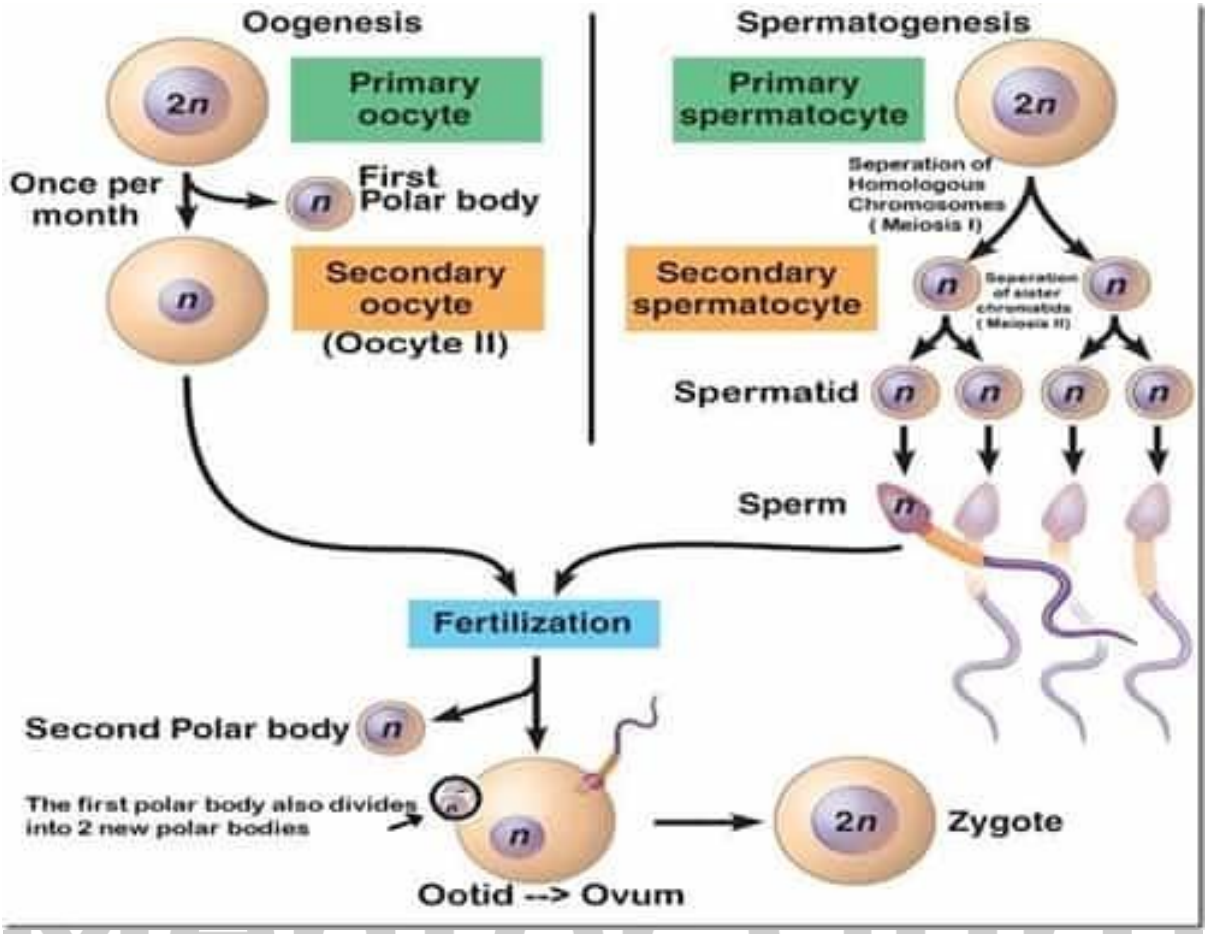
CSIR NET Life Science Unit 4

Gametogenesis, Fertilization and Early Development

Gametogenesis is the production of sperm (spermatogenesis) and egg(oogenesis), which takes place through the process of meiosis.

