Course Title: Embryology Credit hour: 1+1
Course Code: ANHP 217 and 218

Goal of the course

- To achieve an understanding of the embryos developmental stages
- To know the basic facts and concepts of embryology from fertilization to parturition

Definition

- Embryology is the study of the early prenatal development of an animal.
- Embryology is the study of the development of an embryo.

Branches of Embryology:

- General embryology: Study of prenatal (intrauterine) development. It starts from formation of single cell (zygote) in the uterus: division of single cell to multiple
- Special embryology: Compare among the embryo of different animals.
- Experimental embryology: Genetics/Cloning/Test tube.
- Chemical embryology: Studies regarding chemical components of embryo eg.DNA.
- Teratology: Study of malformation eg. Monster baby

Objectives:

- To gain the knowledge of evolution.
- To know the various teratological defects.
- To apply its knowledge towards pathology, immunology and other applied subjects.
- To increase the conception rate of animals.
- Commercial purpose-cloning of animals and its marketing.

The methods of study:

1. Dissection: Gross dissection of embryos at different ages.
2. Microscopic section: at different ages of animals.
3. Descriptive study: Section and photography.
   Experimental study: by using various drugs/chemicals/physical means

Some terminology

- **Developmental anatomy:** It deals with the prenatal and postnatal periods of development.
- **Teratology:** It **i**s the branch of embryology that concerned with the study of malformations.
- **Ontogeny/ontogenesis/morphogenesis:** describes the origin and the development of an organism from the fertilized egg to its mature form. (It is the complete life cycle of an organism commencing with the fertilization upto old stage)
- **Phyolgeny**: phylum or ancestral history of an individual is known as phylogeny.
- **Differentiation (specialization):** Process by which cells become structurally and functionally specialized.
- ***Pluripotent cell/stem cell:*** potential to become any cell of the embryo. the cells of the inner cell mass are called pluripotent. These cells also known as the so-called embryonic stem cells.

Embryogenesis:

- formation of body structures & organs (organogenesis)
- requires cell division (proliferation) and cell differentiation (specialization)
- produces the great variety of cell types and extracellular products found in the body

Different period of embryogenesis: Broadly classified into

- **Embryonic Period —** defined as the time from fertilization to the earliest (primordial) stages of organ development (about 30 days in dog, cat, sheep, pig; almost 60 days in horse, cattle, human).
- **Fetal Period —** the time between the embryonic period and parturition (the end of gestation), during which organs grow and begin to function.

Fertilization:

- Union of a haploid oocyte and a haploid spermatozoon producing a diploid zygote (a pleuripotent cell capable of developing into a new individual) or
- Union of male and female gamete.
- Fertilization begins with gamete fusion (zygote formation)

Cleavage:

- Refers to the **initial series of mitotic divisions** which takes place immediately after fertilization.
- Each daughter cell of the cleavage process is termed a blastomere.
- Cleavage begins with a *zygote*, progresses through compaction to a morula stage and terminates at the start of the blastocyst (blastula) stage.

