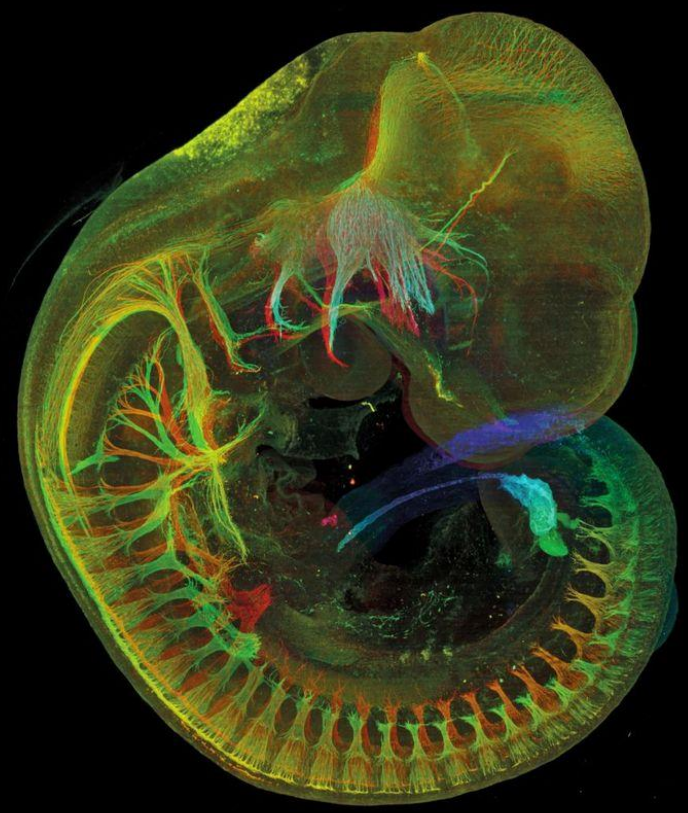
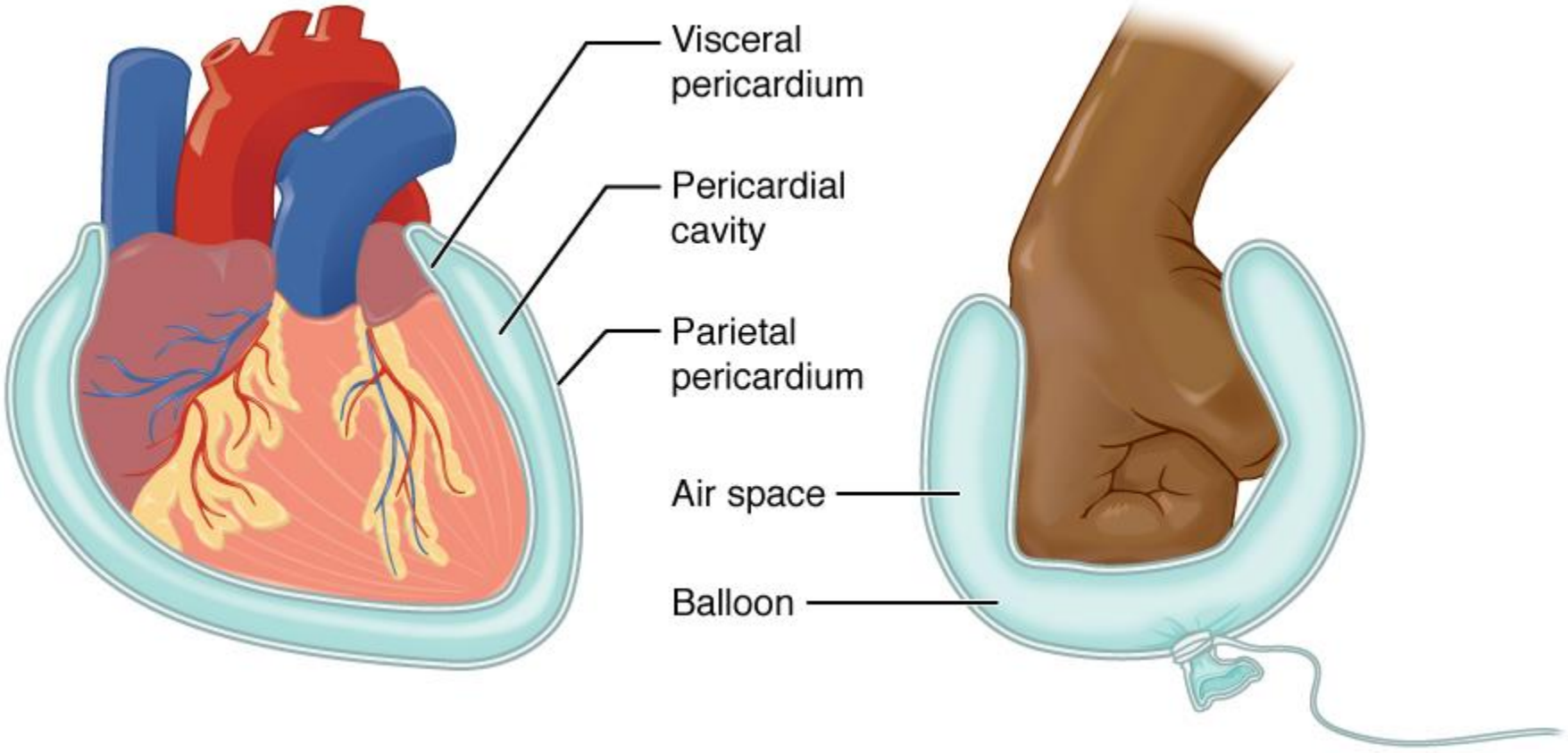


- Coelom and body cavities
- Skull and axial skeleton

Why it is quite good to have a body cavity



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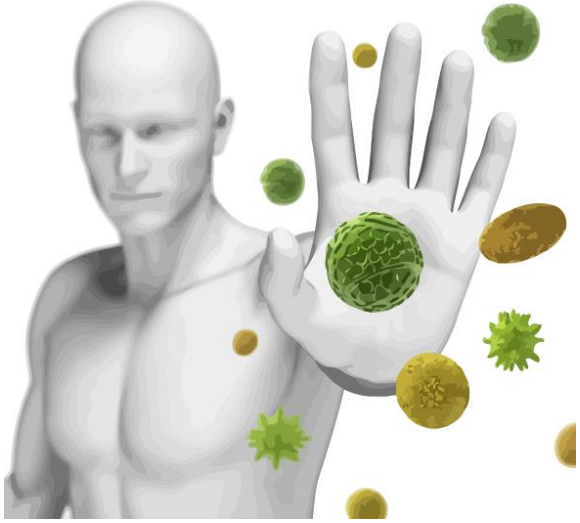
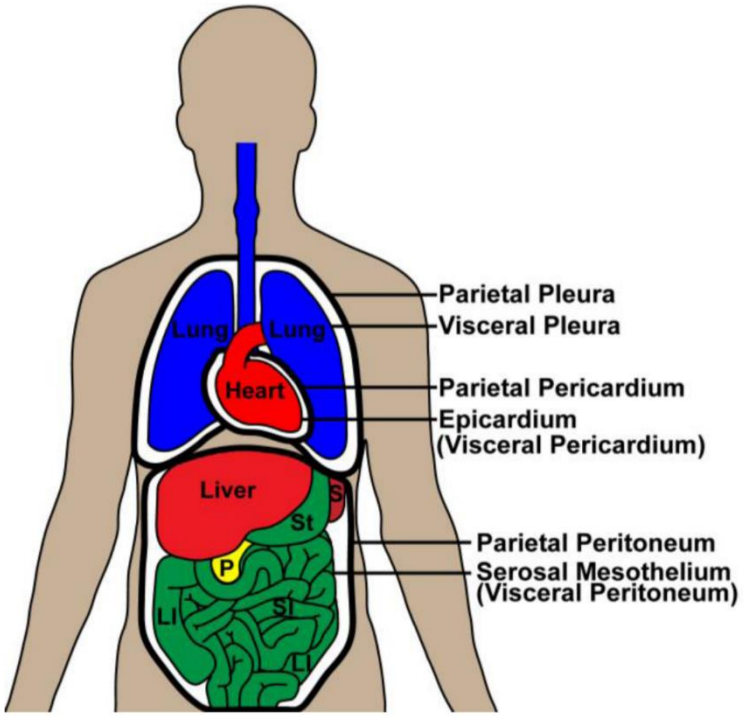
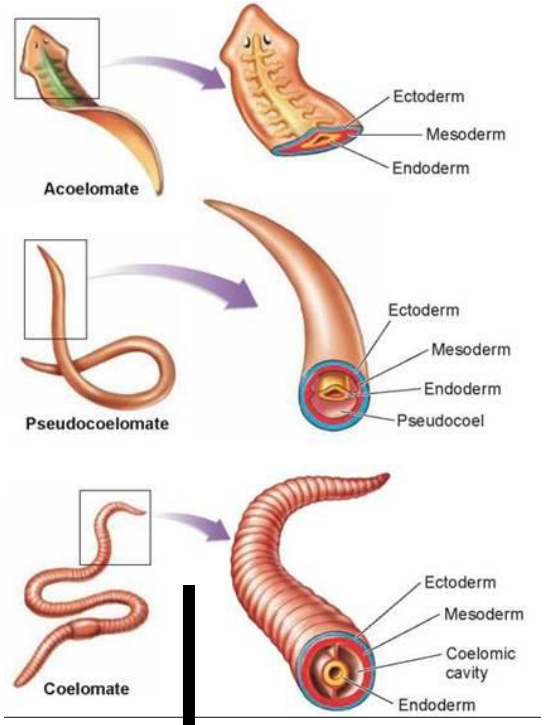
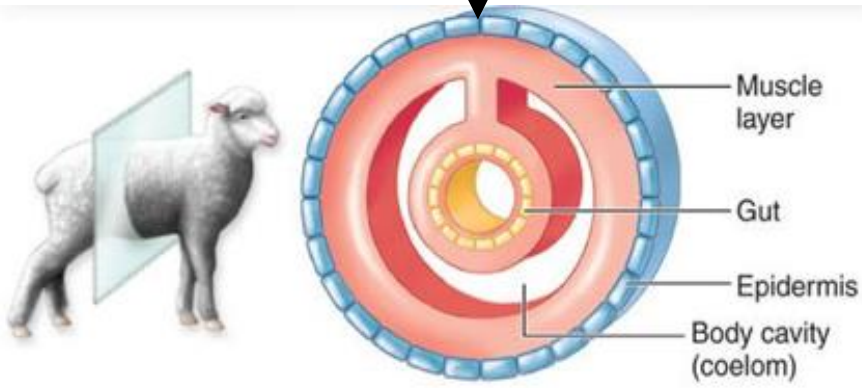


COELOM

- „Coelom is a „true body cavity“ = body cavity within non-segmented lateral plate mesoderm
- Significant evolutionary innovation
- Lined by **coelomic epithelium**
- Filled with **coelomic fluid**





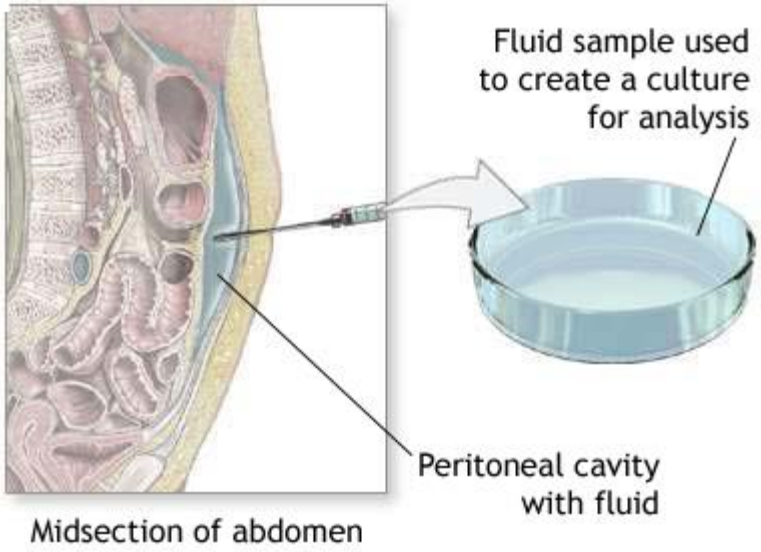


FLUID IN BODY CAVITIES

- normally only a small amount of fluid (50 mL)
- plasma ultrafiltrate
- Proteins (3.0 g/mL)
- Leukocytes (PMN, lymphocytes, macrophages)
- Erythrocytes & Volume: **important indicator of many diseases**

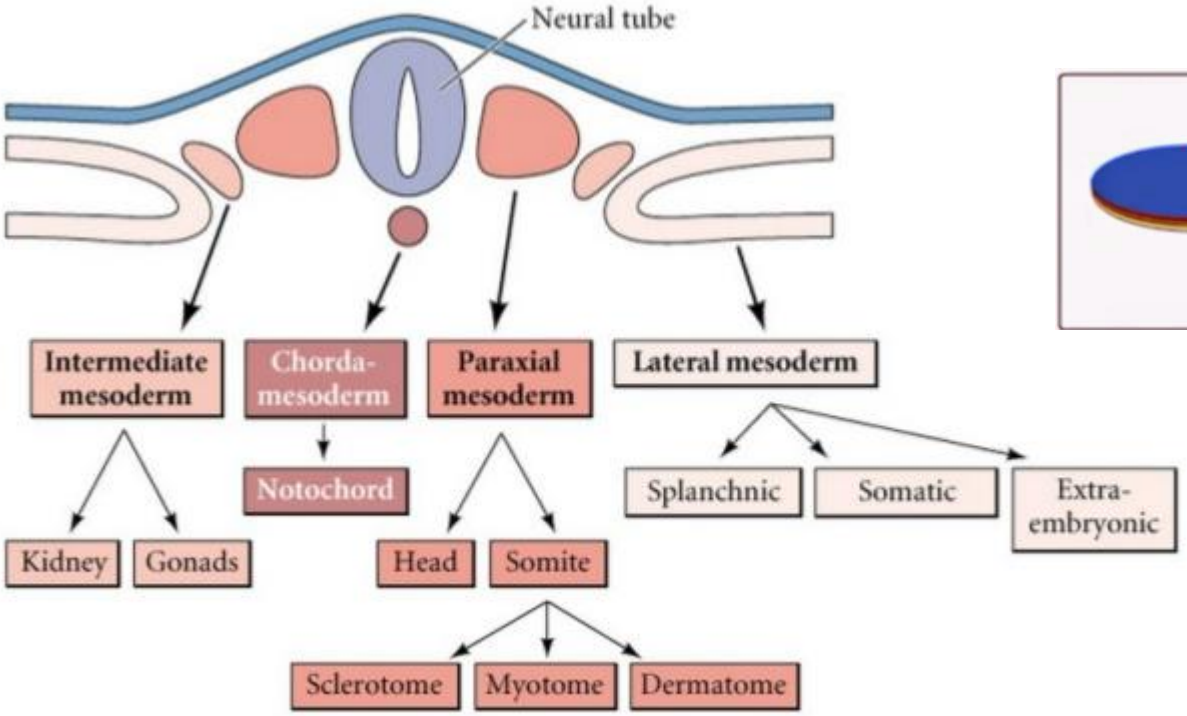
Ascites

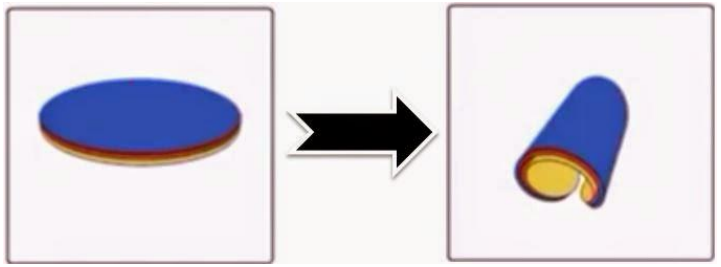
Paracentesis



COELOM IN EARLY EMBRYOGENESIS

- 3rd week of development
- intraembryonic **mesoderm**
  - paraxial → somites (sclerotomes, dermomyotomes)
  - intermediate → nephrotomes
  - lateral → IE and EE somatopleure a splanchnopleure → IE and EE coelom

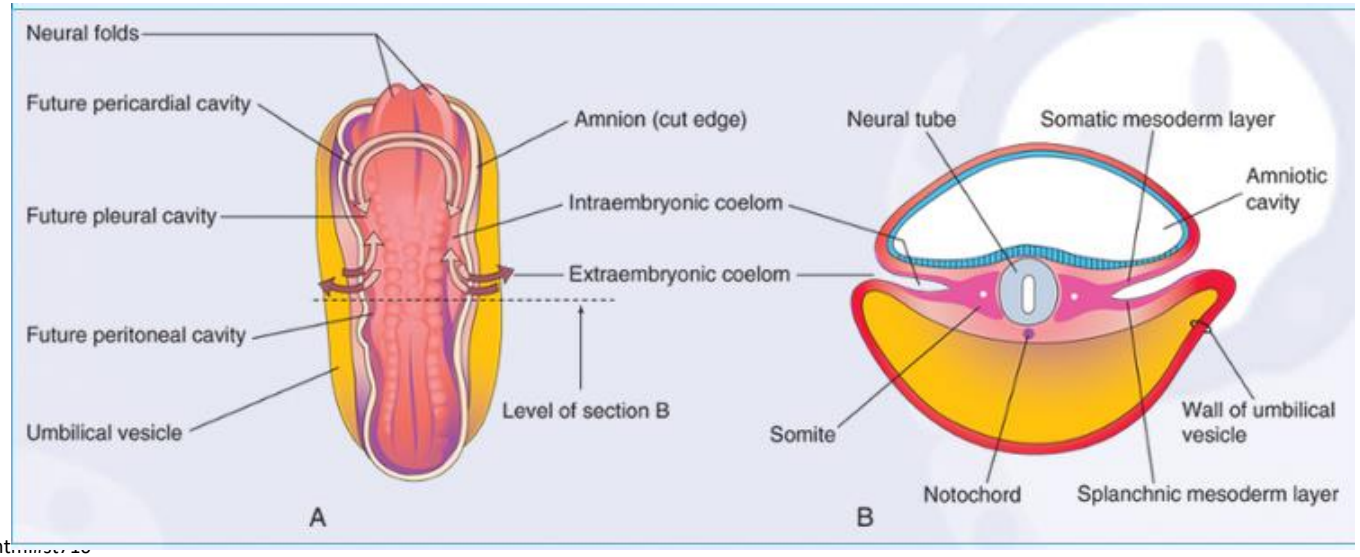




COELOM DEFINITION: A CAVITY IN MESODERM

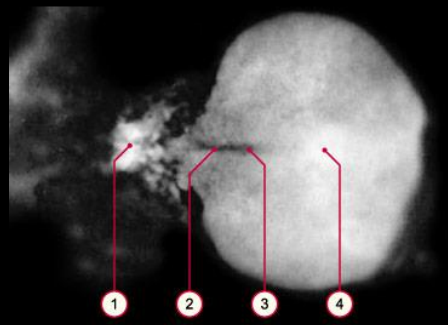
COELOM IN EARLY EMBRYOGENESIS

- Bilaminar → trilaminar germ disc



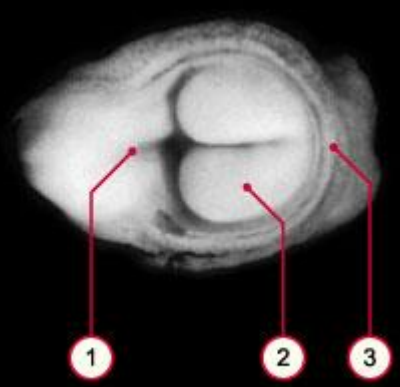
http://www.embryology.ch/anglais/iperiodembry/carnegie03.ht...

