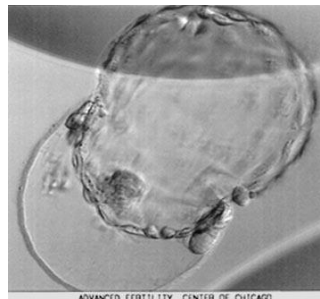
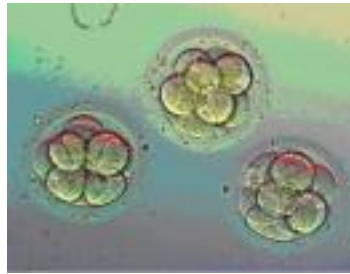
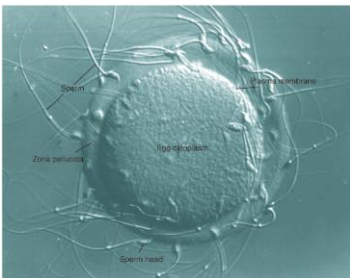
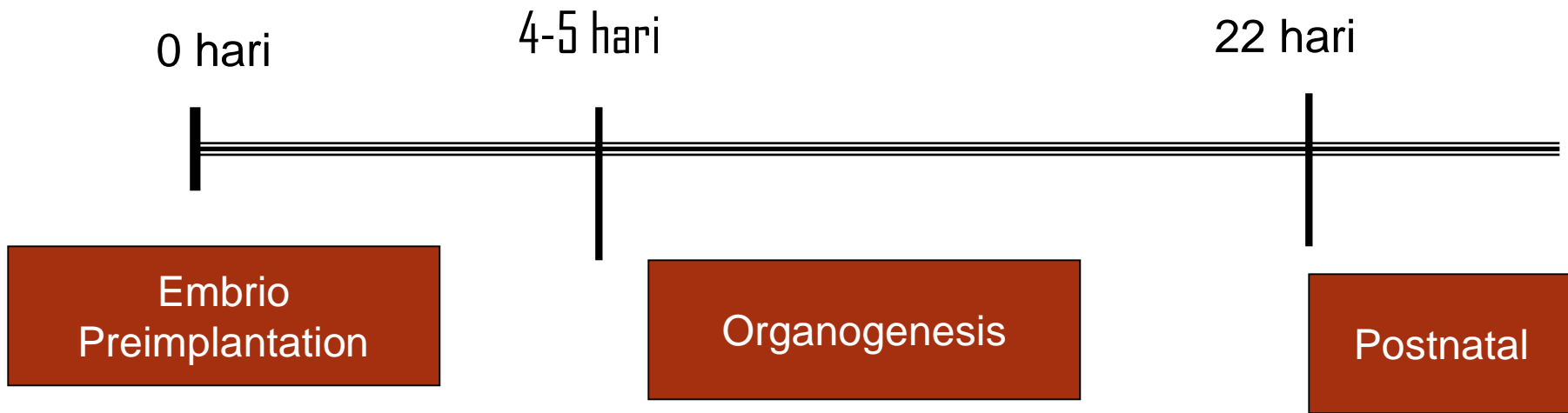


