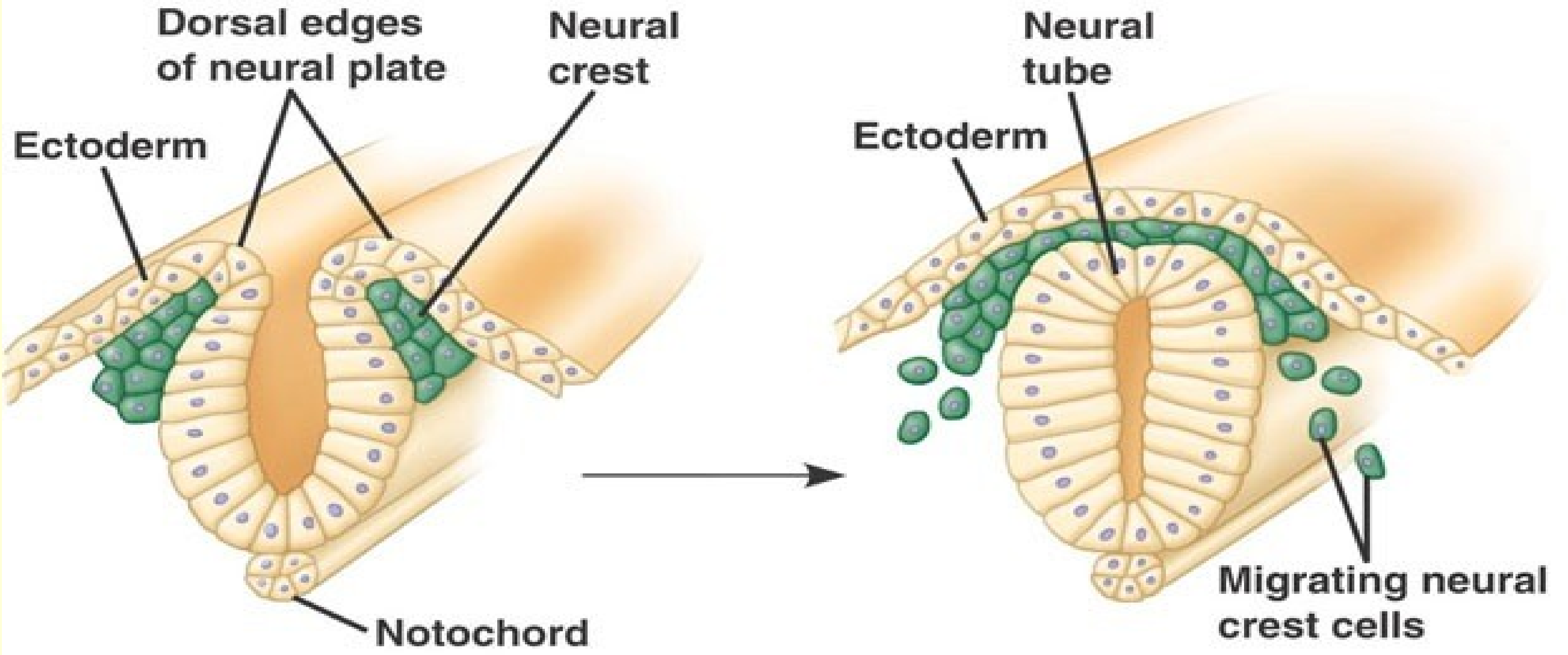


What originate from neural crest



Odontoblasts

Leptomeningeal cells

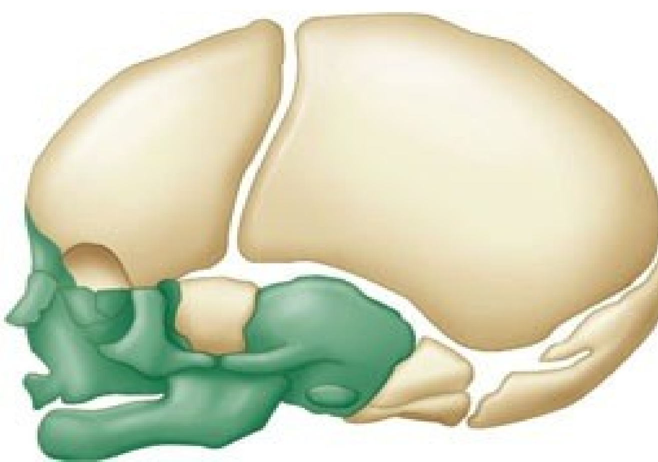


(a) The neural crest consists of bilateral bands of cells near the margins of the embryonic folds that form the neural tube.

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

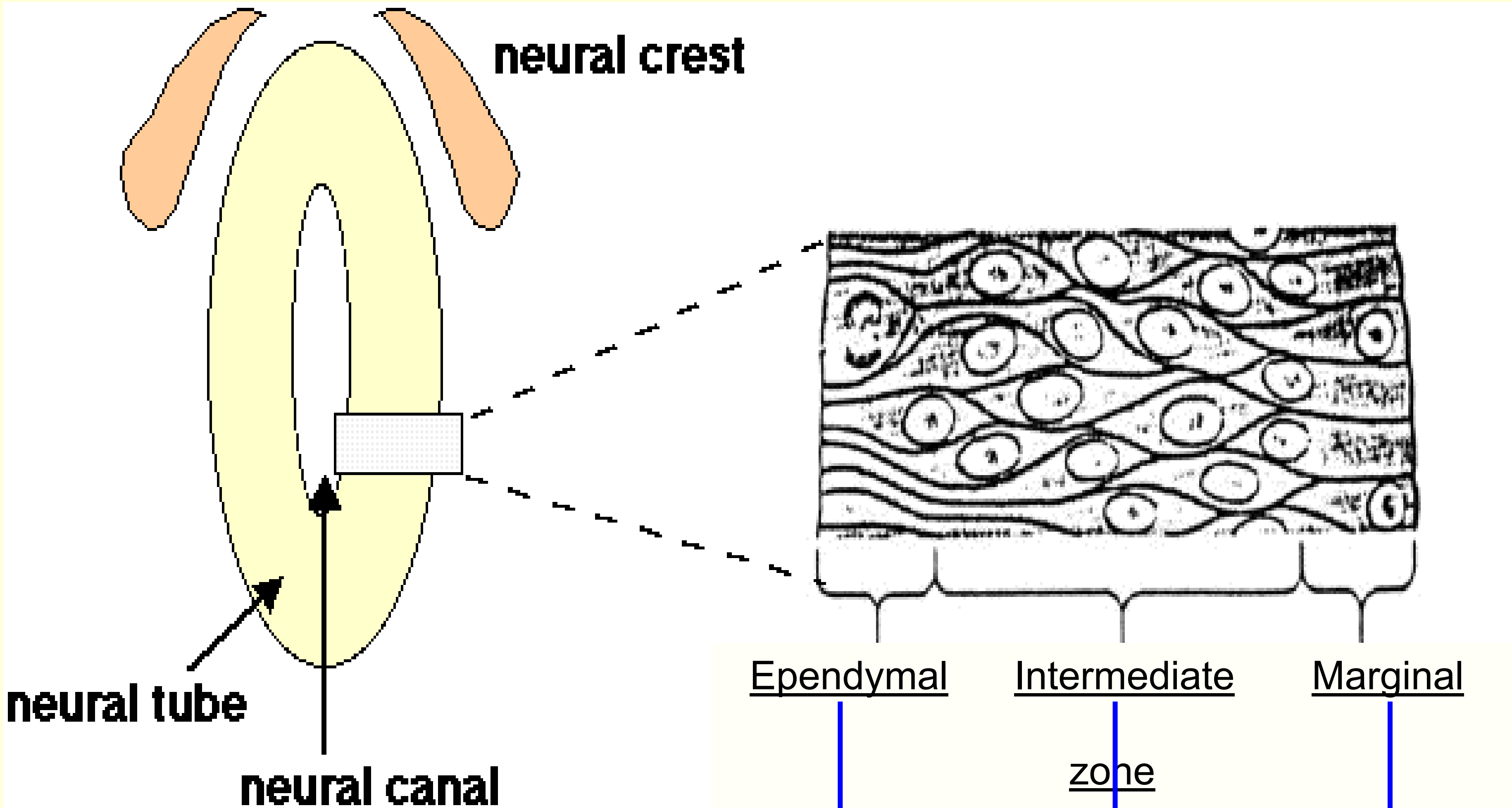
(c) The cells give rise to some of the anatomical structures unique to vertebrates, including some of the bones and cartilage of the skull.

EKTOMESENCHYME



Histogenesis of neural tube

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



Ependymal → Ependyma

Intermediate zone → Gray matter

Marginal → White matter

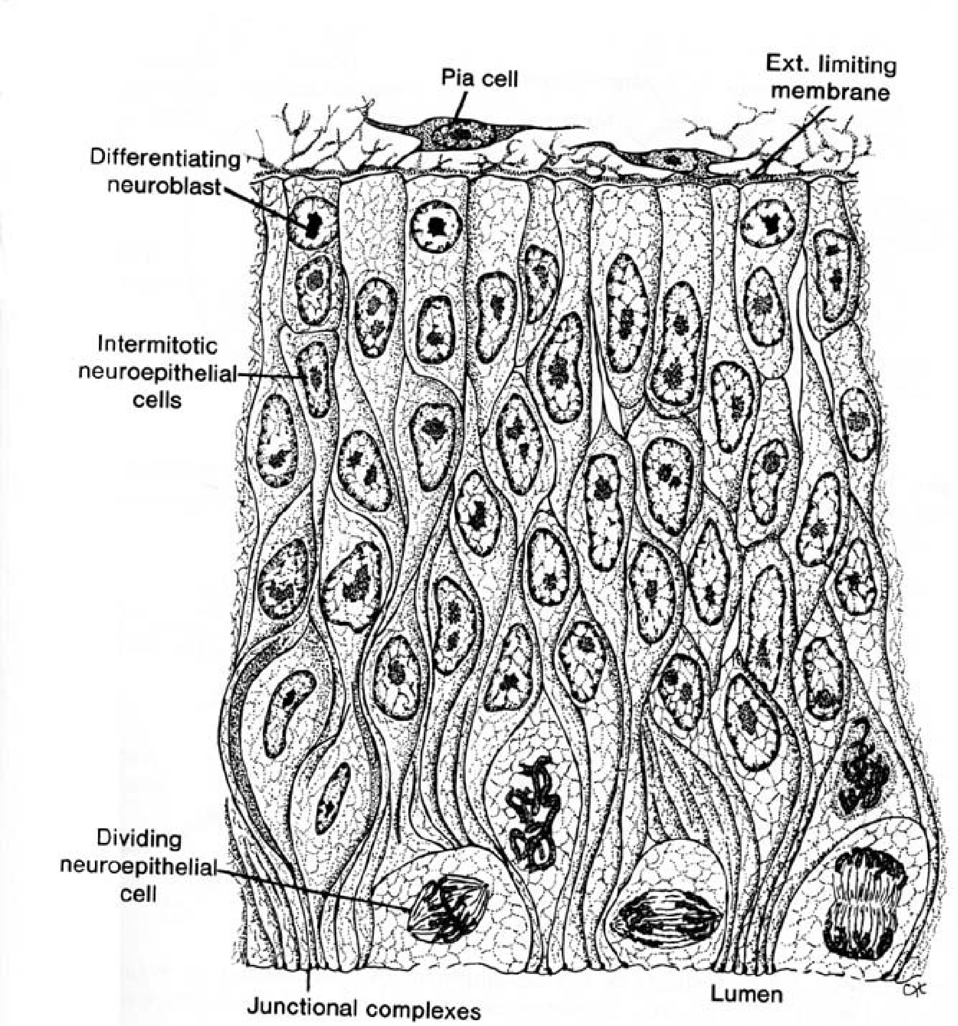
(in medulla spinalis)

HISTOGENESIS of NEURAL TUBE

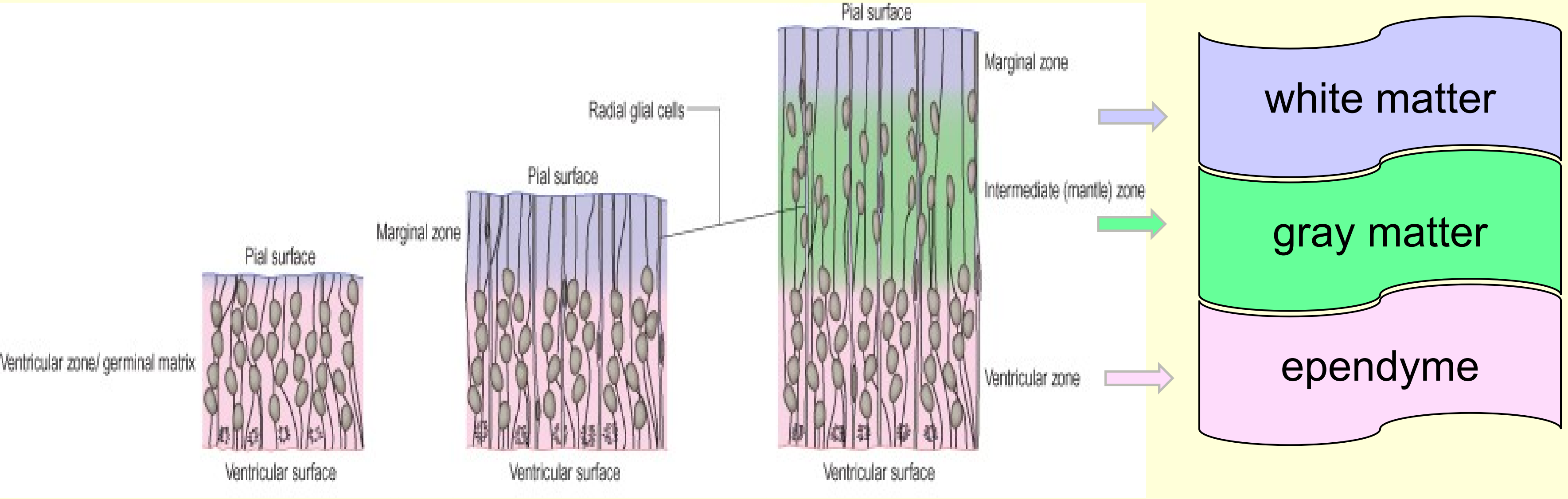
Marginal zone (white matter)

Intermediate zone (gray matter) (mantle zone)

Ependymal zone (germinal)



In spinal cord and brain stem



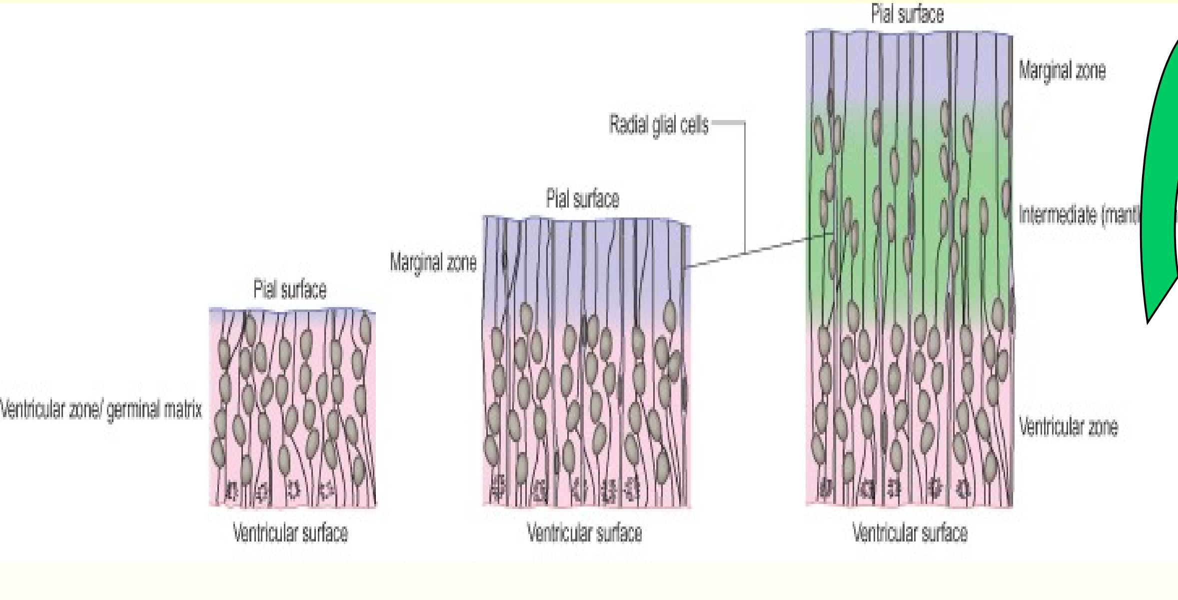
Three zones line neural tube (the spinal cord and brain stem).