19. den
0,4 mm
Carnegie stage 7



1 Yolk sac
2 Primitive streak
3 Primitive node
4 Germ disc

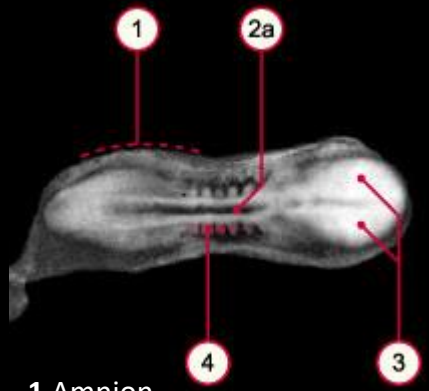
25. den
1,5-2,5 mm
Carnegie stage 9



1 Primitive streak
2 Neural folds
3 Amnion

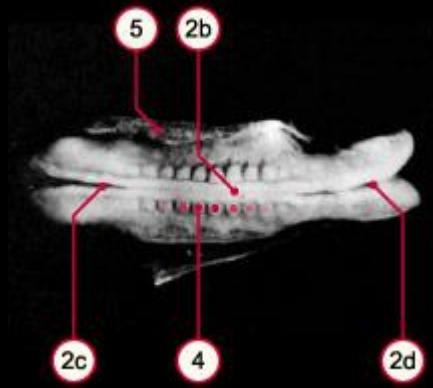
28. den
2-3,5 mm
Carnegie stage 10

Dorsálně



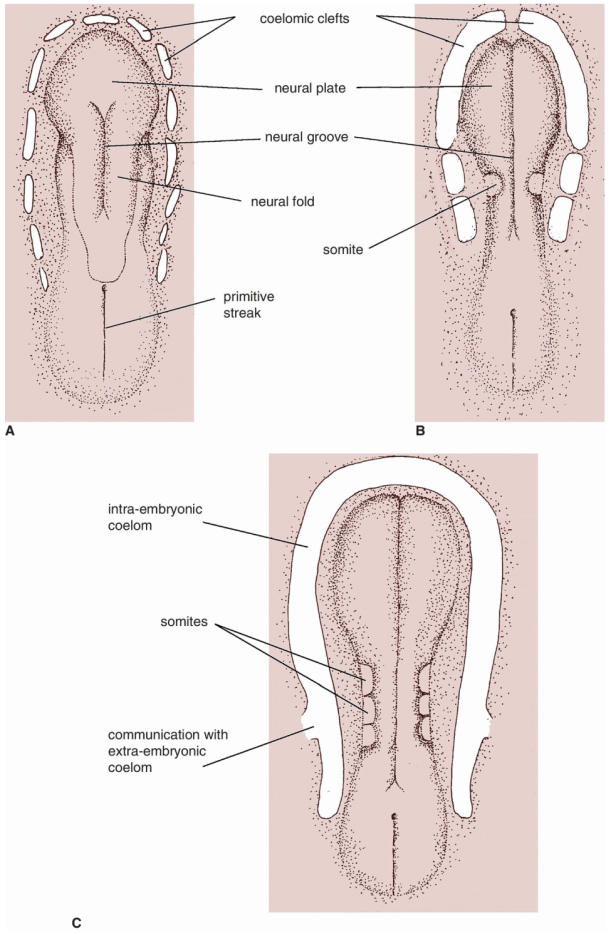
1 Amnion
2a Neural groove
2b Neural tube
2c Caudal neuropor
2d Rostral neuropor

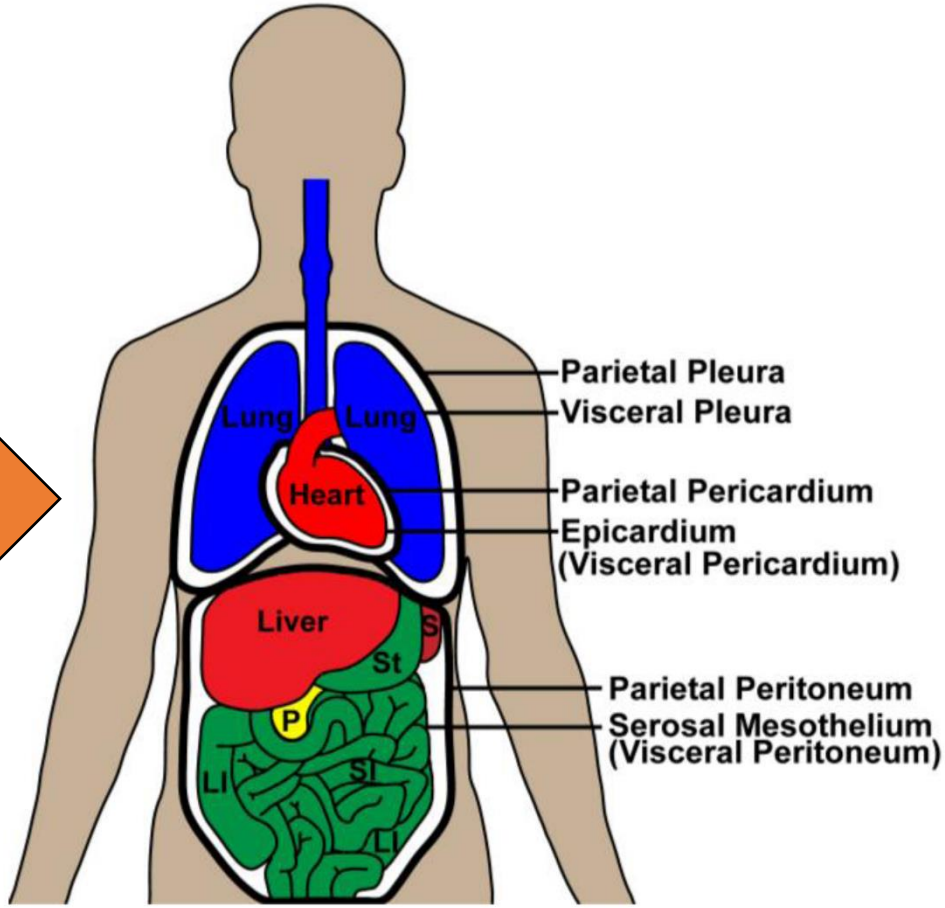
Ventrálně



3 Neural folds
4 Somites
5 Yolk sac

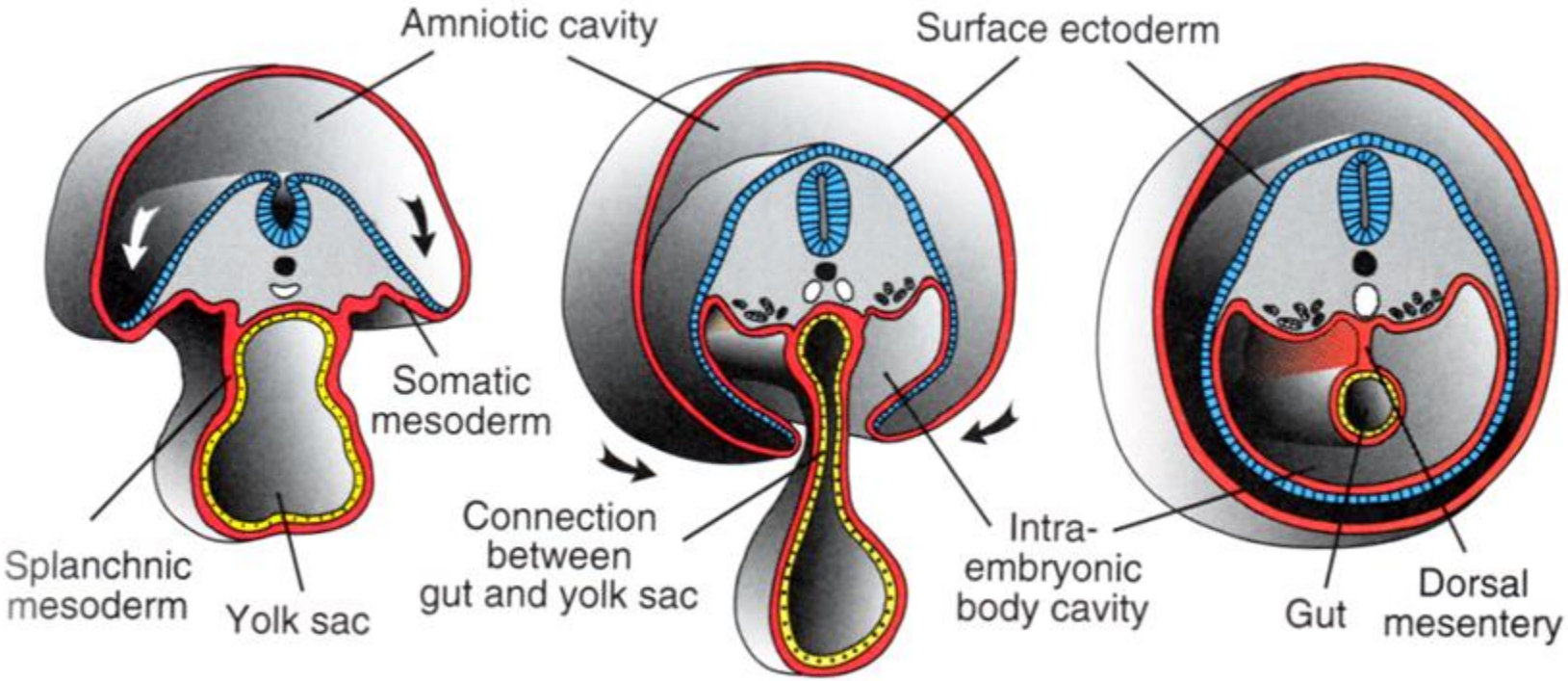
COELOM FORMS A COMMON INTRAEMBRYONIC CAVITY



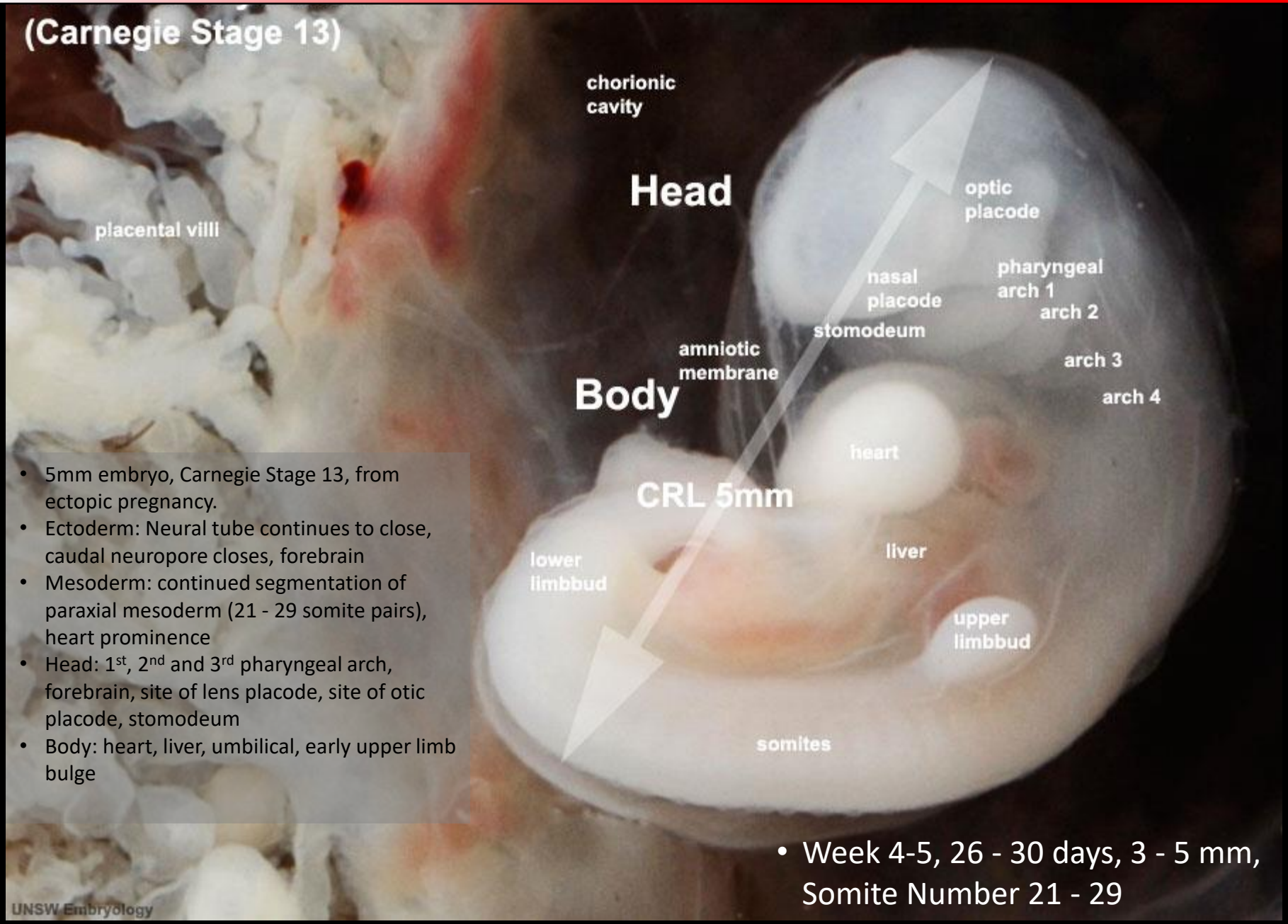


COELOM IN EARLY EMBRYOGENESIS

- Dehiscence of cardiogenic and lateral plate mesoderm
- IE and EE coelom connected until cephalocaudal flexion (except for region within *d. omphaloentericus)*
- Ventral mesogastrium disappears → common intraembryonic cavity that further separates to pericardial, pleural and peritoneal cavities



