**FERTILIZATION AND ZYGOTE FORMATION:**

- When animals mate, the male releases a fluid called semen into the female's private part, and this process is called insemination. The tiny cells in the semen, called sperms, swim through the female's private parts, through the cervix, into the uterus, and finally reach a part called the ampulla in the tubes.
- At the same time, an egg is released by the female's ovary and travels to the ampulla. This is where fertilization, the joining of the sperm and egg, takes place.
- Fertilization can only happen if the egg and sperm reach the ampulla together. That's why not every time animals mate, the female becomes pregnant.
- The first cell division after fertilization is when the male and female chromosomes mix together.

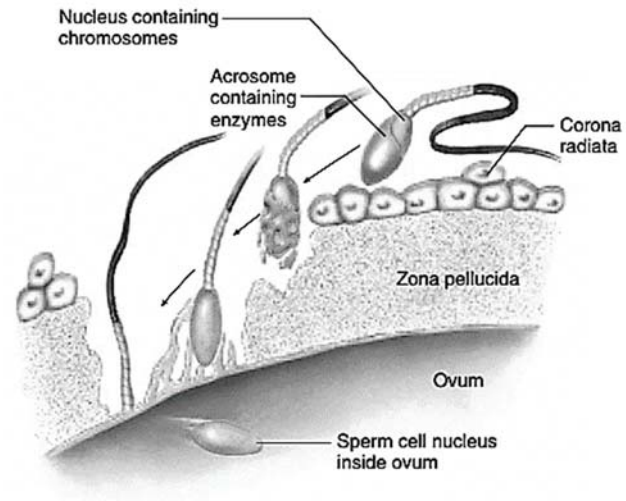



**Fig.** The process of fertilization.

**Movement of Sperms:**

- Only a few thousand sperms make their way to fallopian tube.
- Contraction of uterus and fallopian tube assist in movement of sperms. The average speed of sperm is 1.5 to 3 mm/min.
- Flagellar movement is secondary to contractions which help the sperm movement.
- Leucocytes of vaginal epithelia engulf millions of sperms. These sperms can survive in female genital tract for 24-48 hr.

**Arrival of secondary oocyte:**

- Secondary oocyte is released from the ovary into the abdominal cavity from there it is collected by fimbriae of fallopian tube and propelled by peristaltic movements of fallopian tube towards ampulla.
- Secondary oocyte can be fertilized within 24 hour of its release.

**Capacitation of Sperms:**

- Capacitation is the process by which the sperms are activated in the vaginal duct. It is done by secretions of female genital tract.
- Cholesterol layer is removed from acrosomal surface of sperm to expose its receptors. Acrosomal receptors bind to ZP2 and ZP3 (zona protein) receptors of ova.
- It takes around 5-6 hour for capacitation. Alkaline medium make sperm more active.
- Sperm can survive in female genital tract for 24-48 hours.

**Physio-chemical events of fertilization:**

When a sperm joins with an egg, it's called fertilization. Before this happens, the sperm has to get through some protective layers around the egg called egg membranes. The acrosome, found at the tip of the sperm head, releases chemicals that help the sperm enter the egg's cytoplasm by going through the zona pellucida and the plasma membrane. These chemicals, like corona-penetrating enzyme (CPE), Zonalysin (acrosin), and Hyaluronidase, are collectively known as sperm lysins. To make this process work well, the right pH level and the presence of calcium ($Ca^{2+}$) and magnesium ($Mg^{2+}$) are needed. Without calcium, fertilization can't happen.

**Fast block -**

Normally, only one sperm manages to enter an egg. Once a sperm gets inside the egg, changes in electrical activity or depolarization happen in the egg's outer layer. This helps prevent other sperm from entering, and this quick defense is called the fast block. It occurs because sodium ions ($Na^{+}$) rush into the egg.

**Slow block -**

It is the process in which cortical granules present below plasma membrane of ovum release their contents between plasma membrane and zona pellucida. The enzymes harden zona pellucida which prevent polyspermy.

**Fertilizin-Antifertilizin concept:**

This is when tiny storage sacs, called cortical granules, beneath the outer layer of the egg release their contents between the outer layer and another protective layer called zona pellucida. The released enzymes make the zona pellucida hard, which stops more than one sperm from entering the egg, a condition known as polyspermy.

**Sperm entry:**

- When the first sperm meets the secondary egg, a special area called the fertilization cone or reception cone develops.
- The arrival of the sperm into the egg prompts the completion of the second part of the egg's cell division process. This division is uneven and creates a second tiny cell called a polar body and a single-cell egg (ootid).
- Shortly after, the nucleus of the sperm and the egg join together, creating a new cell with a complete set of chromosomes, known as a diploid zygote.