PERKEMBANGAN SISTEM SYARAF, KULIT & DERIVATNYA

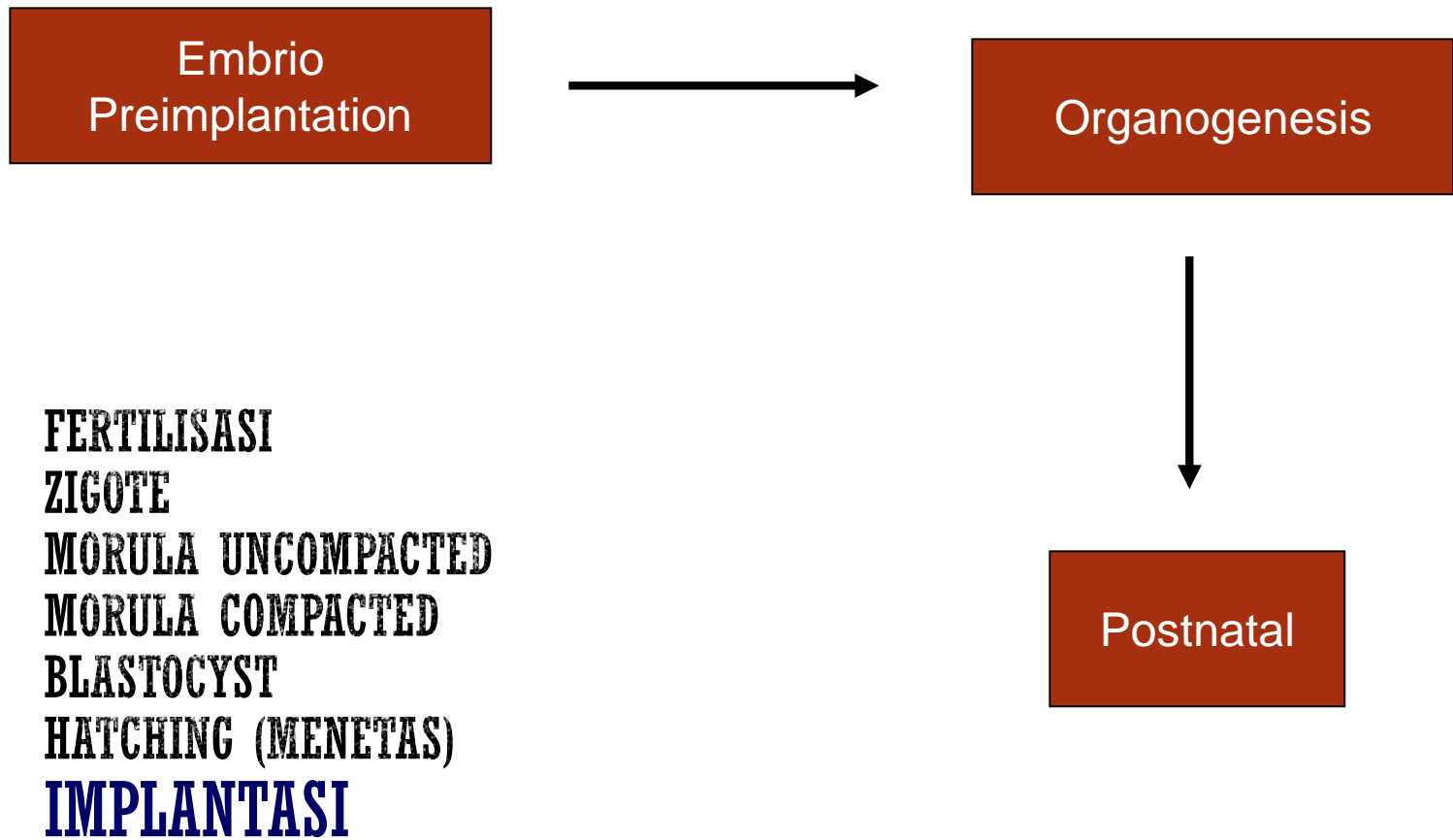


EMBRIOLOGIVETERINER

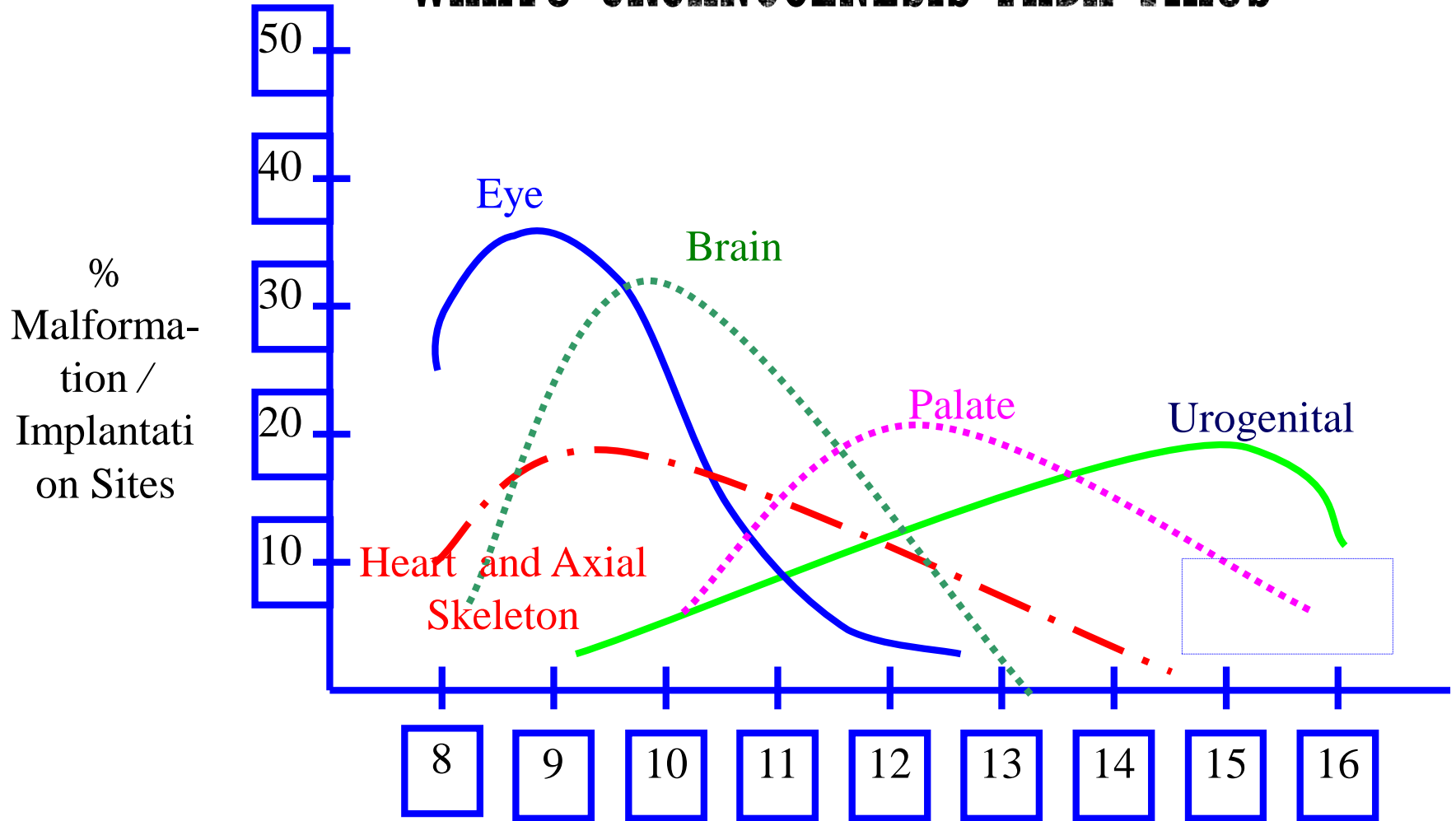
SKEMA WAKTU KEBUNTINGAN TIKUS



Skema Waktu kebuntingan mencit



WAKTU ORGANOGENESIS PADA TIKUS



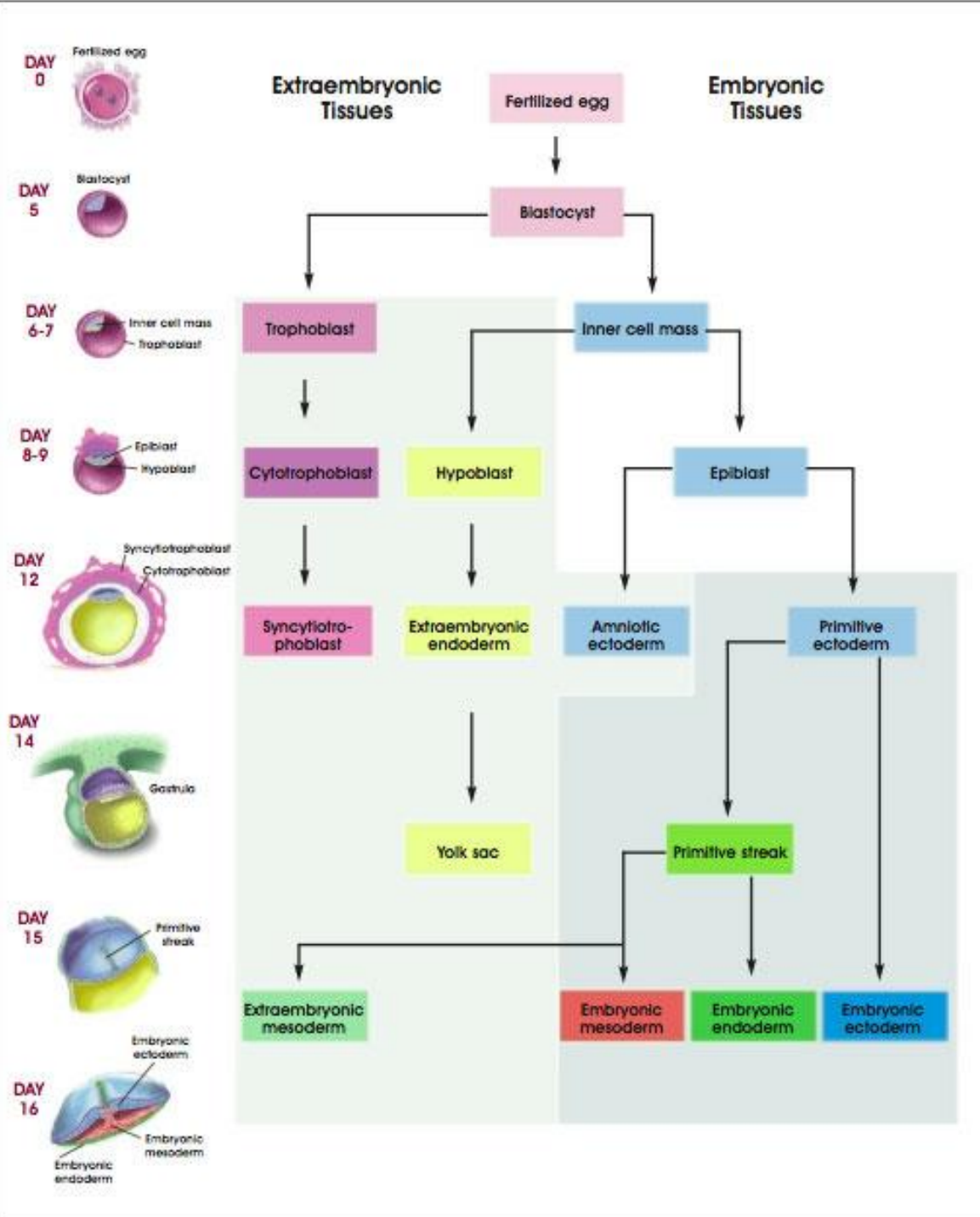
Days of Gestation in the Rat



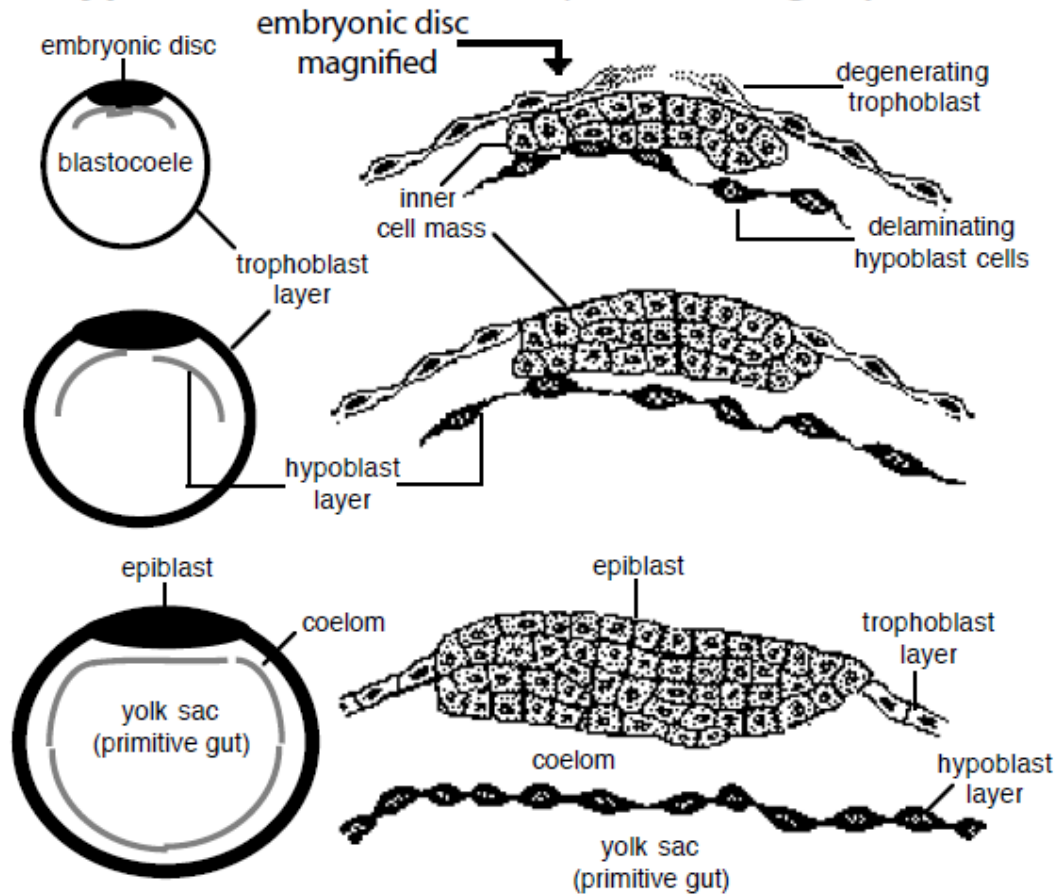
WAKTU PERKEMBANGAN AWAL PADA BEBERAPA SPESES MAMALIA

Mamalia	Waktu perkembangan awal (hari dari ovulasi)			
	Pembentukan blastocyst	Implantasi	Periode organogenesis	Jarak/lama gestasi
Mencit	3-4	4-5	6-15	19
Tikus	3-4	5-6	6-15	22
Kelinci	3-4	7-8	6-18	33
Domba	6-7	17-18	14-36	150
Kera (Rhesus)	5-7	9-11	20-45	164
Manusia	5-8	8-13	21-56	267

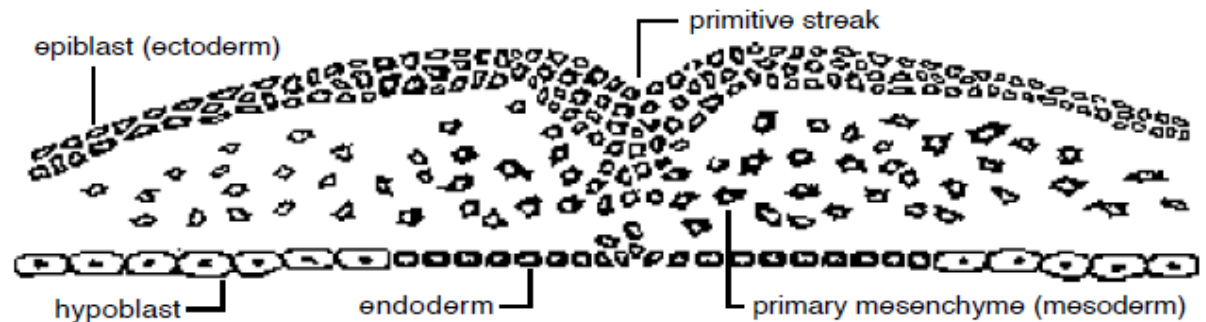




Hypoblast Formation (three stages)



- Hypoblast → endoderm
- Coelom → mesoderm → somatic (dekat ektoderm) & splanhnic (dekat mesoderm)
- Epiblast → ektoderm



Fate of the Germ Layers Formed at Gastrulation

Ectoderm

Nervous system and sense organs
Outer layer of skin (epidermis) and its associated structures (nails, hair, etc.)
Pituitary gland

Mesoderm

Notochord
Skeleton (bone and cartilage)
Muscles
Circulatory system
Excretory system
Reproductive system
Inner layer of skin (dermis)
Outer layers of digestive tube and of structures that develop from it, such as part of respiratory system

Endoderm

Lining of digestive tube and of structures that develop from it, such as lining of the respiratory system



- 1. EKTODERM** {
- **EKTODERM UMUM**
 - **EKTODERM SARAF**
 - **RIGI SARAF**

1.1 EKTODERM UMUM

- a) **EPIDERMIS (KULIT)**
- b) **DERIVAT KULIT : KELENJAR-KELENJAR (AMBING, KERINGAT, LEMAK, GIGI, TANDUK, KUKU)**
- c) **LENSA MATA ; ALAT TELINGA DALAM, INDERA BAU DAN RASA**
- d) **STOMADEUM : RUANG MULUT**
- e) **PROKTODEUM : BAGIAN ANUS**



1.2 EKTODERM SARAF

- a) OTAK DAN SUMSUM PUNGGUNG**
- b) SARAF TEPI**
- c) PERSARAFAN INDERA : MATA, HIDUNG, RABA**

1.3 RIGI SARAF

KHROMATOFOR KULIT → PIGMEN

MELANIN

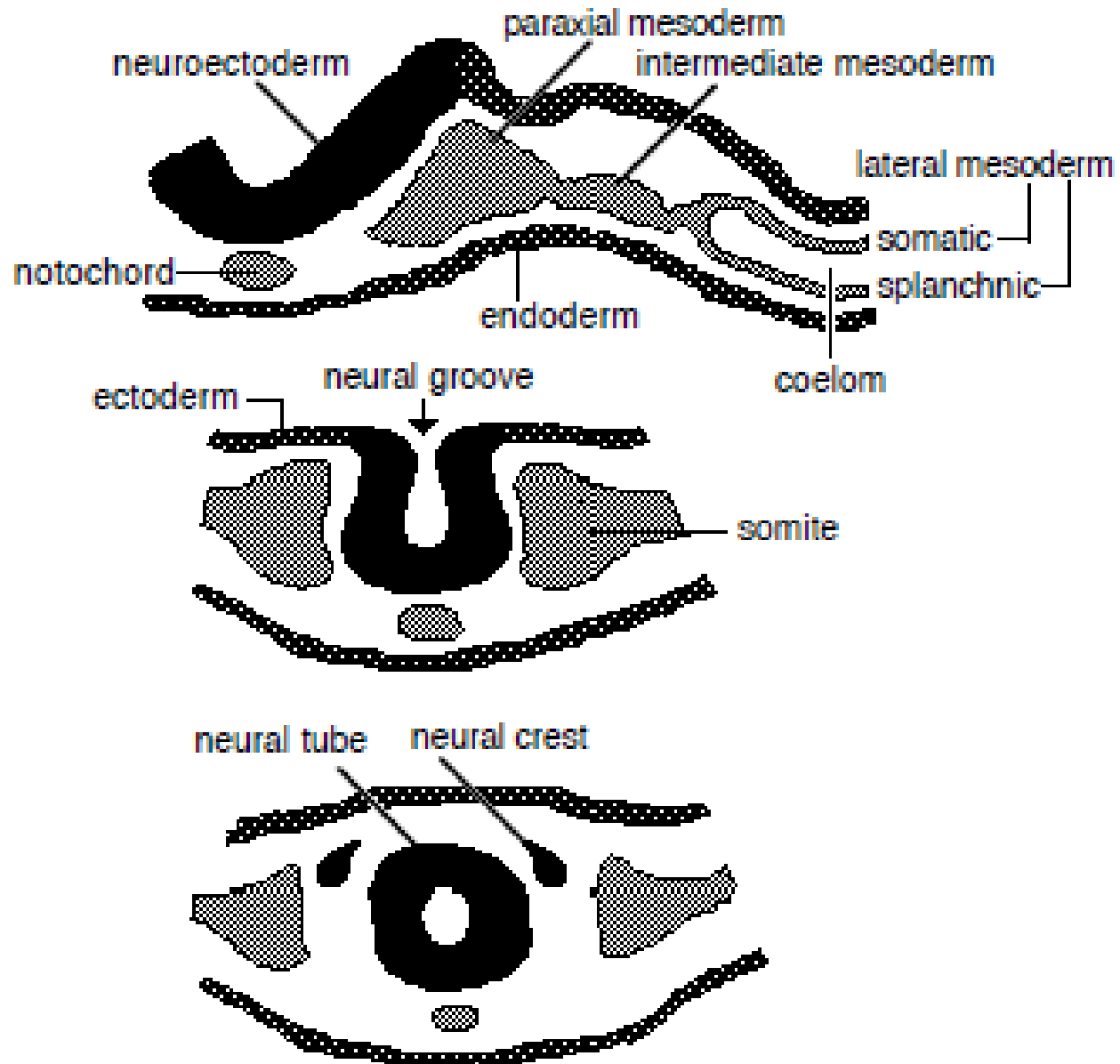


AWAL PEMBENTUKAN SISTEM SYARAF (NEURULASI)

- Notocord menginduksi ectoderm menjadi jaringan saraf
- Tahapan neurulasi:
 - Sel ektoderm yang berada di atas notochord selnya menjadi columnar tinggi → **neural plate**
 - Neural plate melekok pada tiap sisi → **neural groove**
 - Neural groove saling bertemu dan menyatu pada bagian median dorsal → **neural tube**
 - Secara bilateral, jika neural groove bergabung dengan non-neural ectoderm, sel yang berada di dekat neural groove berproliferasi dan menempati tempat di dorso lateral neural tube → **neural crest**

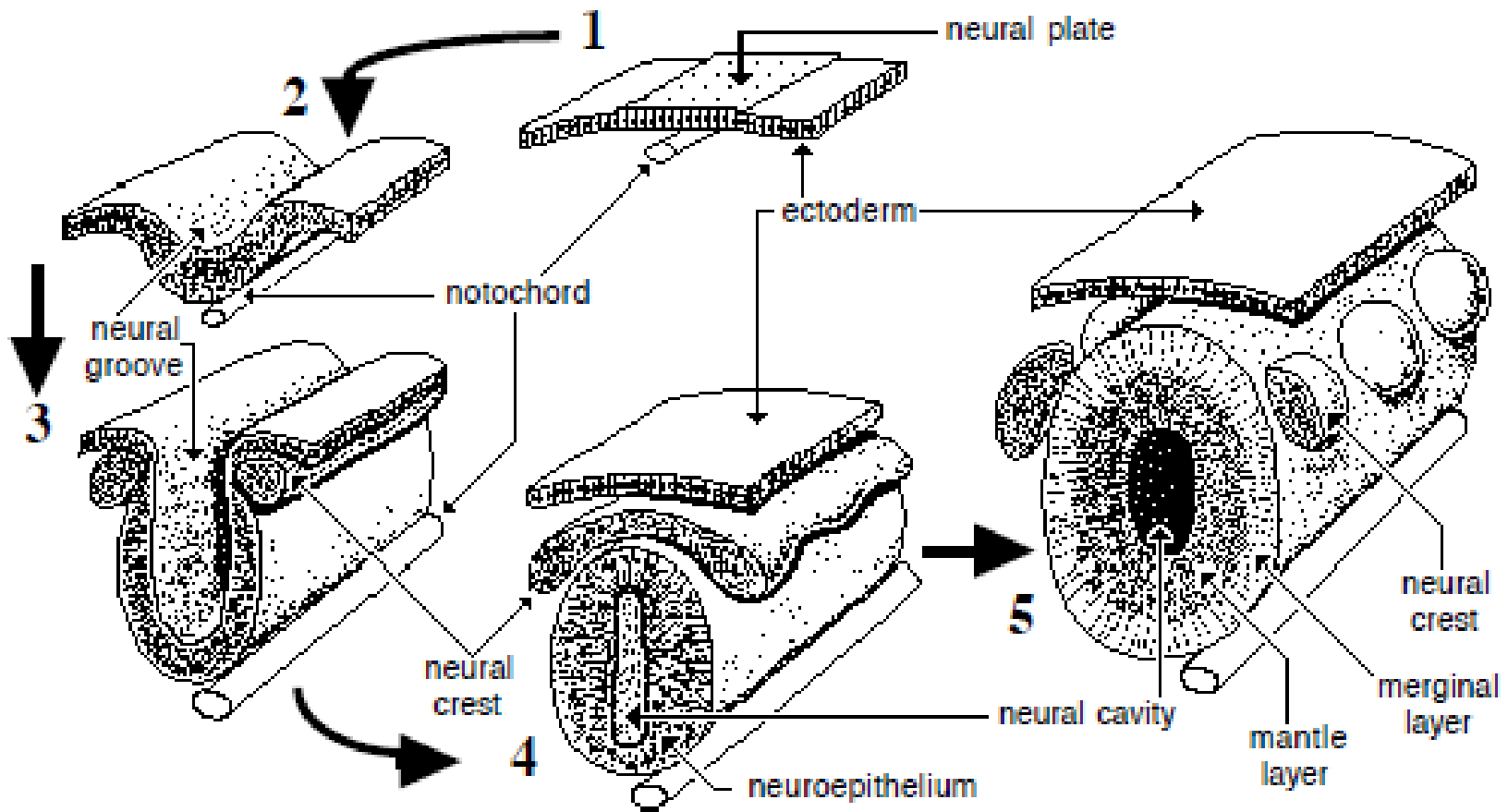


Neurulation



- NEURAL TUBE → sistem syaraf pusat : **otak** dan **sumsum tulang**
→ neural cavity: ventrikel otak; central canal: spinal cord
- NEURAL CREST → migrasi ke dorsal: **sel pigmen pada kulit**
→ migrasi ke ventral: **sel neuron dan sel glia**
pada saraf tepi atau **sel medulla adrenal**
→ pada cranial → mesenchyme
(ectomesenchyme): **meningens, tulang, fascia** dan **gigi**

