

EMBRYOLOGY MODELS

1. BILAMINAR EMBRYONIC DISC WITH AMNIOTIC CAVITY & YOLK SAC

- formed in second week of development

Second week is also known as week of twos

- outer cell mass (trophoblast) differentiates into two layers,
inner cytotrophoblast & outer syncytiotrophoblast
- inner cell mass (embryoblast) differentiates into two layers,
ectoderm above & endoderm below
- two cavities are formed

- amniotic cavity - roof lined by amniogenic cells derived from trophoblast
- floor formed by ectoderm

- yolk sac - lined by cells of Heuser's membrane derived from endoderm

d. extraembryonic mesoderm splits into two layers:

somatopleuric (parietal) layer - lines inside of trophoblast
splanchnopleuric (visceral) layer - surrounds yolk sac

- the two layers are separated by extraembryonic coelom / chorionic cavity

* 1st germ layer to be formed - endoderm; 2nd - ectoderm; 3rd - mesoderm

* Connecting stalk is unsplit part of EEM traversing chorionic cavity; later it becomes umbilical cord.

2. SUBDIVISIONS OF INTRAEMBRYONIC MESODERM

20th - 30th day

IEM is subdivided into three parts:

(i) paraxial mesoderm

- somites are formed by segmentation of paraxial mesoderm
- 42 to 44 pairs appear during 20th to 30th day - called somite period of development
- each somite gets subdivided into 3 parts (from lateral to medial)
 - dermatome - gives rise to dermis of skin & subcutaneous tissue
 - myotome - gives rise to muscles of body wall & limbs
 - sclerotome - migrates to surround neural tube
 - gives rise to vertebral column & ribs

SDS
S.M.D.
(medial to lateral)

(ii) intermediate mesoderm

- also referred to as nephrogenic cord
- forms a bulge on posterior abdominal wall lateral to dorsal mesentery
- covered by coelomic epithelium
- differentiates into urogenital structures

Derivatives of intermediate mesoderm (from medial to lateral side):

a. gonads (ovary / testis) - from coelomic epithelium covering medial side of nephrogenic cord

b. excretory tubules

- are called mesonephric tubules in thoracolumbar region
- develop into efferent ductules of testes, which form epididymis
- tubules in metanephros (formed in sacral region), give rise to excretory part of kidney

c. mesonephric duct develops in relation to the excretory tubules

- gives rise to ureteric bud in both sexes
- in males it also gives rise to male genital organs
 - vas deferens, seminal vesicles, ejaculatory ducts & part of prostate
- in females most of it disappears after giving rise to ureteric bud

d. paramesonephric duct

- in females, it gives rise to female genital organs
 - the two ducts fuse distally and give rise to uterus & part of vagina
 - unfused parts form uterine tubes
- most of it disappears in the males

(iii) lateral plate mesoderm

- splits into parietal & visceral layers, separated by intraembryonic coelom
 - intraembryonic coelom is initially a closed cavity
 - later it communicates with extraembryonic coelom
 - it gives rise to pleural, pericardial & peritoneal cavities
- parietal layer lines the inside of the body cavities
 - forms fibrous pericardium & parietal layer of serous pericardium, parietal pleura, parietal peritoneum
- visceral layer - forms smooth muscle of all viscera, heart & blood vessels, visceral layer of serous pericardium, visceral pleura, visceral peritoneum

3. DEVELOPMENT OF DIAPHRAGM

Diaphragm develops from the following sources:

- a) pleuroperitoneal membrane separating pleural & peritoneal cavities
- b) septum transversum - unsplit lateral plate mesoderm cranial to pericardial cavity
 - with formation of head fold, it comes to lie caudal to heart
- c) mesentery of oesophagus
- d) mesoderm of body wall - gives rise to the peripheral rim

* Diaphragm descends caudally with elongation of neck, dragging phrenic nerve (C3,4,5) along with it.