COELOM IN EARLY EMBRYOGENESIS



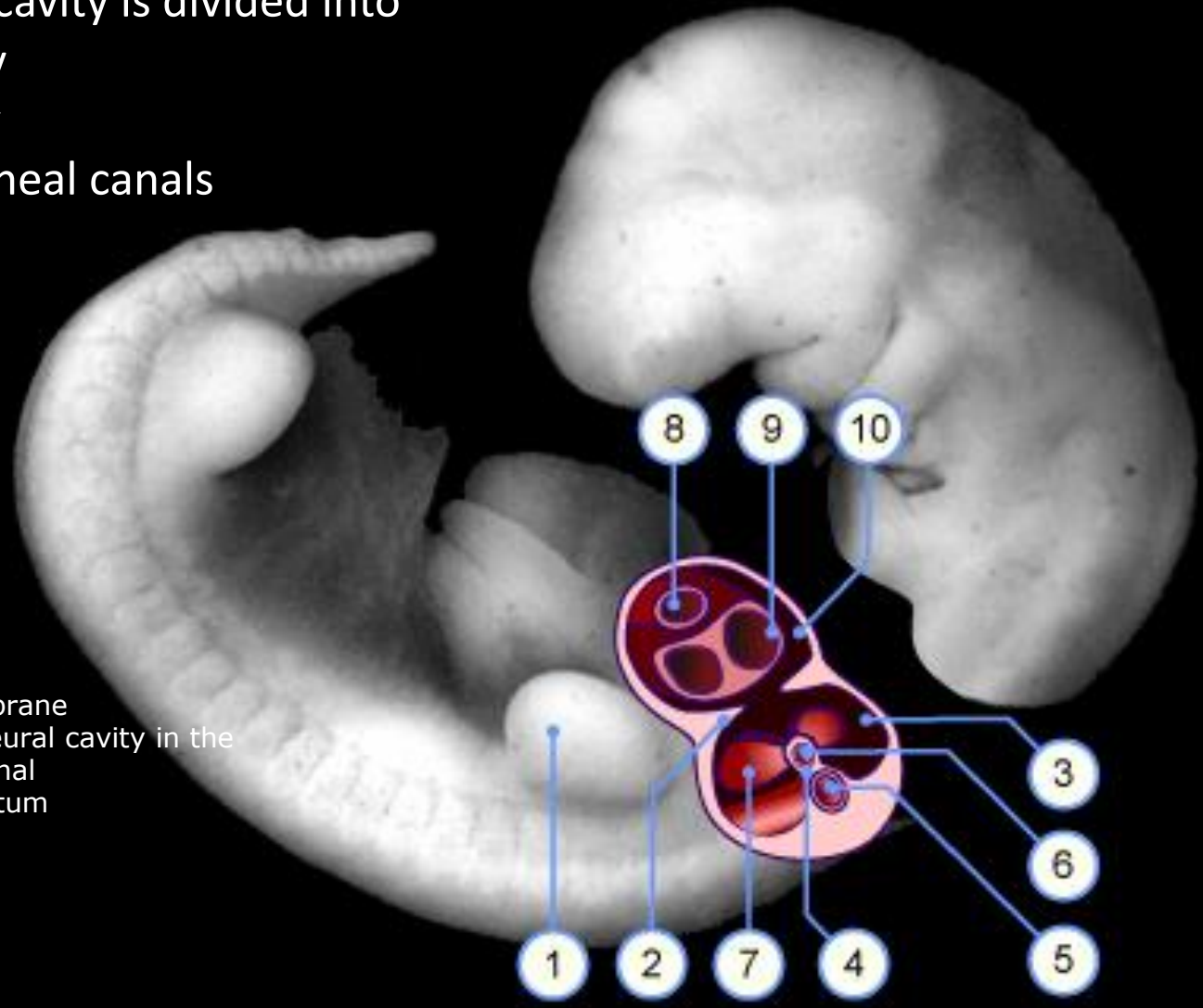
- 5mm embryo, Carnegie Stage 13, from ectopic pregnancy.
- Ectoderm: Neural tube continues to close, caudal neuropore closes, forebrain
- Mesoderm: continued segmentation of paraxial mesoderm (21 - 29 somite pairs), heart prominence
- Head: 1st, 2nd and 3rd pharyngeal arch, forebrain, site of lens placode, site of otic placode, stomodeum
- Body: heart, liver, umbilical, early upper limb bulge

- Week 4-5, 26 - 30 days, 3 - 5 mm, Somite Number 21 - 29

Day 33 (Carnegie stage 14)

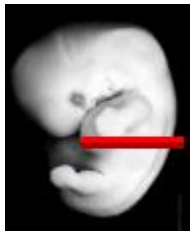
http://www.embryology.ch/anglais/rrespiratory/korperhohlen01.html

Common coelom cavity is divided into
- pericardial cavity
- peritoneal cavity
- pericardioperitoneal canals

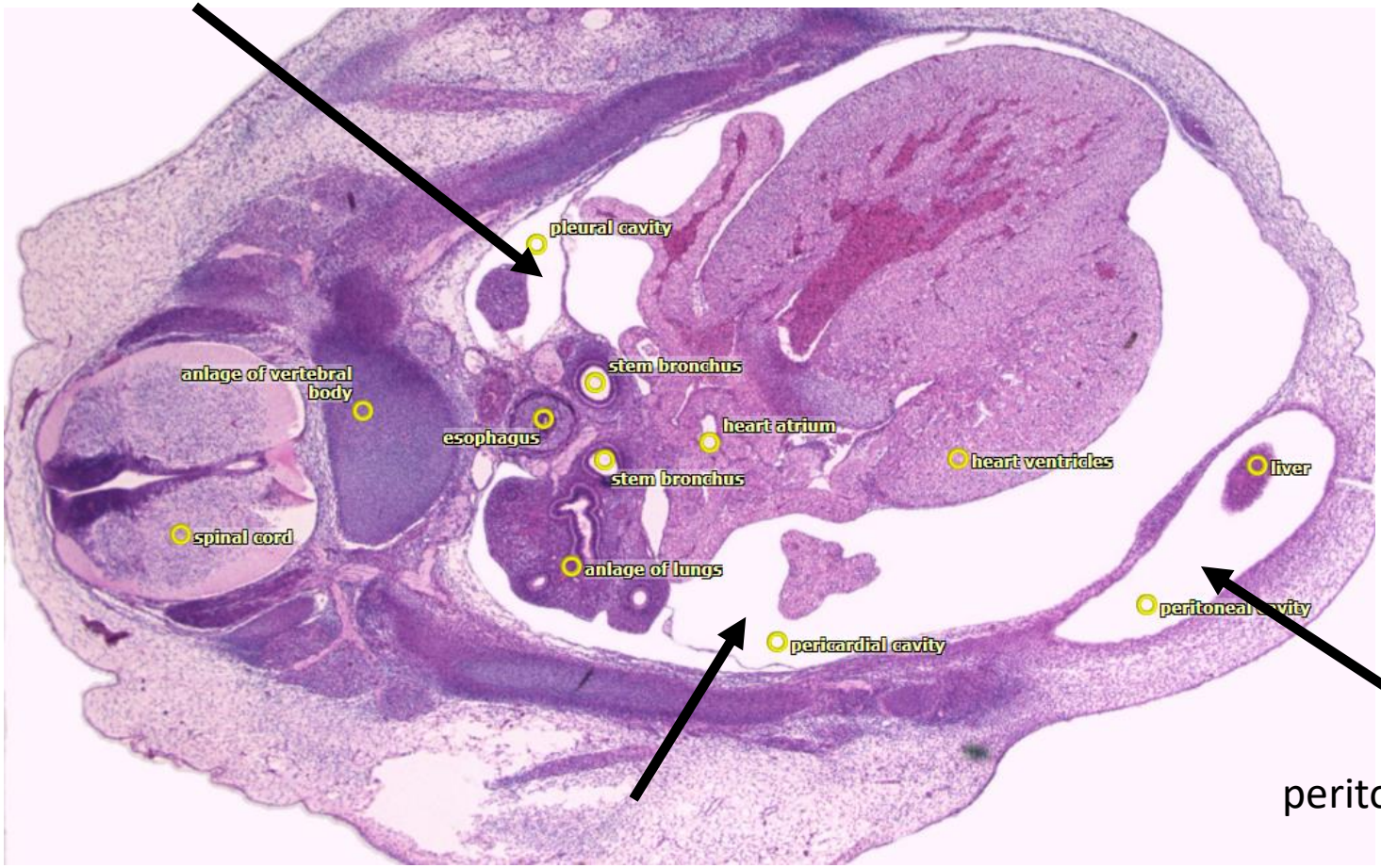


1. Arm buds
2. Pleuropericardial membrane
3. Development of the pleural cavity in the pericardioperitoneal canal
4. Esophago-tracheal septum
5. Esophagus
6. Trachea
7. Lung buds
8. Bulbus cordis
9. Heart
10. Pericardial cavity

SEPARATION OF COMMON INTRAEMBRYONIC CAVITY



pleural



peritoneal

pericardial

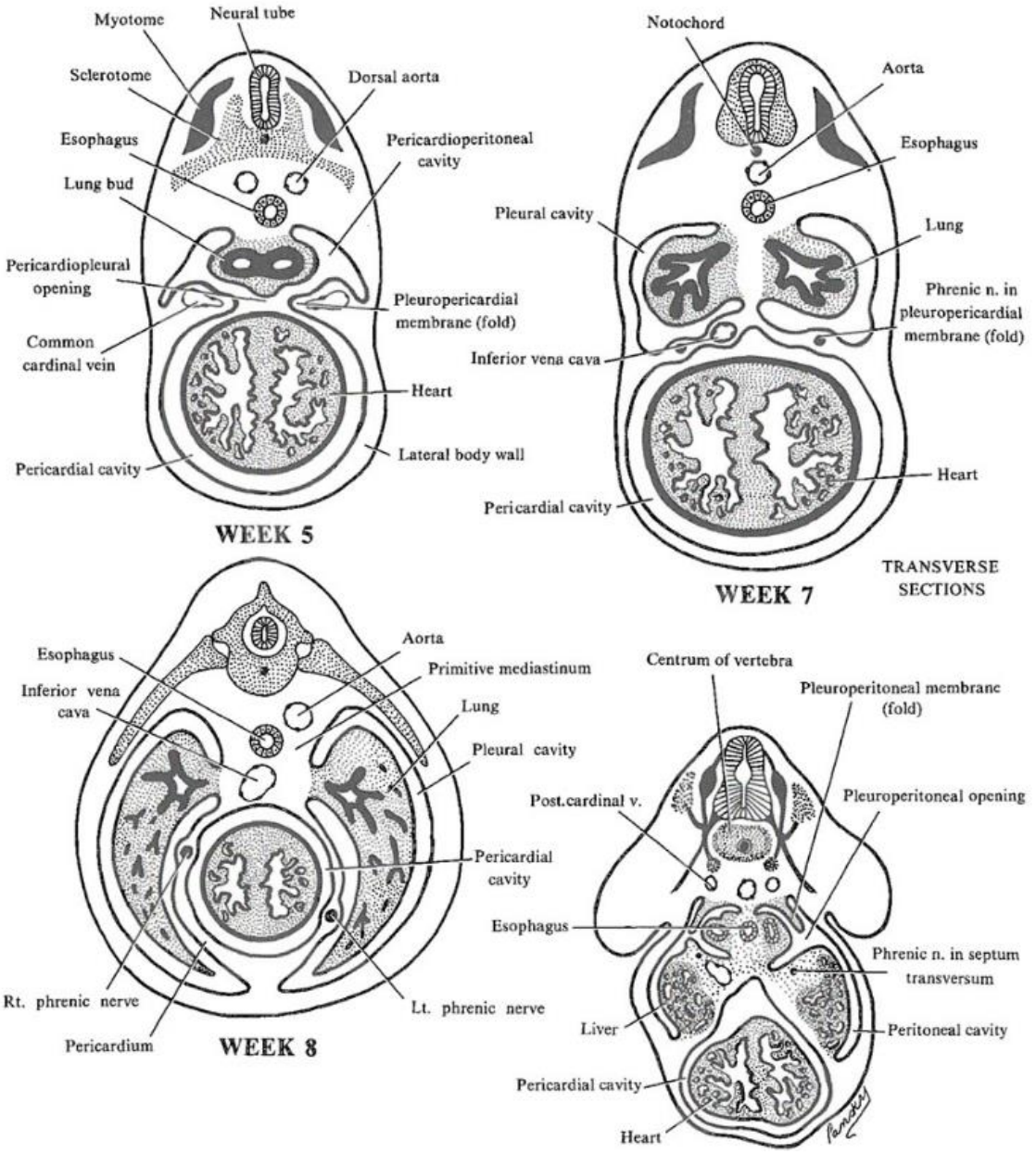
FORMATION OF DEFINITIVE BODY CAVITIES

PLEUROPERICARDIAL MEMBRANES

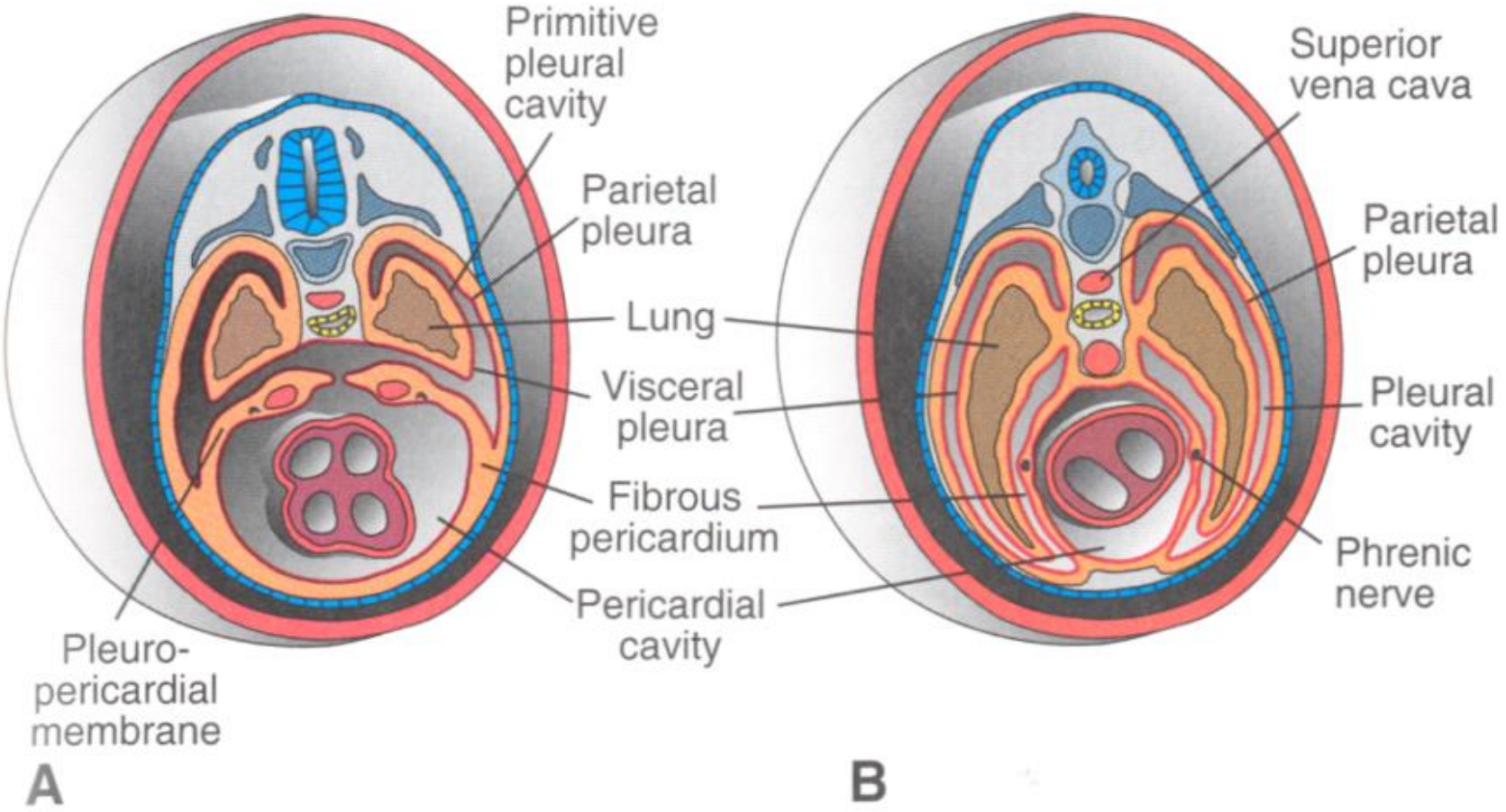
- separate the pleural and pericardial cavities
- by week 7- fusion with mesenchyme located ventrally to esophagus and primitive mediastinum (c.t) - divide the thoracic cavity to pericardial cavity and 2 pleural cavities

PLEUROPERITONEAL MEMBRANES

- separate the pleural and peritoneal cavities
- by week 6 - ventromedial dilatation and fusion with dorsal mesentery of oesophagus and septum transversum

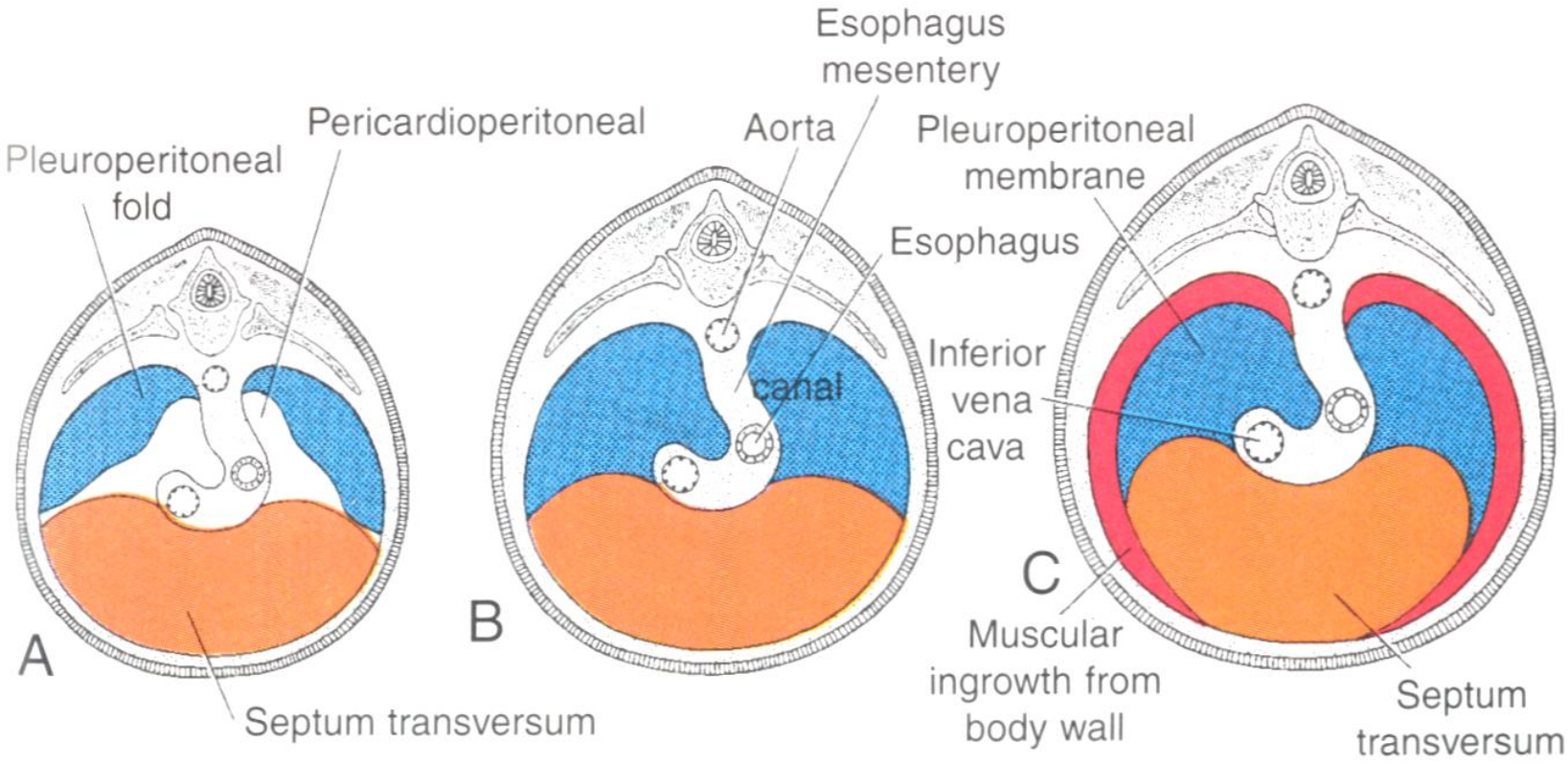


FORMATION OF DEFINITIVE BODY CAVITIES



DEVELOPMENT OF DIAPHRAGM

1. Septum transversum (*centrum tendineum*)
2. Pleuroperitoneal membranes
3. Dorsal mesentery of esophagus
4. Mesenchyme of body wall + myoblasts cervical somites (*crura diaphragmatis*)