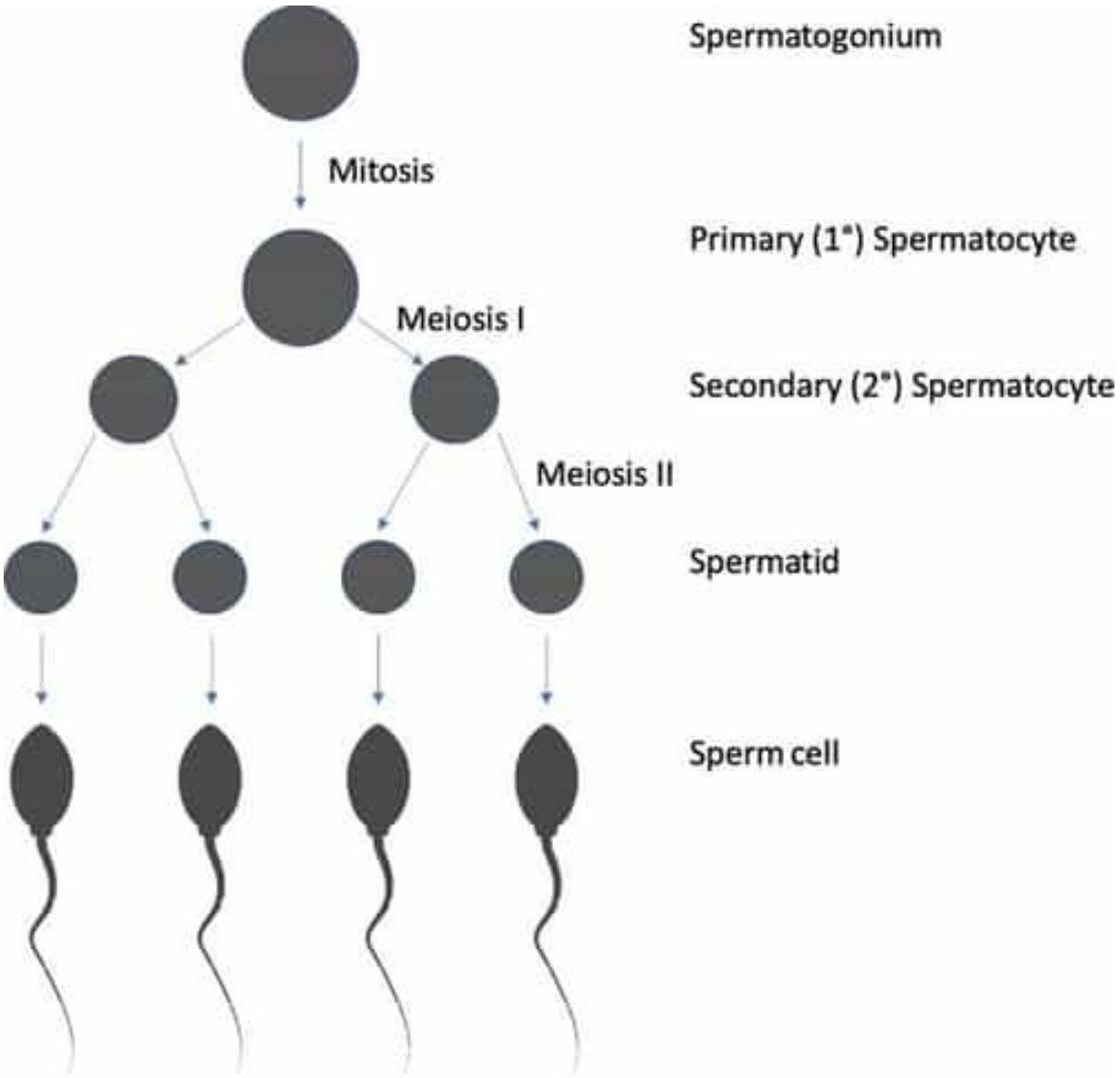


Spermatogenesis

- **Spermatogenesis occurs in seminiferous tubules**, in this tubule are diploid, undifferentiated cells, **called spermatogonia**, go through mitosis and increase number.
- Meiosis begins with a cell **called primary spermatocyte**. At the end of the first meiotic division, a haploid cell is produced called a **secondary spermatocyte**.
- This haploid cell must go through another meiotic cell division. The cell produced at the end of meiosis is called **a spermatid.**
- When it reaches the lumen of the tubule and grows a flagellum it **is called sperm cell**. Four sperm result from each primary spermatocyte that goes through meiosis.
- Spermatogonia cells are deposited during gestation and are present at birth through the beginning of adolescence, but in an inactivation of

these cells and the production of visible sperm. This continues into old age.

