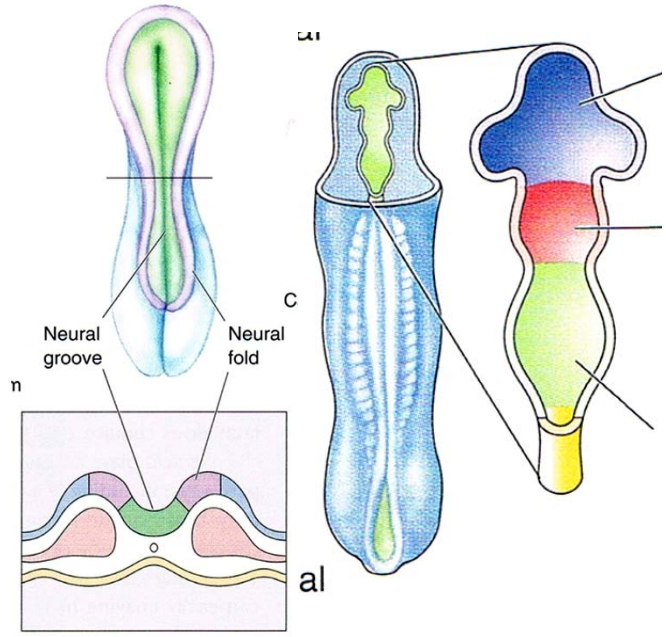
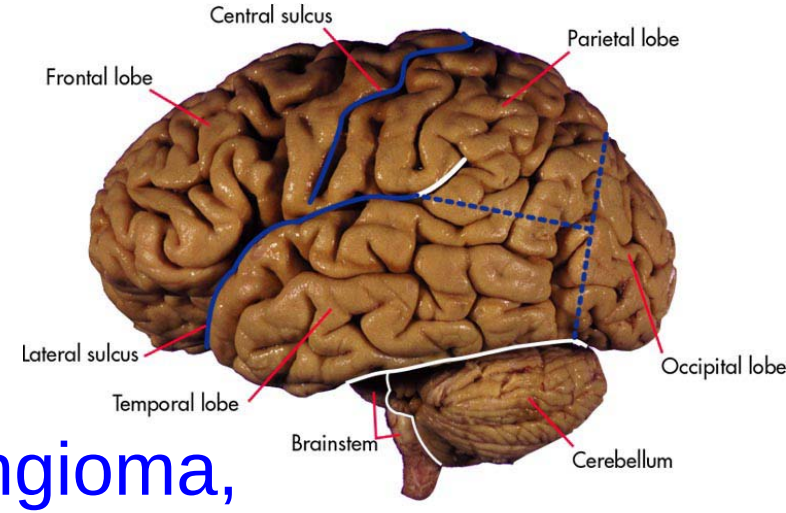
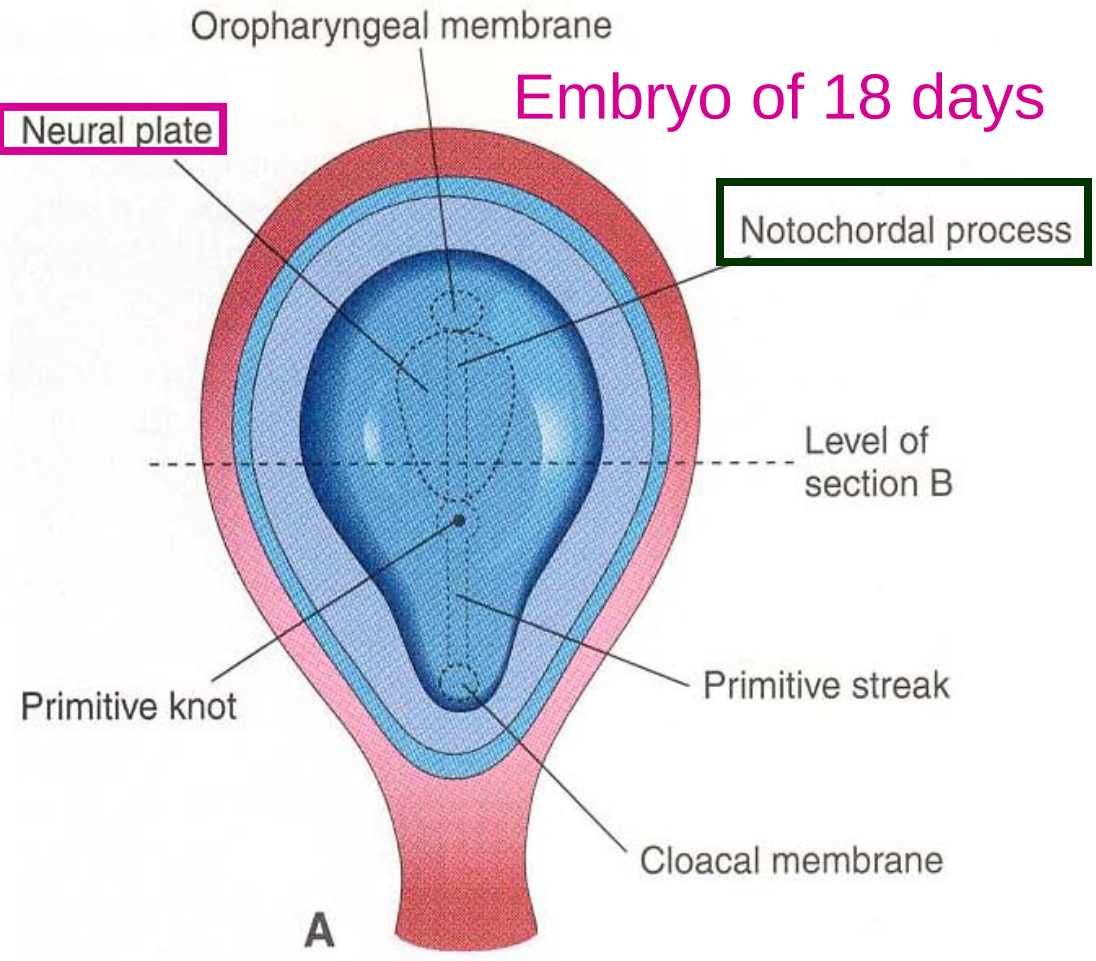
Development of the Nervous System

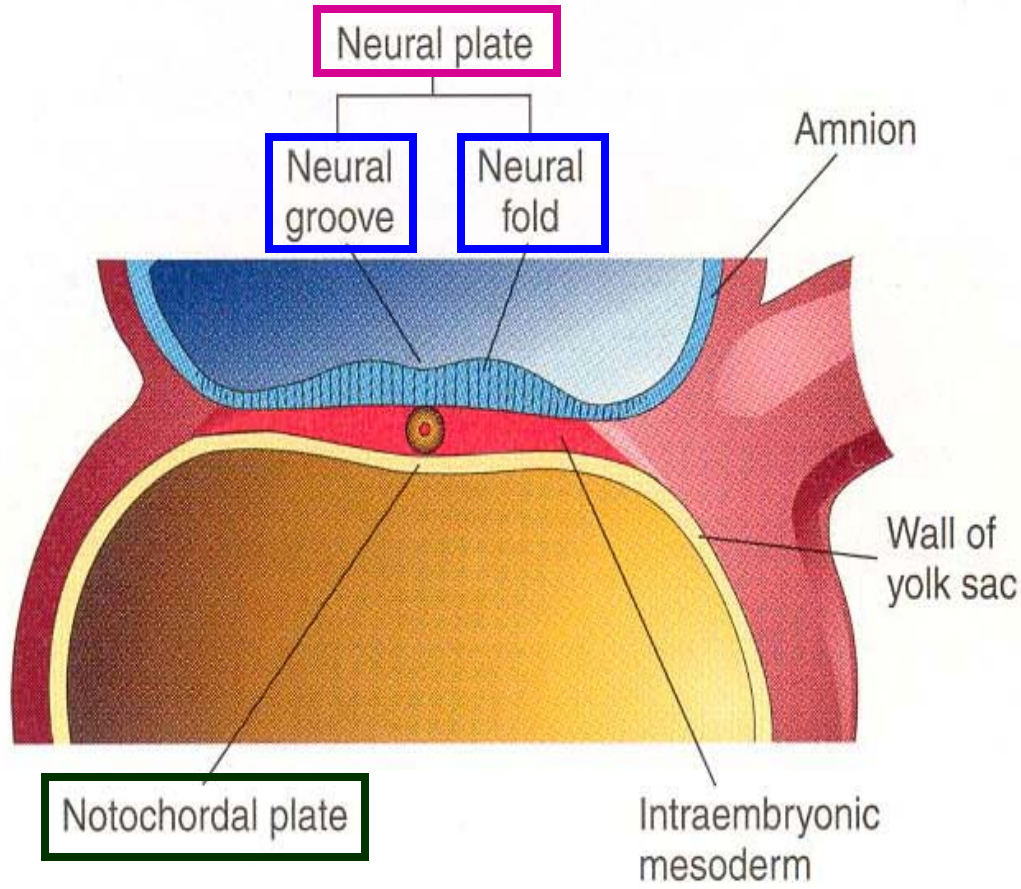
- Neural tube derivatives
  - Spinal cord (alar vs. basal plate)
  - Brain vesicles
    - Brainstem nuclei
    - Cerebral cortex
- Neural crest derivatives
- Puituitary gland development
- Developmental pathology
  - Neural tube defects, craniopharyngioma, agenesis of corpus callosum



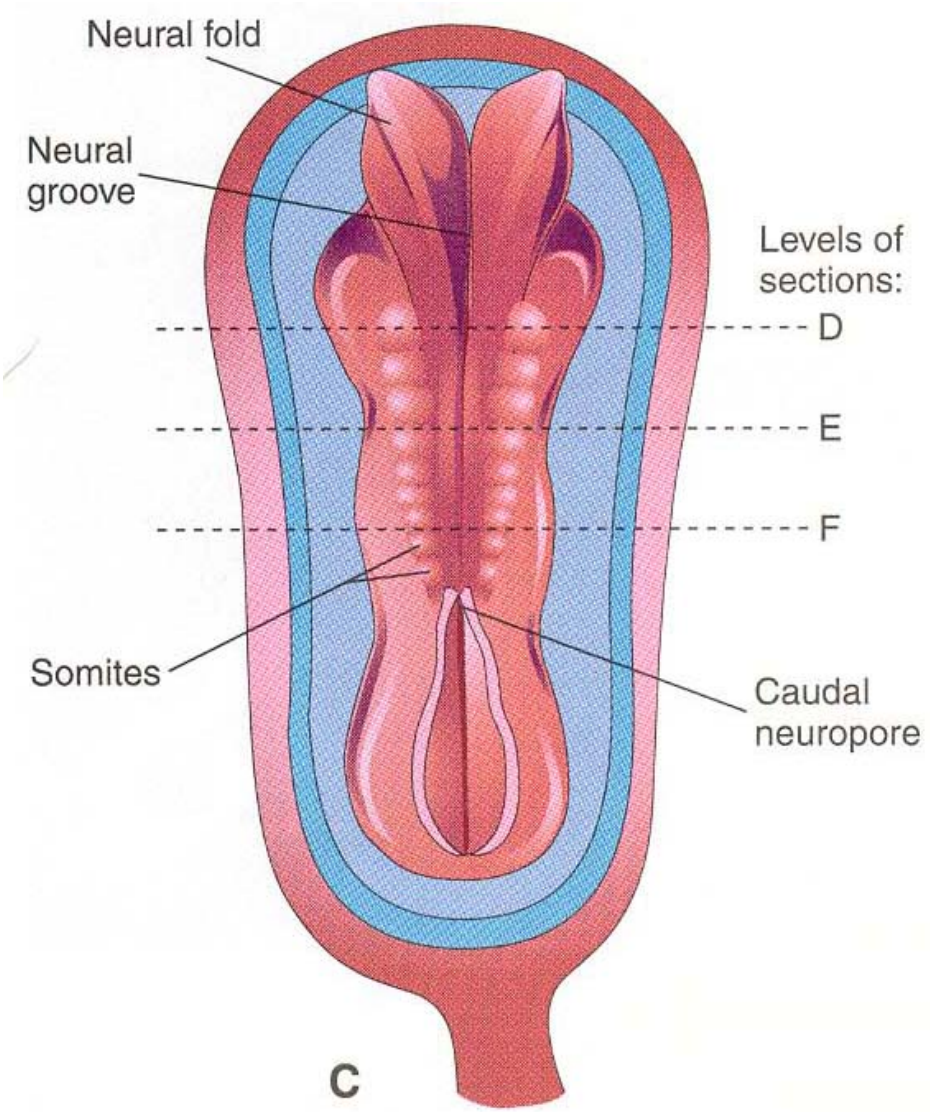


Development of Nervous System



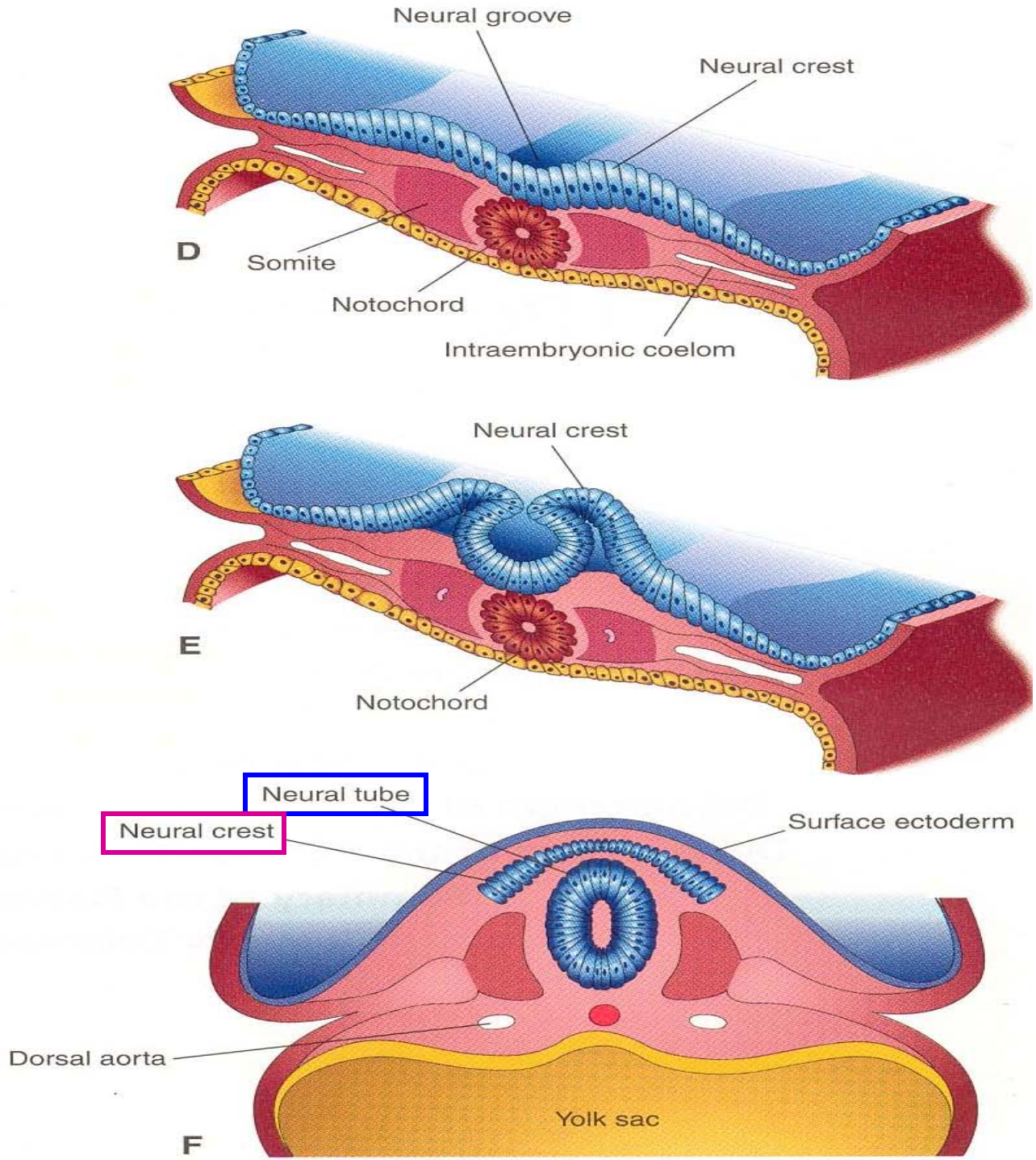


Neural fold development



Embryo of 22 days

- Extension of neural folds
- At Embryo of 22 days
  - Fusion at 4-6 somites
  - Open at both ends:
    - rostral neuropore
    - caudal neuropore



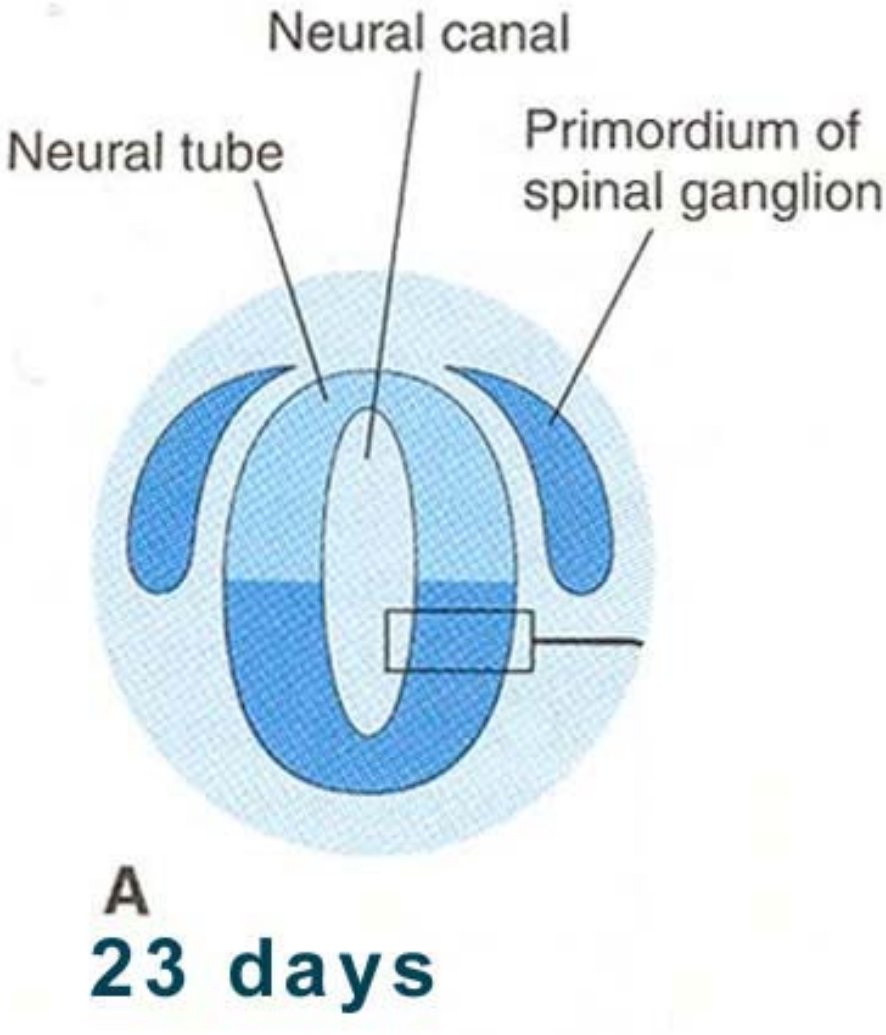
Embryo of 22 days

- Neural groove
- Neural fold
- Neural tube
  - Detachment from surface ectoderm
- Neural crest
  - Neuroectodermal cells between surface ectoderm and neural tube

Neurulation: Formation of neural tube

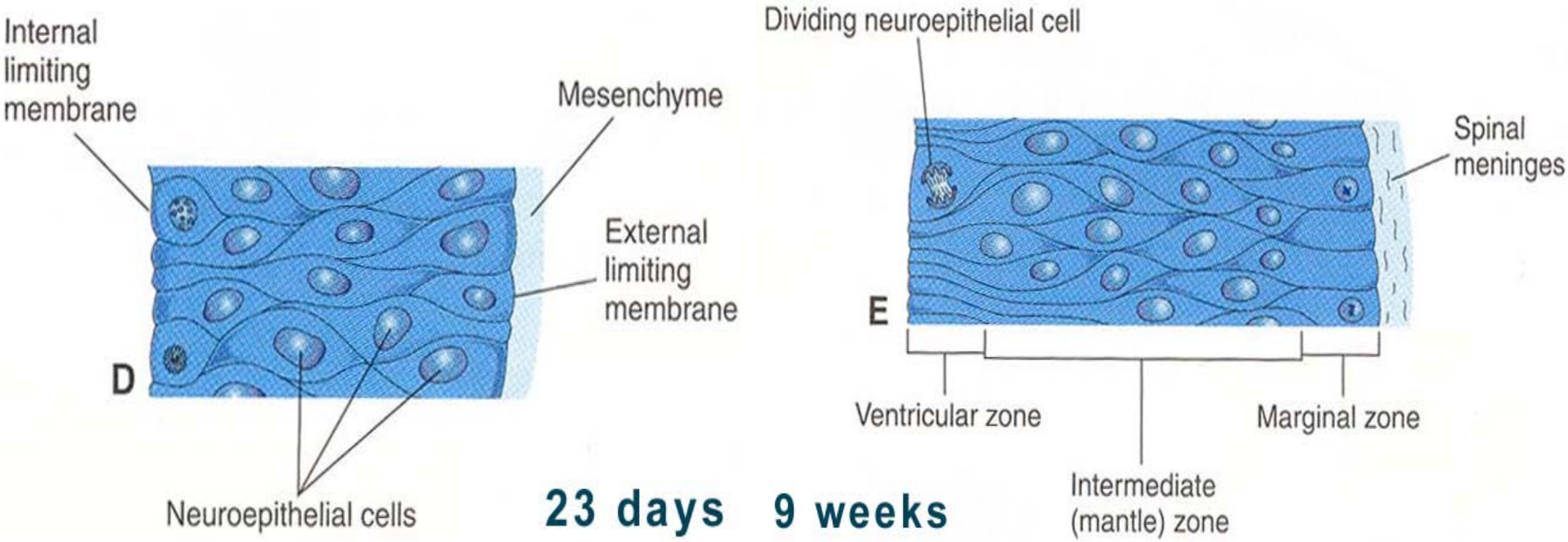
- at embryo of 22-23 days in 4-6 pairs of somites
  - Neural plate / tube: CNS
    - Cranial 2/3 (to 4th somite): brain
    - Caudal 1/3: spinal cord
  - Neural crest: PNS and ANS, muscle/bone of head/neck
- Fusion of neural folds: rostral to caudal direction
  - Neural canal = lumen of neural tube; communicate with amnionic cavity
  - Rostral (Anterior) neuropore: close at 25th day
  - Caudal (Posterior) neuropore: close at 27th day
  - Neural tube defect (NTD)

