

Mesoderm

Divided into three main types

- Paraxial (somite)
- Intermediate
- Lateral (somatic and splanchnic)

Fates of Mesoderm

Paraxial

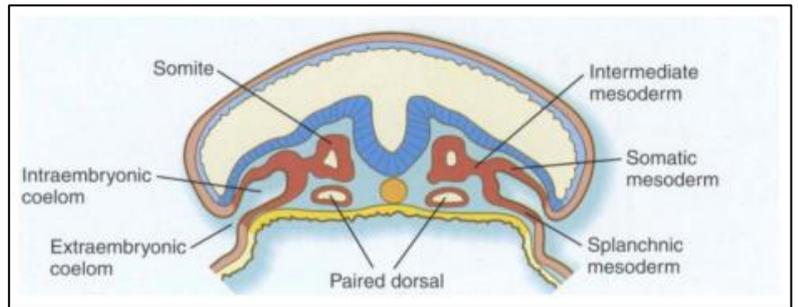
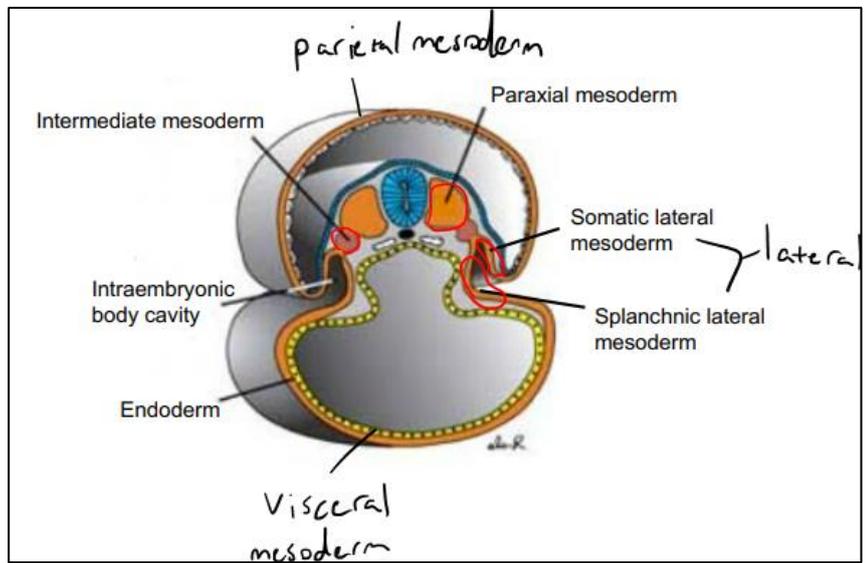
- Dermis of skin
- Axial Skeleton
- Axial and limb muscles/tendons

Intermediate

- Urogenital system (kidney and gonads)

Lateral

- Somatic → inner body wall (connective), pelvis, limb bones (parietal)
- Splanchnic → heart and vasculature (visceral)



Paraxial (somitic) Mesoderm

Head Region

- Head mesoderm + neural crest forms: skeleton, muscles, and connective tissue of the face and skull

Trunk Region

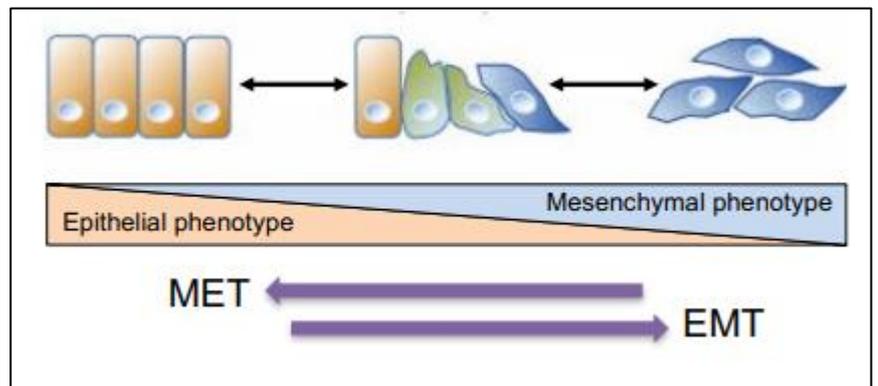
- Forms somites, which will produce: muscle, bone and dermis

Two Cell Types:

Epithelial: regular, simple sheet of cells, immobile

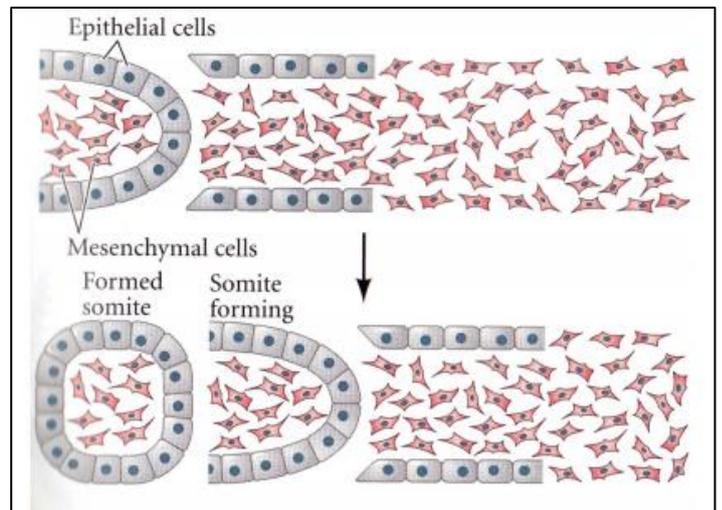
Mesenchyma: irregular and migratory

These two cell types can undergo transformation into one another.



Somitogenesis (Somite Formation)

Somites form progressively from cranial to caudal end of the notochord in a sequential fashion. One closes before the next forms.

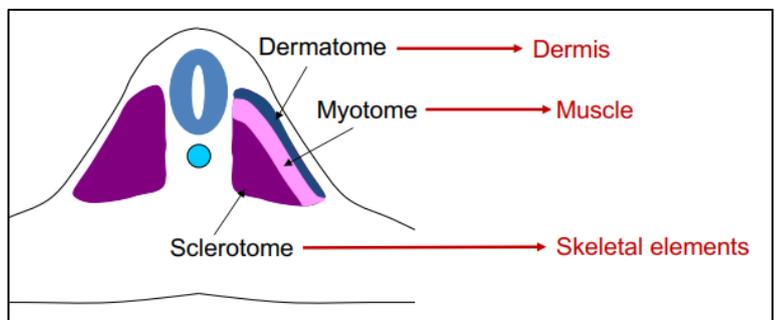


Somite Differentiation

The somite splits into the epithelial dermamyotome (dermis/muscle) and the mesenchymal sclerotome (skeletal).

The somite is all paraxial mesoderm.

Somite location determines the fate of its associates derma/myo/sclerotomes.



Intermediate Mesoderm

Urogenital system:

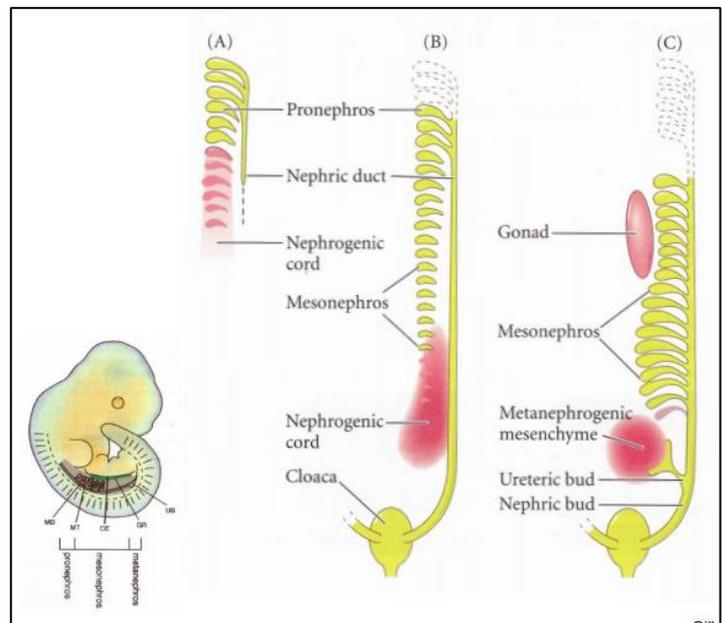
- Kidneys
- Gonads
- Reproductive Duct Systems

Runs alongside the paraxial mesoderm.

Urogenital System

Along mesonephric duct:

- Pronephros, mesonephros, and metanephros
- Pronephros fall away as gonad develops on ventral-medial side of mesonephros.
- Metanephrogenic mesenchyme gives rise to kidney.