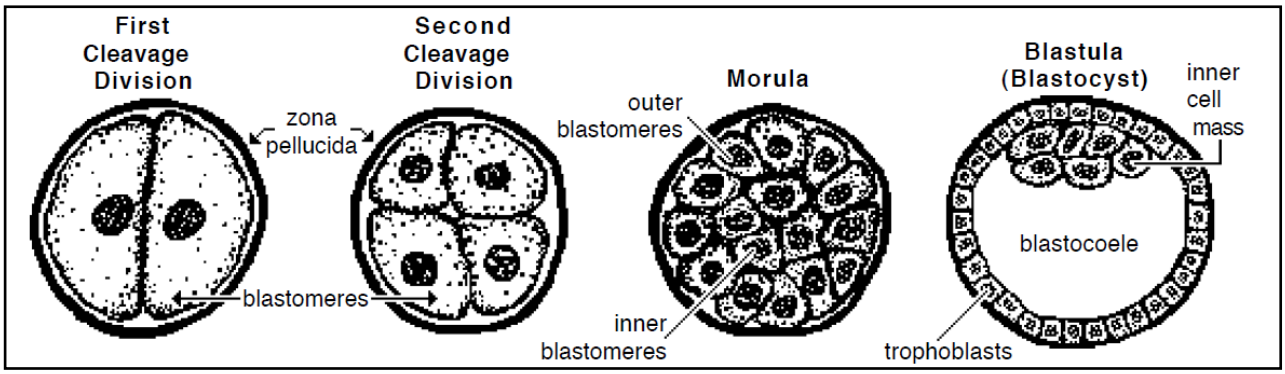


Fig. 1 Cleavage; formation of morula and blastula

Morula (Latin=small mulberry)

- After several segmental division the zygote looks like a solid ball of cell within the zona pellucida (typically consisting of 16 to 64 blastomeres)
- When a morula leaves the uterine tube and enters the uterus (uterine horn) it is at about the 16-cell stage, around 4 to 7 days after fertilization (depending on species).
- The 32-cell stage morula (5-7 days post ovulation) is ideal for embryo transfer in cattle.

Blastocyst/Blastula

- At the developmental process, the cells of the morula are arranged around a newly formed central cavity called blastocoele. This stage is called blastula.
- During the formation of blastula clusters of cells are arranged at one pole of the blastocoele which is known as inner cell mass (embryoblast). ICM will form the embryonic body.
- The outer cells of the blastocyst are called trophoblasts (future chorion of the conceptus)
- the cavity of the blastocyst is called a blastocoele
- The blastocoele filled with fluid.
- Gradually fluid increased in the blastocele which create enormous pressure on trophoblast cells.

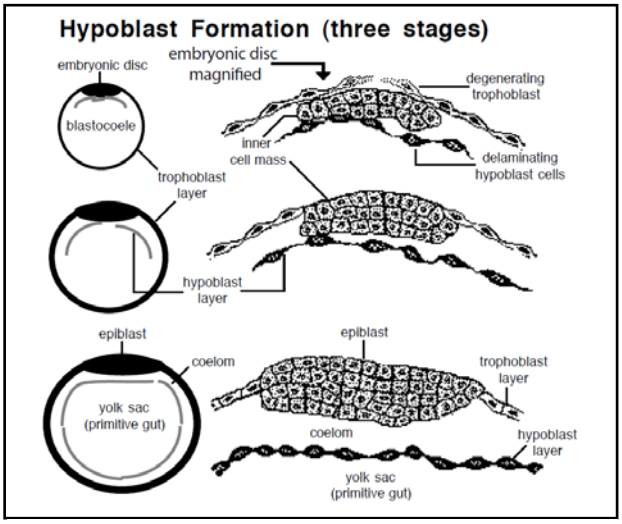


Fig. 2 Formation of ICM, embryonic disc, hyponblast and epiblast formation

- Eventually zonal pellucida rupture and degrades and then blastocyst becomes a free-floating embryo within the lumen of the uterus. This process is called **hatching.**
- Eventually the hatched blastocyst attaches to or implants within the uterine wall (depending species).

Implantation

- Implantation is the attachment of the free-floating blastocyst to the uterine epithelium and corresponding growth or penetration of the epithelium by embryonic tissues.
- In most farm animals, the degree of penetration is much less than in rodents and humans, for example.
- Implantation in most farm animals is considered noninvasive and primarily associated with cell to cell junctions between embryonic and uterine tissues.
- After fertilization, attachment occurs in the cow at about 35 days, the sow about 11 days, and the mare about 55 days.

Gastrulation/Gastrula (*gastrula*= little stomach)

- ✓ The morphogenic process that gives rise to three germ layers (ectoderm, mesoderm, and endoderm) is called gastrula.
- ✓ Formation of three germ layers is called gasrulation.