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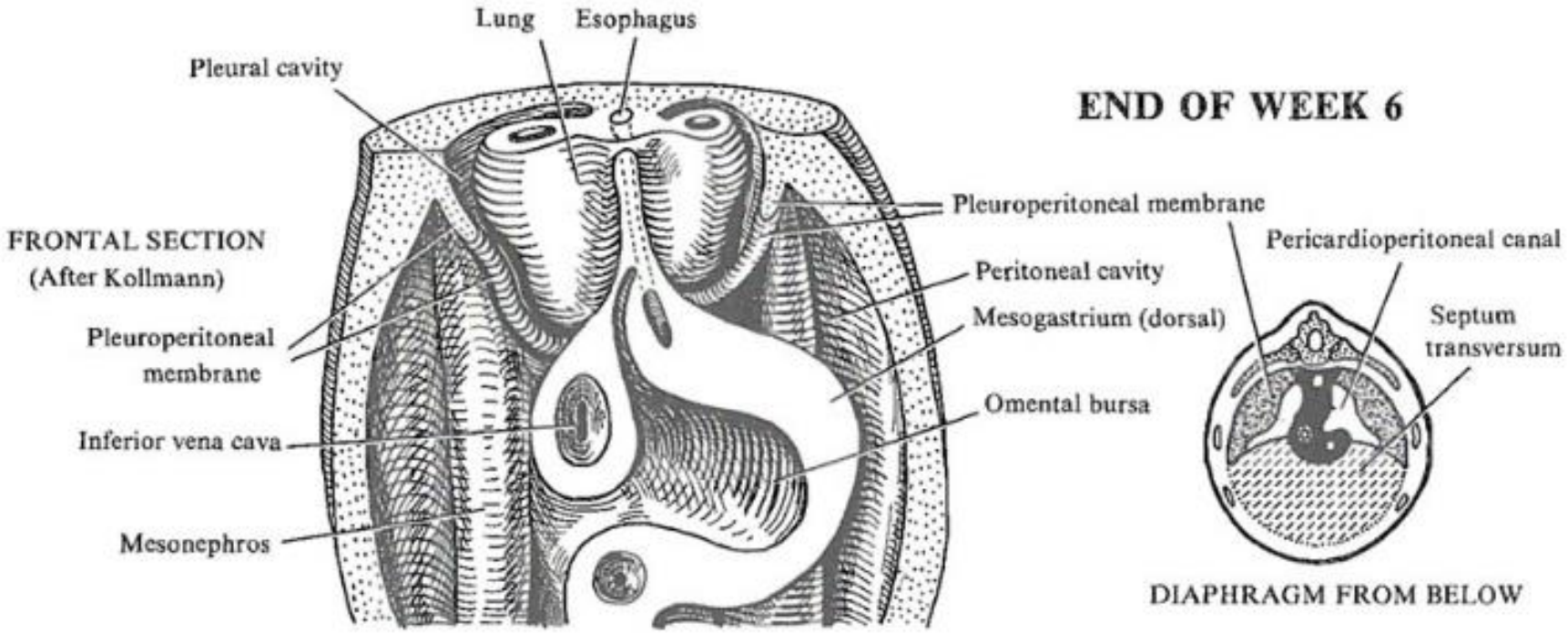


DEVELOPMENT OF DIAPHRAGM

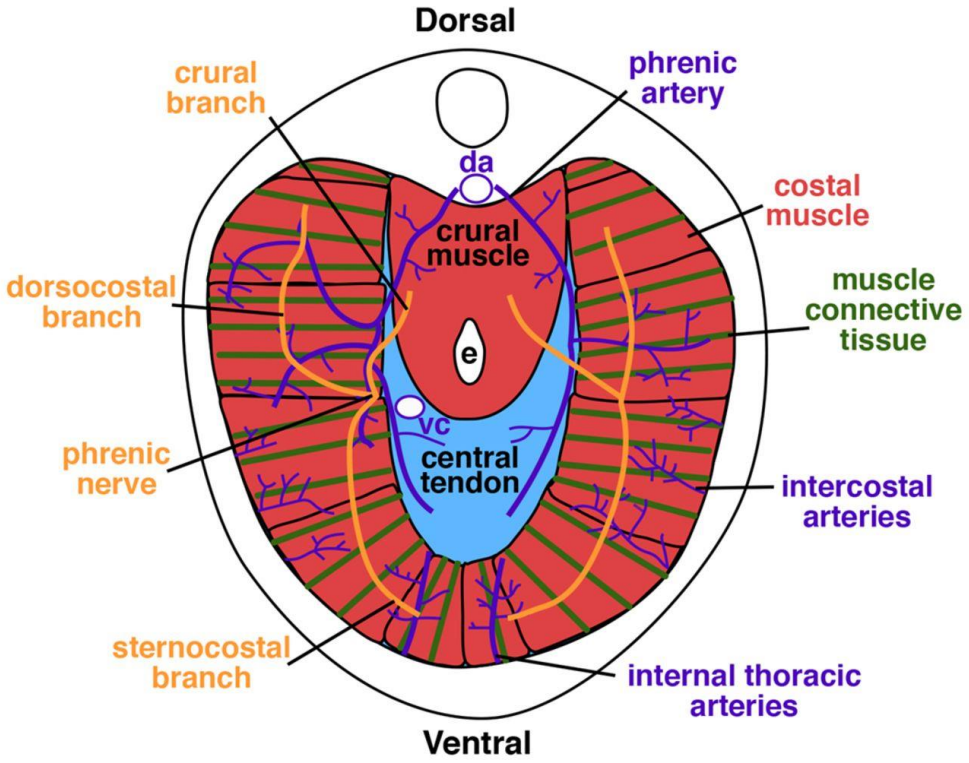
SEPTUM TRANSVERSUM

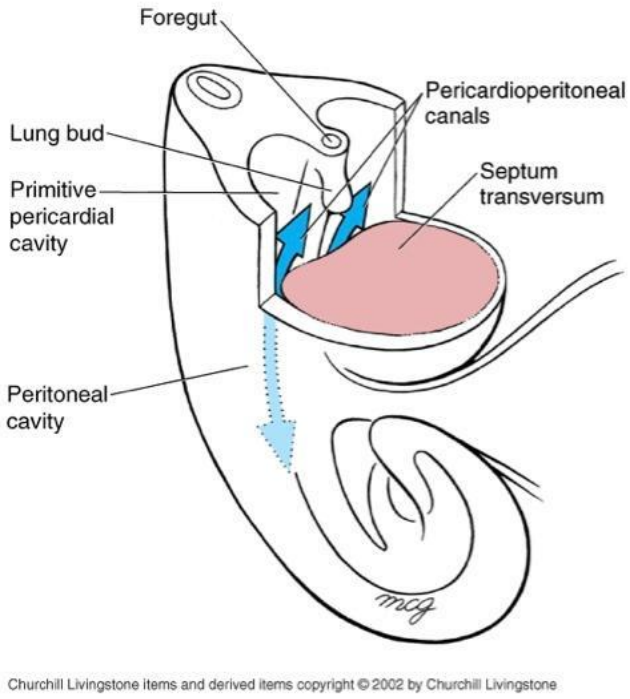
- mesodermal plate separating thoracic and abdominal cavities - level of yolk sac stalk

→ *centrum tendineum*

- separation incomplete → pericardioperitoneal canals → pleuropericardial and pleuroperitoneal folds ***n. phrenicus*** (**C3-C5 spinal segment**)

- descent of septum transversum due to growth of embryo

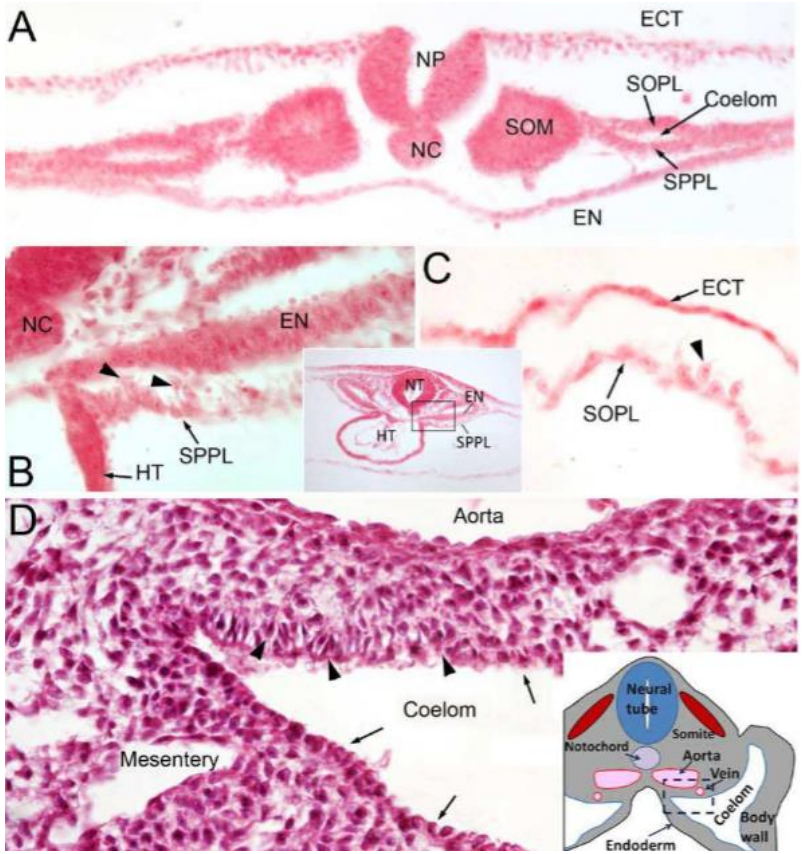




COELOMIC EPITHELIUM & CE-DERIVED CELLS (advanced, not required)

- **CEDC** - biologically very active and plastic stem (progenitor) cell population lining coelomic cavity

- essential for visceral morphogenesis
- provide cells capable of production of ECM, differentiation to vessels or other specialized cells



Epicardium

Urogenital system

Liver

Spleen

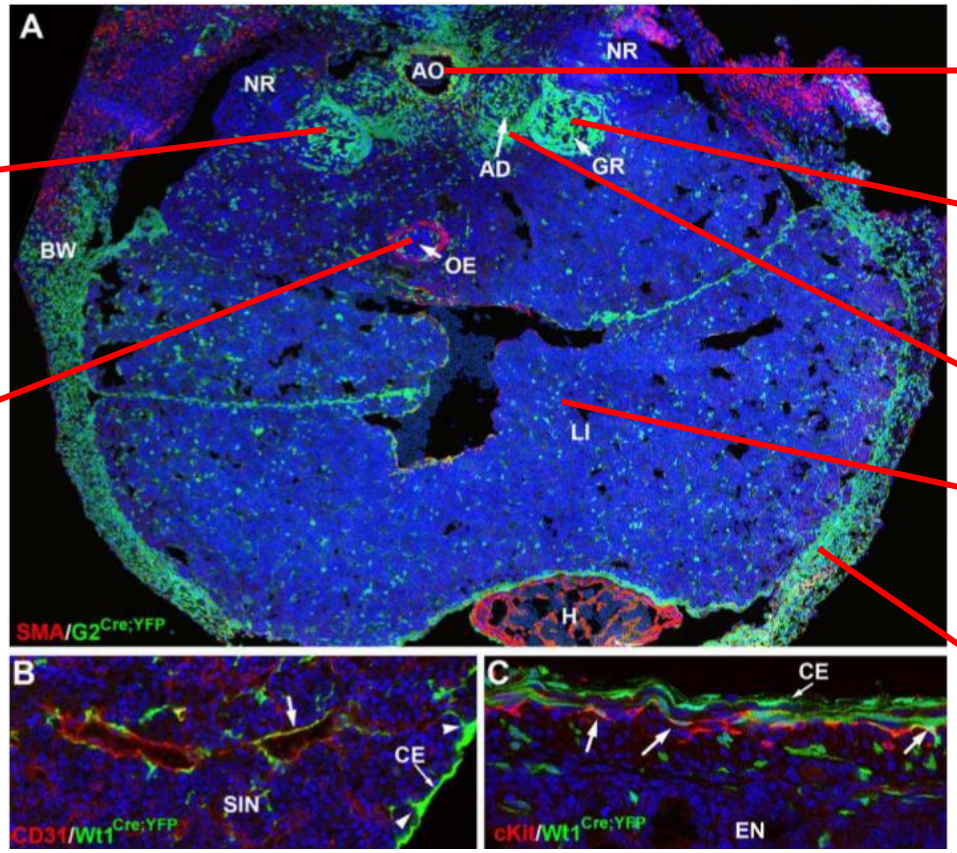
Adrenal cortex

Mesothelium

CEDC CONTRIBUTE TO VISCERAL MORPHOGENESIS (advanced, not required)

E13.5 = human Day 44

G2-GATA4



Aorta

Plica mesonephridica

Plica genitalis

Adrenal cortex

Oesophagus

Liver

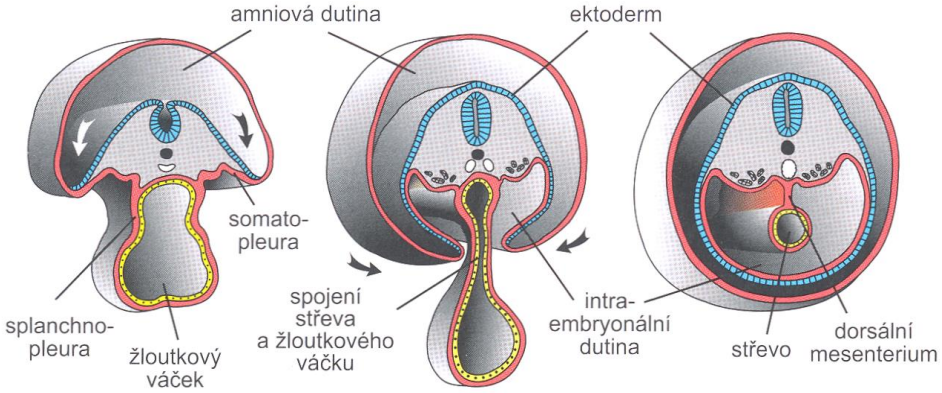
Body wall

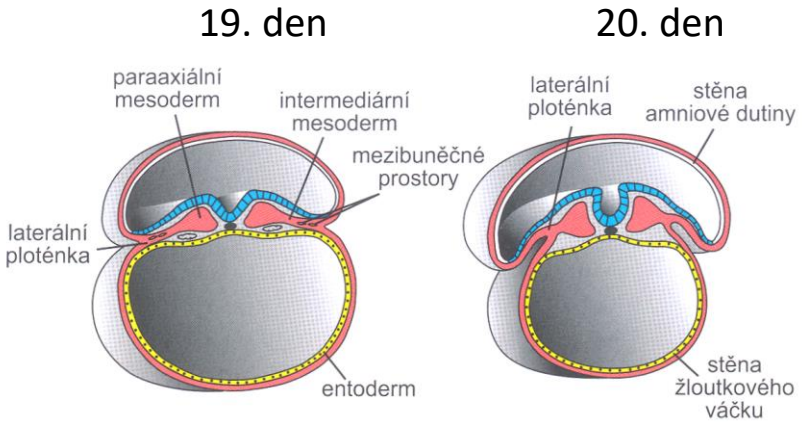
E16.5
(human day 58)