Development of spinal cord

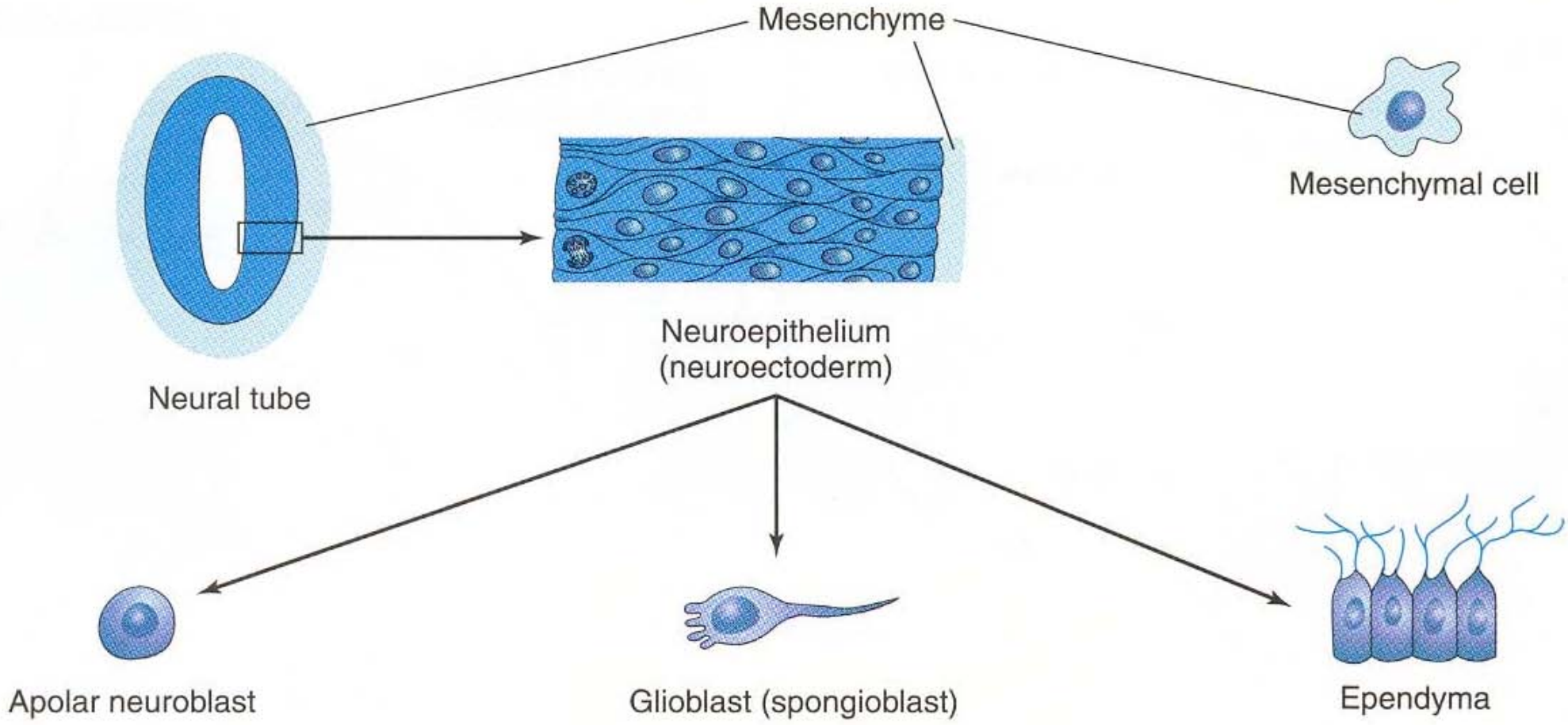


- Spinal cord: from neural tube caudal to 4th pair of somite
- Ventricular zone (ependymal layer): pseudostratified columnar neuroepithelium → neurons, glia
- Marginal zone → white matter of spinal cord
- Intermediate zone (mantle layer)

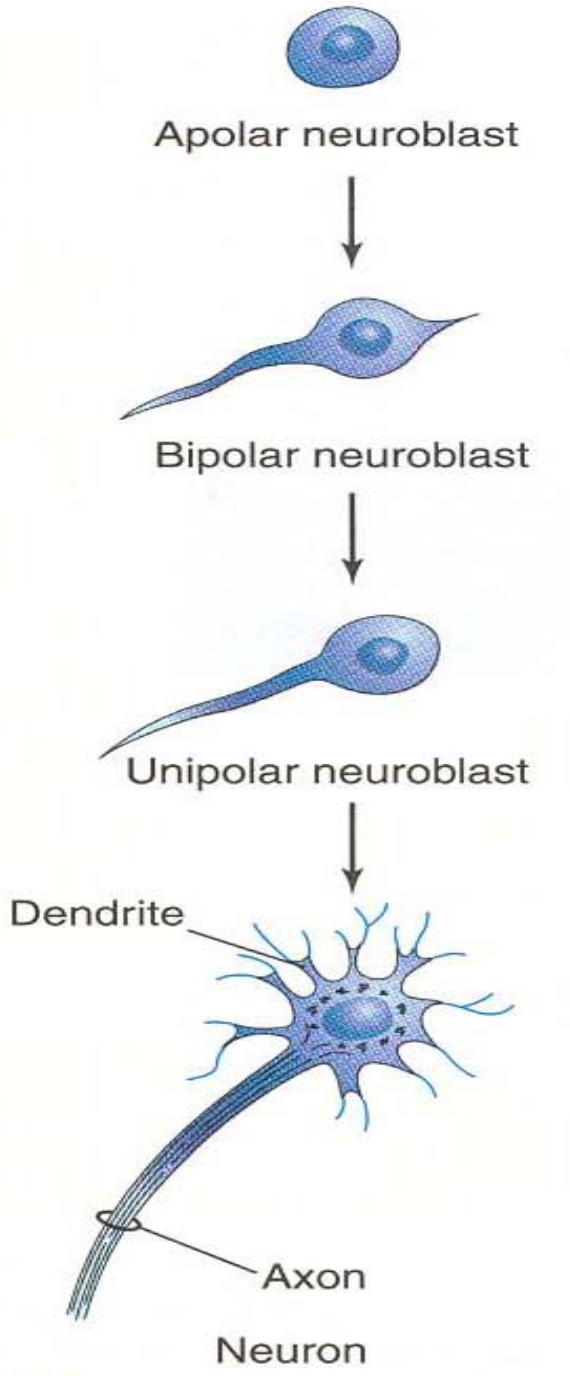
Development of spinal cord: 3 layers



Histogenesis of cells in CNS

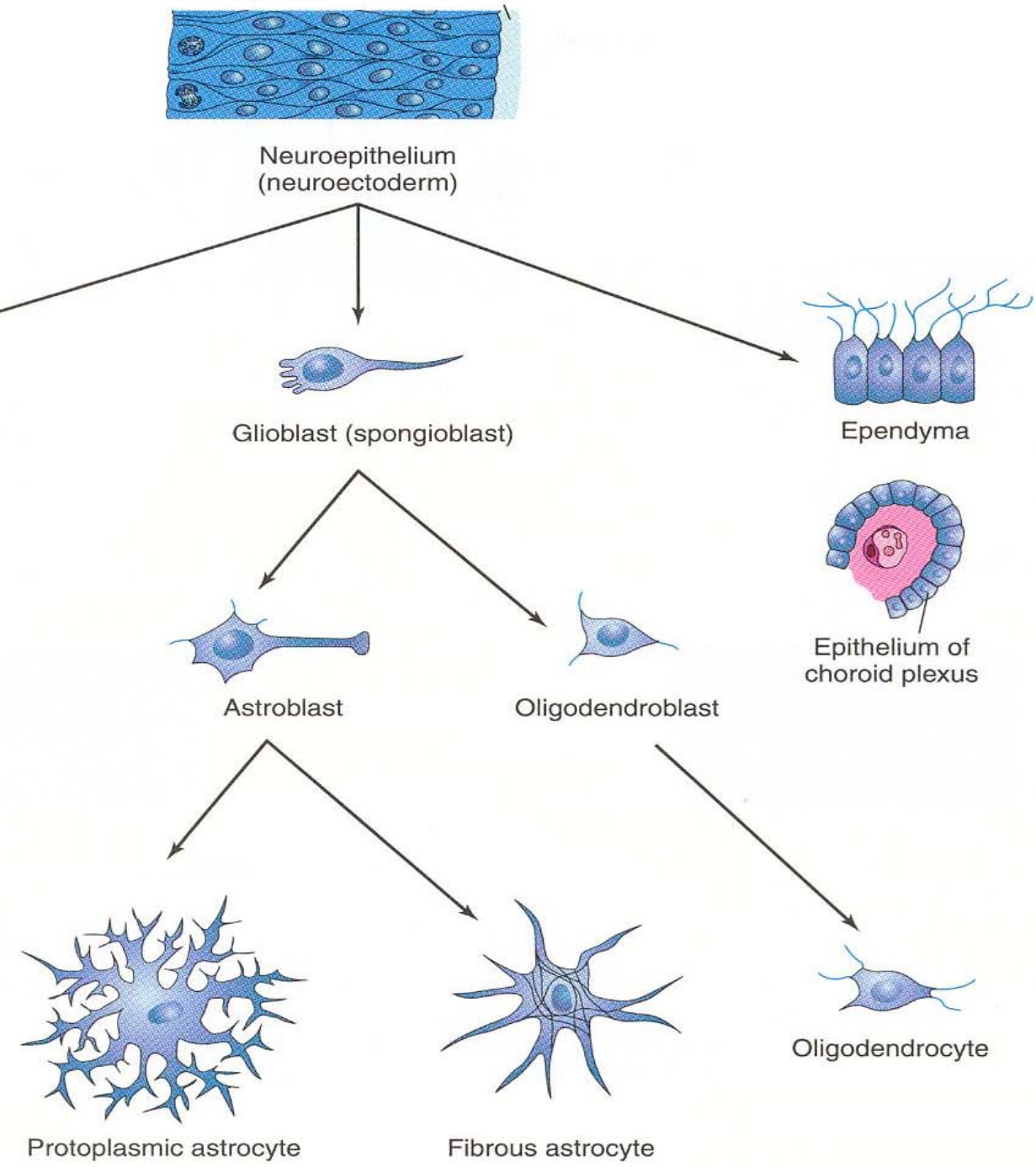


- Neuroepithelium: Neuroblast, Glioblast, Ependyma
- Mesenchyme: Mesenchymal cells



Neuroblast

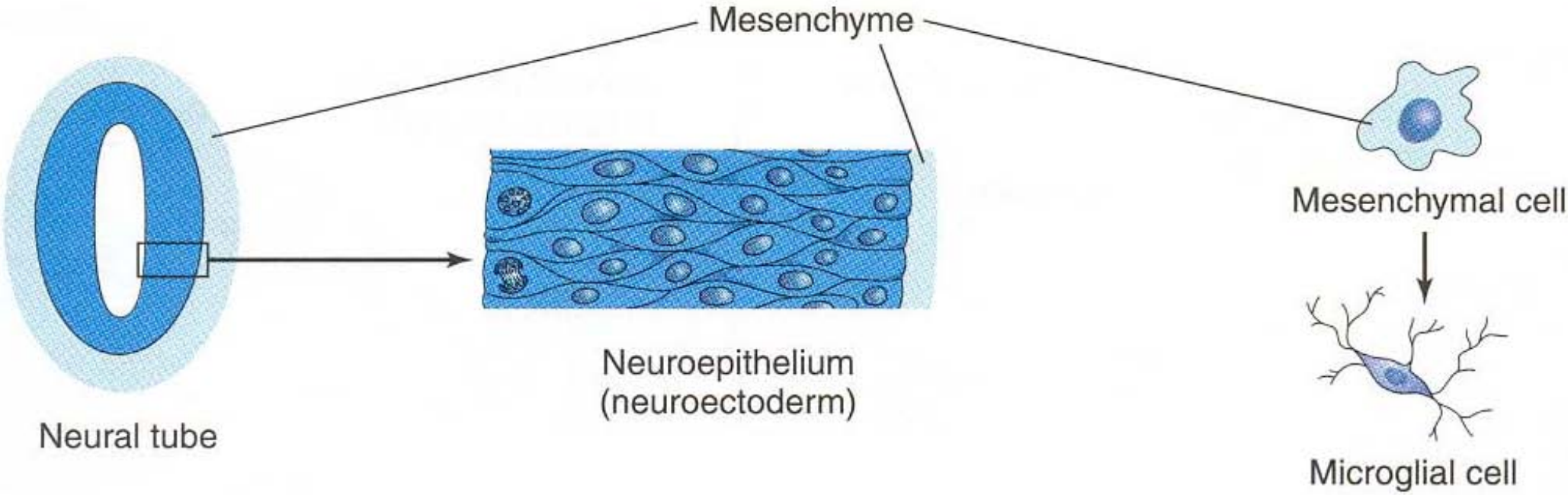
- Apolar neuroblast
- Bipolar neuroblast
- Unipolar neuroblast
- Neuron



Supporting cells

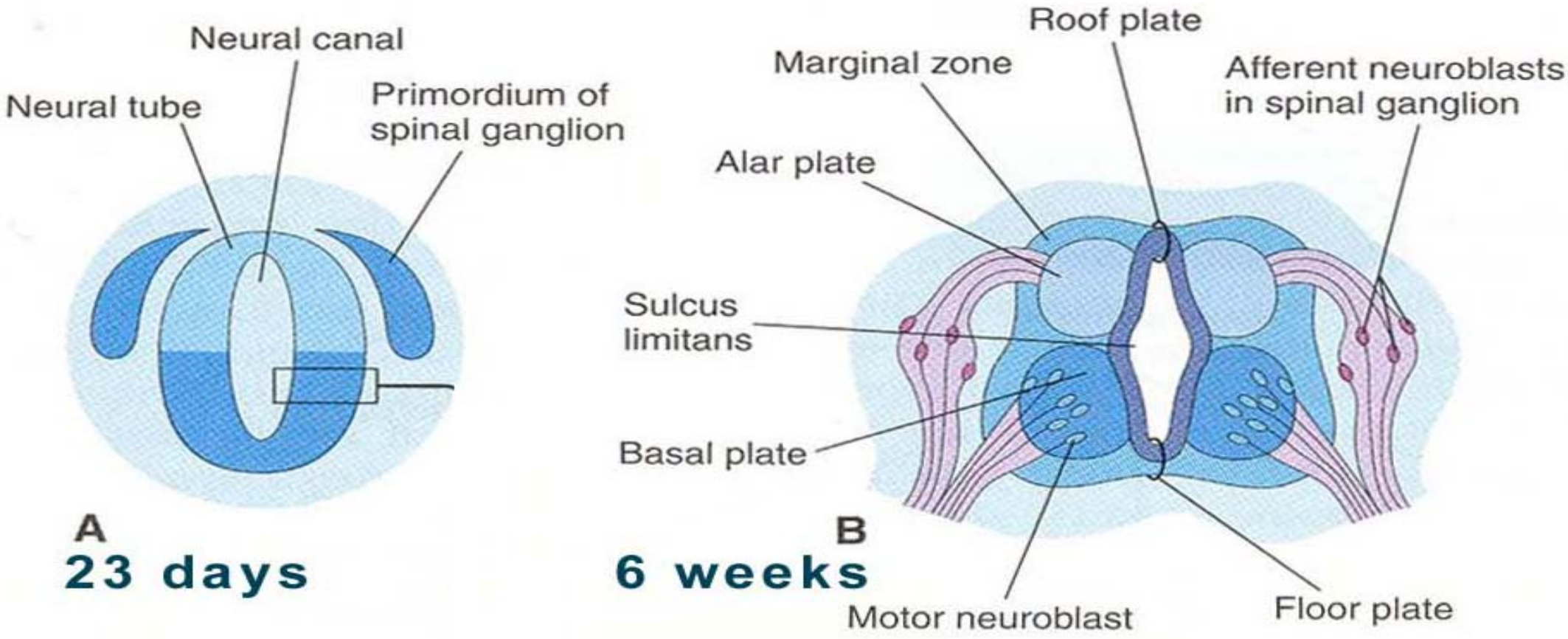
- Gliobast (spongioblast)
  - Astroblast
    - Protoplasmic astrocyte
    - Fibrous astrocyte
  - Oligodendrobalst
    - Oligodendrocyte
- Ependyma
  - Epithelium of choroid plexus

Microglia



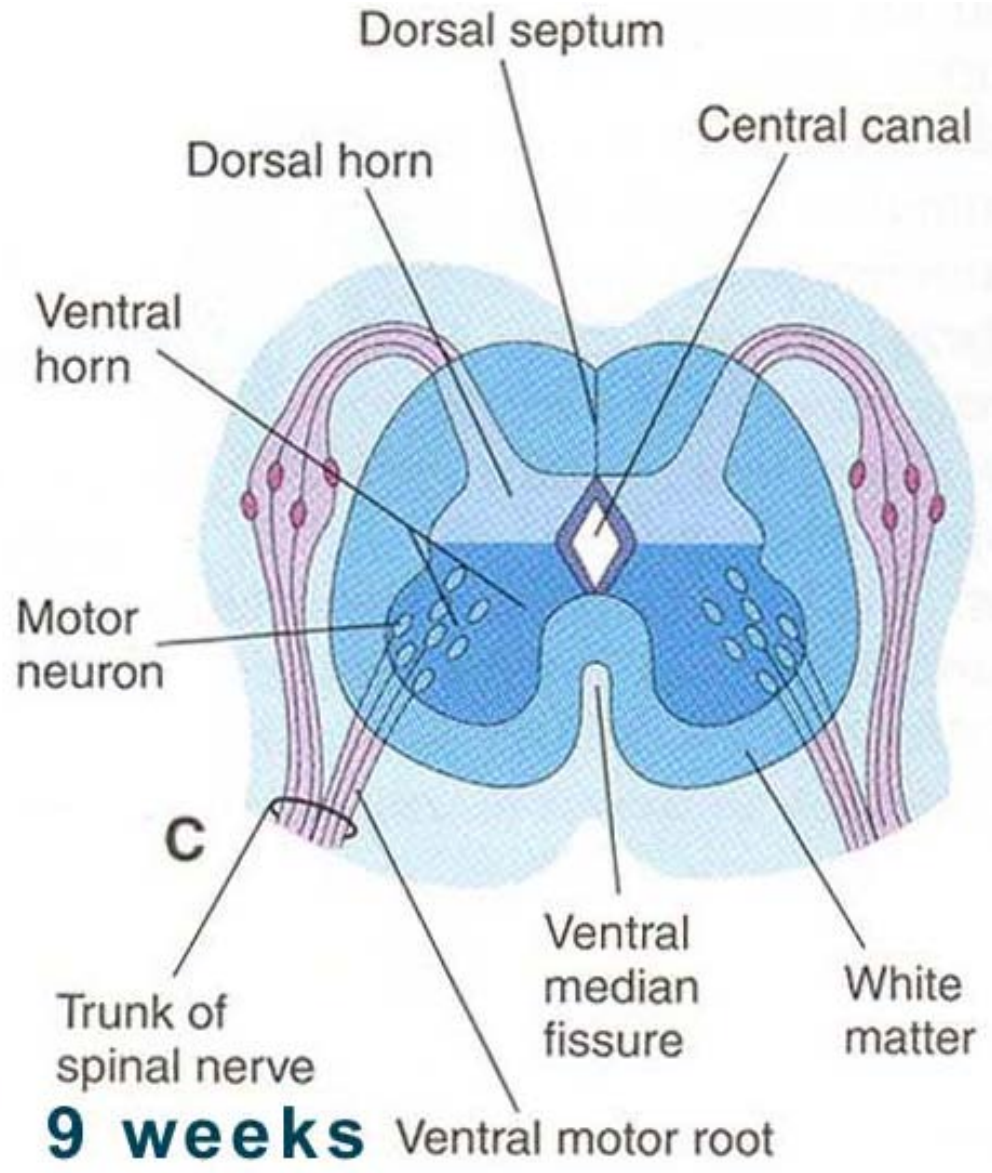
- Mesenchymal cells
  - Microglial cells
- Origin of microglia: monocyte-macrophage lineage, enter CNS with blood vessels in fetal period

Development of spinal cord



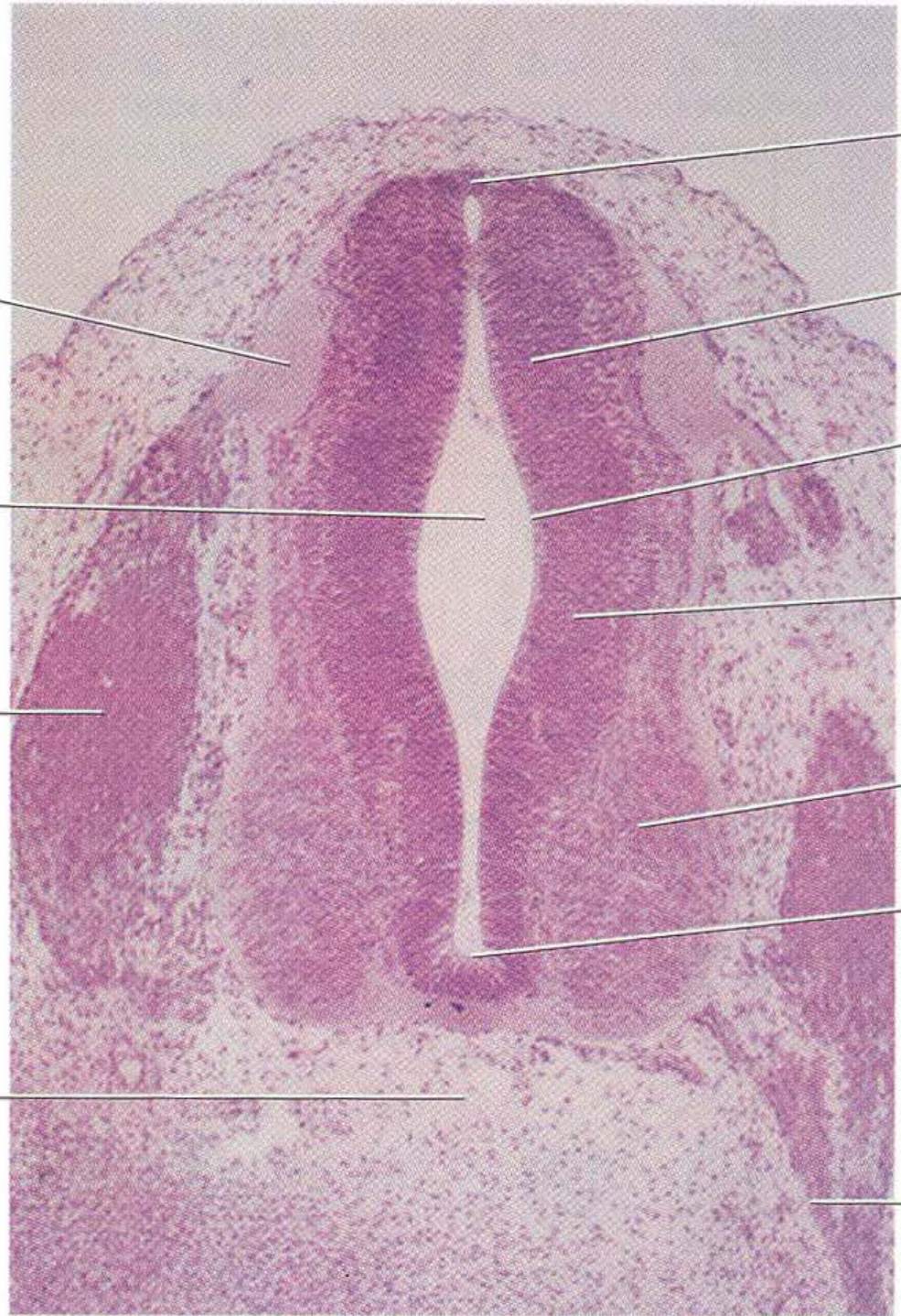
- Differential growth of lateral wall of spinal cord
  - Roof plate / Floor plate
  - Sulcus limitans: shallow, longitudinal groove
  - Dorsal alar plate (afferent); Ventral basal plate (efferent)

