Embryology

Blastocyst formation

- The morula enters the uterine cavity

- Fluid begins to penetrate through the zona pellucida into the intercellular spaces of the inner cell mass.

- A single cavity (blastocoel) forms

- At this time, the embryo is a blastocyst

- Cells of the inner cell mass, now called the embryoblast, are at one pole

- Cells of the outer cell mass, called trophoblast, flatten and form the epithelial wall of the blastocyst

- Zona pellucida has disappeared, allowing implantation to begin.

- Trophoblastic cells begin to penetrate between the epithelial cells of the endometrium on about the sixth day, Fig. (3).

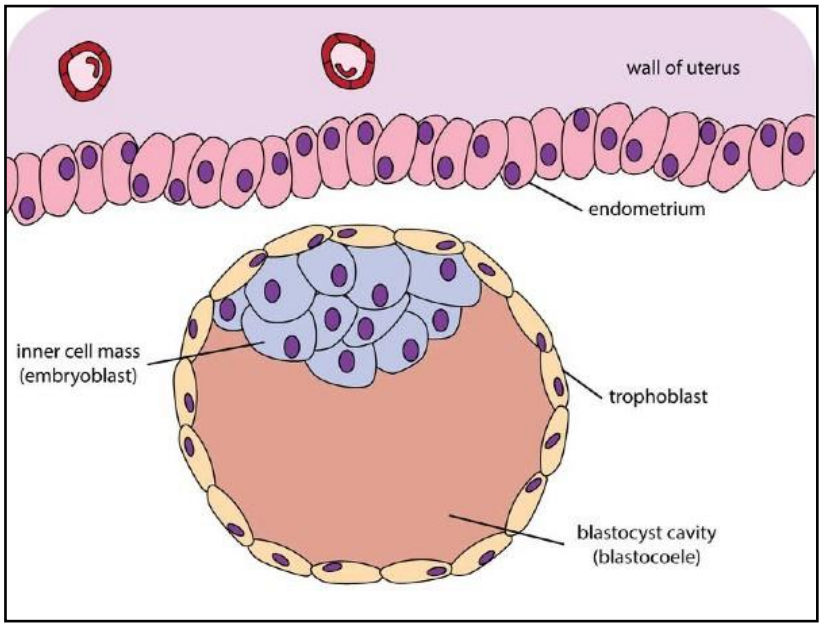


Figure-3: Human Blastocyst

Uterus at time of implantation

In human, the wall of the uterus consists of three layers:

1- Endometrium or mucosa lining inside wall

2- Myometrium, a thick layer of smooth muscle

3- Perimetrium, the peritoneal covering lining the outside wall.

From puberty (11-13 years) until menopause (45-50 years), the endometrium undergoes changes in a cycle of approximately 28 days under hormonal control by the ovaries. During this menstrual cycle, the uterine endometrium passes through three stages:

1- Follicular or proliferative phase

2- Secretory or progestational phase

3- Menstrual phase

The uterus at time of implantation is in the secretory phase, and the blastocyst implants in the endometrium. If fertilization does not occur, then the menstrual phase begins.

Second week of human embryonic development: Bilaminar germ disc

The second week of development is known as the week of 2's because:

1- The trophoblast differentiates into <u>two</u> layers:

a- Cytotrophoblast (inner layer of mononucleated cells)

b- Syncytiotrophoblast (outer multinucleated zone without distinct cell boundaries)

- Mitotic figure found in the Cytotrophoblast but not in the Syncytiotrophoblast.
- By day 9, lacunae develop in the Syncytiotrophoblast.
- Subsequently, cells of the Syncytiotrophoblast penetrate deeper into the stroma and erode the endothelial lining of the maternal capillaries. These capillaries are known as sinusoids.

- The syncytial lacunae become continuous with the sinusoids, maternal blood enters the lacunar network, and by the end of the second week, a primitive uteroplacental circulation begins.
- The cytotrophoblast, forms cellular columns penetrating into and surrounded by the syncytium, these columns are primary villi.
- By the end of the second week, the blastocyst is completely embedded, fig. (5).

