EMBRYOLOGY

3 phases of intrauterine [prenatal] life

- Pre-embryonic period
  - ⇓
  - 1st 2 weeks of IUL
- Embryonic period
  - ⇓
  - 3-8 weeks of IUL
  - ⇓
  - period of organogenesis
  - most crucial period to teratogenous exposure
- Fetal period
  - ⇓
  - 9th week till birth

Implantation:

- Complete embedding of blastocyst into uterine edometrium.
- Occurs 5-7 days after fertilisation
- usual site of implantation → upper post. wall of body of uterus

Morula :

→ 16 celled stage of embryo.
→ 3 - 4 days after fertilisation.

Blastocyst :

→ Post - ~~co~~ morula stage / Implantation stage
→ form the embryo
→ 4 - 5 days after fertilisation.

- Most common site of abnormal implantation [ectopic pregnancy] → Tubal Pregnancy [Ampulla]

- In humans, interstitial implantation occurs.

Fate of fertilisation [effects of fertilisation] :

→ Completion of 2nd meiotic division [of 2° oocyte] so that ovum is formed.

→ Restoration of diploid [2n] chromosome in zygote.

→ Initiation of cleavage [series of mitotic divisions]
→ Determination of sex of individual.

Spermatogenesis :

→ Formation of spermatozoa from spermatogonium.

Site :⇒ Seminiferous Tubules of testis.

Total duration :⇒ 70 - 75 days.

→ storage,
Gaining of motility,
Maturation of sperm } occur in → Epididymis

→ Final maturation of sperms → Capacitation of sperms

- ↑ ability of sperms to penetrate ovum.
- Last for about 7 hrs.

⇓ ♀ genital tract

⇓ mainly in Uterine tubes

[UT > Uterus]

Pathway of movement of sperms : [inside ♂]

Seminiferous tubules → straight tubules → Rete testis → Efferent ductules → Epididymis → Vas deferens → ♂ urethra

Scrotal temp. → 2-3°C lower than body temp.
[for normal spermatogenesis]

steps:

Primordial Germ Cells

⇓

Spermatogonium

~~Gets~~

⇓

1 - Primary Spermatocyte [2n]

1st meiotic division ⇓

2 - Secondary Spermatocytes [n]

2nd meiotic division ⇓

4 - spermatids [n]

Spermiogenesis ⇓

last step of spermatogenesis ← 4 - spermatozoa / Sperms [n]

→ 1 1° spermatocyte → 4 sperms

→ 1 1° oocyte → 1 ovum

→ Polar bodies formed → in oogenesis only

→ Meiosis occurs only in germ cells. [Gonads]

Testis Ovary

Oogenesis :

- formation of ovum from oogonium.

site : - Ovarian Cortex

steps :

Primordial Germ Cells

⇓

Oogonium

⇓

1° oocyte ← gets arrested in diplotene stage of Prophase-I

⇓ 1st meiotic division

2° oocyte + 1st polar body ← gets arrested in metaphase

⇓ 2nd meiotic division

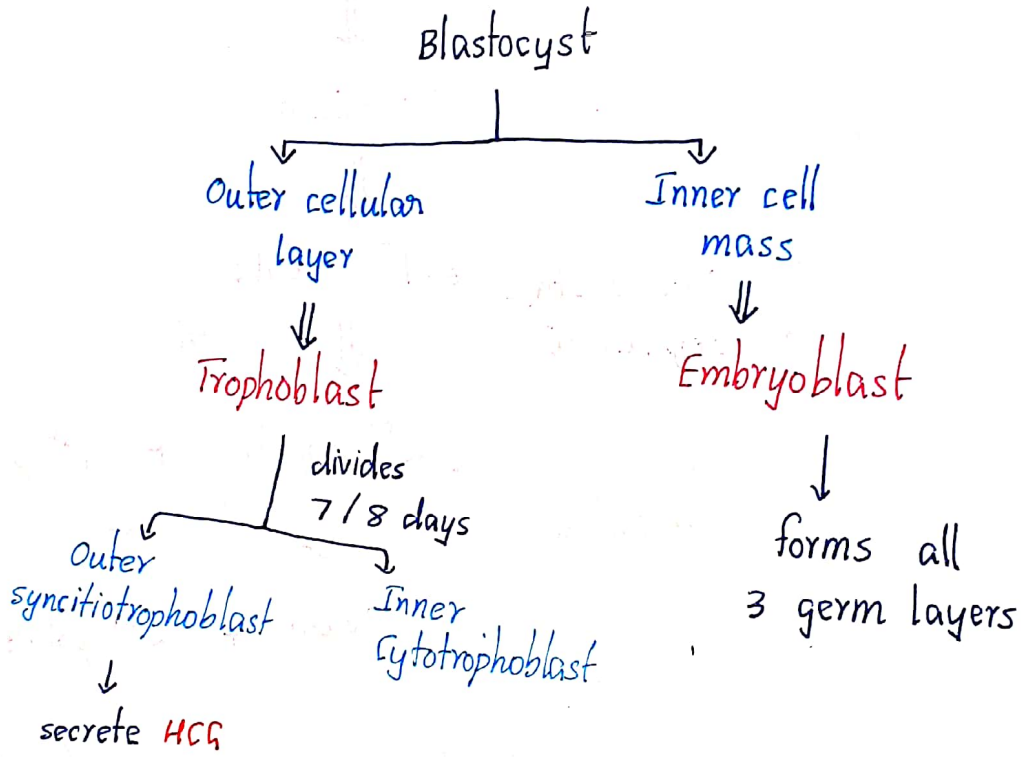
Ovum + 2nd polar body

→ The 1° oocyte formation occurs only before birth.
→ They get arrested in diplotene stage.
→ When they reach puberty, just before ovulation 2° oocyte is formed.
→ This 2° oocyte gets arrested in Metaphase - II.
→ Completion of 2nd meiotic division occurs soon after fertilisation. [(i.e) immidiately after sperm penetrates the ovum].

Cleavage :

→ Continuous mitotic divisions with very less duration of interphase.

→ [Nuclear content & cell number increases.
Cytoplasmic volume decreases.



→ Fertilised ovum enters Uterus in Morula stage.
⇓
Cuterine cavity]

Zona Pellucida :

- Membrane covering embryo till blastocyst stage.
- 2 functions :
  - Prevent polyspermy
  - Prevent ectopic pregnancy

2 fates of Corpus Leutium :

If No fertilisation

↓

Corpus luteum will last for 14 days

↓

Then converts into corpus albicans

Fertisation occured

↓

C.L will last for 3-4 months

↓

secrete progesterone

2nd week of development :

→ Bilaminar Germ-disc formation.

Events occuring :

✱ Blastocyst

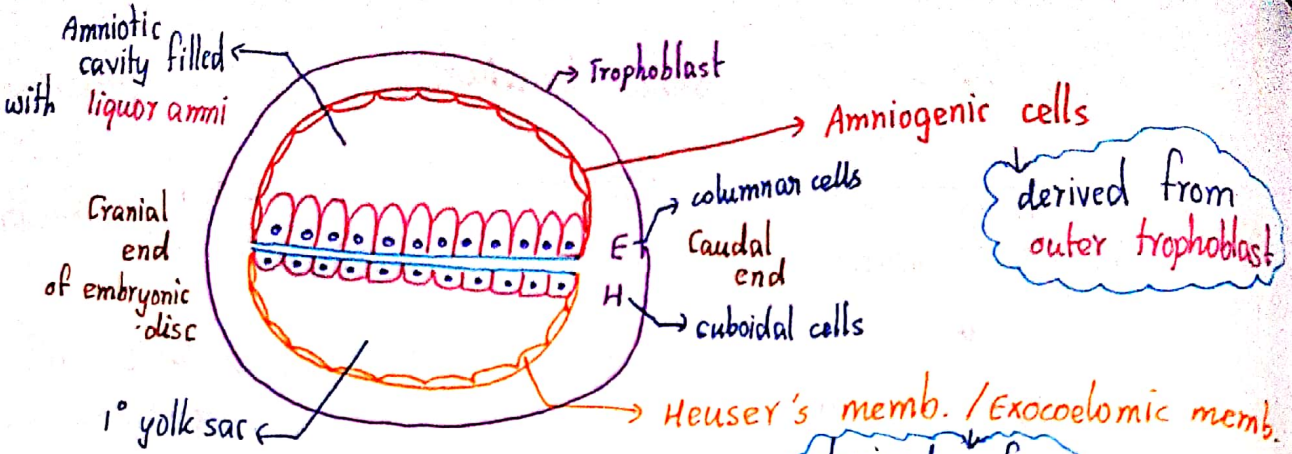
- Trophoblast
  - this occurs @ 8th day
  - inner Cytotrophoblast → secrete HCG
  - Outer Syncitio-Trophoblast
- Inner Cell Mass
  - epiblast → This alone will form all 3 germ layers
  - Hypoblast

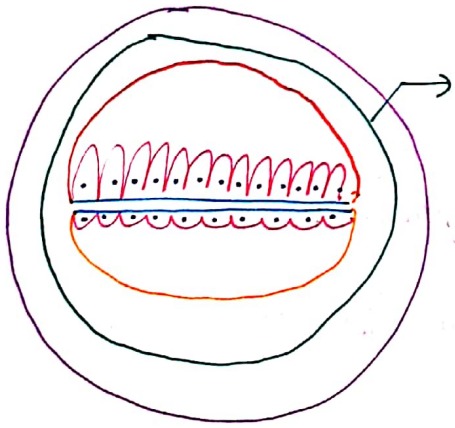
Epiblast forms :

→ Primitive streak
→ Amniotic cavity
→ all 3 germ layers

Hypoblast forms :

→ Prochordal plate
→ 1° yolk sac
→ Exocoelomic membrane / Heuser's memb.





extra-embryonic ~~membr~~ mesoderm

⇓

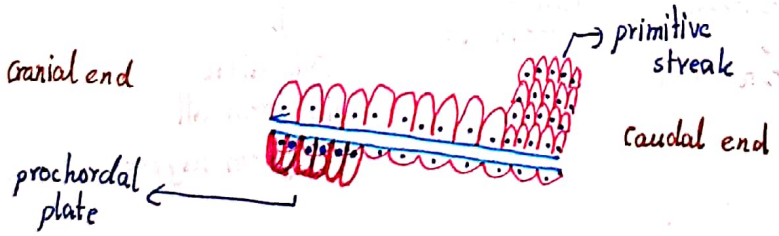
a.k.a primary mesoderm

it then divides into

Outer Somatopleuric layer

Inner Splanchnopleuric layer

This is due to formation of extra-embryonic coelom



3rd week of development

- Trilaminar germ disc formation.

⊛ Gastrulation:

↳ another name of Trilaminar Germ disc formation.

↳ The process of formation of primitive streak & eventually formation of all 3 germ layers is known as gastrulation.

↳ 1st germ layer formed: endoderm

derived from epiblast & replaces hypoblast

⇓

after formed will replace hypoblast

↳ 2nd germ layer formed: intra-embryonic mesoderm

↳ the remaining cells of epiblast persist as } → ectoderm.

⊛ Primitive streak:

→ Formation: proliferation of epiblast cells at the caudal end of embryonic disc.
- formed during 3rd week of development

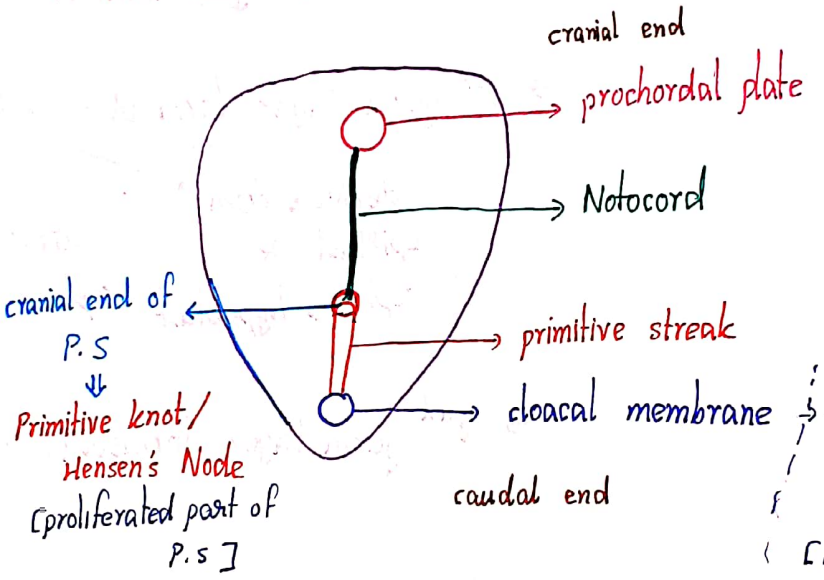
→ formation of primitive streak is the 1st indicator/sign of gastrulation.

→ formation of primitive streak } occurs on 15th day [begining of 3rd week]

→ Functions / derivatives of P.S :

└ P.S gives rise to 3 structures [SIN]

S - Septum Transversum
I - Intra-embryonic Mesoderm
N - Notochord



→ Fate of P.S :

└ Normal P.S cells obliterate after forming all the 3 structures [SIN] in and around 4th week.

└ sometimes abnormally, P.S cells persist ⇓ will give rise to Sacro-Coccygeal Teratoma → most common tumor in New born

also can be due to persistance of Primordial Germ Cells → derived from ectoderm

Notocord :

→ a midline rod-like structure of embryonic disc.

→ formed / derived from Intra-embryonic mesoderm.

→ develops during 3rd week of development.

Formation :

↳ formed by proliferation of cells of cranial end of primitive streak. (i.e) Primitive knot.

Extent :

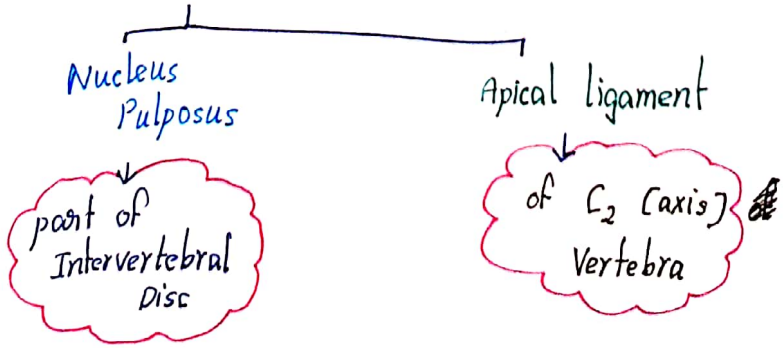
from Primitive knot / Cranial end of P.S
to Caudal end of prochordal plate

Functions :

- defines the axis of embryo.
- Induces ectoderm to form Neural plate. [forms future Neural Tube]

Fate :

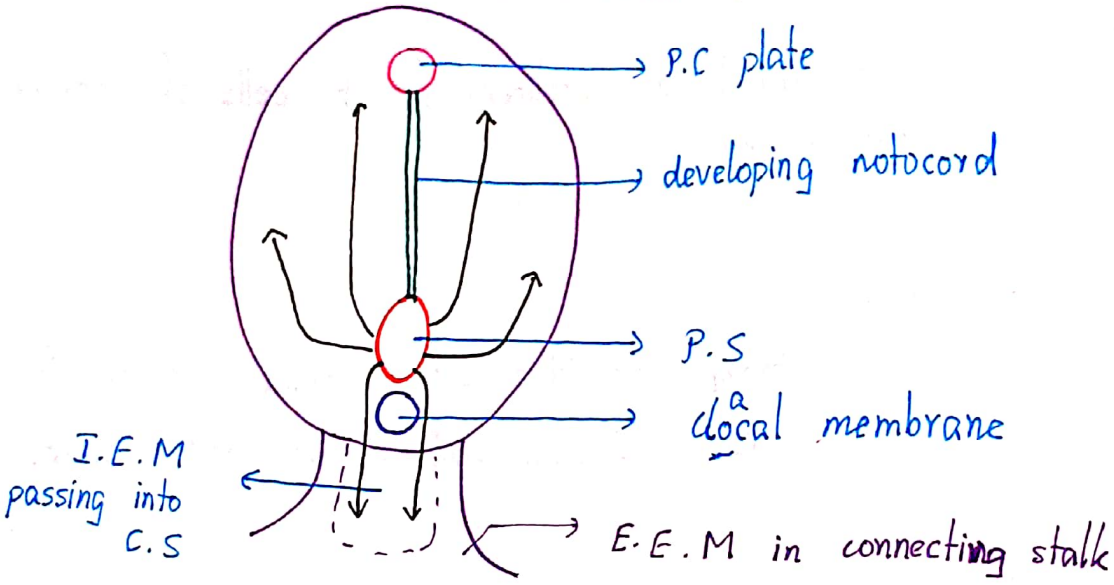
- doesnot give rise to any midline structure in body. [ex: Vertebral column]
- 2 remnants of N.C in adults :



- Normally Notocordal cells disappear /obliterate completely [except the 2 remnants].

- Abnormally N.C persist & forms chordoma → benign tumur

spread of IEM cells after formed from P.S :



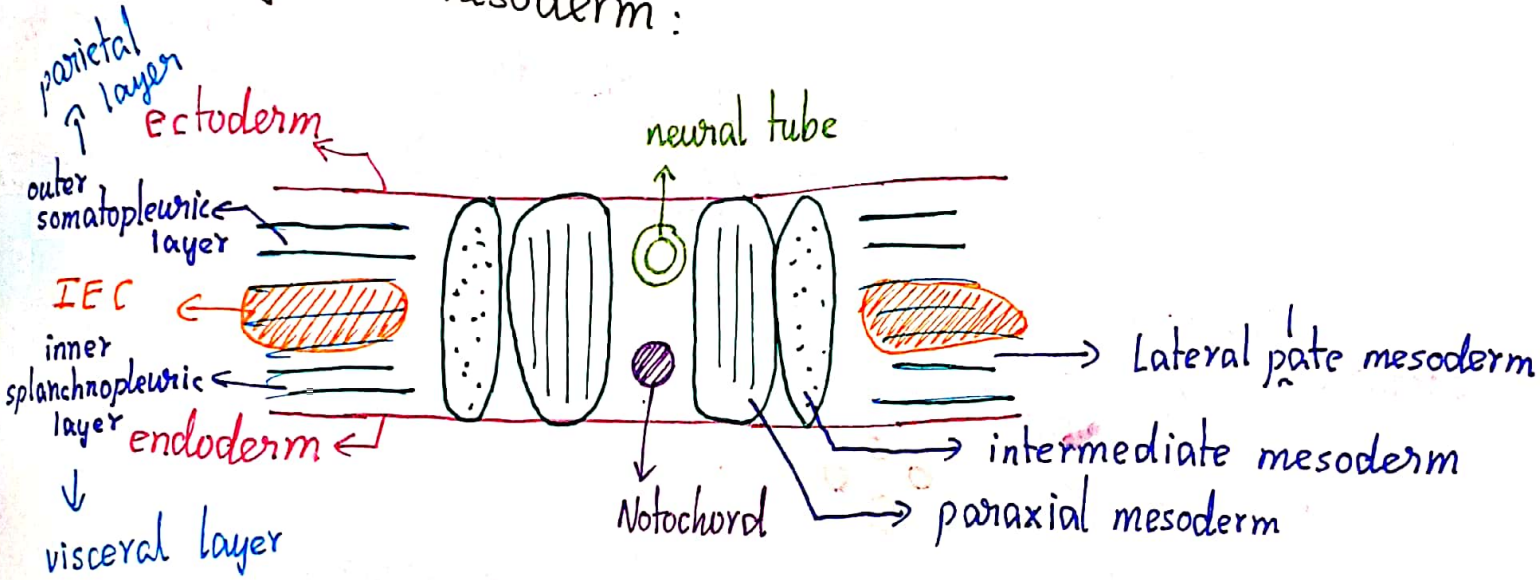
IEM spread throughout embryonic disc except.