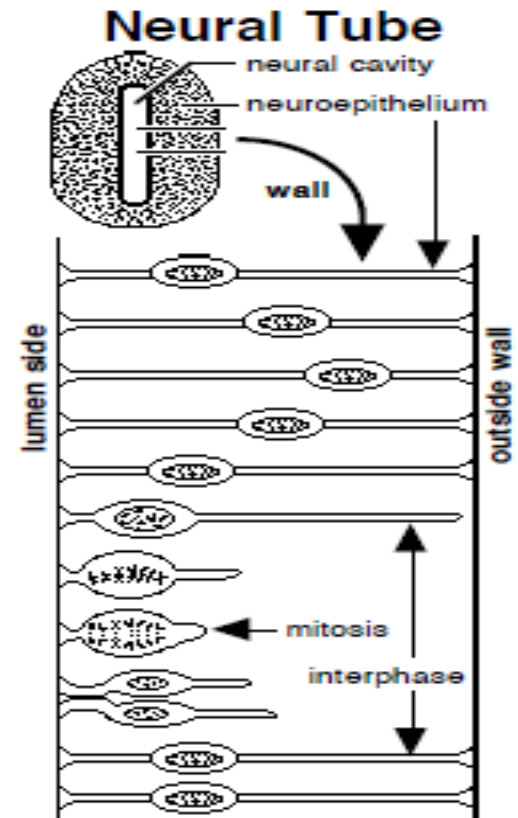




FORMATION OF NEURONS AND GLIAL CELLS FROM NEUROEPITHELIUM:

- Neuroepithelium → **neurons**, **glial cells** (astrocytes dan oligodendrocytes), dan **ependymal cells** (additionally, the CNS contains blood vessels and microglial cells derived from mesoderm).

- Neuroepithelial cells have processes which contact the inner and outer surfaces of the neural tube; they undergo mitotic division in the following manner:
 - ✓ nucleus (and perikaryon) **moves away from the neural cavity for interphase** (DNA synthesis);
 - ✓ nucleus moves toward the neural cavity and the cell becomes **spherical and loses its connection to the outer surface of the neural tube for mitosis**; this inward-outward nuclear movement is repeated at each cell division.

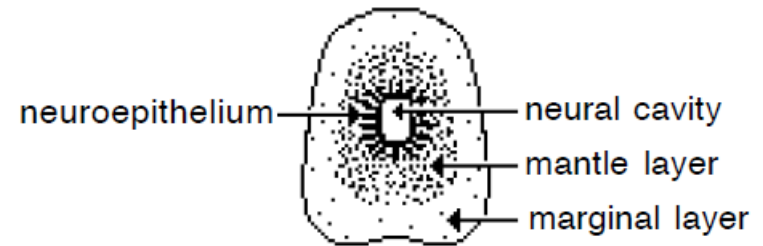


- Some cell divisions are differential, producing **neuroblasts** which give rise to **neurons** or **glioblasts** (spongioblasts) which give rise to **glial cells** (oligodendroglia and astrocytes). Neuroblasts and glioblasts lose contact with surfaces of the neural tube and **migrate toward the center of the neural tubewall.**
- Note: Microglia are derived from mesoderm associated with invading blood vessels

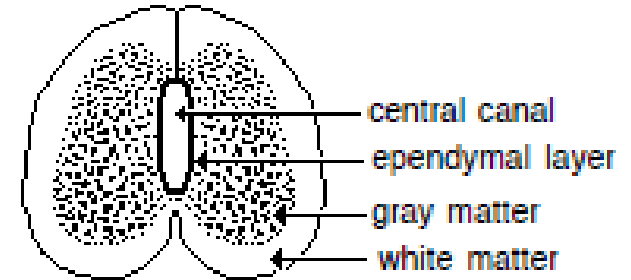


LAYERS AND PLATES OF THE NEURAL TUBE:

- Akumulasi neuroblasts dan glioblasts → **mantle layer**, sebuah daerah yang padat dengan sel di dinding neural tube.
- Sel yang mengelilingi neural cavity terdiri atas **ependymal cells** → **ependymal layer**.
- Disekeliling mantle layer, terdapat zona yang berisi axons dari neurons dan beberapa glial cells → **marginal layer**.
- Mantle layer → **gray matter**
- Marginal layer → **white matter** of the CNS.



Neural Tube

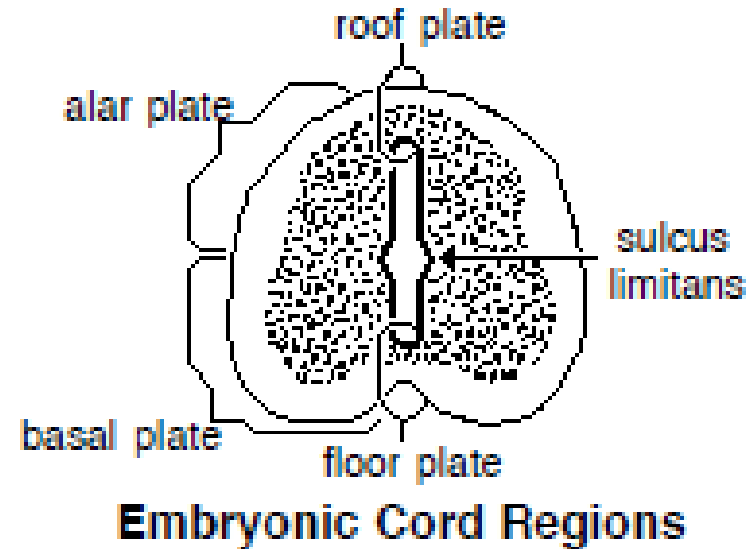


Embryonic Spinal Cord

- ✓ **White matter** refers to CNS regions that have a high density of **myelinated axons**.
- ✓ **Gray matter** has sparse myelinated axons and generally a high density of **neuron cell bodies**.



- Bagian lateral dari neural tube dibagi menjadi dua daerah (plates).
- Bagian bilateral pada neural cavity (*sulcus limitans*) membagi masing-masing dinding lateral menjadi *alar plate* (dorsal) and a *basal plate* (ventral).
- Bagian garis tengah daerah dorsal and ventral neural cavity, terbagi menjadi *roof plate* dan *floor plate*.



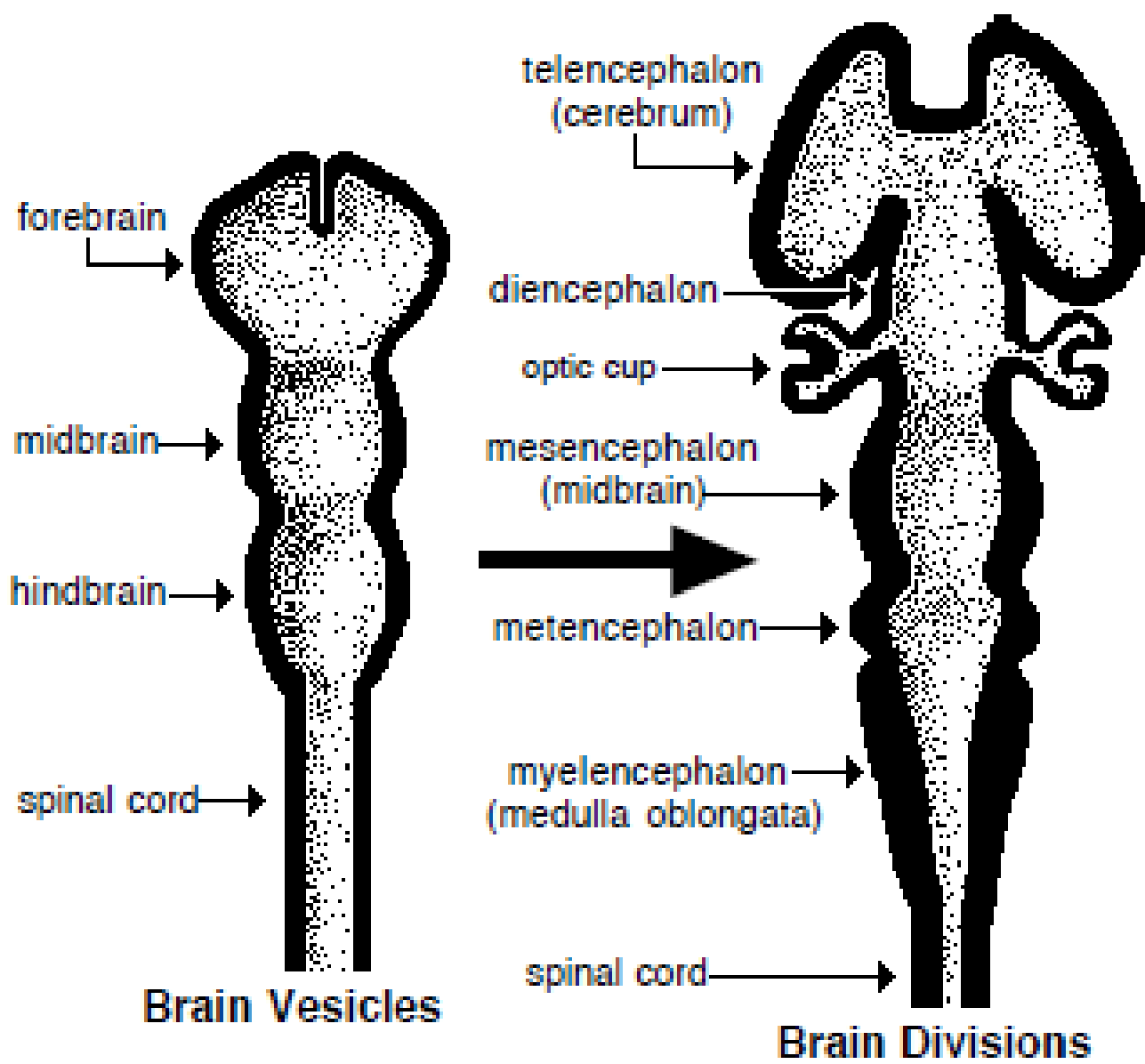
- **Basal plate** → efferent neurons yang mengirim axons ke PNS.
- **Alar plate** → neurons yang menerima input dari PNS.



FORMATION OF THE CENTRAL NERVOUS SYSTEM

- The cranial end of the neural tube forms three vesicles (enlargements) → **five primary divisions of the brain**
- Caudal to the brain the neural tube → **spinal cord**.
- **Flexures**: during development, the brain undergoes **three flexures** which generally disappear (straighten out) in domestic animals.
- The **midbrain flexure** occurs at the level of the **midbrain**.
- The **cervical flexure** appears at the **junction between the brain and spinal cord** (it persists slightly in domestic animals).
- The **pontine flexure** is **concave dorsally** (the other flexures are concave ventrally).