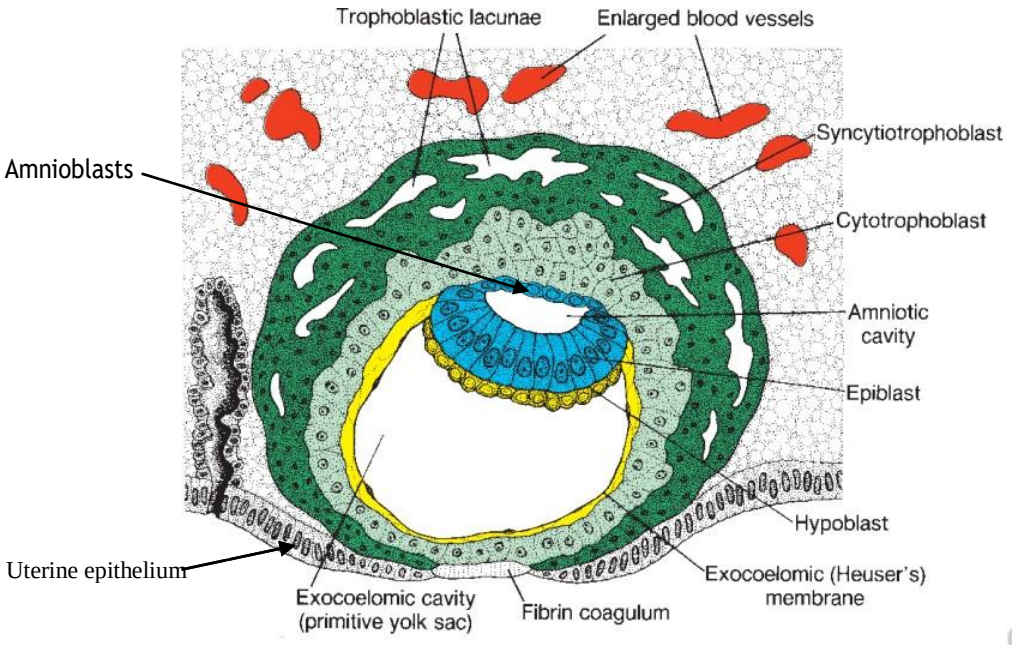


Figure-5: 9-day human blastocyst

2- The embryoblast forms <u>two</u> layers:

a- Epiblast (a layer of high columnar cells)

b- Hypoblast (a layer of small cuboidal cells)

- Together forming a bilaminar disc.
- A small cavity appears within the Epiblast, this cavity enlarges to become the amniotic cavity.

- Flattened cells originated from the hypoblast form a thin membrane called exocoelomic membrane that lines the inner surface of the cytotrophoblast.
- Exocoelomic membrane together with the hypoblast forms the lining of the exocoelomic cavity or (primitive yolk sac), fig. (5).

3- The extraembryonic mesoderm splits into <u>two</u> layers

a- Extraembryonic somatic mesoderm (lining the cytotrophoblast and amnion)

b- Extraembryonic splanchnic mesoderm (covering the yolk sac), fig. (6).

Extraembryonic mesoderm fills the space between:
- The <u>trophoblast</u> externally and - The <u>amnion</u> and <u>exocoelomic membrane</u> internally.

A cavity develops in the extraembryonic mesoderm called **extraembryonic cavity**

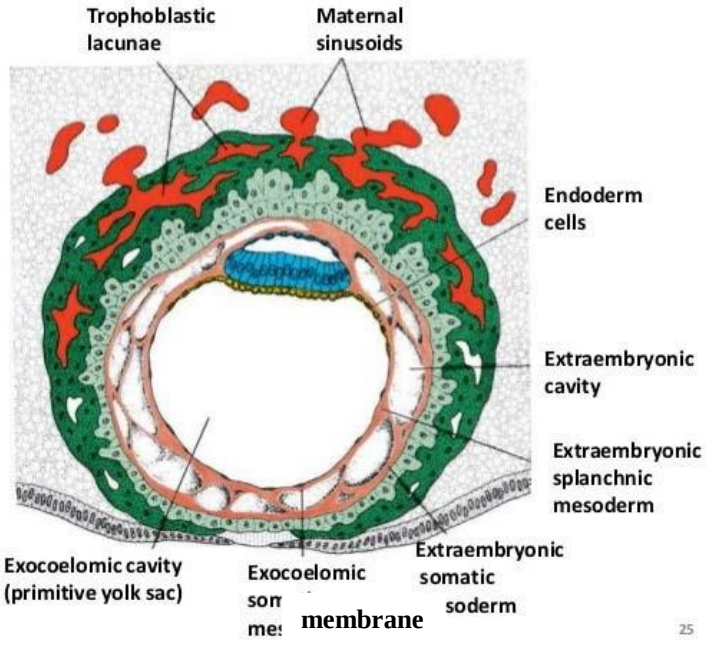


Figure-6: Human blastocyst of approximately 12 days

4- Two cavities form:

a- Amniotic cavity: a small cavity appears within the Epiblast. Epiblast cells adjacent to the cytotrophoblast are called amnioblasts; together with the rest of the epiblast, they line the amniotic cavity.

b- Yolk sac cavity: the hypoblast produces additional cells that migrate along the inside of the exocoelomic membrane. These cells form a new cavity called definitive yolk sac within the exocoelomic cavity, fig. (7).