- Prochordal plate
- Notochord
- Cloacal membrane

P.C.P & C.M ⇒ made up of only ectoderm & endoderm [no mesoderm]

forms Buccopharyngeal membrane

Intraembryonic mesoderm:



Formation:

- formed by proliferation of Primitive streak cells.
- formed in 3rd week of development.

IEC:

give rise to

- Pleural Cavity
- Pericardial Cavity
- Peritoneal Cavity

3 subdivisions & derivatives of IEM:

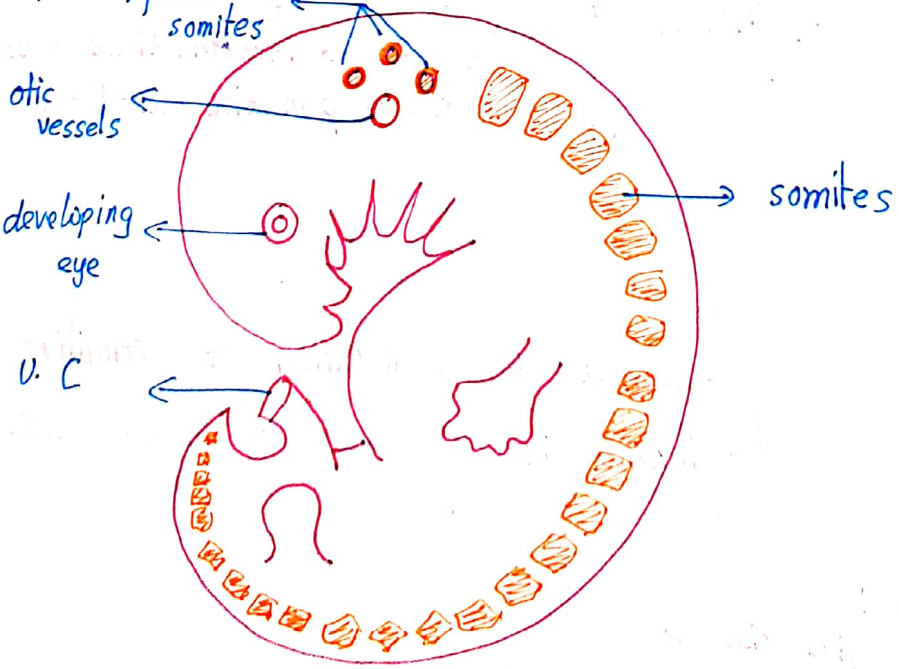
Paraxial mesoderm
↓
gives rise to
- Somites

Intermediate mesoderm
↓
gives rise to
- uro-genital system
[kidneys, Gonads, Mesonephric & Para-mesonephric ducts]

Lateral plate mesoderm
↓
gives / divided into 2 parts by formation of intra-embryonic coelom

- **Outer somatopleuric layer** [Parietal layer]
  ↓
  gives rise to
  - appendicular skeleton
- **Inner splanchnopleuric layer** [Visceral layer]
  ↓
  gives rise to
  - Cardiac muscles
  - smooth muscles

Somites: preoccipital / preotic somites



- somites are cubical structures.
- Counting the somites ⇒ approx. age of ~~so~~ embryo can be found.

- somites are derived from paraxial mesoderm in cranio-caudal direction.

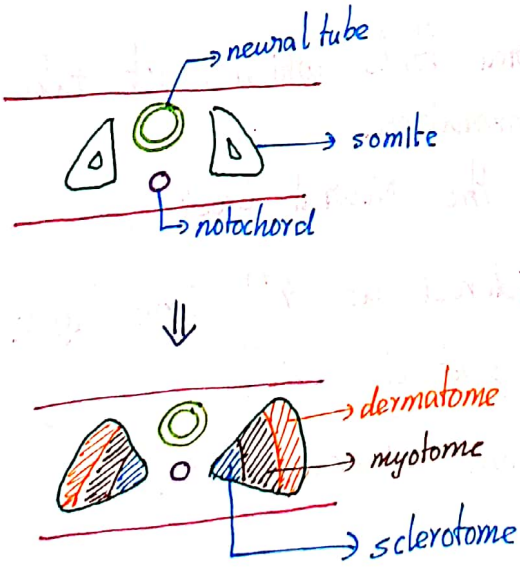
  ⇓

  (i.e) starts from occipital region

  ends at sacrococcygeal region

- 1st pair of somites appear on ⇒ 20th day
- after which, everyday 3-4 pairs of somites are formed.
- at the end of 5th week [35th day] } ⇒ 42-44 pairs of somites
  A total of

- somite period : 20th - 30th / 20th - 35th day



3 parts of somites

- **Dermatome** → gives rise to Dermis of skin
- **Myotome** → gives rise to skeletal muscles
- **Sclerotome** → gives rise to axial skeleton

Significance:

- by counting them, approx. age of embryo [in somite period] can be estimated.

- ✱ pre-occipital somites ⇒ give rise to extraoccular muscles.
- ✱ occipital somites ⇒ give rise to tongue muscles (except palatoglossus)
- ✱ cervical somites [$C_3 - C_5$] ⇒ gives rise to diaphragm

Neural crest cells:

Formation:

→ Tips of neural folds which donot take part in neural tube formation.

→ This forms the Neural Crest

→ It is considered as 4th Germ layer.

→ forms major part of peripheral nervous system.

→ derived from Neuroectoderm.

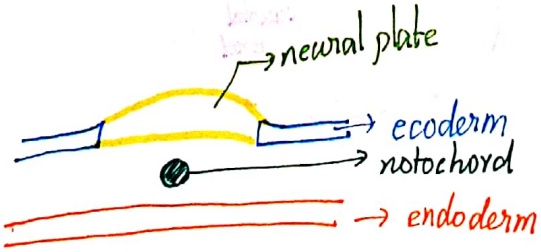
Derivatives :

- Ganglia of cranial Ⓝ & spinal Ⓝ
- Autonomic ganglia [symp. & parasymp. ganglia]
- Nerve Plexuses of GIT [Meisner's Plexus ↙ submucosal Plexus & Auerbach's Plexus ↓ Myenteric Plexus [muscularis externa]]
- Adernal medulla [chromaffin cells]
- Parafollicular ['C' cells] of thyroid gland.
- All neuroglial cells [except microglial cells]
- Arachnoid & Pia matter [leptomeninges]
  [duramatter → mesodermal]
- Conotrunkal Septum of Heart
- Odantoblasts ⇒ give rise to dentine of teeth.
- Melanoblast

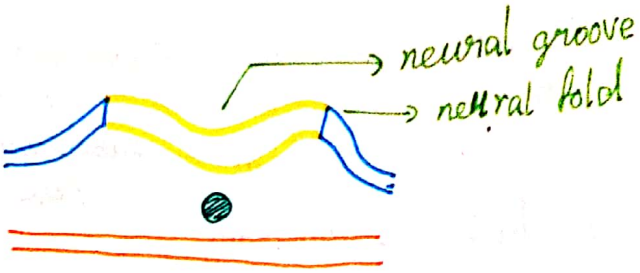
Neurulation :

- Process of nerve tube formation is known as neurulation.

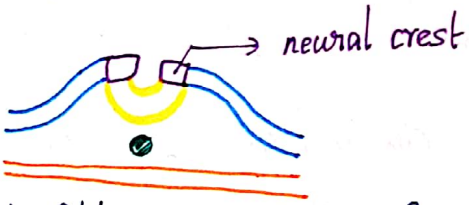
step 1 : Notochord induces overlying ectoderm to form neural ~~tube~~ plate. [sign of neurulation]



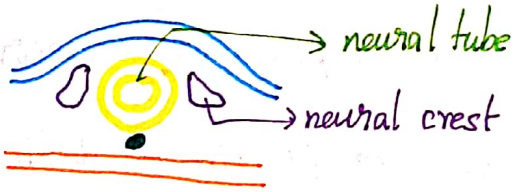
step 2 : Central part of neural plate gets depressed
⇓
Neural groove



step 3 : Edges get elevated ⇒ form neural fold [neural crest]

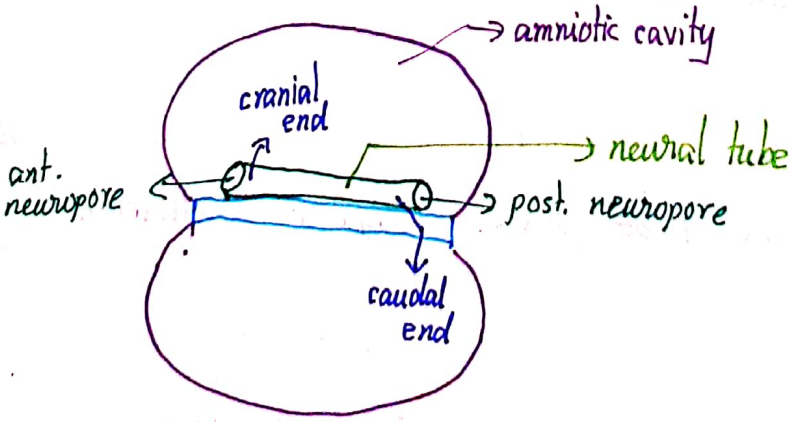


step 4 : Neural folds come closer ⇒ fuse ⇒ form neural tube



2 derivatives of neural tube :

Brain [from cranial part] — Spinal Cord [from caudal part]



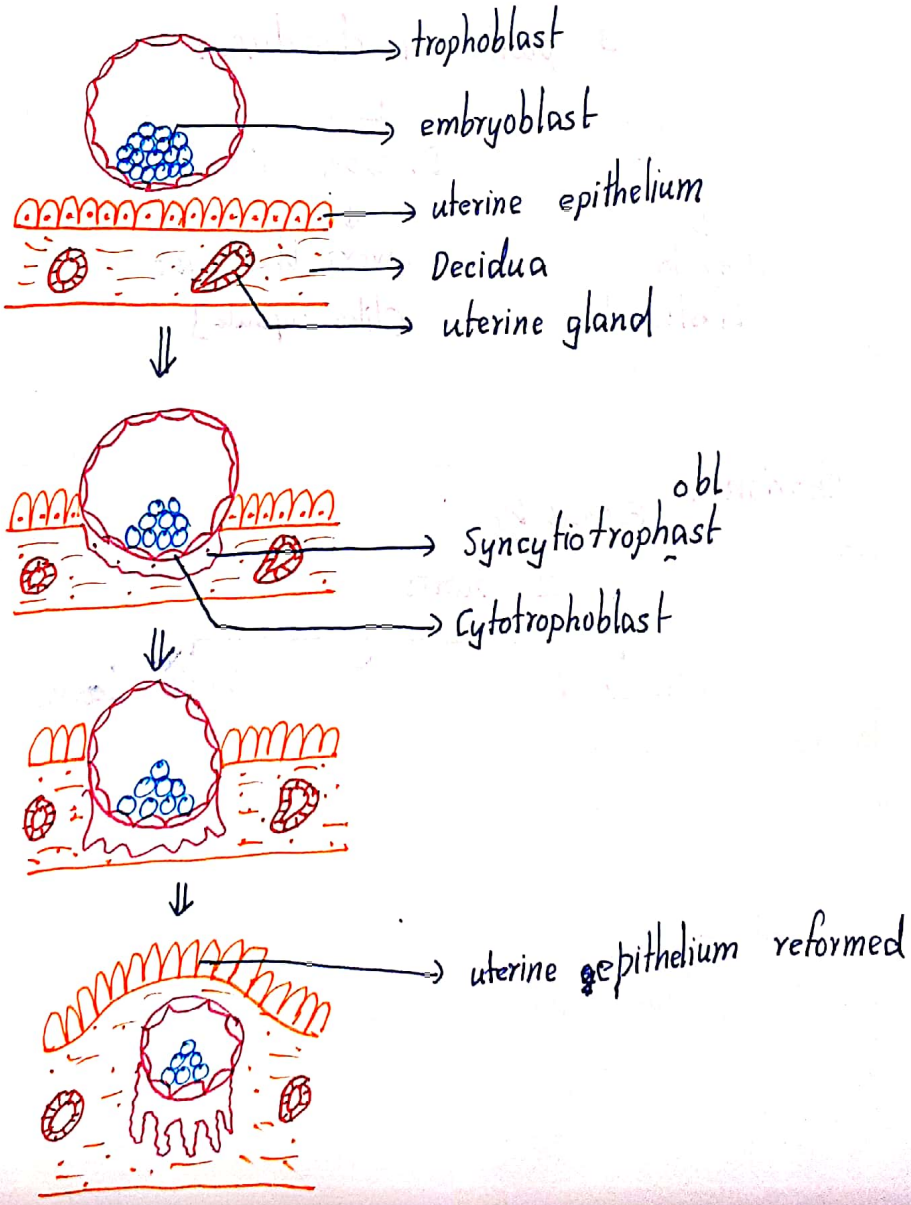
placenta :

→ Discoid shaped organ.
→ Feto-maternal organ.
→ Organ of Respiration. (∵ during fetal life, lungs will be collapsed & non-functional)

Formation :

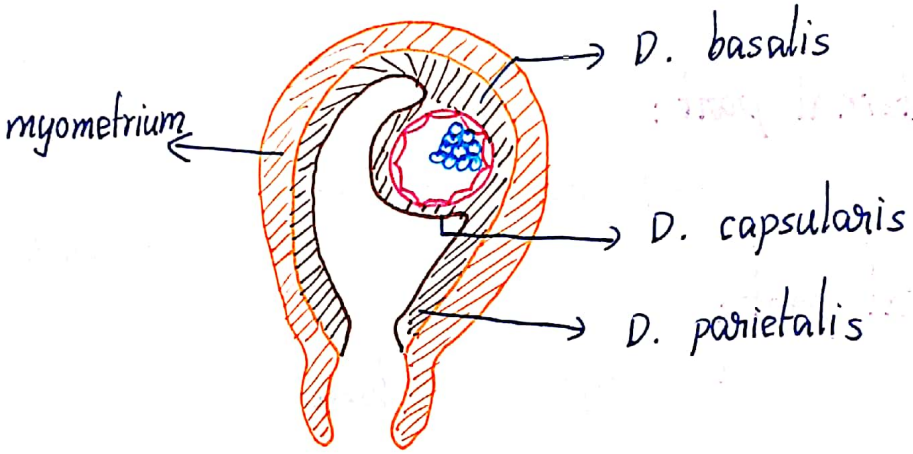
Maternal part :
- Decidua Basalis

Fetal part :
- Chorion frondosam



Decidua :

- Endometrium of uterus after implantation of blastocyst.
- Gravid endometrium is known as decidua.



3 parts of decidua :

- **D. basalis** → deep to blastocyst
- **D. capsularis** → covers blastocyst [like capsule]
- **D. parietalis** → b part of endometrium other than these 2.

Chorion :

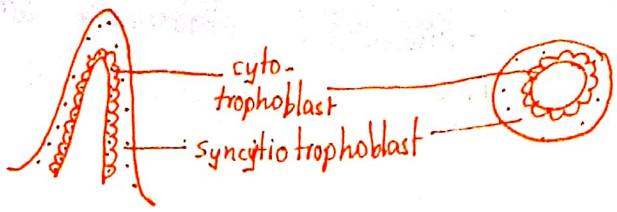
Formed by outer somatopleuric layer of EEM & trophoblast union.

2 parts

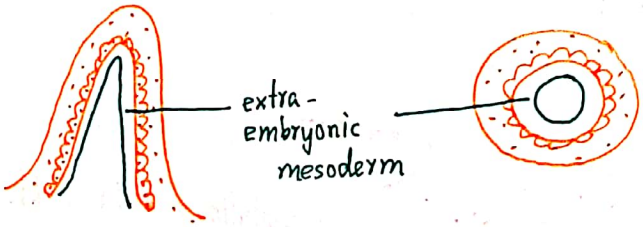
- Chorion frondosum
- Chorion Laeve

3 types of Chorionic Villi :

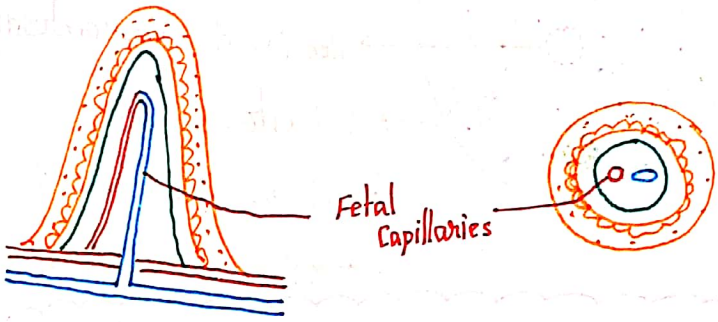
1° villus



2° villus



3° villus



2 surfaces of placenta :

Maternal Surf. ↓

Rough & contains numberous Cotyledons

Fetal Surf. ↓

- smooth & glistening
- Umbilical Cord is attached to the centre of this surf. [normally]

Anomalies of placenta :

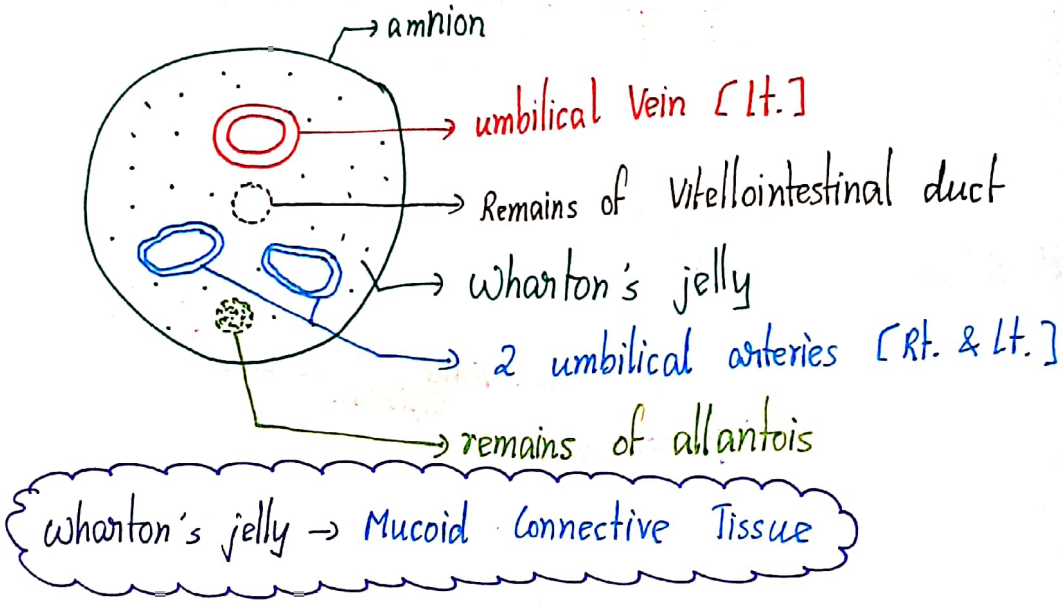
⊛ Bidiscoidal / Bilobed Placenta :
↳ 2 disc shaped placenta instead of 1 disc shaped placenta.