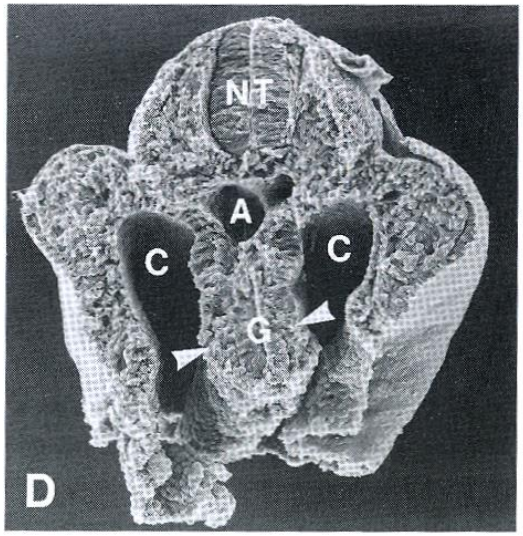
newborn

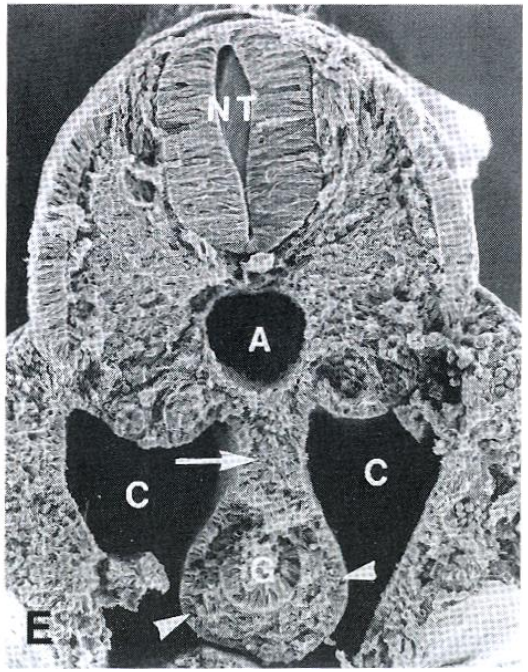
ABNORMALITIES IN DEVELOPMENT OF BODY WALL

- Body wall defects





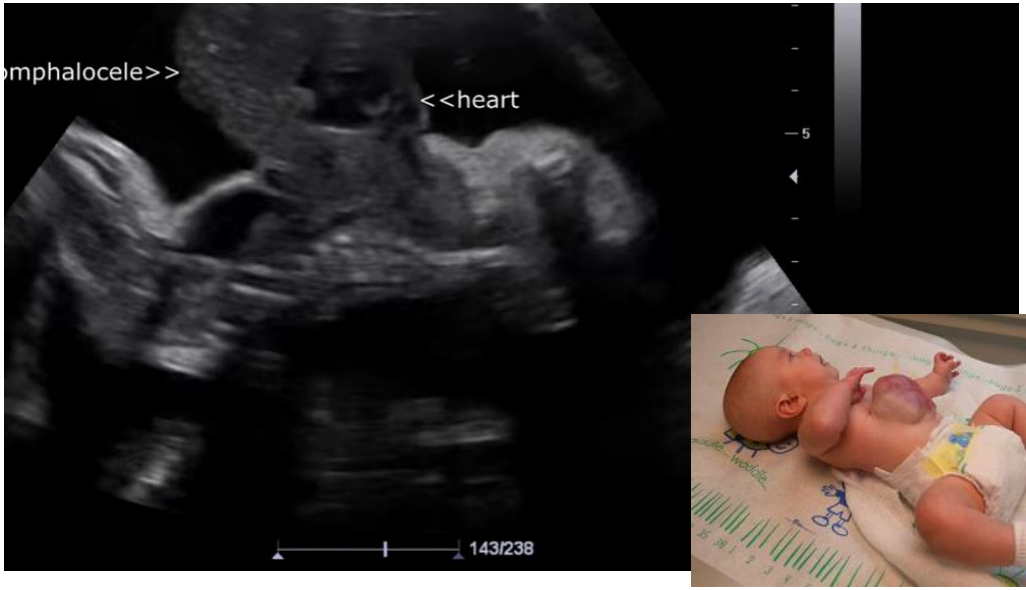




ABNORMALITIES IN DEVELOPMENT OF BODY WALL

- **CLEFT STERNUM / STERNAL FORAMEN**

- failed midline fusion of the sternum
- supraumbilical
- **ECTOPIA CORDIS**
- **PENTALOGY OF CANTRELL** (or thoraco-abdominal syndrome)
- cleft sternum, ectopia cordis, omphalocele, diaphragmatic hernia, CVS disorders
- polyhydramnion
- craniofacial defects, urogenital malformations, limb abnormalities...



ABNORMALITIES IN DEVELOPMENT OF BODY WALL

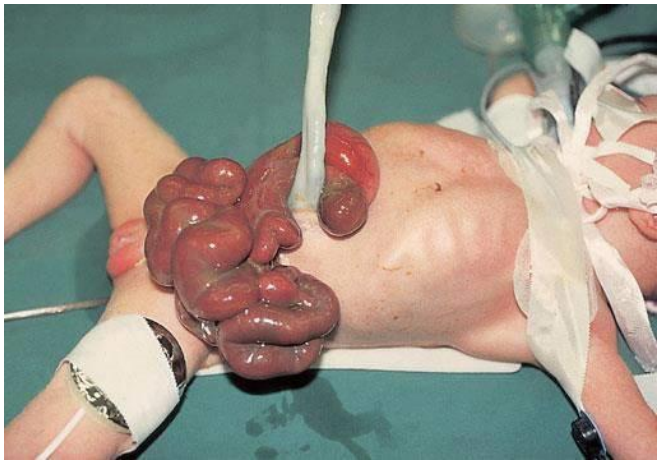
- **OMFALOCELE (EXOMPHALOS)**

- begins in week 6
- failed intestinal rotation and closure of physiological umbilical hernia in week 10 (1:4000)
- intestines, liver, stomach, spleen, urinary bladder
- lined by amniotic ectoderm
- associated defects (CVS, NTD)
- chromosomal aberrations
- α-fetoprotein $\uparrow$ (analogue to serum albinun, elevated in structural body defects)

ABNORMALITIES IN DEVELOPMENT OF BODY WALL

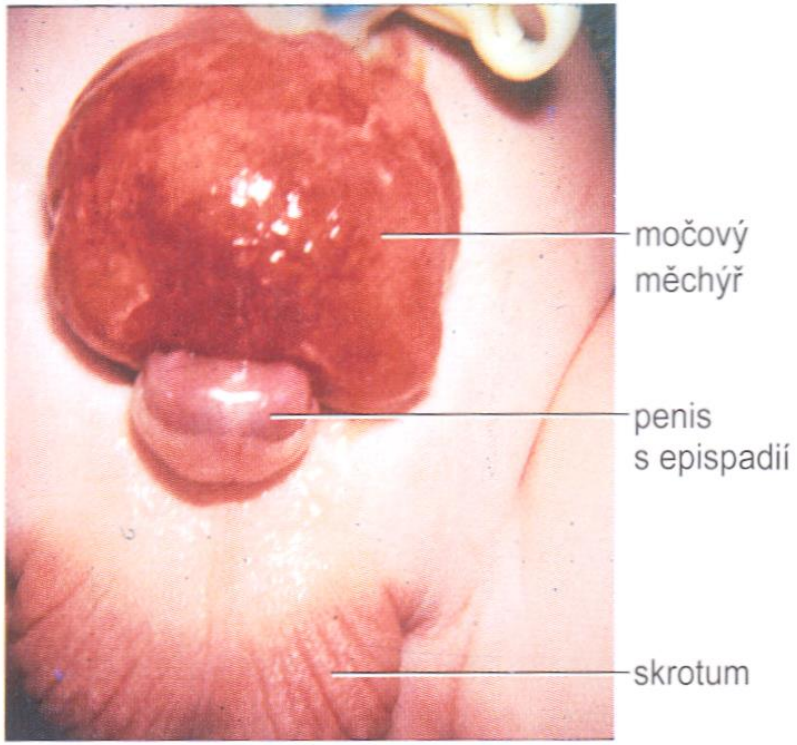
- **GASTROSCHISIS (laparoschisis)**

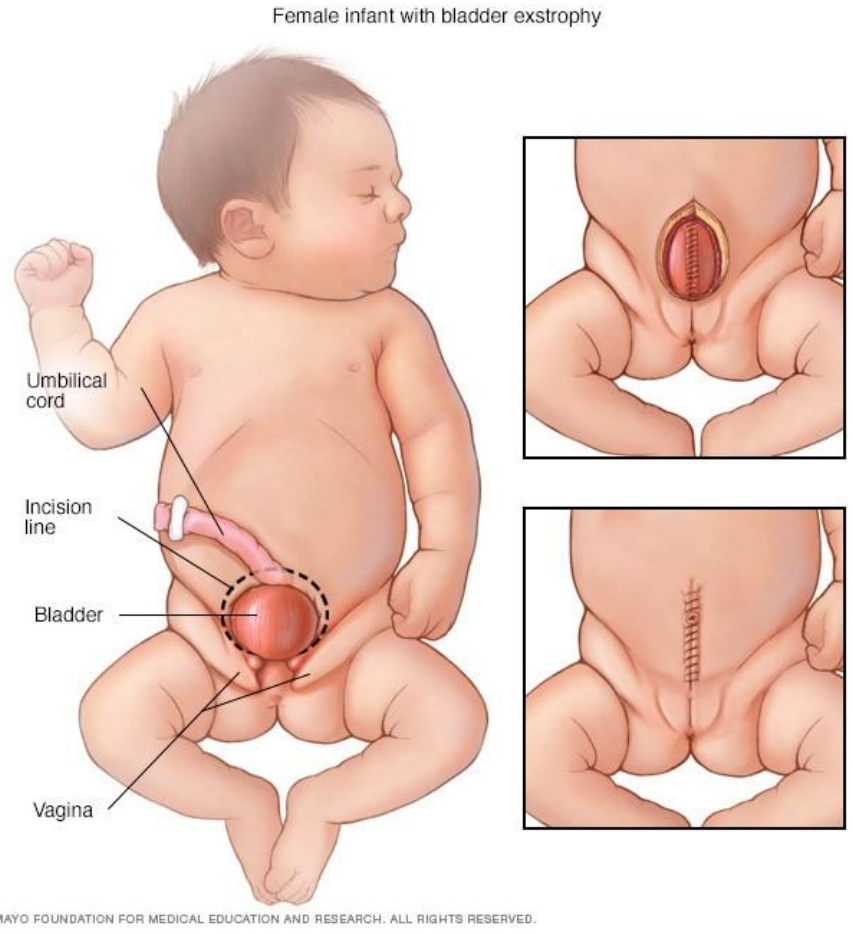
- 1:10000
- organs (intestines) released to amniotic cavity → volvulus
- laterally to umbilicus
- no lining by amniotic ectoderm → maceration
- α-fetoprotein ↑



ABNORMALITIES IN DEVELOPMENT OF BODY WALL

- **BLADDER EXSTROPHY**
- ectopia vesicae
- 1:10 000-50 000
- exstrophy-epispadias complex

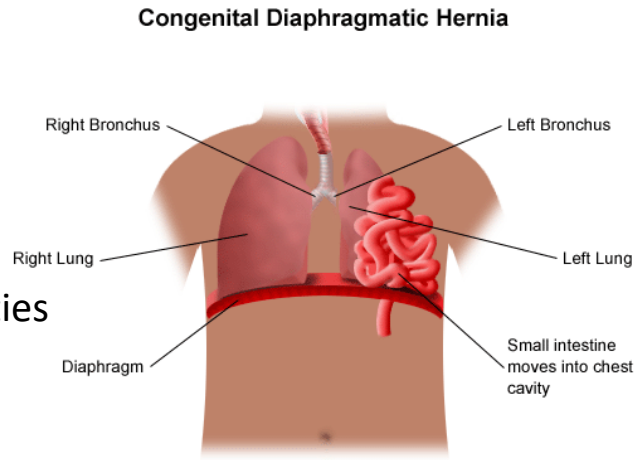


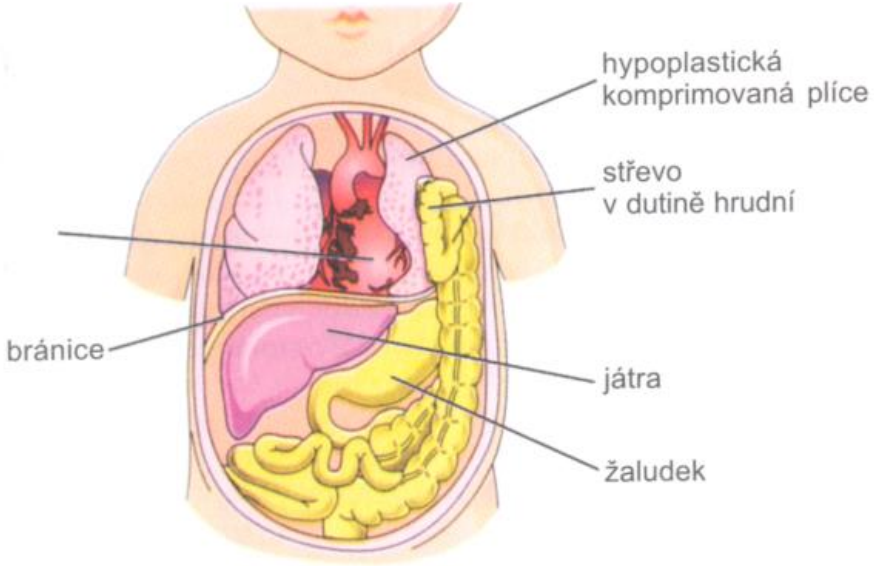


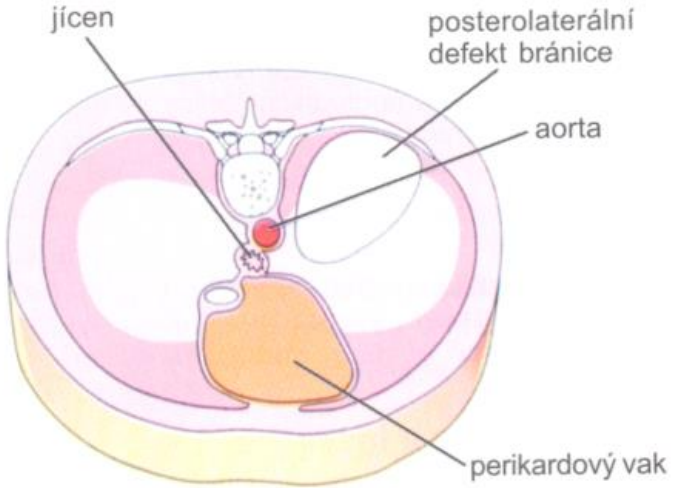
ABNORMALITIES IN DEVELOPMENT OF BODY WALL

- **CONGENITAL DIAPHRAGMATIC HERNIA**

- 1:2000
- pleuroperitoneal membranes fail to close pleuroperitoneal canal(s)
- pleural and peritoneal cavities communicate
- herniation of intestinal loops, liver, spleen, stomach to pleural cavities
- hypoplasia of lungs → respiratory distress → high mortality



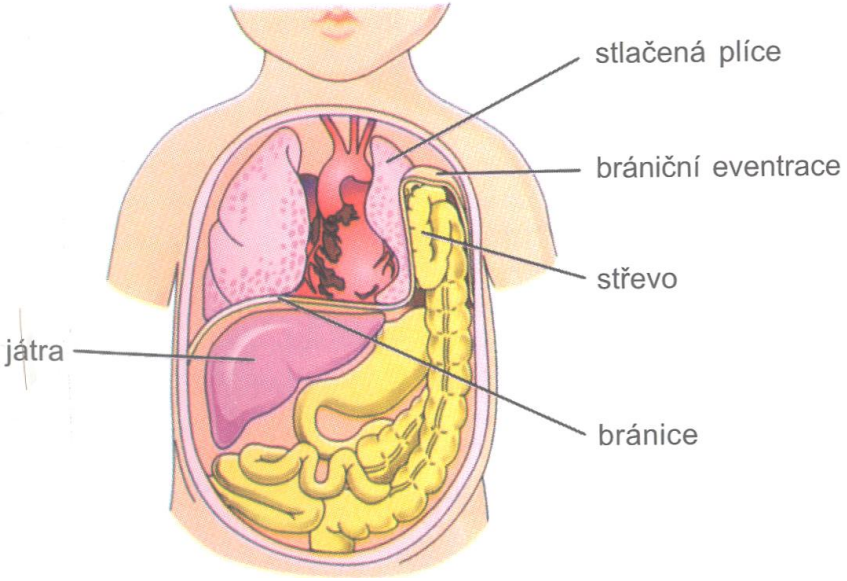


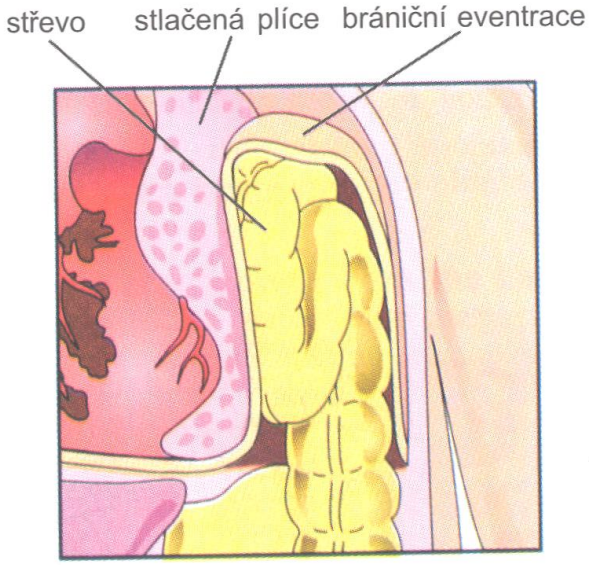


ABNORMALITIES IN DEVELOPMENT OF BODY WALL

- **EVENTRATION OF DIAPHRAGM**
- diaphragm intact, but with defective muscular component
- similar to other posterolateral defects (hernia)

- **ACCESSORY DIAPHRAGM**
- very rare
- hypoplasia of lungs
- fibromuscular membrane on top of normally formed diaphragm dividing the hemithorax into two compartments trapping part of the pulmonary parenchyma