Sequence/steps of Gastrulation: includes the following sequence, beginning with a blastocyst

- ❖ The cells of the trophoblast overlapping the inner cell mass degenerate and inner cell mass comes to be lie at the surface and form a thickened area known as embryonic disc.
- ❖ In the late blastocyst, zonna pellucida is dissolved and start to attach with the wall of the endometrium. The attachment of the blastocyst to the wall of the endomentrium is called implantation.
- ❖ From the inner cell mass, cells proliferate, break loose, and migrate to form a new cell layer inside the trophoblast layer. The new layer of cells, called the *hypoblast, will* form yolk sac. The remaining inner cell mass called the *epiblast. Epiblast and hypoblast are the two layers of blilaminar embryo.*
- ❖ On the epiblast surface, a primitive streak forms.
- ❖ The primitive streak is the longitudinal axis of the embryo and indicates the start of germ layer formation.

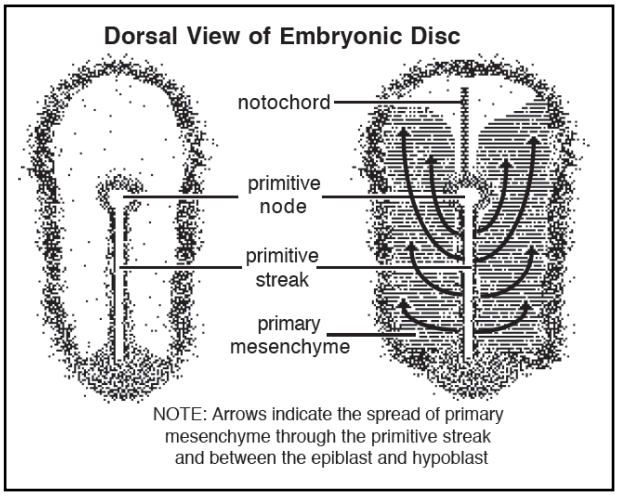
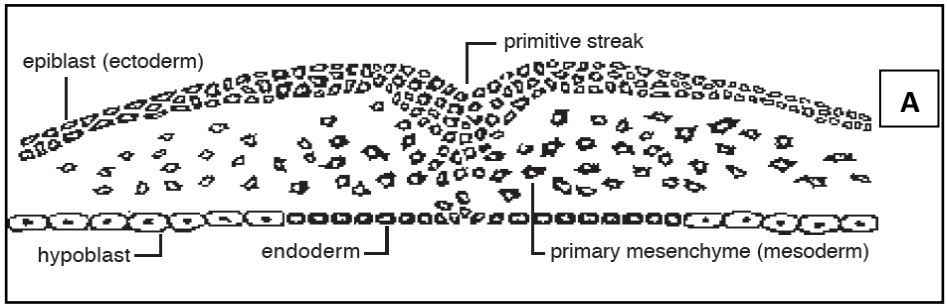


Fig. 3 Formation of primitive streak and primitive node

- ❖ Deep to the primitive streak, a space (**coelom**) becomes evident between the hypoblast layer and epiblast. Subsequently, the coelom is filled by mesoderm that undergoes cavitation and gives rise to body cavities.



- ❖ Epiblast cells proliferate along primitive streak margins and migrate through the streak into the coelom. The migrating cells form endoderm & mesoderm layers.

- Initial migrating cells join the hypoblast layer, forming embryonic **endoderm** (hypoblast cells constitutes yolk sac endoderm).
- The majority of migrating cells enters the coelom as primary mesenchyme and become **mesoderm**.
- The primary mesenchyme migrates laterally and cranially. Mesoderm divides into: paraxial, intermediate, and lateral mesodermal regions.