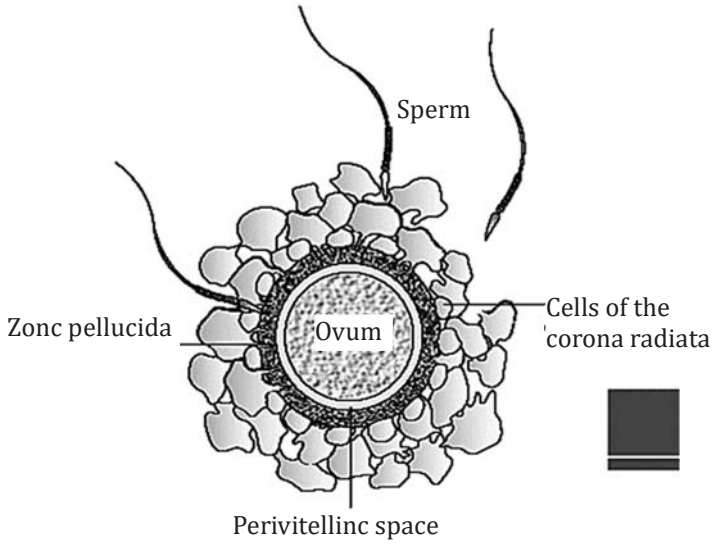


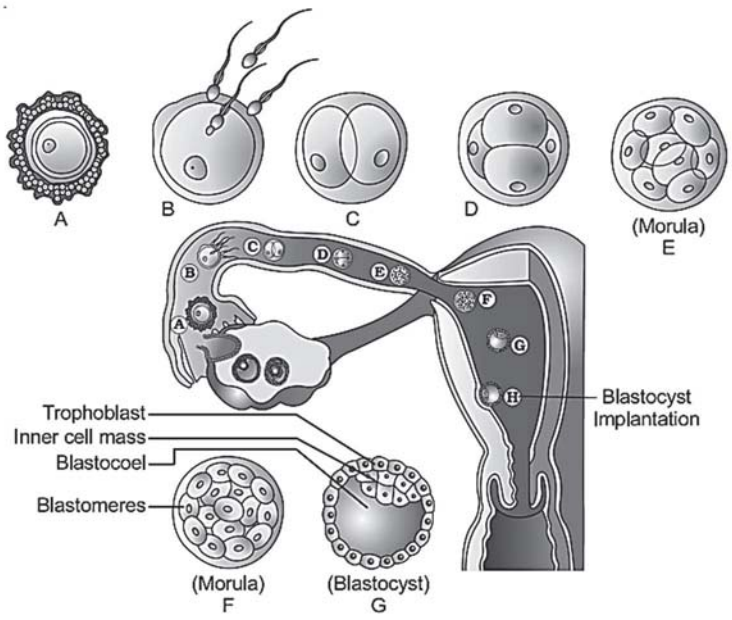

Fig. Ovum surrounded by few sperms

Each gamete contains 23 chromosomes, the haploid (n) number. Thus fusion of a sperm nucleus and an egg nucleus makes a zygote that have 46 chromosomes, thus restoring the diploid (2n) number.

**Cleavage, Morula And Blastocyst**

**Cleavage and Implantation**

- Just a few hours after the egg is fertilized in the fallopian tube, it starts dividing into multiple cells through a process called cleavage, forming 2, 4, 8, and eventually 16 daughter cells called blastomeres.
- When the embryo has around 8 to 16 blastomeres, it's called a morula. It's a solid ball of cells, still the same size as the original fertilized egg. The morula continues to divide and turns into a blastocyst as it moves into the uterus. The size of the morula remains the same as the original egg.
- By the end of the fourth day, the embryo reaches the uterus.
- A Blastocyst is a ball made up of nearly 64 cells, with a big, fluid-filled space called a blastocoel. The cells in the blastocyst arrange themselves into an outer layer called trophoblast and an inner mass of cells (attached to trophoblast) called the inner cell mass.
- The side of the blastocyst where the inner cell mass is located is called the embryonic pole, while the opposite side is the abembryonic pole.
- On the fifth day, the protective layer called zona pellucida breaks, and on the seventh day, the blastocyst implants itself.
- The cells in the trophoblast that touch the inner cell mass are called cells of Rauber.




- After the blastocyst is formed, the protective layer called zona pellucida breaks down. This exposes the sticky outer layer of the cell, which is necessary for the implantation process because implantation can't happen with the zona pellucida in place.
- The trophoblast, also known as trophoectoderm, doesn't play a role in forming the actual embryo. Instead, it creates the part of the placenta that supports the growing embryo by providing it with nourishment.
- The cells in the inner mass are meant to become the body of the developing embryo. Therefore, the trophoblast layer attaches to the uterus lining, and the inner mass transforms into the embryo. After attachment, the cells in the uterus rapidly divide and cover the blastocyst.
- About one week after fertilization, the blastocyst firmly attaches itself to the thickened wall of the uterus, a process known as implantation. This marks the beginning of pregnancy.

## Implantation

Implantation is the attachment of the blastocyst to the uterine wall. It occurs after 7 days of fertilization. About 8 days after fertilization, the trophoblast develops into two layers in the region of contact between the blastocyst and endometrium.