Adult CNS Structures Derived From Embryonic Brain Divisions

Embryonic Brain Division	Derived Brain Structures	Definitive Brain Cavities	Associated Cranial Nerves
FOREBRAIN Telencephalon Diencephalon	Cerebrum Thalamus; hypothalamus; etc.	Lateral ventricles Third Ventricle	Olfactory (I) Optic (II)
MIDBRAIN Mesencephalon	Midbrain	Mesencephalic aqueduct	III & IV
HINDBRAIN Metencephalon Myelencephalon	Pons and Cerebellum Medulla Oblongata	Fourth ventricle	V VI—XII

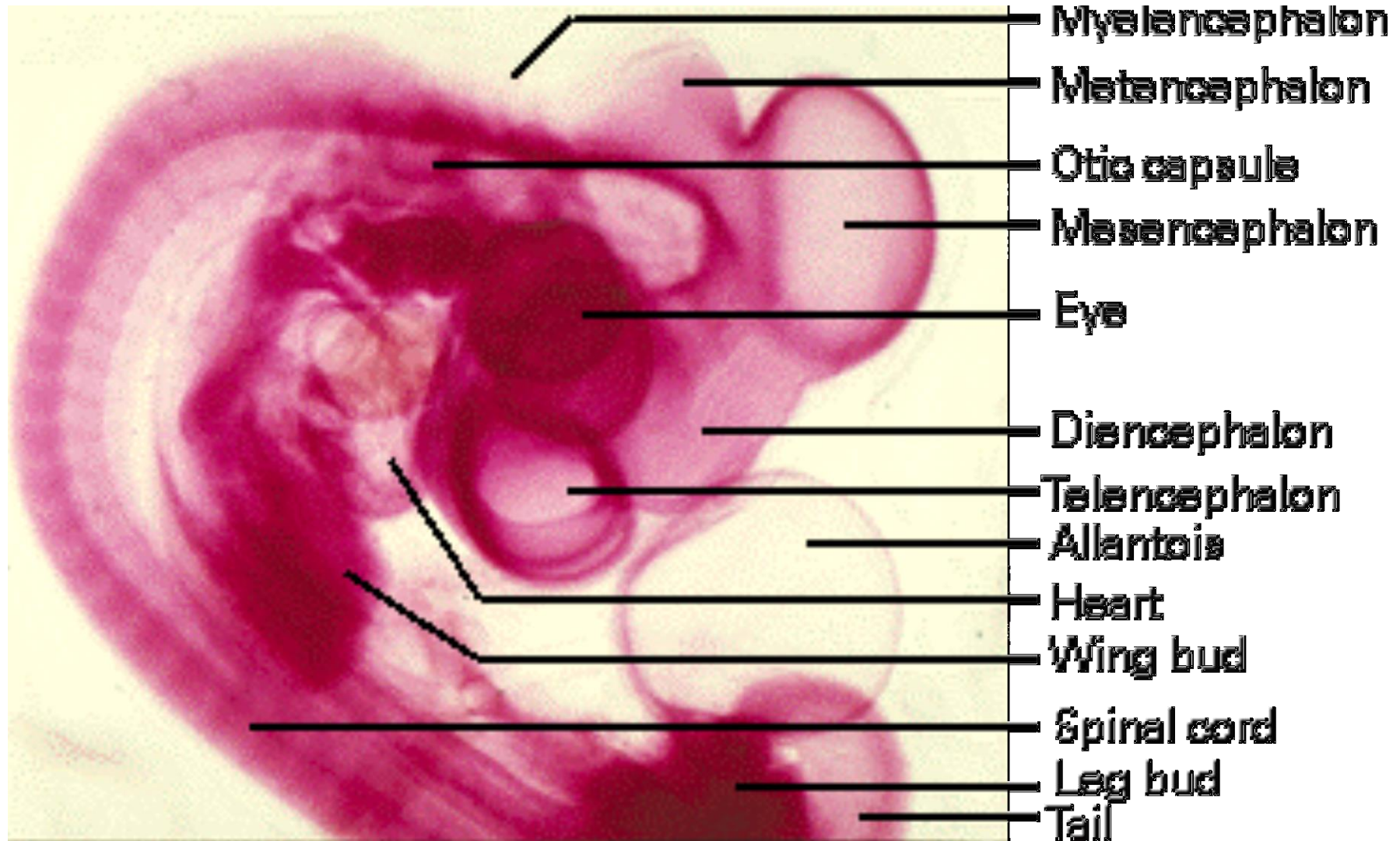
Note: The portion of brain remaining after the cerebrum and cerebellum are removed is referred to as the *brain stem*.



SYARAF CRANIAL, FUNGSI DAN DISTRIBUSINYA

Nervus	Komponen yg berhubungan dg CNS	FUNGSI KOMPONEN	DISTRIBUTION
I	TELECEPHALON	OLFACTOR	NOSE
	DIENCEPHALON	VISION	RETINA
III	MECENCEPHALON	MOTOR	INTRAOCULAR
V	METENCEPHALON	SOMATIC	BRACHIAL ARCH
VII	METENCEPHALON	HEARING, BALANCE	INNER EAR
XIII	MYELENCEPHALON	MOTOR	TONGUE MUSCLE





FOREBRAIN (DERIVED ENTIRELY FROM ALAR PLATE)

TELENCEPHALON (CEREBRUM):

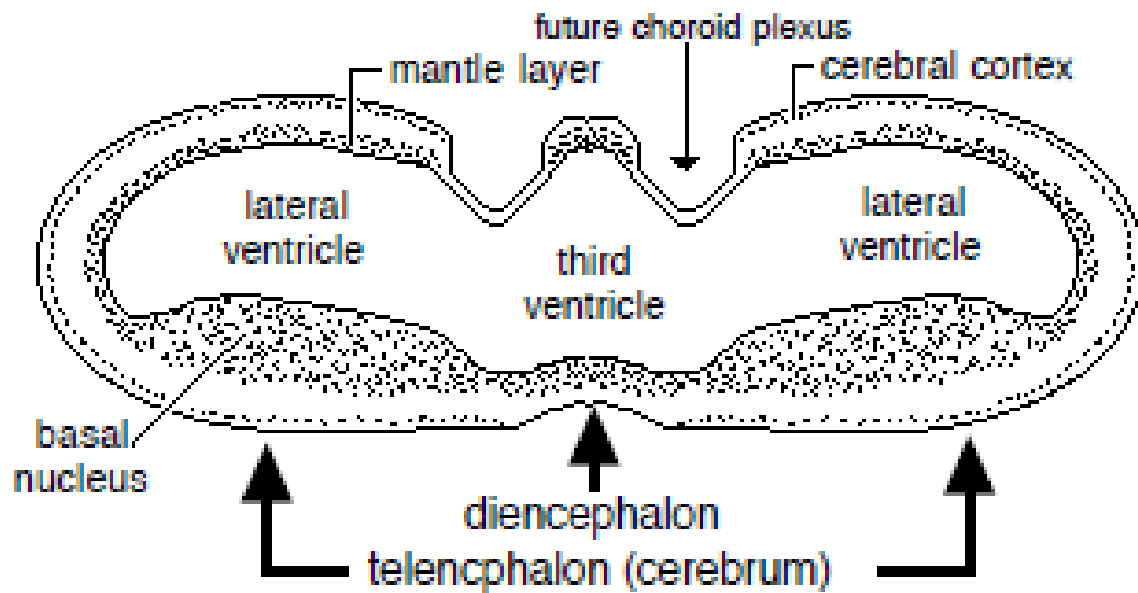
- bilateral hollow berkembang menjadi *hemispheres cerebral kanan* dan *kiri*; rongga masing-masing pertumbuhan membentuk *lateral ventricle* yang berhubungan dengan ventrikel ketiga melalui **foramen interventricular** (plexus coronoideus berkembang pada dinding masing-masing ventricle lateral, yang berhubungan dengan pexus coronoideus ventrikel ketiga melalui foramen interventricular);
- Pada midline, ujung rostral telencephalon membentuk **dinding rostral dari ventrikel ketiga** (dinding tersebut membentuk lamina terminalis);
- Mantle layer yang mengelilingi ventricle lateral pada setiap hemisphere membentuk **basal nuclei** dan *cerebral cortex*;



Migrasi sel untuk membentuk kortek cerebri:

- Dari mantle layer, sel bermigrasi secara radial menuju permukaan dari cerebral hemisphere, di arahkan oleh sel glial yang terdapat pada permukaan ventricular sampai permukaan luar dinding cerebral (setiap locus mantle membentuk area spesifik dari cerebral cortex);
- Migrasi terdiri dari beberapa gelombang; gelombang pertama (membentuk lapisan kortek paling dalam) migrasi ke arah permukaan kortek; gelombang kedua (membentuk lapisan kortek dalam selanjutnya) migrasi ke arah permukaan cortical, melewati neuron yang telah terbentuk pada gelombang migrasi pertama di posisi lebih dalam; gelombang ketiga . . . dst. (sampai terbentuk tujuh lapisan kortek cerebri).





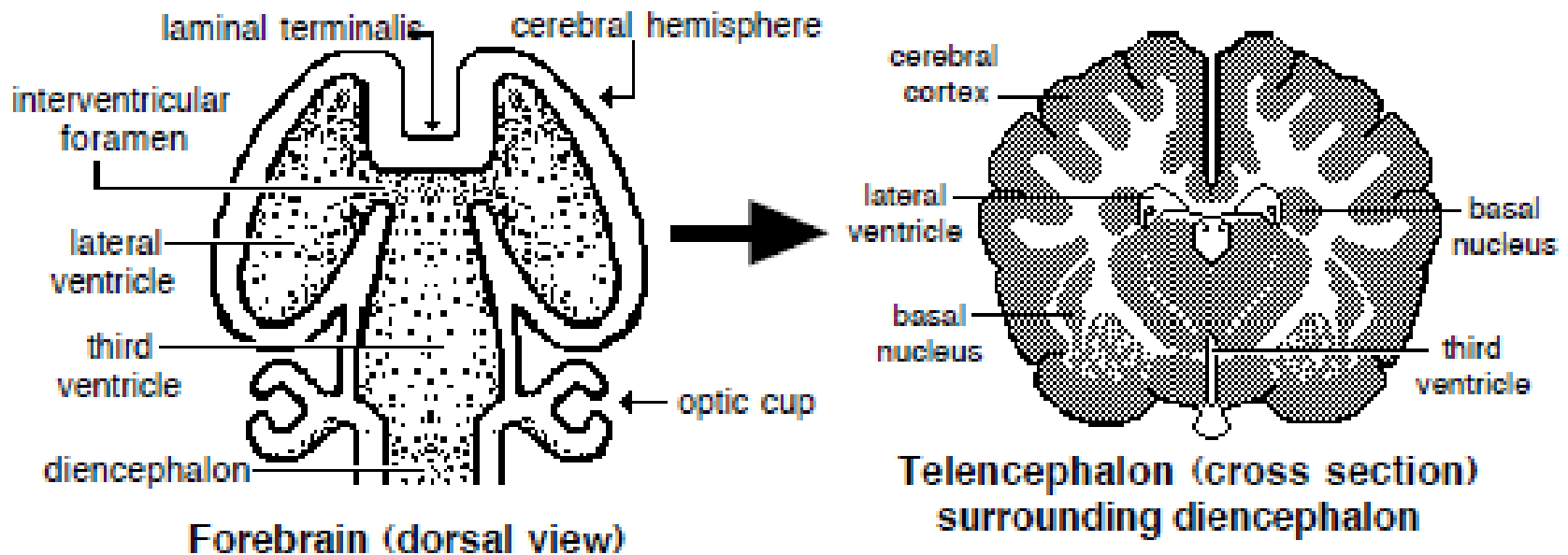
Developing Forebrain (transverse section)



DIENCEPHALON:

- neural cavity meluas secara dorsoventral dan menjadi **ventrikel ketiga**, roof plate melebar dan plexuses choroideus berkembang secara bilateral di atas ventrikel ketiga dan mensekresikan **cairan serebrospinal**
- Bagian bawah ventrikel ketiga → **neurohypophysis** (neural lobe dari pituitary gland);
- Mantle layer dari diencephalon → **thalamus, hypothalamus, etc.**
- Nervus opticus berkembang kearah luar → **dinding diencephalon.**





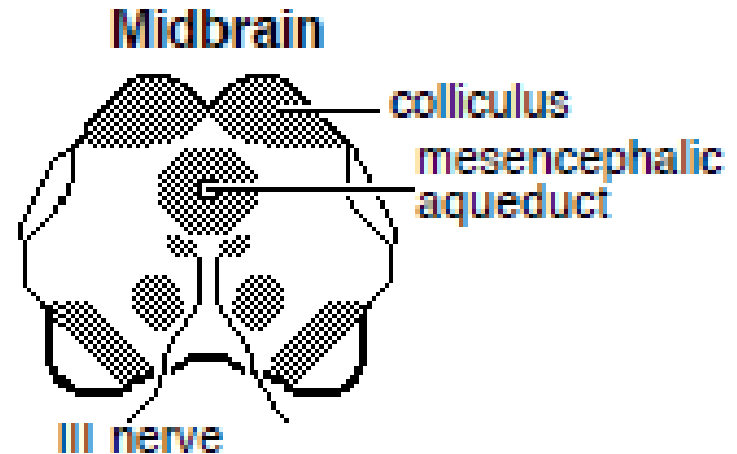
NOTE:

- Carnivores → born with a nervous system that does not mature until about six weeks postnatally (mature behavior is correspondingly delayed).
- In herbivores -->the nervous system is close to being mature at birth.



MIDBRAIN

- Neural cavity midbrain → *mesencephalic aqueduct* (bukan berupa ventricle karena terdiri dari jaringan saraf dan hanya terdapat sedikit plexus coronoideus).
- Alar plates → dua pasang tonjolan di dorsal yang membentuk **rostral** dan **caudal colliculi** (berhubungan dengan visual dan auditory reflexes, respectively);
- Basal plate → **nervus oculomotor (III)** dan **trochlear (IV)** yang menginnervasi muskulus yang menggerakkan mata.



Note: The midbrain is the rostral extent of the basal plate (efferent neurons).