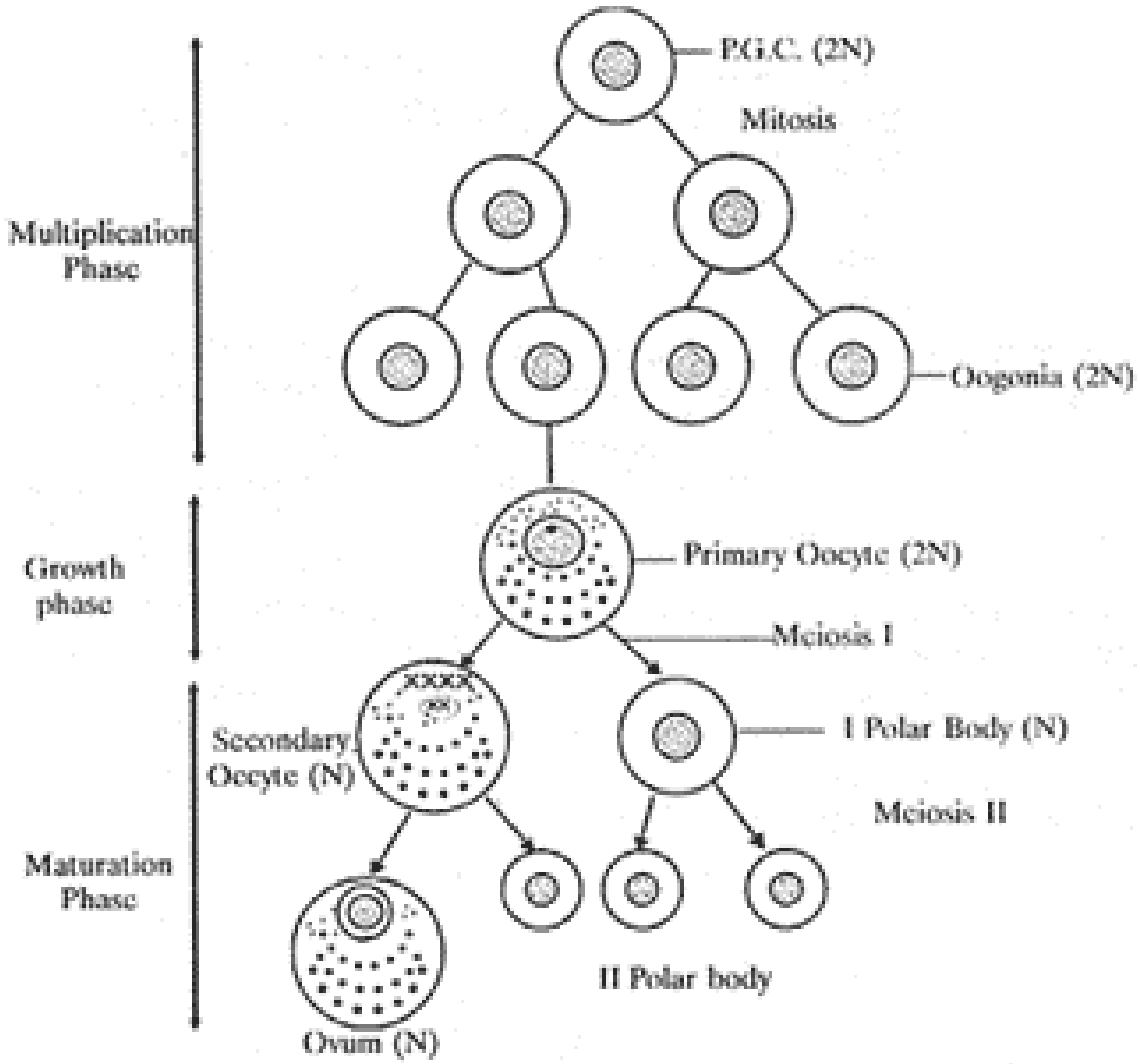
- **Spermatozoa are later called sperms.**