Case reports: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4091454/

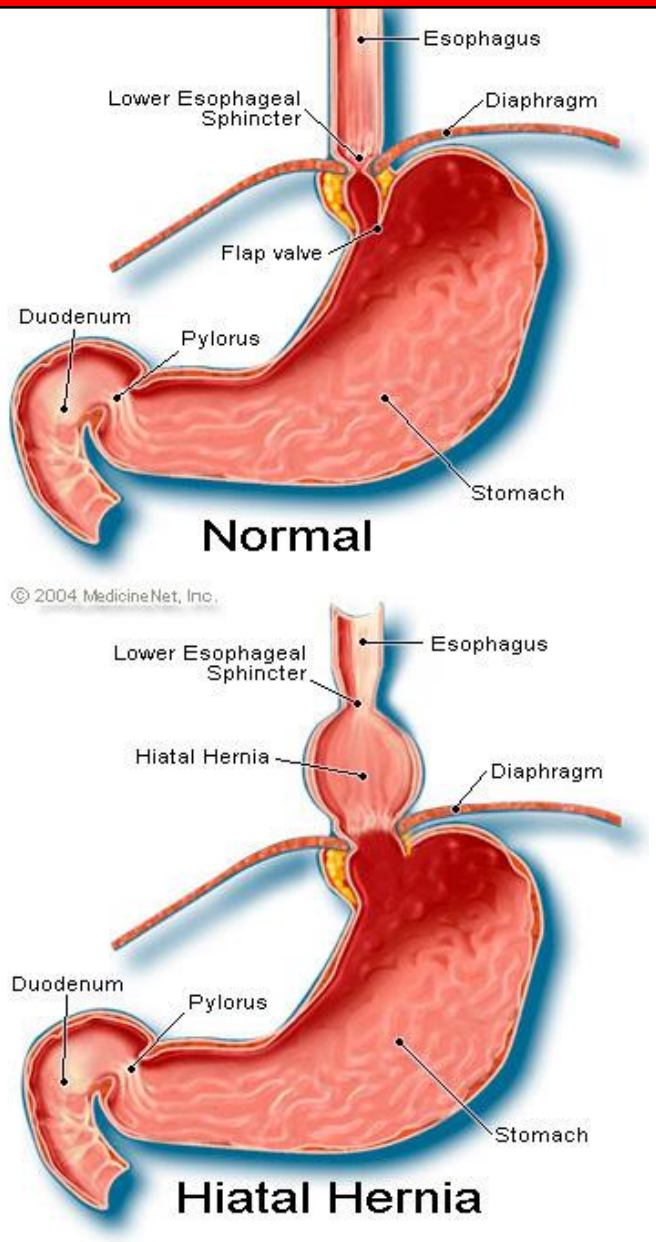
ABNORMALITIES IN DEVELOPMENT OF DIAPHRAGM

- **PARASTERNAL HERNIA**

- sternocostal area (foramen singulare Morgagni)
- herniation of intestines to pericardial cavity
- other abnormalities (omphalocele)

- **CONGENITAL HIATAL HERNIA**

- short oesophagus
- often asymptomatic



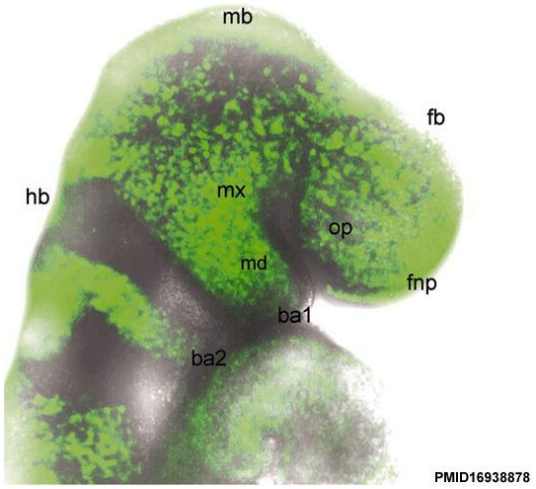
DEVELOPMENT OF SKULL

DEVELOPMENT OF SKULL

SKULL DEVELOPMENT

- Unique anatomy (complexity of morphology, rigidity, flexibility)
- Unique embryonic origin (mesenchyma, neural crest)
- Unique way of ossification (intramembranous, endochondral)

Neural crest cells



HISTOGENETIC PERIODS IN SKULL DEVELOPMENT

- **Blastemal** : all bones of skull
- **Chondrogenous** : only basis cranii
- **Bone** : calva – intramembranous ossification

  basis cranii – endochondral

DEVELOPMENT OF SKULL

- **neurocranium** (brain and sensory organs)
- **splanchnocranium** (viscerocranium) – face, jaws, palate, hyoids
- cranial **mesenchyme** (including ectomesenchyme)

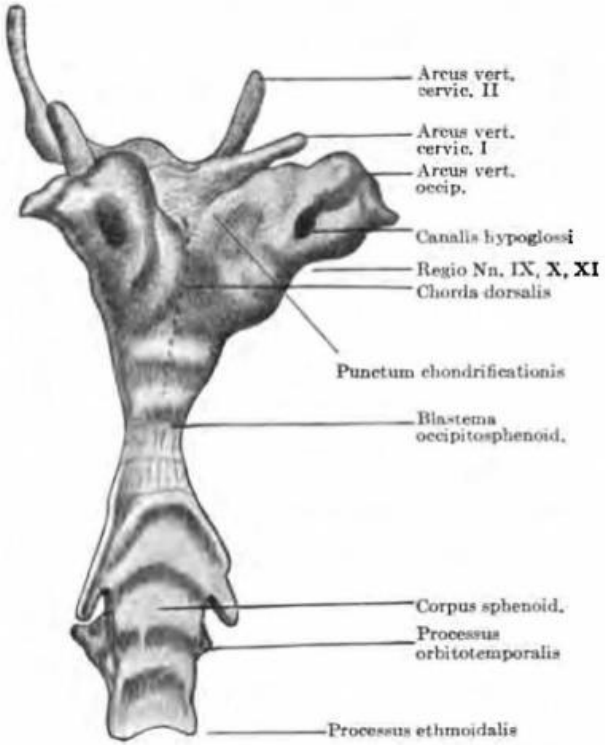
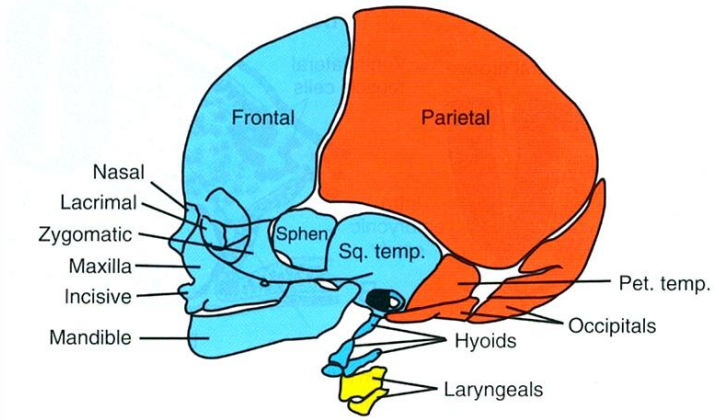
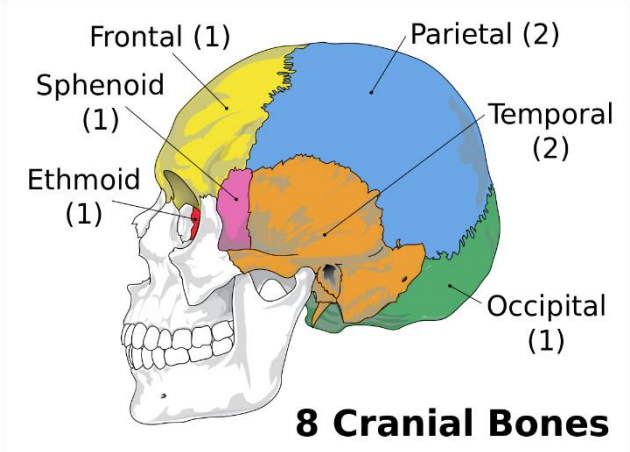


FIG. 308.—(After G. Levi, Arch. f. mikr. Anat. u. Entwicklungsgeschichte, 1900, vol. lv, Fig. 1.) Membranous skull of an embryo 13 mm. long.



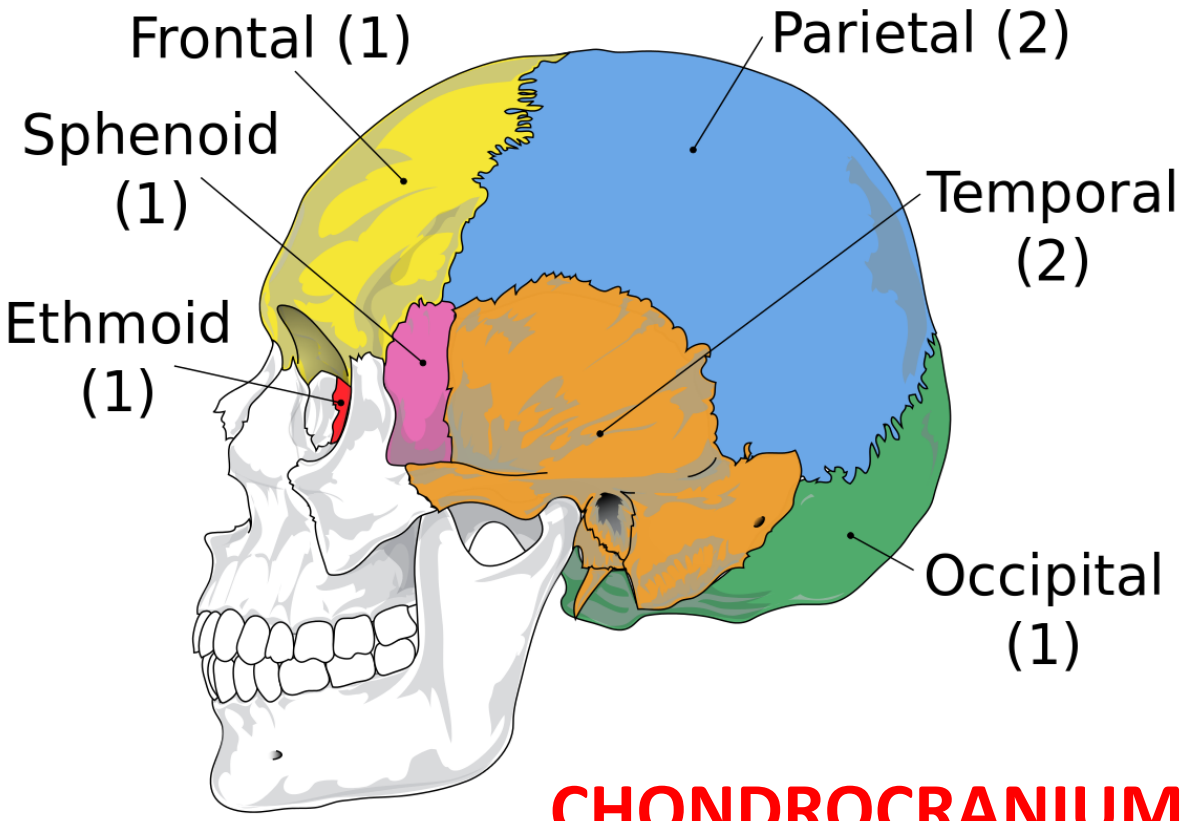
etal structures of the head and face. Mesenchyme for these structures is derived from neural crest *(blue)*, m (somites and somitomeres) *(red)*, and lateral plate mesoderm *(yellow)*.



NEUROCRANIUM

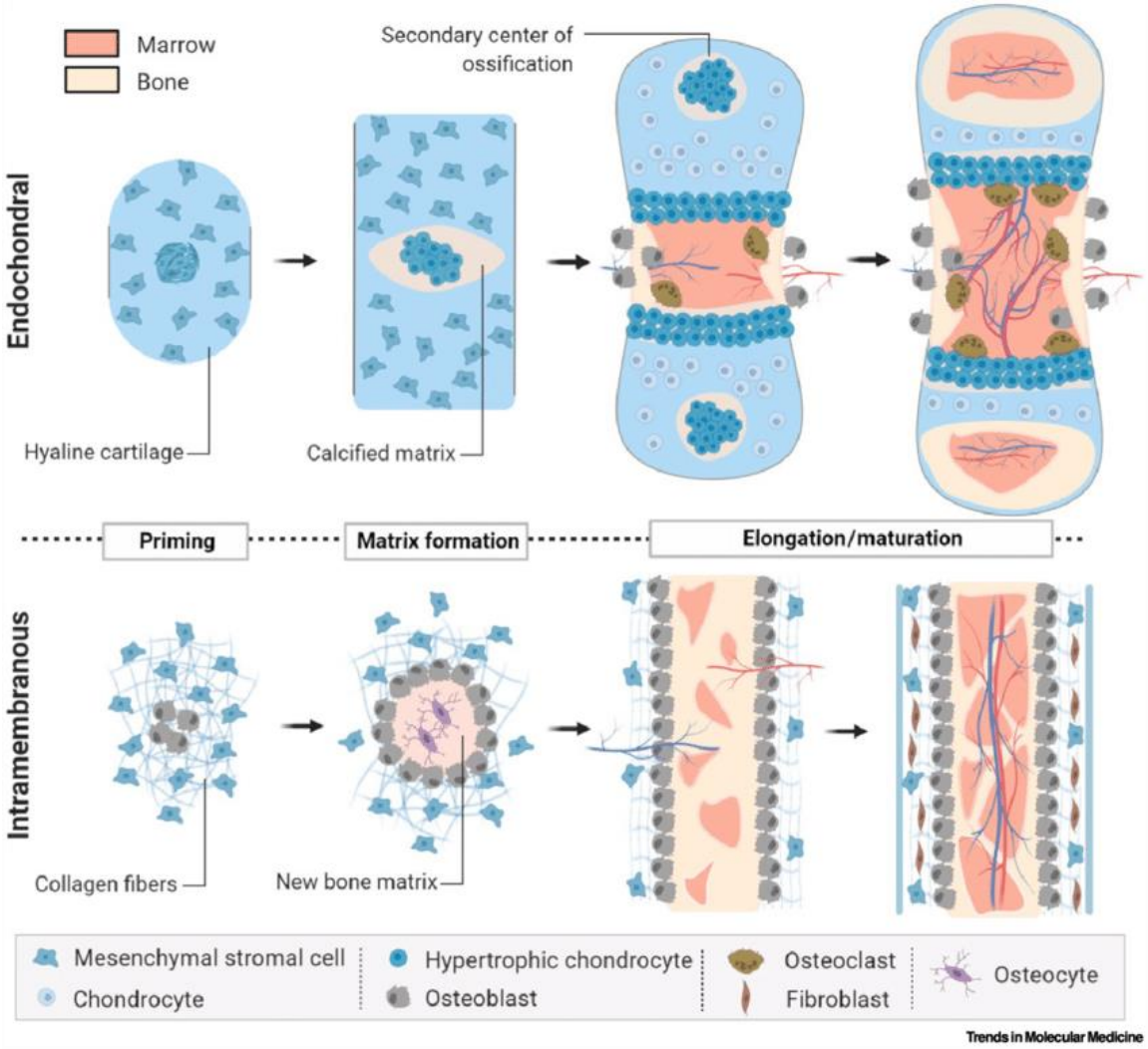
- chondrocranium (cranial base) - inductive role of chorda dorsalis - chondrification centers in mesenchyme blastema of cranial base and cartilaginous capsules around sensory organs
- desmocranium (calva)