The mesonephric duct will become the Wolffian duct forming at the nephric bud.

The Mullerian duct forms via an invagination on the dorsal side of the nephric duct.

The gonad will degenerate one of the two ducts depending on the hormones it produces.

XX → degenerates Wolffian duct – no testosterone, anti-Mullerian hormone (AMH) not produced, and Mullerian duct can develop in addition to female reproductive organs (ovaries, vagina)

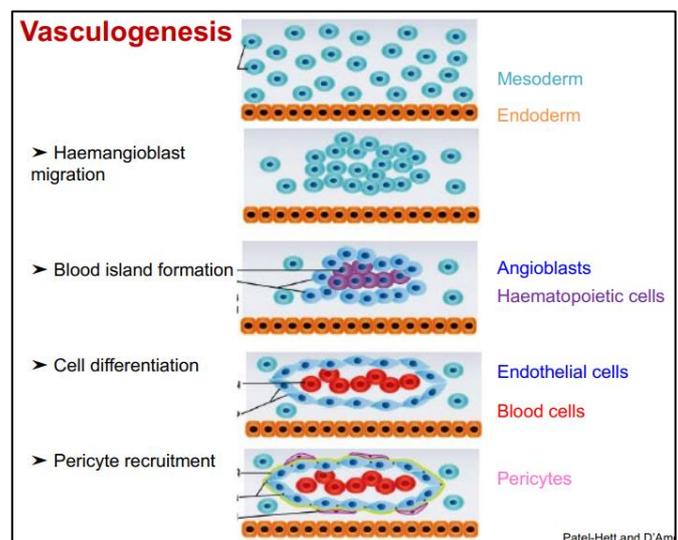
XY → degenerates Mullerian duct – testosterone, AMH produced, Wolffian duct continues as male reproductive organs (testes, penis) develop.

Vasculogenesis and Angiogenesis (Splanchnic Mesoderm)

Vasculogenesis:

- De novo assembly of blood vessels from mesoderm derived cells
- Occurs only during embryogenesis
- Needs the mesoderm cells to form micro-vessels

Involves mesoderm cell differentiation with all vessels lined in endothelial cells and some pericytes.



The heart forms this way with two tubes forming into one fused tube, which loops into the 4 chambers.

Angiogenesis:

- blood vessels form from pre-existing vasculature
- occurs during embryogenesis and in the adult
- organisation is specific

Vessels will grow towards hypoxia (low O₂) cells which have release a hormone (VEGF-A) which causes the growth towards them. Tumours release this hormone in order to receive a blood supply.

Lymphangiogenesis

- lymphatic vasculature forms from the cardinal veins which produce VEGF-C, which causes some cells to migrate and form lymph sacs
- the sacs develop into the lymph vascular system

Lecture 4

Endoderm

- Important for inducing formation of mesodermal organs (e.g. heart, blood vessels)
- Forms lining of digestive tract
- Digestive tract: whole length of the body
- Buds off liver, gall bladder, pancreas, lungs
- Cranial part (anterior of lungs): pharynx
- Epithelial pockets of pharynx: thyroid, thymus, and parathyroid

Lateral folding of the mesoderm causes the gut tube to be formed.

Somatic (parietal) mesoderm lines the body cavity while splanchnic (visceral) lines the gut tube.

They are connected by dorsal mesentery.