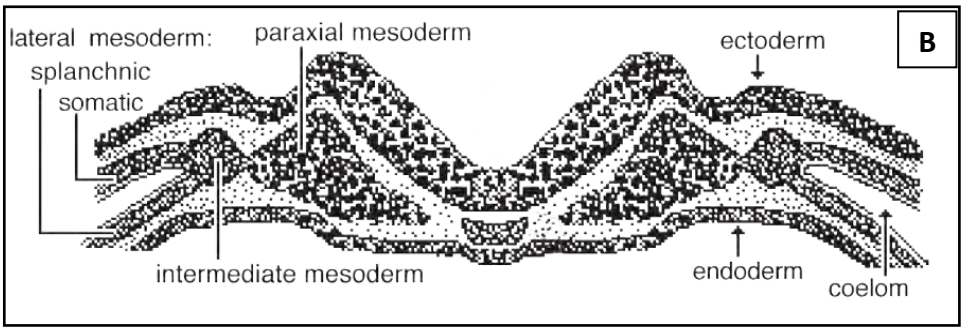


Fig. 4 Formation of 3 germ layers (A), division of mesoderm (B)

GERM LAYER DERIVATIVES

Ectoderm, mesoderm and endoderm are called primary germ layers because origins of all organs can be traced back to these three layers.

- Ectoderm forms epidermis of the skin, epithelium of the oral and nasal cavities, and the nervous system and sense organs.
- Mesoderm forms muscle and connective tissue, including bone, and components of the circulatory, urinary and genital systems.
- Endoderm forms mucosal epithelium and glands of respiratory and digestive systems.

Formation of the Notochord:

- The **notochord** is a rod-shaped aggregate of cells located between ectoderm and endoderm anterior to the primitive streak of the embryo. It occupies the midline coelomic space that was not invaded by migrating primary mesenchyme.

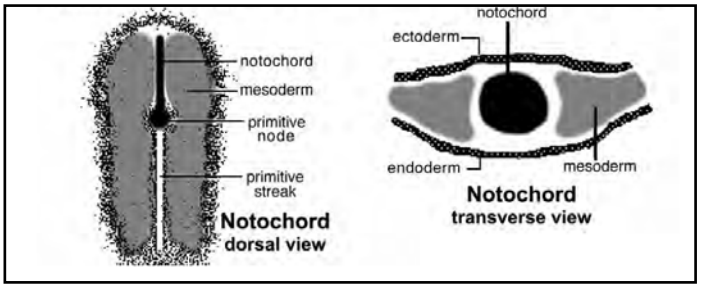


Fig. 5 Formation of notochord

- The notochord is important because it induces: formation of the head process, development of the nervous system, and formation of somites.
- The notochord marks the future location of the vertebral column and the base of the cranium.

Somites:

- Mesoderm blocks located just lateral to the notochord, which induced somite development.
- A pair of somites develops for every vertebra, plus a half dozen somite pairs in the head.
- Number of somites in an embryo is indicative of age, individual somites develop chronologically, in craniocaudal order.

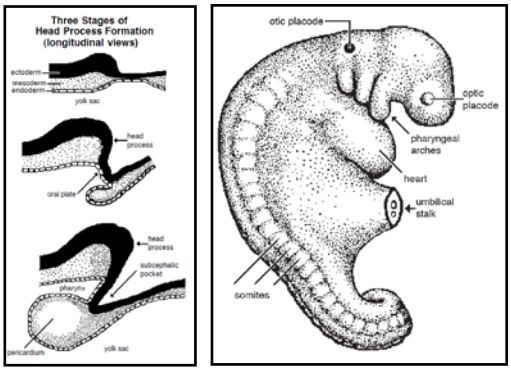


Fig. 6 Formation of somites

Each somite differentiates into three regions:
Sclerotome (ventromedial region) gives rise to vertebrae, ribs, and endochondral bones at the base of the skull.
Dermatome (lateral region) gives rise to the dermis of skin
Myotome (intermediate region) gives rise to skeletal muscles of the body

Development of a Cylindrical Body:

Transition from a flat embryo to a cylindrical one involves the following developments:

Head Process Formation

The cranial end of the embryo grows dorsally and forward so that it projects above the region originally in front of the embryo.