DESMOCRANIUM



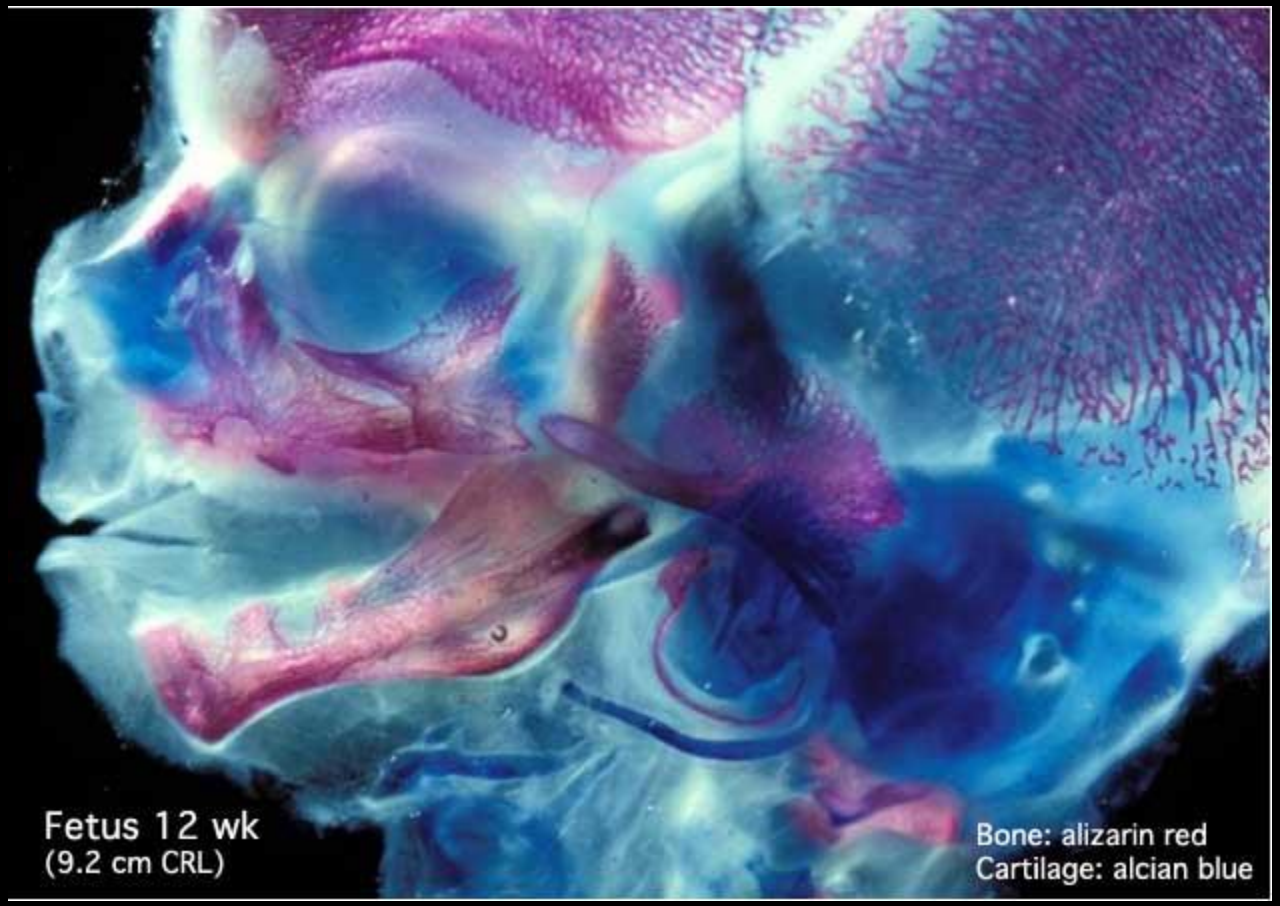
CHONDROCRANIUM

ENDOCHONDRAL vs. INTRAMEMBRANOUS OSSIFICATION



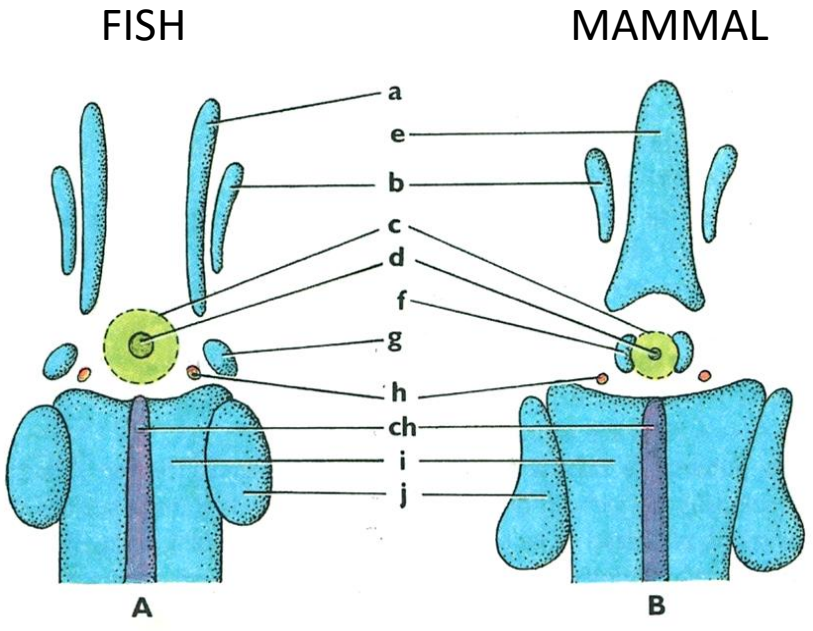
how ossification works? see the video

https://www.youtube.com/watch?v=p-3PuLXp9Wg&feature=emb_logo


Fetus 12 wk
(9.2 cm CRL)
Bone: alizarin red
Cartilage: alcian blue

CHONDROCRANIUM

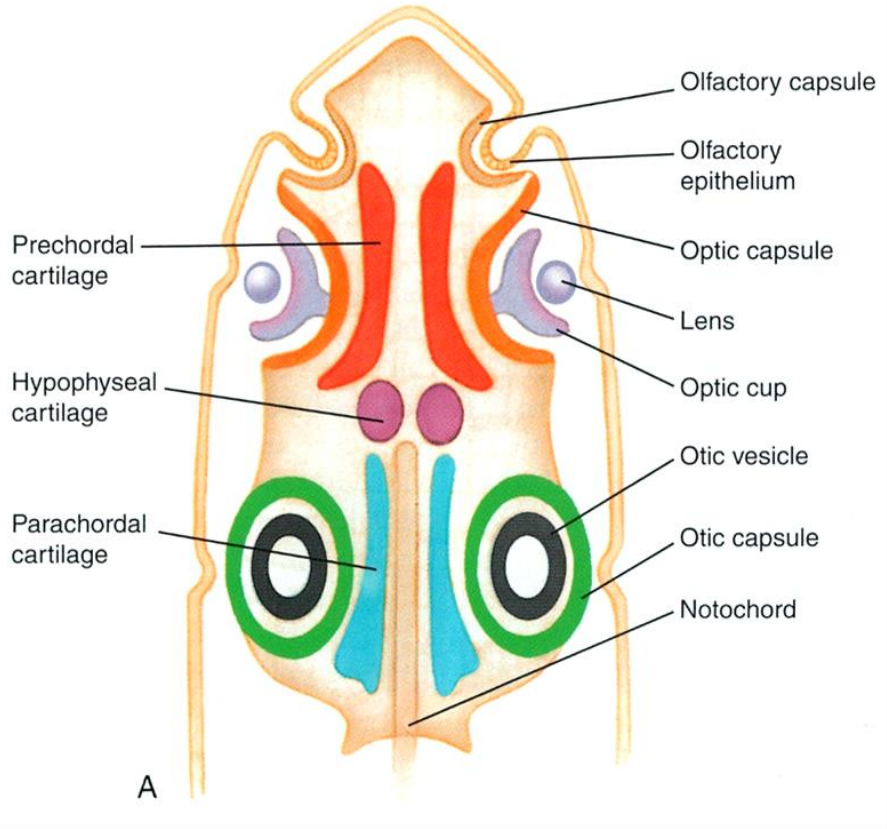
- paired cartilage plates (parachordalia) - parachordal plate,
- paired cartilage trabecules (prior chorda), trabeculae cranii - trabecular plate
- between trabecular and parachordal plates - paired hypophyseal cartilages - around pituitary primordium
- all cartilages fuse into a single basal plate (→ origin of occipital and sphenoid bone)
- basal plate growths anteriorly - forms processus ethmoidalis
- laterally around otic vesicels - capsulae oticae, form majority of temporal bone
- chondrification goes anteriorly towards nasal region - capsula nasalis (septum nasi from trabecular plate)



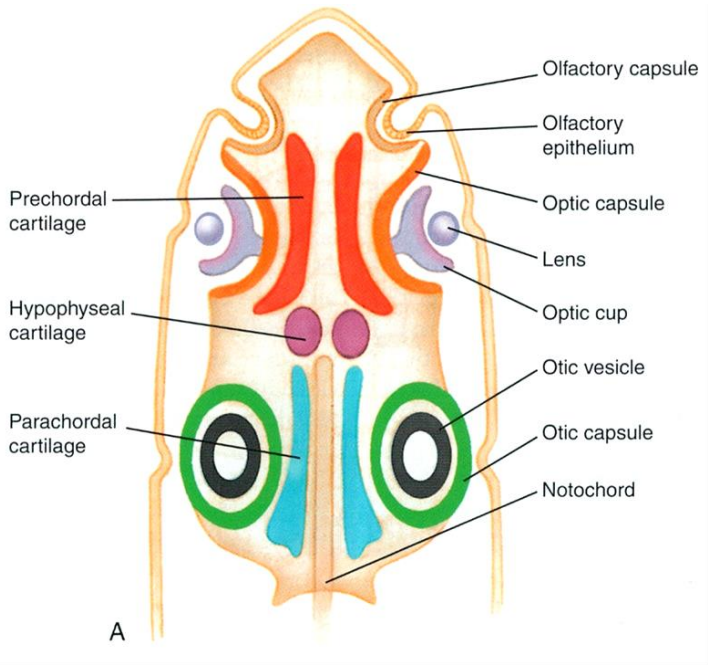
Obr. 74. **Schéma vývoje neurokrania:** A — u ryb; B — u savců; a — trabecula cranii; b — sfenolaterální chrupavka; c — hypofyzární vkleslina; d — infundibulum; e — trabekulární ploténka; f — hypofyzární chrupavka; g — pólová (hypofyzární) chrupavka; h — arteria carotis interna; ch — chorda dorsalis; i — parachordální chrupavky (parachordalia); j — capsula otica

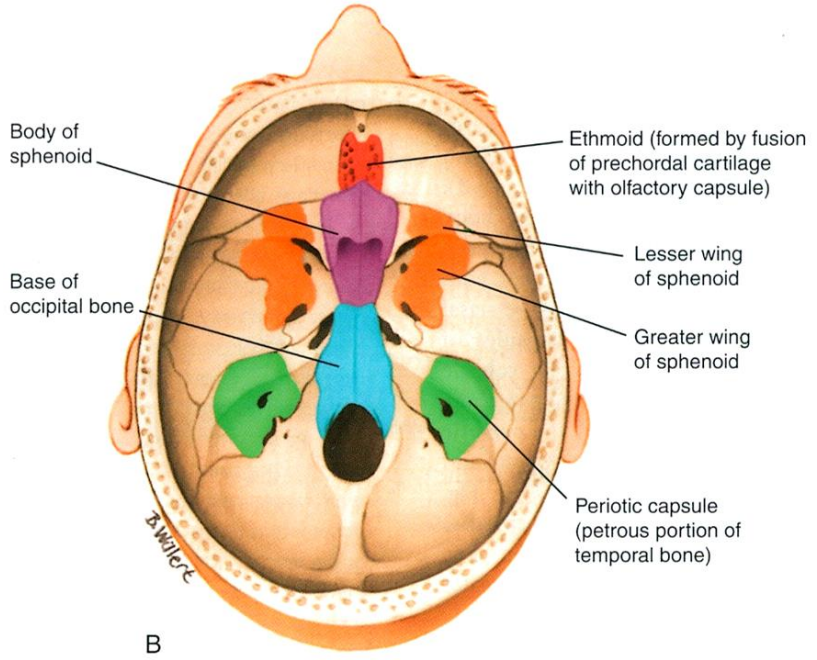
CHONDROCRANIUM

- paired cartilage plates (parachordalia) - parachordal plate,
- paired cartilage trabecules (prior chorda), trabeculae cranii - trabecular plate
- between trabecular and parachordal plates - paired hypophyseal cartilages - around pituitary primordium
- all cartilages fuse into a single basal plate ($\rightarrow$ origin of occipital and sphenoid bone)
- basal plate growths anteriorly - forms processus ethmoidalis
- laterally around otic vesicels - capsulae oticae, form majority of temporal bone
- chondrification goes anteriorly towards nasal region - capsula nasalis (septum nasi from trabecular plate)



CHONDROCRANIUM



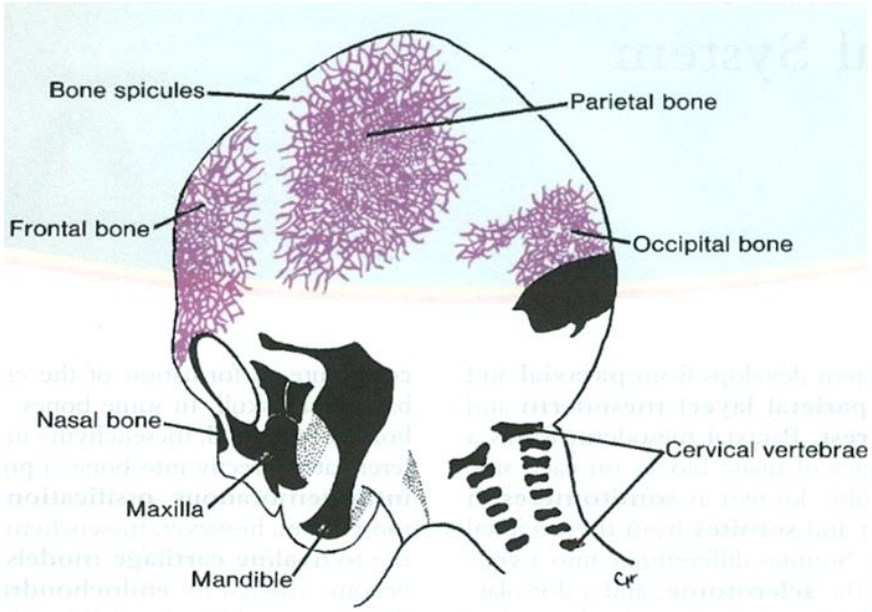


- regio occipitalis - from basal plate - paired processes surrounding brain stem (joining to tectum posterius and lamina parietali) - the only parts of calva that ossify through cartilage
- foramen occipitale magnum between base and tectum posterius
- regio otica - capsula otica - base for pars petrosa ossis temporalis
- orbitotemporal region - development of sphenoid bone (fossa hypophysealis and sella turcica, allae) - cartialge model
- ethmoid region - septum interorbitale and septum nasi, paranasal plates laterally fuse with nasal septum → capsula nasi

SPLANCHNOCRANIUM

- Viscerocranium
- **Membranous ossification** of mesenchymal blastema of branchial arches

- maxilla, partly mandible, zygomatic)

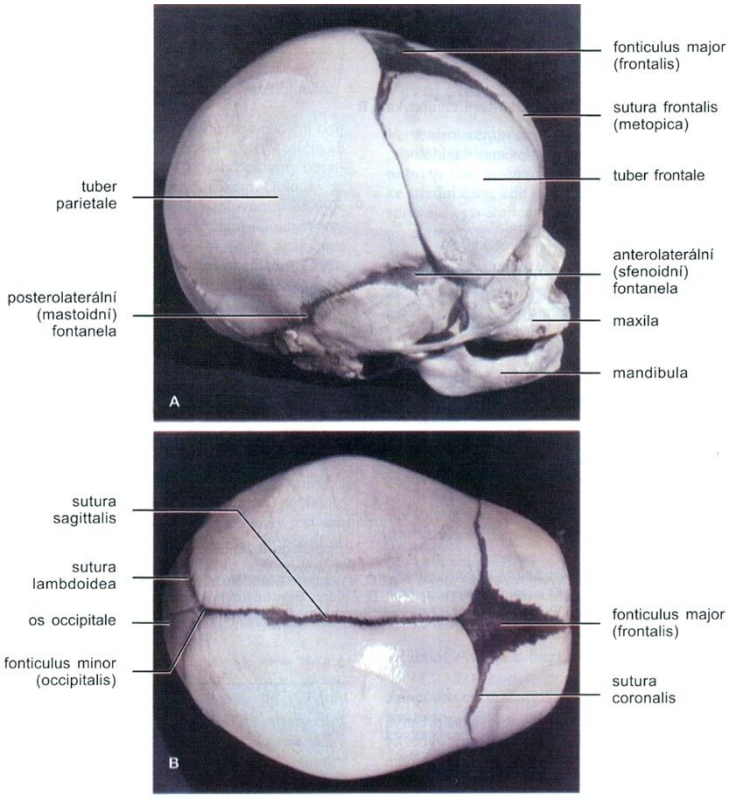


- **Chondrogenic ossification** - cartilages within branchial arches

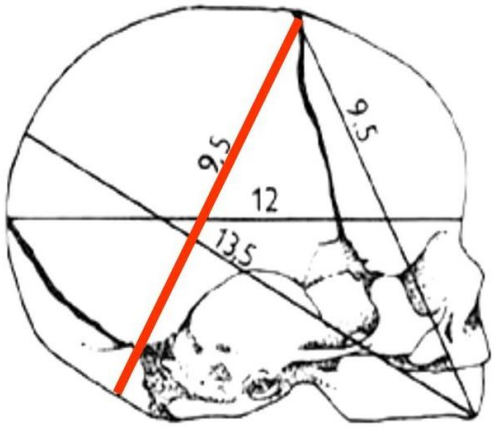
- **1st arch** - three cartilages: incus, maleus, cartilago Meckeli (neck, head, processus condylaris and processus coronoideus of mandible)
- **2nd arch** - stapes, cartilago Reicherti (processus styloideus, cornu minus and upper part of body of hyoid)

SKULL FLEXIBILITY

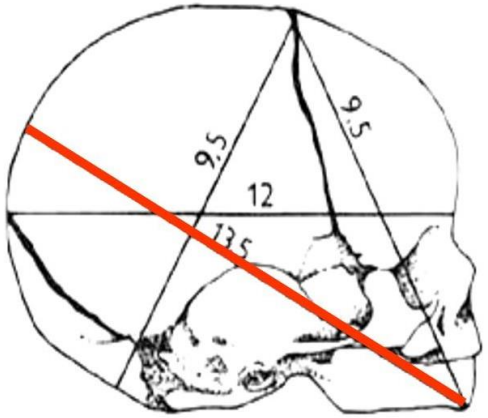
- During ossification, skull bones remain separated
- Basis cranii - synchondrosis (after birth synostosis)
- Calva - sutures develop late in development (allow growth of brain).
- C.t. membranes :
  - Fontanela major, minor
  - Paired fonticulus mastoideus a sphenoidalis
- Ossify around the end of the 1st year of life