Differential growth of spinal cord

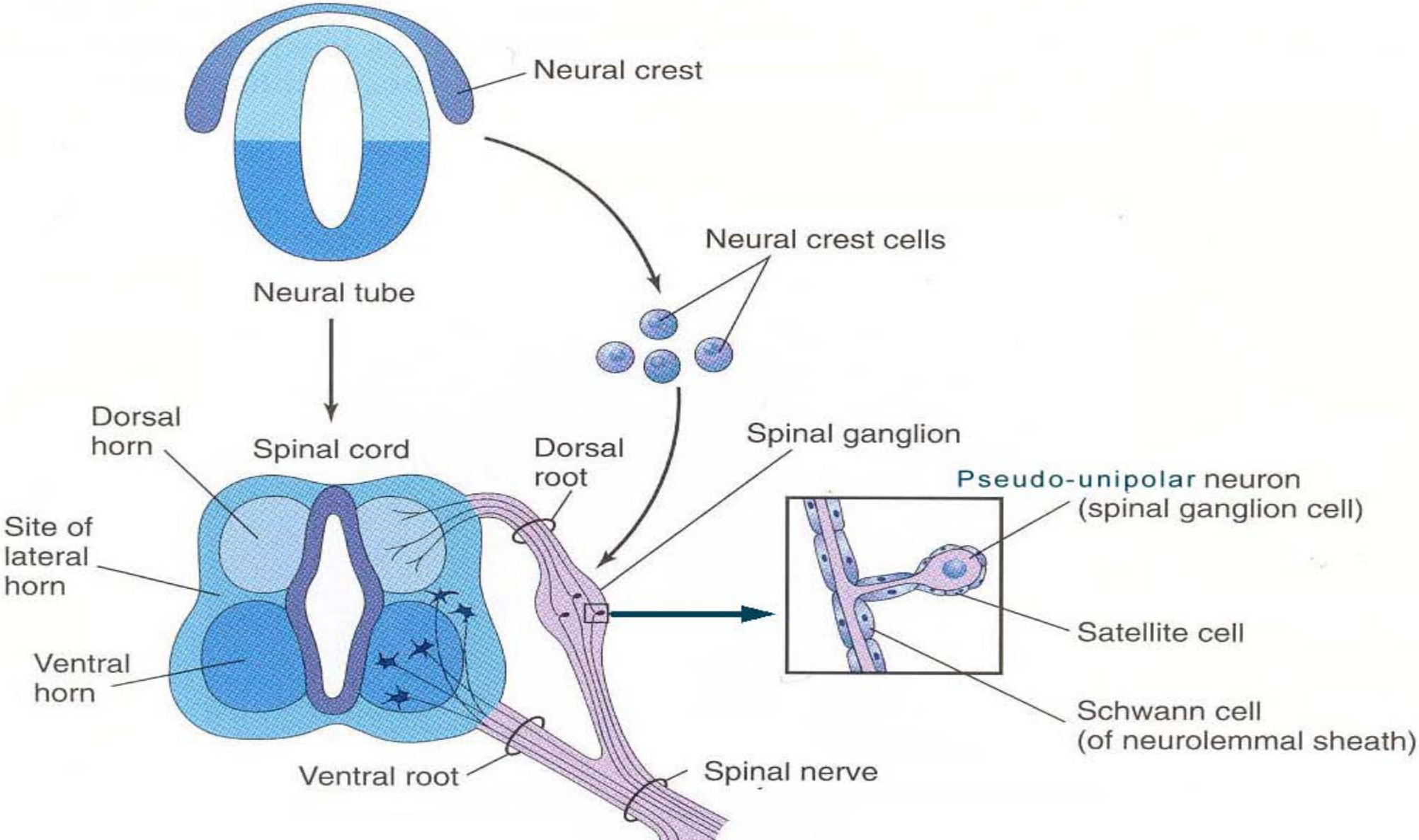


- Dorsal gray columns: cell bodies in alar plate
  - Dorsal (gray) horns
  - Dorsal roots
  - Dorsal septum or raphe
- Ventral / Lateral gray columns: from cell bodies in basal plate
  - Ventral (gray) horns / Lateral (gray) horns
  - Ventral roots
  - Ventral median septum → ventral median fissure

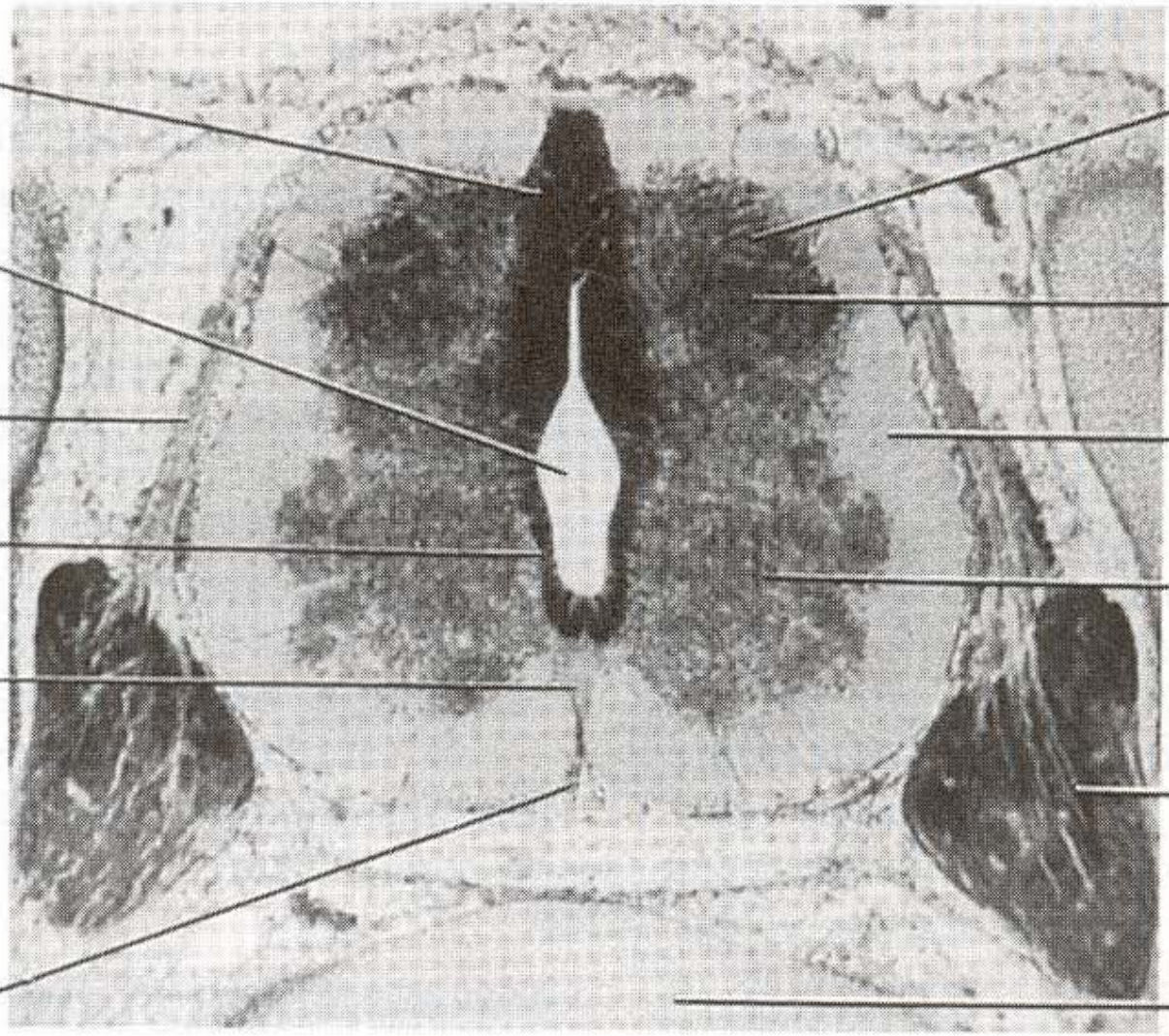
40 days


Roof plate
Dorsal root of spinal nerve
Alar plate
Sulcus limitans
Central canal
Neuroepithelium
Spinal (dorsal root) ganglion
Basal plate
Floor plate
Developing body of vertebra
Ventral root of spinal nerve

Neural crest development: spinal ganglia / dorsal root ganglia (DRG)

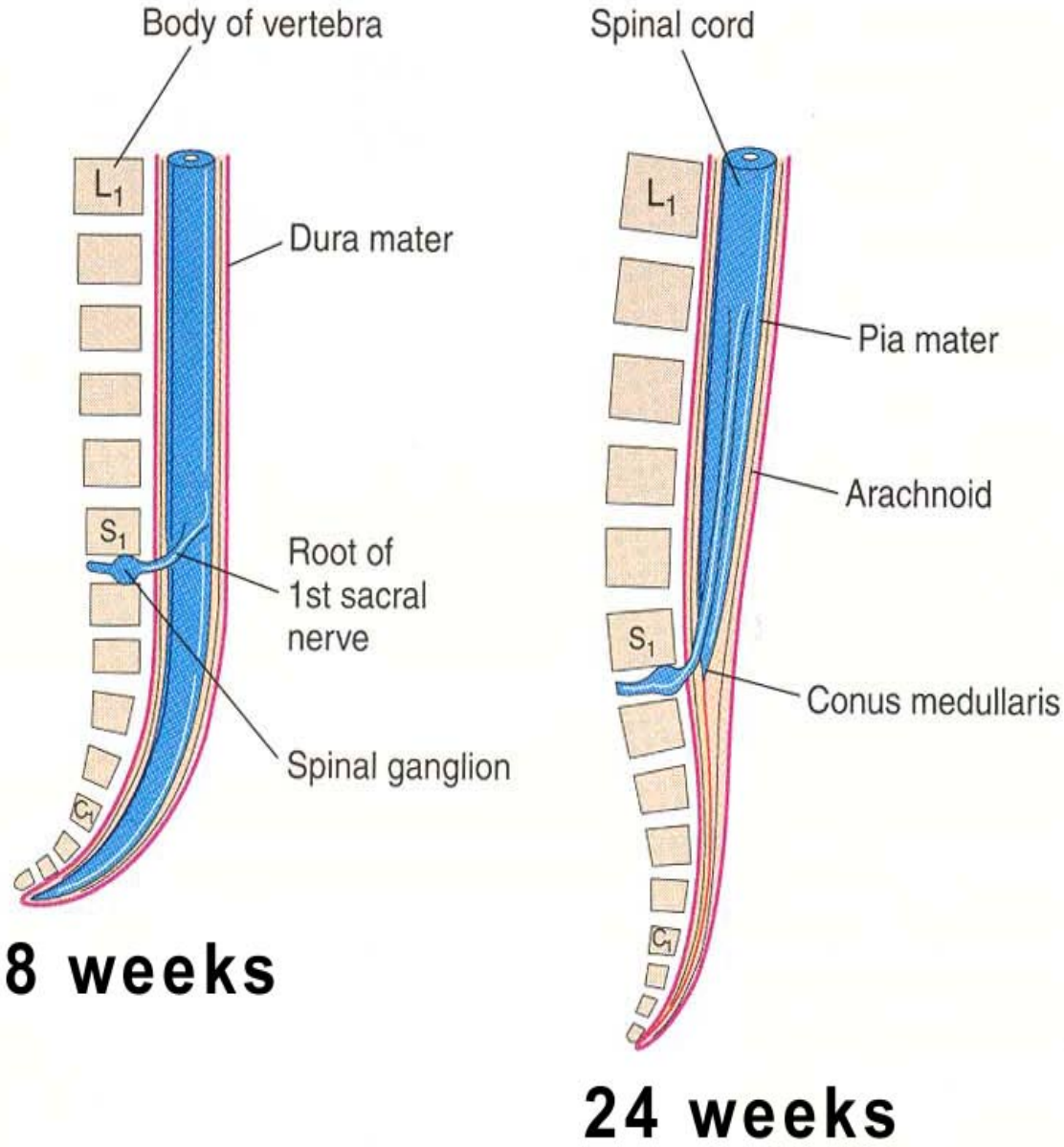


50 days

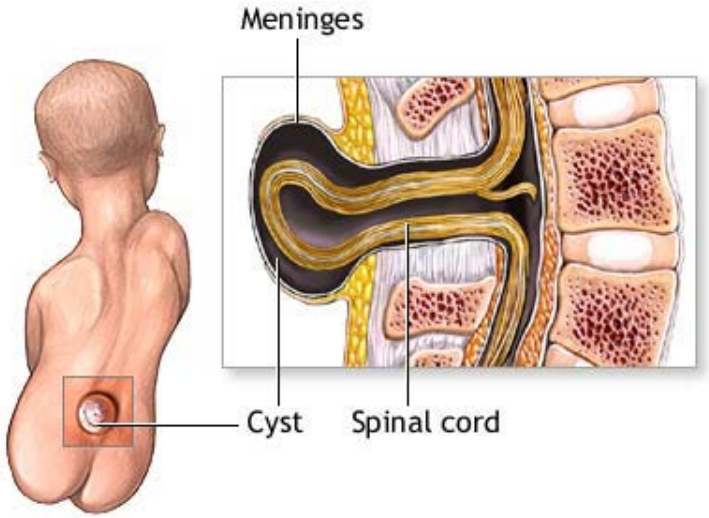


Embryo: NS 16

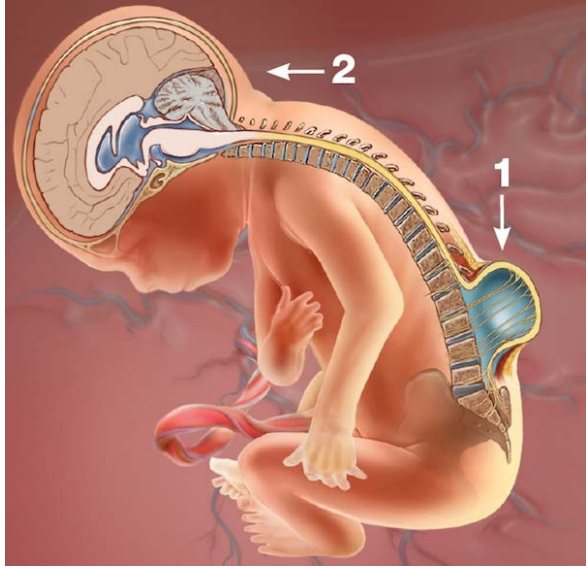
Development of spinal meninges



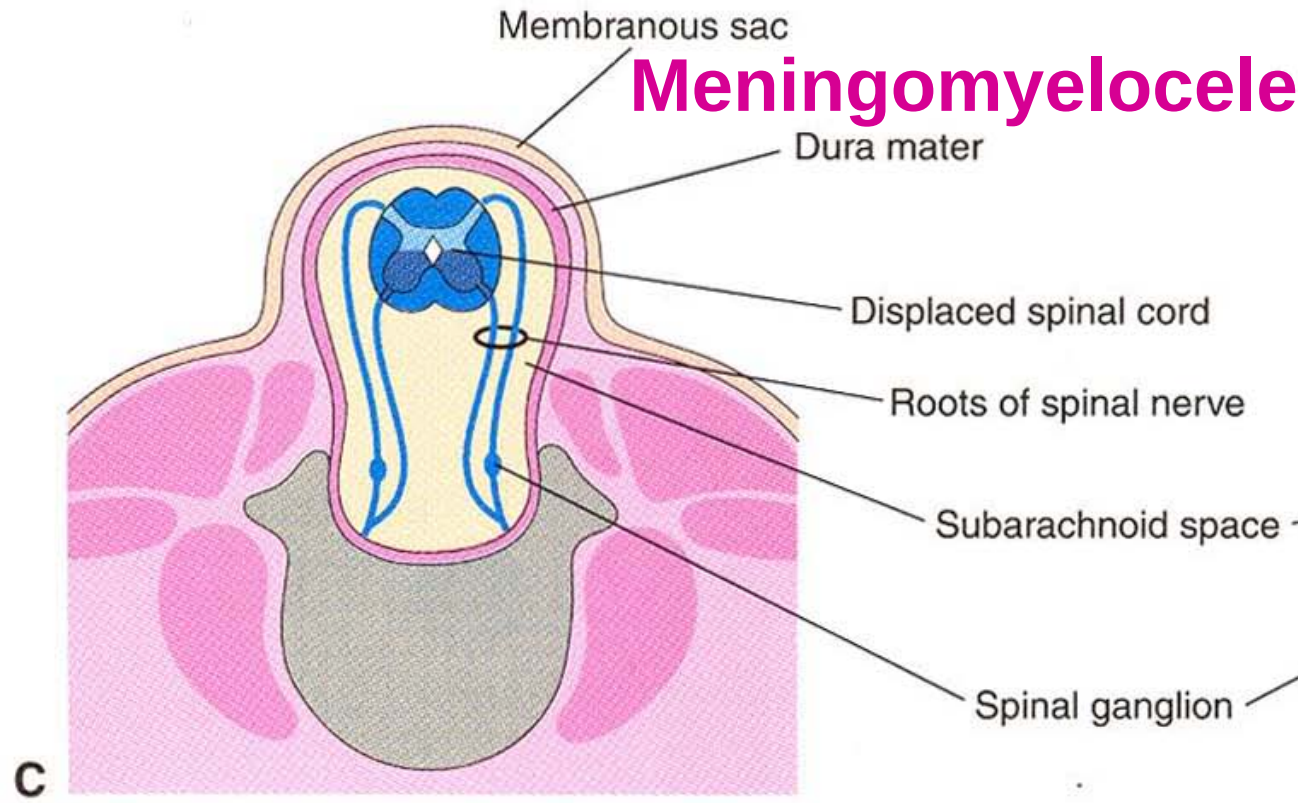
- Primordial meninx (membrane): from mesenchhyme surrounding neural tube
- External layer: dural mater
- Internal layer: pia-arachnoid (leptomeninges)
  - pia mater, arachnoid mater
  - participated by neural crest cells
  - Arachnoid trabeculae
  - Subarachnoid space with cerebrospinal fluid at 5th week



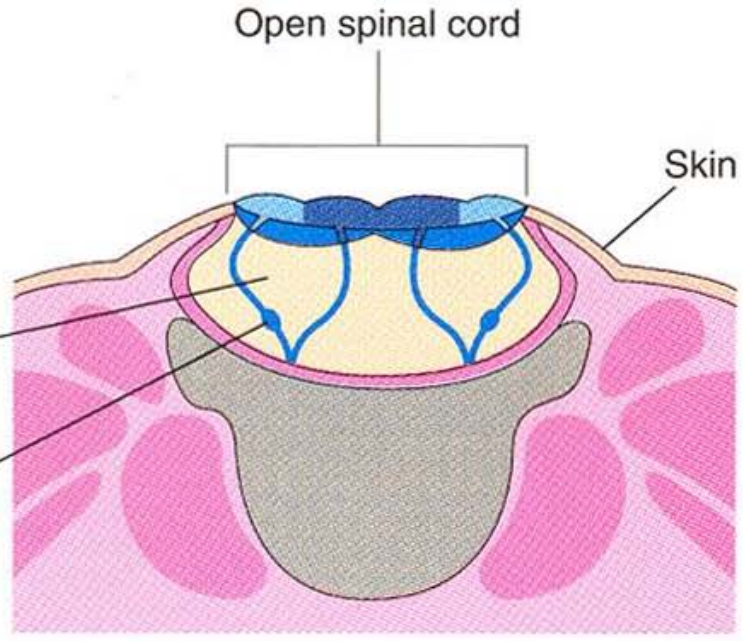
Spina bifida

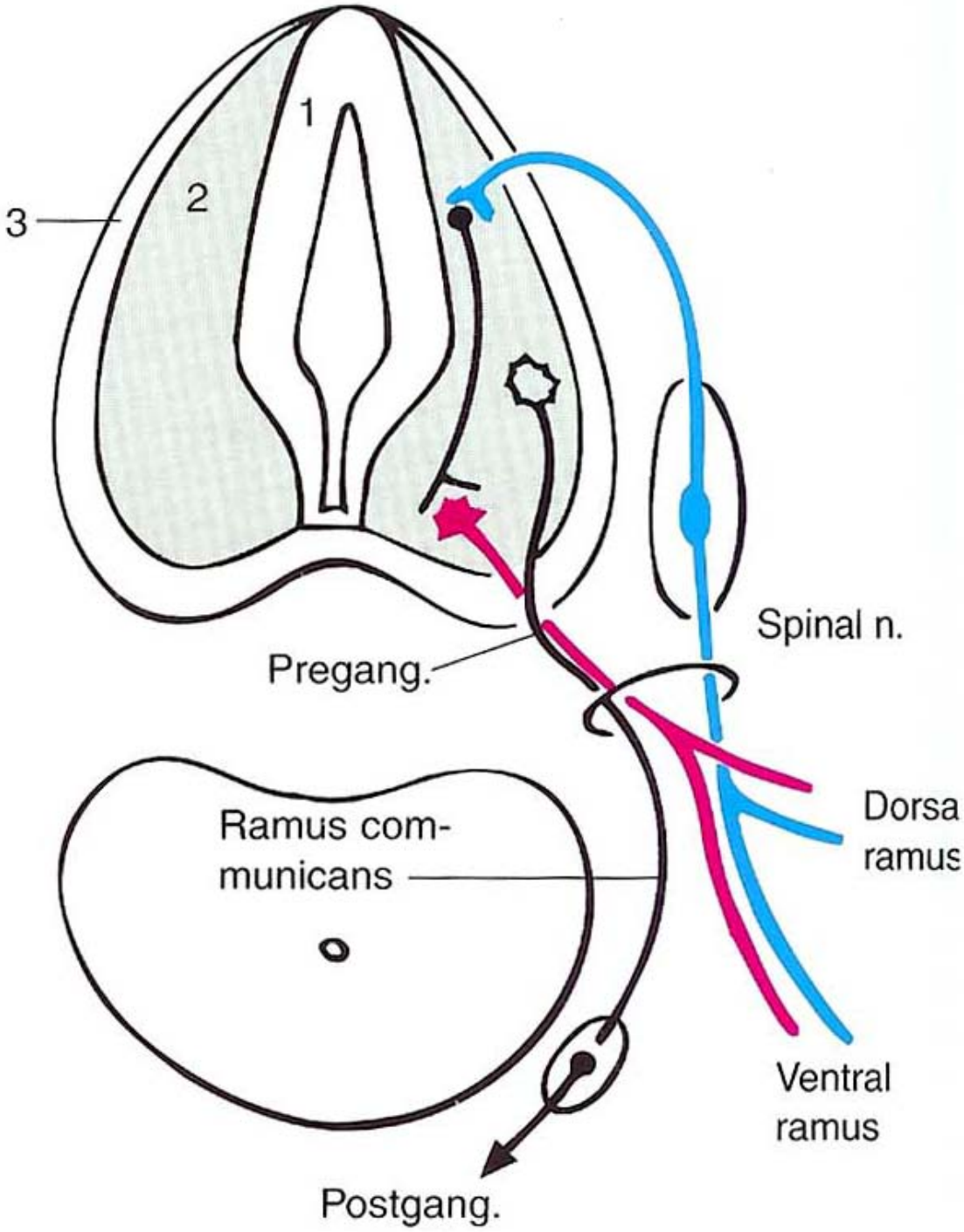


Meningomyelocele



Myeloschisis





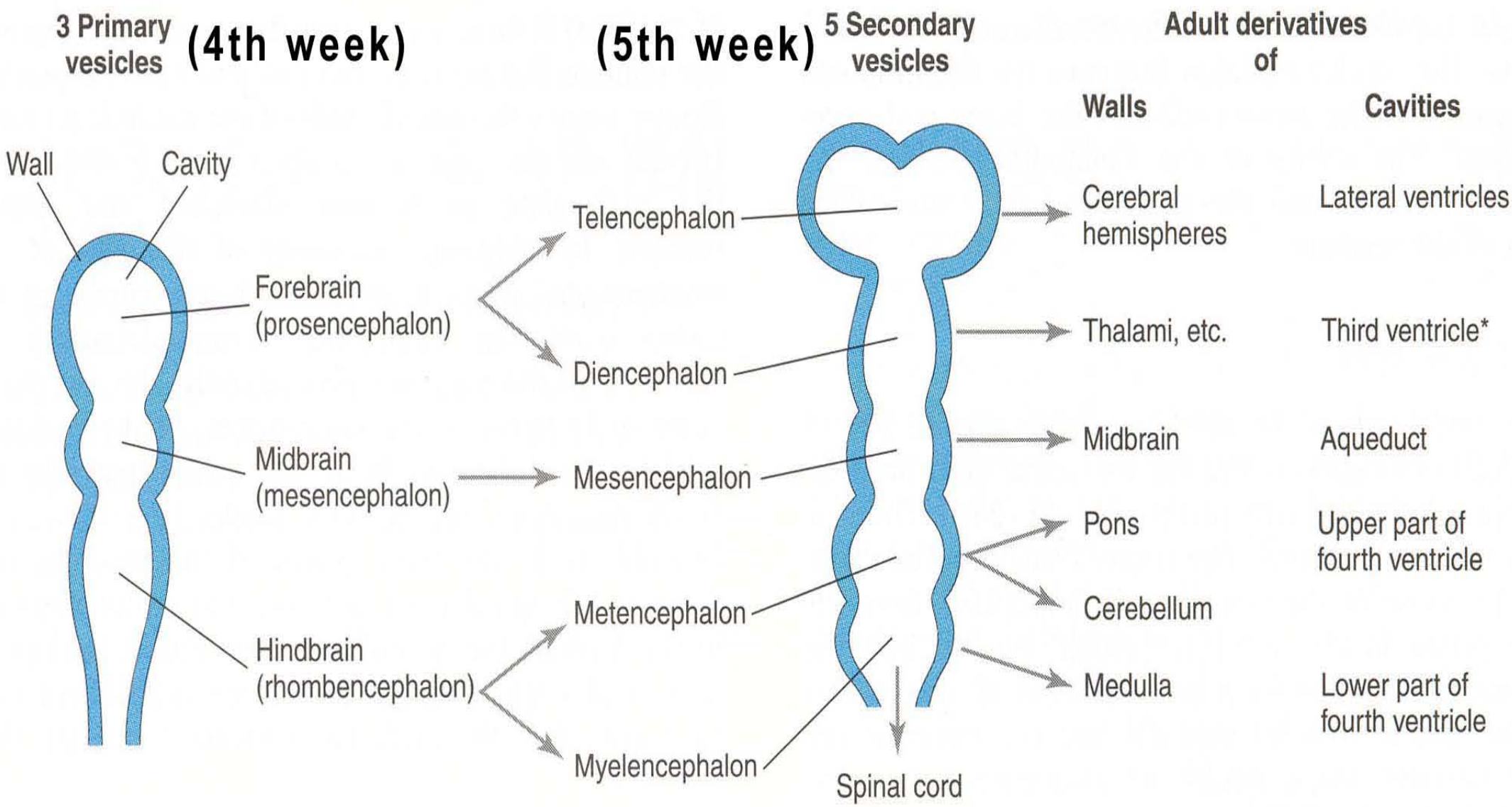
Development of sympathetic nerves

- Post-ganglionic neuons: migration of Neural crest
  - Paravertebral ganglia
  - Preaortic ganglia (celiac, mesenteric ganglia)
  - Sympathetic trunks
- Pre-ganglionic neurons: Neural tube (Intermediate cell column, lateral horn)