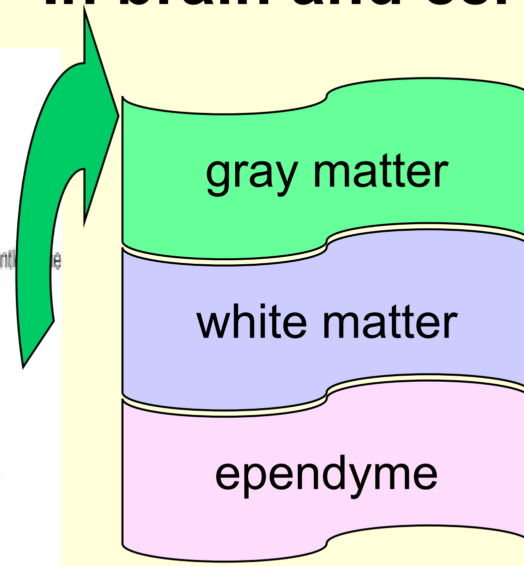
Marginal zone (white matter) – without neurons, but with axons of neurons and glial cells

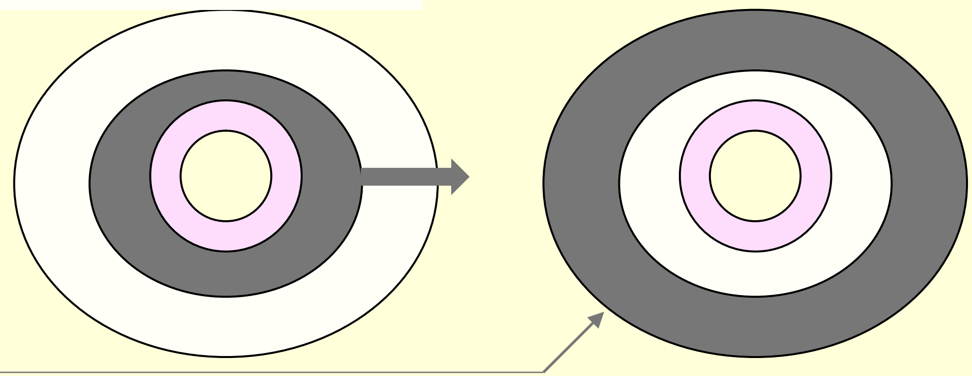
Mantle zone (gray matter) – neuroblasts + spongioblasts give rise to bodies of neurons and glial cells

Ependymal zone (germinal) – lining of central canal

In brain and cerebellum



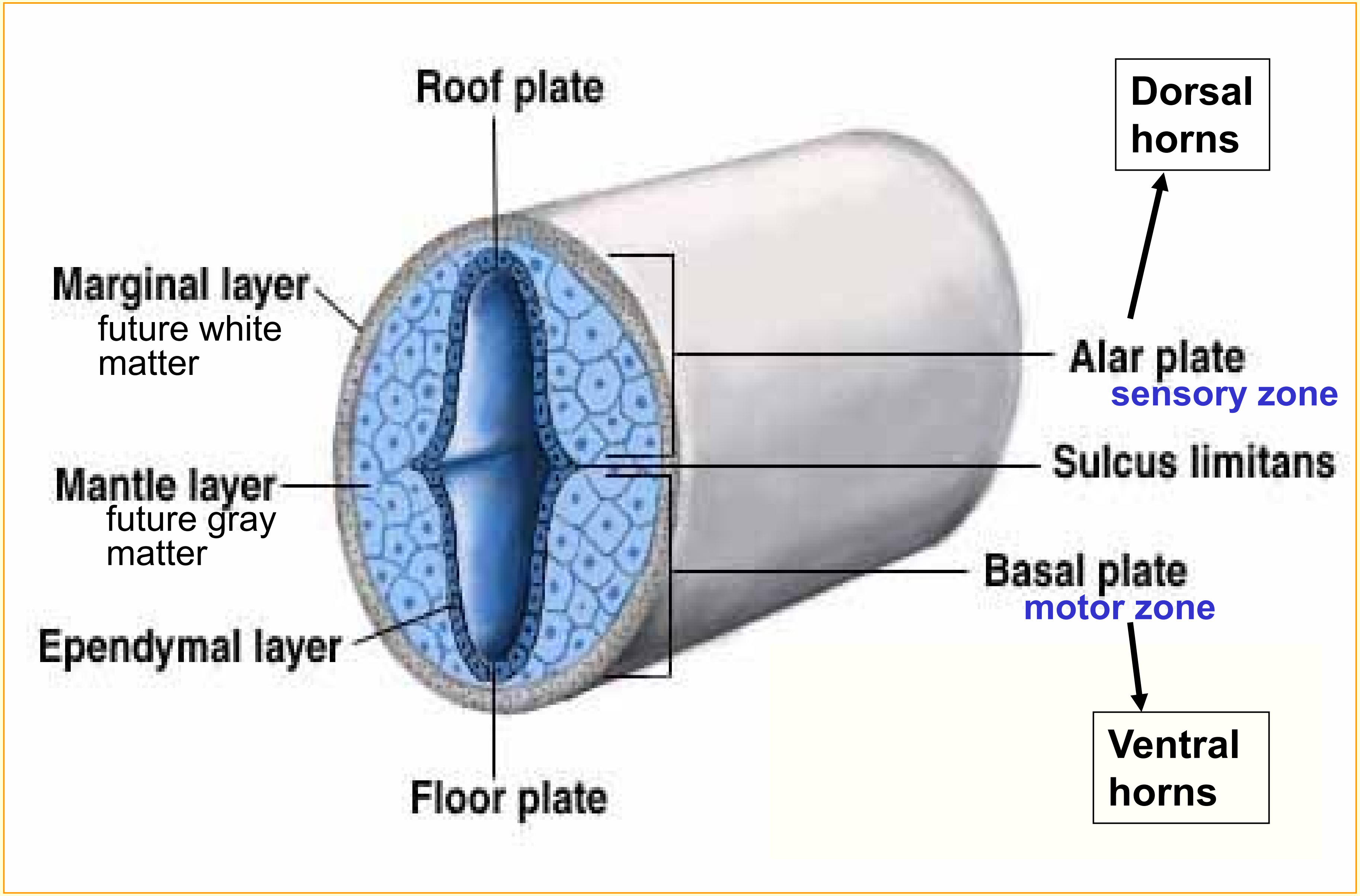




In brain and cerbellum:

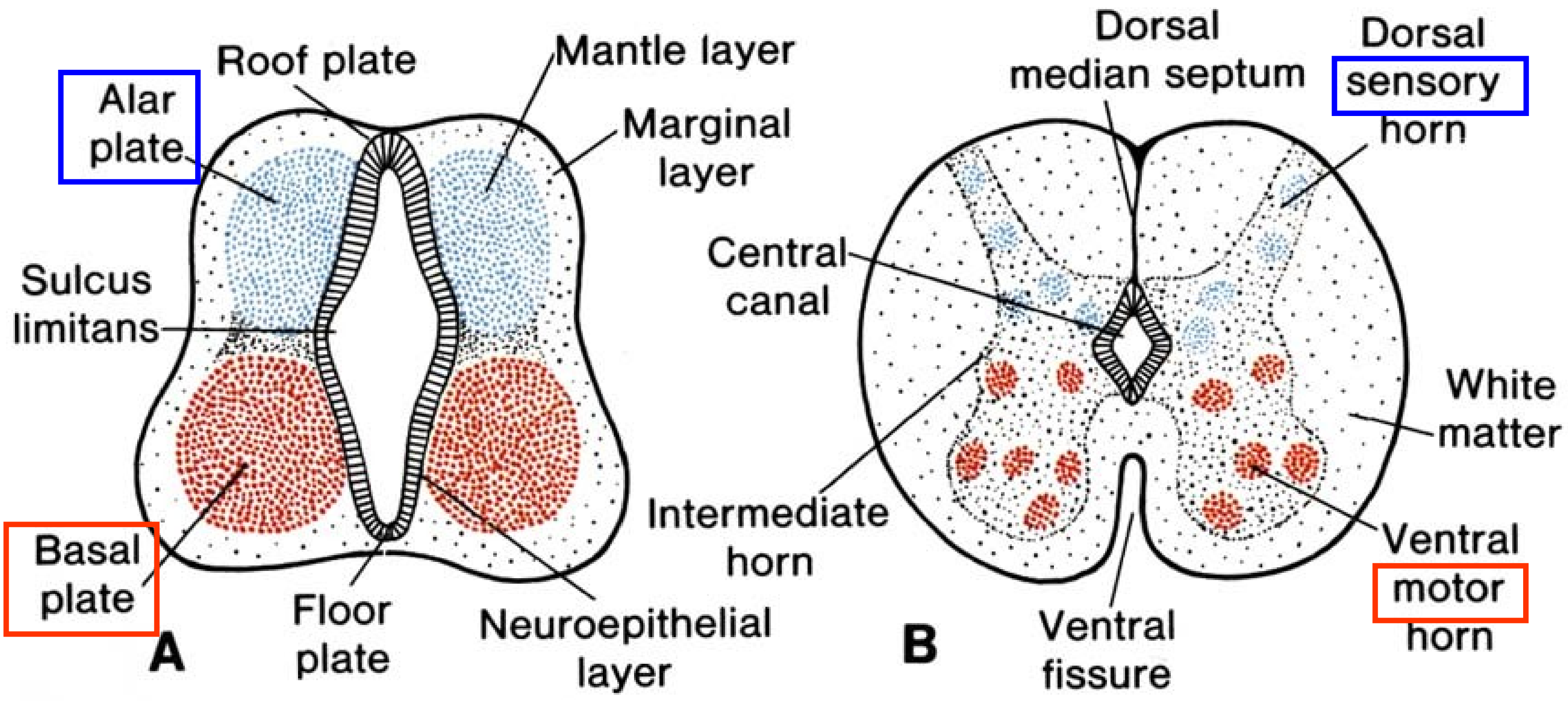
mantle zone cells migrate through marginal layer and the gray matter coveres white matter. Some neurons stay in white matter ⇨ nuclei.

Spinal cord development



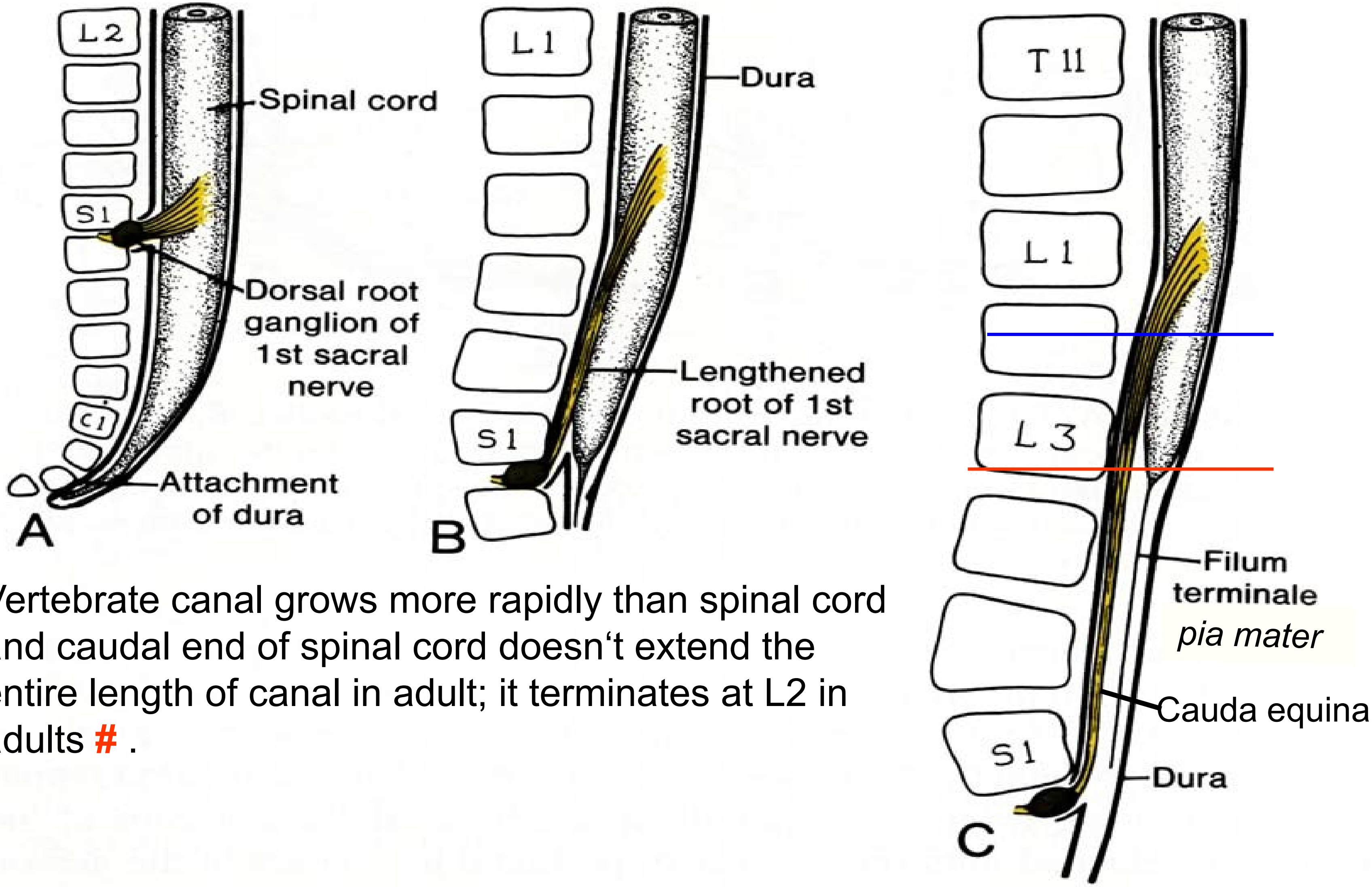
SPINAL CORD:

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 #

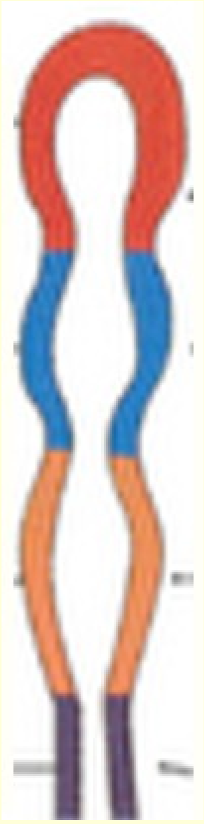


Vertebrate canal grows more rapidly than spinal cord and caudal end of spinal cord doesn‘t extend the entire length of canal in adult; it terminates at L2 in adults # .