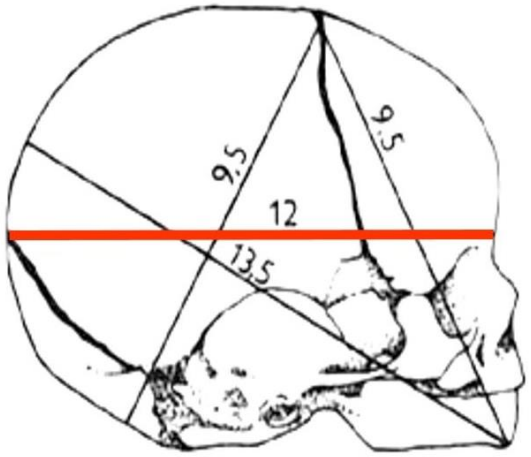
IMPORTANT SIZES



Diameter suboccipitobregmatica 9.5 cm
Circumferentia suboccipitobregmatica 32 cm

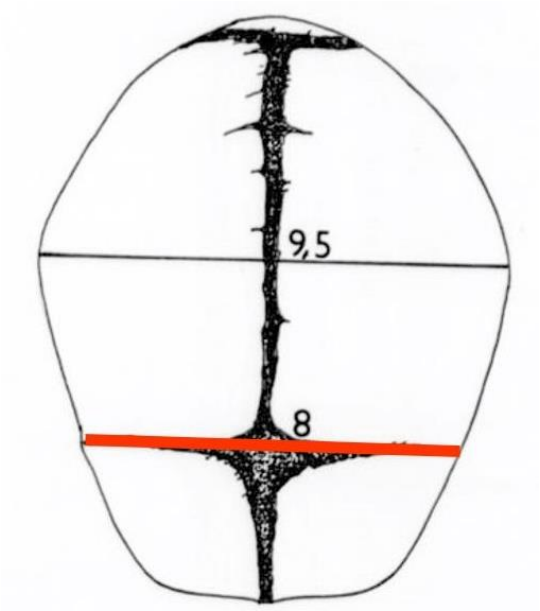


Diameter mentooccipitalis 13.5 cm
Circumferentia mentooccipitalis 36 cm



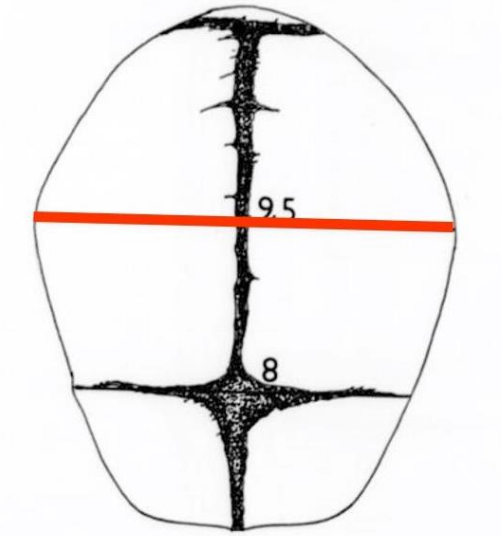
Diameter frontooccipitalis 12 cm
Circumferentia frontooocipitalis 34 cm

IMPORTANT SIZES

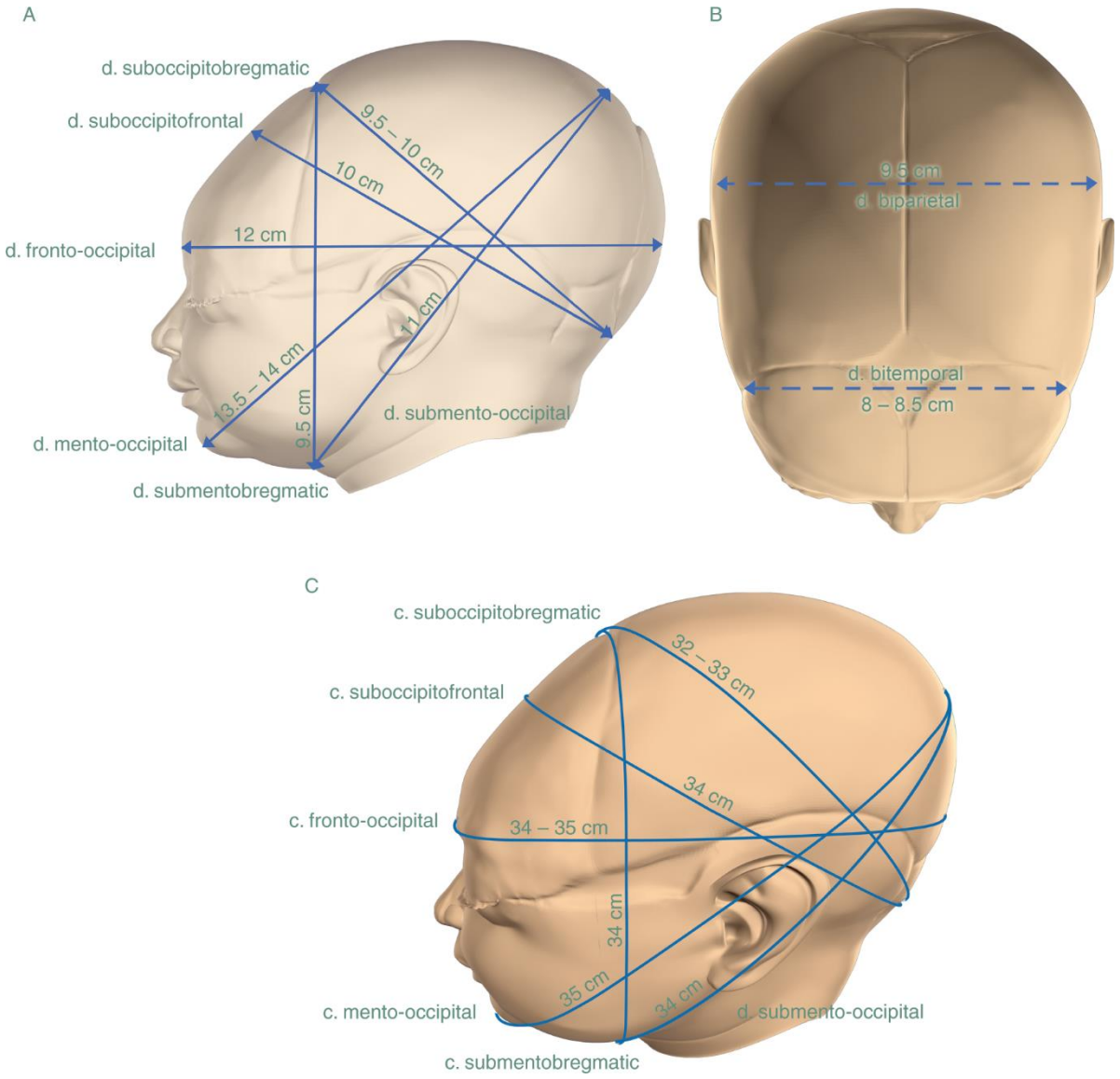


Diameter bitemporalis 8 cm

Diameter biparietalis 9.5 cm

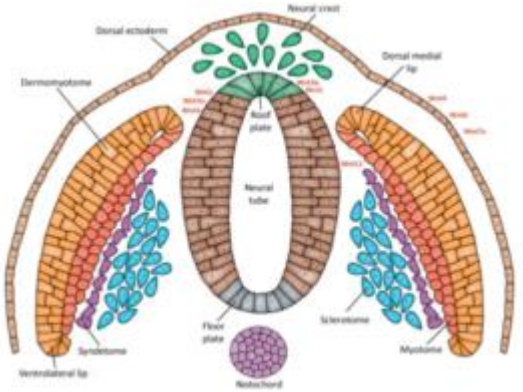


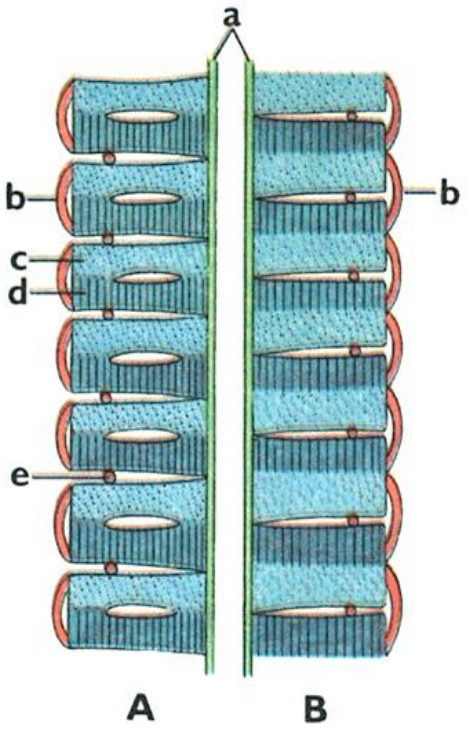
IMPORTANT SIZES



DEVELOPMENT OF THE BACKBONE

- Paraxial mesoderm
- Left and right sclerotome surrounds chorda
- Sclerotomes are not homogeneous (loose and dense regions)
- Intersegmental arteries
- caudal (dense) regions fuse with adjacent cranial (loose) region of neighbor sclerotome - future vertebral body
- Muscles derived from myotomes attach to adjacent vertebrae
- Anulus fibrosus
- Chorda dorsalis - nucleus pulposus

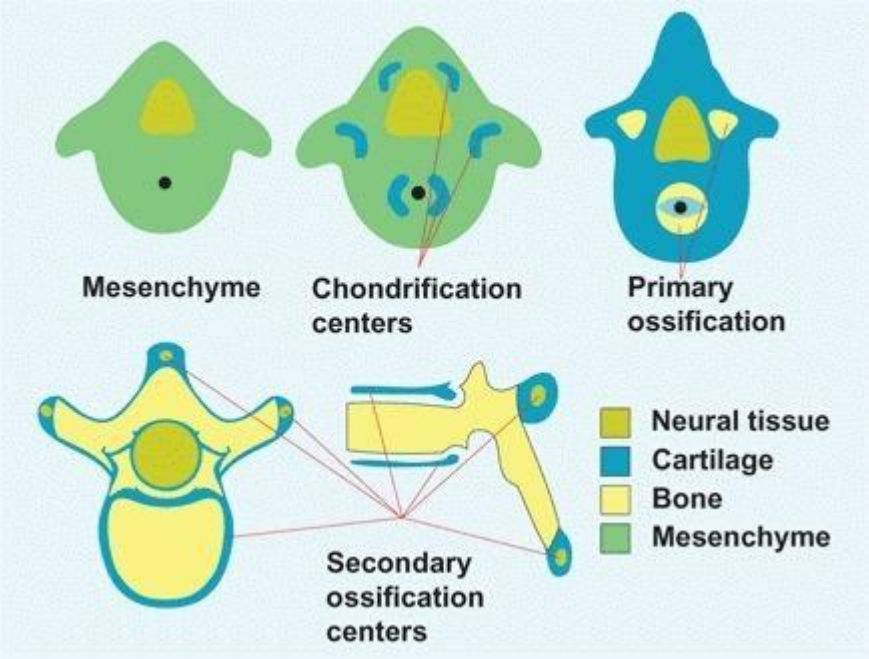


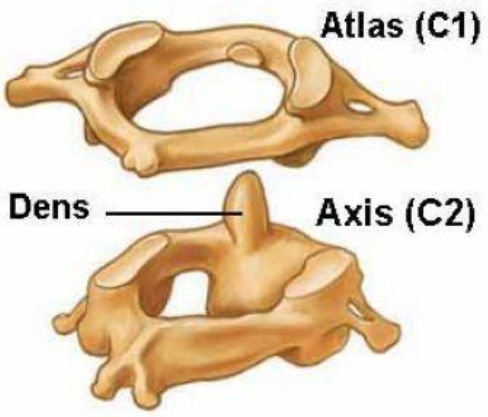


DEVELOPMENT OF THE BACKBONE

- **Development of vertebrae**
- From vertebral body – dorsally: processus neurales (neurapophysis) -arcus vertebrae and ventrolaterally: processus costales (pleurapophysis).
- Chondrification by the week 4: 3 pairs of chondrification centres (1 pair in vertebral bodies, 1 pair in neurapophysis, 1 pair in pleurapophysis)
- Chorda dorsalis replaced by cartilage
- On arcus vertebrae – processus transversus, p. articularis superior and inferior, p. laminaris - p. spinosus.

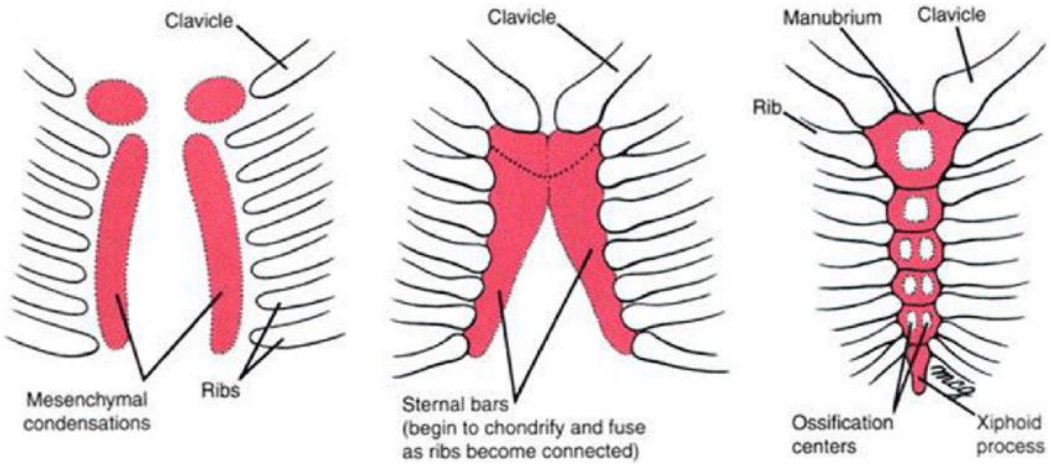
- Morphogenesis of the first two cervical vertebrae is different



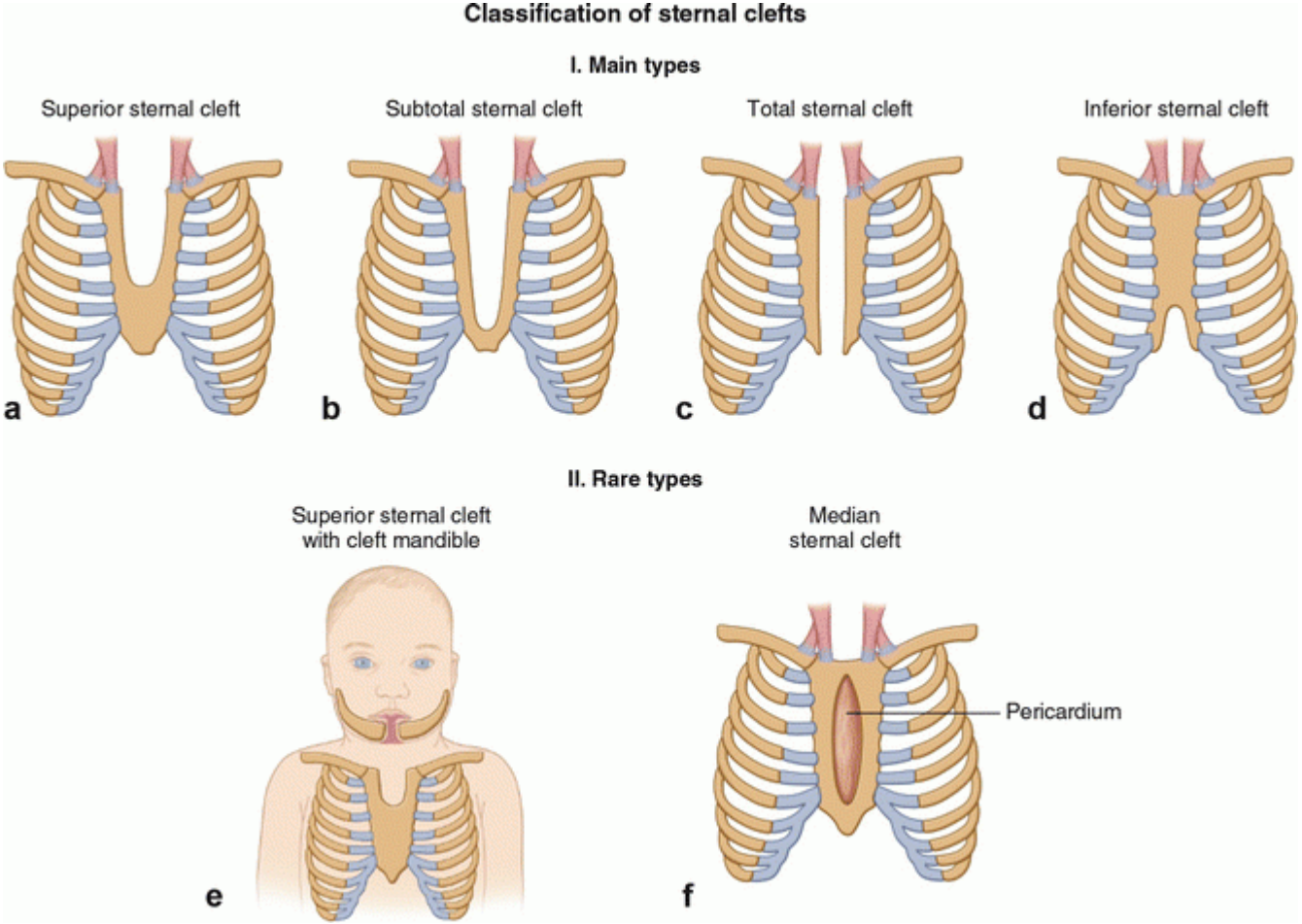


DEVELOPMENT OF THE RIBS AND STERNUM

- Processus costales of thoracic vertebrae grow ventrally and form anlage for ribs
- Ventral ends fuse and form the sternal bars (paired basis for body of sternum). Manubrium sterni from interclavicular blastema
- Processus costales of cervical and lumbar vertebrae are short, fuse with processus transversi. In sacral region, processus costales fuse with vertebral bodies and processus transversi - ala sacralis. Processus articulares also fuse.



ABNORMAL DEVELOPMENT OF STERNUM



https://www.youtube.com/watch?v=TcVJdMSGPX8

Thank you for attention

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