⊛ Marginal Placenta :
↳ Umbilical Cord is attached to the periphery (margin) of fetal surf. of placenta.

⊛ Placenta Previa:

↳ Placenta is abnormally attached to lower part of uterus / cervix.

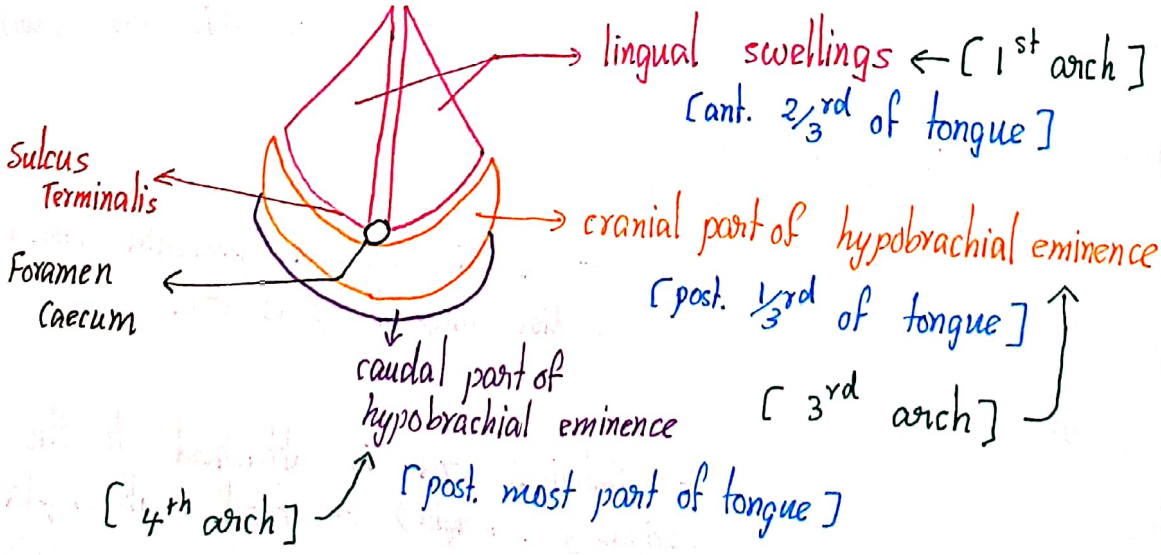
Umbilical Cord:



Wharton's jelly → Mucoid Connective Tissue

Anastomoses b/w 2 umbilical arteries ⇒ Hyrtl's anastomoses

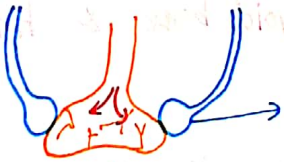
Development of tongue:



Pharyngeal arches	Embryonic structures	Part of Tongue derived
1st arch	→ pair of lingual swellings + 1 tuberculum Impar	ant. 2/3rd of tongue
3rd arch	→ cranial part of Hypobranchial eminence	post. 1/3rd of tongue
4th arch	→ caudal part of Hypobranchial eminence	Epiglottis & post. most part of tongue

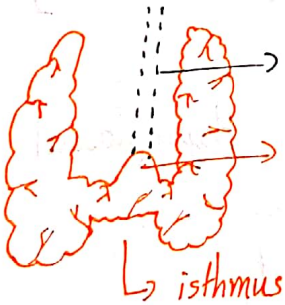
All tongue muscles ⇒ derived from occipital Myotomes/Somites
- except palatoglossus [4th pharyngeal arch]
- supplies by Hypoglossal (N).

Development of thyroid:



ultimobranchial body [caudal pharyngeal complex]

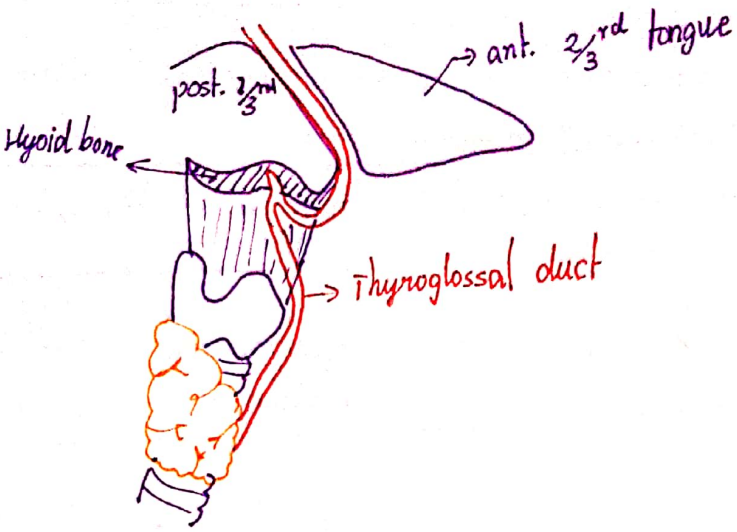
developing thyroid from Thyroglossal duct



remnant of thyroglossal duct

pyramidal lobe

isthmus



→ Thyroid diverticulum [Thyroglossal duct] is an outgrowth from the floor of primitive pharynx

→ Thyroid gland is endodermal in origin.

→ Thyroglossal duct runs downwards in front of hyoid & then below hyoid bone & finally reach in front of trachea.

↳ Here it enlarges to form bilobed thyroid gland.

→ After forming of Thyroid, usually entire Thyroglossal duct disappears.

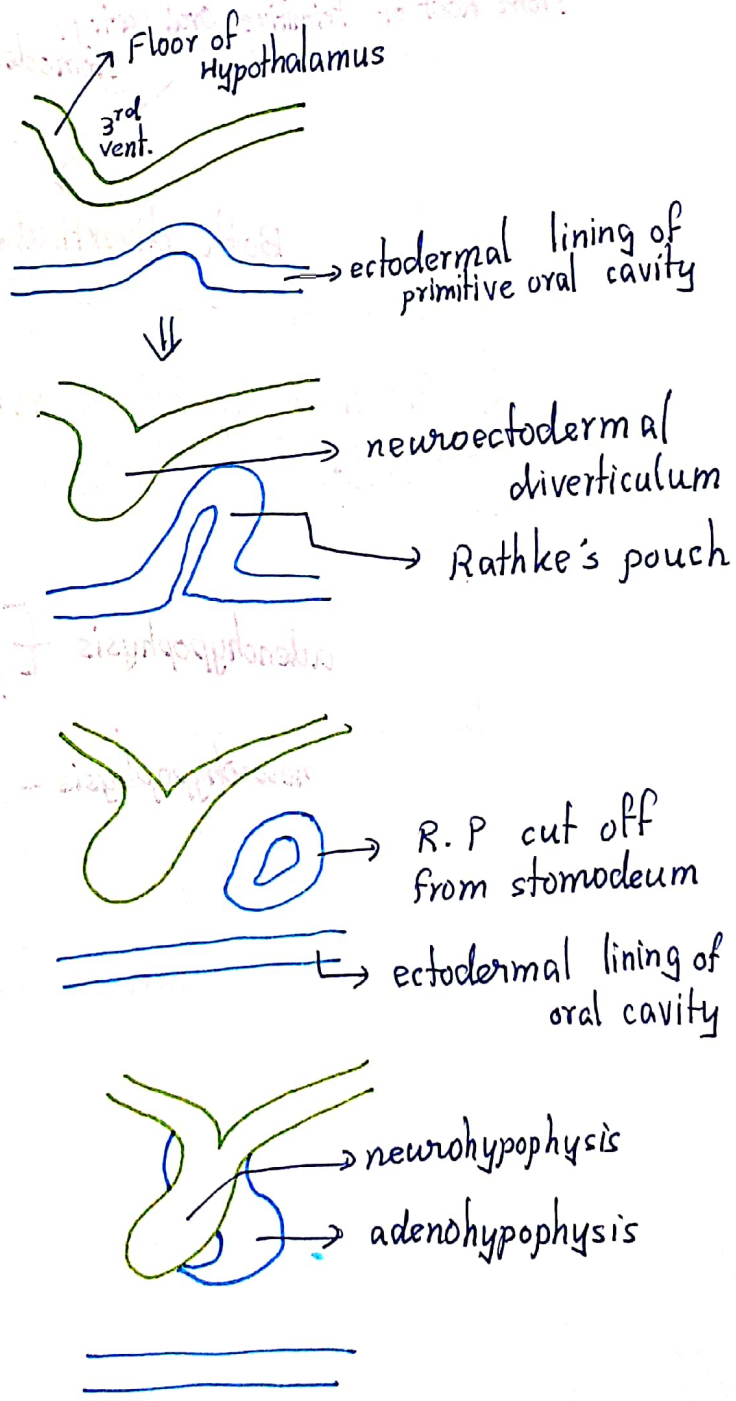
→ Abnormally, a part of thyroglossal duct may persist called Thyroglossal cyst.

- most common site ⇒ Subhyoid region
- rupture leads to Thyroglossal Fistula

Parafollicular cells → derived from Neural Crest Cells & Ultimobranchial body

Thyroid gland starts functioning by the end of → 12th week [end of 3rd month]

Development of Pituitary Gland:



2 parts of pituitary

Adenohypophysis [ant.]

⇓

develops from

Rathke's pouch

⇓

ectodermal diverticulum from Roof of Primitive oral Cavity / stomodeum

Neurohypophysis [post.]

⇓

develops from

from Diencephalon ← Hypothalamus [floor]

⇓

It forms neuroectodermal diverticulum

Both diverticulum fuse to form Pituitary Gland

Pituitary gland ⇒ ectodermal origin

adenohypophysis — Pars Distalis, Pars Intermedia, Pars Tuberalis

neurohypophysis — Pars nervosa

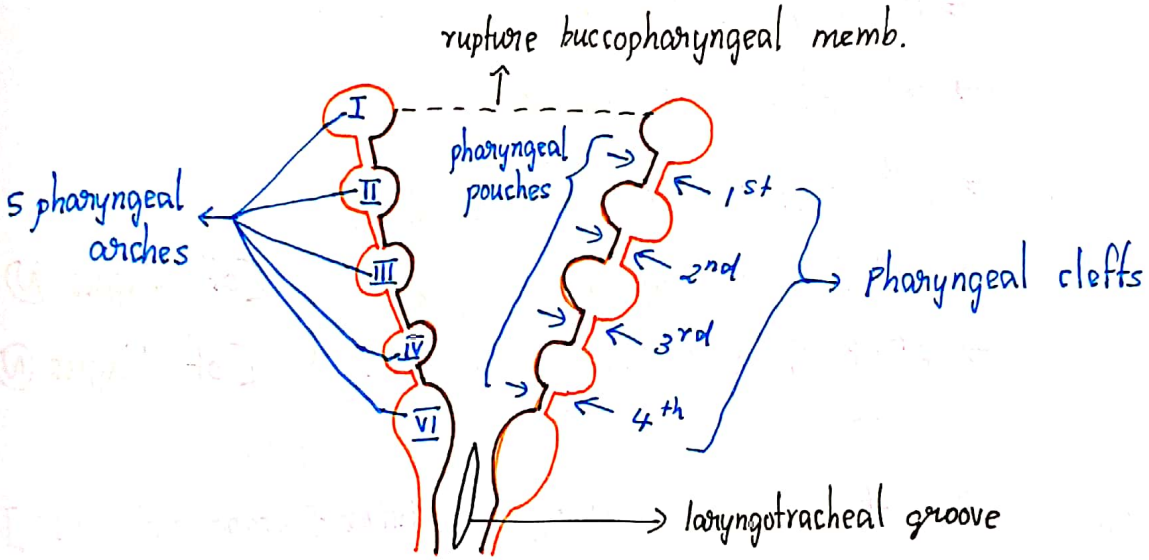
pharyngeal / Branchial Apparatus :

3 parts [CAP]

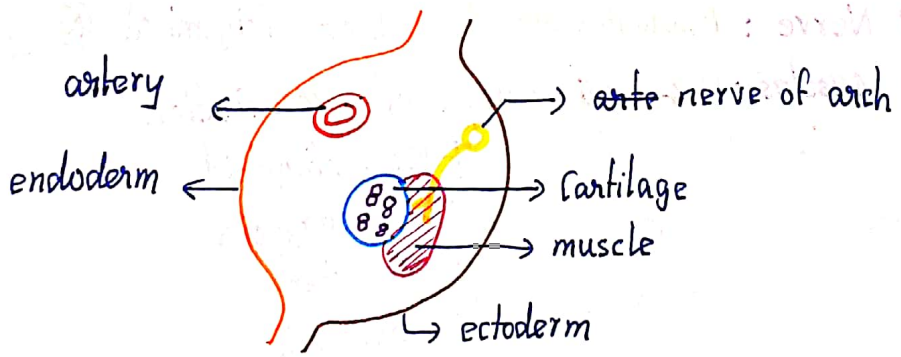
C- clefts → derived from Ectoderm

A- Arches → derived from mesoderm

P- Pouches → derived from endoderm



Pharyngeal arches :



There are totally 5 pharyngeal arches.

5th P.A ⇒ disappears [absent]

Each P.A has:

- own artery
- own (N)
- own cartilage [give rise to bones, lig.]
- muscles

Nerve of

→ 1st P.A : Mandibular (N) [of Trigeminal (N)]

→ 2nd P.A : Facial (N)

→ 3rd P.A : Glossopharyngeal (N)

→ 4th P.A : Superior Laryngeal (N) [of Vagus (N)]

→ 6th P.A : Recurrent laryngeal (N) [of Vagus (N)]

Derivatives of 1st P.A : [Majority derivatives => start with 'M']

⇒ 1st P.A is a.k.a Mandibular arch.

⇒ Nerve : Mandibular (N) [of Trigeminal (N)]

⇒ Muscles : → 4 main muscles of mastication : [8]

- Med. Pterygoid
- lat. Pterygoid
- Masetter
- Temporalis

→ MATT :

M - mylohyoid
A - Ant. belly of Digastric
T - Tensor tympani
T - Tensor Palati

⇒ Cartilage of 1st P.A : ~~Re~~ Meckel's Cartilage

⇒ Bones : - Maxilla, Mandible,
- Malleus, Incus

⇒ ligaments : → Spheno-mandibular lig.
→ Ant. lig. of malleus

⇒ Artery : Maxillary artery

Derivatives of 2nd P.A :

⇒ 2nd P.A is a.k.a Hyoid arch.

⇒ Nerve : Facial Ⓝ

⇒ Muscles : → muscles of facial expression

→ 2 'p's → Post. belly of digastric
→ Plastysma

→ 2 's' → stapedius
→ stylohyoid

⇒ Cartilage of 2nd P.A : Reichert's cartilage

⇒ Bones & ligaments : 5 's'

- stapes
- styloid process of Temporal bone
- stylohyoid lig.
- Smaller [lesser] Horns
- superior part of body of Hyoid

⇒ Artery : - Hyoid artery
- stapedial artery
} significant mainly during fetal life.

Derivatives of 3rd P.A :

⇒ Nerve : Glossopharyngeal Ⓝ

⇒ Muscles : Stylopharyngeus muscle

⇒ Bones : - Greater Horns
- Inf. part of body of Hyoid

⇒ Arteries : 3 carotid art. [CCA, ICA, ECA]

∴ 3rd P.A is a.k.a Carotid arch.

Derivatives of 4th P.A

⇒ Nerve : Sup. laryngeal Ⓝ [of Vagus Ⓝ]

⇒ Muscles : → all muscles of pharynx [except stylopharyngeus]
→ all muscles of soft palate [except Tensor Palati]
→ Cricothyroid

Derivatives of 6th P.A → a.k.a Pulmonary arch

recurrent laryngeal Ⓝ [of Vagus Ⓝ]

→ all intrinsic muscles of larynx [except cricothyroid]

⇒ Cartilages : All cartilages of larynx are derived from cartilages of 4th & 6th P.A [except : Epiglottis]
↳ caudal part of hypobranchial eminence

⇒ Arteries : Rt. side : Rt. subclavian art.
Lt. side : Arch of aorta

→ Rt. / Lt. } → Rt. & Lt. pulmonary Ar.

Ductus Arteriosus [Lt. side]

Pharyngeal Pouches: [Endodermal]

Derivatives of

- ✱ 1st P.P:
  - → Tubo-tympanic recess: [Eustachian tube, Tympanic cavity, Tympanic antrum/ Mastoid antrum.]
- ✱ 2nd P.P:
  - ↳ Ventral part of P.P ⇒ Palatine tonsils / Tonsillar fossa
- ✱ 3rd P.P: [Th IIrd]
  - Th → Thymus
  - IIrd → pair of Inf. Parathyroid Glands
- ✱ 4th P.P:
  - ↳ Sup. parathyroid Glands
  - ↳ Ultimobranchial body → parafollicular / C cells of thyroid gland

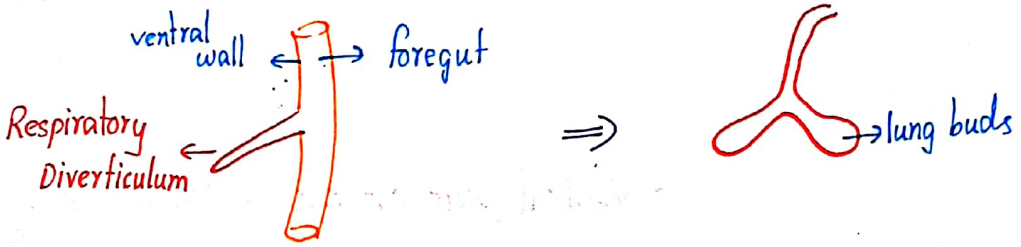
Pharyngeal Clefts:

- → Only 1st cleft gives rise to definitive structure [External Auditary Meatus]
- → Other 3 clefts will disappear.

Development of Respiratory System:

→ Respiratory System is **Endodermal in origin.**

→ Respiratory Diverticulum arises from ventral wall of foregut.



→ R. D grows downwards & divides into 2 lung buds / Bronchial buds.