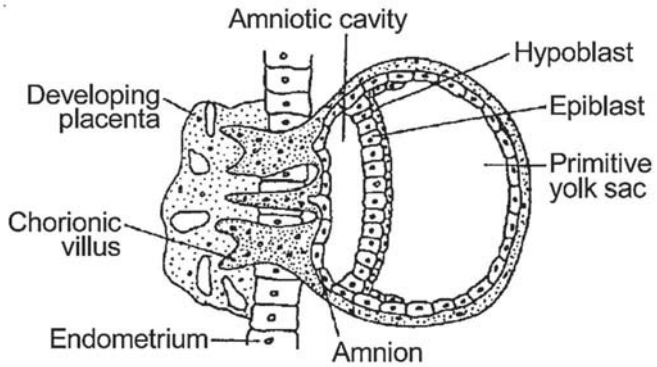



**Fig. :** Implanted blastocyst

**Gastrulation**

During a process called gastrulation, cells group together in small masses or sheets to create the primary germinal layers. These layers are named endoderm, ectoderm, and mesoderm. The movements of cells during gastrulation are called morphogenetic movements because they kickstart the process of morphogenesis. The end result of gastrulation is the formation of a structure called a gastrula. This process involves getting rid of the blastocoel and forming the primitive gut.

Between the lower part of the ectoderm and the trophoblast, a space appears known as the amniotic cavity. This space is filled with amniotic fluid. Cells derived from the trophoblast create the roof of this cavity, and they are called amniogenic cells.

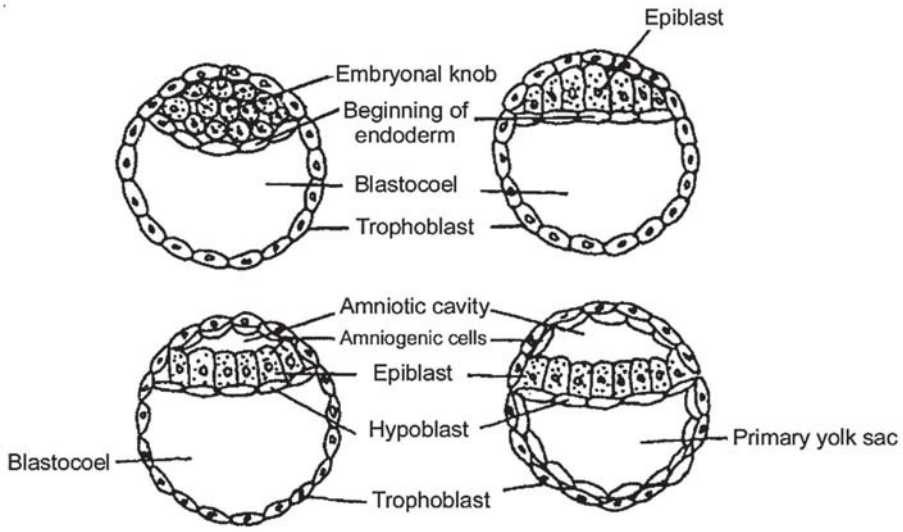
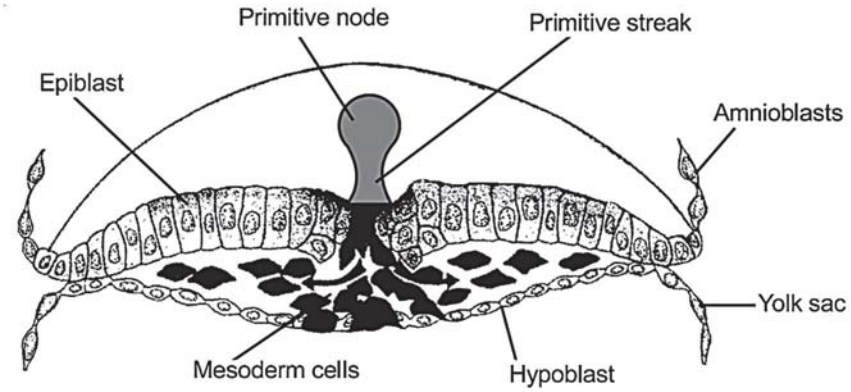



**Fig. :** Formation of endoderm and amniotic cavity

When the primary germinal layers are forming, cells from the inner cell mass or embryonal knob organize themselves to make a flat embryonic or germinal disc. This disc then separates into two layers: an outer layer called the epiblast, made up of larger columnar cells, and an inner layer called the hypoblast, consisting of smaller cuboidal cells.




a. The picture shows a cut-through view of the head area of the streak at 15 days, displaying how epiblast cells move. The first cells that move inside push aside the hypoblast, creating the final endoderm.
b. After the final endoderm is established, the epiblast moving inward generates mesoderm.
c. The cells that remain in the epiblast then form the ectoderm. This means that the epiblast is where all the germ layers in the embryo originate.