Brain development

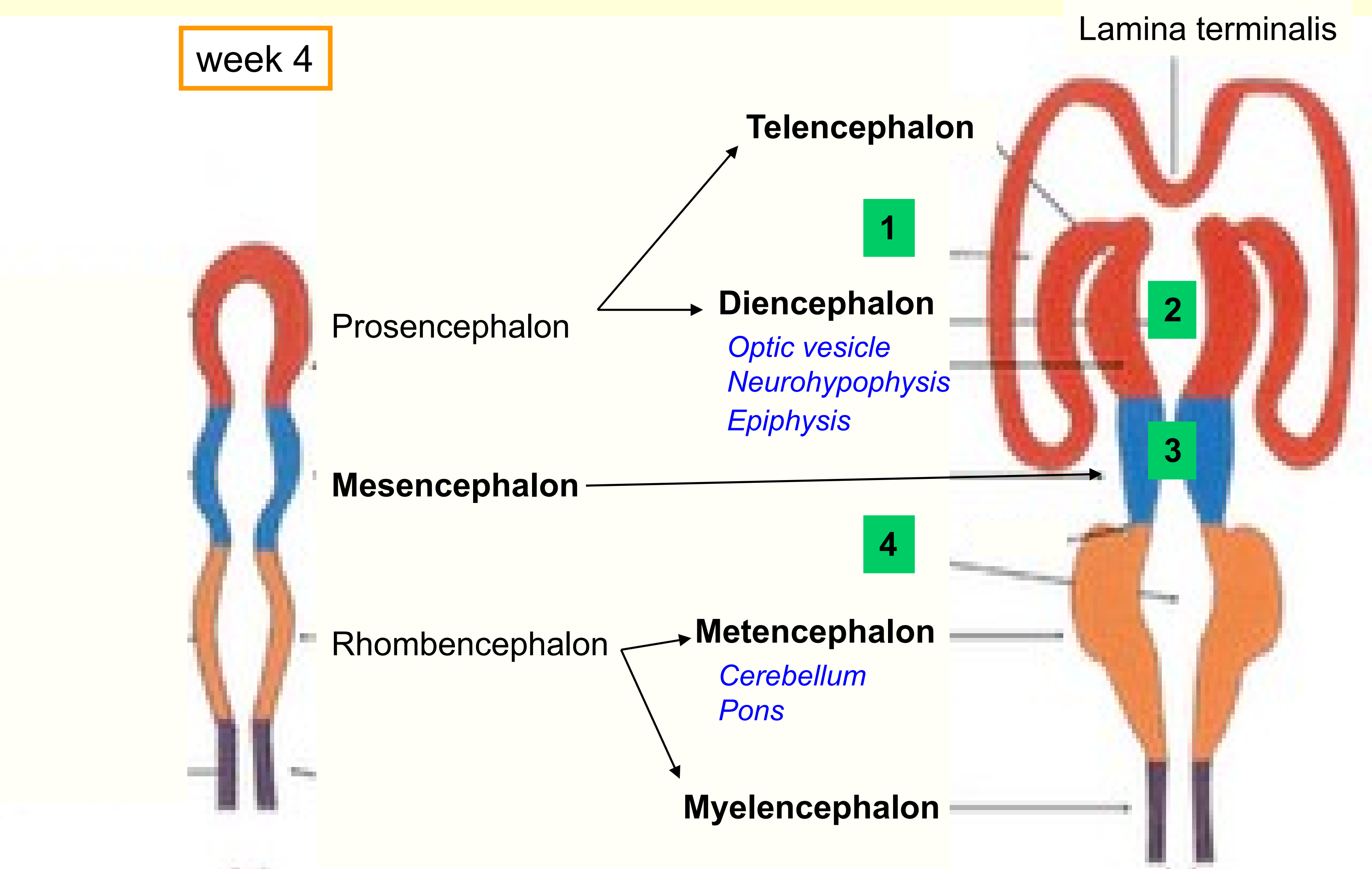
- Brain develops from cranial part of neural tube
- Week 4 – three primary brain vesicles:

  - prosencephalon (forebrain)
  - mesencephalon (midbrain)
  - rhombencephalon (hindbrain)

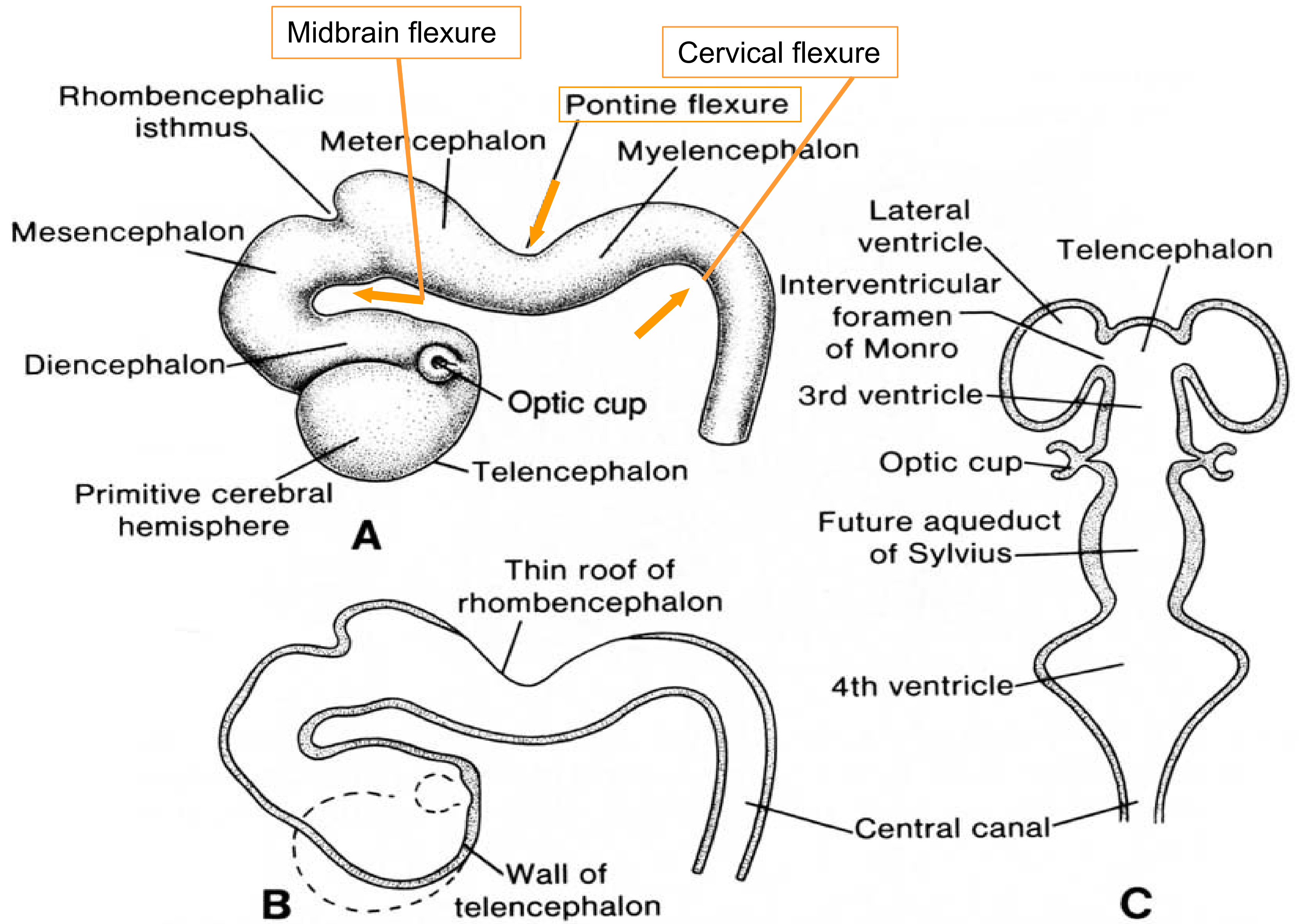


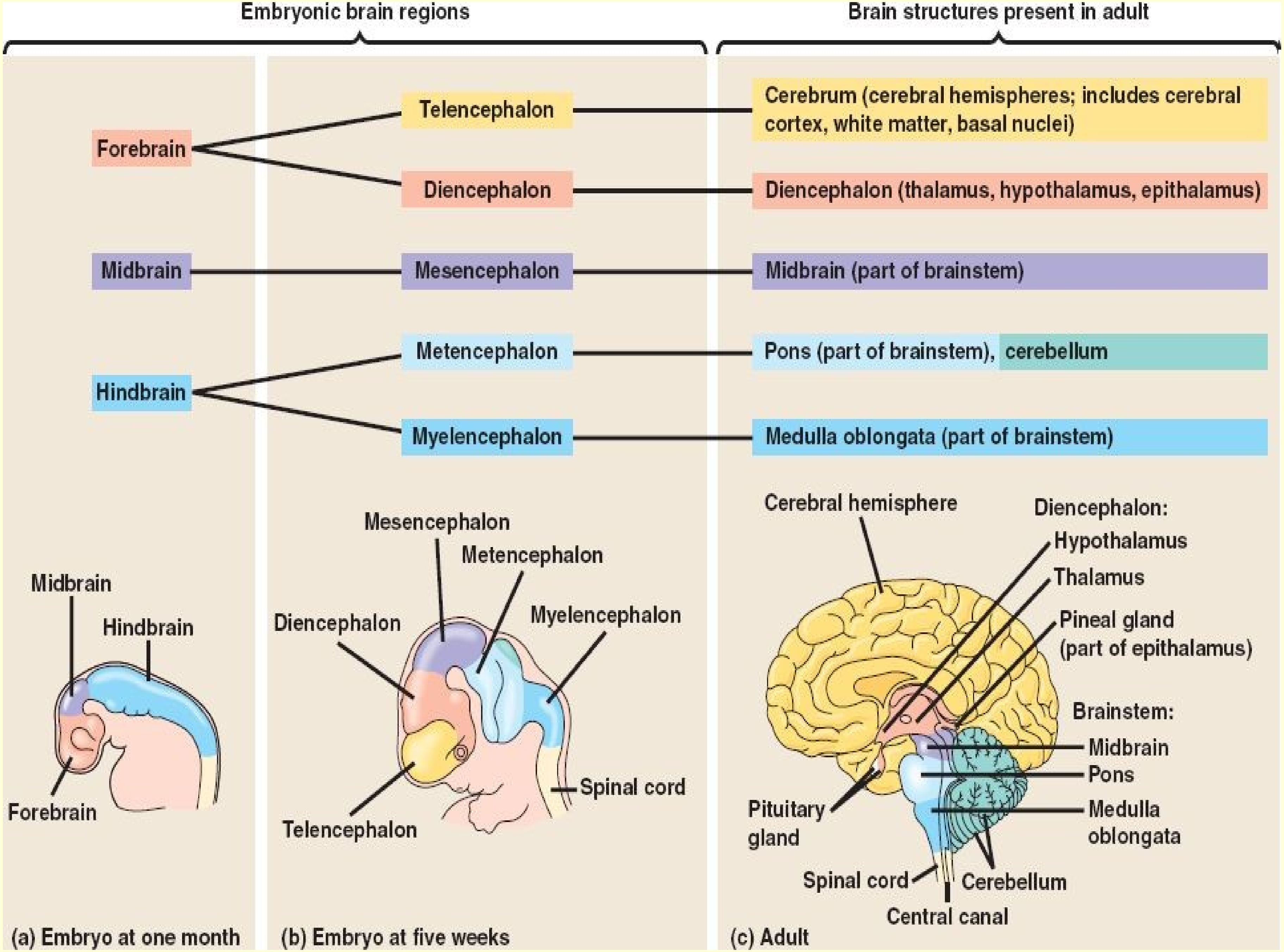
3 primary → 5 **secondary vesicles**:

week 5



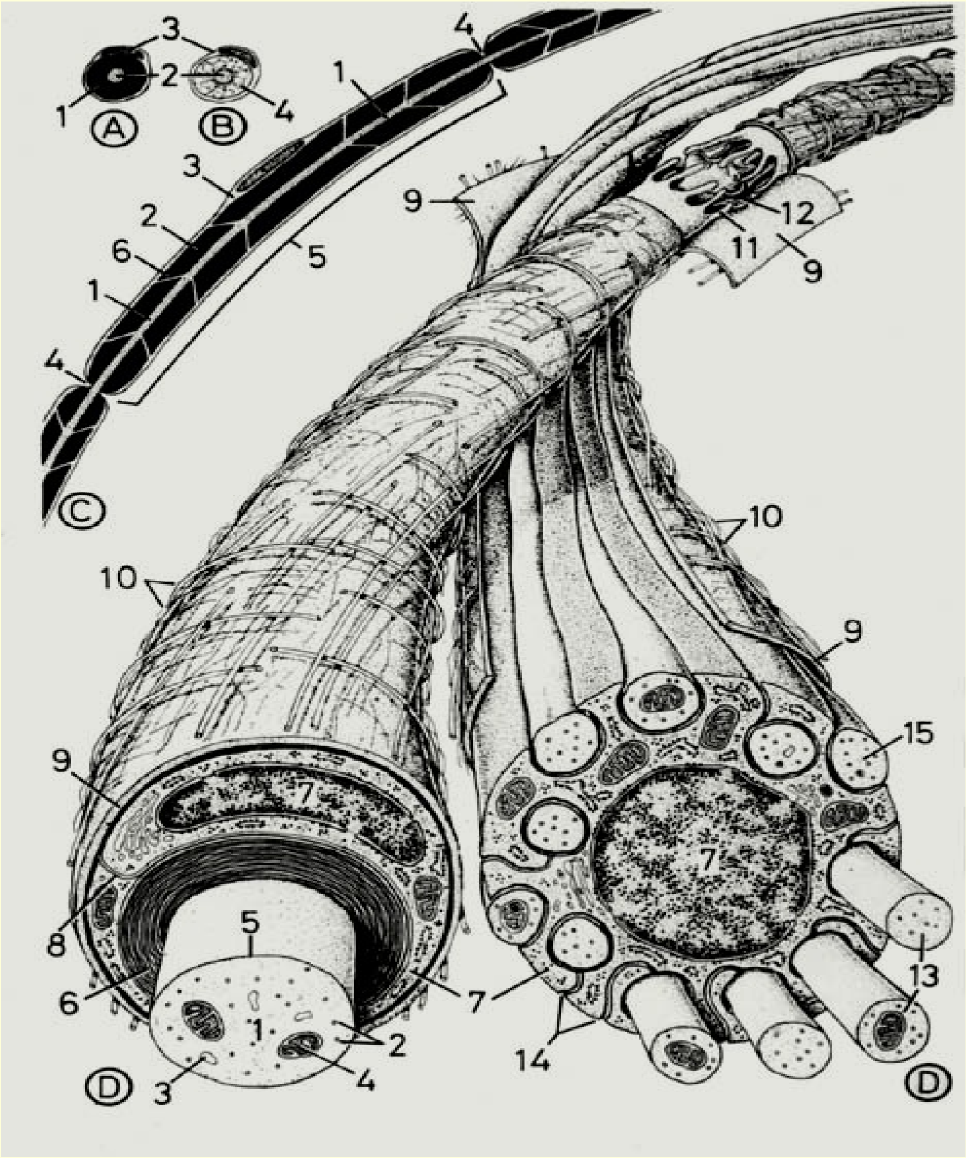
1 – ventriculi lat., 2 – ventriculus tertius, 3 – aqueductus cerebri, 4 – ventriculus quartus


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

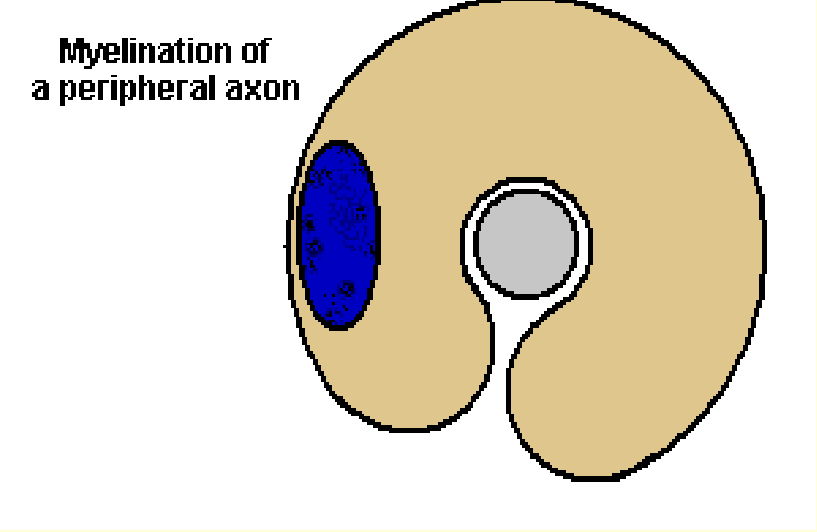
Myelination of nerve fibers



from the 4th prenatal month

to the end of 2nd postnatal year

animated picture



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.