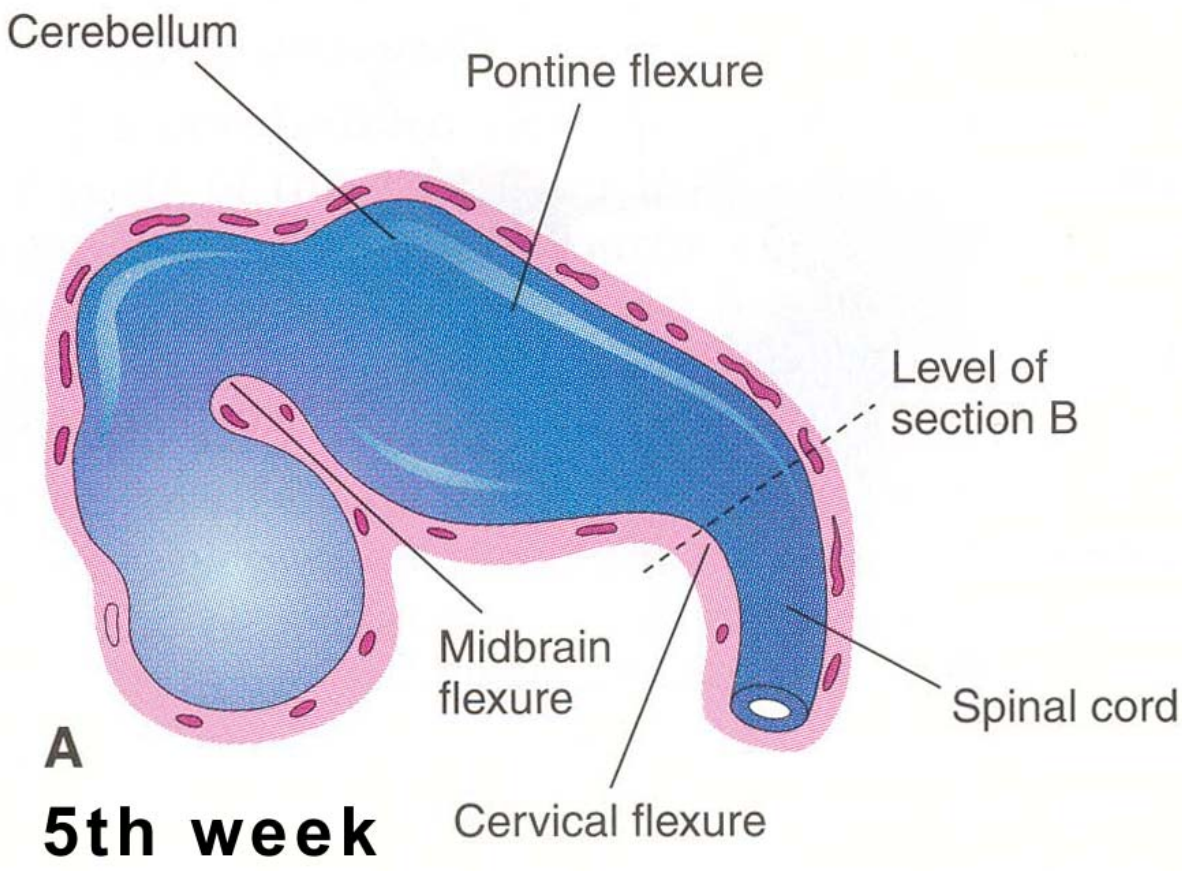
Development of parasympathetic nerves

- Pre-ganglionic neurons: nuclei in brainstem and spinal cord of sacral segments
  - Brainstem nuclei:
    - CN 3: Edinger-Westphal nucleus
    - CN 7: Salvatory nuclus (superior)
    - CN 9: Salvatory nuclus (inferior)
    - CN 10: Dorsal vagal nucleus
- Post-ganglionic neurons in peripheral ganglia or in plexuses near/within structures being innervated

Brain vesicles

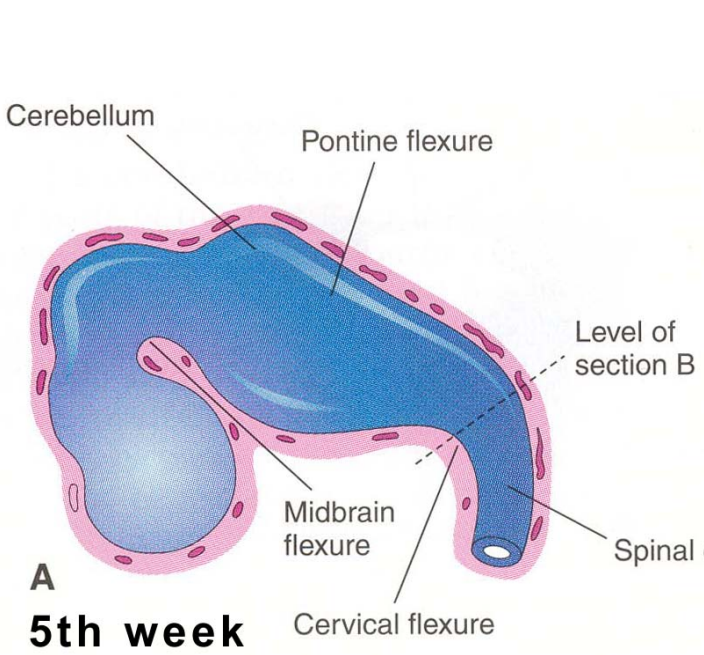


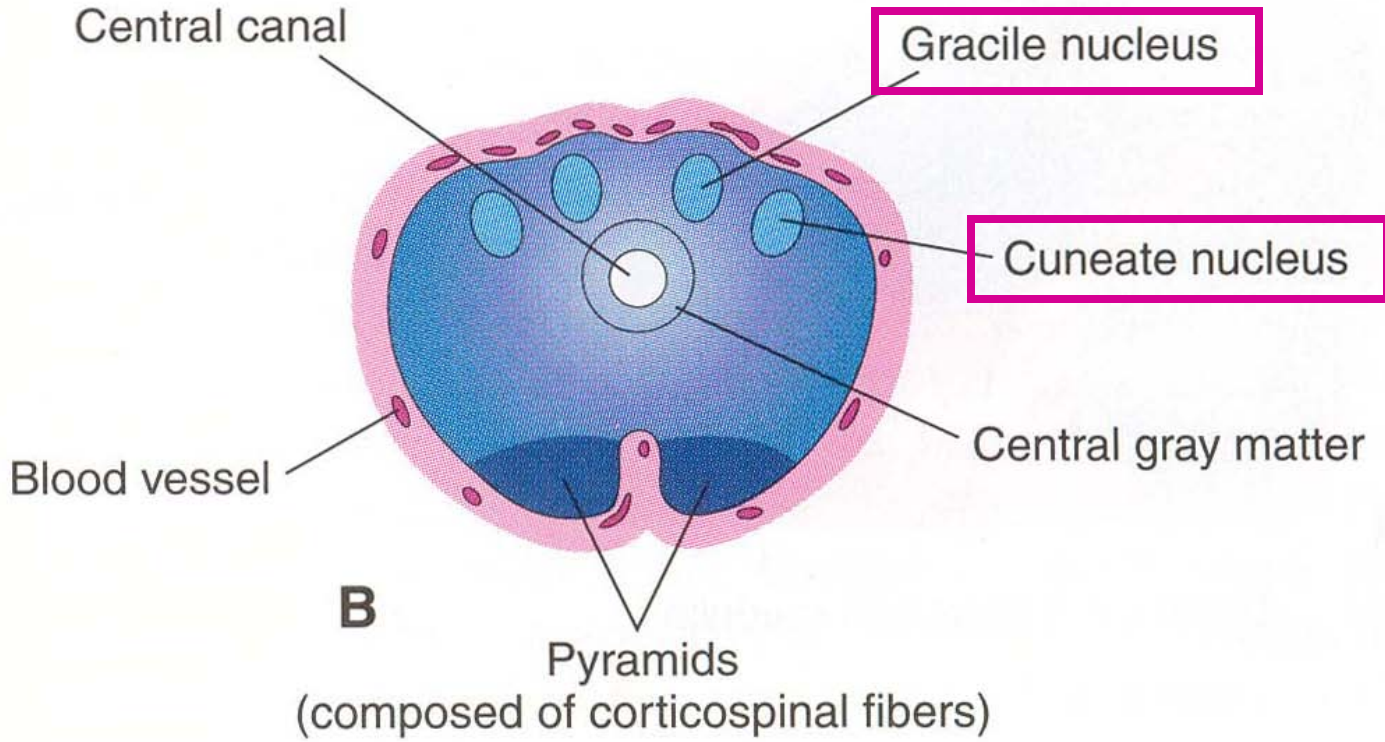
Brain flexures



- Start from 4th weeks: ventral bending
  - Midbrain flexure
  - Cervical flexure
  - Pontine flexure
- Consequences: change in outline and position of gray/white matter

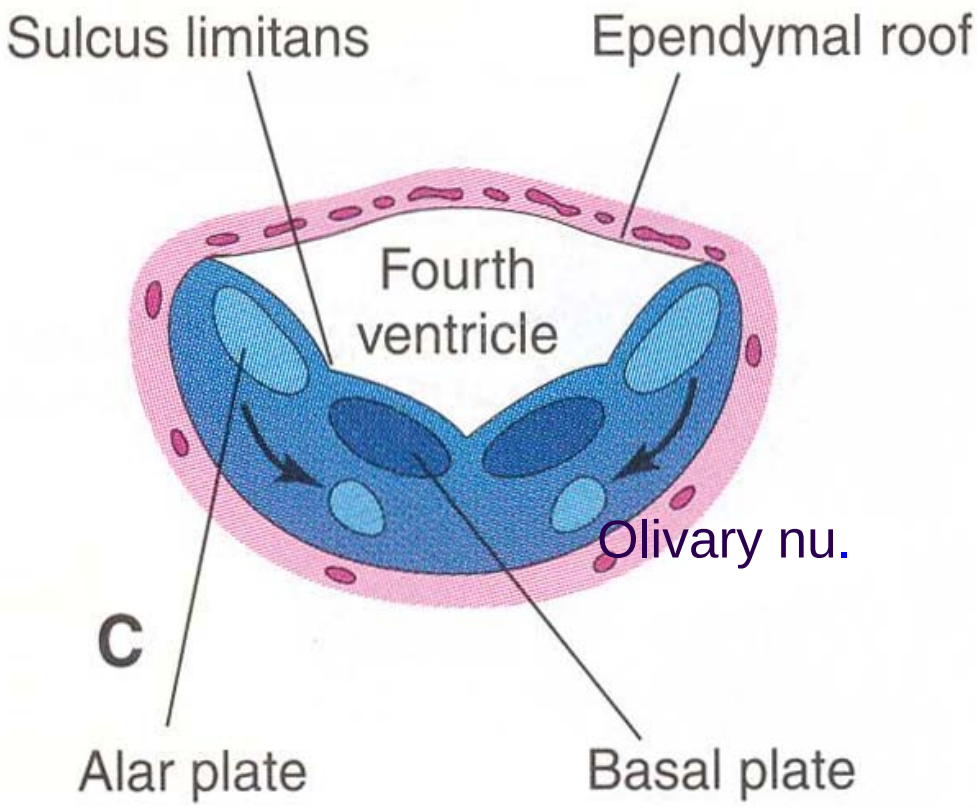
Myelencephalon (caudal): “closed” medulla



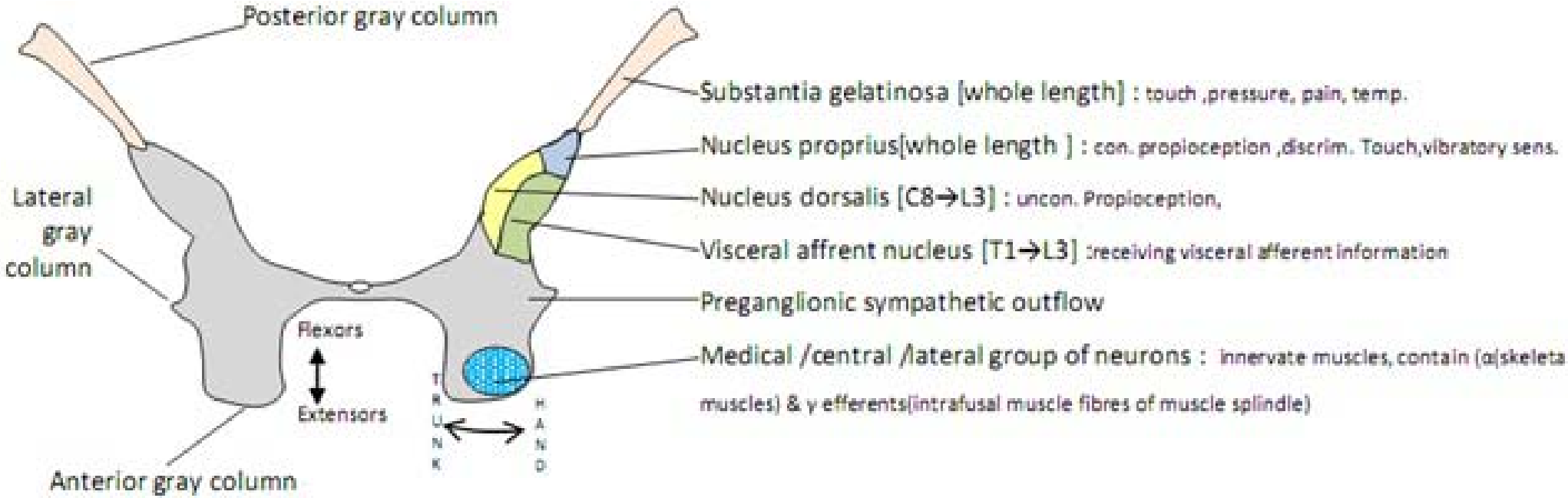


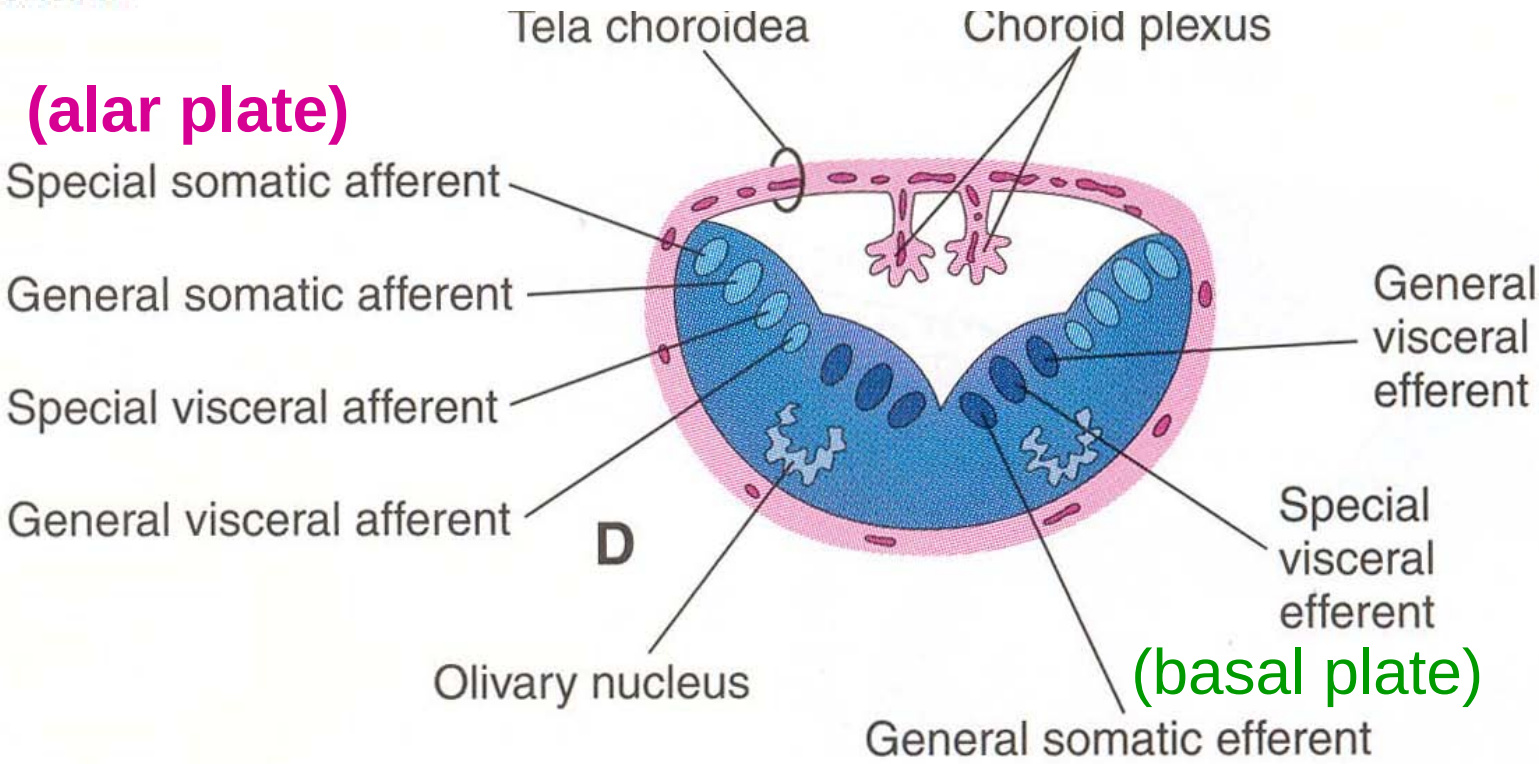
- Gracile nuclei (medial) and Cuneate nuclei (lateral): neuroblasts from alar plates of myelencephalon migrate into marginal zone
- Pyramids: in ventral area; corticospinal fibers from developing cortex

Myelencephalon (rostral): “open” medulla-1

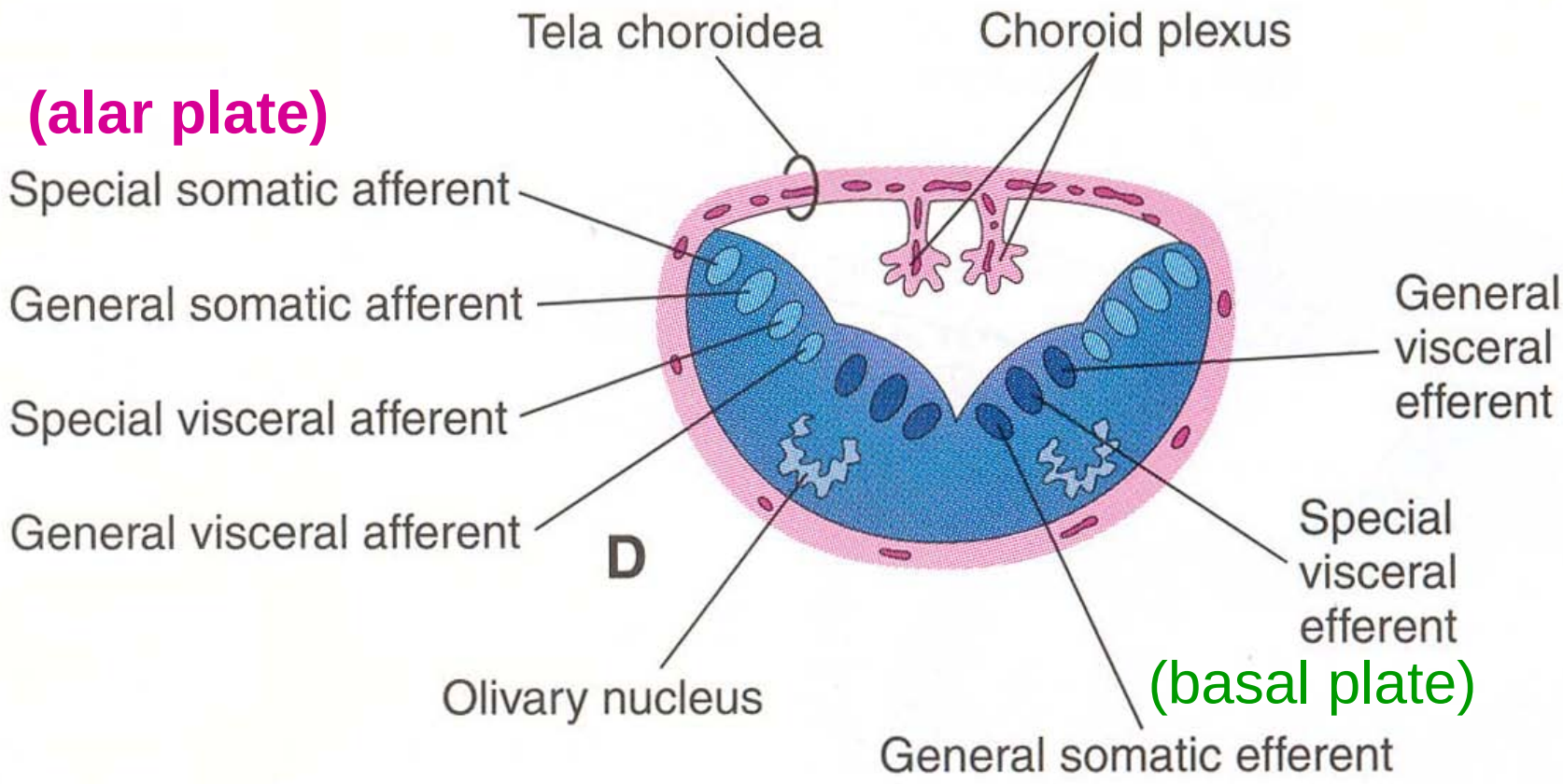


- Effect of pontine flexure
  - thinning & stretching of roof
  - rhomboid cavity (Fourth ventricle)
  - lateral movement of walls
- Ventral movement of sulcus limitans
  - Alar plates: lateral to basal plates
  - Olivary nuclei: from alar plate