→ Proximal part of R.P forms ⇒ Larynx & Trachea

→ 2 Lung buds of R.P forms

⇓

form 2 primary bronchi

⇓ divides to

secondary bronchi [lobar bronchi]

⇓ divides to

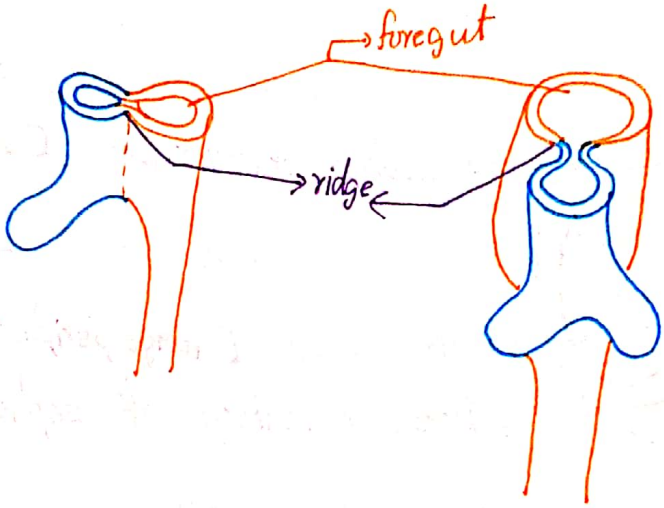
tertiary bronchi [segmental bronchi]

⇓ further divisions & sub-divisions

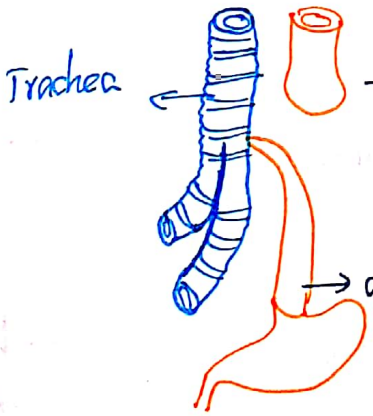
Terminal bronchioles, Respiratory bronchioles, Alveolar sac, Alveoli

Cartilages, Smooth muscles, Connective tissue components → derived from splanchnopleuric mesoderm

Tracheo-esophageal fistula:

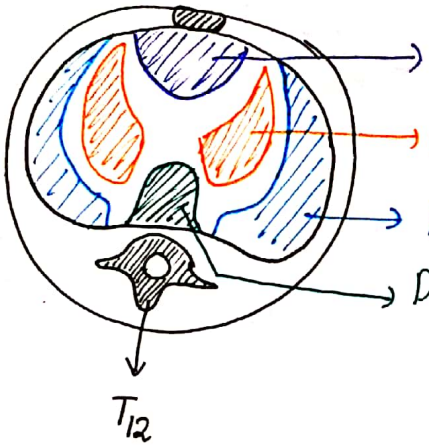


- Abnormal communication b/w trachea & esophagus.
- due to defective development of tracheo-esophageal septum.
- TEF is associated with esophageal atresia.
- Most common type of TEF is



→ This can be suspected by immediate vomiting of anything taken in [milk] by the neonate.

Development of diaphragm :



Diaphragm is mesodermal origin.

Embryonic Structure	Part of Diaphragm formed
→ septum Transversum	– Central tendon of diaphragm.
→ Pleuroperitoneal Memb.	– small peripheral part around the central tendon.
→ Mesoderm of body wall	– large peripheral part of diaphragm.
→ Dorsal mesentery of oesophagus	– Crura [Rt. & Lt. crus]
→ Cervical myotomes / [C_3 - C_5] somites	– muscular part of diaphragm.

Congenital Diaphragmatic Hernia:

Most common cause: defective development of Pleuroperitoneal memb.

CDH is more common on left side, Post. lat. aspect.

⇓

most common CDH ← Bochdalek Hernia

This hernia will cause accumulation of abdominal contents into thorax

⇓

This will colapse / compress the lung

⇓

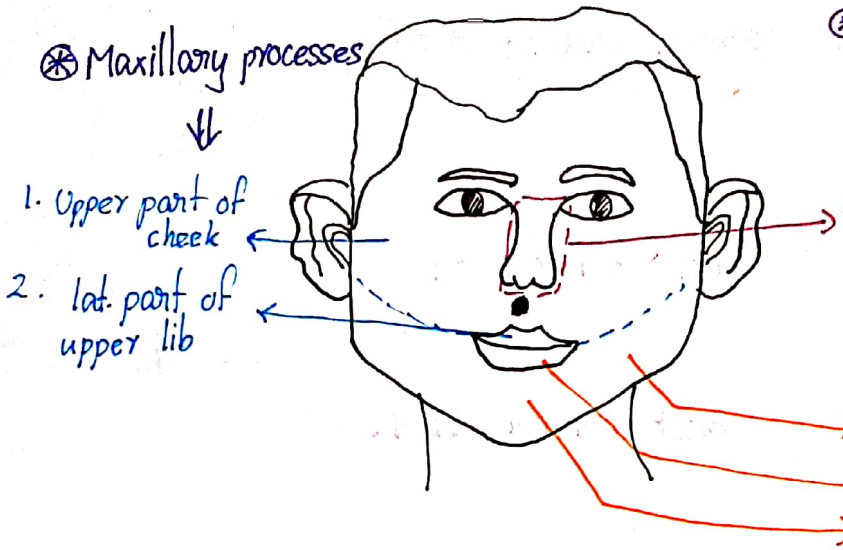
Pulmonary Hypoplasia
(Mainly Lt. lung)

⇓

This will cause death of fetus.

- Morgagni Hernia:
  - occurs through foramen of morgagni into Rt. ant. side / direction.

Development of face :

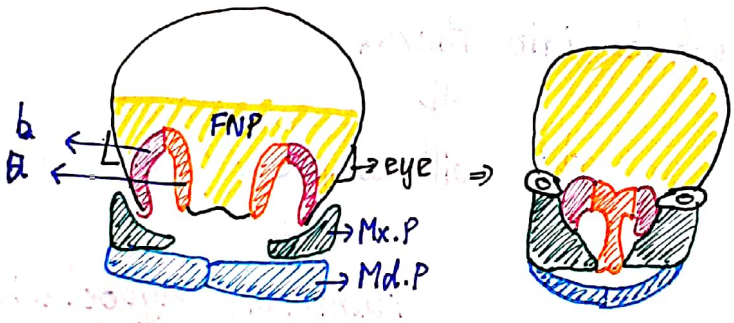


⊛ Maxillary processes
⇓
1. Upper part of cheek
2. lat. part of upper lib

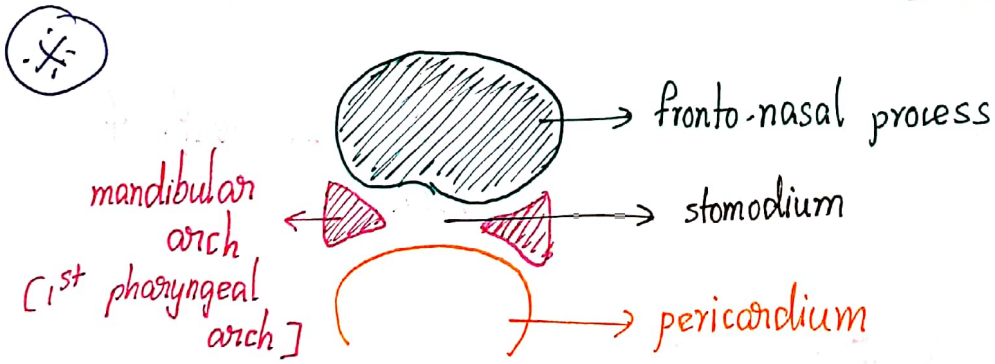
⊛ Fronto-nasal Process
⇓
1. Forehead.
2. Ext. nose, nasal cavity, nasal septum
3. Philtrum of Up. Lib

1. Lower part of cheek
2. entire lower lip
3. chin / mentum

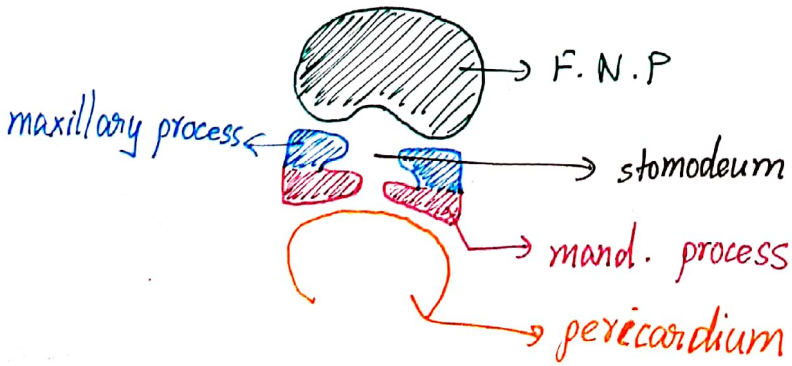
⇑
⊛ Mandibular process



a → med. nasal process
b → lat. " "



⇓



Face develops from
5 processes around the stomodeum

Fronto-nasal Process [unpaired]

→ Forehead
→ Ext. nose
→ Nasal cavity
→ Nasal septum
→ Philtrum of Upper ~~limb~~ lip

Maxillary Process [paired]

→ upper part of cheek
→ Lateral part of Upper lip

Mandibular process [paired]

→ lower part of cheek
→ Chin
→ lower lip

Derivatives :

Upper lip :
- ⊛ Philtrum : from medial nasal processes [FNP]
- ⊛ Lat. part : from Maxillary processes

Lower lip : from mandibular process

Cheek :
- ⊛ Upper part : Maxillary process
- ⊛ Lower part : Mandibular process

Congenital anomalies of face:

Most common congenital anomaly of face ⇒ unilateral cleft of upper lip

↓

cleft is present b/w
- Philtrum
- Lat. part of upper lip

↓

due to failure of fusion of [on one side]
* Med. Nasal Process
* Maxillary process

Midline Cleft of Upper lip:

↓

cleft present at middle of philtrum.

↓

due to failure of fusion the 2 med. nasal processes.

Cleft of lower lip:

cleft present at midline from lower lip.

↓

due to failure of fusion of the 2 mandibular processes

oblique facial cleft:

└ The cleft is present b/w
- lat. part of nose &
- Upper part of cheek

⇓

due to failure of fusion of
* Lat. nasal process
* Maxillary process

Development of palate:

Primary / Primitive Palate

↓

derived from Fronto-Nasal Process [med. Nasal Process]

Secondary Palate

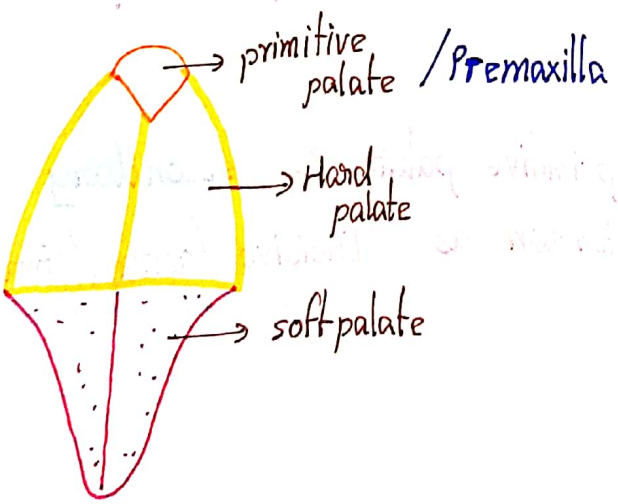
↓

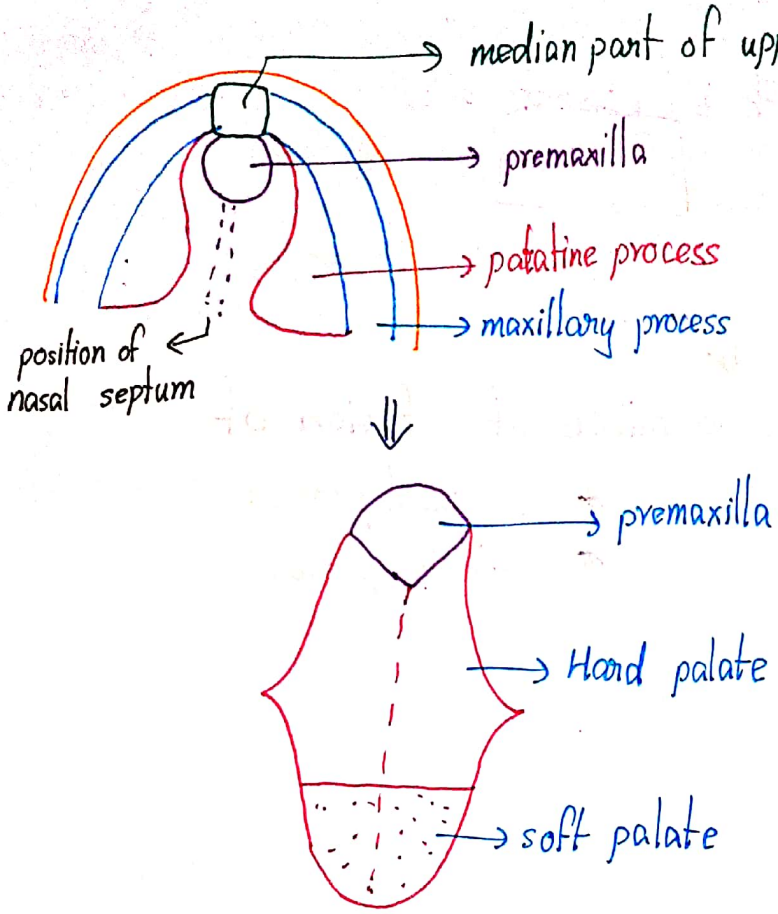
derived from Palatine Processes of Maxillae [maxillary processes]

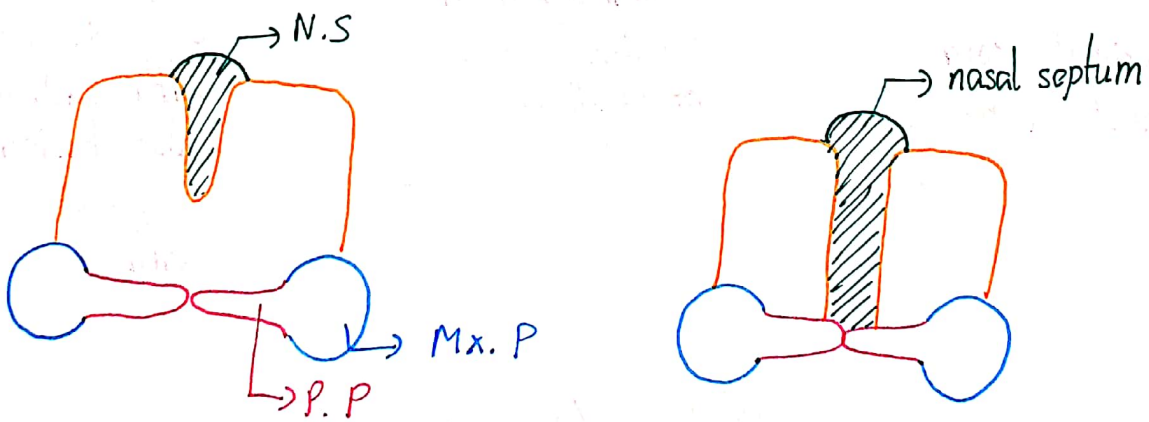
Definite / Permanent palate

↓

by fusion of 2 palatine processes with each other & also fusion of 2 palatine processes with post. margin of primitive palate.







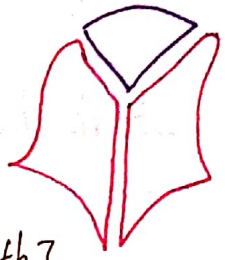
Junction b/w primitive palate & secondary palate in adult is known as Incisive fossa / Foramen.

Cleft Palate :

⊛ Bilateral Complete C.P :

failure of fusion of

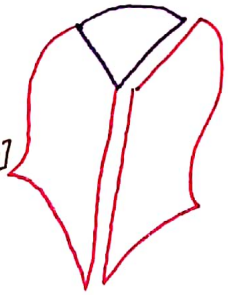
- P.P with each other
- P.P with premaxilla [Both]



⊛ Unilateral Complete C.P

failure of fusion of

- P.P with each other
- P.P with P.M [one side]



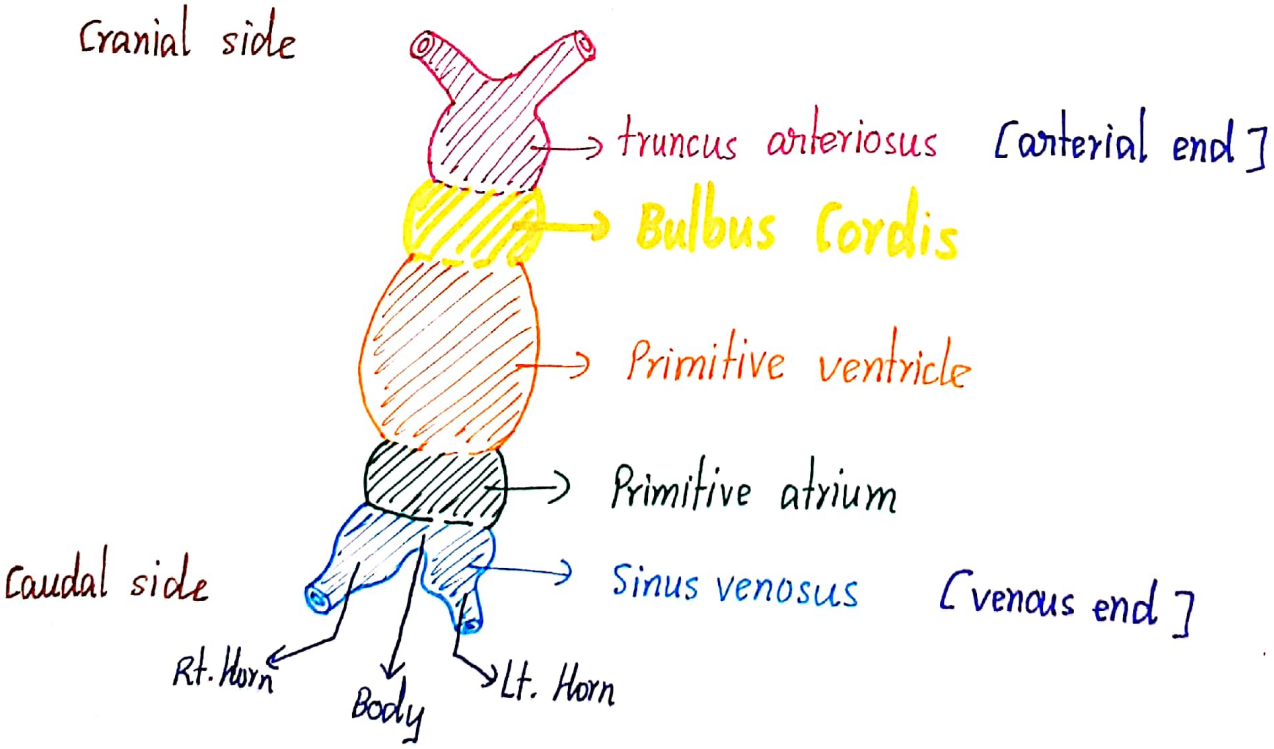
~~Embry~~

Embryology of CVS :

- 1st system in our body to start functioning.
- Heart starts beating from 21st / 22nd day [end of 3rd week]
- Heart, Vessels, Blood cells & lymphatics ⇒ Mesodermal origin

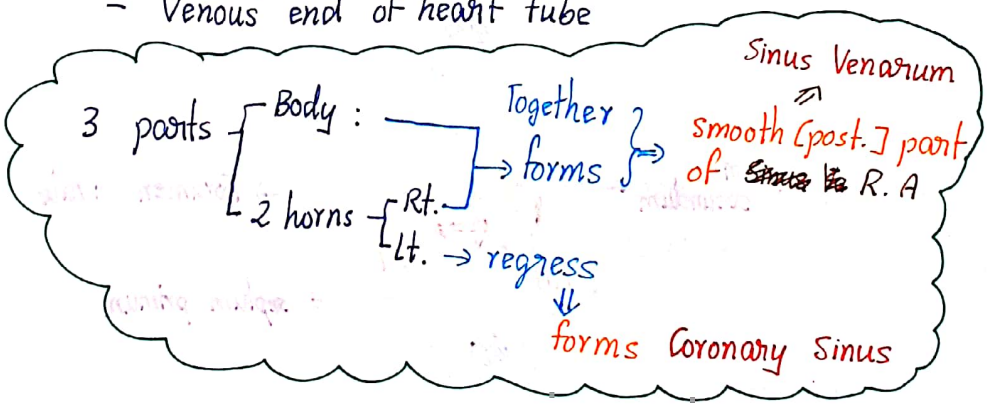
Cardiogenic area : located in / Part of Splanchnopleuric layer of L.P.M [Cranial to Prochordal plate / Cranial to Buccopharyngeal memb.]