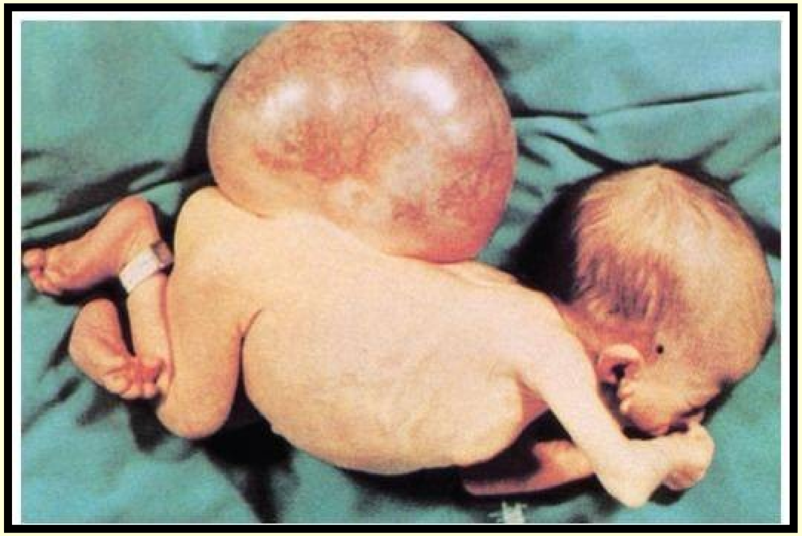
Spinal cord malformations

Defects (clefts) of vertebral arches

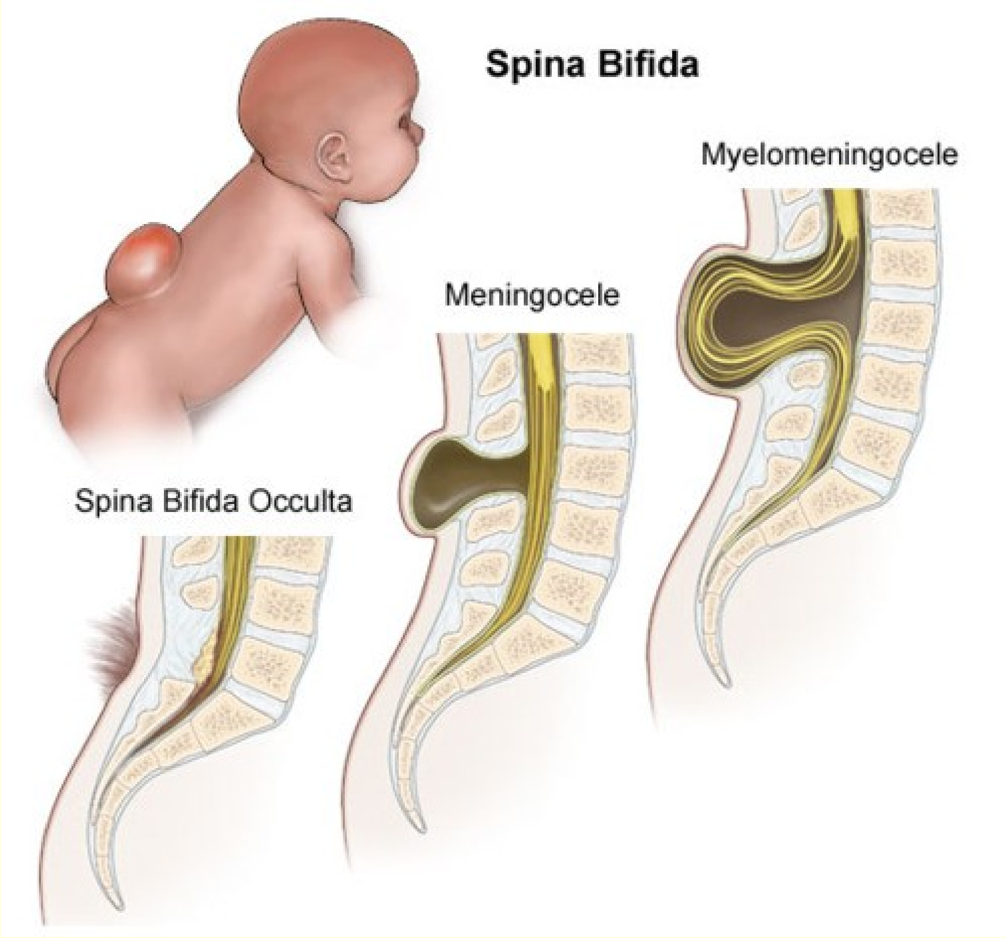
- Menigocele
- Menigomyelocele
- Menigohydromyelocele

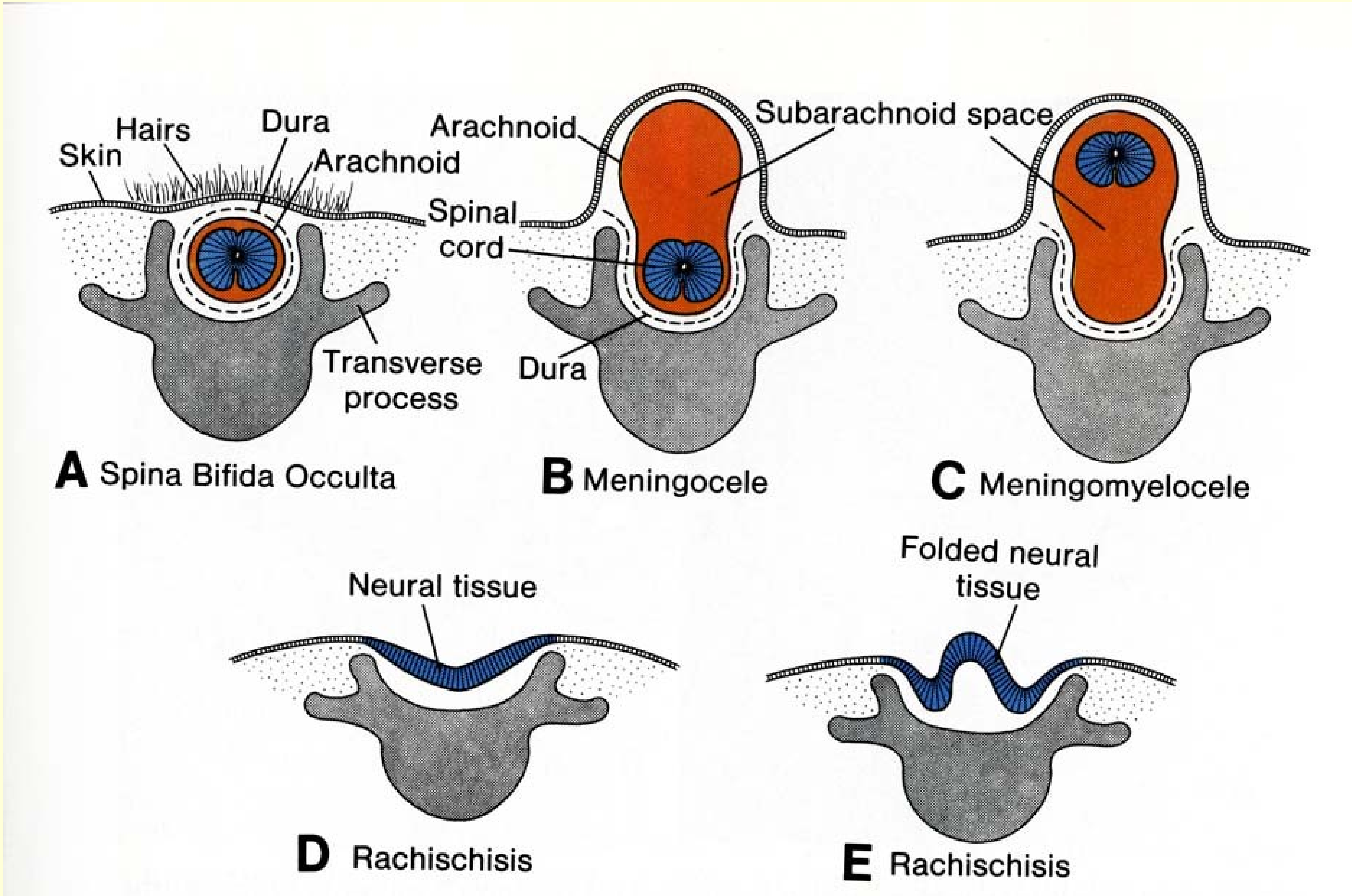
spina bifida cystica

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




Meningomyelocele


Spina Bifida
Myelomeningocele
Meningocele
Spina Bifida Occulta


Hairs
Dura
Skin
Arachnoid
Transverse process
A Spina Bifida Occulta
Arachnoid
Spinal cord
Dura
Subarachnoid space
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

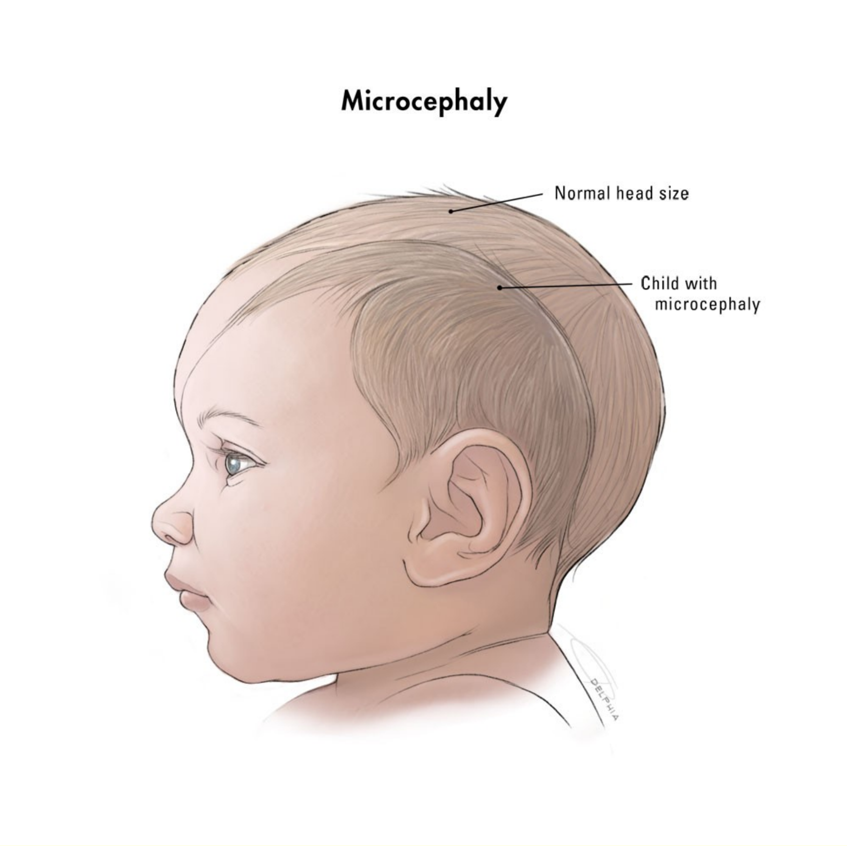
Brain malformations

- Anencephalia (†) (with myeloschisis)

Anencephalia

Brain malformations

MICROCEPHALIA



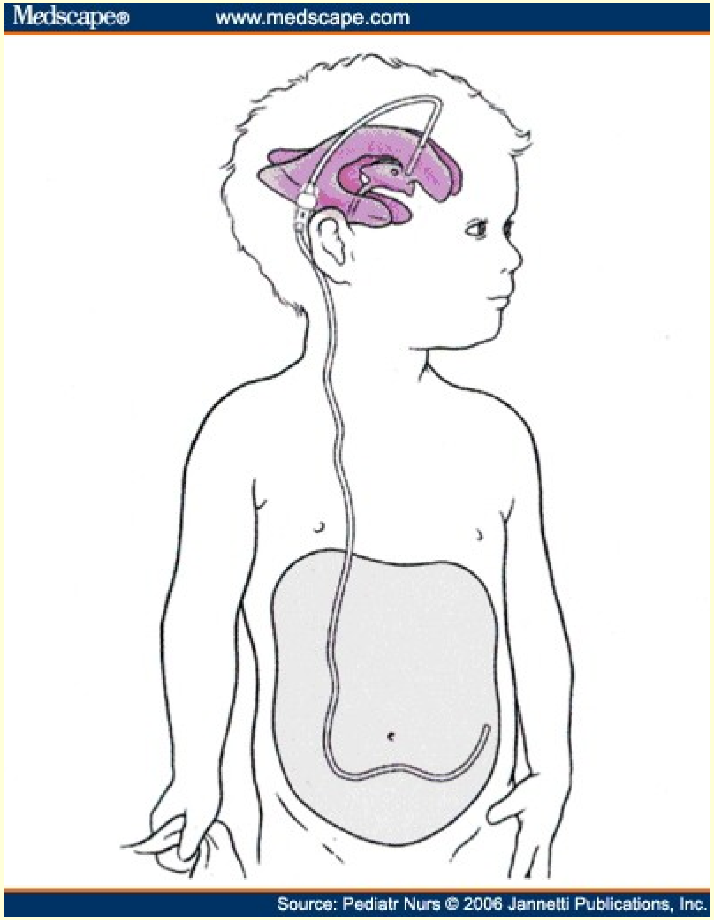
ANENCEPHALIA

Hydrocephalus

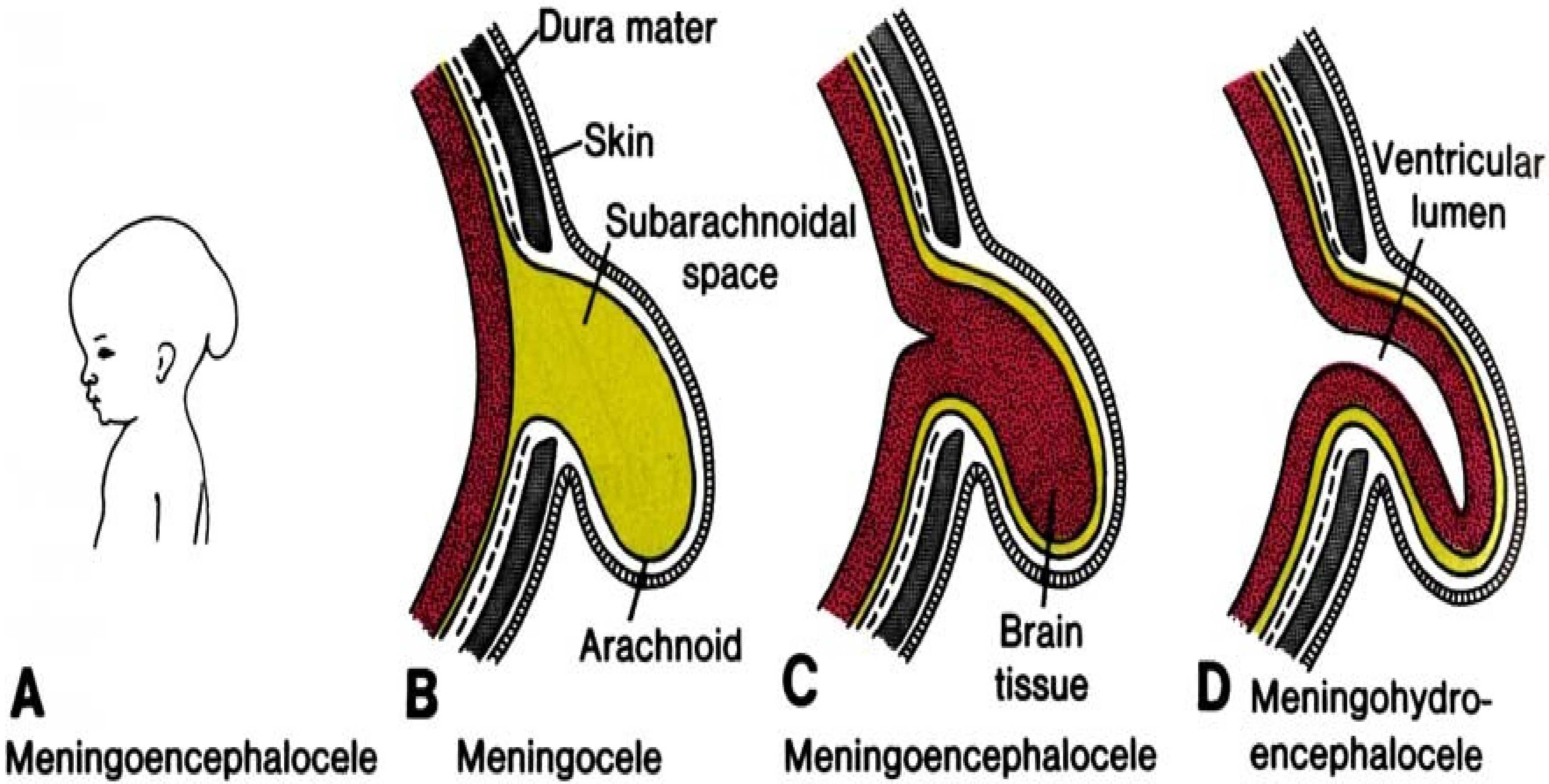
- accumulation of abundant cerebrospinal fluid in brain ventricular system,
- etiology: stenosis or obliteration of aqueductus cerebri between the 3rd and 4th ventricles ➡ fluid is accumulated in lateral ventricles ➡ pushes on the brain tissue (is thinned); internal pressure complicates drenage of fluid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