Posterior gray column
Substantia gelatinosa [whole length] : touch ,pressure, pain, temp.
Nucleus proprius[whole length] : con. propioception ,discrim. Touch,vibratory sens.
Lateral gray column
Nucleus dorsalis [C8→L3] : uncon. Propioception,
Visceral affrent nucleus [T1→L3] :receiving visceral afferent information
Preganglionic sympathetic outflow
Flexors
Medical /central /lateral group of neurons : innervate muscles, contain (α)skeletal muscles) & γ efferents(intrafusal muscle fibres of muscle splindle)
Extensors
TRUNK
HAND
Anterior gray column


Tela choroidea
Choroid plexus
(alar plate)
Special somatic afferent
General somatic afferent
Special visceral afferent
General visceral afferent
D
General visceral efferent
Special visceral efferent
Olivary nucleus
(basal plate)
General somatic efferent

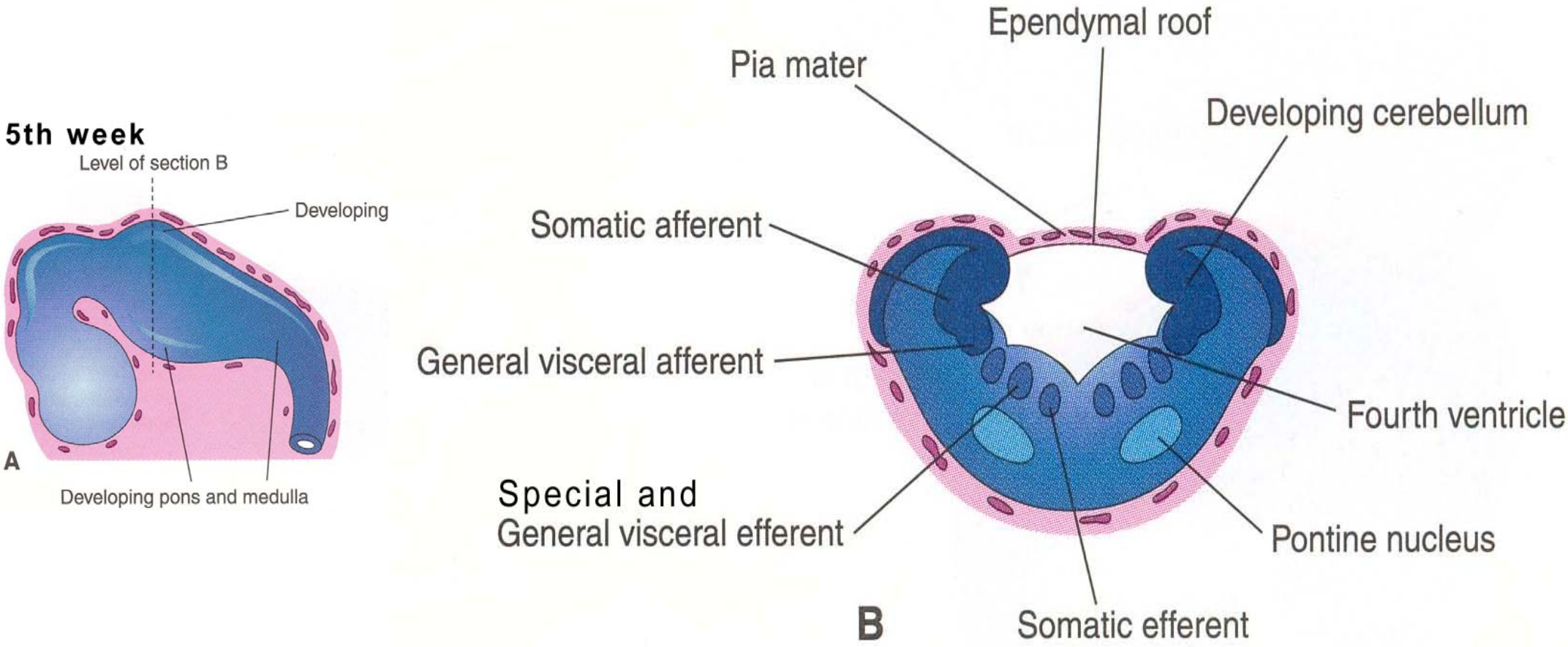
Myelencephalon (rostral): “open” medulla-2



- SSA: hearing
- GSA: from head/face
- SVA: taste
- GVA: from viscera

- GSE: hypoglossal nucleus
- SVE: muscles of pharyngeal arches
- GVE: nuclei of 9th and 10th CN

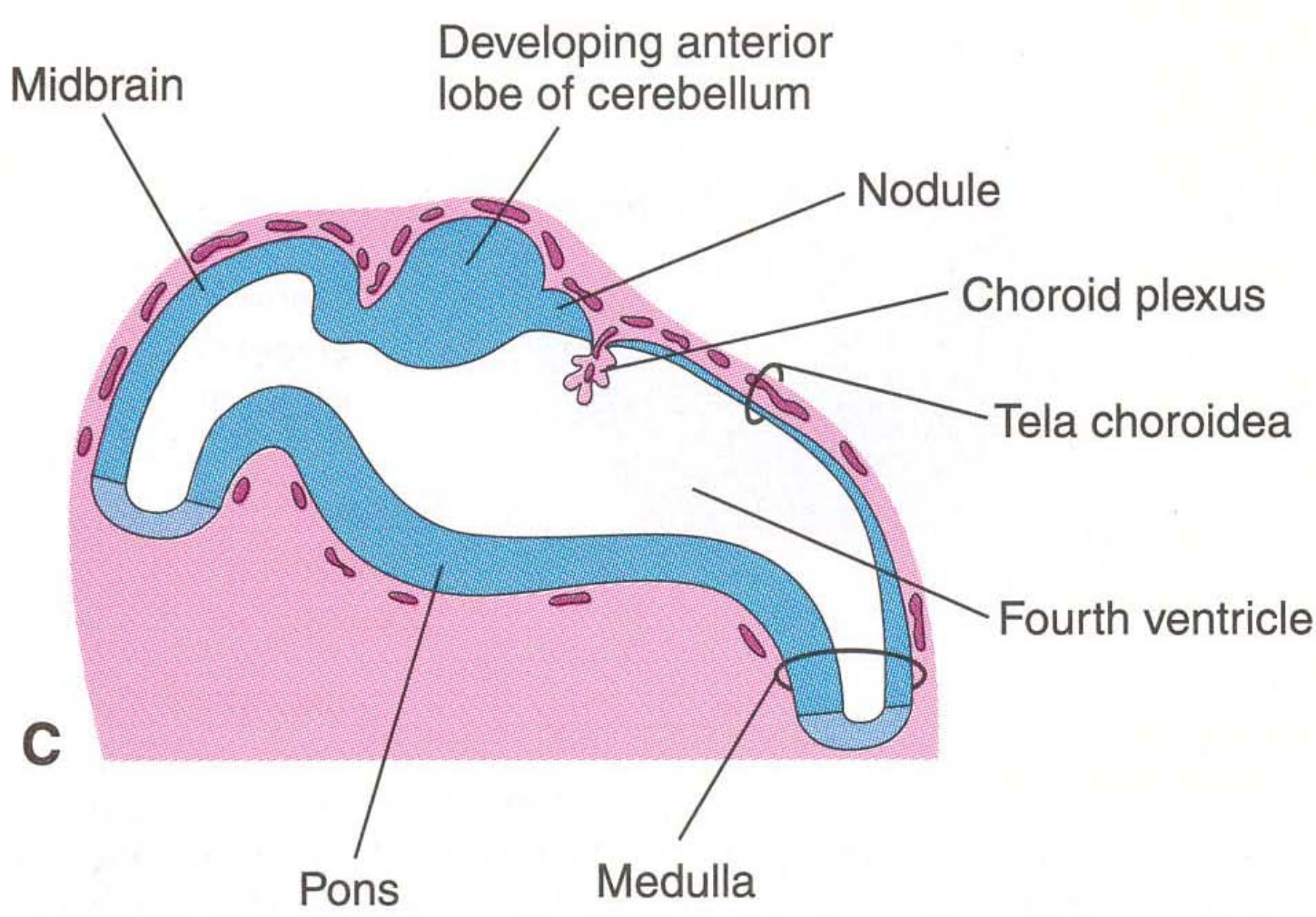
Pons: development of Metencephalon



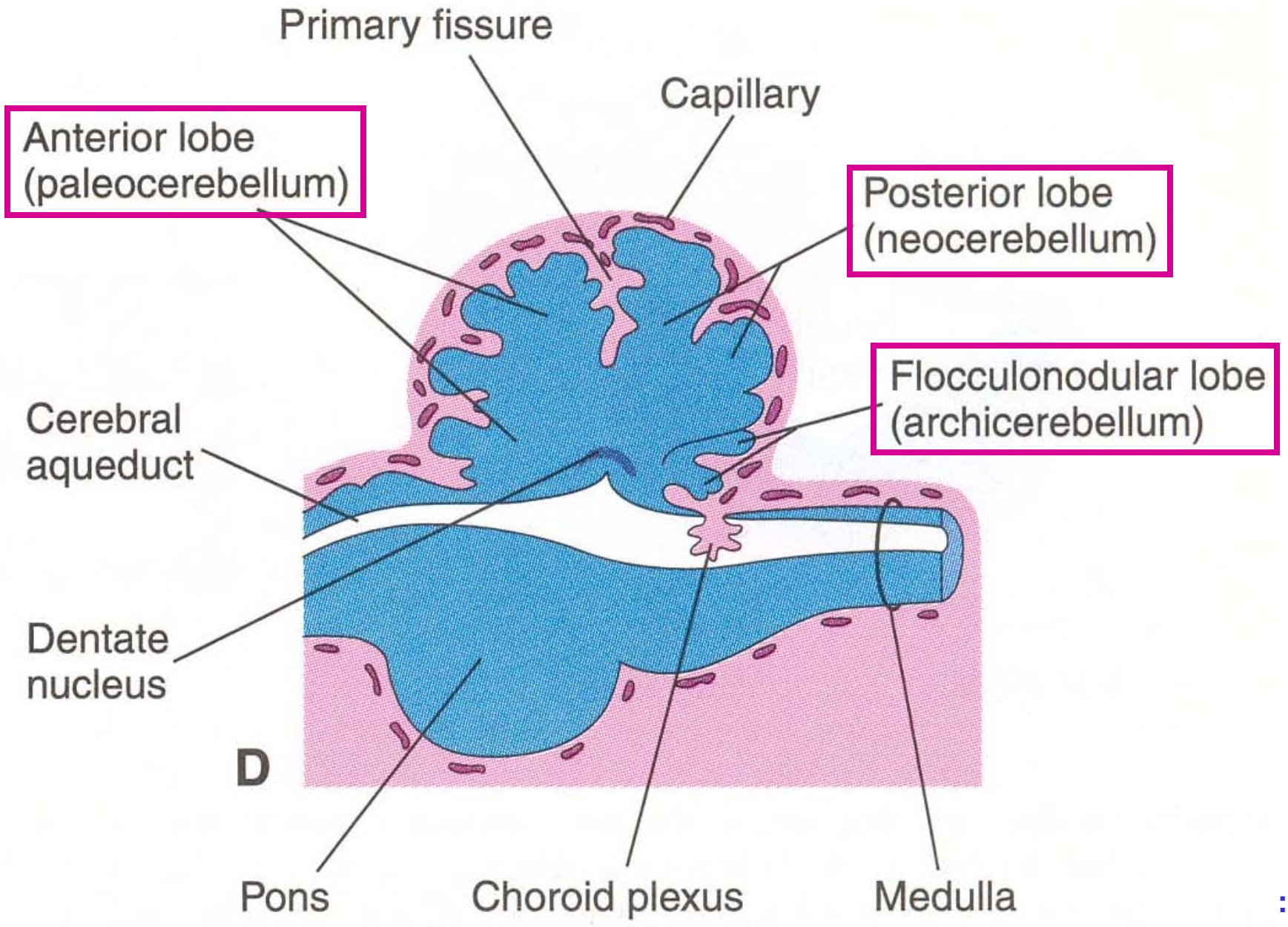
- Pontine flexure: divergence of lateral walls of pons
  - Gray matters: spread in floor of 4th ventricle
  - Motor nuclei in ventral pons: pontine nuclei

Development of Cerebellum

- Cerebellum: thickening of dorsal part of alar plates
  - Initially: project into 4th ventricle
  - Later: enlarge & fuse in median plane



Development of Cerebellum

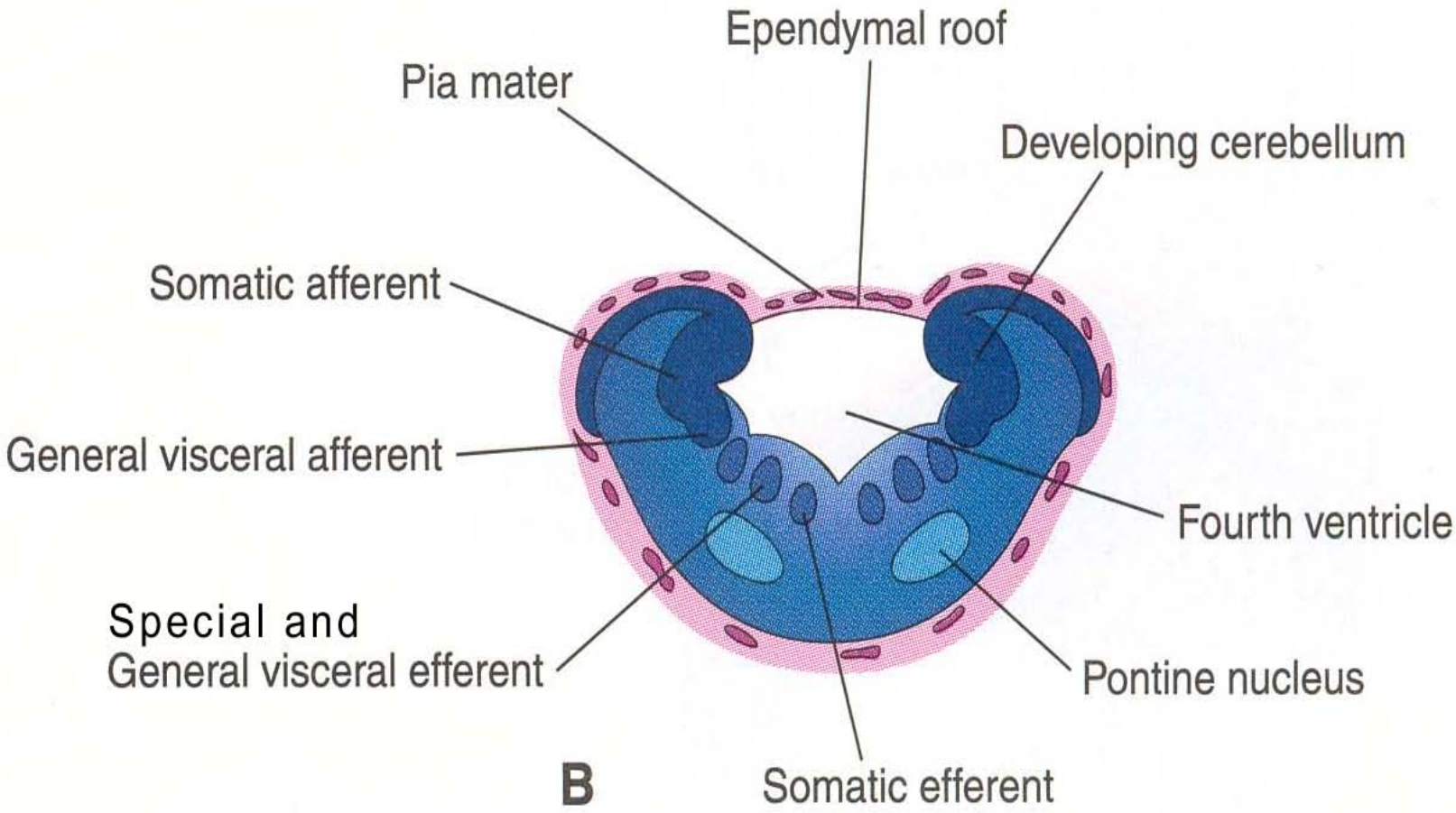


Cerebellum: embryology and functions

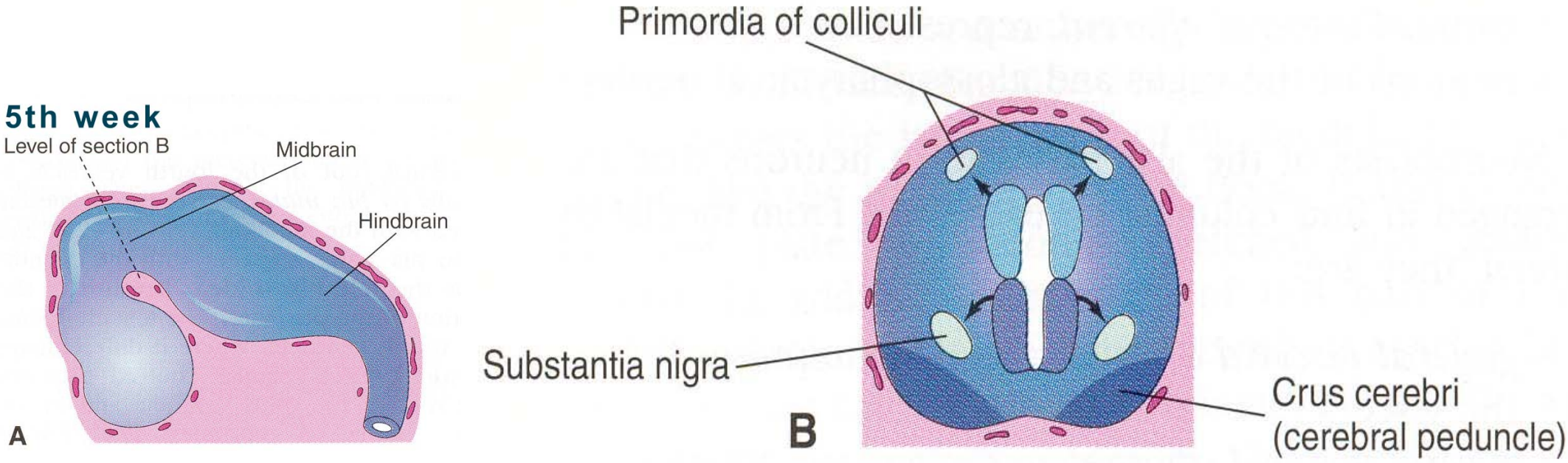
- Archicerebellum (floculonocular lobe)
  - phylogeny: oldest part
  - function: with vestibular system
- Paleocerebellum (vermis & anterior lobe)
  - phylogeny: intermediate
  - function: with sensory input from limbs
- Neocerebellum (posterior lobe)
  - phylogeny: the newest
  - function: with selective control of limb movements

Metencephalon: Alar and Basal plates

- Cerebellum: Cortex and Central (deep) nuclei
- Cochlear, Vestibular
- Pontine nuclei, 5th CN nuclei