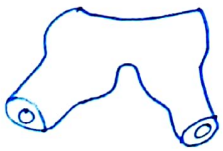
Heart tube :

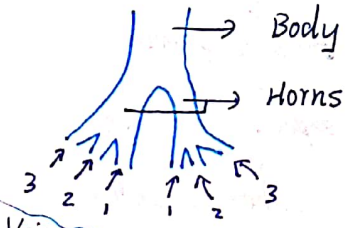


derivatives of Heart tube part [in adults]:

- ✱ Truncus arteriosus:
  - Asc. aorta
  - Pulmonary trunk
- ✱ Bulbus cordis:
  - outflow part of both ventricles [smooth part]
  - rough part of Rt. ventricle
- ✱ Primitive Ventricle:
  - Rough part of Lt. ventricle
- ✱ Primitive atrium:
  - Rough part of both atria
- ✱ Sinus venosus:
  - Caudalmost part of Heart tube.
  - Venous end of heart tube







Each Horn will receive 3 veins

① Vitelline Vein
② Umbilical Veins
③ Common Cardinal Vein

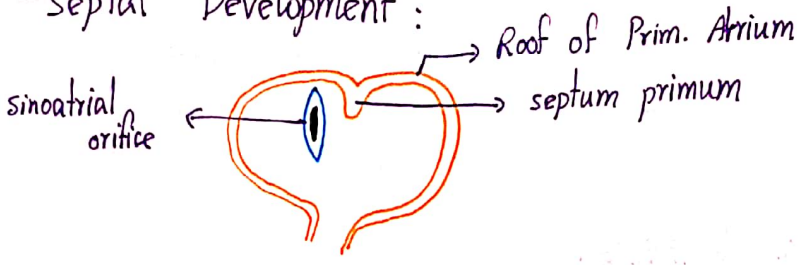
Rt. C.C.V ⇒ forms SVC

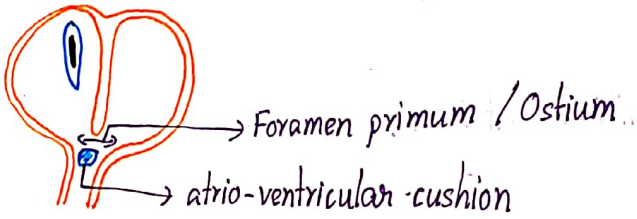
U.V ⇒ disappear

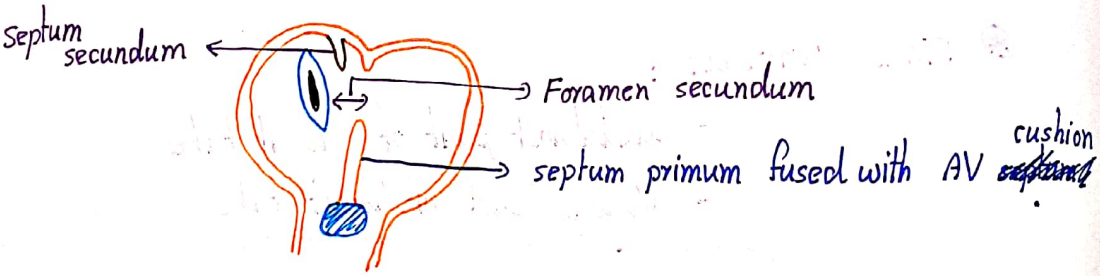
Rt. V.V ⇒ forms part of IVC

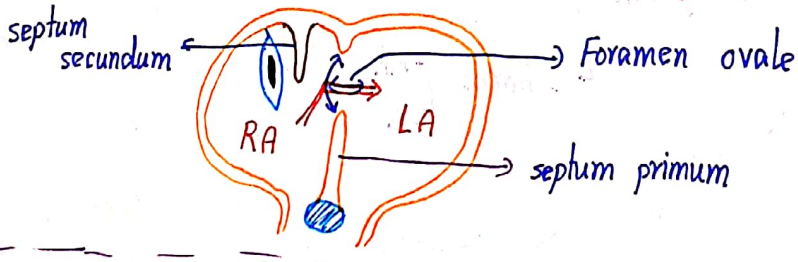
Lt. side veins ⇒ insignificant

Interatrial Septal Development :









septum primum
↓
foramen primum
↓
foramen ~~septum~~ secundum
↓
septum secundum
↓
Foramen ovale

steps in IAS development:

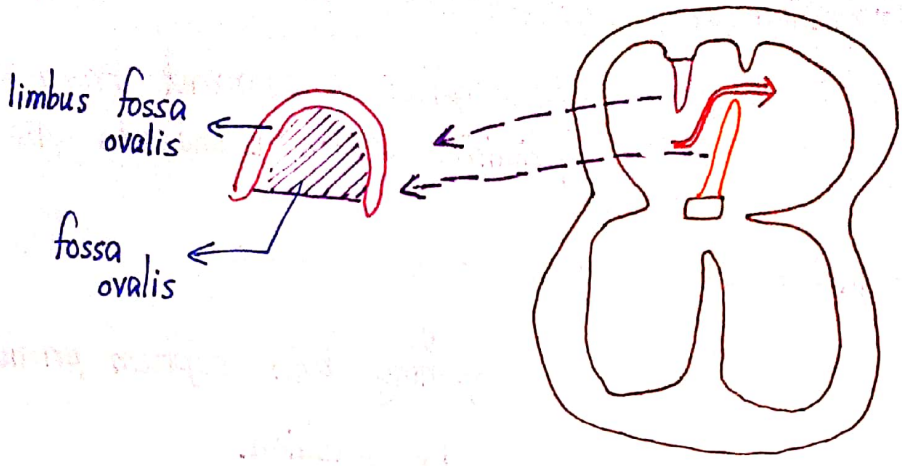
- Formation of **Septum primum**:
  ⇓
  grows downward from roof of primitive atrium [towards AV cushion]

- Formation of **foramen primum / ostium**:
  ⇓
  opening b/w septum primum & AV cushion.

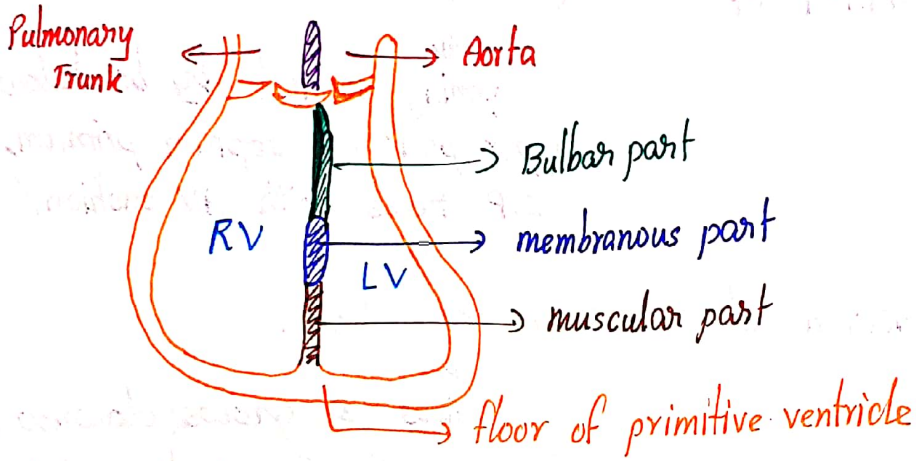
- Formation of **Foramen Secundum**:
  ⇓
  opening formed by breakdown of upper part of septum primum, while S.P fuses with AV cushion/

- Formation of **Septum Secundum**:
  ⇓
  arises & grows downwards from roof of primitive atrium

- Formation of **Foramen ovale**:
  ⇓
  b/w S.S & S.P there is an oblique passage formed called F.O through which blood moves from R.A → L.A.



Interventricular Septum development:



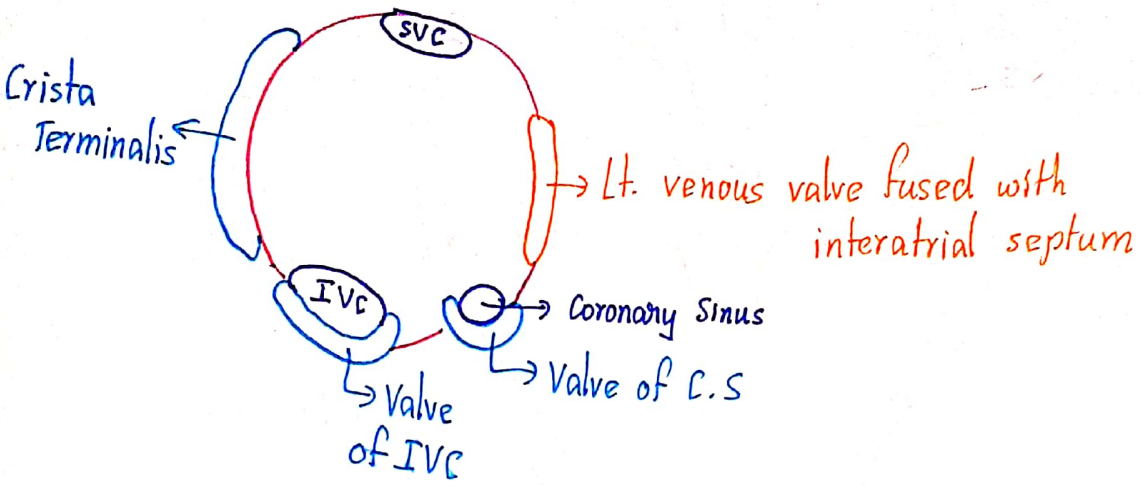
3 parts of IVS:

- ✱ Bulbar part:
  from Rt. & Lt. Bulbar Ridges
- ✱ Membranous part:
  from A.V. Cushion
- ✱ Muscular part:
  from floor of primitive ventricle [Myocardium]

Applied:

Ventricular Septal Defect: [Most common defect of Heart]
└ mostly affects membranous part.

Development of Rt. atrium :



R.A

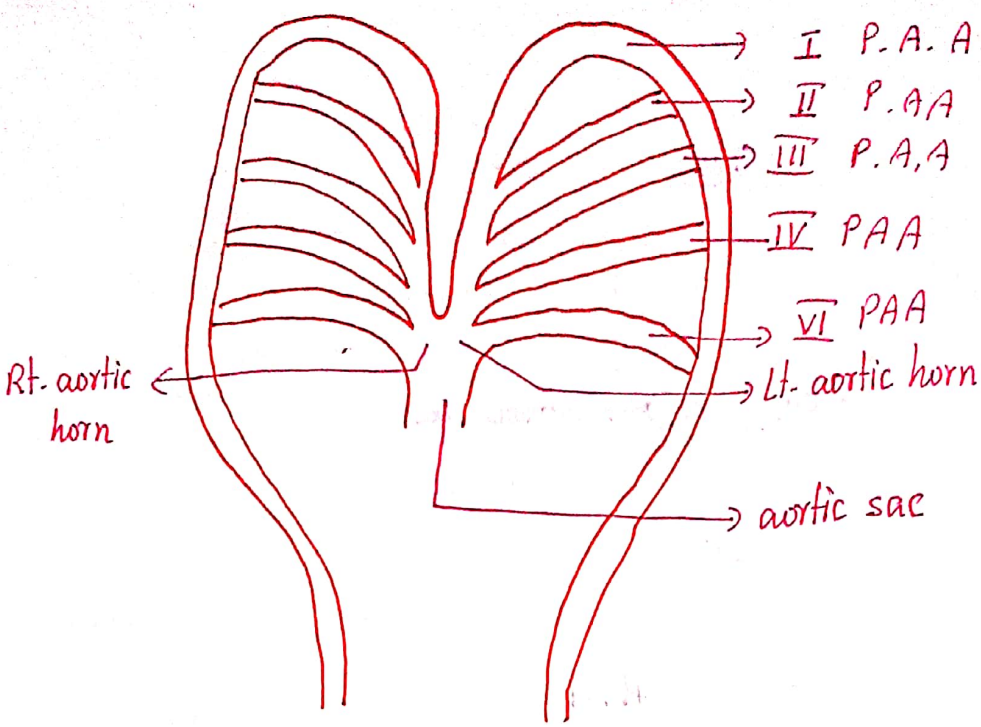
Ant. part
[rough]
↓
a.k.a Atrium proper
⇓
from primitive atrium

Post. part
[smooth]
↓
a.k.a sinus venarum
⇓
from Rt. Horn of Sinus Venarum

Crista Terminalis
IVC valve
CS valve
} → develop from Rt. Venous Valve

Fossa ovalis → remnant of septum primum
Limbus fossa ovalis → " " septum secundum

Pharyngeal Arch Arteries:



I - P.P.A :
- Maxillary art.

II - P.P.A :
- Hyoid art.
- Stapedial art.

III - P.P.A :
- CCA
- ICA
- ECA

IV - P.P.A :
- Rt. → Rt. SCA
- Lt. → part of arch of aorta

VI - P.P.A :
- Rt. → Rt. Pul. ar.
- Lt. → Lt. Pul. ar.
  - → Ductus ar.

Development of arch of aorta:

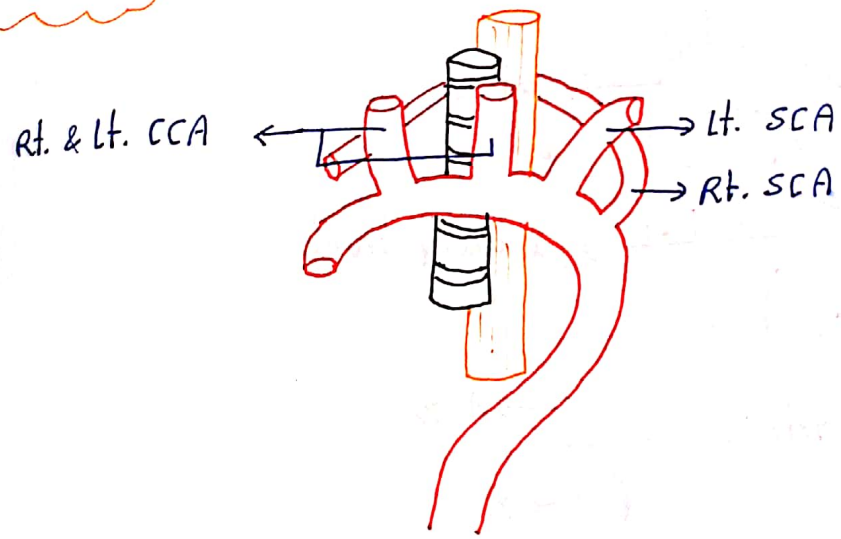
4 sources:

- aortic sac
- Lt. Horn of aortic sac
- Lt. 4th P.A art.
- Lt. Dorsal aorta

Dysphagia Lusoria:

Due to abnormal origin of Rt. SCA, it passes behind esophagus, compressing it causing dysphagia.

retro-esophageal

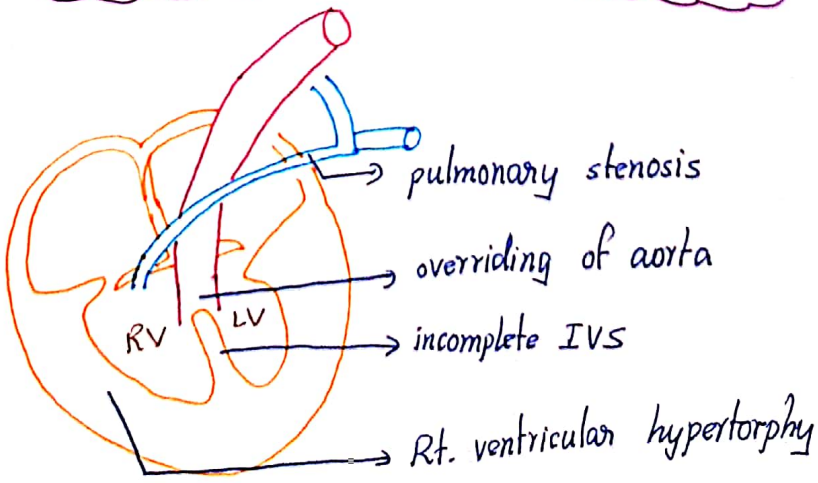


Fallot's tetralogy:

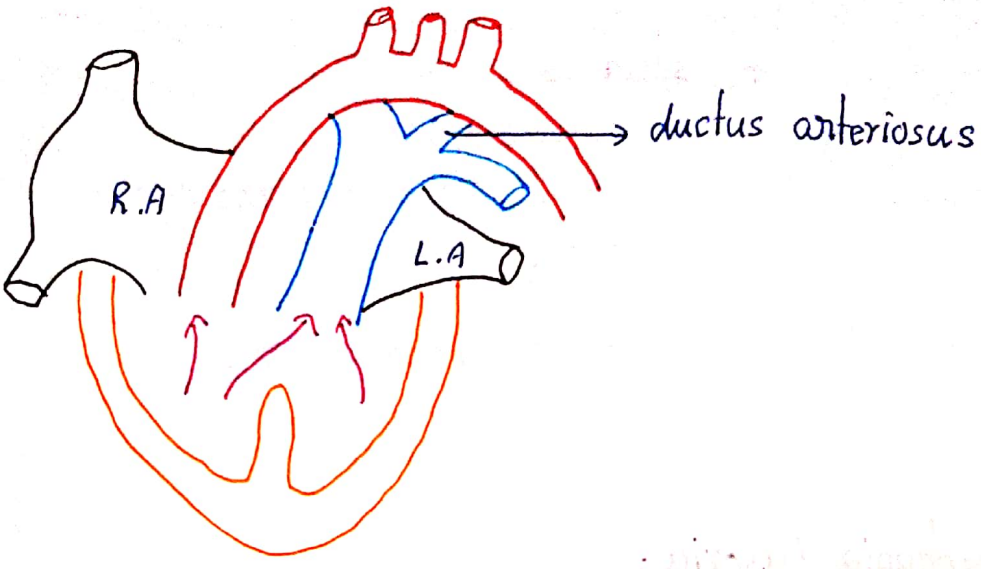
Most common congenital cyanotic cardiac anomaly.