HINDBRAIN: CEREBELLUM

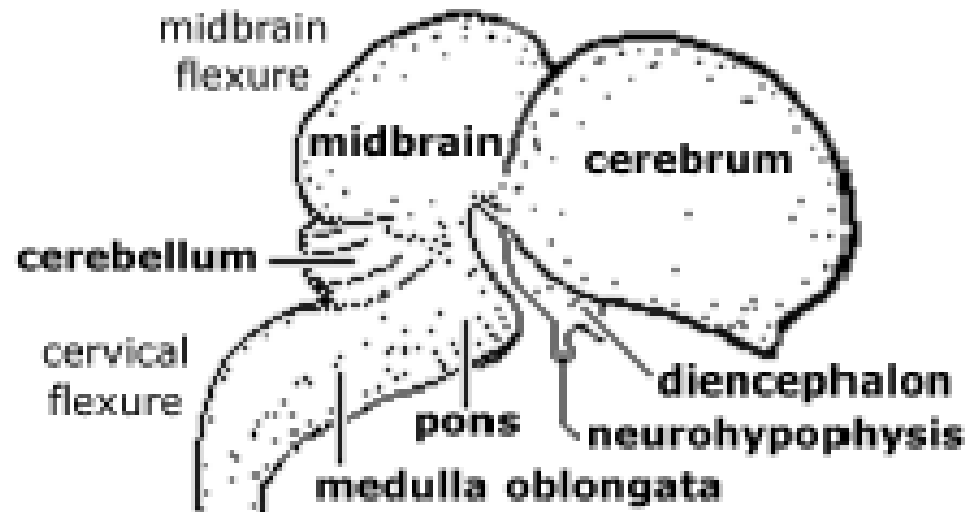
- • Adult cerebellum features surface **gray matter**, called **cerebellar cortex**, and three pair of **cerebellar nuclei** located deep within the cerebellar white matter.
- Cerebellum dihubungkan dengan brain stem melalui tiga pasang *peduncles cerebellar*, yang masing-masing terdiri atas white matter fibers.
- Cerebellar cortex terdiri atas tiga lapisan:
 - lapisan superficial → **molecular layer**;
 - lapisan tengah → **piriform** (Purkinje) *cell layer*;
 - lapisan dalam → **granular** (granule cell) *layer*.



cellular migrations:

- **superficial and deep layers of neurons** are evident within the mantle layer of the future cerebellum; the deep cells migrate (pass the superficial cells) toward the cerebellar surface and become **Purkinje cells** of the cerebellar cortex; meanwhile, neurons of the superficial layer migrate deeply and become cerebellar nuclei;
- **neuroblasts** located laterally in the rhombic lip migrate along the outer surface of the cerebellum, forming an ***external germinal layer*** (which continues to undergo mitosis); subsequently, neurons migrate deep to the Purkinje cells and form the **granule cell layer** of the cerebellar cortex;
- some **alar plate** neurons migrate to the ventral surface of the pons, forming **pontine nuclei** which send axons to the cerebellum.





Brain Divisions & Flexures

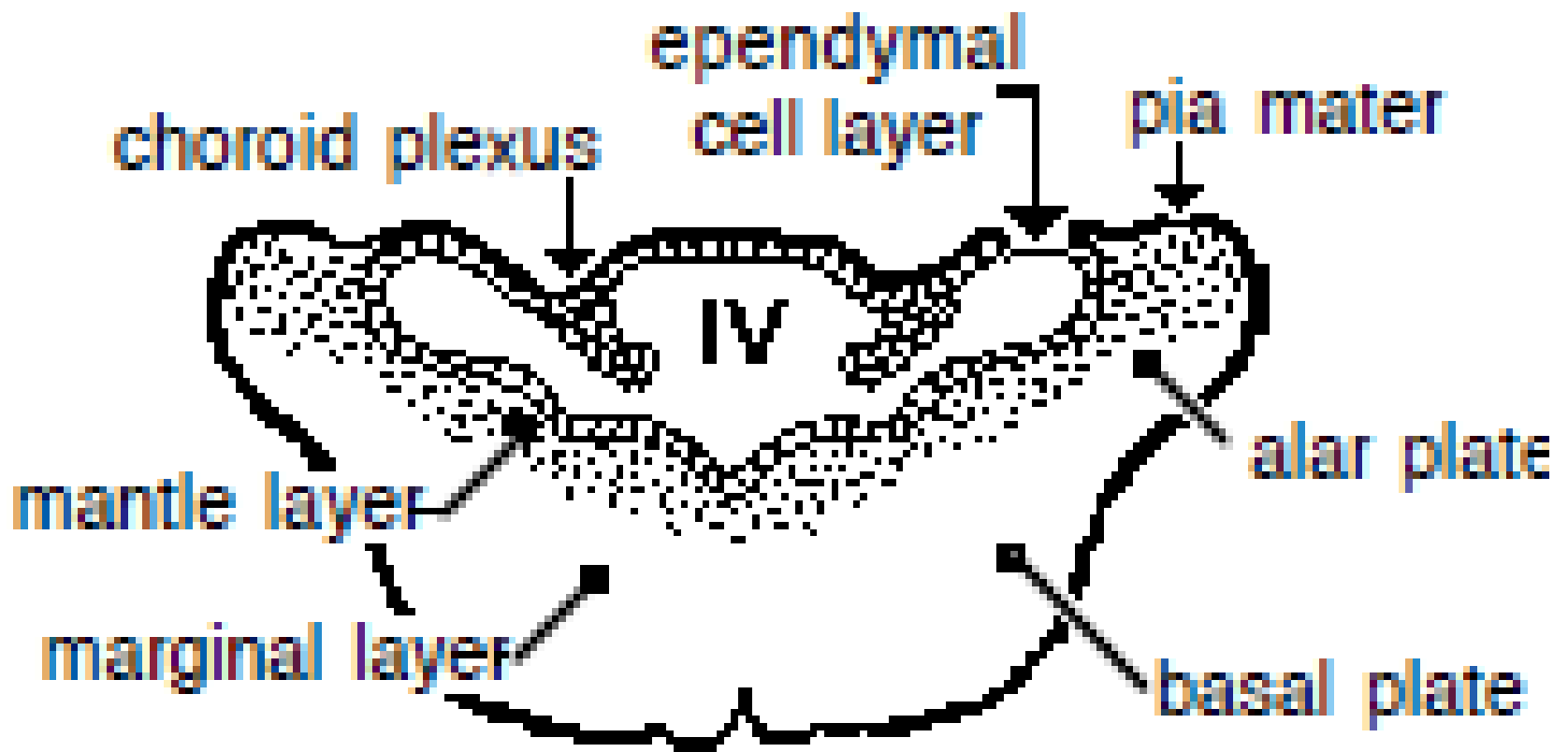
- Migration of neuron populations past one another allows connections to be established between neurons of the respective populations.
- Neurons that fail to connect are destined to **degenerate**.
- Connections are made by axons that subsequently elongate as neurons migrate during growth.



HINDBRAIN: MEDULLA OBLONGATA AND PONS

- **alar plates** → move laterally
- **cavity of the neural tube** expands dorsally → **fourth ventricle**;
- the roof of the fourth ventricle (**roof plate**) is stretched and reduced → **a layer of ependymal cells** covered by **pia mater**;
- **choroid plexus** develops bilaterally in the roof of the ventricle and secretes → **cerebrospinal fluid**;
- **basal plate** (containing efferent neurons of cranial nerves) is positioned medial to the alar plate and ventral to the fourth ventricle;
- **white and gray matter** (marginal & mantle layers) become **intermixed** (unlike spinal cord); cerebellar development adds extra structures.





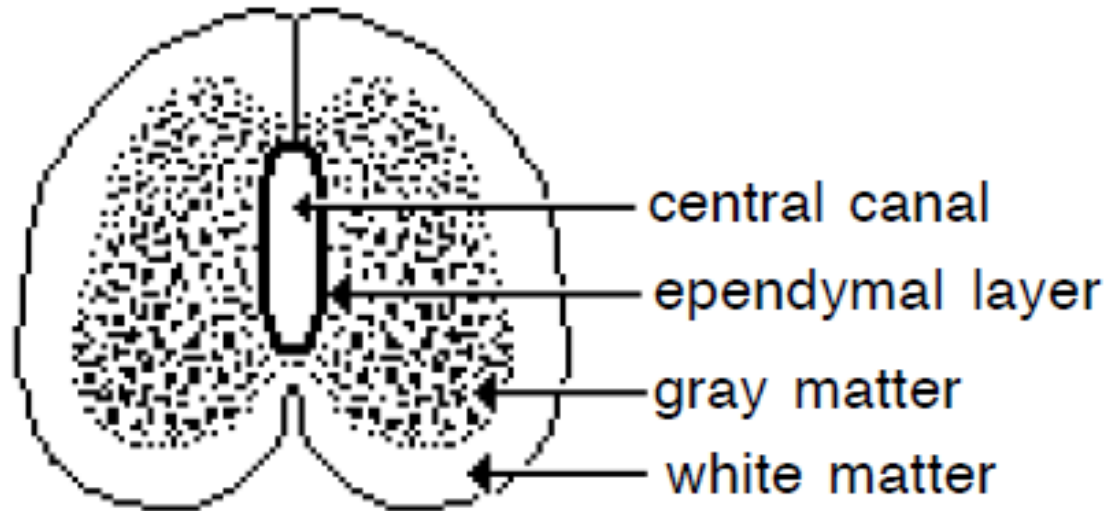
Medulla Oblongata



SPINAL CORD DEVELOPMENT

- neural cavity → *central canal* dikelilingi **sel ependymal**
- Pertumbuhan daerah alar dan basal plates (daerah roof dan floor tidak ikut berkembang) → bagian kiri dan kanan dibatasi oleh **ventral median fissure** dan **dorsal median fissure** (septum)
- Lapisan mantel → **gray matter**, i.e., dorsal and ventral *gray columns* separated by intermediate gray matter (in profile, the columns are usually called *horns*); cell migration from the basal plate produces a lateral gray column (horn) at thoracic and cranial lumbar levels of the spinal cord (sympathetic preganglionic neurons);
- Lapisan tepi → **white matter** (which is subdivided bilaterally into a *dorsal funiculus* (bundle), a *lateral funiculus*, and a *ventral funiculus*).





Embryonic Spinal Cord

Enlargements of spinal cord segments that innervate limbs (cervical and lumbosacral enlargements) are the result of greater numbers of neurons in those segments, due to less neuronal degeneration compared to segments that do not innervate limbs.



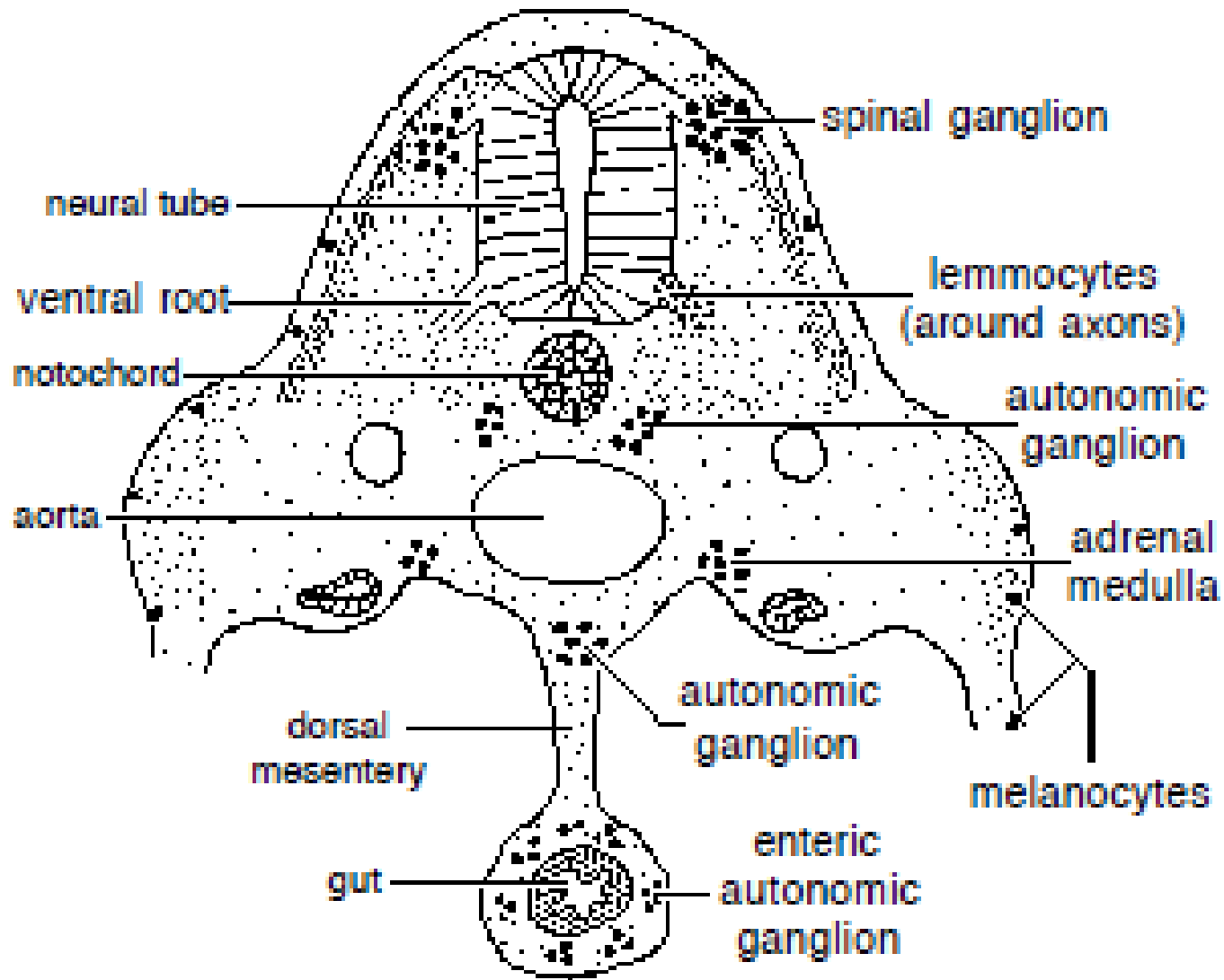
PERIPHERAL NERVOUS SYSTEM

- • The peripheral nervous system (PNS) consists of **cranial and spinal nerves**.
- Nerve fibers within peripheral nerves may be classified as **afferent (sensory) or efferent (motor)** and as **somatic (innervating skin and skeletal muscle) or visceral (innervating vessels and viscera)**.
- The visceral efferent (autonomic) pathway involves two neurons: 1] a **preganglionic neuron** that originates in the CNS and 2] a **postganglionic neuron** located entirely in the PNS. The glial cell of the PNS is the neurolemmocyte (Schwann cell).
- • All afferent neurons are unipolar and have their cell bodies in sensory ganglia, either spinal ganglia on dorsal roots or ganglia associated with cranial nerves. Somatic efferent and preganglionic visceral efferent neurons have their cell bodies located in the CNS, but their axons extend into the PNS. Postganglionic visceral efferent neurons have their cell bodies in autonomic ganglia.