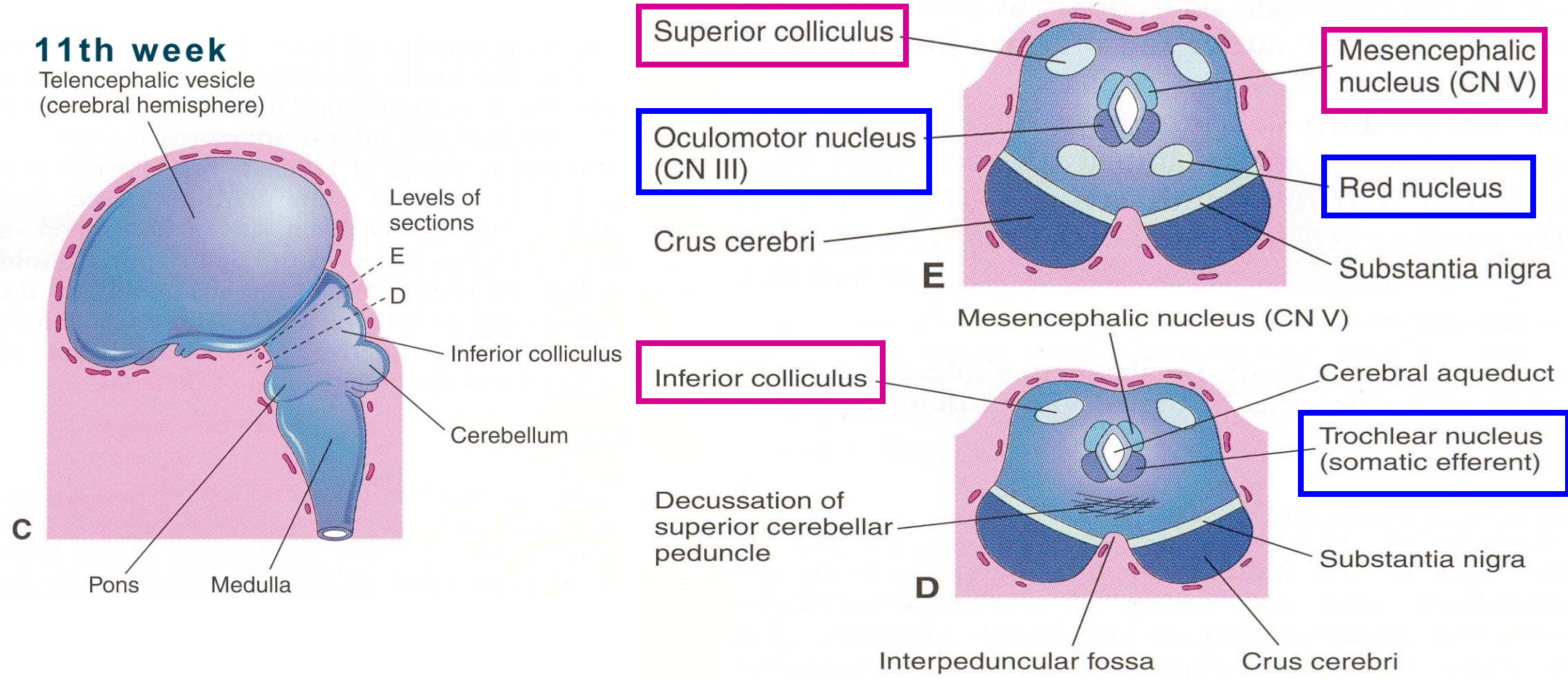


Development of midbrain-1

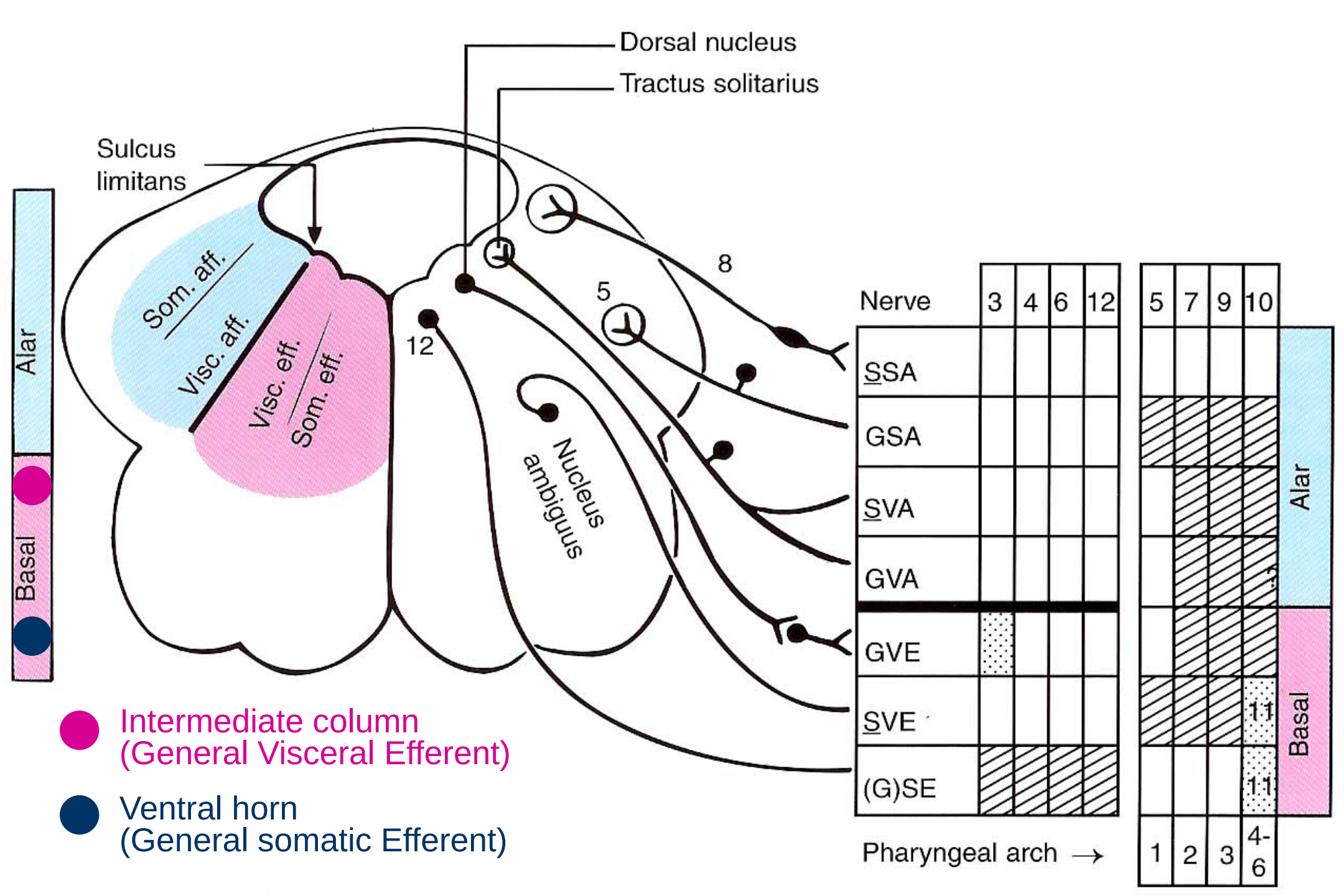


- Neural canal→ cerebral aqueduct
- Alar plate → tectum (colliculi); Basal plate → tegmentum
- Substantia nigra: from alar or basal plates
- Crus cerebri (Cerebral peduncles): corticobulbar, corticopontine, corticospinal fibers

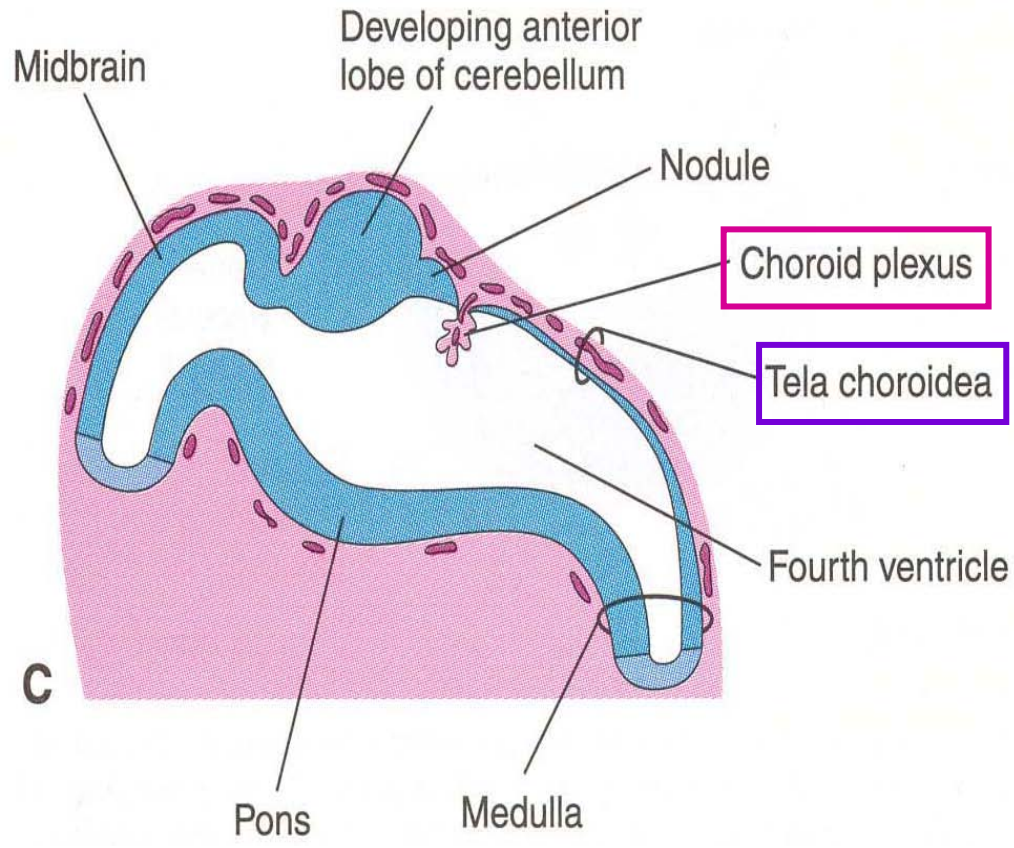
Development of midbrain-2

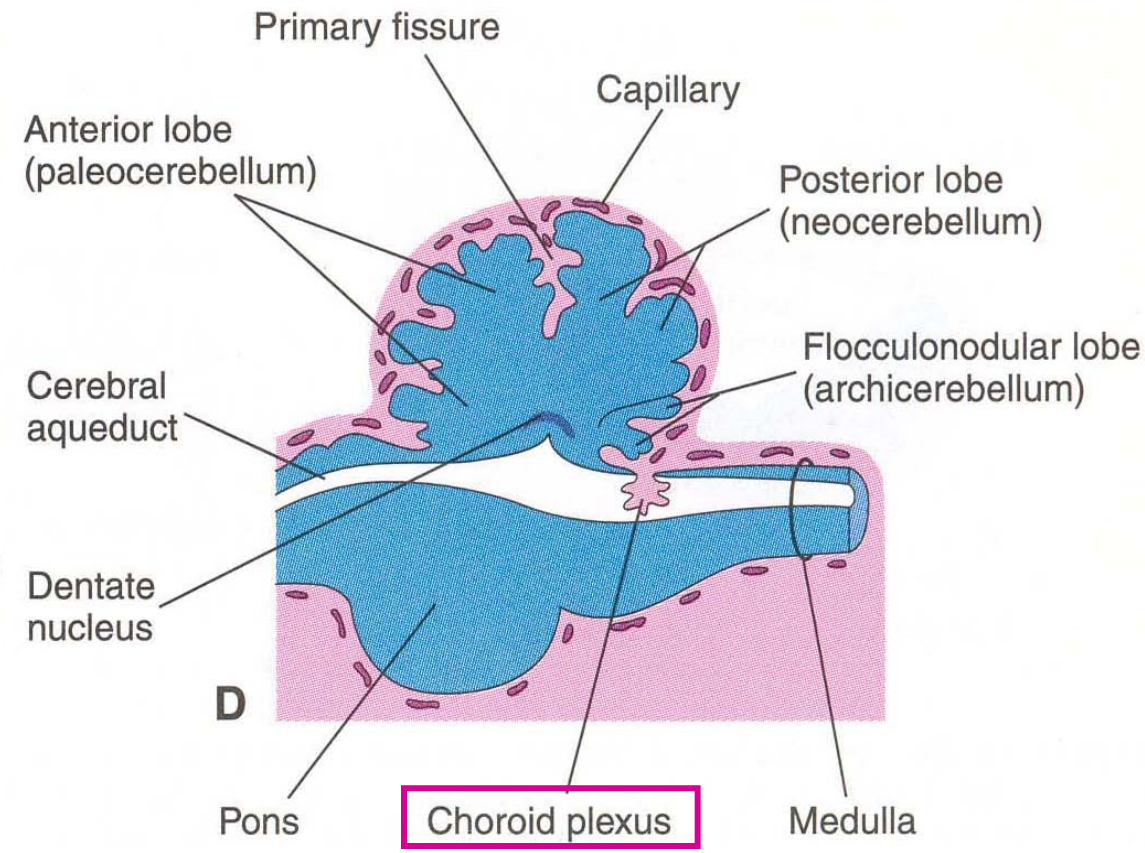


- Alar plate → tectum (roof): superior & inferior colliculi; mesencephalic nucleu of CN V
- Basal plate → tegmentum: red nuclei; 3rd, 4th CN nuclei; reticular nuclei


Dorsal nucleus
Tractus solitarius
Sulcus limitans
Som. aff.
Visc. aff.
Visc. eff.
Som. eff.
Alar
Basal
12
5
8
Nucleus ambiguus
Nerve
3
4
6
12
5
7
9
10
SSA
GSA
SVA
GVA
GVE
SVE
(G)SE
11
11
Alar
Basal
Pharyngeal arch →
1
2
3
4-6
Intermediate column
(General Visceral Efferent)
Ventral horn
(General somatic Efferent)

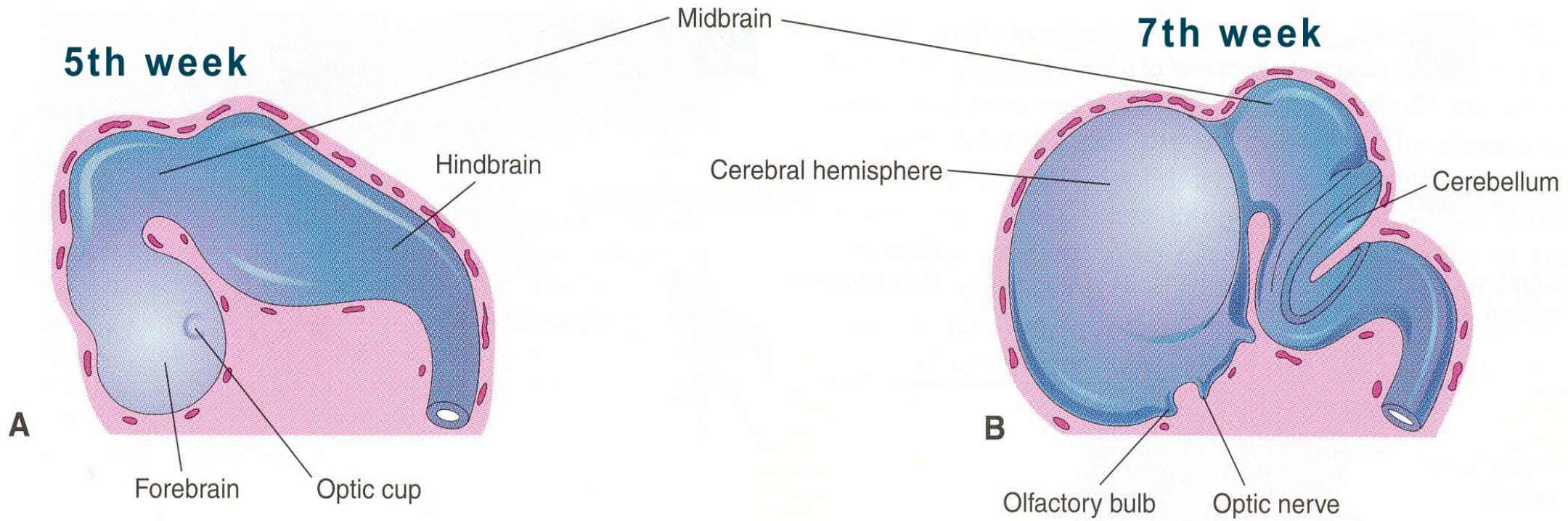
Formation of choroid plexus



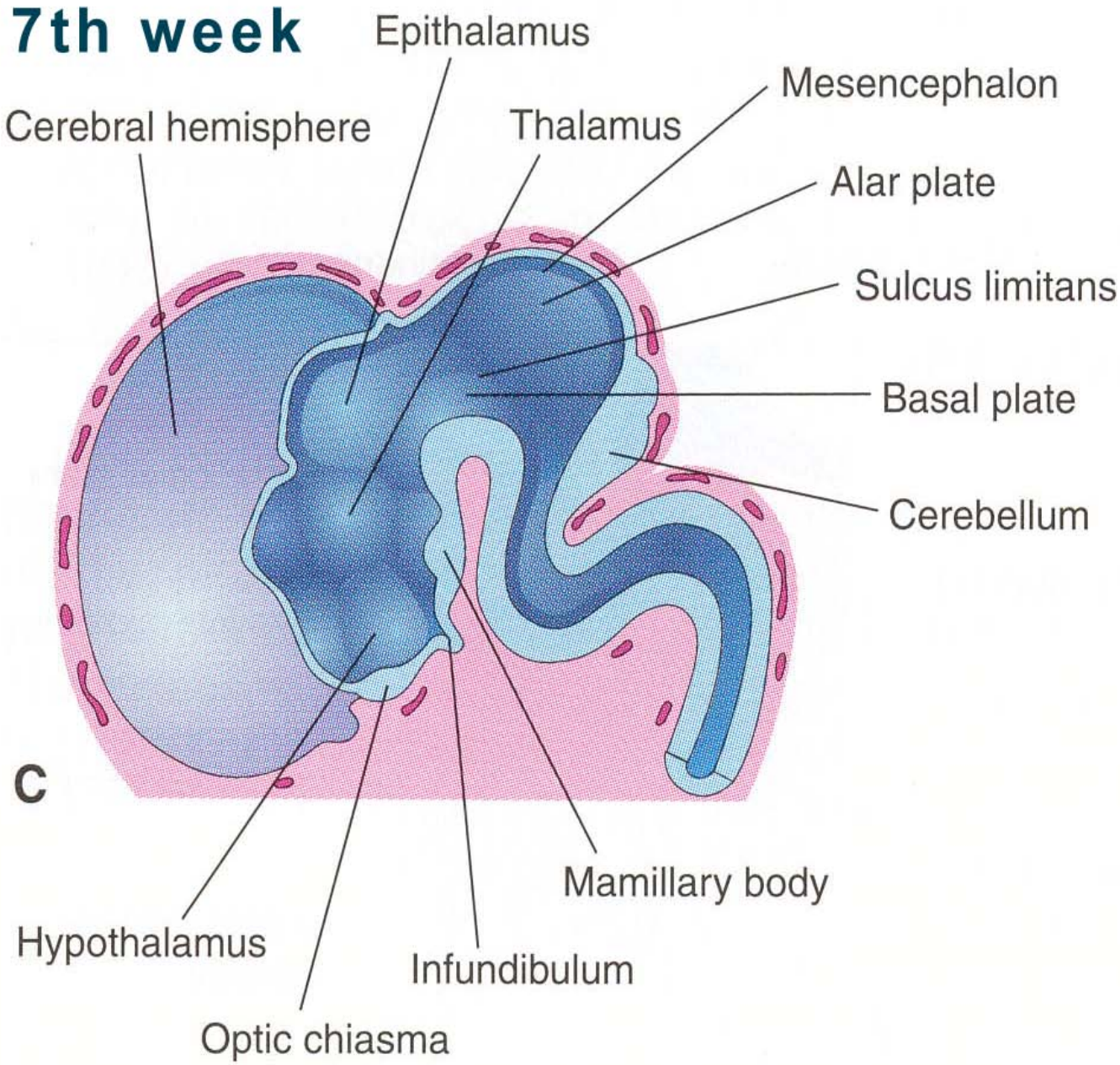


- Tela choroid: ependyma + mesenchyme
- Choroid plexus: tela choroid + vessels

Development of forebrain



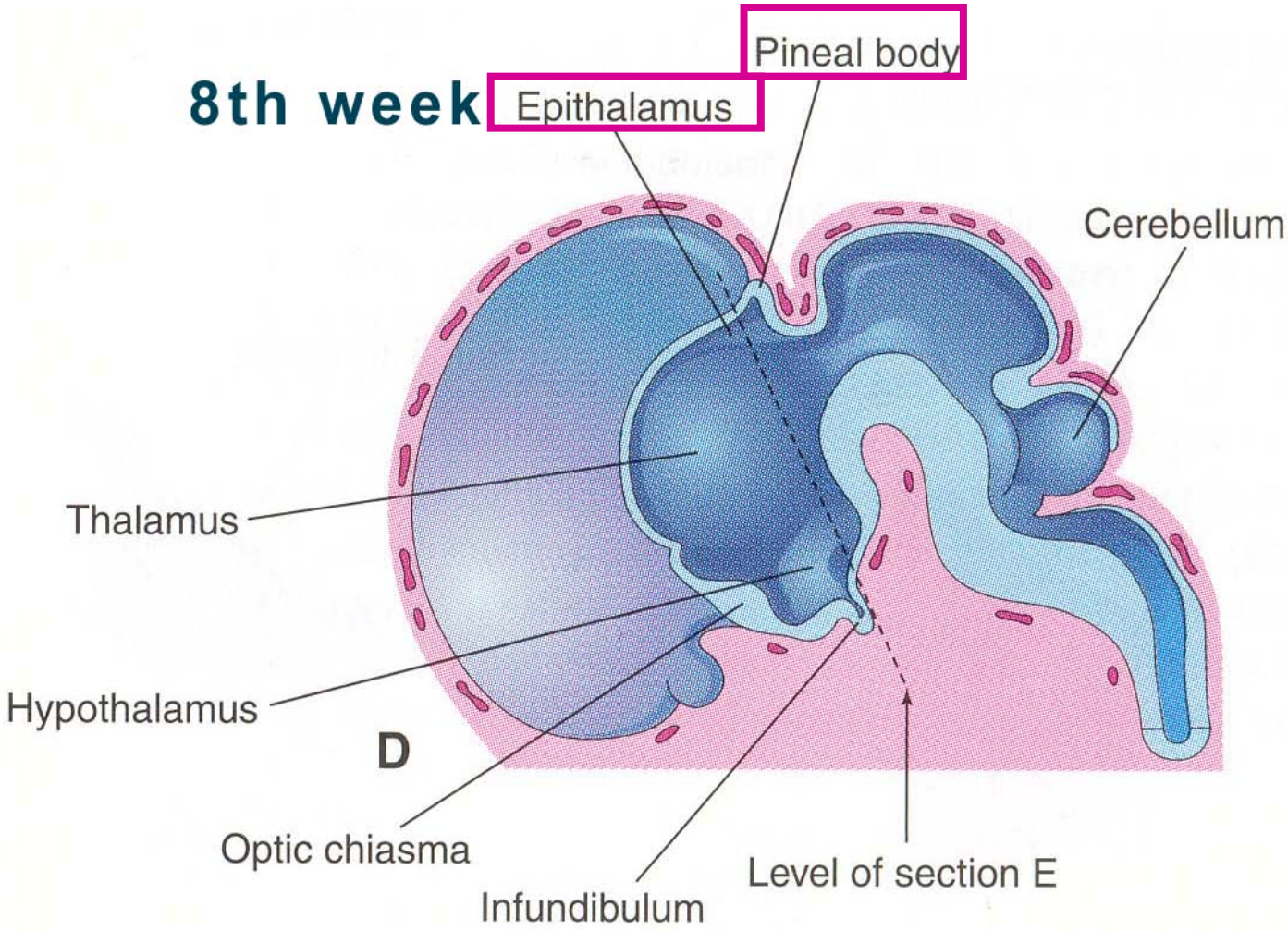
- Forebrain vesicles: upon closure of rostral neuropore,
  - Optic vesicles: primodia of retinae, optic nerve
  - Cerebral (telencephalic) vesicles: primodia of cerebral hemisphers, lateral ventricles



Development of diencephalon

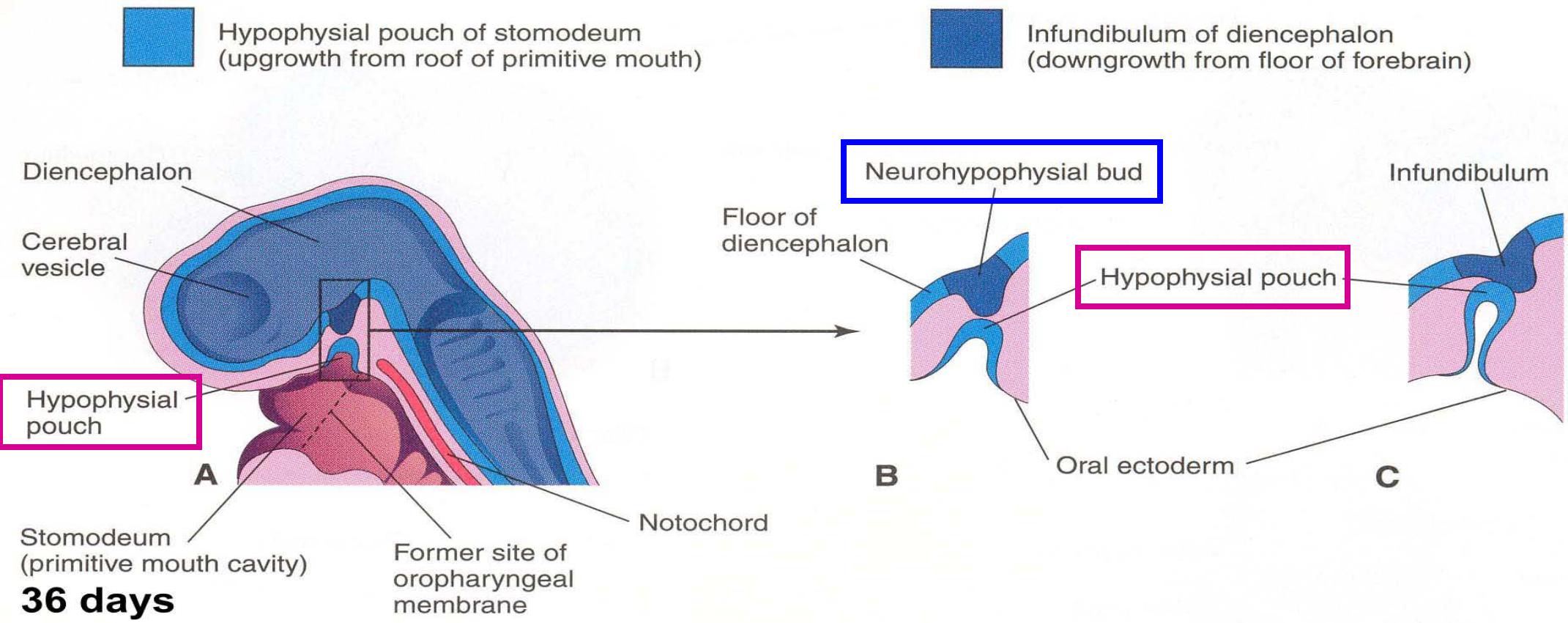
- caudal part of forebrain:
  - Epithalamus, Thalamus, Hypothalamus
  - epithalamic sulcus, hypothalamic sulcus
- Interthalamic adhesion (mass intermedia)