4. DEVELOPMENT OF FACE

Face develops from five prominences around stomatodaeum

- frontonasal process from above
- right & left maxillary processes
- right & left mandibular processes on either side

Frontonasal process - downward projection from mesoderm over developing forebrain

- shows two thickenings, nasal placodes which sink below surface to form nasal pits, which are continuous with stomatodaeum
- edges of the nasal pits are raised by mesodermal proliferation, forming

medial & lateral nasal processes

Mandibular arch - each arch gives a bud from its dorsal end, maxillary process

- main part of arch is called mandibular process
- both processes grow ventromedially on either side

Formation of various parts of face

- Lower lip and lower jaw - by midline fusion of the two mandibular processes ✓
- Upper lip - lateral part - by fusion of maxillary process with lateral & medial nasal processes ✓
- median part (philtrum) - mesoderm from frontonasal process ✓
- ectoderm from maxillary process overgrows the mesoderm ✓

Cheek - by fusion of maxillary process with mandibular process on either side ✓

Nose - olfactory epithelium from nasal placode ✓

- nasal septum from deeper part of frontonasal process ✓

- lateral wall of nose from lateral nasal process ✓

- nasal cavity from nasal pit ✓

Eye - lens of eye from lens placode ✓

- retina from optic vesicle, an outgrowth of diencephalon ✓

- sclera & choroid from mesoderm surrounding optic vesicle ✓

- cornea & eyelids from surface epithelium ✓

Ear - membranous labyrinth from otic placode ✓

- middle ear from tubotympanic recess (from 1st & 2nd pharyngeal pouches - endodermal) ✓

- external acoustic meatus from 1st pharyngeal (ectodermal) cleft ✓

- pinna - by fusion of mesodermal thickenings (tubercles) around the cleft - auditory hillocks ✓

* cleft lip/hare lip - failure of fusion of maxillary process with medial nasal process ✓

* oblique facial cleft - failure of fusion of maxillary process with lateral nasal process ✓

5. DEVELOPMENT OF PALATE

Palate develops from frontonasal process & right & left palatal processes ✓

- frontonasal process - forms premaxilla, triangular area in midline anteriorly ✓

- bears four incisor teeth ✓

- palatal process - a medial shelf like projection from each maxillary process ✓

- on either side fuses with posterior edge of primitive palate ✓

- of the two sides fuse in the midline ✓

- on either side fuses with lower edge of nasal septum, separating the two nasal cavities from each other & from the oral cavity ✓

Primitive palate
1^o palate

Definitive palate

Mesoderm of the palate undergoes intramembranous ossification - forms hard palate ✓

Ossification does not extend into the posterior part - forms soft palate ✓

* failure of fusion of different components result in cleft palate ✓

(cleft palate)
*

6. PHARYNGEAL ARCH DERIVATIVES

- Pharyngeal / branchial arches (six in number) are mesodermal thickenings in wall of primitive pharynx (floor) ✓
- each arch has skeletal element, muscle, nerve & arterial arch ✓

First arch (mandibular arch):

Meckel's cartilage - forms malleus, incus, anterior lig of malleus & sphenomandibular lig ✓

Muscles - of mastication, anterior belly of digastric, mylohyoid, tensors tympani & palati ✓

Nerve - mandibular nerve (post trematic) & chorda tympani nerve (pre trematic) ✓

- 1) skeletal element
- 2) muscle
- 3) nerve
- 4) Arterial arch

→ Face
→ post belly
→ Muscular
→ stylohyoid
→ Stapedius
→ platysma
→ occipitofrontalis
Face & auricle. SSSS

Reichert's Second arch (hyoid arch):
Cartilage - forms stapes, styloid process, stylohyoid lig, upper part of body & lesser cornu of hyoid
Muscles - of face & auricle, occipitofrontalis, platysma, post. belly of digastric, ~~stylohyoid~~, ~~stapedius~~.
Nerve - facial nerve

Third arch:
Cartilage - greater cornu & lower part of body of hyoid
Muscle - stylopharyngeus
Nerve - glossopharyngeal nerve

Fourth & sixth arches:
Cartilages of larynx are derived from both arches
Fourth arch - forms cricothyroid muscle
- nerve is superior laryngeal nerve (ext.)
Sixth arch - all other muscles of larynx
- nerve is recurrent laryngeal nerve

4th arch: Cricothyroid muscle.
6th arch: All others.