- *neurolemmocytes* (Schwann cells) arise from **neural crest** and migrate throughout the PNS, ensheathing and myelinating axons and forming satellite cells in ganglia;
- *afferent neurons* originate from **neural crest** as bipolar cells that subsequently *ferent* become unipolar; in the case of cranial nerves, afferent neurons also originate from placodes (placode = localized thickening of ectoderm in the head);
- *postganglionic visceral efferent neurons* arise from **neural crest**, the cells migrate to form autonomic ganglia at positions within the head, or beside vertebrae (along sympathetic trunk), or near the aorta, or in the gut wall (the latter are parasympathetic and come from sacral and hindbrain regions);
- *somatic efferent neurons* and *preganglionic visceral efferent neurons* arise from the **basal plate of the neural tube**; their cell bodies remain in the CNS and their axons join peripheral nerves;





Developing Peripheral Nervous System



- *Note:* Cranial nerves innervate specific pharyngeal arches and their derivatives:
- **trigeminal (V)** - innervates first pharyngeal arch (**muscles of mastication**)
- **facial (VII)** - innervates second pharyngeal arch (**muscles of facial expression**)
- **glossopharyngeal (IX)** - innervates third pharyngeal arch (**pharyngeal muscles**)
- **vagus (X)** - 4 & 6 pharyngeal arches (**muscles of pharynx, larynx, & esophagus**)



FORMATION OF MENINGES

Meninges surround the CNS and the roots of spinal and cranial nerves.

Three meningeal layers (**dura mater**, **arachnoid**, and **pia mater**) are formed as follows:

- mesenchyme surrounding the neural tube aggregates into two layers;
- outer layer → **dura mater**;
- cavities develop and coalesce within the inner layer → **arachnoid** and **pia mater**; the cavity → **subarachnoid space** which contains cerebrospinal fluid.

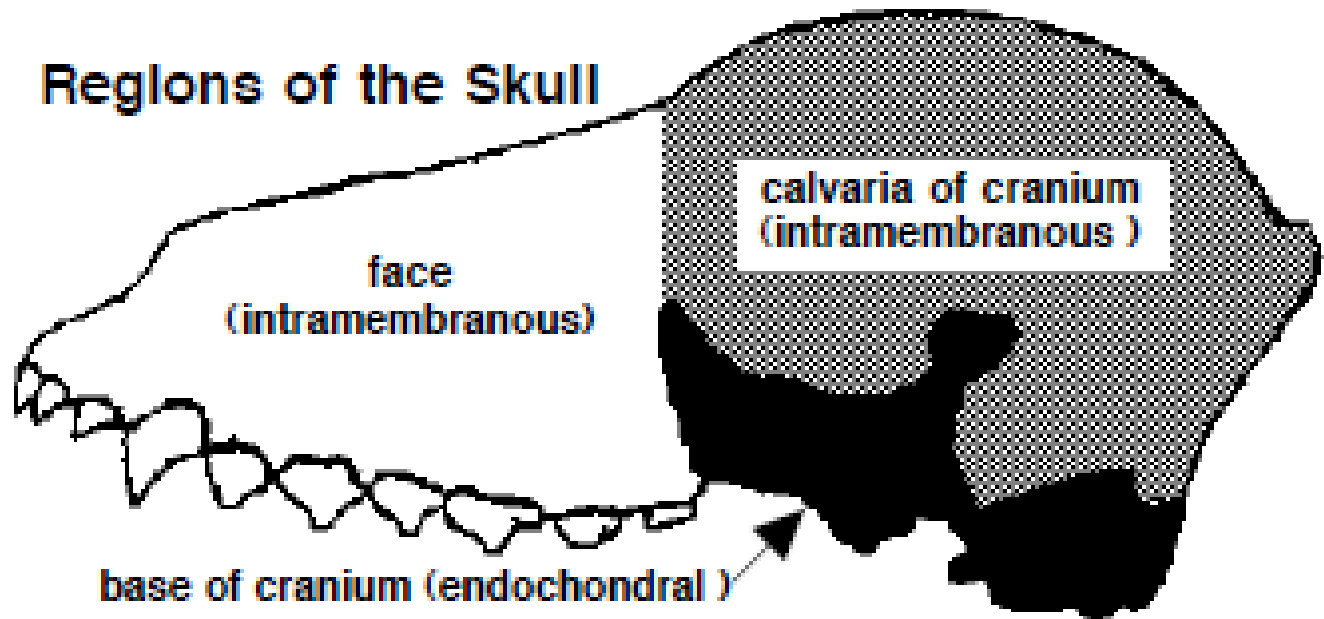


TULANG TENGGORAK

- Dasar cranium berkembang secara **endochondral**, bagian dorsal cranium dan daerah faciei berkembang secara **intramembranosus**
- **Endochondral**: tulang terbentuk dari **sclerotome somitomers** dan **sclerotome somite keempat** (somite occipital)
- **Intramembranosus**: tulang terbentuk dari **ectomesenchyme** (mesenchyme yang berkembang dari neural crest) yang membentuk tulang rawan, tulang dan jaringan ikat pada faciei dan dorsal kepala.



- Persendian intramembranosus → **suture**
- Daerah suture yang luas diantara tulang → **fontanel**s
- Suture dan fontanel yang memungkinkan terjadinya overlap lempeng tulang saat partus



TULANG TENGGORAK

1. Chondrocranium

- dasar tengkorak,
- kapsula sensoris
- otak, organ indera

endochondral ossification

2. Membrane (dermal) bone

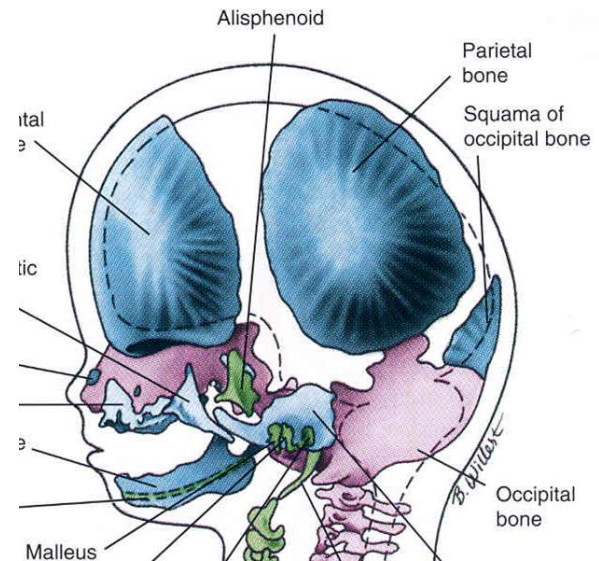
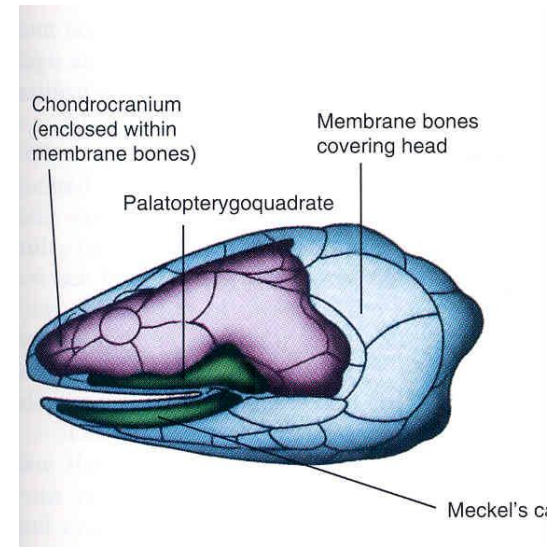
- atap tengkorak

ossification of mesenchyme
neural crest

3. Viscerocranium

- insang (Ikan) dan rahang
- mulut dan faring

pharyngeal atau branchial arch



TULANG TENGGORAK

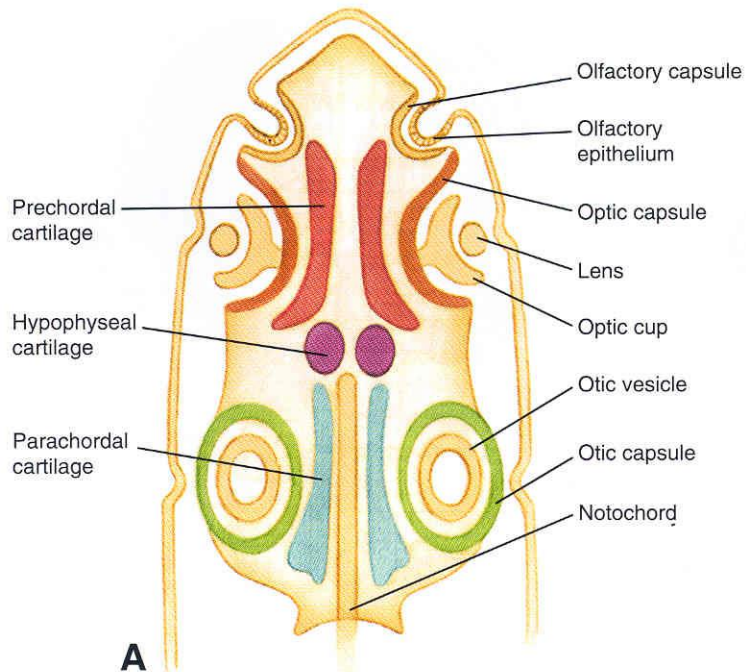
Chondrocranium

→ Prechordal cartilages

→ Hypophyseal cartilages

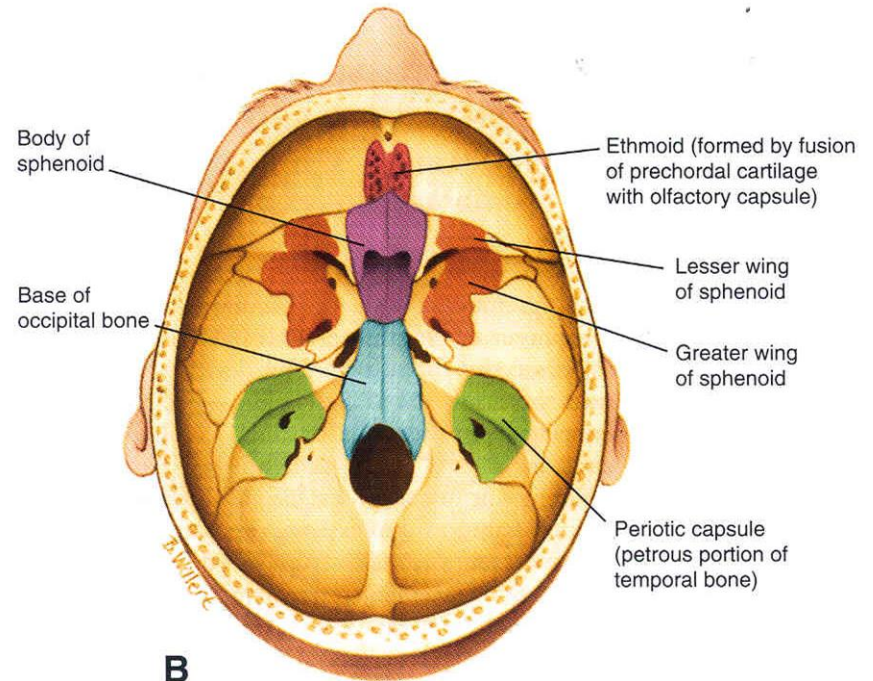
→ Parachordal cartilages

→ Kapsula sensoris: mata, telinga, hidung



A

Dasar Tengkorak.....