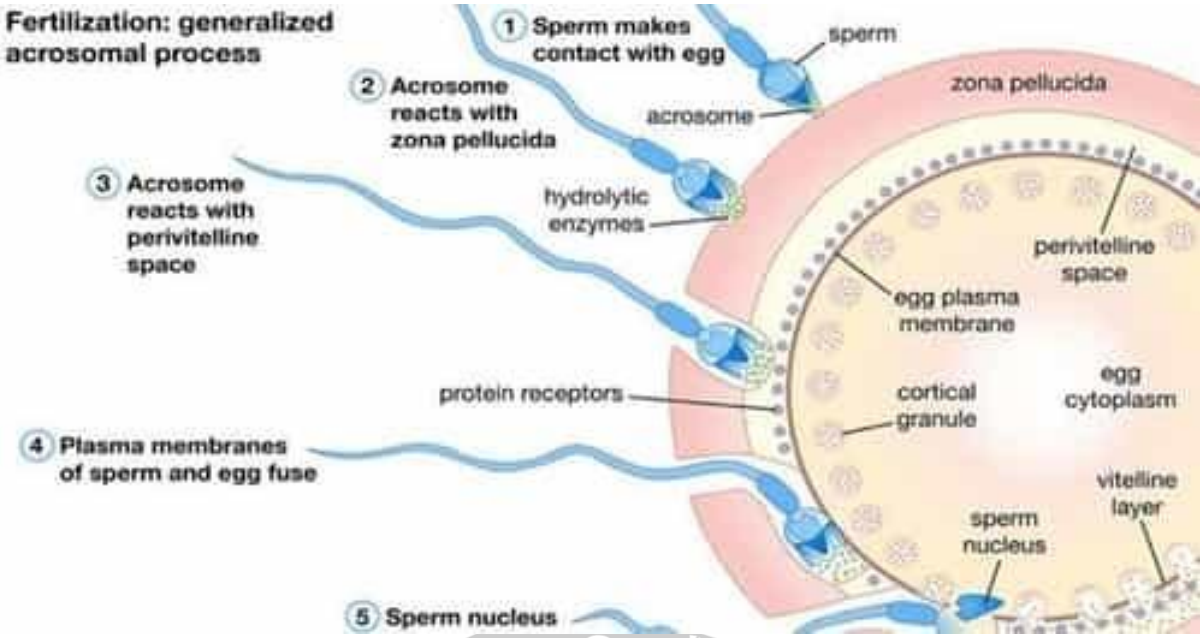
<u>Oogenesis</u>

- **Oogenesis occurs in the ovaries**.
- **Oogenesis starts with a germ cell, called an oogonium**, but this cell undergoes mitosis to increase the number, eventually resulting in up to one to two million cells in embryo.
- The cell's starting meiosis is **called primary oocyte.** This cell will begin the first meiotic division but **be arrested in its progress in the first prophase stage. (Prophase 1)**
- At the time of birth, all future eggs are in prophase stage.
- At adolescence, another pituitary hormone causes the development of a number of follicles in an ovary. This results in the primary oocyte finishing the first meiotic division.

- The cell divides unequally, with most of the cellular and organelles going to one cell**, called a secondary oocyte**.
- Only one set of chromosomes and a small amount of cytoplasm going to another cell. This second cell is **called polar body**.
- **A secondary meiotic arrest occurs, this time at the metaphase 11 stage**.
- At ovulation, this secondary oocyte will be released and travel toward the uterus through the oviduct. If the secondary oocyte is fertilized, the cell continues through the meiosis 11, completing meiosis, producing a second polar body and fertilized egg containing all 46 chromosomes of human being, half of them coming from sperm.
- Arrest is due to lack of sufficient cell cycle proteins to allow meiotic progression.