Tail Fold Formation: At the caudal end of the embryo, a cylindrical tail fold is formed in a manner similar to that of the head process.

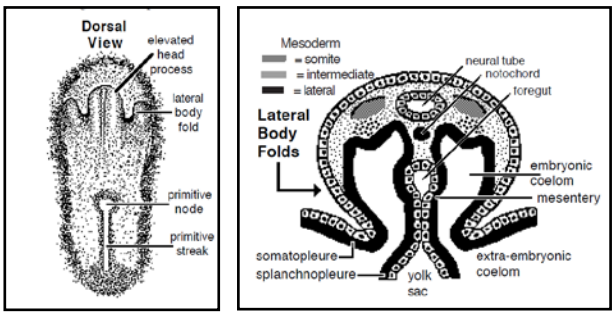


Fig. 7 Formation of somtopleure and splanchnopleure

Lateral Body Folds:

Ventral fusion of lateral body folds separate the embryo from extra-embryonic tissue (fetal membranes):

- embryonic coelom (future body cavities of the trunk) is distinguished from extra-embryonic coelom within fetal membranes.
- somatopleure (somatic mesoderm+ectoderm) that forms body wall is distinguished from that forming fetal membranes (chorion and amnion).
- splanchnopleure (splanchnic mesoderm+endoderm) merges bilaterally to form gut and mesentery, differentiated from extra-embryonic yolk sac (and allantois).

Placentation : is the process of development of the extraembryonic membranes or placenta.

- Placenta is the region where metabolites are exchanged between fetus and mother.
- Placenta has two major parts: fetal part and maternal part
  - Fetal membranes are called fetal placenta
  - Endometrium that is shed at parturition is called maternal placenta or decidua.

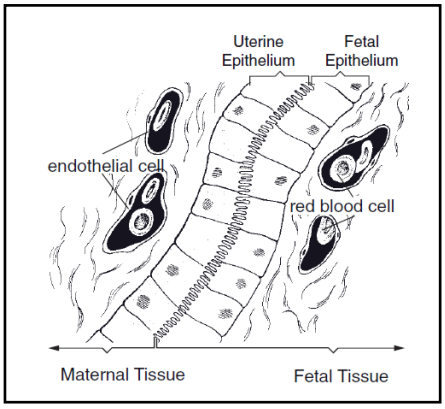


Fig. 8 Formation of Placenta under LM

Grossly, placentas are 4 types:

- Diffuse (Pig)
- Zonary (carnivore)
- Discoid (Primates and rodents)
- Cotyledonary/placentomes (ruminants)

A placentome is formed by maternal caruncle and a fetal cotyledon.

- Diffuse placenta (epitheliochorial): extension of the chorion project into the crypts scattered over the entire endometrium. e.g., mare and sow
- Cotyledonary placenta: involves placentomes; exchage takes place at placentomes. e.g. cow, ewe, doe
- Discoidal placenta (Hemochorial): attached to the uterus in a disk-shaped area only. e.g., rodent
- Zonary and discoidal types of placental attchment are deciduate (shed at parturition)

Histologically: Placentas classified according to the tissue layers separating fetal and maternal blood. Uterine epithelium, uterine connective tissue and uterine endothelium may be eroded, giving rise to three placental types:

1. Epitheliochorial (swine, equine, cattle)-chorion of fetus is in direct contact with the epithelium of uterus.

2. Endotheliochorial (carnivores): chorion is in direct contact with the endothelium of blood vessels of dam.

3. Hemochorial (primates & rodents)- fetal vessels and chorion are invaginated into pools of maternal blood

Fetal membranes:

Four fetal membranes develop in a conceptus. Two arise from the trophoblast layer of the blastocyst (and are continuous with the somatopleure of the embryo). Two arise from the inner cell mass of the blastocyst (and are continuous with splanchnopleure of the embryo); these two splanchnopleure membranes are vascular. The four fetal membranes are:

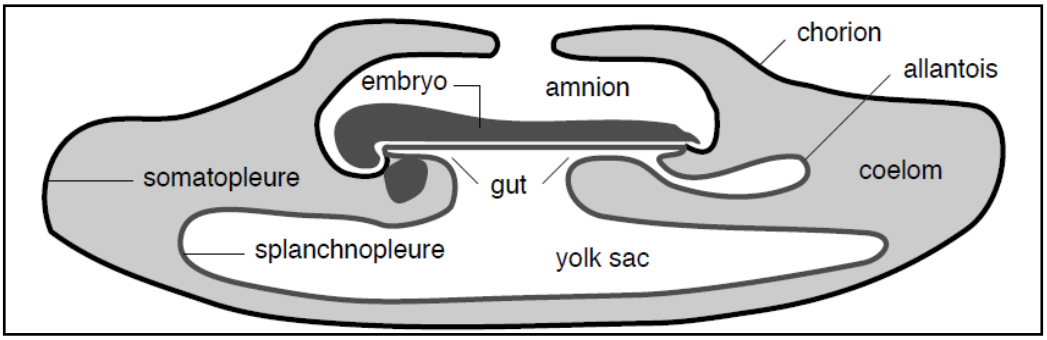


Fig. 9 Fetal membranes (diagrammatic)

1. **Chorion -** forms the outer boundary of the entire conceptus (from trophoblast)
2. **Amnion -** encloses the embryo within a fluid-filled amnionic cavity; formed by folds of chorion in domestic mammals
3. **Allantois -** develops as an outgrowth of hindgut splanchnopleure (originates from inner cell mass). Allantois grows to fill the entire extra-embryonic coelom, with fluid-filled allantoic cavity in domestic mammals. The outer surface of allantois binds to the inner surface of chorion (and the outer surface of amnion).

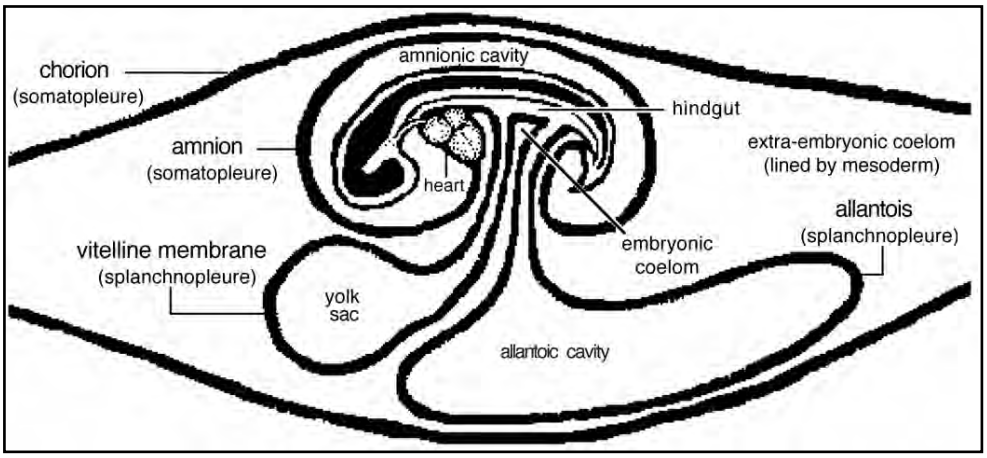


Fig. 10Fetal membranes

The allantois is highly vascular and provides the functional vessels of the placenta, via umbilical vessels.

4. **Yolk sac** — continuous with midgut splanchnopleure (develops early with hypoblast formation from inner cell mass). Supplied by vitelline vessels, it forms an early temporary placenta in the horse and dog. **Yolk sac is most important in egg laying vertebrates.**

Note: The term *conceptus* refers to the embryo or fetus plus its fetal membranes.