- * Fifth arch disappears soon after formation
- * Fourth and sixth arches together give rise to muscles of pharynx and soft palate

7. PHARYNGEAL POUCHES

They are endodermal pouches on lateral wall of primitive pharynx between pharyngeal arches

ventral part is differentiated by the formation of the first pouch:

First pouch:
- dorsal part - along with dorsal part of second pouch forms tubotympanic recess, which gives rise to auditory tube, middle ear cavity & mastoid antrum

Second pouch:
- ventral part gives rise to tonsil

Third pouch:
- dorsal part gives rise to inferior parathyroid gland III
- ventral part gives rise to thymus

(Caudal pharyngeal complex).
4th & 5th pouch
↓
thyroid gland
thymic element
ultimobranchial body
which gives rise to parafollicular cells of thyroid gland

Fourth pouch:
- dorsal part gives rise to superior parathyroid gland IV
- ventral part - along with fifth pouch forms ultimobranchial body/ caudal pharyngeal complex, body which gives rise to parafollicular cells of thyroid gland

* Pharyngeal clefts are ectodermal grooves on the outer side of neck between pharyngeal arches

The 1st pharyngeal cleft forms the epithelial lining of external acoustic meatus.

- * Tympanic membrane - formed by apposition of tubotympanic recess and 1st ectodermal cleft
 - inner mucous layer - endodermal
 - middle fibrous layer - mesodermal
 - outer epithelial layer - ectodermal

8. SUBDIVISIONS OF PRIMITIVE GUT TUBE

(a) Foregut: supplied by coeliac trunk

Derivatives - tongue, pharynx, oesophagus, stomach, duodenum upto opening of bile duct, liver, extrahepatic biliary apparatus, pancreas, lower respiratory tract

* lower respiratory tract - from tracheobronchial (respiratory) diverticulum from floor of pharynx
- the diverticulum divides into two lung buds

↳ separate from the larynx and elongate

* tongue - anterior 2/3rd - fusion of two lingual swellings & tuberculum impar (all three from 1st arch)
- posterior 1/3rd - from cranial part of hypobranchial eminence (from 3rd arch)
- posterior most part - from 4th arch

Muscles of tongue develop from occipital myotomes

Nerve supply of tongue - anterior 2/3 - from post trematic & pre trematic nerves of mandibular arch
(lingual & chorda tympani nerves)

- posterior 1/3 - glossopharyngeal nerve

- posterior most part - vagus

- muscles of tongue - hypoglossal nerve
(occipital myotomes)

* liver - hepatocytes - from hepatic bud (endoderm) arising at distal end of foregut - Parenchyma
- Glisson's capsule & connective tissue - from septum transversum (mesoderm) - Stroma

Hepatic bud enlarges and divides into:

- pars hepatica - large cranial part; forms right & left lobes of liver

- pars cystica - small caudal part; gives rise to gall bladder & cystic duct

* spleen - from mesenchymal cells of dorsal mesogastrium

* pancreas - from dorsal & ventral pancreatic buds at distal end of foregut

- with rotation of gut, ventral bud moves dorsally & fuses with dorsal bud

- ventral bud forms lower part of head of pancreas including uncinat process

- dorsal bud forms upper part of head, neck, body & tail of pancreas

(b) Midgut: supplied by superior mesenteric artery

Derivatives - duodenum distal to opening of bile duct, jejunum, ileum, caecum, appendix,
ascending colon and right 2/3rd of transverse colon

(c) Hindgut: supplied by inferior mesenteric artery

Derivatives - left 1/3rd of transverse colon, descending colon, sigmoid colon, rectum and

upper part of anal canal

(upto the pectinate line)

* Anal canal - upper part from endoderm of primitive rectum (dorsal part of hindgut distal to allantois)
- lower part from ectoderm of proctodaeum (anal pit)

pectinate line

Junction of the two parts is represented by pectinate line (anal valves)

9. DEVELOPMENT OF HEART TUBE

✓ Two endothelial tubes fuse to form a single heart tube, which has an ^(cranial)arterial end & a ^(caudal)venous end.