4 components:

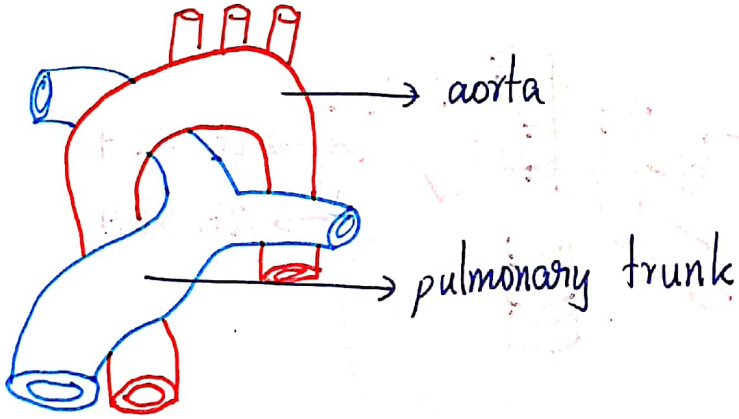
- Pulmonary stenosis
- Over-riding of aorta
- Ventricular Septal Defect
- Rt. ventricular hypertrophy.



Transposition of Great arteries :



normal position of Aorta & P.T



Trunkus Arteriosus → Aorta
Trunkus Arteriosus → P.T

due to formation of Aortico-pulmonary Septum / Spiral septum / Conotrunkal septum

derived from Neural Crest Cells

Congenital anomalies due to spiral septum:

⊛ Absence of Spiral Septum:

failure of its development causes inability of ⊛ T.A to divide into A.A & P.T.

⇓

Persistant / Patent Truncus Arteriosus

⊛ Spiral septum forms but is not spiral:

This causes

⇓

Transposition of Great arteries

⊛ Ant. displacement of Spiral septum:

This will cause unequal division of A.A & P.T (i.e)

A.A ⇒ very broad

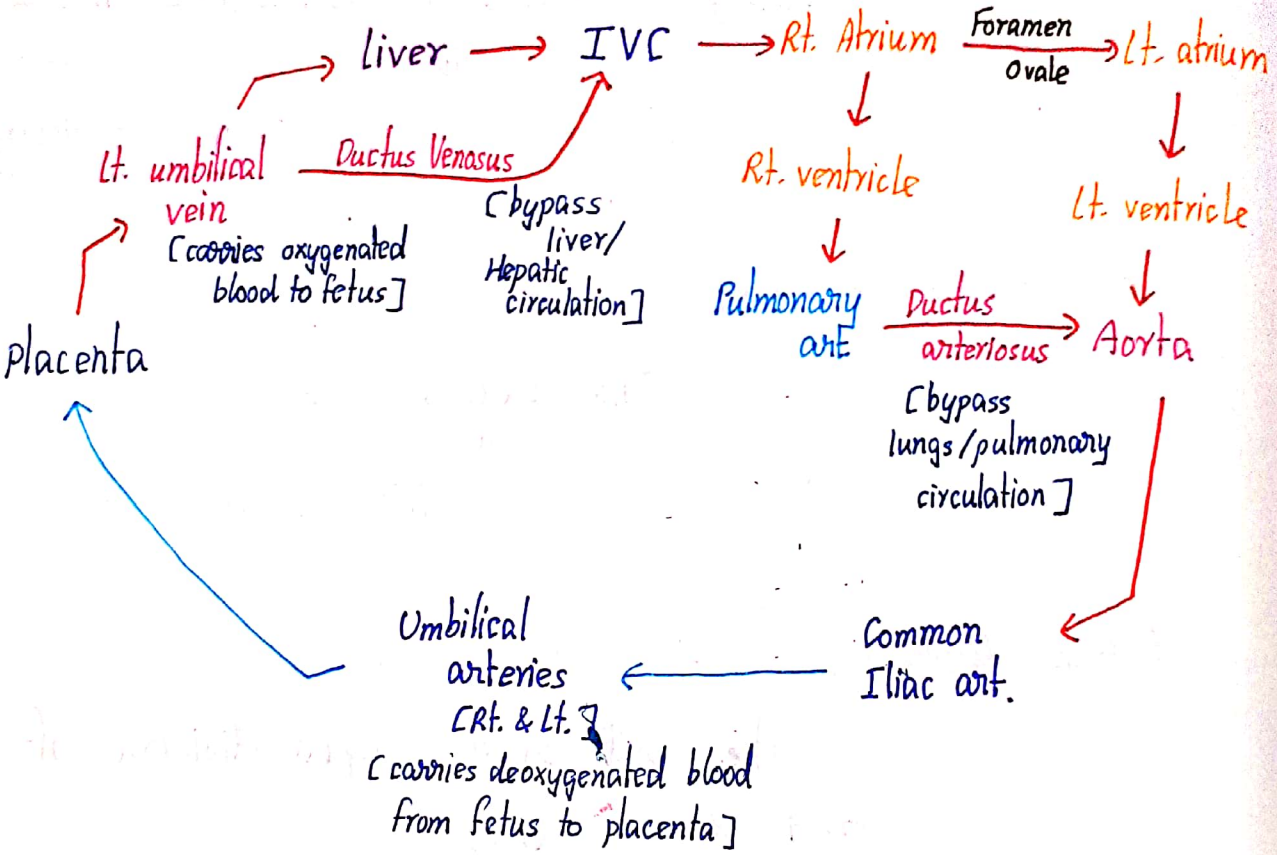
P.T ⇒ very narrow

This is known as [a component of] Fallot's tetralogy

Fetal Circulation :

→ Fetal lungs are non-functional [collapsed state].

→ ∴ Placenta is the organ of respiration in fetus.



Changes in F. C after birth :

→ Umbilical arteries : — [Proximal part : persist as Superior Vesical Ar.
Distal part : obliterate ⇒ Medial Umbilical lig.s.

→ Lt. Umbilical vein : obliterate to form ligamentum Teres Hepatis.

→ Ductus venosus : obliterate to form ligamentum venosum

→ Ductus arteriosus : " " " ligamentum arteriosum

→ Foramen ovale : gets closed [due to approximation of septum primum & septum secundum] & form fossa ovalis.

Axis artery of Upper limb : derived from 7th cervical intersegmental ar.

⇓

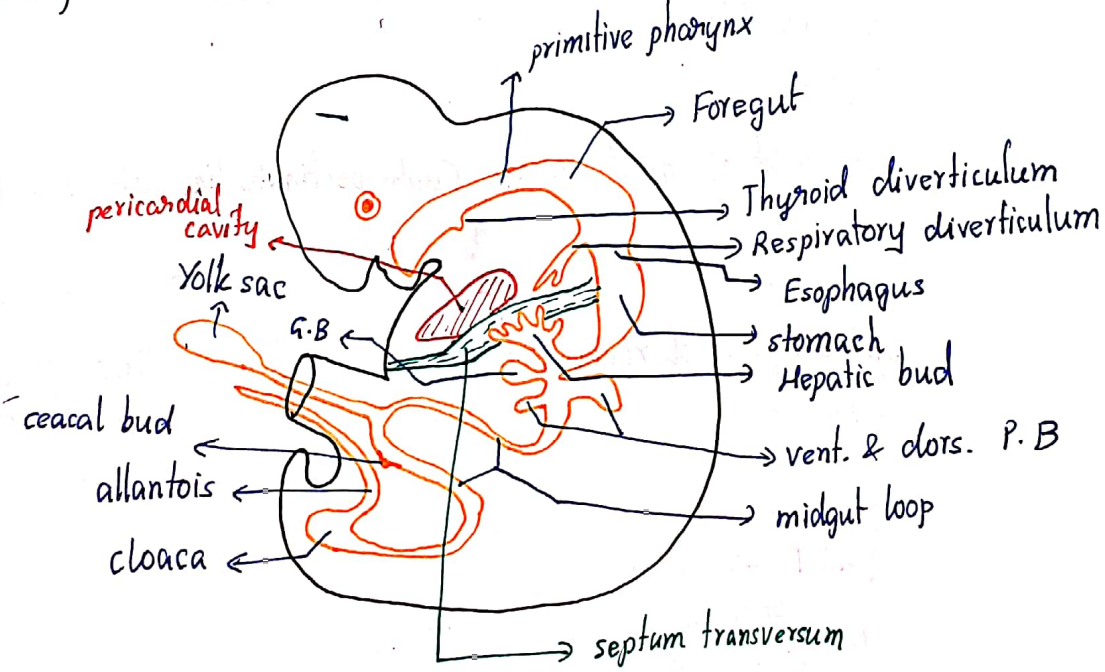
give rise to SCA

Axis artery of Lower limb : derived from 5th lumbar intersegment ar.

⇓

give rise to Ext. Iliac Ar.

Development of GIT :



Foregut :

- floor of mouth
- Tongue
- Pharynx
- Thyroid
- Esophagus
- stomach
- Upper half of duodenum (upto opening of CBD)
- liver
- pancreas
- pharyngeal pouch

Midgut :

- lower half of duodenum
- Jejunum
- Ileum
- Caecum & Appendix
- Asc. colon
- Prox. 2/3rd of Transverse Colon

Hindgut :

- Distal 1/3rd of T.C
- Desc. Colon
- Sigmoid Colon
- Rectum
- Upper part of anal canal [upto pectinate line of A.C]

spleen ⇒ derived from mesoderm [not from endoderm]

GIT ⇒ endodermal origin

Nervous System ⇒ ectodermal

CVS ⇒ mesodermal

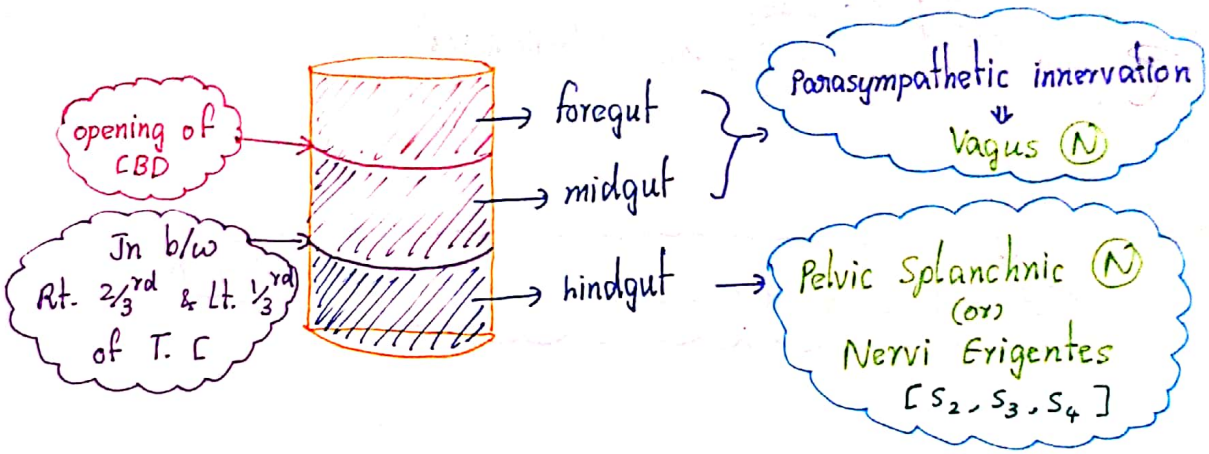
Resp. Sys. ⇒ endodermal

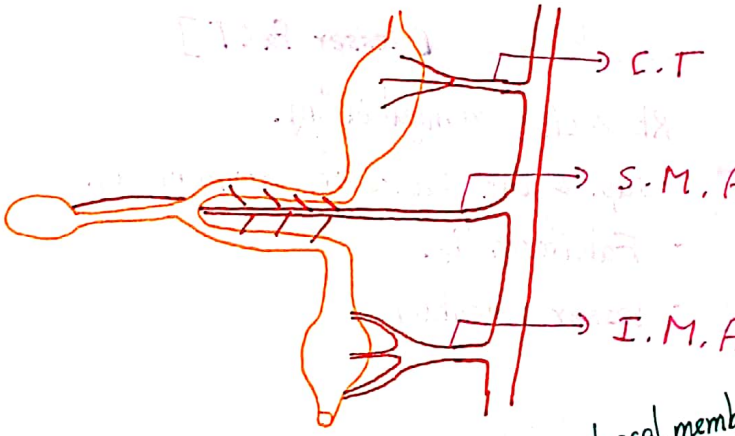
Genital & Urinary Sys. ⇒ mesodermal

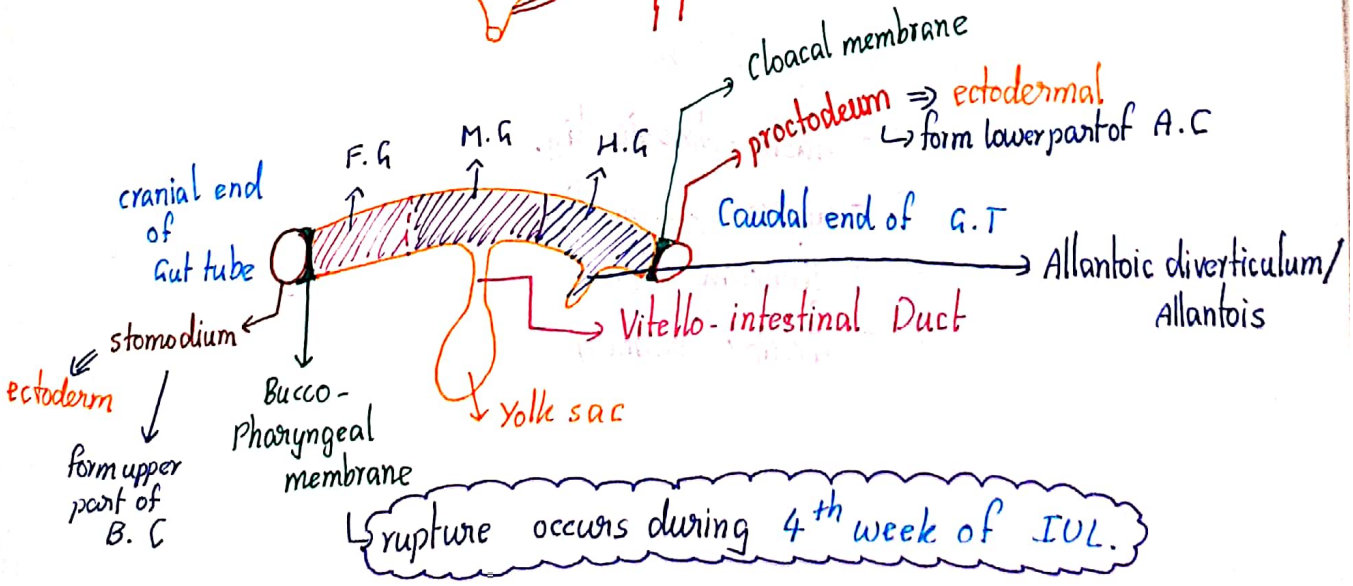
Yolk sac gives rise to Gut-Tube ⇒ endodermal

divided into

Foregut | Midgut | Hindgut

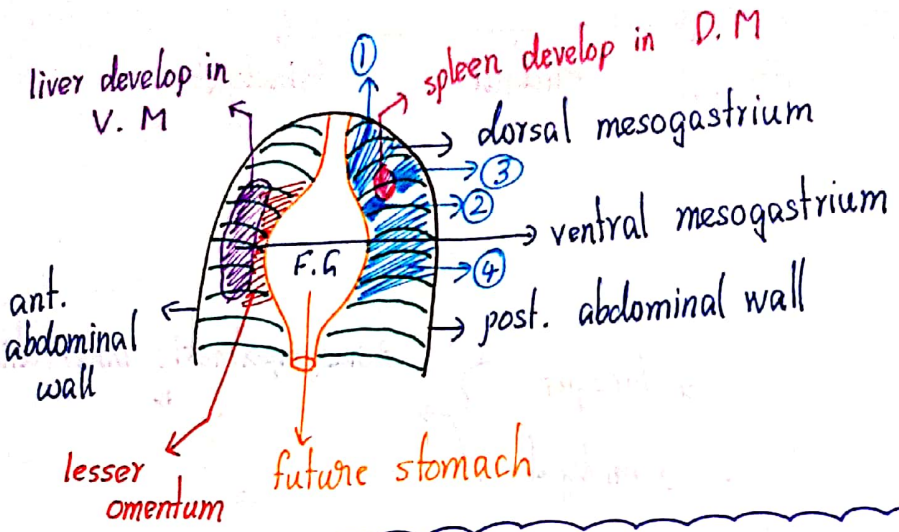






↳ rupture occurs during 4th week of IUL.

Bucco-pharyngeal membrane rupture during 4th week.
Cloacal membrane rupture during 7th / 8th week



derived from dorsal part of ventral mesogastrium.

Derivatives of

⊛ Ventral mesogastrium: [lesser FaCT]

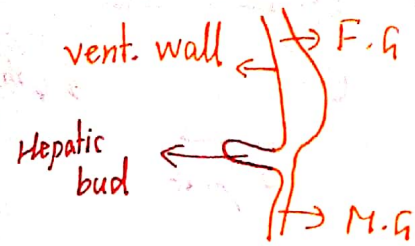
derived from Ventral part:
- Rt. & Lt. triangular lig.
- sup. & Inf. layers of Coronary lig.
- Falciform lig.