HYDROCEPHALUS

ventriculoperitoneal shunt



Brain and meninges hernia(tion)

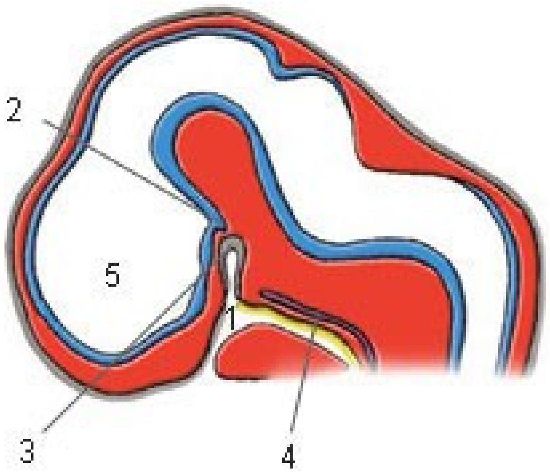


Brain and meninges hernia(tion)

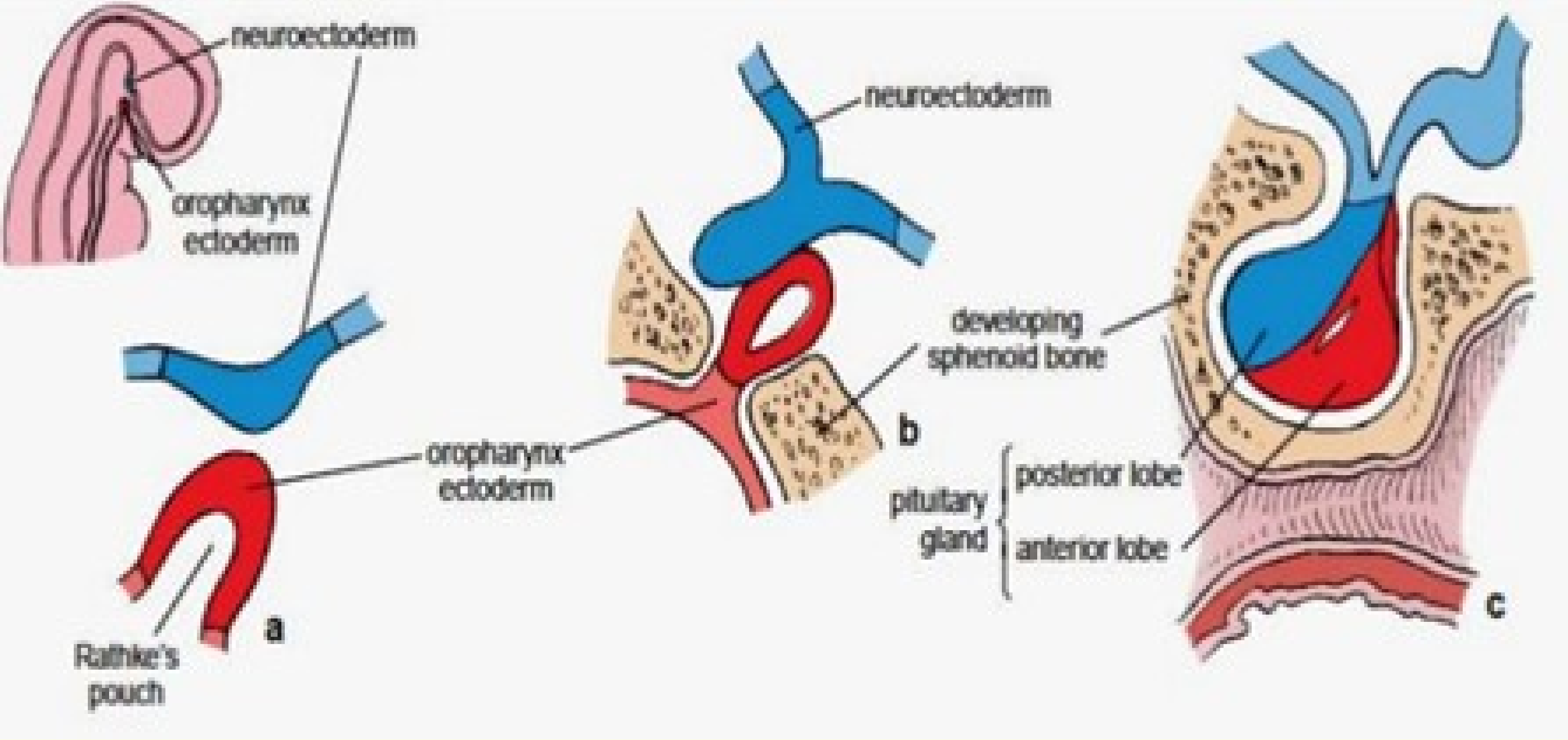

End

Endocrine glands development

Hypophysis	adenohypo – ectoderm	(roof of stomodeum)
	neurohypo – neuroectoderm	(floor of diencephalon)
Pineal gl.	– neuroectoderm	(floor of diencephalon)
Thyroid gl.	– endoderm	(tongue)
Parathyr. gll.	– endoderm	(pharyngeal pouches)
Langerhans islets	– endoderm	
Adrenal gll.	Cortex – mesoderm	
	Medulla – neuroectoderm	



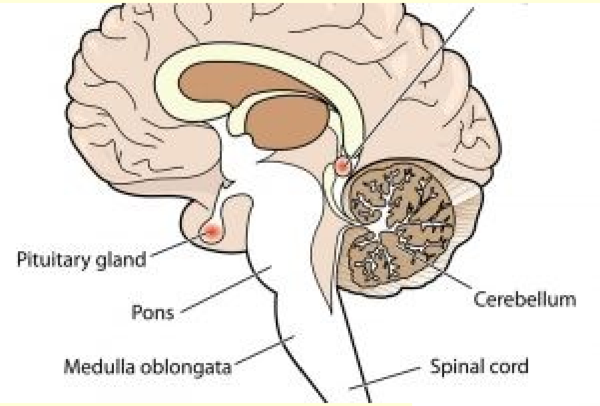
Neurohypophyseal diverticle
of diencephalon floor
+
Rathke's pouch
of stomodeum roof

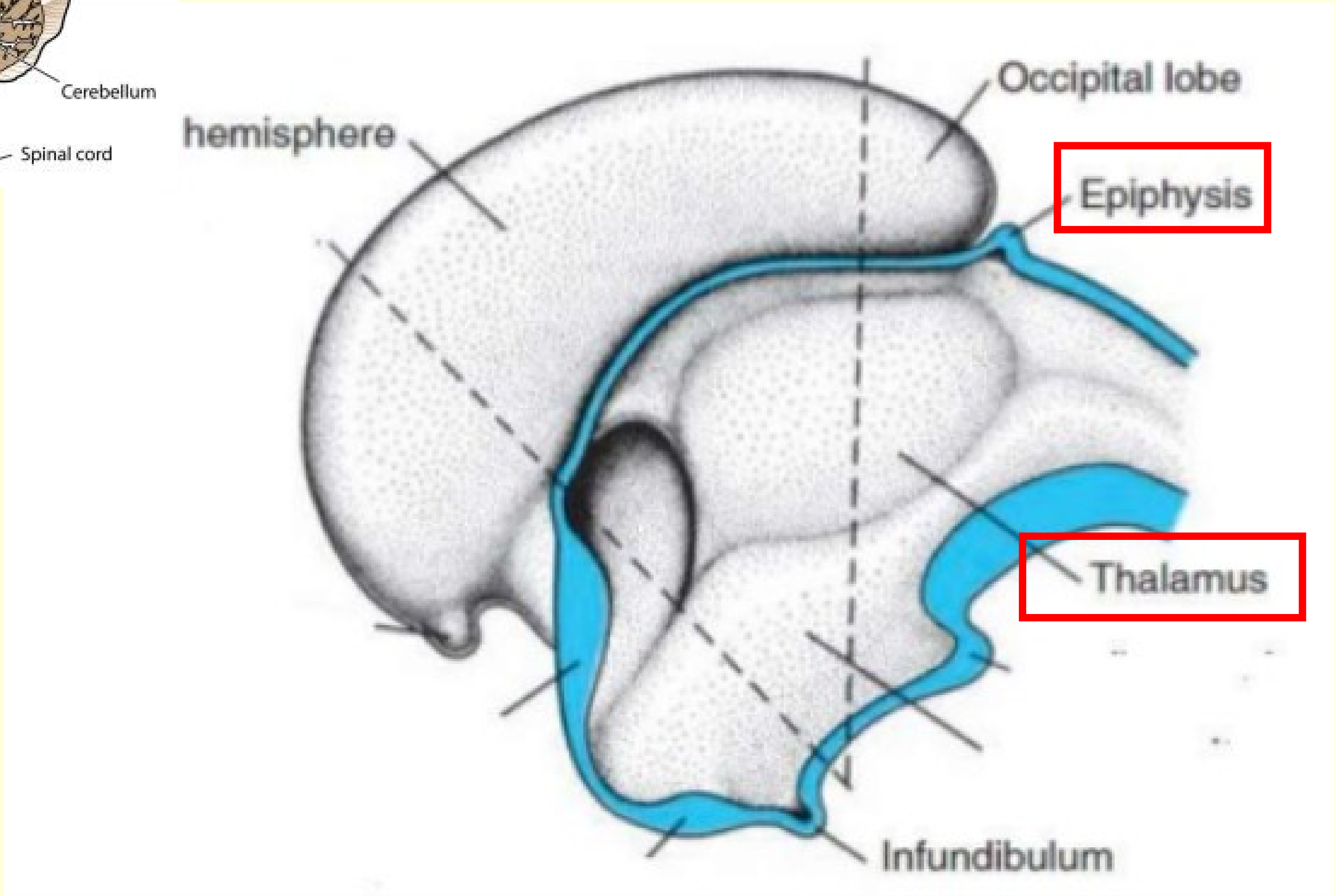


Possible congenital anomalies

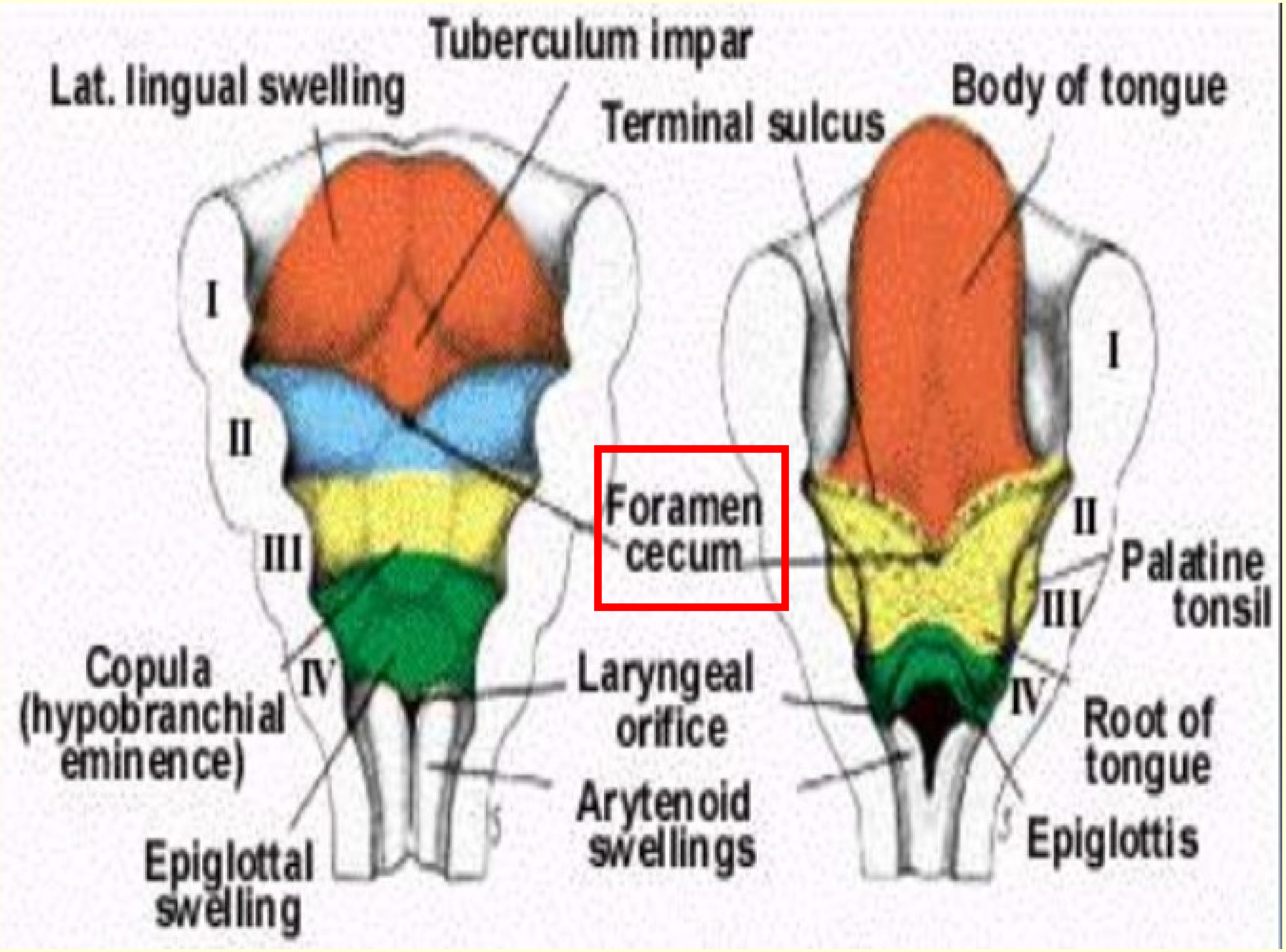
- Pharyngeal hypophysis
- Agenesis/Hypogenesis of pituitary gland
- Duplication of pituitary gland
- Congenital tumor of the gland (Craniopharyngioma)

