Chordates

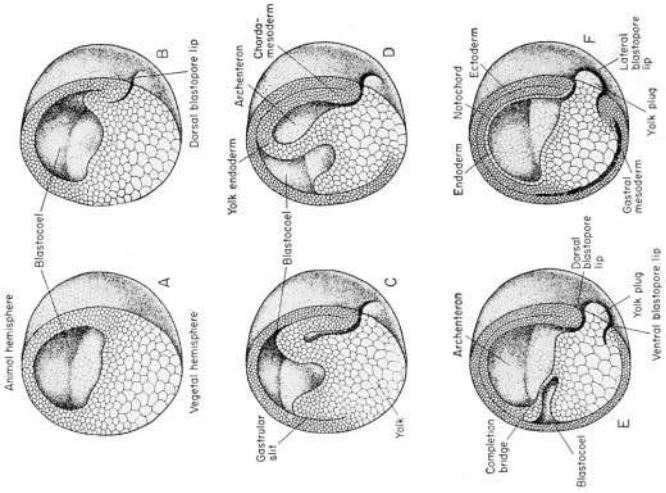
- Overview vertebrate embryonic development
  - Embryogenesis: Process by which a single celled zygote is transformed into a complex, multicellular triploblastic body form.
  - Determination is the process by which a cell's fate is determined (happens before differentiation). This is determined in part by the uneven distribution of maternal RNA and in part by the prescribed movement of cells during gastrulation. Differentiation is instead the process by which cells become morphologically and functionally different from each other.
  - Ovum → (fertilization) Zygote → (cleavage and blastulation) Blastula → (gastrulation) Gastrula → (neurulation) Neurula → (organogenesis and growth) Mature Embryo
- Understand the processes of cleavage, blastulation, gastrulation and neurulation
  - Fertilisation: Egg and sperm fuse to forma a diploid nucleus (zygote). Induced cell division occurs when the egg is provoked and stops shortly after beginning. The zygote is polarized. The vegetal pole is nutrient/yolk rich, whereas the animal pole is nutrient/yolk poor. This polarization is due to the uneven distribution of maternal mRNA, maternal proteins, mitochondria and nutrients (yolk). Consequently, from the 8 cell stage onwards, cells are not identical in terms of content.
  - Cleavage: Transforms one cell into many blastomeres. The pattern of cell division is influenced by yolk content: the greater the amount of yolk, the more difficult cell division becomes. This is why mammals, who experience placental exchange of nutrients, have complete cleavage (holoblastic) resulting in cells of equal size. The alternative is incomplete cleavage (meroblastic)

YOLK CONTENT	CELL DIVISION	CONSEQUENCE	EXAMPLE	GASTRULATION
Low = Microlecithal Even distribution = Isolecithal	Holoblastic	Cells of approximately equal size.	Mammals	Invagination
Moderate = Mesolecithal	Holoblastic	Uneven sized cells. Macromeres accumulate at vegetal pole and micromeres at animal pole.	Amphibians	Involution
High = Macrolecithal Concentrated at vegetal pole = telolecithal	Meroblastic	Embryo forms a disc of cells on top of a large yolk.	Most fish. All reptiles and birds.	Ingression

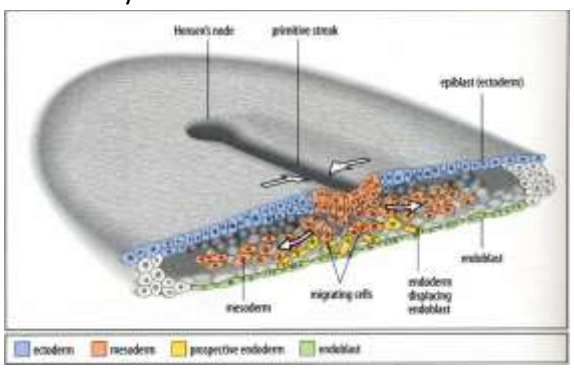
  - Blastulation: Cells form a ball surrounding a blastocoel (holoblastic) or a blastoderm/disc atop the yolk (meroblastic). This is where determination based on location occurs.
  - Gastrulation: Cell movement to create the 3 distinct germ layers. The method of gastrulation depends on the amount of yolk present. Microlecithal embryos experience invagination. This is the in-folding of the blastula to form an archenteron. Involution occurs in mesolecithal embryos. This involves the formation of a dorsal lip and the movement of cells into the archenteron over the lips of the blastopore. Macrolecithal embryos use ingression. In this case, any in-folding a cell streaming occurs along a line called the primitive streak.

Gastrulation in a frog embryo

1. Early → Dorsal lip forms. The first cells to move in over this lip become chordamesoderm (will form notochord).
2. Mid → Lateral lip forms. Cells moving over the lateral lip form mesoderm. As the archenteron increases, the blastocoel is reduced.
3. Late → Ventral lip forms and cells move over it to form mesoderm. Chordamesoderm induces the ectoderm above it to become neuro-ectoderm. This forms the neural plate and triggers neurulation.