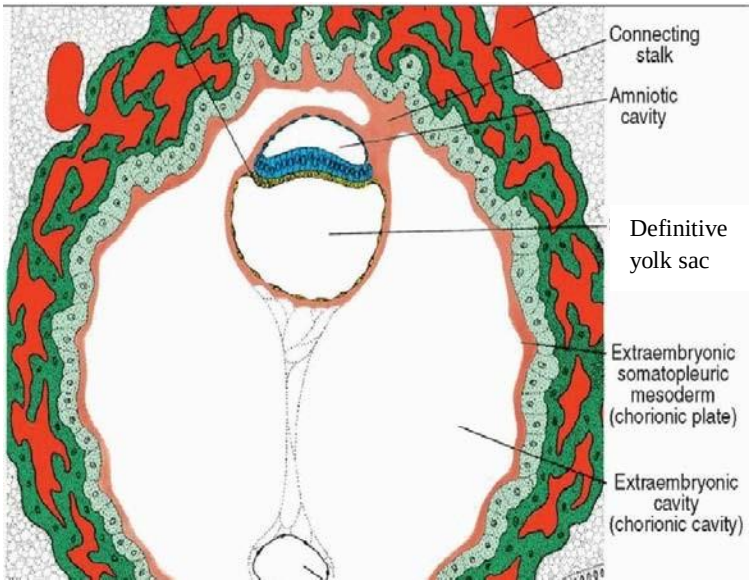


Figure-7: Human blastocyst of approximately 13 days

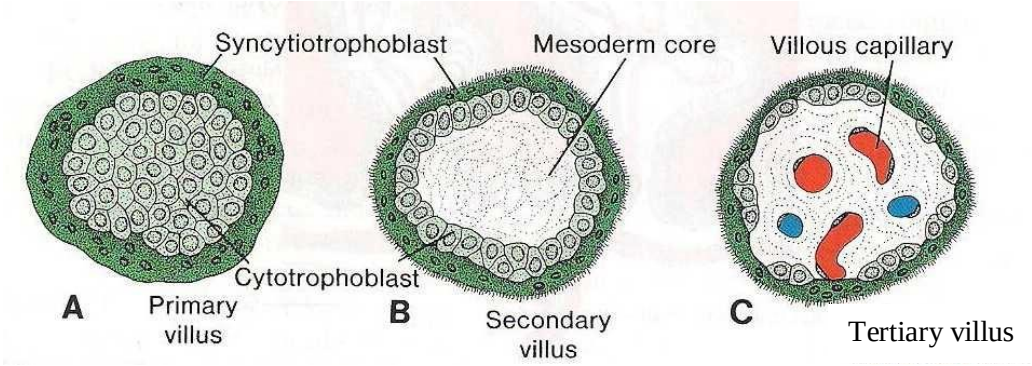
Development of the trophoblast

By the beginning of the third week, the trophoblast is characterized by:

A- Primary villi: consist of a cytotrophoblastic core covered by a syncytial layer