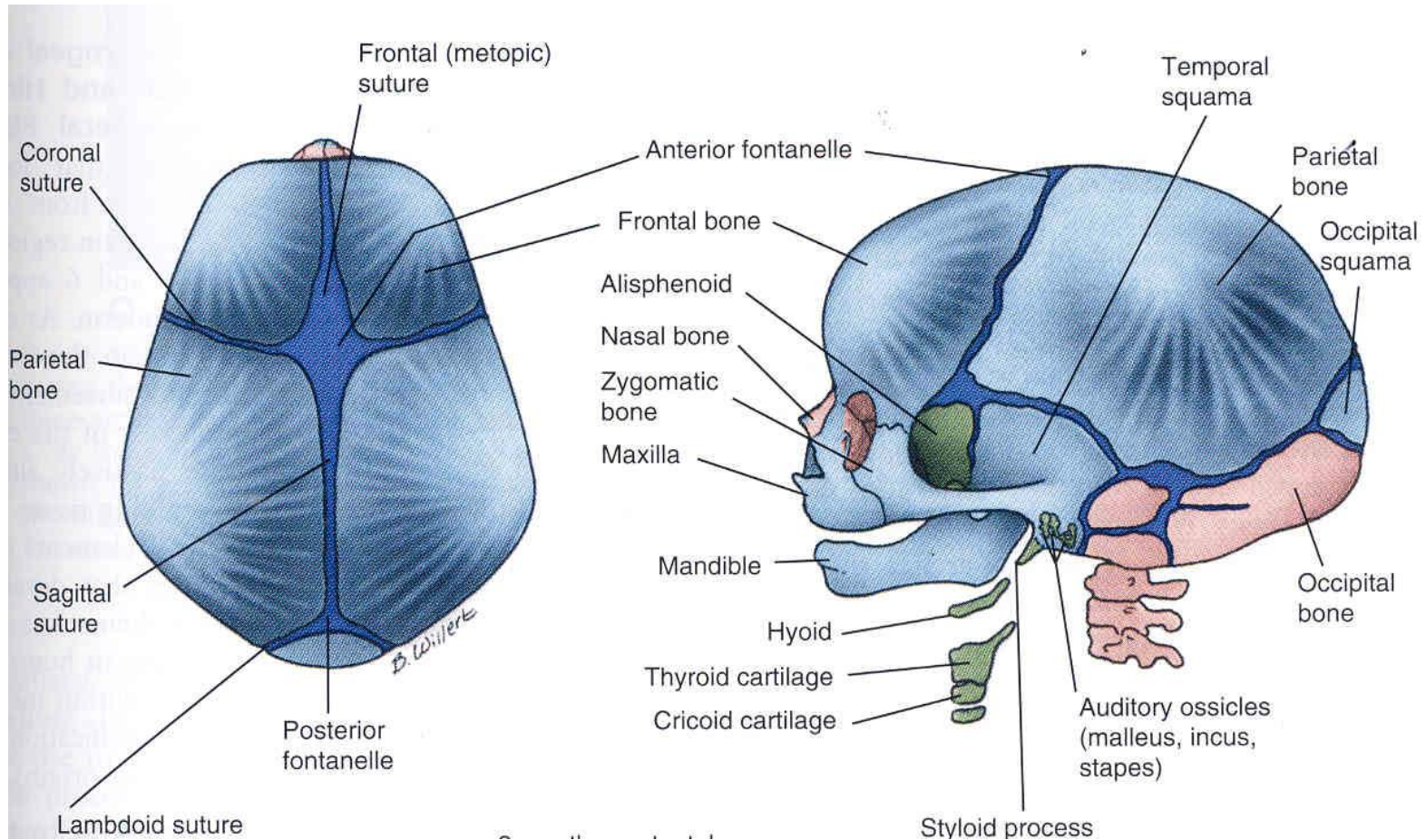
B



TULANG TENGGORAK

Membrane bone

→ **Fontaneles (ubun-ubun)**

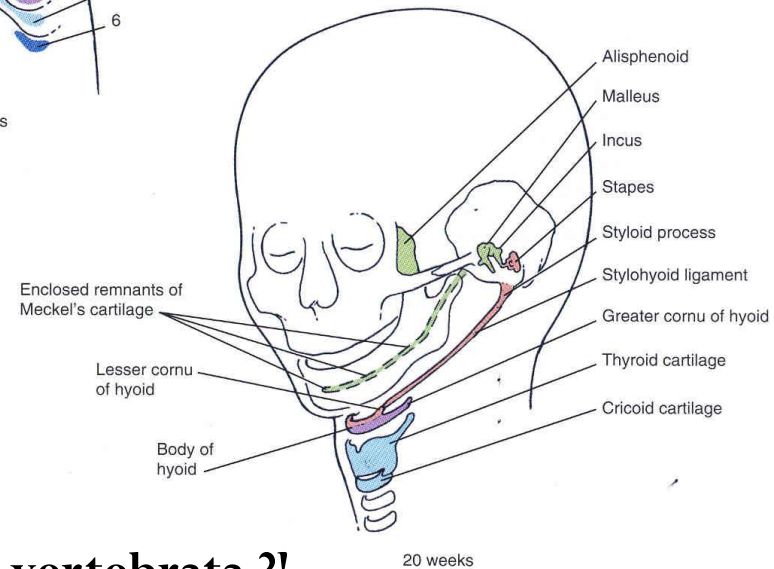
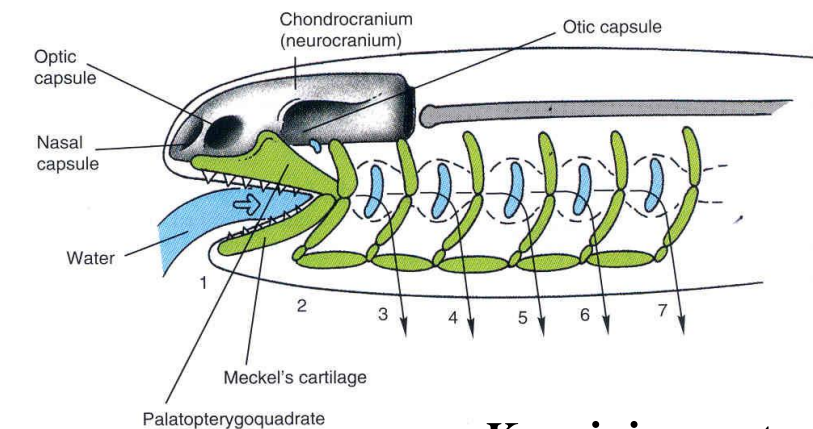
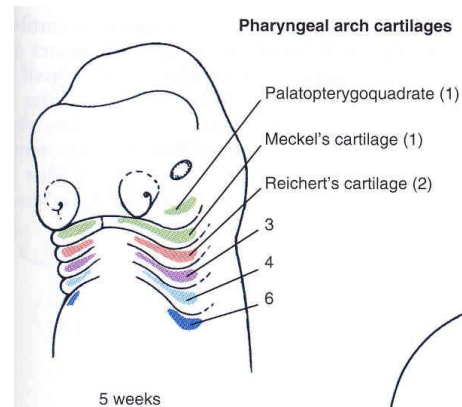
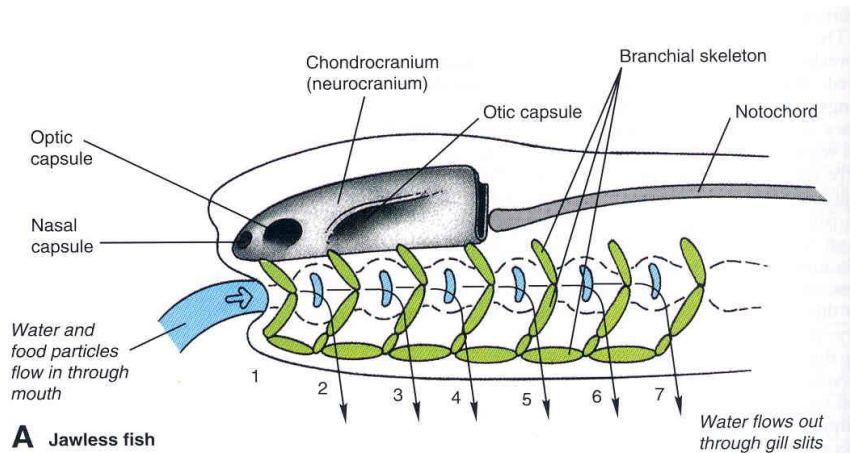


Tulang Pipih Tengkorak.....



TULANG TENGGORAK

Lengkung Branchial atau Pharyngeal (Pharyngeal arch)



Kemiripan struktur pada vertebrata ?!

Tulang Rahang, dll



PERKEMBANGAN KULIT & DERIVATNYA

Ektoderm → Epidermis

**Mesoderm (Dermatome dari somite) →
Dermis**

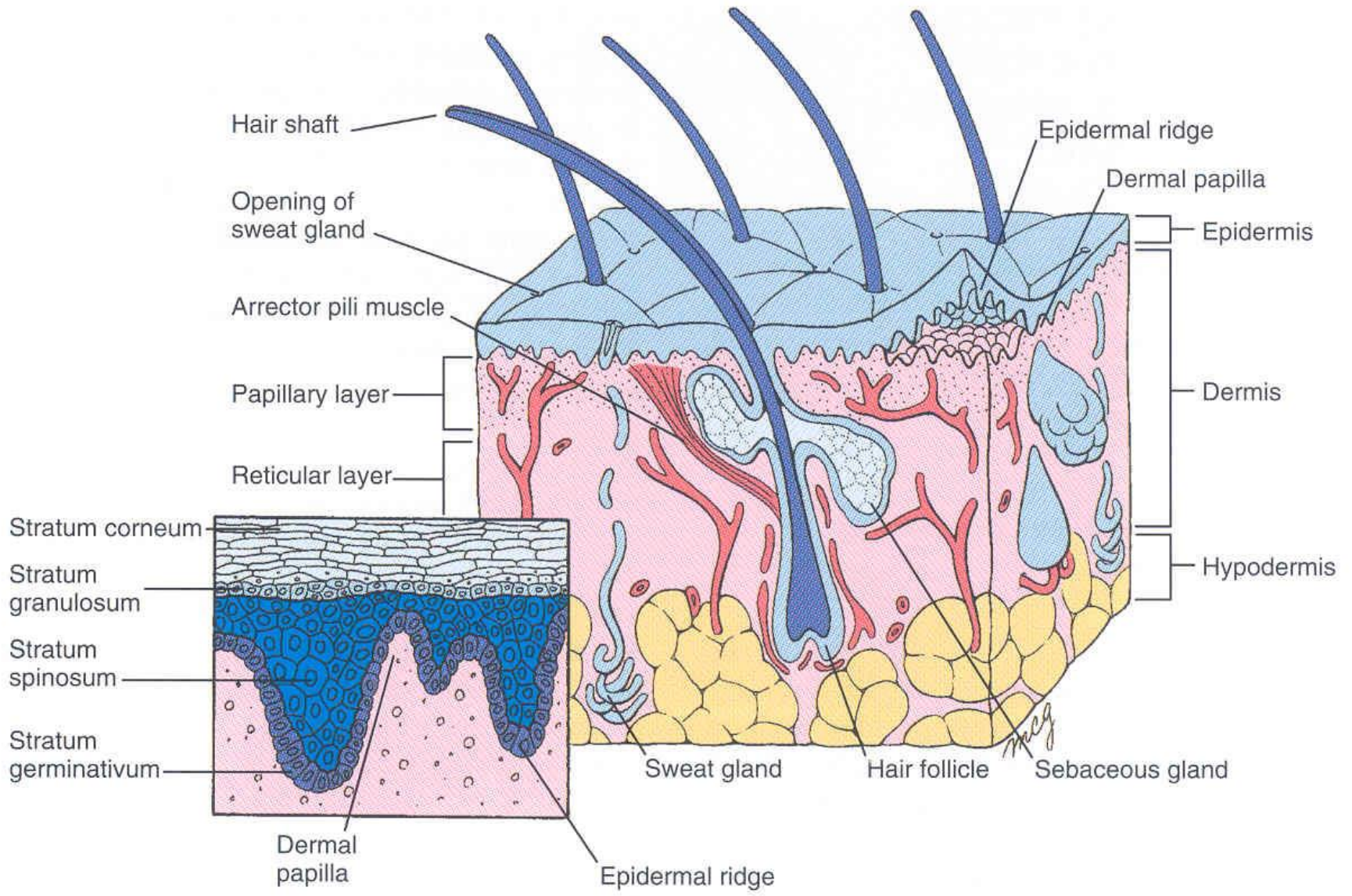
- **epidermis: sel neural crest migrasi pada epidermis dan menjadi melanosit**
- **Dermis: setiap dermatome membentuk suatu area kulit yang diinervasi oleh saraf spinal.**



Derivat kulit:

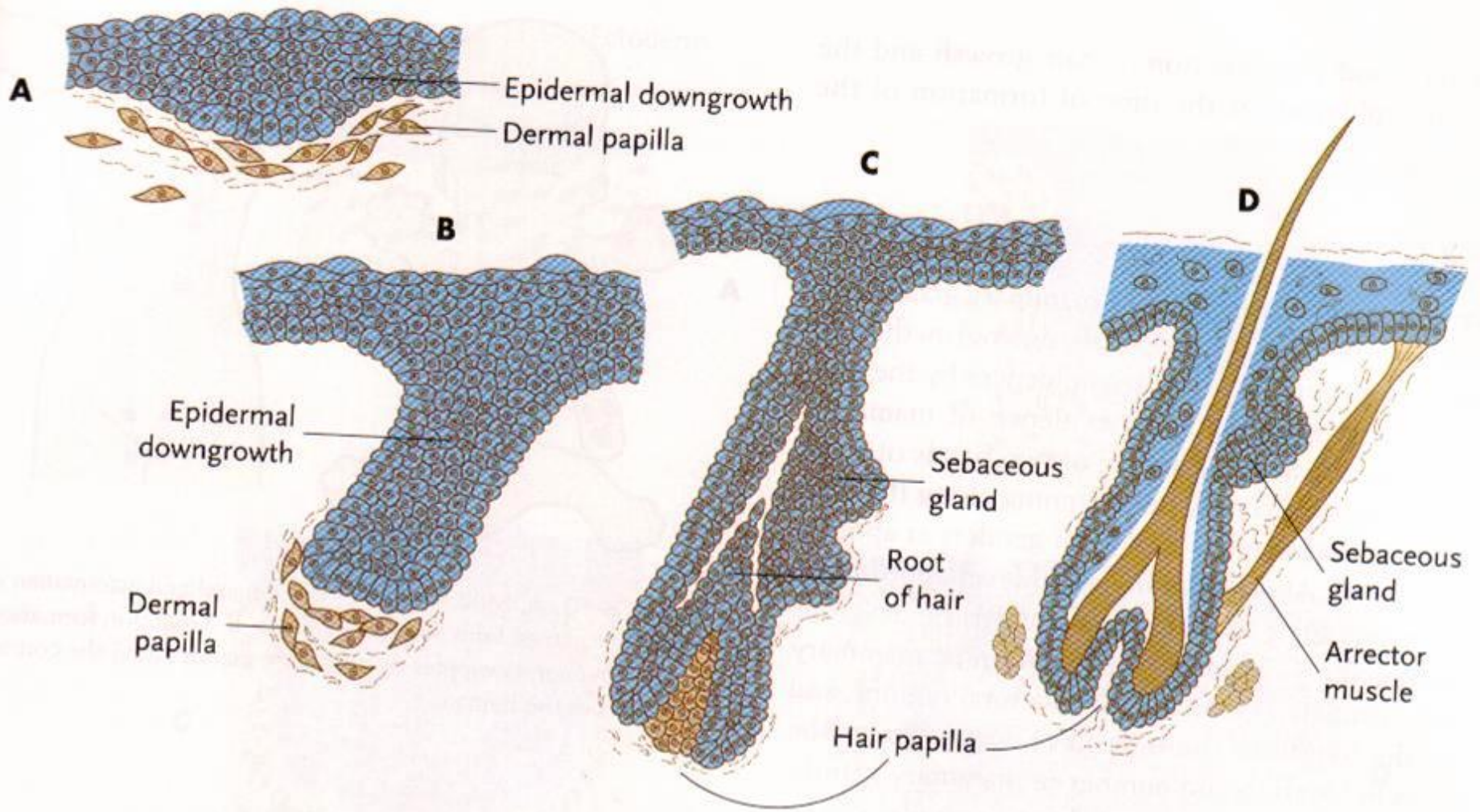
- **Folikel rambut**
- **Kelenjar sebaceous, keringat dan apokrin**
- **Kelenjar mammae**
- **Gigi**
- **Dll (kuku, tanduk, dll)**