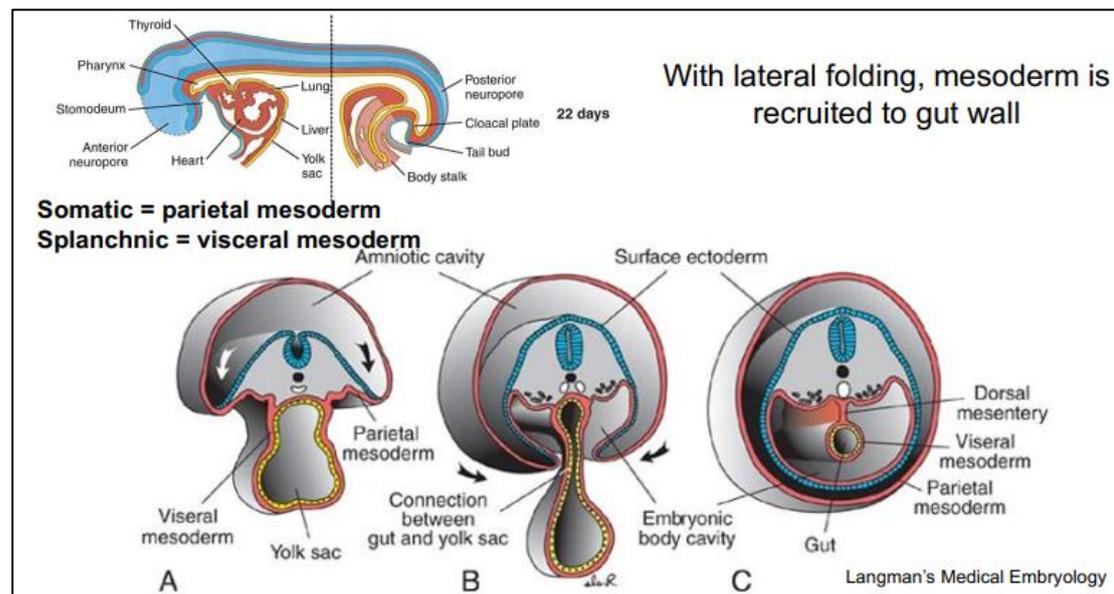
The buccopharyngeal (mouth) and cloacal (anus) membranes form the start and the end of the gut cavity.

Septum Transversum

Made of mesoderm, this separates the coelom into thoracic and abdominal cavities. It develops into the diaphragm and ventral mesentery of stomach/duodenum.

Allantois

Endodermal and surrounded by umbilical nerve/artery precursor blood vessels. Sac like structure involved in gas exchange and secretion; located at the tail end. Becomes the urachus → connects foetal bladder to yolk sac



Gut Development

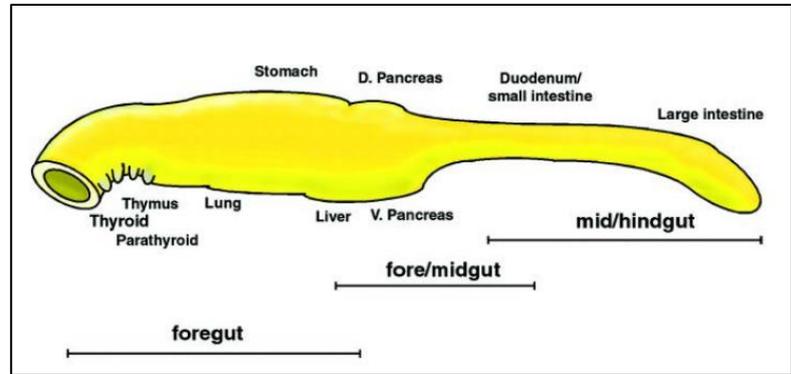
Develops at the 4th week.

Closed at:

- Cranial end → oropharyngeal membrane
- Caudal end → cloacal membrane

Three parts, defined by their blood supply:

fore/mid/hindgut



Foregut → from celiac artery to superior mesenteric artery

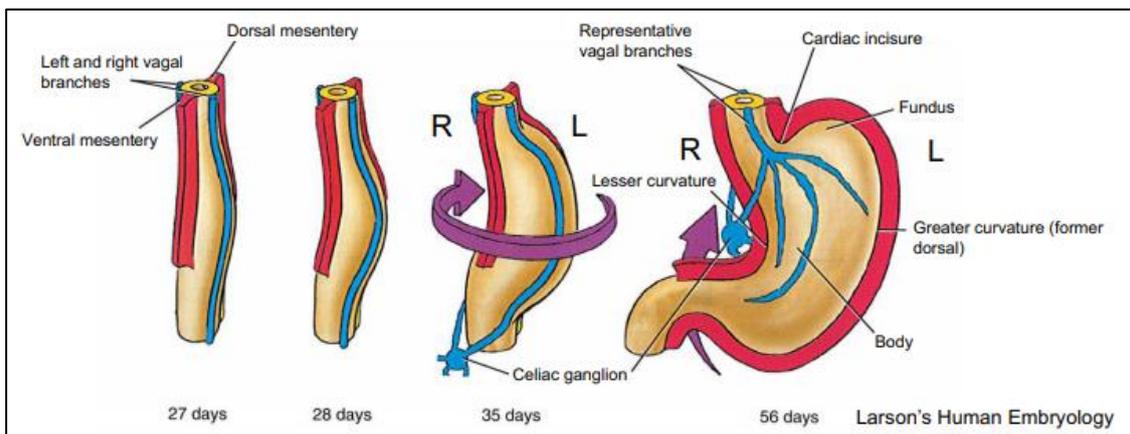
Midgut → from superior to inferior mesenteric artery