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

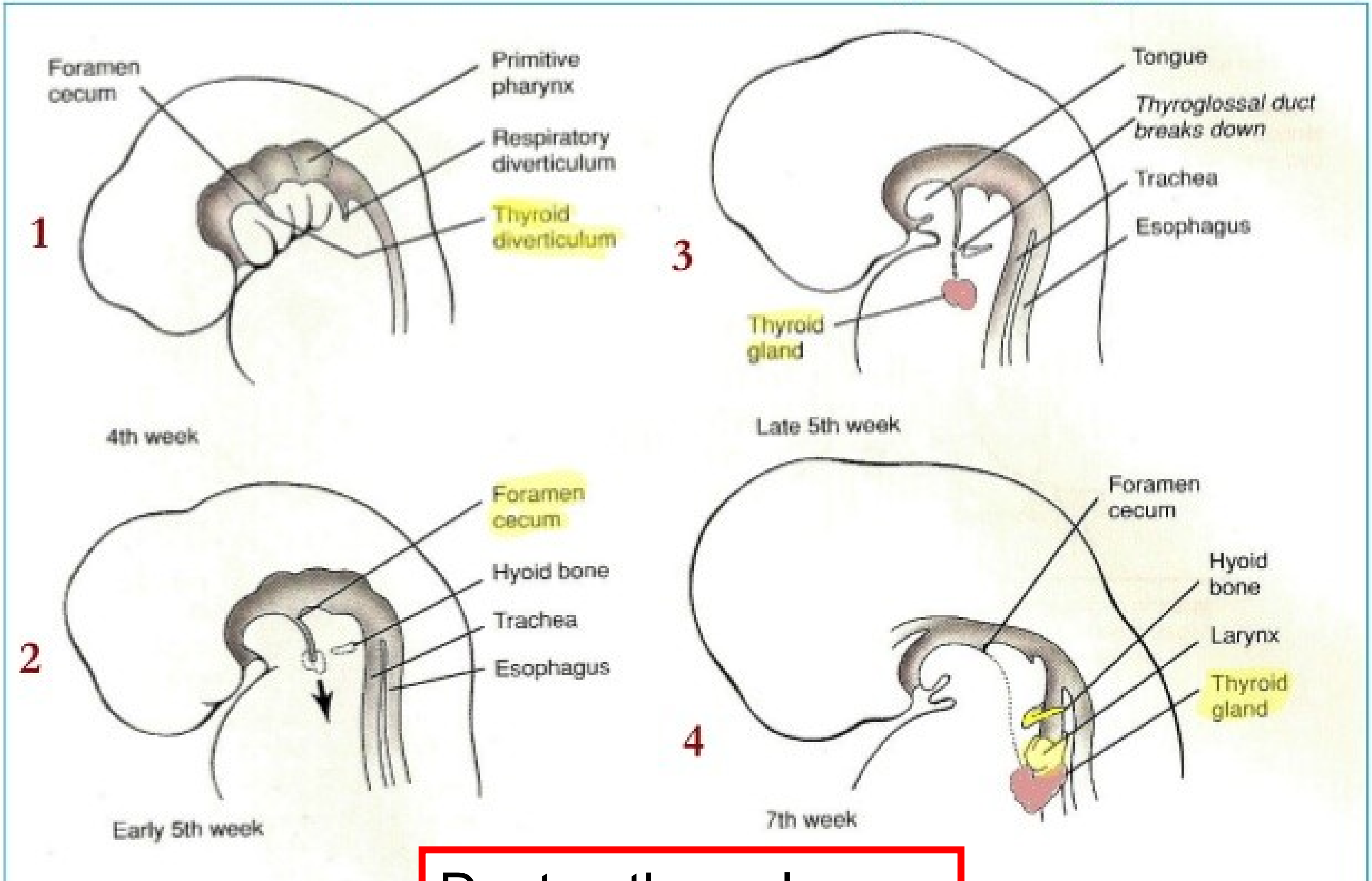




Thyroid gland

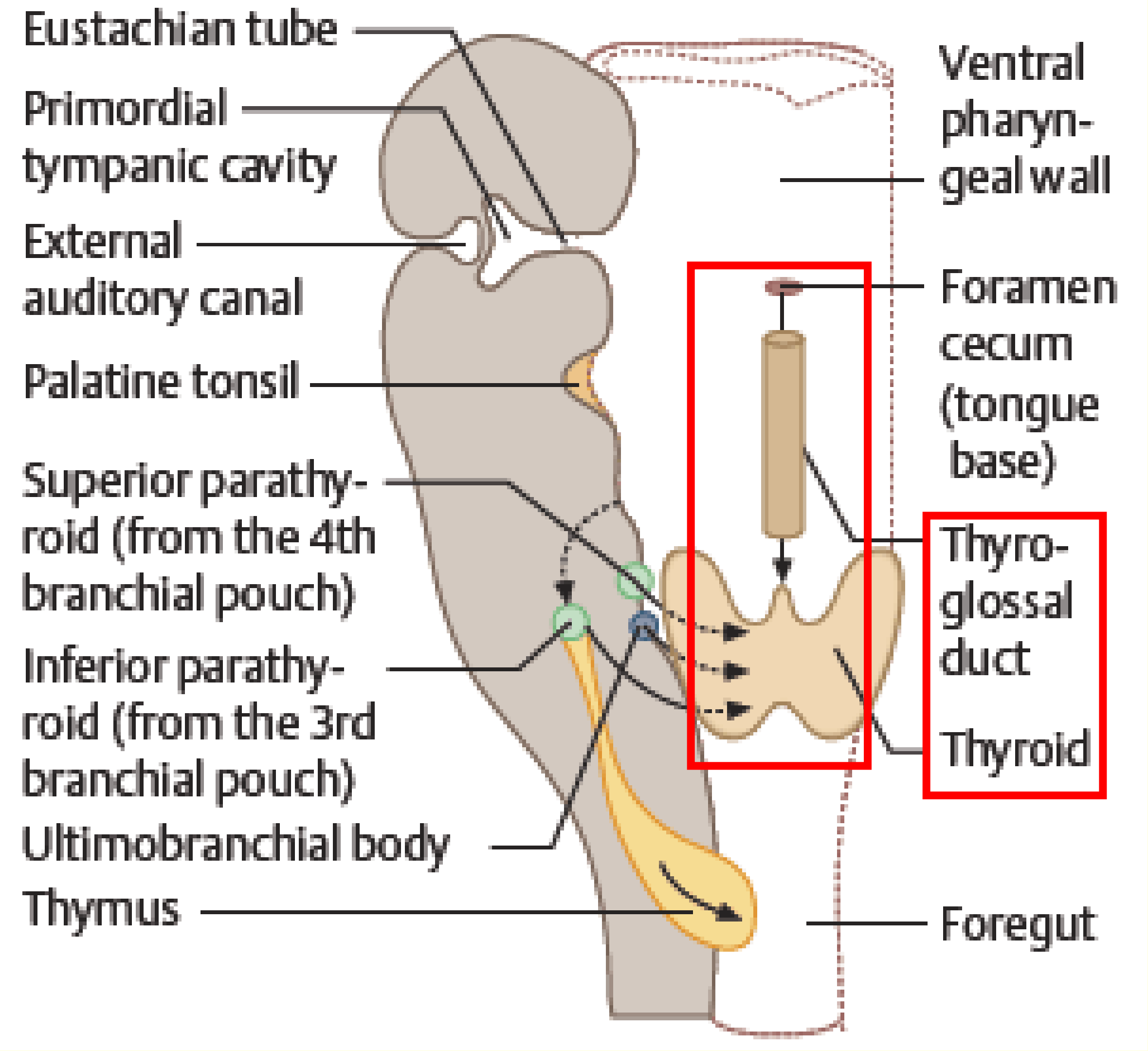


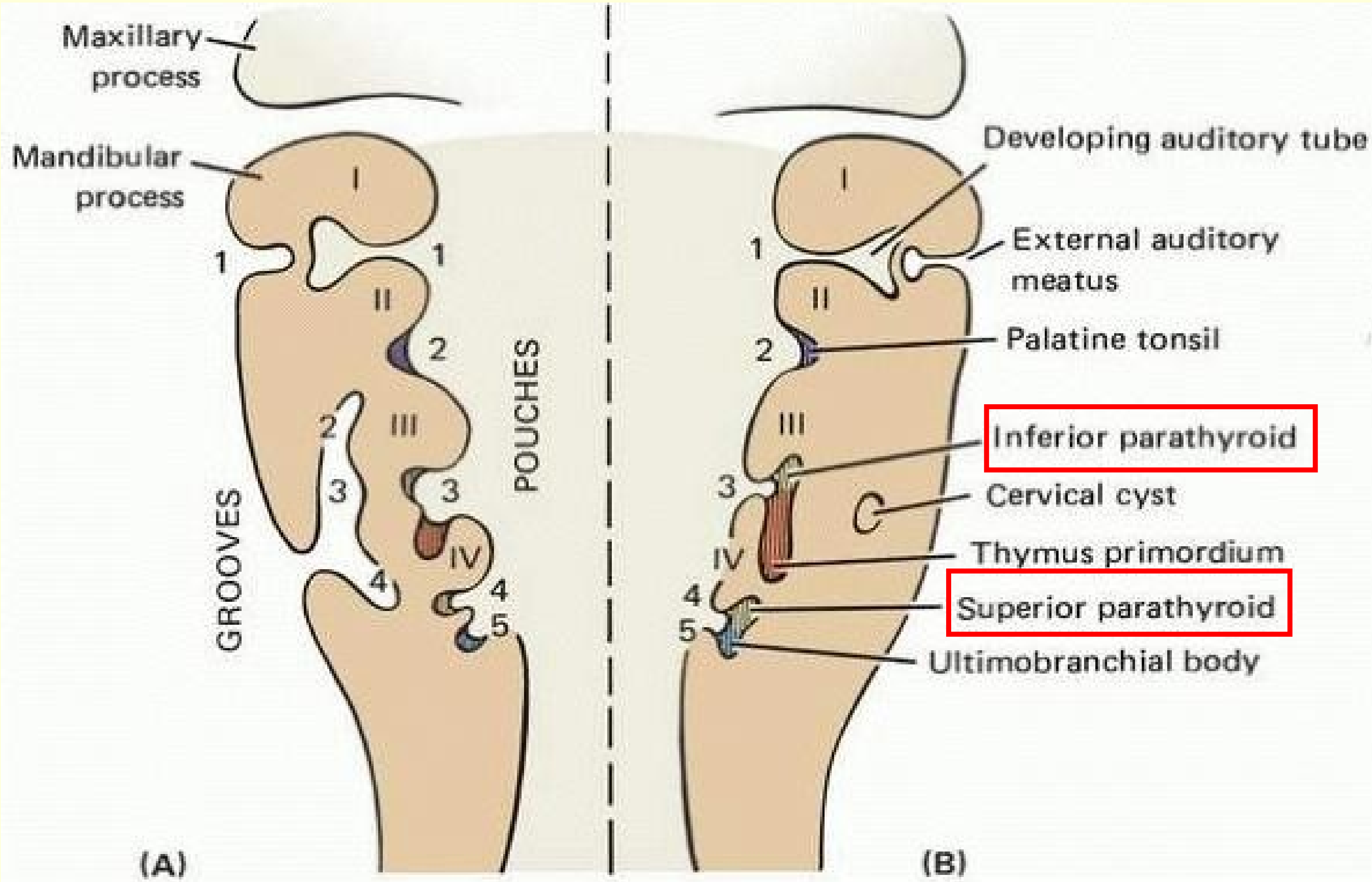
Descensus of thyroid gland



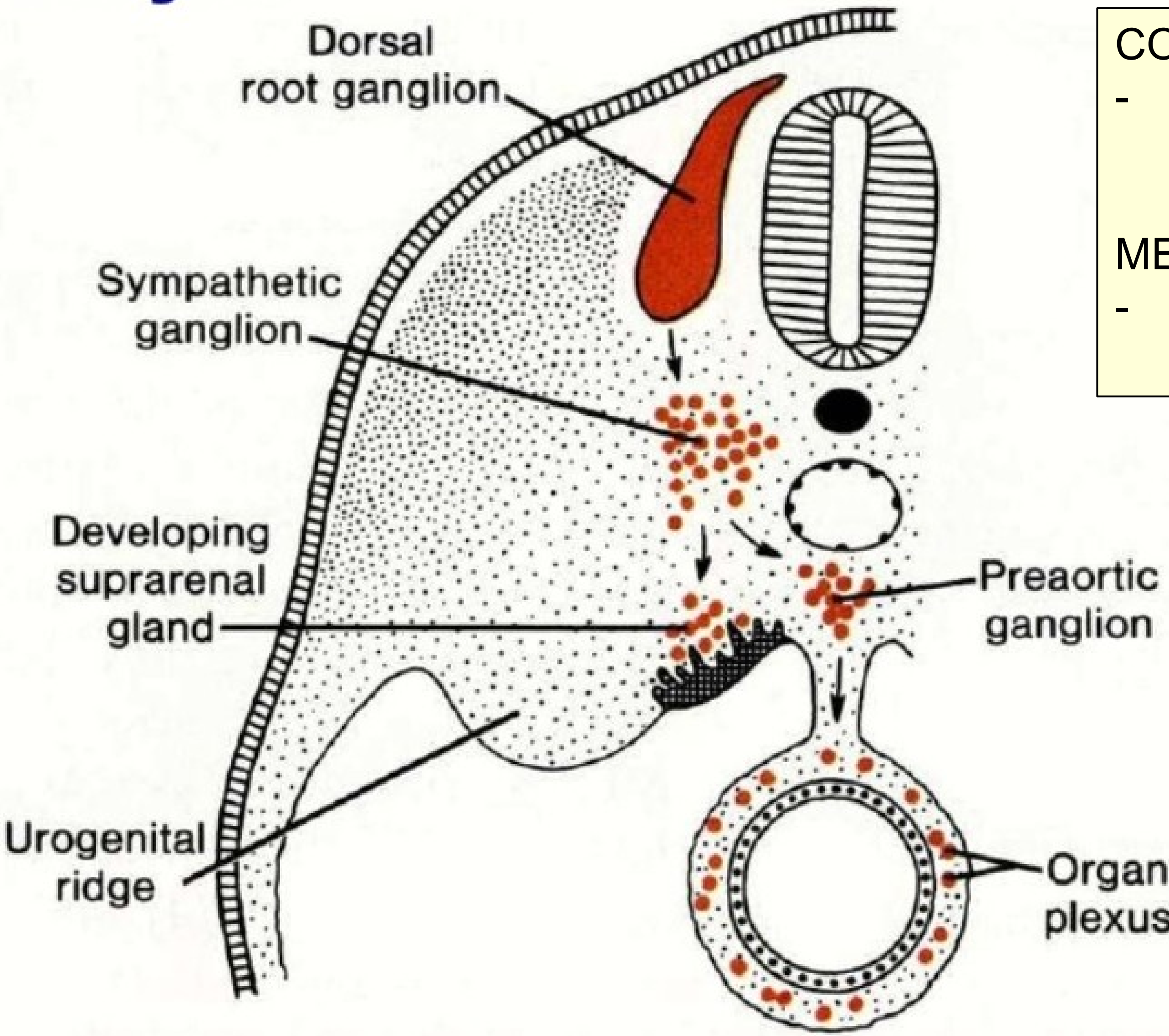
Ductus thyroglossus

Ultimobranchial body – the 4th endodermal pouch – parafollicular cells


Eustachian tube
Primordial tympanic cavity
External auditory canal
Palatine tonsil
Superior parathy-roid (from the 4th branchial pouch)
Inferior parathy-roid (from the 3rd branchial pouch)
Ultimobranchial body
Thymus
Ventral pharyn-geal wall
Foramen cecum (tongue base)
Thyro-glossal duct
Thyroid
Foregut


Maxillary process
Mandibular process
I
1
1
II
2
III
2
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)