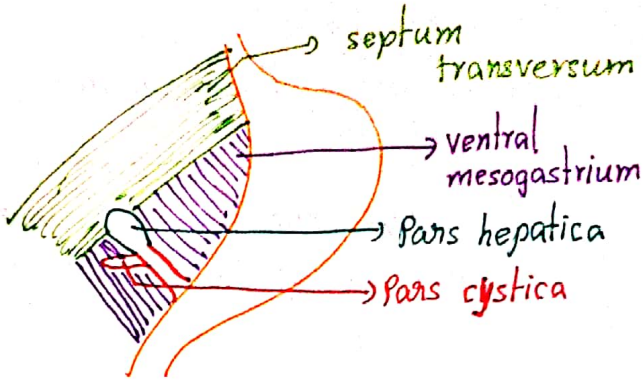
derived from dorsal part:
- Lesser omentum

⊛ Dorsal mesogastrium:

1 - Gastro-phrenic lig.
2 - Gastro-spleenic lig.
3 - Lienorenal lig.
4 - Greater omentum

Development of liver:



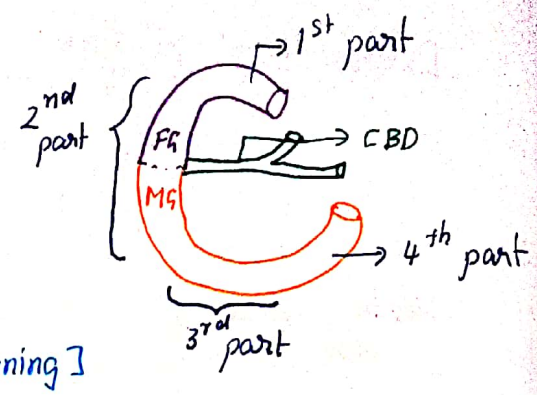


liver develops from 2 sources

- Hepatic bud
  [ventral wall of foregut]
  endodermal
  - Pars Hepatica
    ⇓
    form
    → parenchyma of liver
    → Biliary passages [except G.B, C.D]
  - Pars cystica
    ⇓
    form
    → Gall bladder
    → Cystic duct
- Septum Transversum
  mesodermal
  ⇓
  forms
  → Stroma of liver

* Kupffer cells → hepatic macrophages
* Microglia → CNS macrophages
* Dust cells → alveolar "
* Osteoclast → bone "
  ↳ osteolytic in nature

Development of duodenum :



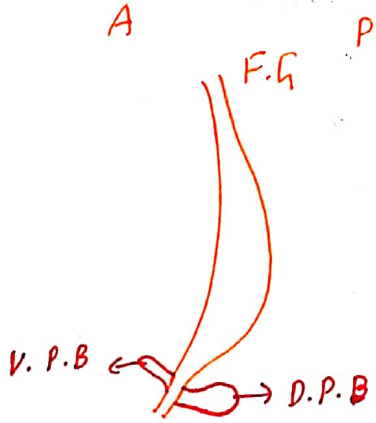
- Dual origin

upper half (above CBD opening)	lower half (below CBD opening)
↓	↓
derived from Foregut	derived from midgut
↓	↓
supplied by Coeliac trunk	supplied by Sup. Mesenteric Ar.
↓	↓
Sup. Pancreatico-Duodenal Artery	Inf. pancreatico-duodenal artery

Development of pancreas :

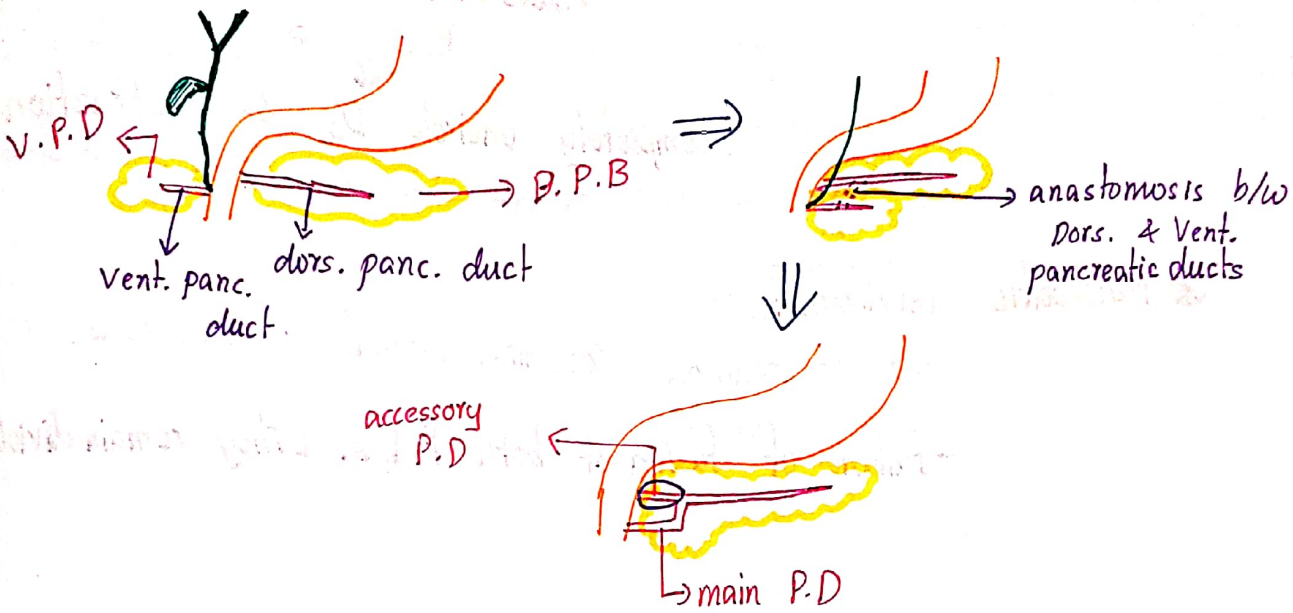
- develops from 2 pancreatic buds

ventral P.B (vent. wall of F.G)	dorsal P.B (dorsal wall of F.G)
↓	↓
~~form~~ smaller	larger
⇓	⇓
forms → lower part of head, Uncinate process	forms — major part of pancreas (upper part of head, Neck, Body, Tail)

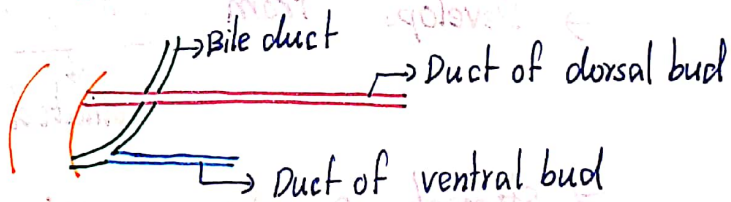


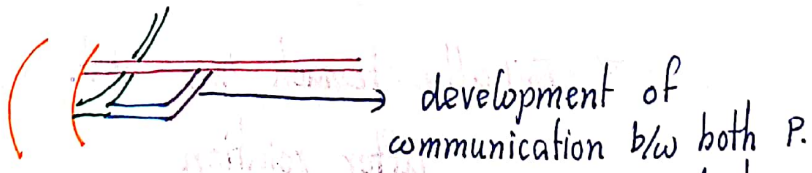
During rotation of duodenum. [upper half]

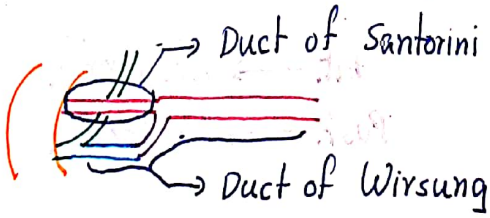
Vent. Pancreatic Bud comes to lie just below the Dorsal Pancreatic Bud.



Development of ducts of pancreas:







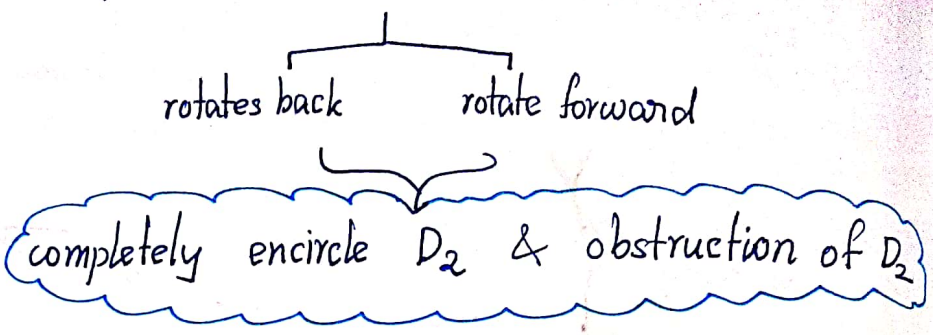
Main Pancreatic Duct : Ventral P.D & distal part of Dorsal P.D

Accessory " : Proximal part of Dorsal P.D

Congenital anomalies of pancreas:

✱ Annular pancreas:

↳ V.P.B splits into 2 parts



✱ Pancreatic divisum:

→ most common Congenital anomaly of pancreas.

↳ failure of fusion of both P.Bs. [They remain divided]

Development of stomach:

→ Develops from distal part of foregut.
↓
dilated to form stomach

→ stomach undergoes 90° clockwise rotation.

→ Initially stomach has Ant. & post borders, after rotation

Ant. ⟶ Rt. border [lesser curvature]

Post. ⟶ Lt. border [Greater curvature]

Septum Transversum:

- Derived from lateral plate mesoderm [IEM]
- Derivatives of S.T:
  - ⊛ Central tendon of diaphragm
  - ⊛ Stroma of liver
  - ⊛ Fibrous pericardium
  - ⊛ Ventral mesogastrium & its derivatives
    - [lesser omentum,
      Falciform lig.,
      Coronary lig.,
      Triangular lig.]

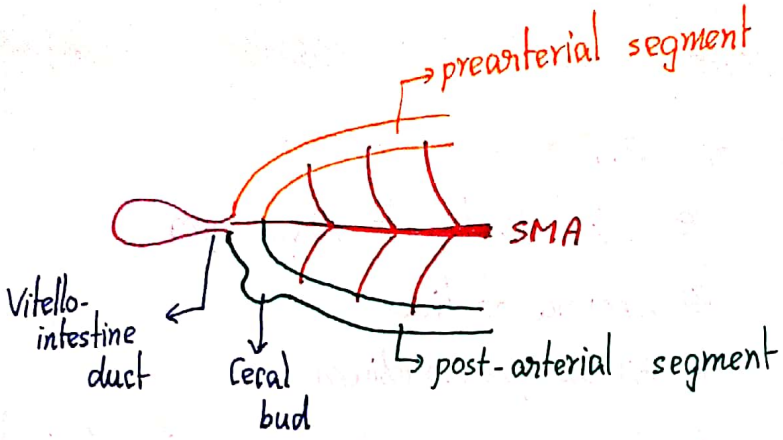
- Cranial-most structure in embryo before folding of embryo.
  - ⇓ septum Transversum

Development of spleen:

- Derived from mesoderm
- Develops in dorsal mesogastrium.
- formed by union of numerous mesenchymal masses [lobules].
- Most common site of accessory spleen ⇒ Hilum of spleen
- Spleen projects into greater sac.
- Notches of spleen:
  - along sup. border of spleen
  - indicate lobular development of spleen.
  - indicate site of fusion of lobules.

Kehr's sign: refered pain to lt. shoulder.

Midgut rotation: / Rotation of midgut loop:



Midgut loop divided into 2 ~~loops~~ segments [by SMA]

Pre-arterial segment

- lower ½ of duodenum
- Jejunum
- Ileum

Post-arterial segment

- Caecum
- Appendix
- Ascending colon
- Rt. 2/3rd of Transverse colon

Physiological Umbilical Herniation:

- Occurs during 6th week of IUL.
- It occurs because of failure of accomodation of rapidly enlarging / elongating midgut loop (mainly pre-arterial segment) by the abdominal cavity of embryo.
- Reduction of hernia occurs by around 10th week of IUL. [return of intestine back into abd. cavity]

3 stages of midgut rotation :

Totally midgut undergoes 270° counter-clockwise.

1st 90° anticlockwise

⇓

→ occurs within umbilicus.

→ occurs in & around 6th week

→ As a result pre-arterial segment comes to Rt. side & post-arterial segment comes Lt.

2nd 90° anticlockwise

⇓

→ occur within abdominal cavity

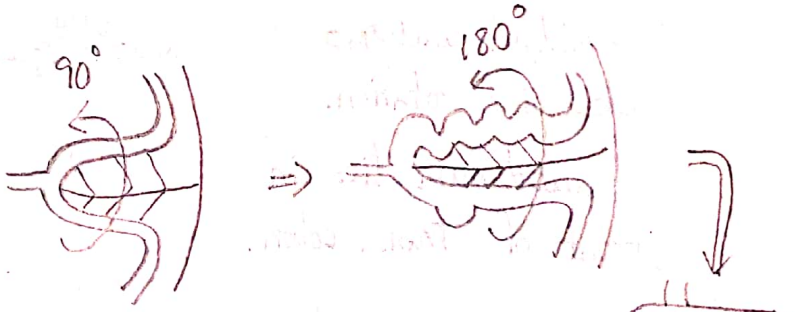
→ as a result, pre-arterial seg. occupies Lt. of abd. cavity.

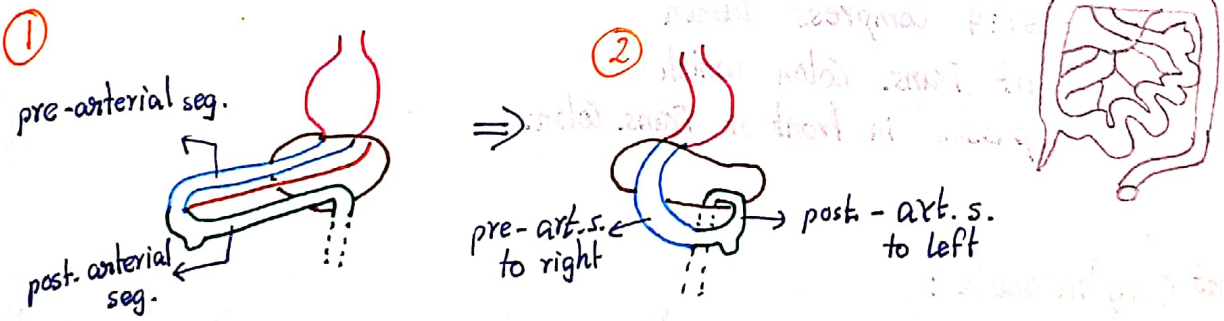
3rd 90° anticlockwise

⇓

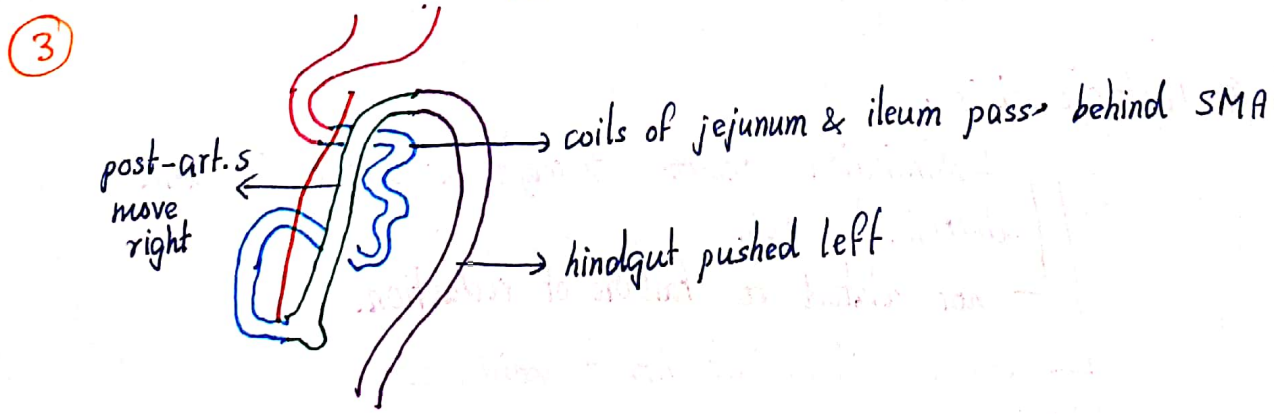
→ occur within abdominal cavity.

→ as a result, pre-arterial seg. passes behind SMA.





[after 90° [1st] anti-clockwise]



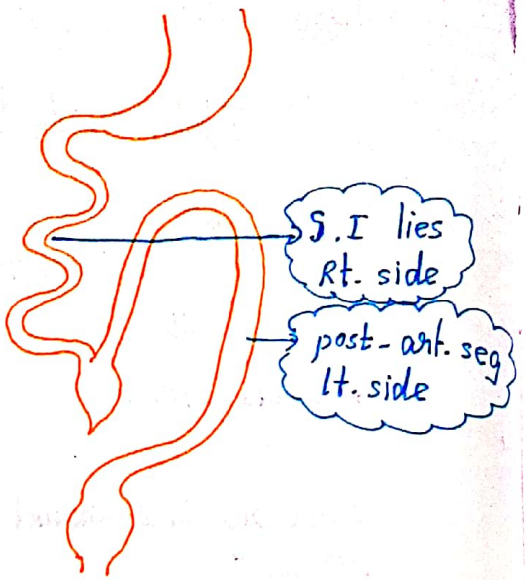
[after 270° anti-clockwise]

Midgut rotation anomalies :

⊛ Non-rotation of midgut :

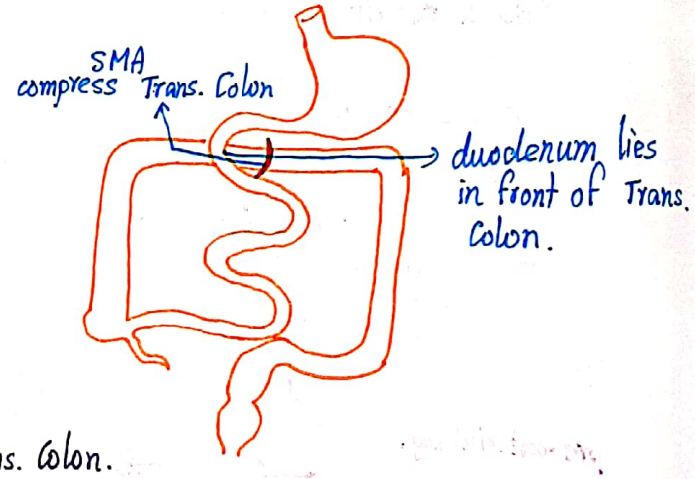
→ Post-art. seg. occupy lt. side of Abd. cavity.

→ ~~op~~ only 1st 90° A.C rotation will take place



⊛ Reversed rotation :

- midgut undergo clockwise rotation.
- - duodenum lies in front of Trans. colon.
- SMA compress lumen of Trans. Colon which passes in front of Trans. Colon.



⊛ Omphalocele :

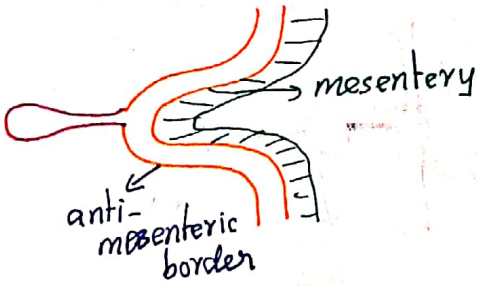
└ failure of reduction of physiological umbilical hernia.