Hindgut → from inferior mesenteric to umbilical artery

- Derivatives of foregut: thyroid, parathyroid, lungs, liver, gall bladder, pancreas
- Derivatives of hindgut: urinary bladder
- Derivatives of midgut: (nothing)

Stomach Development

- Distal part of foregut, around middle of fourth week, slight dilatation
- Enlarges and broadens ventral-dorsally
- Dorsal part grows faster than ventral part: greater curvature of stomach
- While growing: rotation 90° clockwise
- Ventral border (smaller curvature) moves to right
- Dorsal border (greater curvature) moves to left
- Rotation around dorsal-ventral axis bends duodenum into C-shape

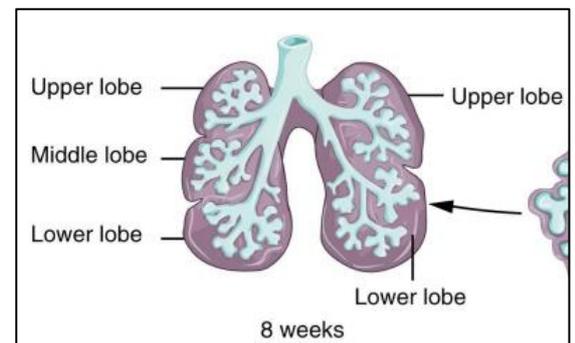


Endodermal Organ Development Pattern

- Endodermal thickening
- Cells proliferate into bud
- Branching and bifurcation from bud

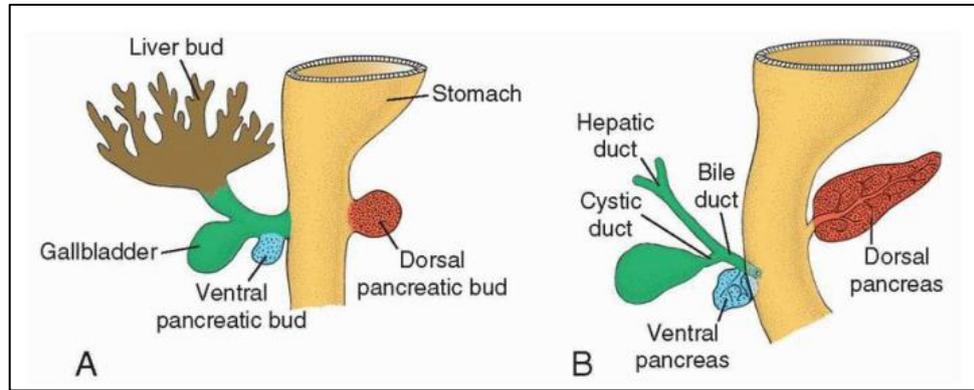
Lung Development

- Lung starts as a single tube from foregut
- Bud and bifurcate into trachea and forms bronchi and will bifurcate three more times.
- 3 right (left) lung lobes and 2 left (right) lung lobes.



Liver, Pancreas, & Gall Bladder

- All form from buds
- Stomach rotation will fuse the two opposing pancreases into a single one



Head Structures

- Many head structures are formed by the neural crest cells
- The human embryo has 4 pairs of well-defined pharyngeal (brachial) arches.