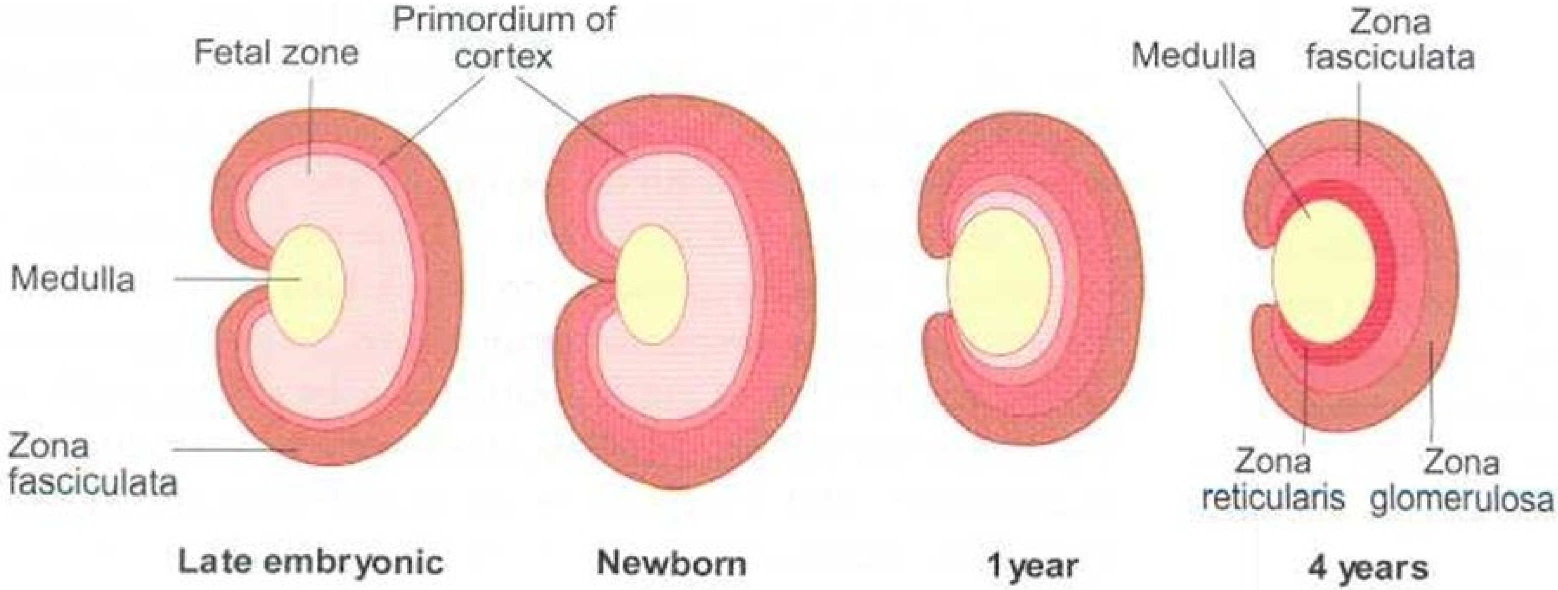
Adrenal gland



CORTEX
- mesoderm
  (coelomic epithelium)

MEDULLA
- neuroectoderm
  (neural crest)

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




End

Terms repetition

- 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 membrane, synaptic cleft, postsynaptic memrane)
- Neurotransmitters

Terms

repetition

- <u>Neuroglia - classification</u>
- Oligodendroglia
- Astrocytes
- Microglia (of Horteg)
- Ependyma - tanycytes
- Schwann cells
- Satelite cells

in CNS

in PNS

Terms

- Brain cortex – 6 layers (lamina)
- Cajal cells, Martinotti cells, granular and pyramidal cells
- Membrana limitans gliae superficialis and 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

(following pictures are not included in the lecture, but can help students)

Development of the skull base

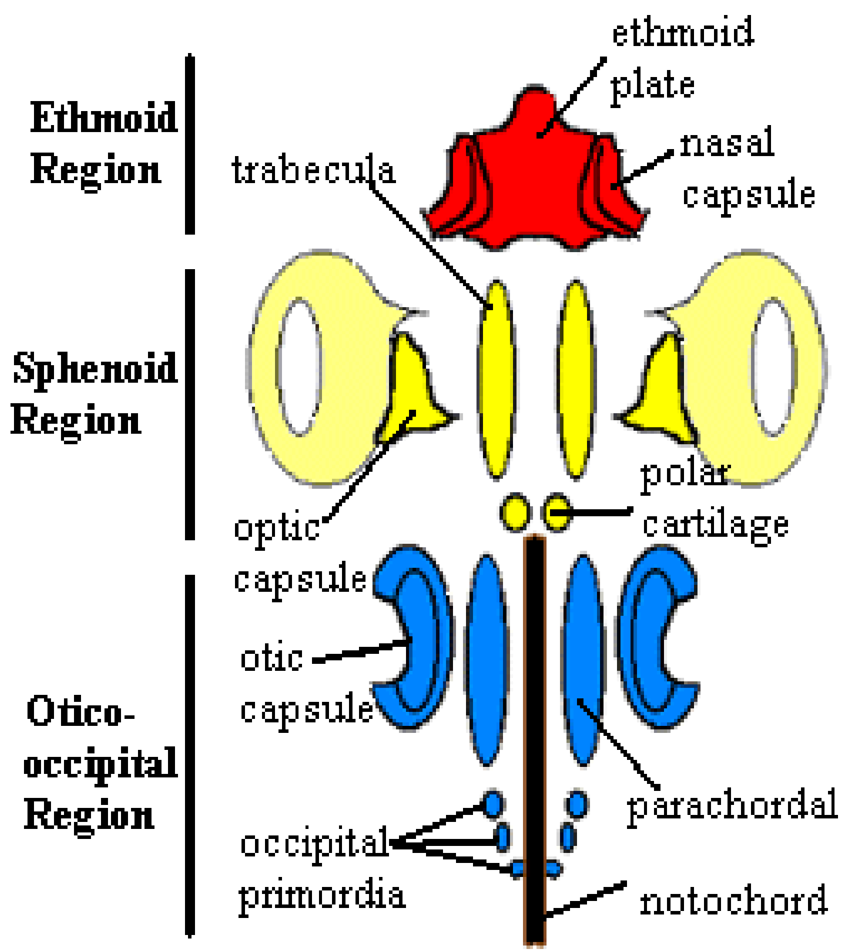


Figure 3. Schematic view of vertebrate braincase development

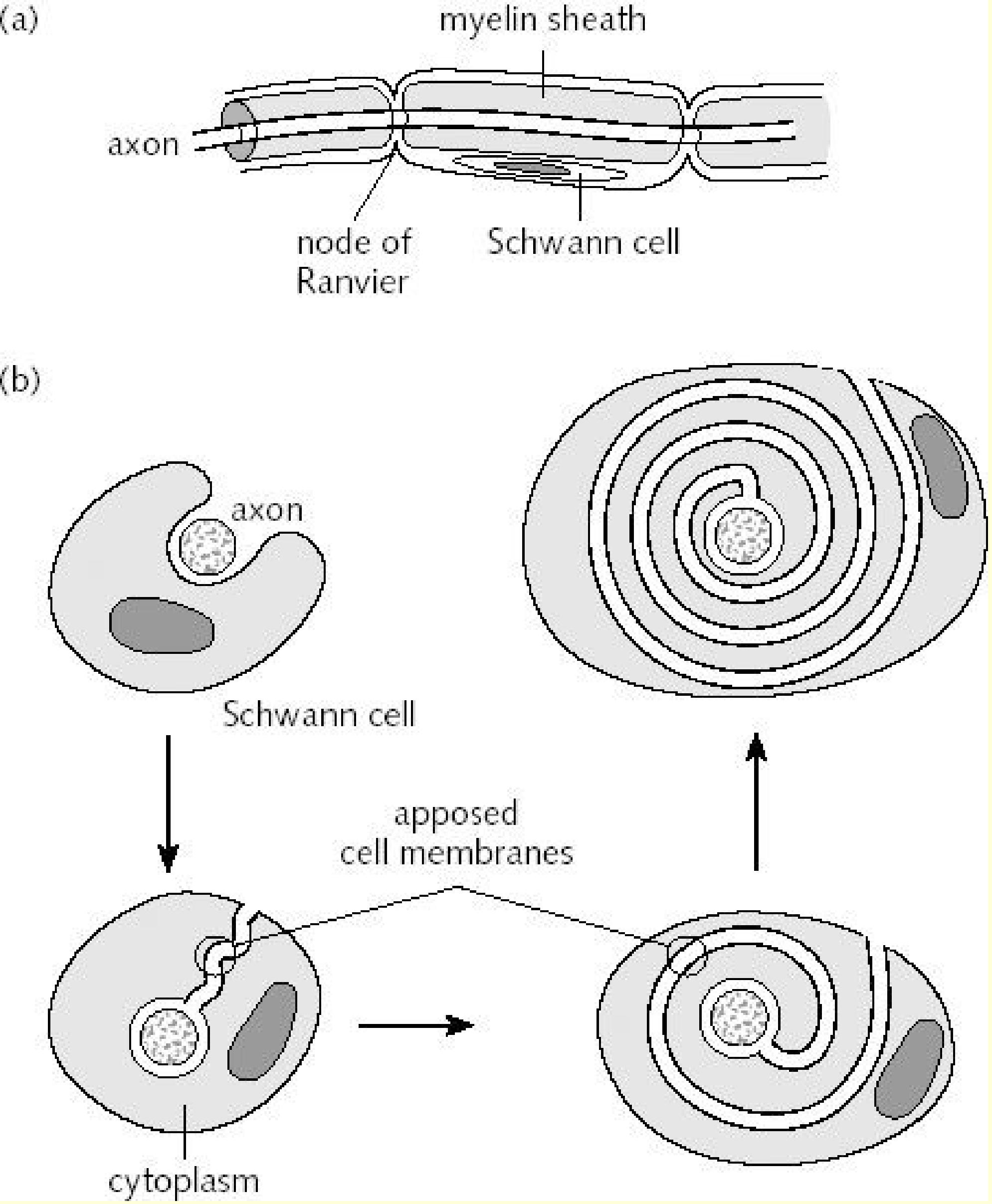


Fig. 1 (a) A myelinated axon in the peripheral nervous system and (b) its development. Each Schwann cell myelinates a single axon, to which it is directly apposed. During development (anticlockwise) Schwann cells loosely ensheath axons and the myelin sheath grows around the axon to form concentric layers,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