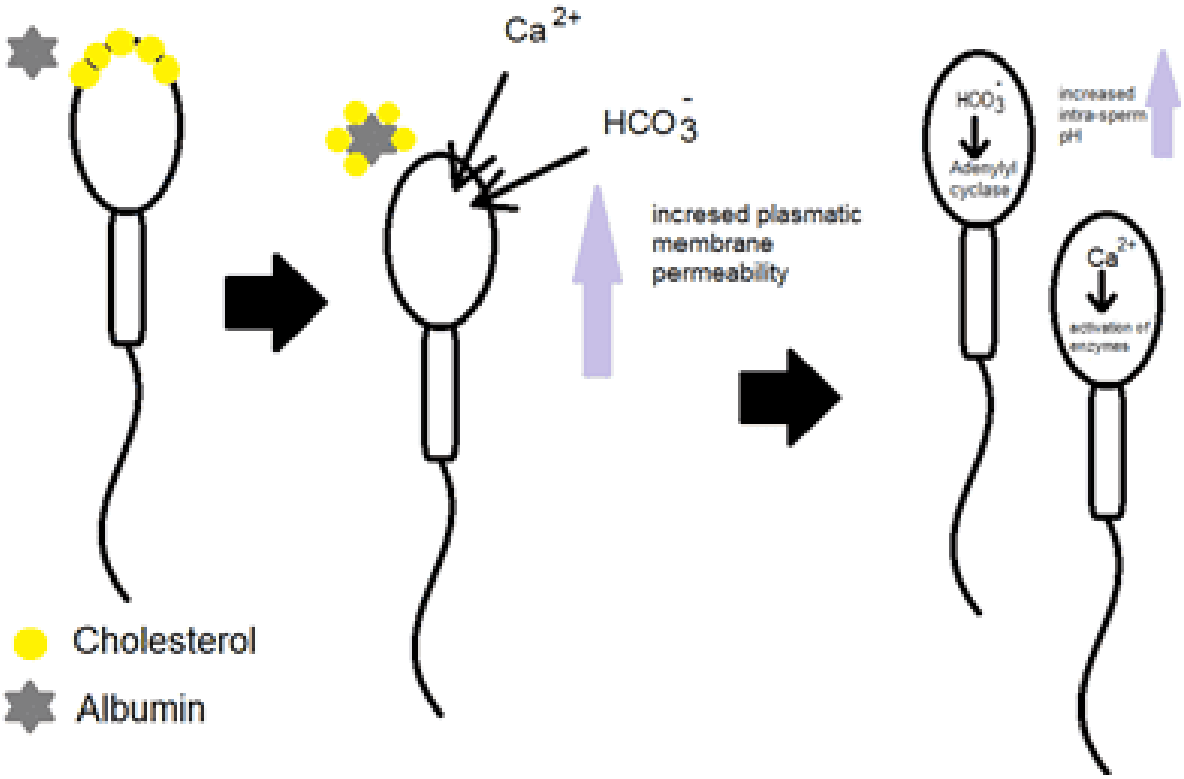


Fertilization



Events of Fertilization

1. Capacitation
2. Chemoattraction
3. Binding of sperm to cumulus
4. Acrosomal reaction
5. Binding of sperm to zona pellucida
6. Fusion of sperm plasma membrane to egg plasma membrane