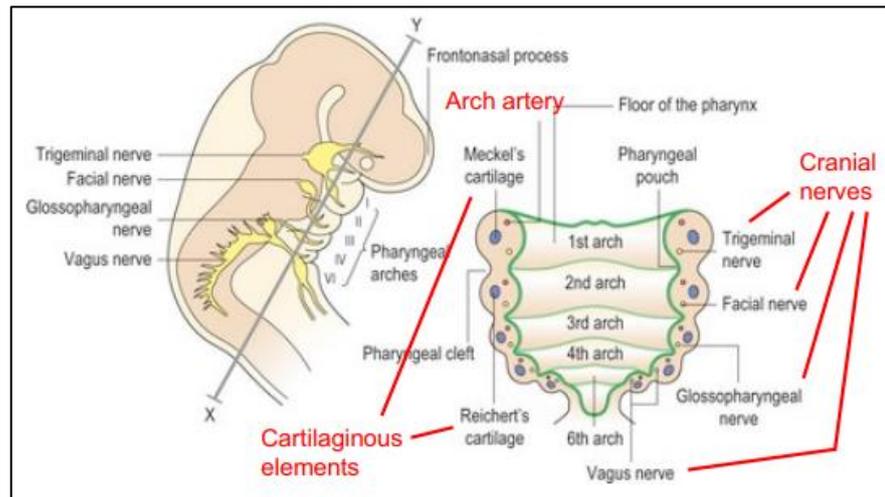
Pharyngeal Arches

- Outer covering of ectoderm
- Lined inside with endoderm
- Mesenchymal core derived from paraxial and lateral plate mesoderm as well as neural crest cells
- Inner divots → pouches
- Outer divots → clefts

Each arch contains:

- Central cartilaginous skeletal element (derived from neural crest)
- Striated muscle rudiment (derived from head mesoderm)
- Arch-specific cranial nerve
- Aortic arch artery (endothelial cells derived from mesoderm)

These all lead to the head, muscles and bones of the head during development.



Germ Cells

NOT from the three primary germ layers.

Originate from a special group of cells → Primordial Germ Cells (PGCs)

Primordial Germ Cells

- Precursors of sperm and eggs
- Occur early in development on the embryonic disc
- Cells told to remain pluripotent by inductive signalling from surround cells.

They are also not specified in the gonads, but migrate towards them from the base of the allantois.

- Migrate via the hindgut, through the dorsal mesentery and split up to coalesce with the L/R genital ridges and then stop once they make it.

Lecture 5

Taxonomy

- Classification and grouping of organisms based on similar properties

First done by Aristotle → plant/animal, air/land/water, etc.

Next by Carl Linnaeus → physical/structural similarities

Kingdom | Superphylum | Phylum | Subphylum | Class | Order | Family | Genus | Species

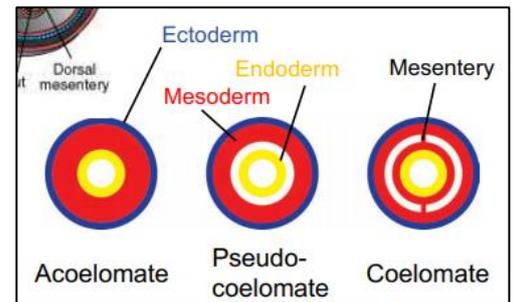
Kingdom – Animalia

- Capable of independent movement
- External energy source (food)
- Cells surrounded by a membrane (not a wall)

Superphylum – Coelomate

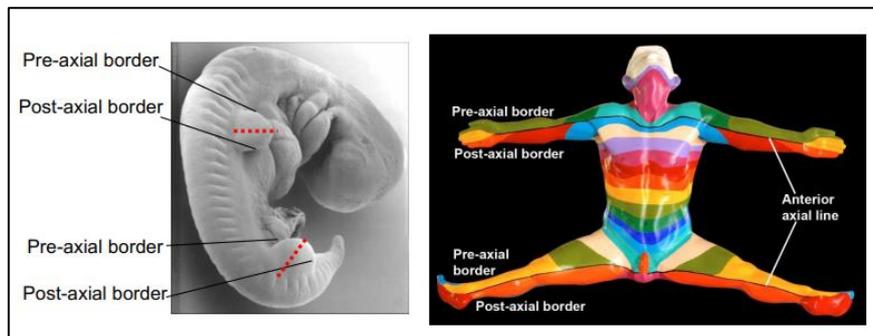
- 3 germ layers → ecto, meso, endo
- Fluid filled internal body cavity
- Gut tubed suspended in coelom and lined with mesoderm

(These features must be present during the development or in the adult)



Phylum – Chordata

- Notochord and tail (mesodermal) → can just be in embryo
- Dorsal hollow nerve cord (ectodermal) → neural tube
- Pharyngeal pouches → covered in ecto, lines in endo
- Segmentation (somites) with polarity (cranial to caudal)



Subphylum – Vertebrate

- Backbone
- Skeleton + Skull
- Spinal Cord and Spinal Nerves
- Four limbs + Five digits (tetrapod)

Superclass – Tetrapod

- Proximal principal bone (stylopod)
- Paired long bones (zeugopod)
- Short bones and five digits (autopod)