Development of Epithalamus



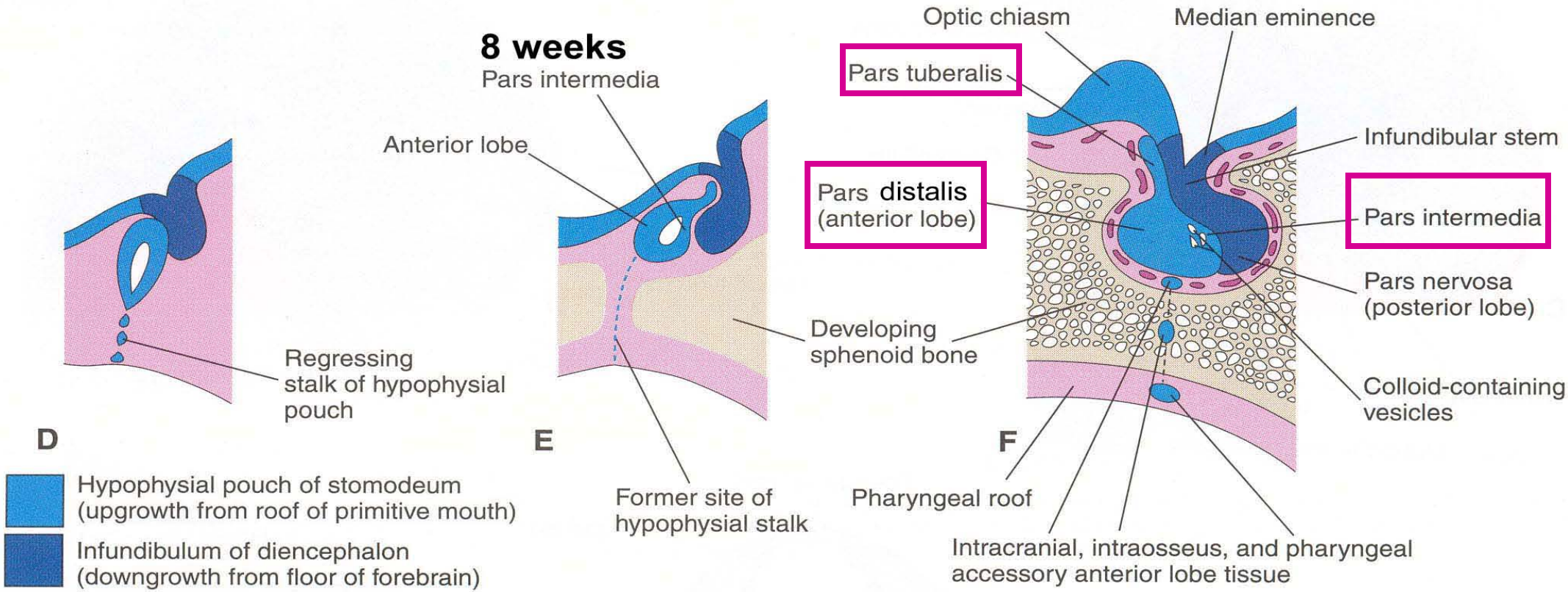
- From roof & dorsal part of lateral wall of diencephalon
- Pineal glands: median diverticulum of caudal part of roof of diencephalon

Development of Pituitary gland



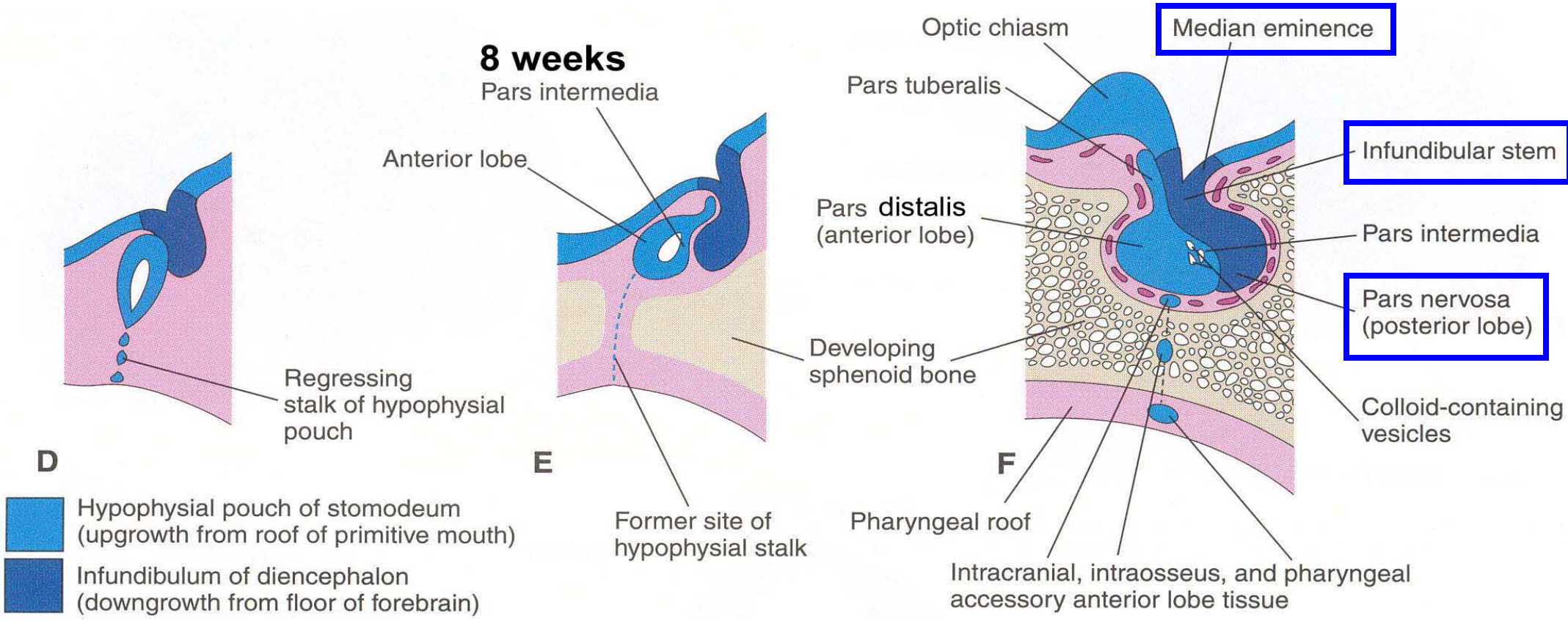
- Upgrowth from epidermal roof of stomodeum: hypophysial pouch or Rathke pouch at 4th week; constricted attachement at 5th week
- Downgrowth of neurohypophysial bud, neuroectoderm of diencephalon; contact of infundibulum with hypophysial pouch

Development of Adenohypophysis



- Pars distalis: anterior wall of hypophysial pouch
- Pars tuberalis: around infundibulum stem
- Pars intermedia: posterior wall of phypophysial pouch
- Regressing stalk of hypophysial pouch in developing sphenoid bone at 6th week

Development of Neurohypophysis



- Infundibulum give rise to Median eminence, Infundibulum stem, and Pars nervosa
- Pituicytes in posterior lobe of pituitary gland

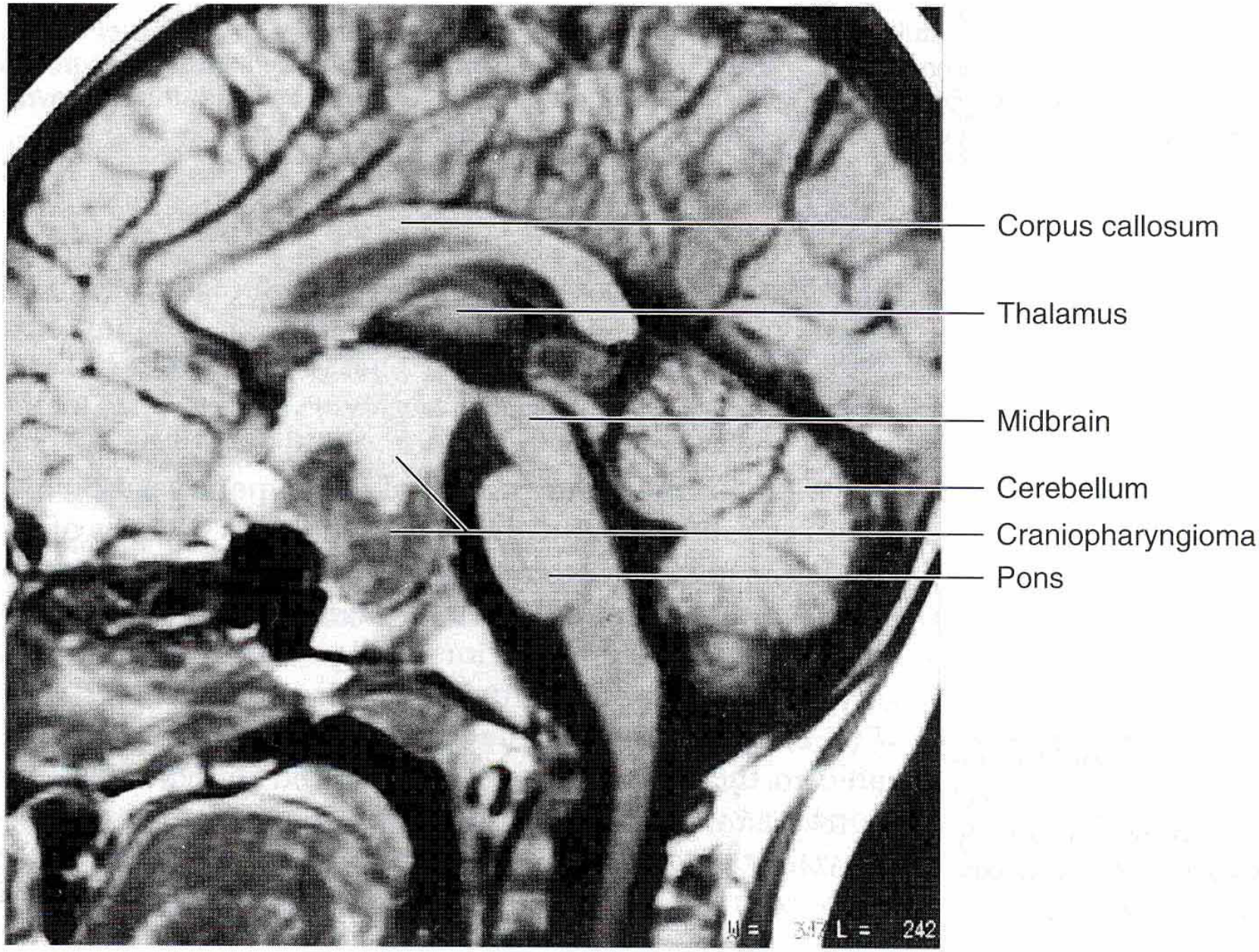
Development of pituitary gland: Summary

Table 18–1 ■ Derivation and Terminology of the Pituitary Gland

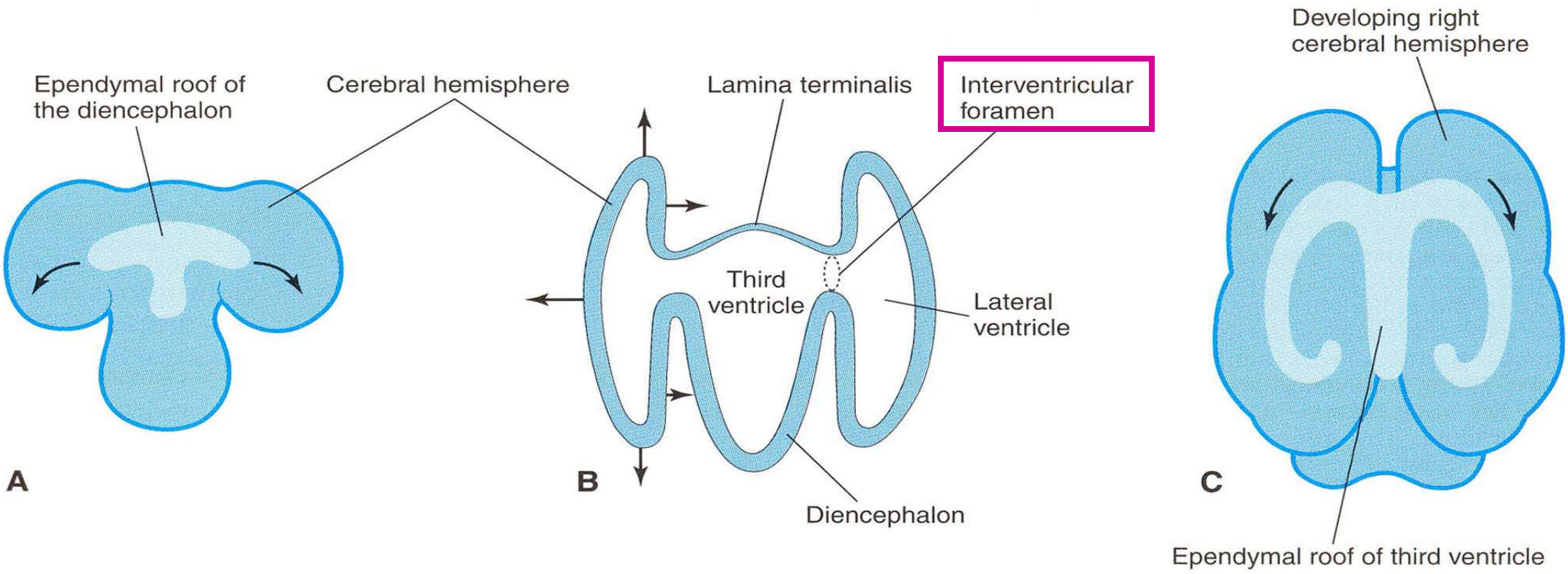
Oral Ectoderm (Hypophysial pouch from roof of stomodeum)	→ Adenohypophysis (glandular portion)	Pars distalis, Pars tuberalis, Pars intermedia	Anterior lobe
Neuroectoderm (Neurohypophysial bud from floor of diencephalon)	→ Neurohypophysis (nervous portion)	Pars nervosa, Infundibular stem, Median eminence	Posterior lobe

- Intraglandular cleft between pars distalis and pars intermedia

Craniophryngioma

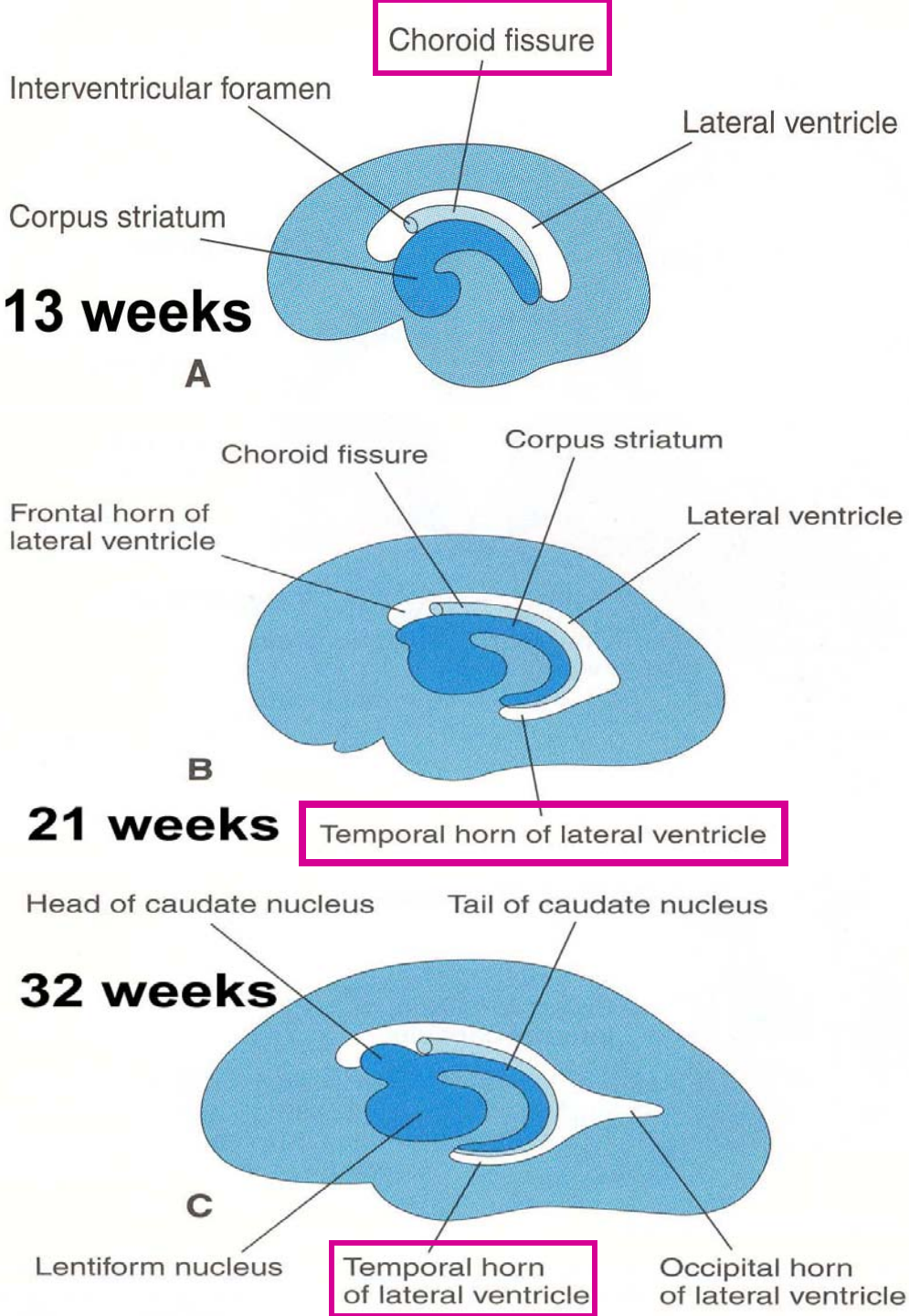


Development of Telencephalon



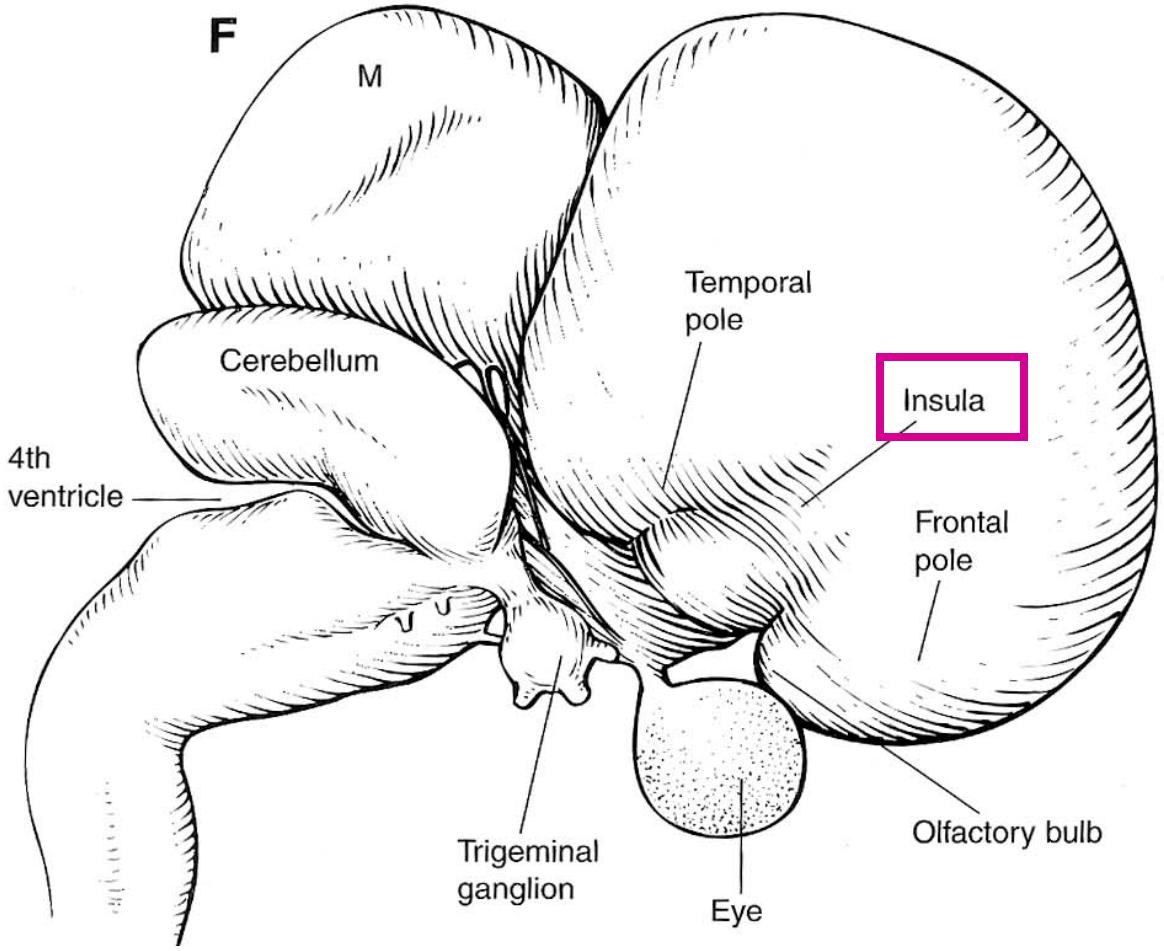
- **Cerebral vesicles: primordium of cerebral hemispheres**
- **Falx cerebri: mesenchyme in longitudinal fissure**
- **Cavity of median part: future 3rd ventricle**

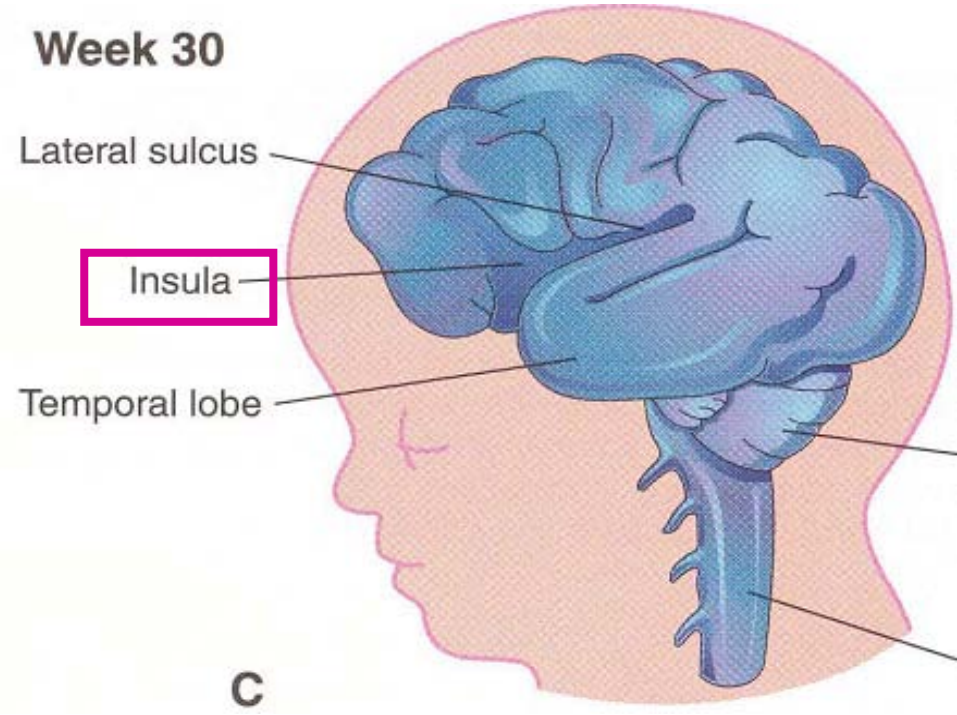
Growth of cerebral hemisphere



- C-shaped curvature of cerebral hemisphere and ventricles
- Temporal lobe: ventral and rostral turning with caudal end of cerebral hemisphere
- Choroid fissure: with temporal horn of lateral ventricle; formation of choroid plexus