OCCURS IN - AMPILLA OF OVIDUCT

Important Events Occurs in Capacitation

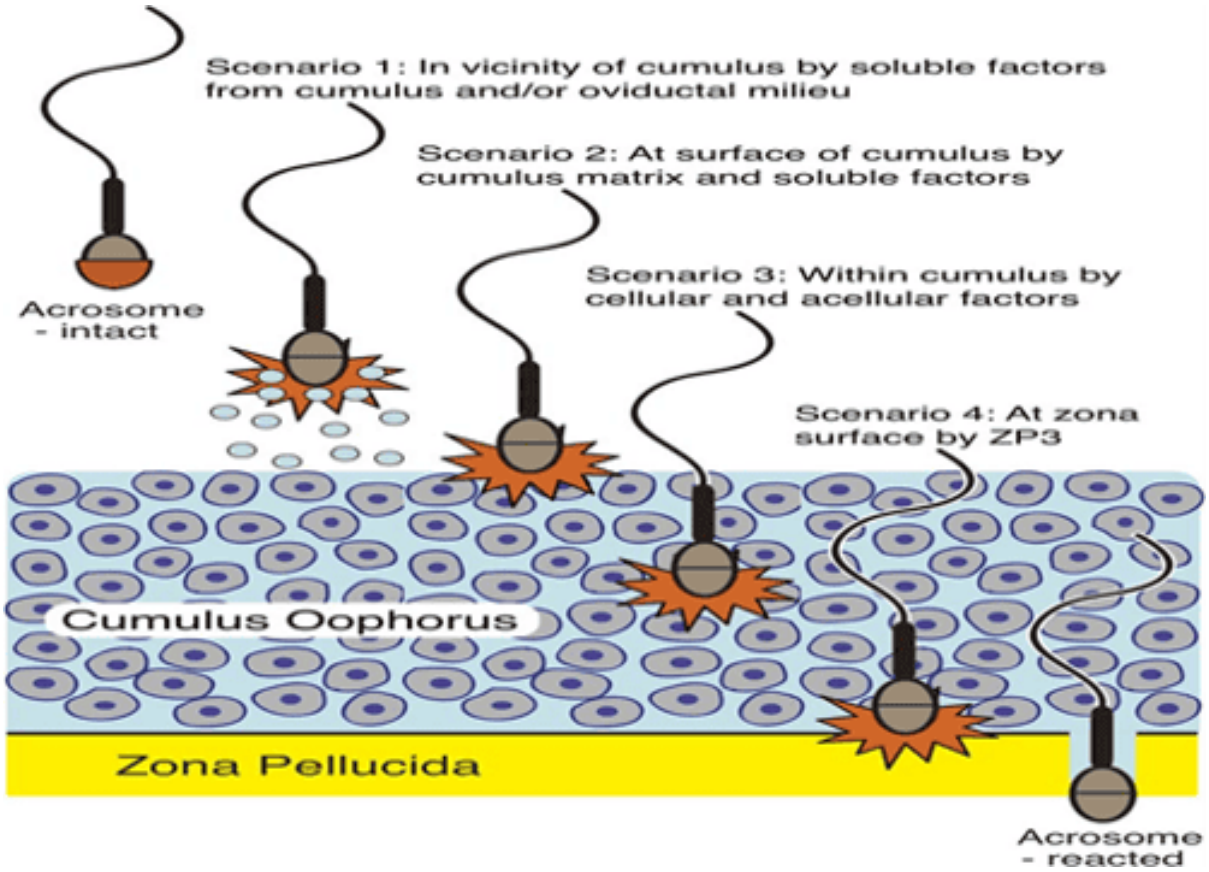
- Final Maturation Occurs in Capacitation.
- Sperm maturation occurs.
- Proteins and carbohydrates are lost on sperm.
- Removal of cholesterol. (as shown above in diagram)
- Efflux of K+ from sperm head
- Calcium permeability increases inside sperm.