⊛ Gastroschisis :

└ Herniation occurs through a defect in ant. abdominal wall.
└ not related to failure of reduction.
└ defect will be just Rt. to midline.

Vitello - Intestinal Duct:

→ narrow diverticulum through which Yolk sac communicates with Gut tube [midgut]
↳ Ileum



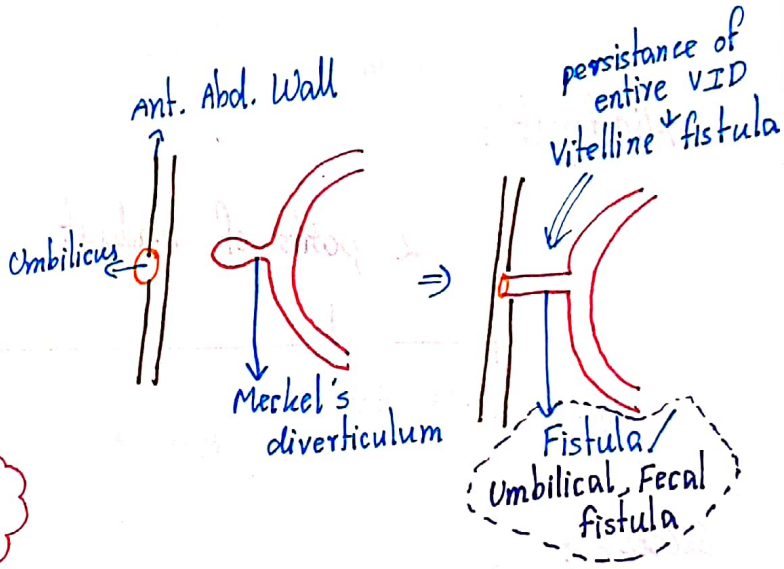
→ VID normally disappears completely.

Meckel's diverticulum:

→ Proximal persistant part of VID.

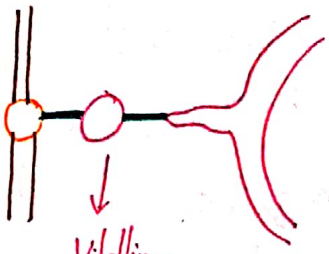
→ It is a True diverticulum. [∵ it contains all 4 layers of GIT]

→ Most common congenital anomaly of GIT.

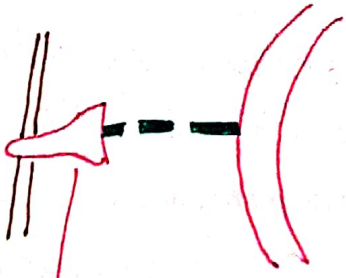


→ attached to / arise from anti-mesenteric border of ileum.

→ Rule of '2':
- frequency of M.D : 2% of individuals.
- length of M.D : 2 inches [5cm]
- location " " : 2 feet proximal to ileo-caecal jn.
- only 2% of M.D cases are symptomatic (i.e) they are mostly asymptomatic.
- 2 ectopic tissues : → Gastric tissue [most common]
  → Pancreatic tissue
- 2 symptoms : → cause bleeding
  → cause intestinal obstruction



Vitelline Cyst
[middle part of VID persist]



Vitelline sinus
[distal part of VID persist]

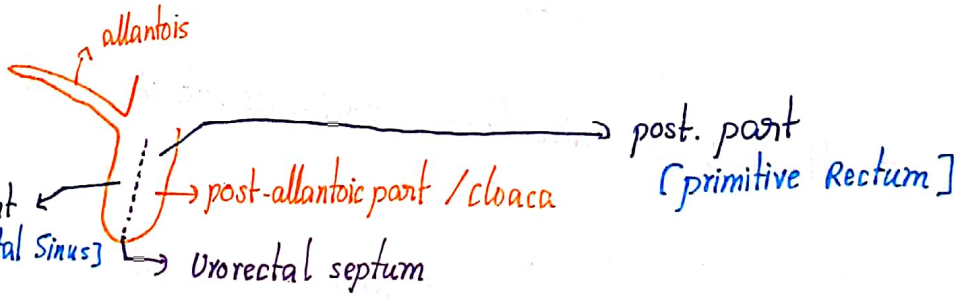
Hindgut :

2 parts of hindgut

- Pre-allantoic part
- Post-allantoic part [cloaca]

Cloaca :

- Endodermal



2 divisions of cloaca by Urorectal Septum.

- Primitive Urogenital Sinus
  - Vesico-Urethal Canal
    - Urinary Bladder [except Trigone]
    - Urethra
  - Definitive Urogenital Sinus
    - Pelvic part
    - Phallic part
- Primitive Rectum
  - Rectum
    - Upper part of anal canal [above pectinate line]

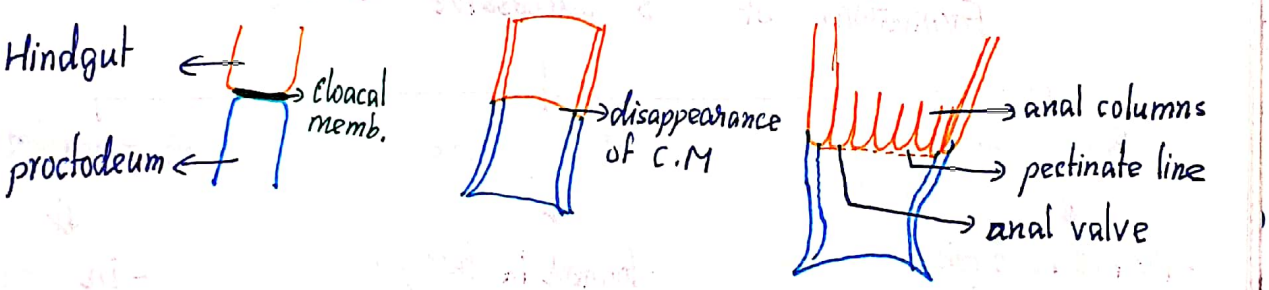
Development of Urinary Bladder:

→ Major part of U.B : from Vesico-Urethal canal.
[from primitive UGS → cloaca]
[endodermal]

→ Trigone of U.B : from Mesonephric duct [caudal part]
[mesodermal]
└ intermediate mesod.

→ Apex of U.B —Median Umbilical lig.→ Umbilicus

Development of Anal Canal:



→ Pectinate line ⇒ represent site of cloacal membrane [Anal memb.]

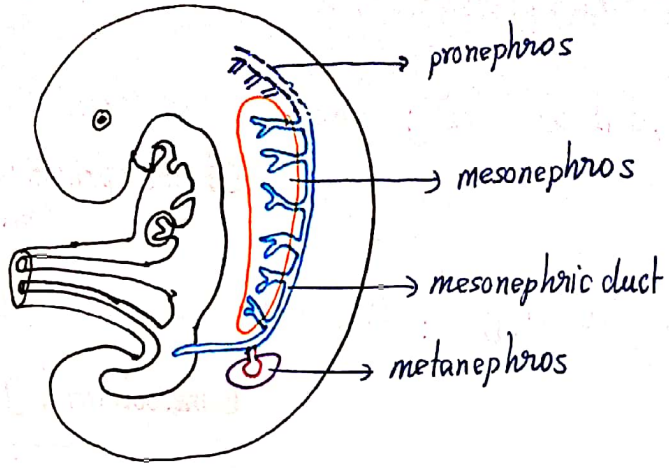
- Upper part of anal canal : Hindgut [cloaca]
- lower part of anal canal : Proctodeum
- both parts of A.C are separated by anal membrane
[part of cloacal memb.]

⇓

ruptures by 7th/8th week of IUL.

cloacal membrane : both ectoderm & endoderm.

Development of ~~Urogenital~~ Urinary System :



- develop from intermediate mesoderm, mesoderm [U.B, urethra]
  ↳ kidney, ureter

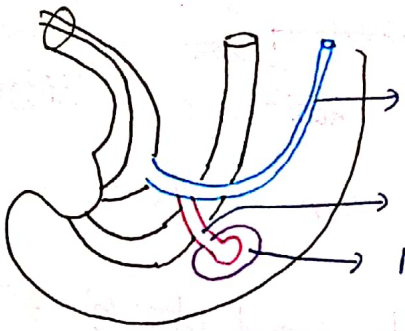
Development of kidney :

Formations of 3 successive kidneys

Pronephros	Mesonephros	metanephros
⇓	⇓	⇓
- formed in cervical region of embryo	- formed in thoraco-lumbar region of embryo	- in sacral/ pelvic region
- formed during begining of 4th week	- formed during end of 4th week	- formed during begining of 3rd month
- It is entirely non-functional.	- It is temporarily functional.	- It is the permanent kidney.

Definitive kidney → develop in pelvic region [Metanephros]

Sources
- metanephros : form excretory part of kidney → - Glomerulus, - B.C, - PCT, - DCT, - Henle's loop
- Ureteric bud [mesonephric duct] : form collecting part of kidney → - collecting duct, - minor & major calyces, - Pelvis, - Ureter



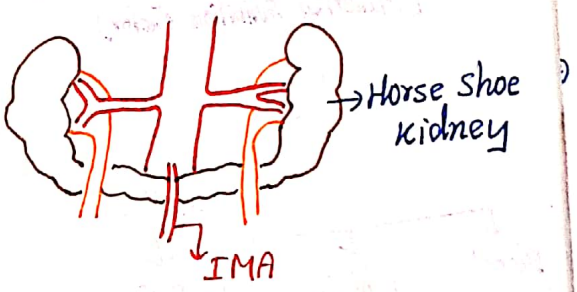
Ascent of kidney:

after formation of kidney in pelvic region, both ascend to reach lumbar region.

Congenital anomalies:

- **Pelvic kidney:**
  - Kidney retained in pelvic region [failure of ascent]

- **Horse shoe kidney:**
  - lower poles of both kidneys fuse with each other.
  - Ascent is arrested by IMA.
  - most common Congenital Renal Anomaly.



- **Polycystic kidney:**
  - numerous cysts on surface of kidney.

- Most common congenital Renal Vascular Anomaly
  - Accessory / Supernumerary Renal artery

Genital System : [from Intermediate mesoderm]

- a pair of mesonephric & paramesonephric ducts [genital ducts]
- forms Genital / Gonadal Ridge → form gonads

Primordial Germ Cells : → invade Genital ridge @ 6th week of IUL.
↳ derived from epiblast [Ectoderm]

Gonads

♂ [XY] → SRY gene (in short arm of Y chrom.) → TDF → Testis → MIF (Mullerian Inhibition Factor) + testosterone

♀ [XX] → spy gene (X) → TDF, MIF, testosterone (X) → Ovary

Testis

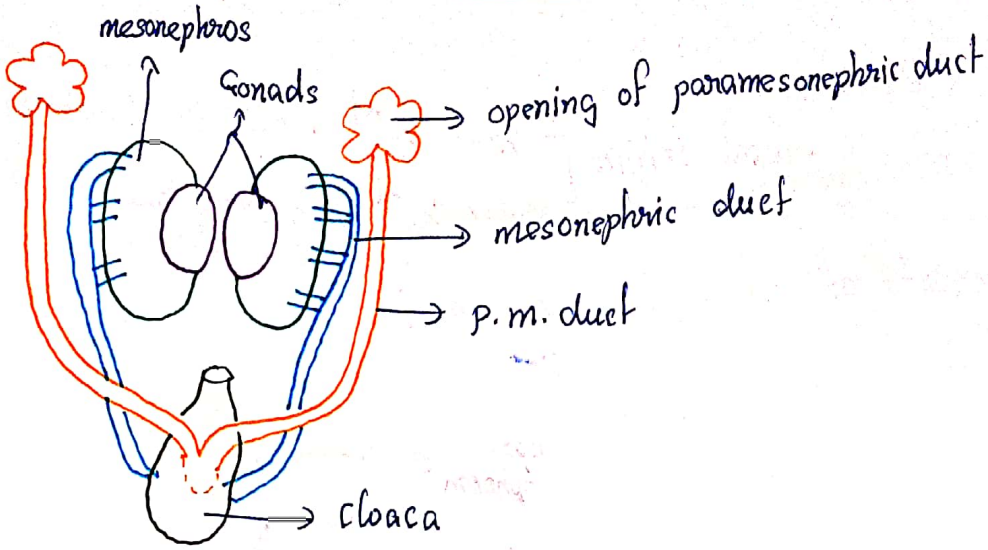
Sertoli cells → Blood Testis Barrier; inhibin; MIF → inhibit development of paramesonephric duct

Leydig cells → Testosterone → stimulate development of mesonephric duct (efferent ductules, epididymis, vas deferens, seminal vesicles]

Leydig cells → Dihydrotestosterone → stimulate ext. genitalia [penile growth, scrotal & prostatic growth]

Ovary → Estrogen

- stimulate paramesonephric duct [uterine tube, uterus, upper 2/3rd vagina]
- development of ext. genitalia



Gonads → genital ridges

Scrotum, labia majora → Genital swelling

Penis, Clitoris → Genital tubercles

main genital duct :

♂ ⇒ mesonephric / Wolffian ducts

♀ ⇒ paramesonephric / Mullerian ducts.

Derivatives of mesonephric ducts : PUT A DEEP SEMEN

U → ureteric bud [collecting part of kidney]

T → Trigone

A → Appendix of epididymis

D → Ductus deferens / Vas deferens

E → Epididymis

E → Ejaculatory duct

SEMEN → Seminal Vesicles

Derivatives of paramesonephric duct [in ♀] :

→ Fallopian tube [from unfused / upper part of P.M.D]

→ Uterus [from fused / lower part of P.M.D]

→ Upper 2/3rd of vagina ~~[lower part of vagina]~~

Mullerian agenesis :

→ absence / agenesis of P.M.D.

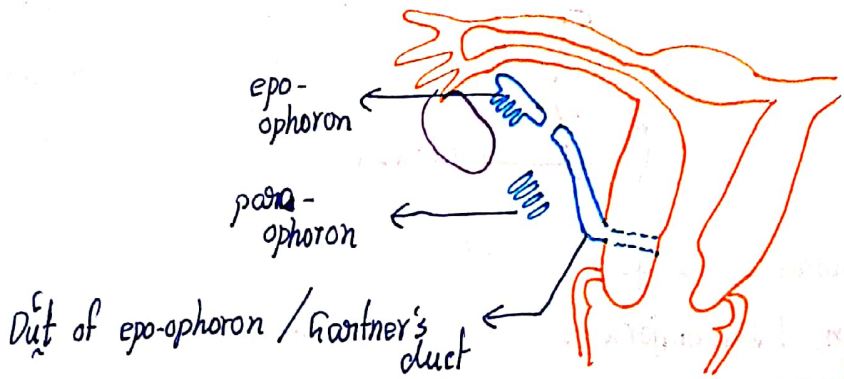
→ °°° absence of F.T, Uterus, upper 2/3rd vagina.

→ Ovary present.

Vagina :

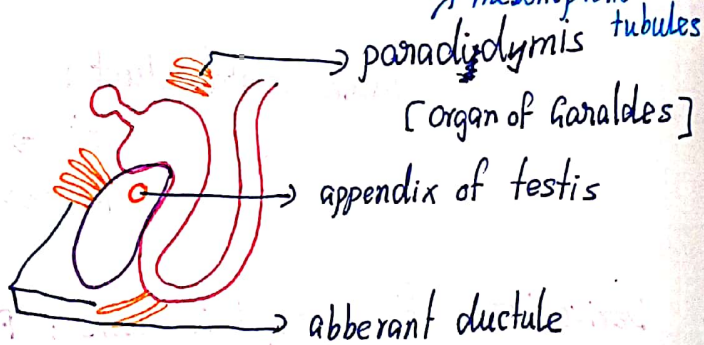
- dual origin { Upper 2/3rd → P.M.D [mesodermal]
  Lower 1/3rd → Primitive Urogenital Sinus [endodermal]

Remnants of mesonephric duct in ♀ :



Remnants of P.M.D in ♂ :

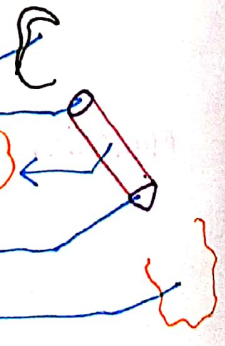
→ Appendix of testis
→ Prostatic utricles



Descent of Testis :

→ Testis develops in lumbar region [Post. abd. wall] of embryo
→ After development [during 2nd month] testis descend to scrotum. [just before birth]
→ Factor responsible :
- Gubernaculum Testis : - fibromuscular band
  └ attached to lower/caudal pole
- Processus Vaginalis : - Peritoneal fold _ help for testis descent.
- Increased Intra-Abd. Pressure & Temp.
- ♂ sex hormones [esp. Testosterone]

→ Duration :
- 3rd month → Iliac fossa
- 4th-6th month → Deep Inguinal Ring
- 7th month → Passes through Inguinal Canal
- 8th month → Sup. Inguinal Ring
- just before birth → lower part of scrotum



Applied :

Cryptorchidism :

Failure of descent of testis to scrotum bottom.

Complications :

S - Sterility
I - Injury to tesis [more chance]
T - Testicular tumor [seminoma]

Yolk Sac :

- One of the fetal membranes.

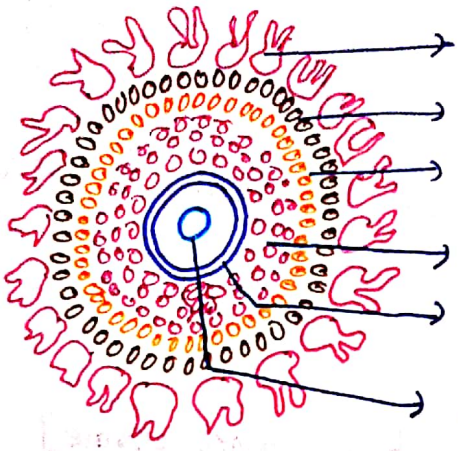
stages :

1° yolk sac — 2nd week of IUL
Formation of EEC in EEM ↓
2° yolk sac — 3rd week of IUL
Formation of Head & Tail fold & Incorporation of Y.S to form gut-tube ↓
Definitive yolk sac — 4th week of IUL
[communicated with Midgut via VID]

Graffian follicle :

→ One of the tertiary follicles reach maximum size.
↓
Graffian follicle [largest mature follicle]
↓
remaining all will atrophy

→ G.F reaches the periphery of ovarian cortex.
→ The layer of cells surrounding 2° oocyte is Coronary Radiata



→ corona radiata
→ Theca externa → secrete ~~estr~~ estrogen
→ Theca interna
→ Cumulus oophorus
→ Zona pellucida
→ 2° oocyte.

→ After LH surge, ovulation occurs.
→ After ovulation, GF → gets converted into corpus luteum.