✗ A series of dilatations appear in the heart tube from cranial(arterial) to caudal(venous) end:

- ✓ bulbus cordis - subdivided into truncus arteriosus & conus (bulbus cordis proper)
- ✓ primitive ventricle
- ✓ primitive atrium
- ✓ sinus venosus - represents venous end of heart tube; it has right & left horns
 - each horn receives vitelline, umbilical & common cardinal veins
 - later left horn regresses & becomes just another tributary of right horn

Truncus arteriosus - subdivided by spiral septum into ascending aorta & pulmonary trunk

Conus & primitive ventricle join to form a single ^{be}ventricular chamber which is partitioned to form right & left ventricles by interventricular septum

Primitive atrial chamber gets divided into right & left atria by interatrial septum

Sinus venosus - body & right horn are absorbed into right half of primitive atrial chamber
left horn becomes coronary sinus

* right atrium - rough anterior part from right half of primitive atrial chamber
 - smooth posterior part from absorbed right horn of sinus venosus

* interatrial septum develops from - septum primum (remnant - fossa ovalis)
 - septum secundum (remnant - limbus fossa ovalis)

* foramen ovale is the valvular passage between septum primum & secundum ^(slit-like)

* interventricular septum - from primitive IV Septum, AV cushions and bulbar septum

* pharyngeal arch arteries connect aortic sac with dorsal aortae

(Aortic sac - formed by fusion of the two ventral aortae)

- first arch artery is represented by maxillary artery
- second arch artery is present in foetal life as stapedial artery
- third arch artery gives rise to common & internal carotid arteries
- fourth arch artery - on the left side forms arch of aorta
on the right side forms right subclavian artery
- sixth arch artery forms pulmonary arteries

(Left subclavian artery - 7th cervical intersegmental artery)

* arch of aorta - from ventral part of aortic sac & its left horn, left 4th arch artery

Arch of aorta :- ventral part of aorta + its left horn + left 4th arch artery.

10. DEVELOPMENT OF URINARY SYSTEM

- Kidneys - pronephros is formed in cervical region - soon disappears ✓
 - mesonephros is formed in thoracolumbar region - not functional in humans ✓
 - metanephros is formed in relation to sacral region ✓
Kidneys initially develop in the sacral region and later ascend to the lumbar region. ✓

Excretory part - from metanephric blastema (lowest part of nephrogenic cord) ✓

- gives rise to Bowman's capsule, PCT, DCT & loop of Henle ✓

Collecting part - from ureteric bud (from lower part of mesonephric duct) ✓

- gives rise to collecting tubules, minor & major calyces, renal pelvis & ureter. ✓

Ureter

From ureteric bud arising from mesonephric duct ✓

Urinary bladder

Trigone of bladder - from absorbed mesonephric ducts (mesoderm) ✓

Rest of the bladder - from the cranial part of vesico urethral canal (endoderm) ✓

(urogenital sinus)

From the cranial part of vesico urethral canal (CUAS proper).

11. DEVELOPING NEURAL TUBE

- neural tube develops from neurectoderm lying dorsal to notochord ✓
- cranial dilated part forms brain & caudal tubular part forms spinal cord ✓
- cranial part shows three dilatations as follows: ✓

a) Prosencephalon (forebrain):

- telencephalon gives rise to cerebral cortex & corpus striatum ✓

- cavity forms lateral ventricle ✓

- diencephalon forms thalamus, hypothalamus, pars nervosa of pituitary & optic vesicle ✓

- cavity forms third ventricle ✓

b) Mesencephalon (midbrain):

- cavity forms cerebral aqueduct ✓

c) Rhombencephalon (hindbrain):

- metencephalon gives rise to pons & its rhombic lip forms cerebellum ✓

- myelencephalon gives rise to medulla oblongata ✓

- cavity forms fourth ventricle ✓

* Metencephalon: - Pons & cerebellum

* Myelencephalon: - Medulla oblongata.

* Pituitary gland

- anterior & intermediate parts - from Rathke's pouch (ectodermal diverticulum growing upwards from roof of stomatodaeum; later it is cut off from stomatodaeum) ✓

- anterior wall of the pouch proliferates to form pars anterior ✓

- posterior wall remains thin to form pars intermedia ✓

- pars nervosa & infundibulum - as a downgrowth from floor of 3rd ventricle (Diencephalon) ✓

- this fuses with posterior aspect of Rathke's pouch - neuroectoderm ✓