Chemo-attraction

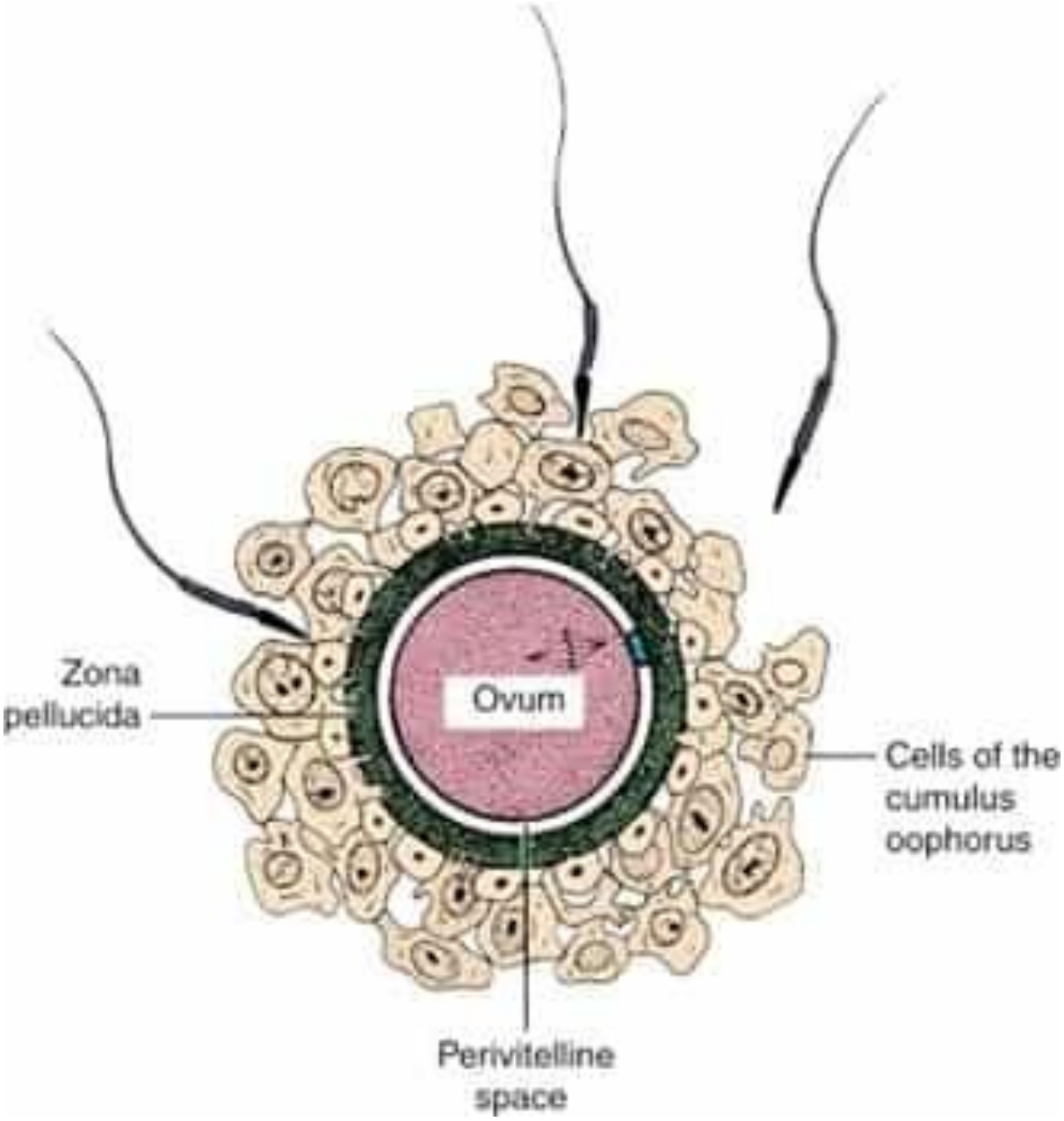
Thermotaxis – sperm sense heat

There is thermal gradient of 2-degree c between the is thymus of oviduct and the warmer ampullary region. This ability to sense temperature difference and preferentially swim from cooler to warmer sites(thermotaxis) is found only in capacitated sperm.

Chemotaxis- progesterone (e.g., rabbit, mouse) progesterone has been shown to bind to receptor that activates Ca2+ channels in cell membrane of the sperm tail, leading to sperm hyperactivity.



Binding of Sperm to Zona Pellucida



The human zona pellucida has four major glycoproteins- ZPQ, ZP2, ZP3, AND ZP4. The binding of sperm to the zona pellucida occurs. (as shown in diagram above)

Species Interaction

Sperm recognize ZP2 Protein on Zona Pellucida. In gain of function experiment, ZP2 was shown to be critical for human sperm-egg.