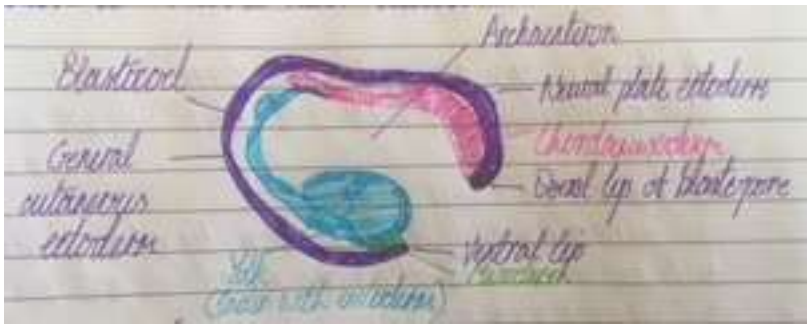


Bird Embryo:



- Neurulation

Early → The mesoderm grows down between the ectoderm and endoderm. The endoderm grows up and the mesoderm differentiates.

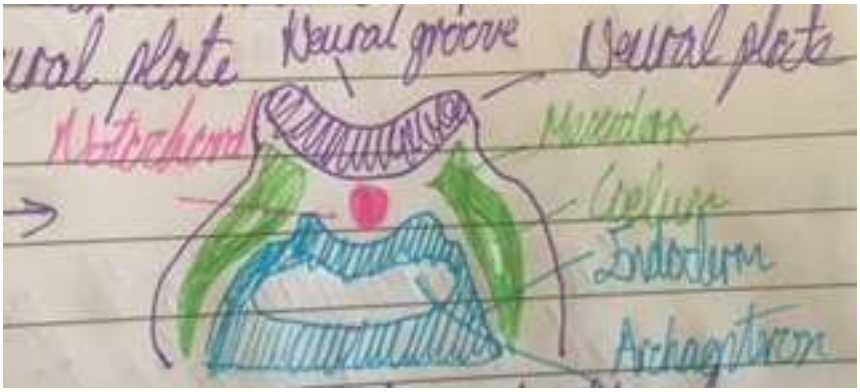


End of gastrulation

Start of neurulation

Mid → Neural folds and neural groove are formed. Endoderm growth completed to form a gut surrounding the archenteron. The mesoderm differentiates into:

1. Epimere = forms somites (muscle and skeleton)
2. Mesomere = Forms urinogenital system
3. Hypomere = Forms body cavity connective tissue. Splits to form coelum.



Late → Neural tube is formed. Some cells are pinched off to the sides to form neural crest cells. These migrate as individual cells throughout the developing embryo and induce other cells to form structures associated with the nervous system and other tissues. Further differentiation of:

1. Epimere = Inner layer of skin
2. Mesomere = Kidney and gonads
3. Hypomere = Mesentries

- List the derived traits for: chordates, craniates (vertebrates)
  Derived from invertebrates:
  1. Bilateral symmetry
  2. Anterio-posterior axis
  3. Coelum
  4. Tube-within-a-tube body plan
  5. Metamerism
  6. Cephalisation

  Key characteristics unique to chordates:

1. Notochord: Muscles attach to notochord, allowing bending without shortening and therefore undulation. In vertebrates, this is replaced by vertebrae although remnants may join them together.
2. Dorsal, tubular nerve chord
3. Pharyngeal slits: gills or clefts in pharynx
4. Endostyle: node in pharynx (thyroid gland in animals)
5. Postanal tail

- Describe and distinguish between the 3 sub-phyla of chordates:
  1. Subphylum Urochordata (Tunicates)
     - Sea squirts and salps
     - Marine
     - Most sessile but some are free living
     - Sea squirts are the most diverse. They are filter-feeding and have a pharyngeal basket separating two main siphons. They can be colonial or stalked, and are used in food and bioprospecting (targeting cancers and viruses).
     - Salps are pelagic, lemon-shaped and transparent. Larvae have all the key characteristics of an adult form. They build their own homes out of mucus with inhalant and exhalant siphons.

  2. Subphylum Cephalochordata (Lancelets)
     - Only about 25 species
     - Fish-like. All marine.
     - They remain buried in sediment with their head exposed and filter feed by maintaining a flow through their pharynx by beating cilia.
     - Clearly show all chordate characteristics.

  3. Subphylum Vertebrata (Craniata)
     - Chordates that have a head. They represent a shift in body plan in the direction of a head with a skull.
     - Neural crests: Made of plastic cells that form skull, skeleton around pharynx and structures for hearing.
     - Ectodermal placodes: Situated under neural crests. They are plate-like ectodermal thickenings that appear on either side of the neural tube. They form the olfactory, eye, ganglia and other critical nerve tissues.
     - Brain is now tripartite