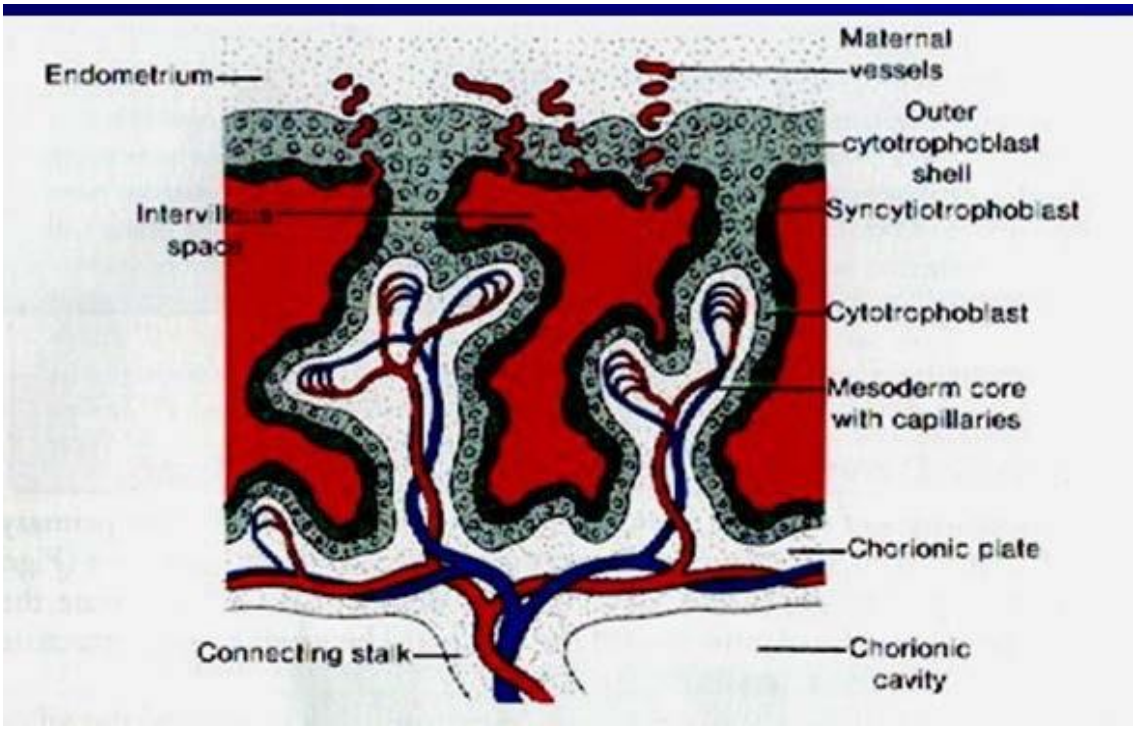
B- Secondary villi: consist of a mesoderm core covered by a single layer of cytotrophoblastic cells, which in turn is covered by syncytium.

C- Tertiary villi: by the end of the third week, mesodermal cells in core of the villus begin to differentiate into a number of capillaries and venules.



Capillaries in tertiary villi make contact with capillaries of the chorionic plate and connecting stalk. These vessels, in turn, connecting the placenta and the embryo, (see the figure below).

In human, when the heart begins to beat in the 4th week of development the villous system is ready to supply the embryo with essential nutrients and oxygen.



Gastrulation

During gastrulation, cell movements result in a massive reorganization of the embryo from the blastula into a multi-layered organism. Although the details of gastrulation differ between various groups of animals, the cellular mechanisms involved in gastrulation are common to all animals. Gastrulation involves changes in cell motility, cell shape, and cell adhesion. Gastrulation has been studied in a large variety of animal models, during gastrulation; cells undergo two types of movements, **called morphogenetic movements.** Some cells that are located on the surface of a hollow ball (in amphibians) or a flattened disc (fishes, amniotes) move through an opening to enter the embryo. In some classes of vertebrate embryos (e.g. amphibians), this movement occurs through a blastopore. In others (most amniotes), cells enter through a primitive streak, fig. (8).