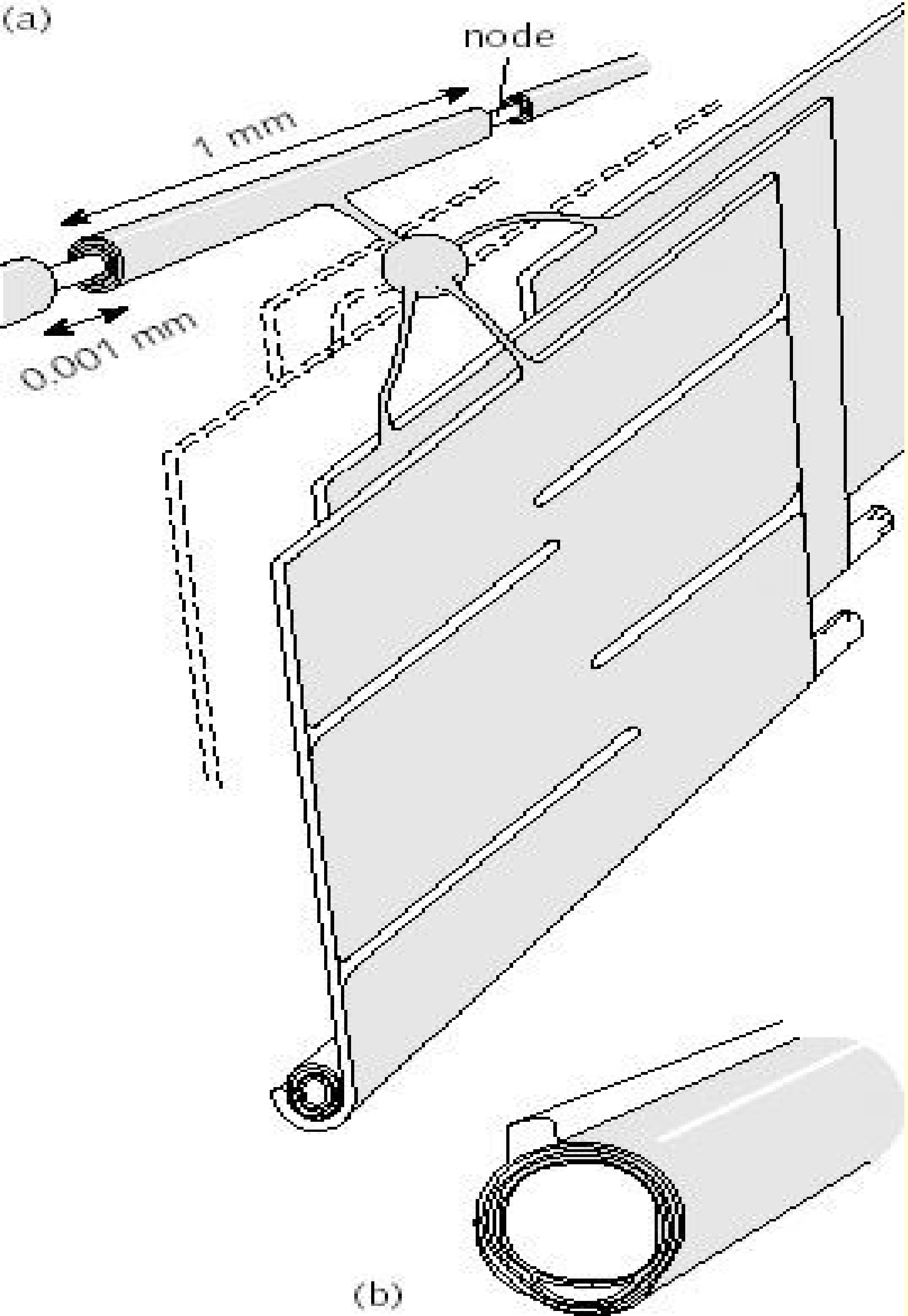
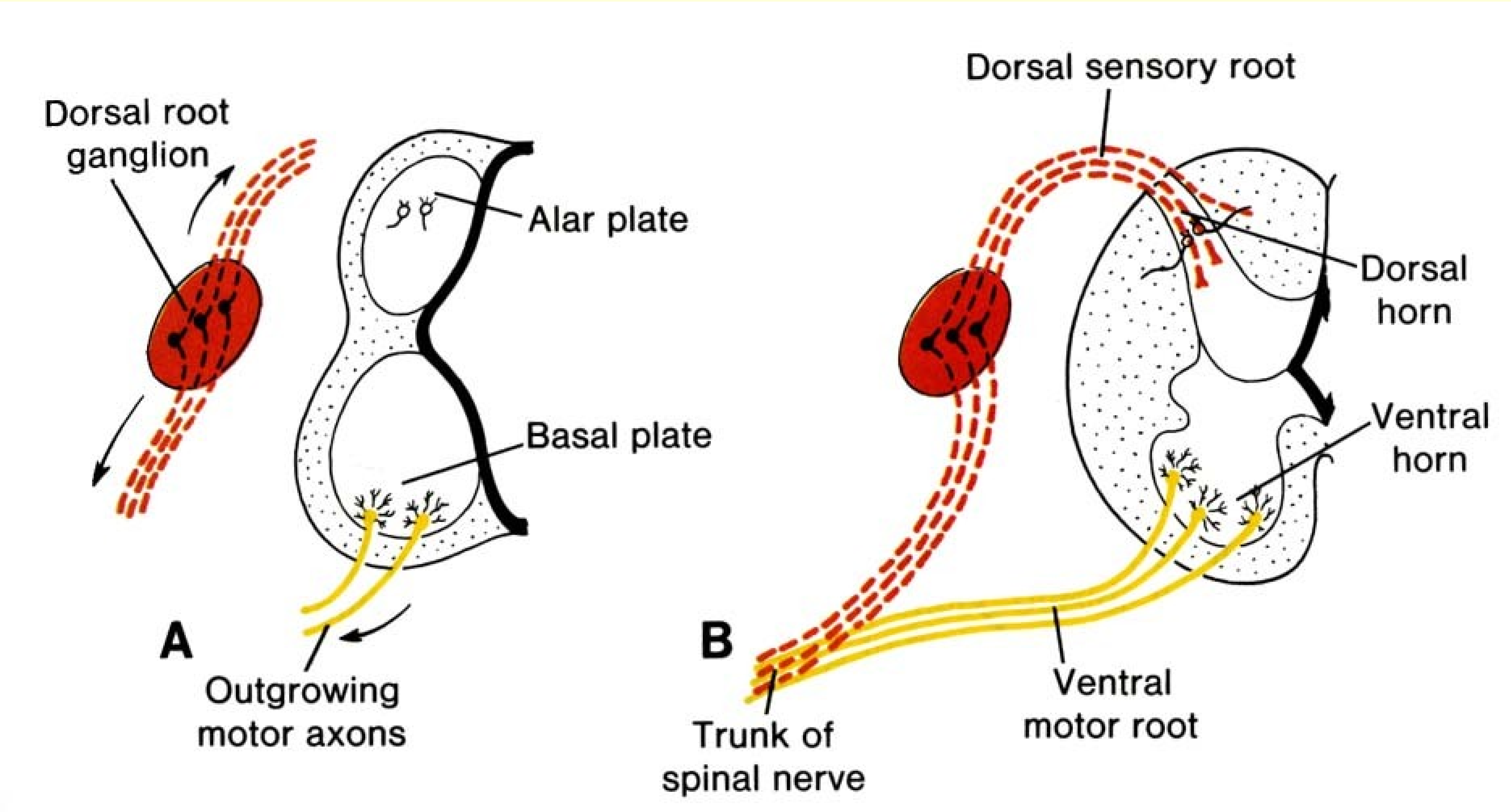
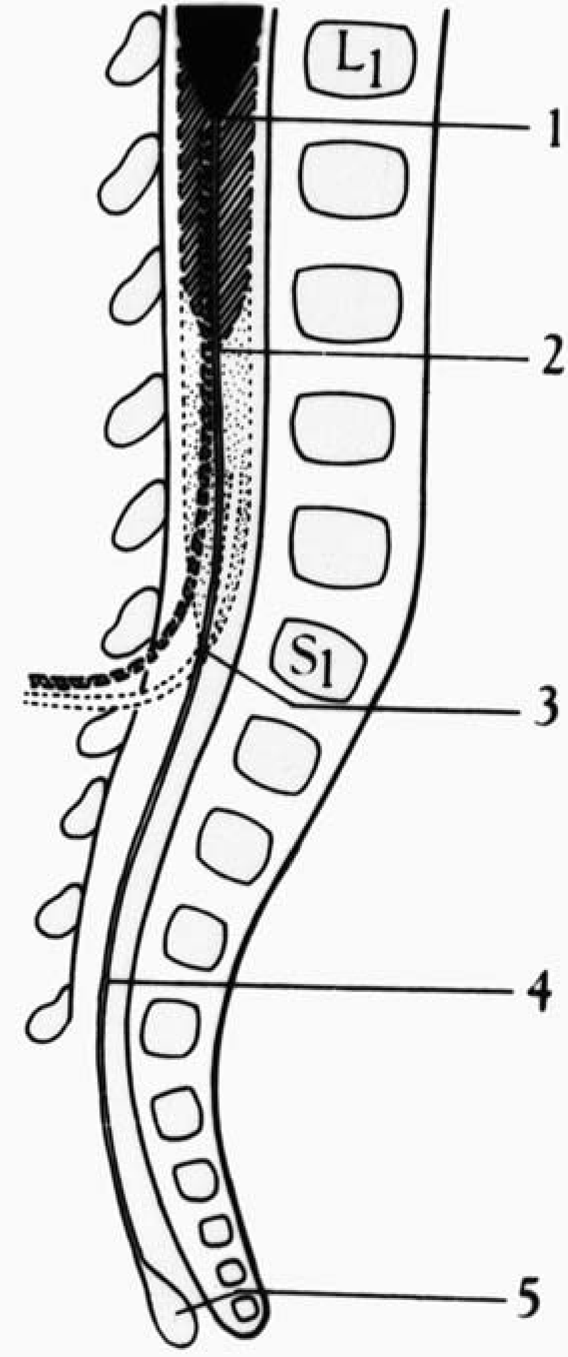
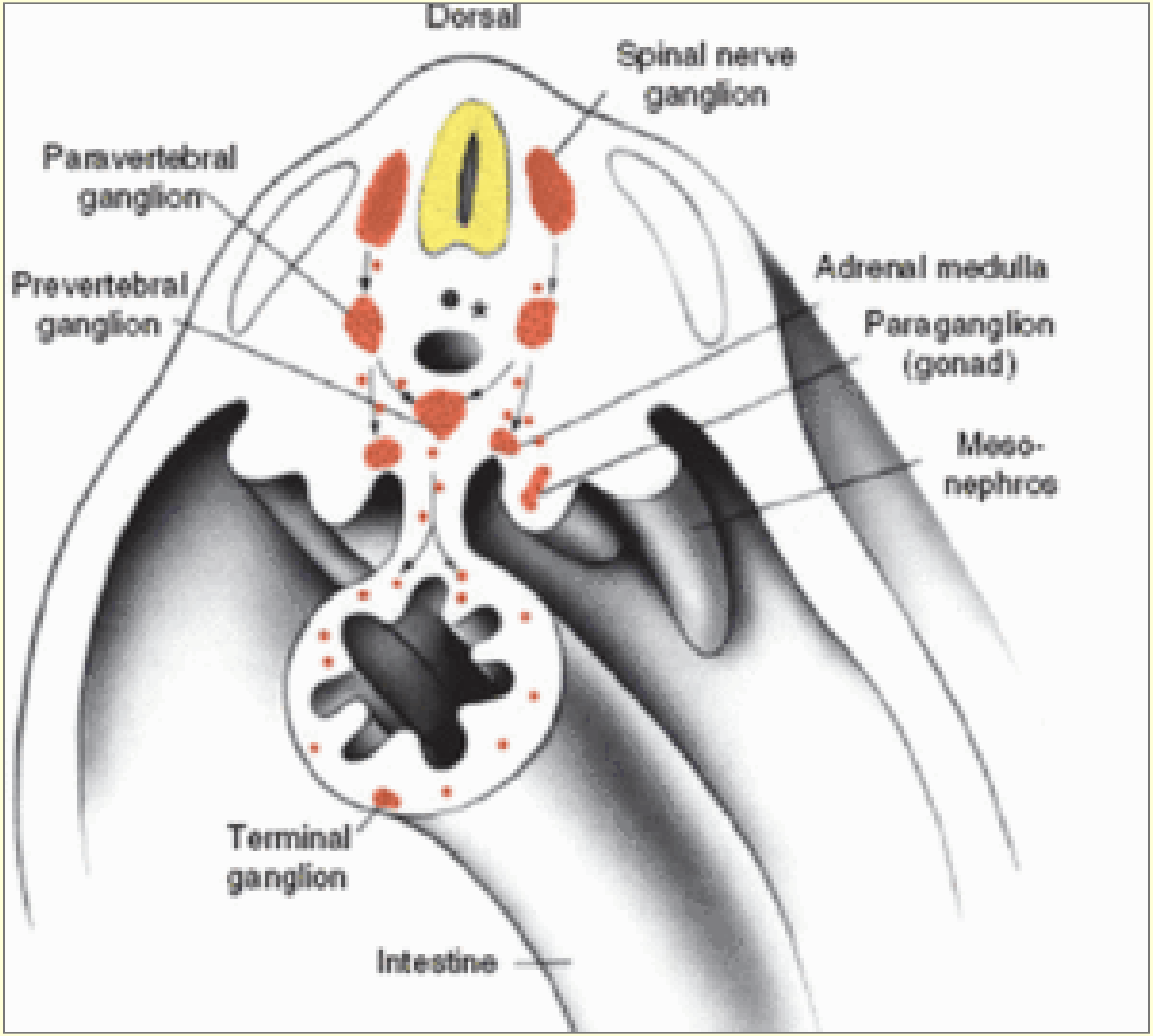


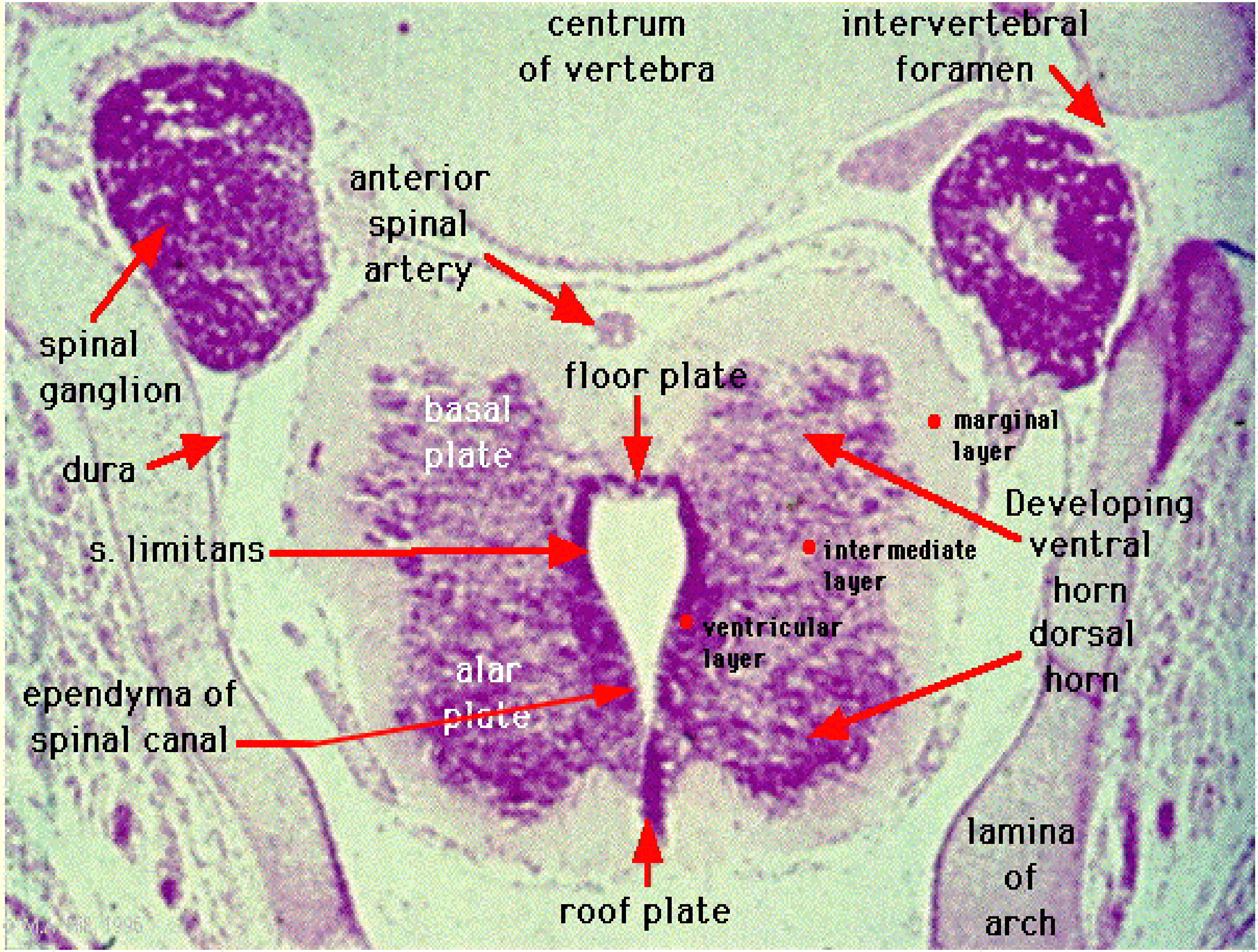
Fig. 3 Myelination in the central nervous system. A single oligodendrocyte myelinates numerous axons (a) and, in section, concentric layers of myelin are seen to spiral around the axon (b). Myelin sheaths are arranged along axons in segments 1 mm long separated by short nodes, and would appear as large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



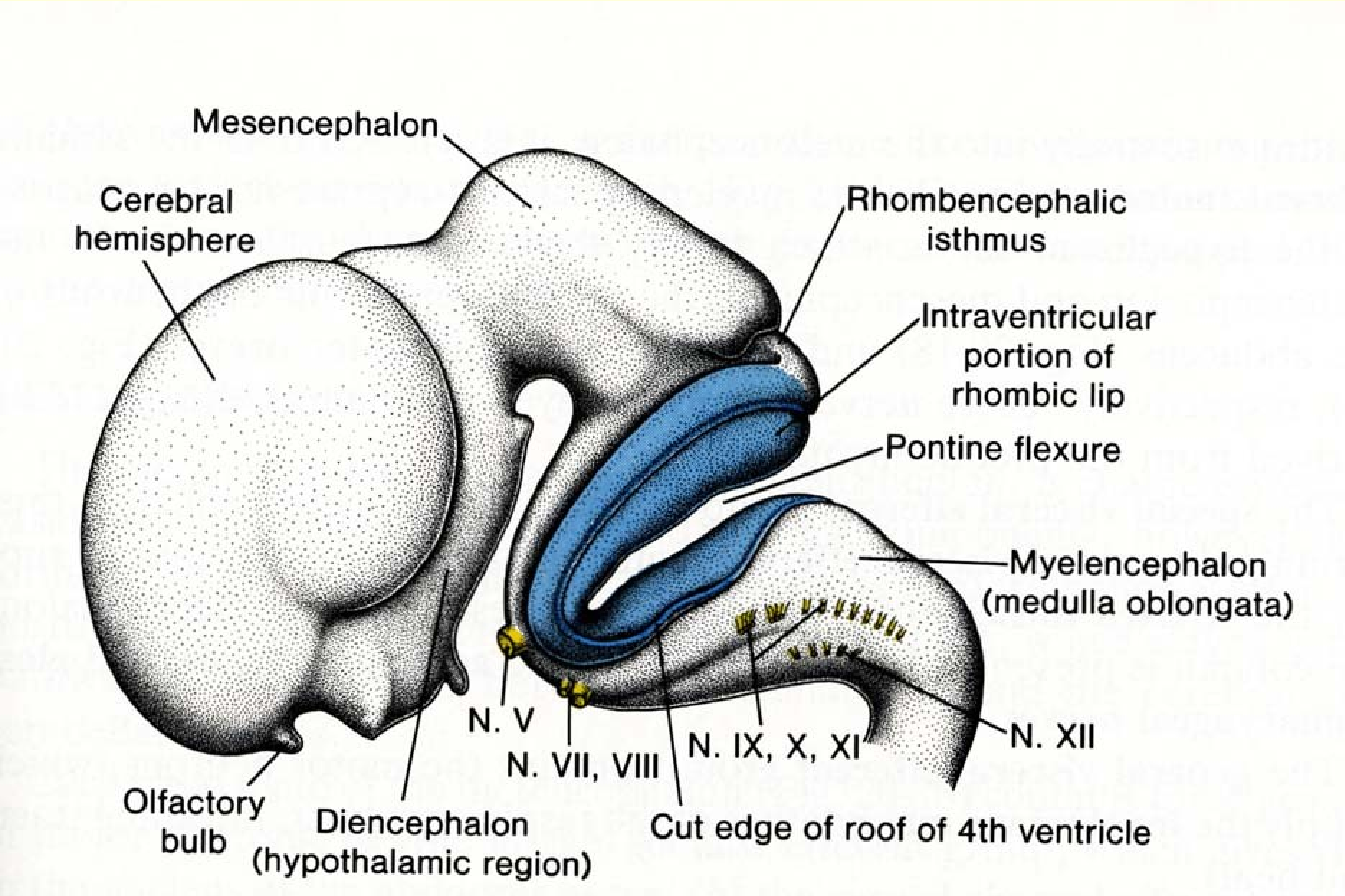
Dorsal root ganglion
Alar plate
Basal plate
A
Outgrowing motor axons
Dorsal sensory root
Dorsal horn
Ventral horn
B
Ventral motor root
Trunk of spinal nerve


L1
1
2
S1
3
4
5


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



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