Gamete Fusion

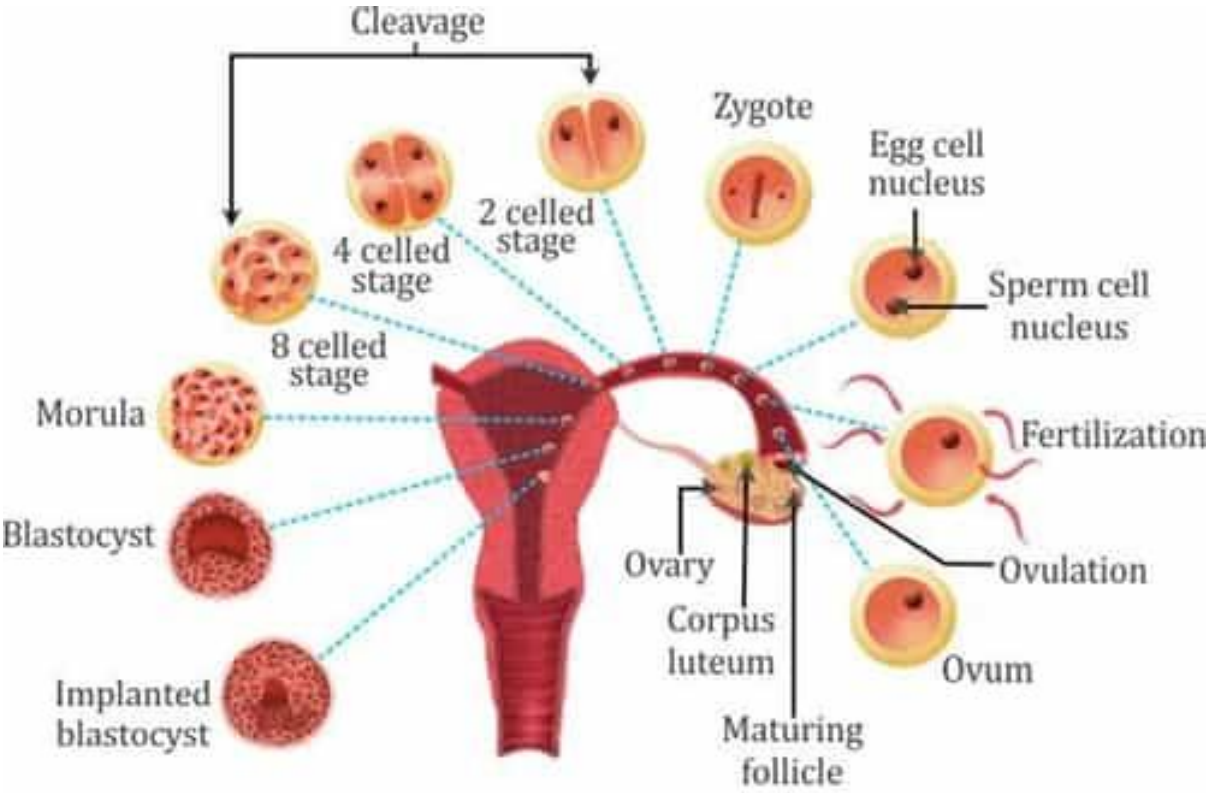
The acrosome reaction in addition to expelling the enzymatic contents of the acrosome also exposes the inner acrosomal membrane to outside. The

junction between this inner acrosomal membrane and the sperm cell membrane is called the equatorial region.

Izumo Protein

It is originally found in the membrane of the acrosomal granules. However, after the acrosome reaction, Izumo redistributes along on the surface of acrosome reacted sperm, where it is found primarily in the equatorial section, where mammalian sperm-egg binding takes place.

Stages of early development in mammals



Development of the embryo

Prior to fertilization the mammalian oocyte, wrapped in cumulus cells, is released from the ovary, and swept by the fimbriae into the oviduct. Fertilization occurs in the ampulla of oviduct, a region closes to ovary, mitosis is completed after sperm entry, and the first cleavage begins about a day later. The cilia in the oviduct push the embryo toward the uterus and, first cleavages occur along this journey.

1. Zygote
2. 2 celled stage -zygote divide into 2- cells
3. Further 2 celled stages divide to form 4- celled stage.
4. After 4 celled comes 8- celled stage

5. Morula- After 8-celled stage further division occurs and a ball of cells form called Morula.
6. Blastula- After morula stage comes blastula stage in which ball of cells divide into trophoblast outer group of cells and Inner cell mass (ICM).
7. Finally, this get implanted into mother's womb.