

## **FERTILIZATION**

The union of male gamete and female gamete is known as fertilization. The male gamete or sperm a motile cell move in the liquid medium, the body fluid (in case of internal fertilization) or in water (in case of external fertilization) towards the motion less female gamete or egg in this process. Finally, the sperm enter the egg by invading the wall and both the pro-nucleus unite to form a diploid cell, the zygote. Fertilization is of two types- External and Internal.

- i) External fertilization- among vertebrates it is found in fishes and amphibian. In these organisms the female laid eggs in the aquatic environment and male deposit the sperms over the eggs. So fertilization occur in the outer environment.
- ii) Internal fertilization-In reptiles, birds, and mammals the male deposit the sperms in the genital duct of the female and so, the fertilization occur inside the body of the female

### **Process of fertilization**

The process of fertilization whether external or internal can be studied under the following headings-

1. Approximation of spermatozoa to ova-
2. Capacitation and contact-
3. Acrosomal reaction and penetration-
4. Activation of ovum-
5. Amphimixis-

#### **Approximation of spermatozoa to ova-**

After release of spermatozoa they move towards the ovum in the liquid medium. The viability of sperm is limited from a few minutes to few hours. Several adaptation or mechanism helps to ensure fertilization within this limited period of time. These are- release of gametes at a particular time – the breeding season, release of spermatozoa near the ovum, release of spermatozoa in an astronomical number so that at least a few able to reach the female gamete, enlargement of female gamete with egg envelopes etc.

In case of external fertilization as in fish and amphibian the sperm viability is few minutes only, so male discharge the sperm directly on the ova in order to ensure fertilization.

#### **Capacitation and contact-**

Fertilization is always species specific, ie. ovum of a particular species is fertilize by the sperm of the same species only This is ensured by a chemical mechanism. The egg surface release a chemical called *fertilizin*. Another chemical substance present on the surface of spermatozoa called *antifertilizin*. The fertilizin molecule are quite large and each are having more than one active groups. The antifertilizin molecule also have

complementary active group. The fertilizin and antifertilizin molecule of the same species attach like lock and key attachment of enzyme- substrate. This mechanism ensures the species specific fertilization. By this fertilizin –antifertilizin attachment the spermatozoa attain capacity for fertilizing the egg.

The fertilizin is a glycol-protein or acid mucopolysaccharide chemically. The fertilizin –antifertilizin reaction result agglutination of spermatozoa by egg water and adhesion of spermatozoa to the egg surface.

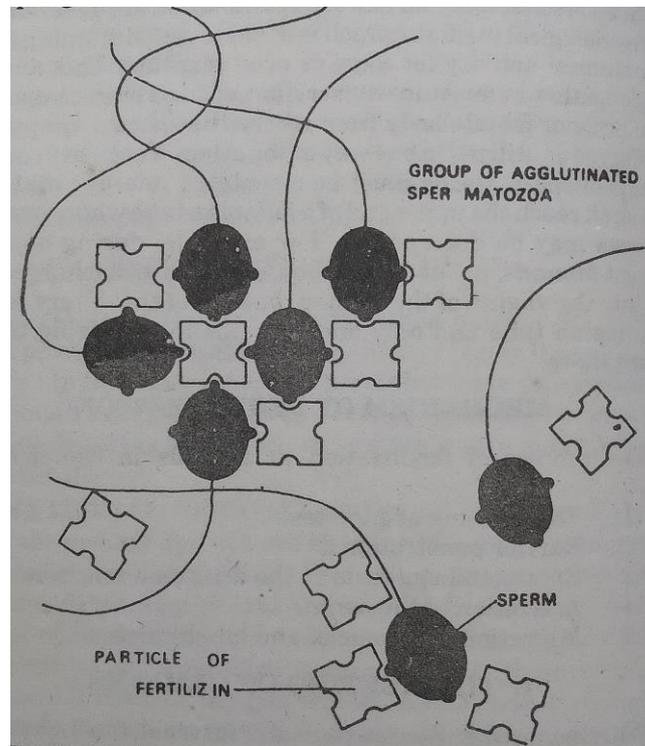


Fig- Showing binding of fertilizin and antifertilizin molecule

#### **Functions of Fertilizin- Antifertilizin reaction-**

- i) Sperm identifies the egg of same species by this reaction.
- ii) Initial attachment between sperm and egg resulted.
- iii) The antifertilizin released to water resulted agglutination of a section of sperm away from the egg, which reduces the chance of polyspermy.
- iv) By holding together many sperms on the egg surface fertilizin- antifertilizin reaction ensures the accumulation of sufficient amount of lytic enzymes to dissolve the egg membrane.
- v) This reaction initiates the acrosomal reaction.