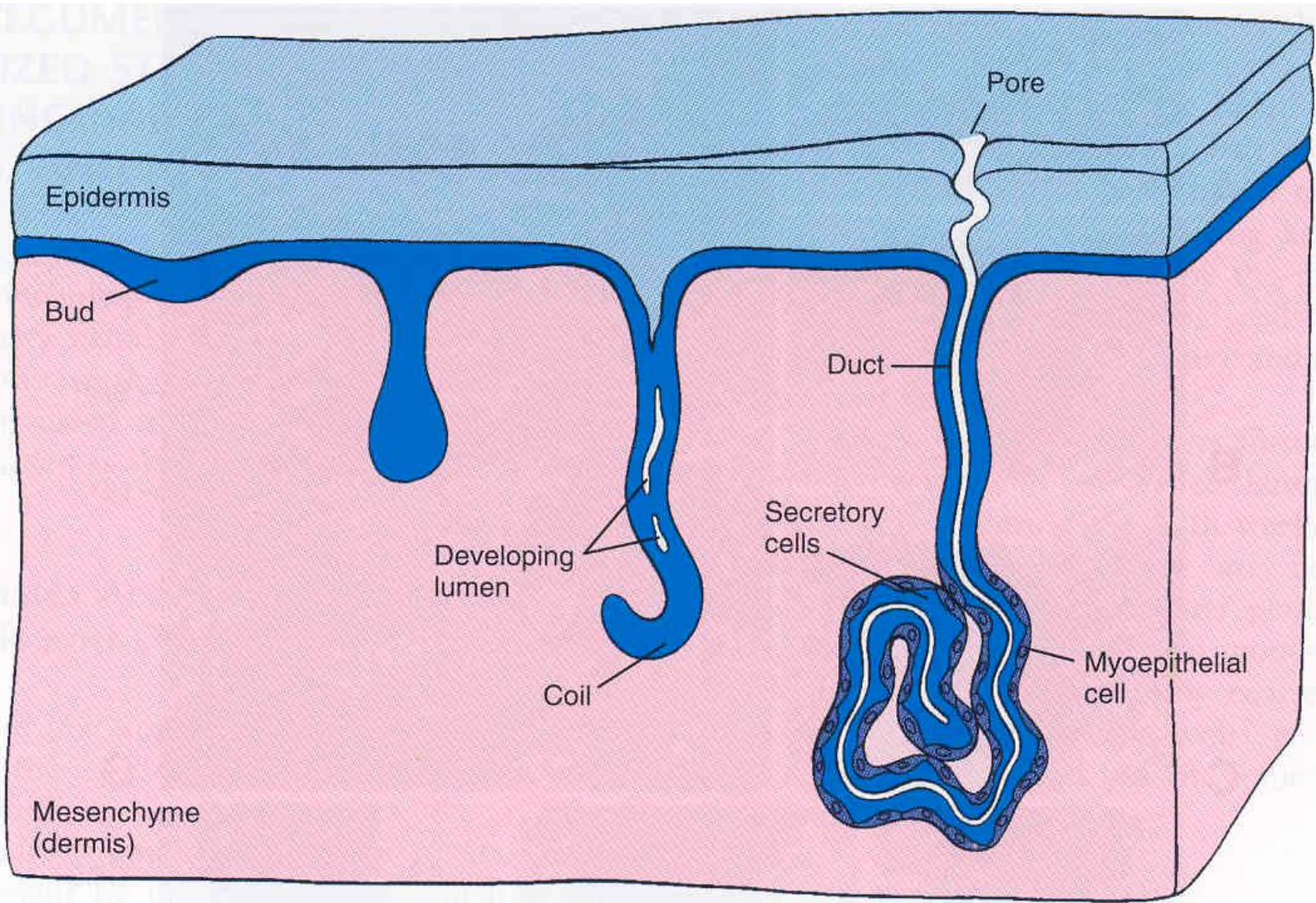
Struktur kulit





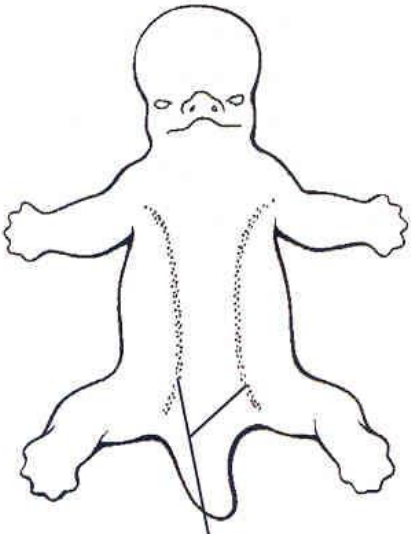
Folikel rambut



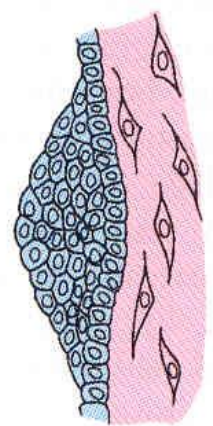


Kelenjar keringat

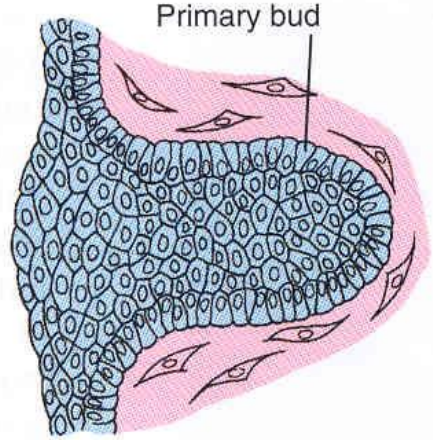




Mammary ridges

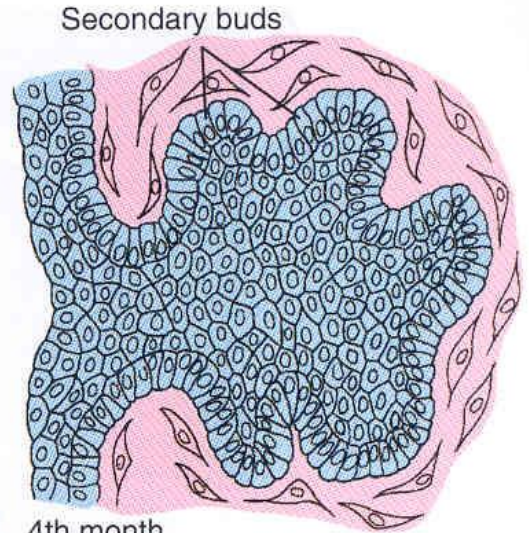


A 6th week



B 7th week

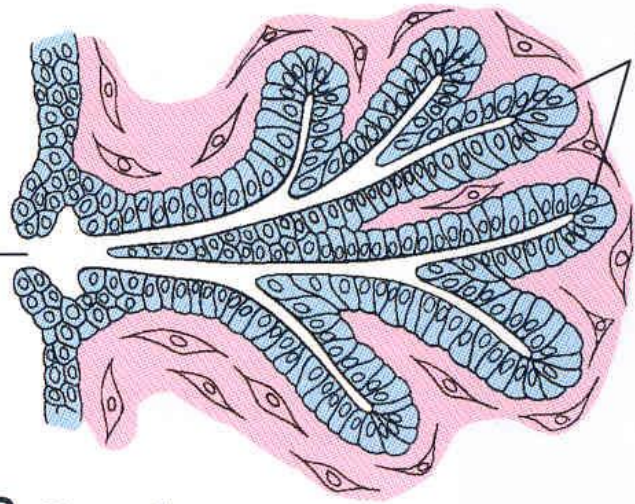
Primary bud



C 4th month

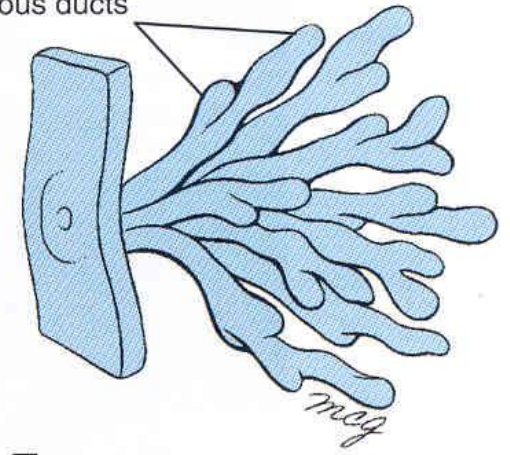
Secondary buds

Mammary pit



D 6th month

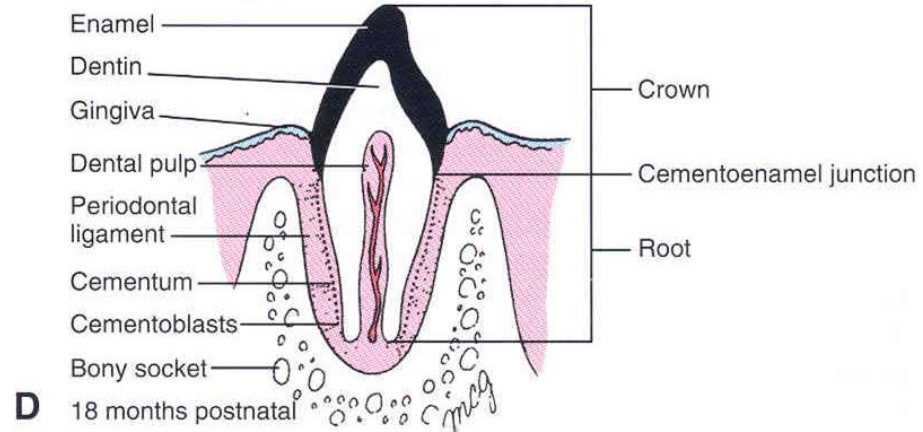
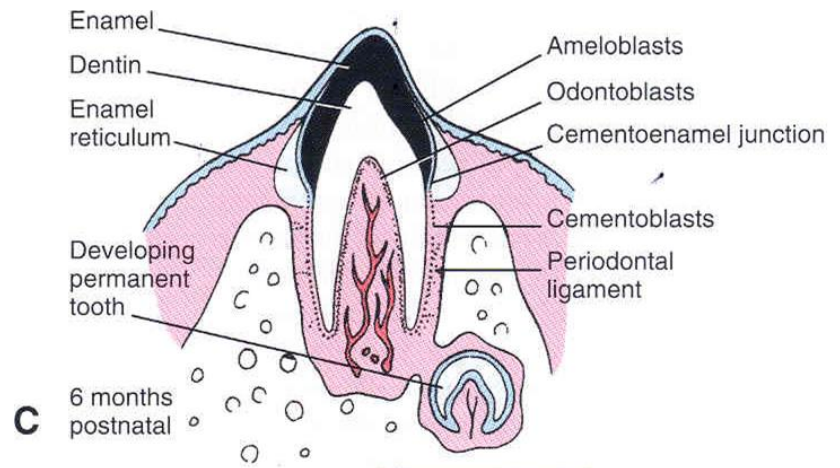
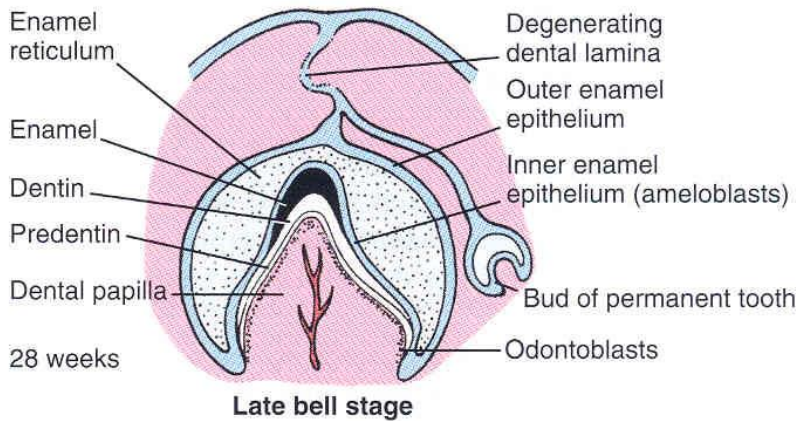
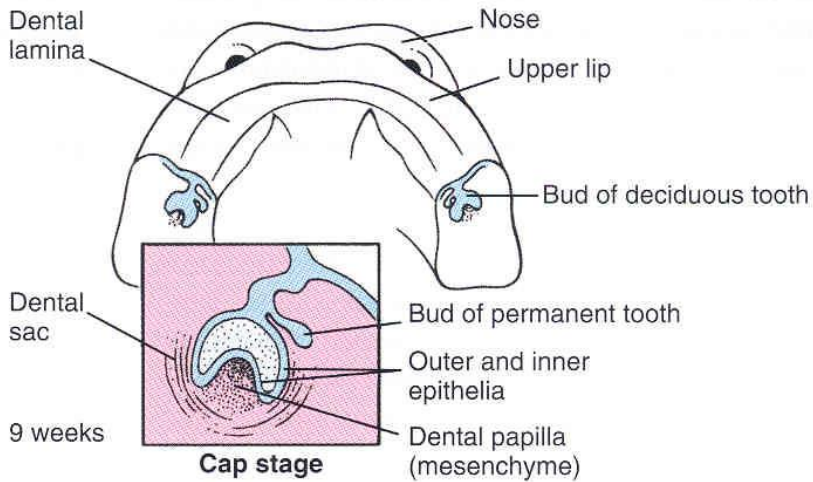
Lactiferous ducts



E 8th month

Kelenjar mammae





Perkembangan gigi



TERIMA KASIH