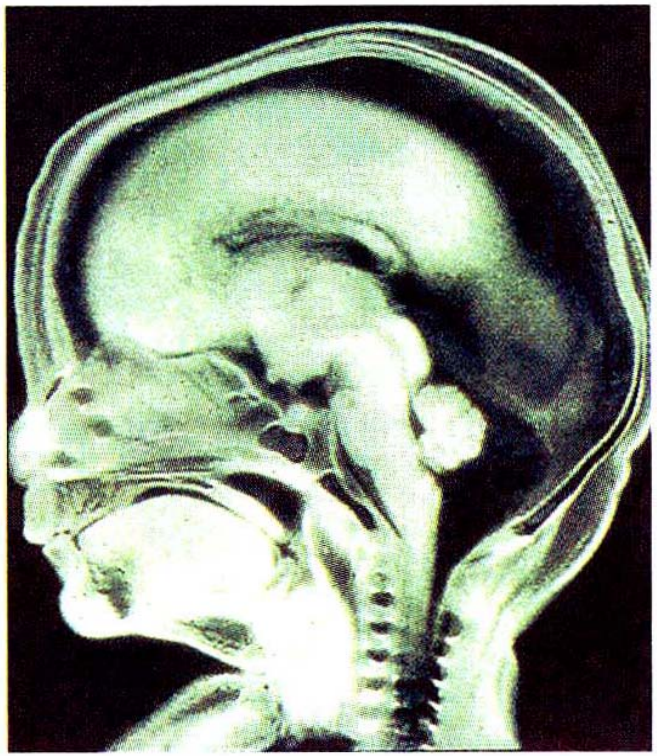
Differential growth of cerebral cortex: Insula

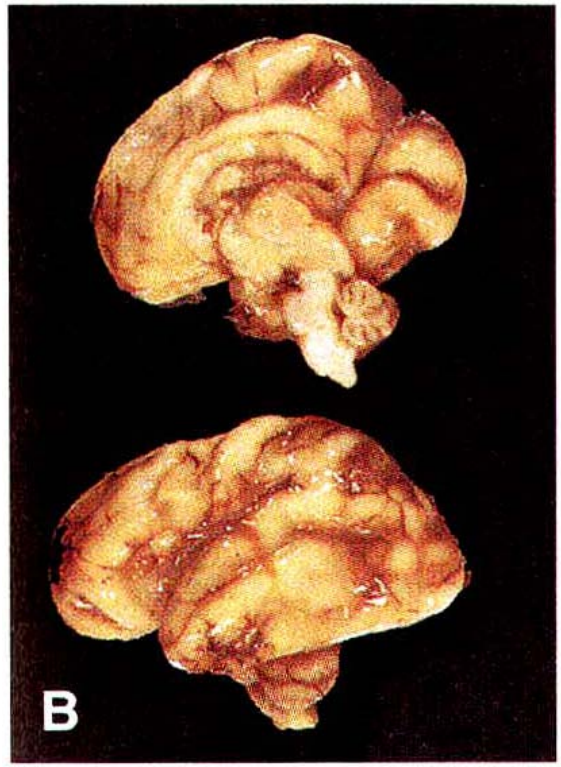


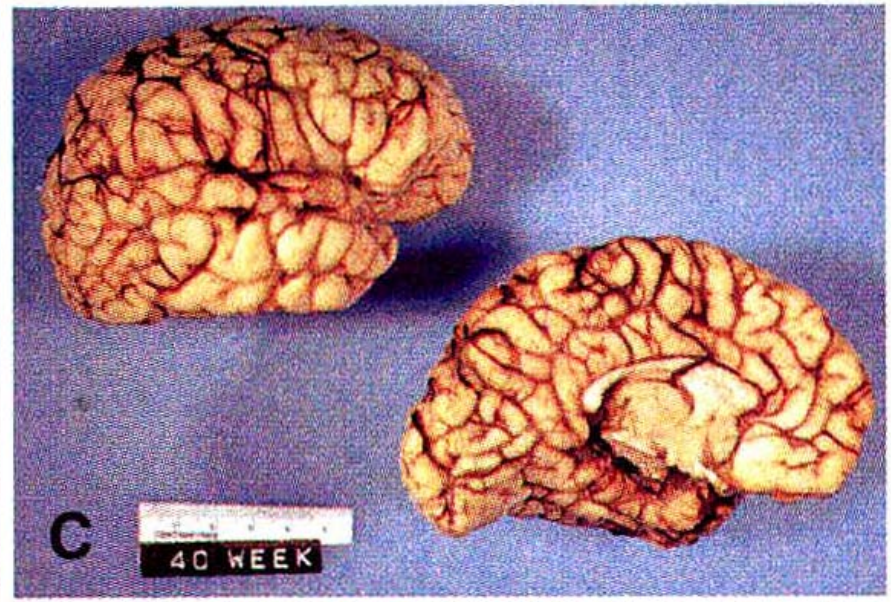


Gyral formation during fetal period

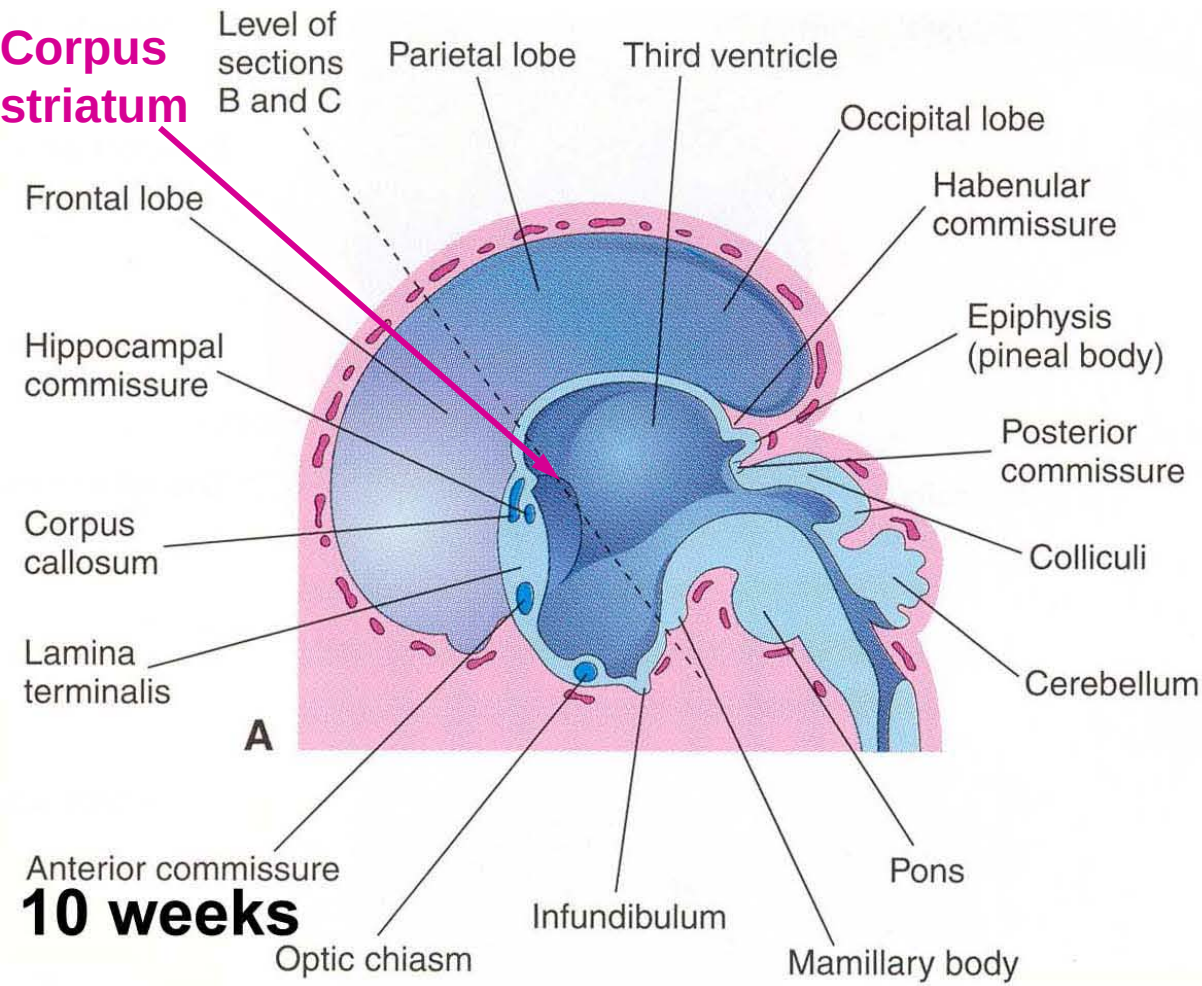
24-25 weeks

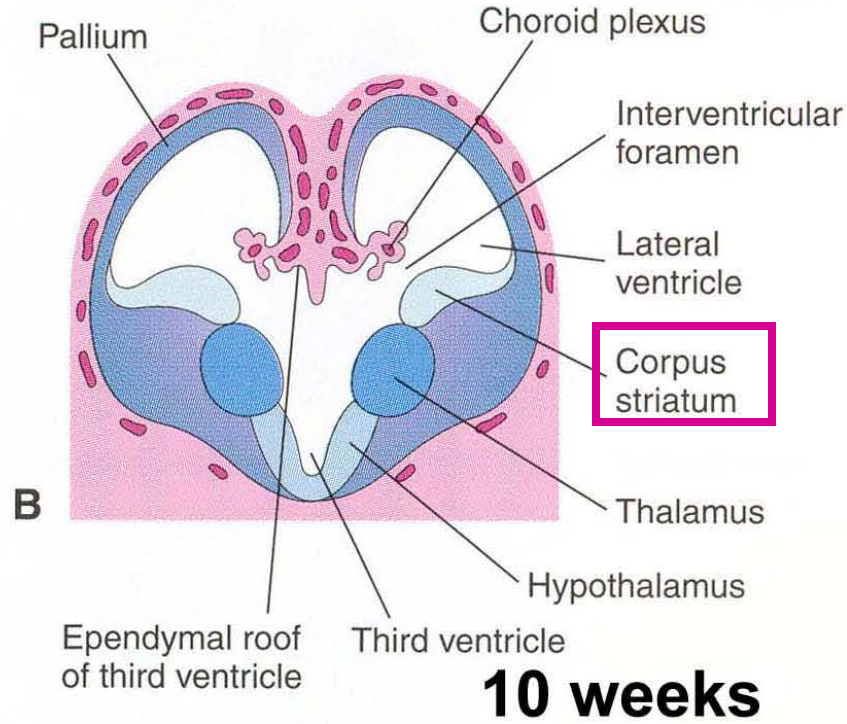






Development of Basal ganglia

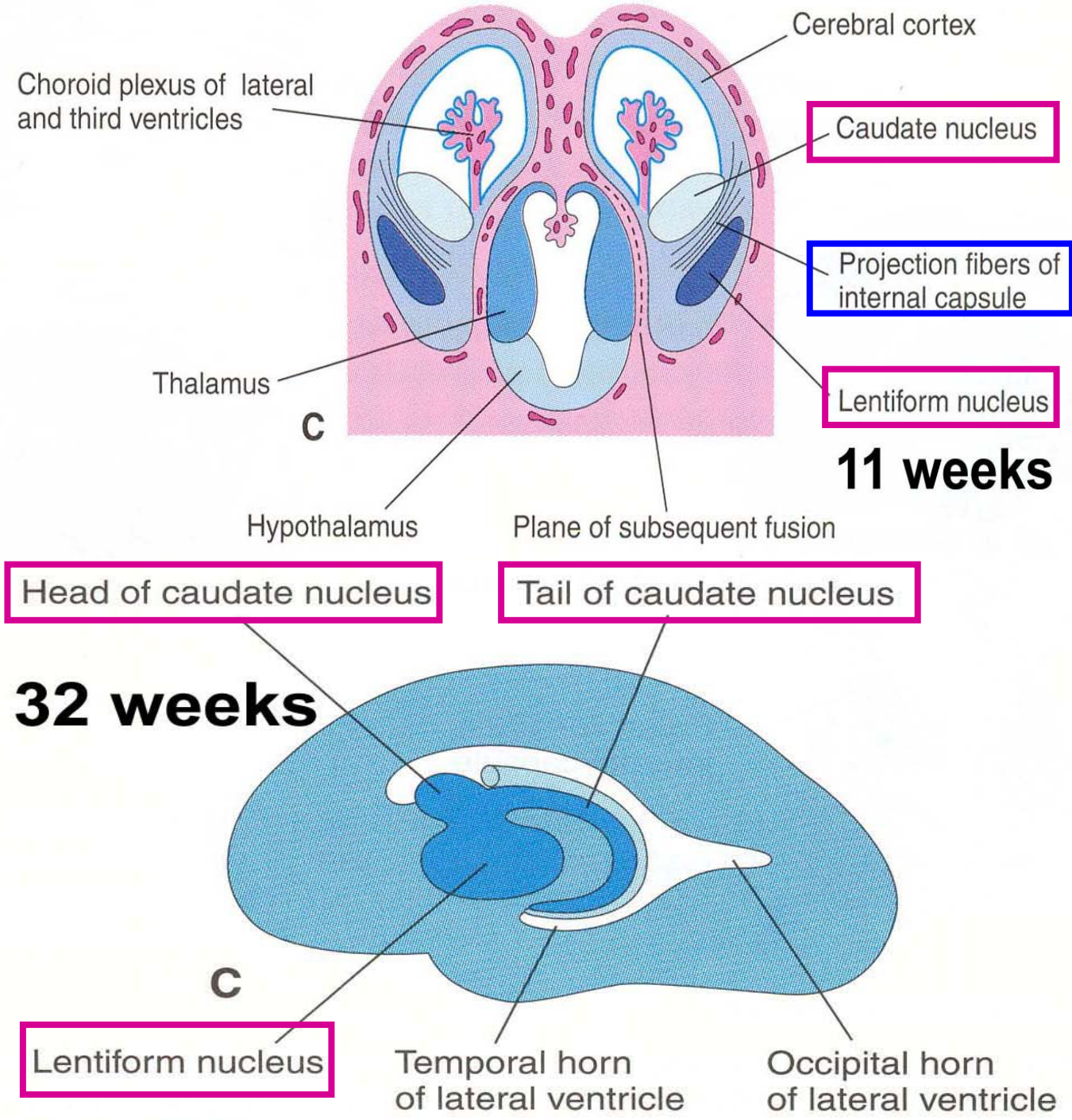




- Corpus striatum: appear at 6th week, in floor of hemisphere

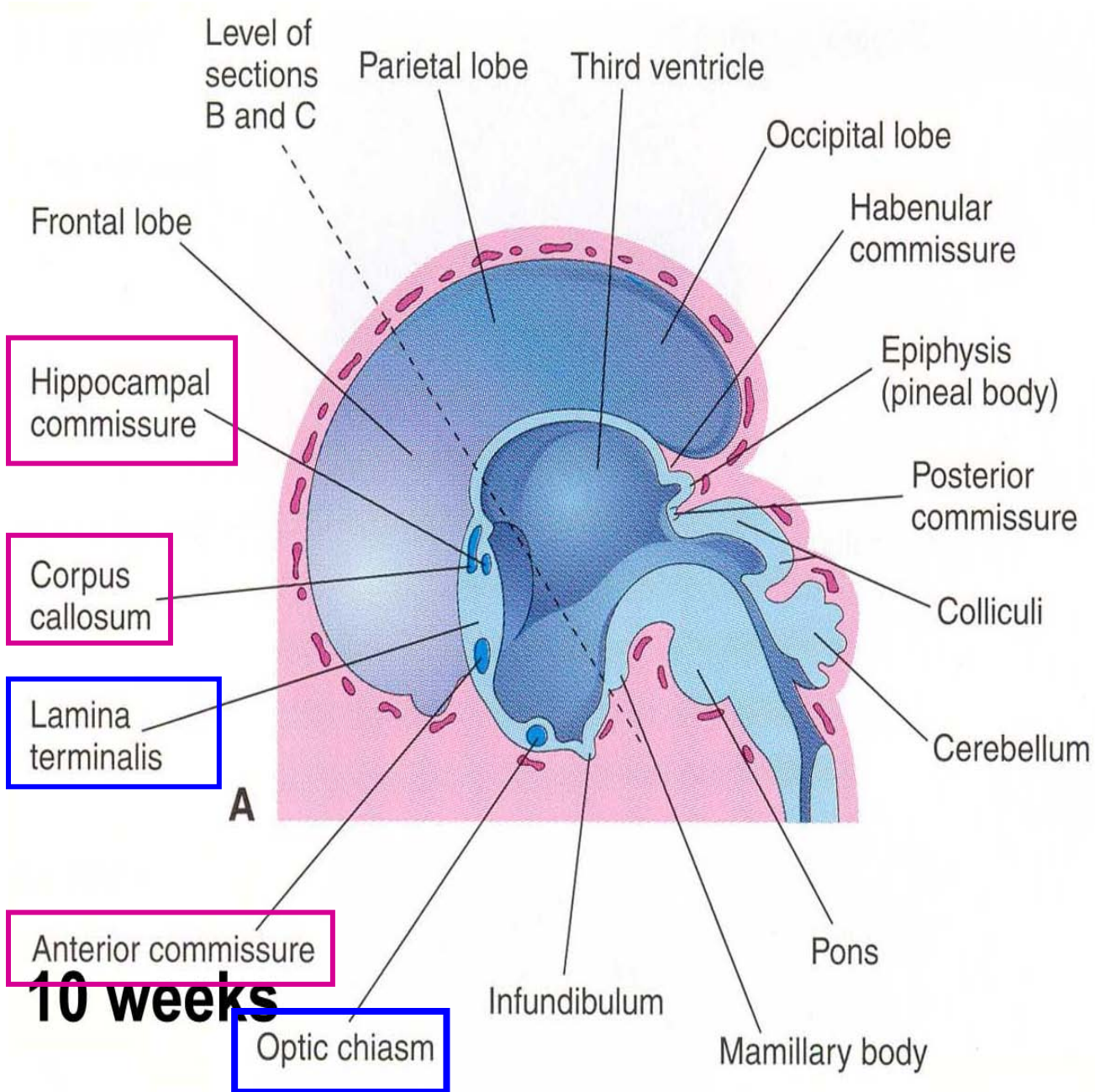
Development of Basal ganglia

- Divided by fibers (internal capsule) passing through corpus striatum:
- Caudate nucleus: inner
- Lentiform nucleus: outer

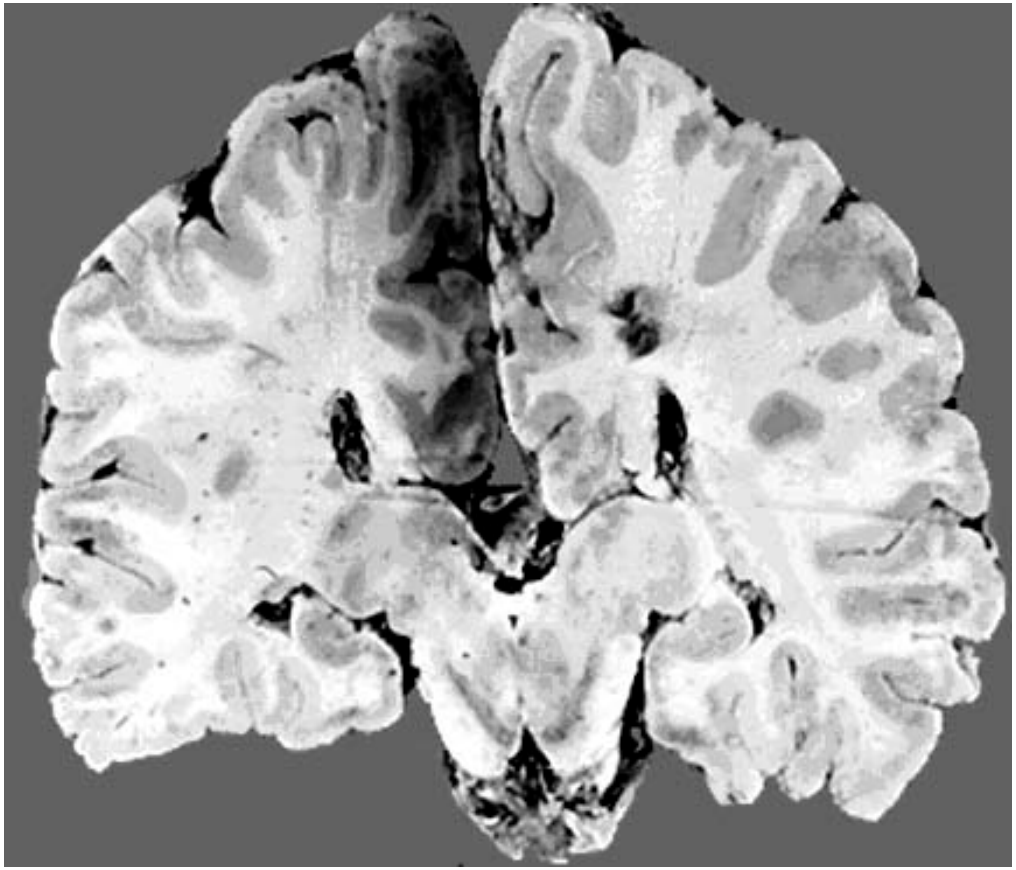


Development of cerebral commissural fibers

- Lamina terminalis: from roof plate of diencephalon to optic chiasm
- The first to form
  - Anterior commissure: connect olfactory bulb
  - Hippocampal commisure: connect hippocampal formation
- The largest: corpus callosum, connect neocortical areas



Agenesis of corpus callosum



Summary-1

- Neural plate: dorsal thickening of ectoderm at 3rd week, induced by underlying notochord & paraxial mesoderm
- Neural groove: infolding of neural plate, with neural folds on each side
- Neural tube: fusion of neural folds at 4th week
- Neural crest: neuroectodermal cells between neural tube& surface ectoderm

Summary-2

- Derivatives of neural tube
  - Forebrain: cerebral hemisphere, diencephalon
  - Embryonic midbrain: midbrain
  - Hindbrain: pons, medulla, cerebellum
  - Neural canal: ventricles, central canal
- Walls of neural tube: neurons and glia
  - Microglia: mesenchymal cells of blood vessels

Summary-3

- Pituitary gland
  - Ectodermal upgrowth from stomodeum: hypophysial pouch, become adenophypophysis
  - Neuroectoderm from diencephalon: neurophypophysial bud, become neurohypophysis
- Neural crest cells
  - Neurons in cranial, spinal & autonomic ganglia
  - Schwann cells
  - Chromaffin cells (adrenal medulla; cortex from mesoderm)