#### **Acrosome reaction and penetration of sperm-**

- i) Release of acrosomal content- In sea urchin, contact with egg jelly causes the breakdown of acrosomal vesicle present at the anterior part of sperm. Acrosomal vesicle release protein digesting enzymes which digest the path through the jelly coat to the egg surface. The rupture of the acrosomal vesicle is caused by the calcium mediated fusion of the acrosomal membrane with the adjacent sperm plasma membrane. This is an exocytosis reaction, where vesicle membrane fuses with the cell surface to release its content.

- ii) Formation of acrosomal tube- This part of acrosomal reaction involve the extension of acrosomal process. The protrusion arises from the polymerisation of globular actin molecules in the actin filaments. The apical part of the sperm plasma membrane form the acrosomal tube. The tube project through the egg envelop to reach the ooplasm. The shape and size of the tubule varies with the species.

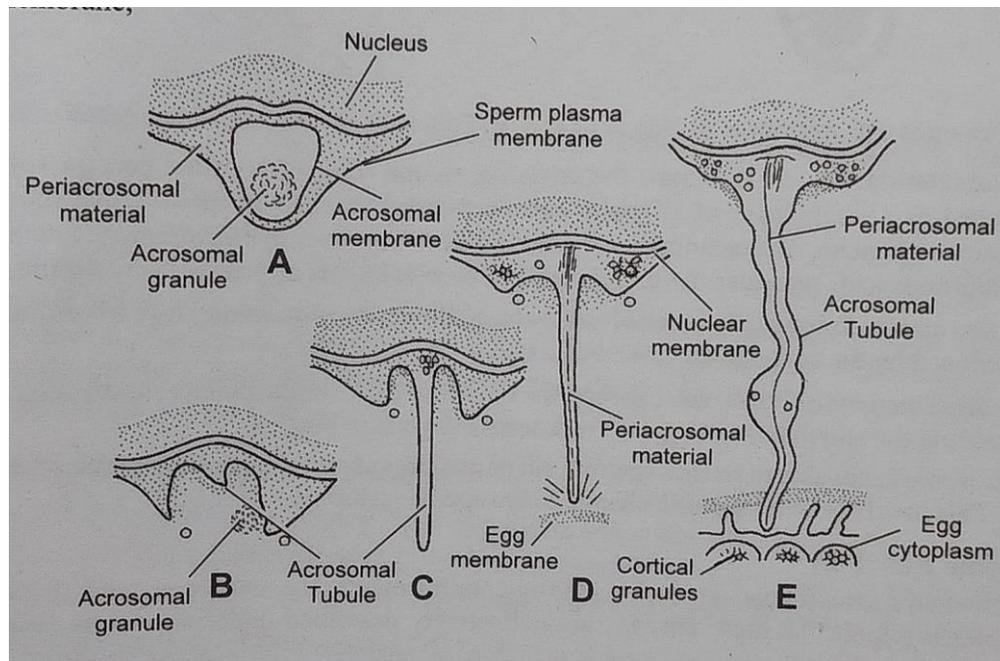


Fig- showing acrosomal changes during fertilization

- iii) Fusion of sperm and egg plasma membrane- The tip of the acrosomal tube first fuse with the egg membrane, the oolemma and a continuity between the cytoplasm of the sperm and ooplasm established.