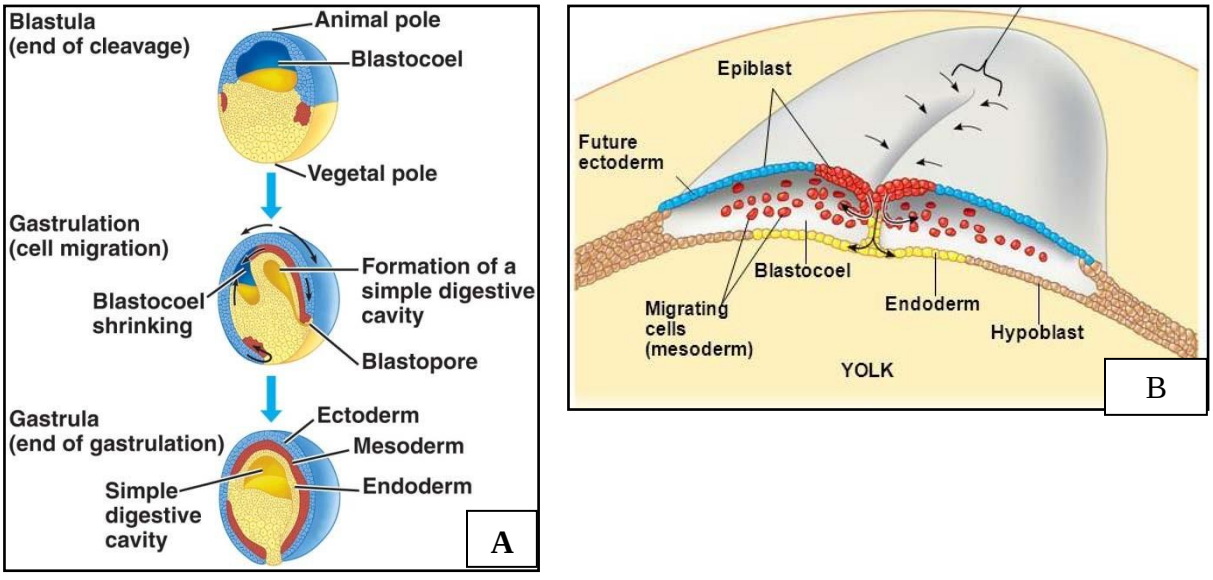


Figure- 8: (A) Gastrulation in amphibians, (B) Gastrulation in amniotes

[**The amniote** a group that includes reptiles, birds, and mammals, in which the egg is protected by amniotic membranes].

Types of morphogenetic movements that occur during gastrulation:

1- Epiboly:

- It occurs only in the ectodermal blastomeres.

- Involves the spreading of a sheet of cells (an epithelial sheet) on the surface of an embryo.

- Ex. Amphibian and Sea urchins.

2- Emboly:

- It occurs in mesodermal and endodermal blastomeres.

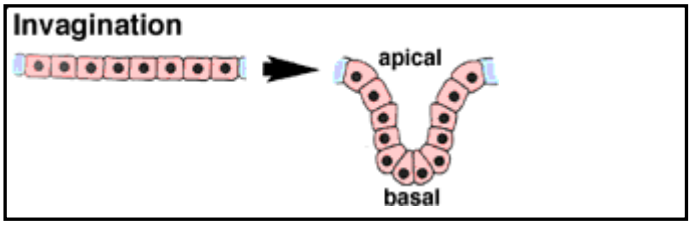
- Involves the movement of individual cells or sheets of cells into the interior of an embryo

- Is classified into different types depending on the behavior of migrating cells, **these are:**

a- Invagination:

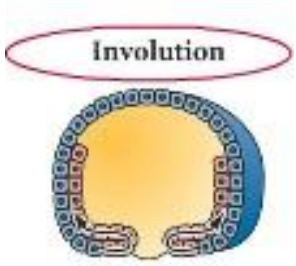
- Infolding of sheet of cells into the embryo to form a cavity.

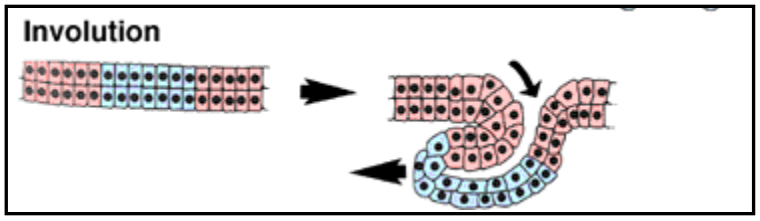
- For example: the gastrulation of Amphioxus and frog, the wall of the blastoderm is invaginated inside the blastocoel. This creates a new cavity called the archenteron (or primitive gut) which opens to the exterior by a blastopore.



b*-Involution:*

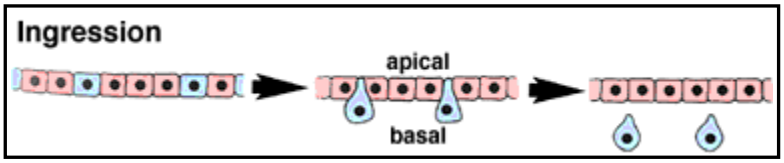
- Inward movement of an expanding outer layer (epithelial layer) to form an underlying layer.
- For example: the gastrulation of amphibian and avian eggs; from one end near the edge of the blastoderm, the cells begin to move inwards to form the inner lining of the blastoderm.





c*-Ingression:*

- Individual cells leave an epithelial sheet and become freely migrating mesenchyme cell.
- For example: sea urchin mesoderm.



Animals can be divided into two main groups based on the type of symmetry of their body plan:

1- Radially symmetric animals are Diploblastic

During gastrulation, diploblastic organisms form a gastrula which consists of:

1- Two germ layers (ectoderm and endoderm) but not mesoderm.

2- Coelom is absent

3- Ex. Hydra (coelenterates), Sponges (Porifera).

2- Bilaterally symmetric animals are Triploblastic

During gastrulation, triploblastic organisms form a gastrula which consists of:

1- Three germ layers (ectoderm, endoderm and mesoderm)

2- Coelom is present

3- Ex. Annelids, Arthropods, Mollusca, Echinoderms, and Chordates (common examples are Mammals, birds, reptiles, and amphibian).