#### Activation of ovum or reaction of the ovum-

When the cytoplasm of both the gametes touches each other, a sequence of events occurs which can be referred as Activation of ovum or reaction of the ovum. The events of this step can be studied under following heading-

- i) **Formation of fertilization cone-**As soon as the acrosomal tube touches the egg surface, the cytoplasm of the egg bulges out towards the point of fusion and produce a cone of hyaline cytoplasm called **fertilization cone**. This conical protrusion contains several pseudopodia like processes of cytoplasm. In some species where there is a resistant membrane around the egg the sperm enter the egg through a special canal or pore called micropyle.
- ii) **Cortical reaction-** Soon there is a great physicochemical changes in the cortical region of the ooplasm, collectively known as cortical reactions. Beneath the surface layer of oolemma, there is a thin layer of cytoplasm filled with numbers of small membrane bounded vesicle called cortical granule. Within seconds of sperm-egg contact these granules fuse with the oolemma, which results in a dramatic increase in the surface area of the egg with formation of several tiny microvilli. Massive amount of protein and mucopolysaccharide is released from the cortical granules to the perivitelline space.

The vitelline membrane soon initiates the formation of a membrane at the entry point of the sperm, called **fertilization membrane**. This membrane prevents the entry of a second sperm, i.e., it prevents **polyspermy**. The fertilization membrane gradually spreads over the entire oocyte.

### Migration of pronuclei and Amphimixis-

In most of the vertebrate eggs oogenesis stops after the first mitosis and resumes after the entry of spermatozoa to the egg. As the head and the middle piece of sperm enter the egg, these parts rotate at an angle of  $180^\circ$ , so that the mitochondria and proximal centriole assume the leading position. The nucleus of the sperm swells up by absorbing fluid from the surrounding cytoplasm and at this stage the nucleus is called as **male pronucleus**.

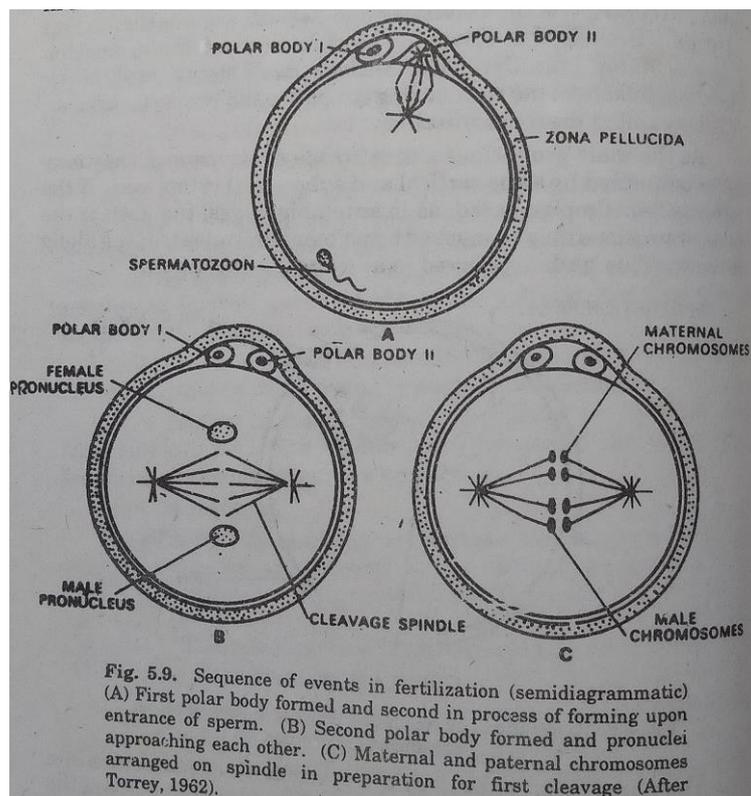


Fig. 5.9. Sequence of events in fertilization (semidiagrammatic) (A) First polar body formed and second in process of forming upon entrance of sperm. (B) Second polar body formed and pronuclei approaching each other. (C) Maternal and paternal chromosomes arranged on spindle in preparation for first cleavage (After Torrey, 1962).

After the formation of second polar body the female pronucleus is ready for the union with male pronucleus. The union of male and female pronucleus or amphimixis then occurs. In sea urchin and in vertebrates the nuclear membrane breaks at the point of contact and their nuclear contents get surrounded by a common membrane forming the zygote nucleus. The site of amphimixis lies in the centre of active cytoplasm at the animal pole in macro and telolecithal eggs, while in microlecithal eggs it lies near the centre of the egg.