Fertilization

- Fertilization is the union of spermatozoon and egg resulting in the formation of zygote.

Significance of fertilization

- Fertilization maintain the diploid number of chromosomes in the race.
- Fertilization produces genetic variation by bringing together chromosomes from two different parents.
- Fertilization activates the egg and thus development is initiated.

External and Internal Fertilization

- In majority of aquatic animals, sperms and ova are released into the water where fertilization takes place. It is called External fertilization.
- In amniotes sperms are introduced into the females genital tract, where fusion takes place. It is called Internal fertilization.

Monospermy and polyspermy

- Generally only one spermatozoon enters the egg and fuse with it. Such a fertilization is said to be monospermy.

Polyspermy

- In other animals normally many sperms enter the egg. Such a fertilization is said to be polyspermy. Eventhough many sperms enter the egg, only one sperm-nucleus fuses with the egg-nucleus. Other sperm-nuclei degenerate.

Life-span of the gametes

- Generally the eggs which are fertilized externally, have shorter life-span than those which are fertilized internally. For example the life time of the human spermatozoon in the female tract is about 24 hours.

Approximation of gametes

1) The meeting of the gametes
2) Capacitation
3) Sperm penetration
4) Acrosome reaction
5) Cortical reaction
6) Amphimixis

1.The meeting of the gametes

The meeting of the gametes is promoted by the following methods:

1.Chemotaxis

2.Fertilizin and antifertilizin reaction

3.Production of enormous number of sperms

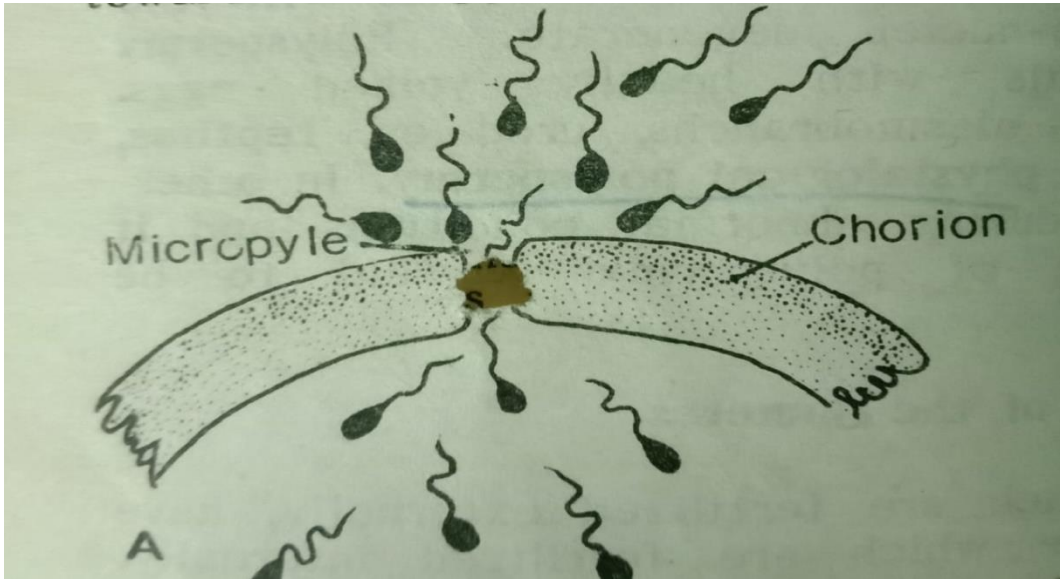
4.Random collision

5.Mechanical juxtaposition of gametes

6.Synchrony in the production and release of gametes

1.Chemotaxis

- In certain animals sperms are attracted towards the egg by chemicals. This happens in coelenterates, fishes, insects etc.
- In fishes and insects this chemical is present in the **chorion** lining the **micropyle**.
- When the chorion is removed from the egg, the activity of sperm slows down



2.Fertilizin – antifertilizin Reaction

- The sperm identifies the egg by the reaction between fertilizin and and antifertilizin.

Fertilizin:

- The egg contains on its surface a chemical substance called Fertilizin.

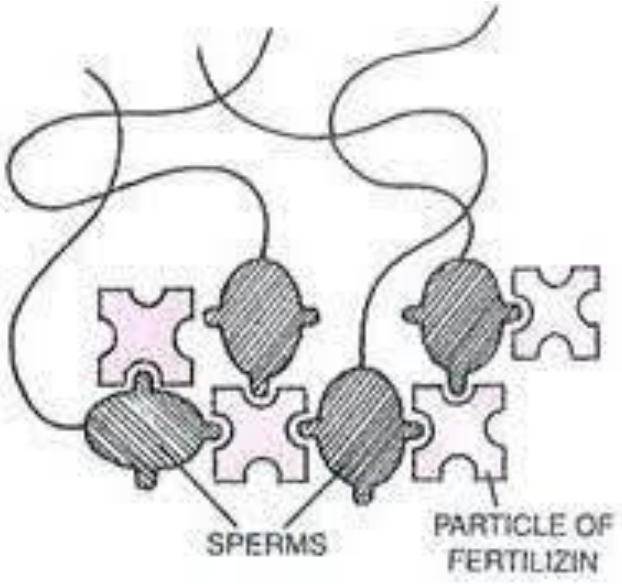
It is a glycoprotein. It has a receptor weight of 300000.

- The fertilizin molecule has many receptor or binding sites for antifertilizin.
- Fertilizins are species specific and there may be different fertilizin for different species.
- The main source of the fertilizin is jelly coat or plasma membrane.

The fertilizin present in the jelly coat and vitelline membrane is called jelly coat fertilizin. The fertilizin present in the plasma membrane is called cytofertilizin

Antifertilizin

- The surface of the sperm contains a chemical substance called antifertilizin (Fig). It is an acid protein. It is smaller than fertilizin.
- It has a molecular weight of 10000. there may be different antifertilizins in different spices.



Fertilizin-Antifertilizin reaction in sea urchin.

Reaction

Fetilizin reacts with the antofertilizin in a manner comparable to the reaction between antigen and antibody. This reaction can also be compared to the lock and key system.

- The fertilizin molecule has many receptor sites or binding sites. These receptor sites are complementary to the antifertilizin molecule.
- When eggs and sperms are released in the water, the fertilizin particles embrace the antifertilizin particles.
- As a result, the sperms agglutinate or clump together . This reaction is strictly species-specific.

Function of Fertilizin – Antifertilizin

1. The sperm identifies the egg by fertilizin – antifertilizin reactions.
2. The initial attachment of the sperm to the egg is the result of the linking between fertilizin particles and antifertilizin particles.
3. Certain amount of fertilizin is released from the egg into the surrounding water. These released fertilizin combines with the sperms. This leads to the agglutination of sperms. As a result this only a few sperms reach the surface of the egg. This prevent polyspermy.
4. As the reaction between fertilizin and antifertilizin species – specific, fertilization between different species prevented.

5. Sperms contain lytic substance which can break down the egg-coat. By holding together many sperms on the surface the fertilizin-antifertilizin reaction ensures the production of sufficient quantities of lytic enzymes to dissolve the egg coverings.
6. Fertilizin activates the sperms and initiates acrosome reaction.

Production of enormous number of gametes

The meeting of gametes is enhanced by the production of enormous number of sperms.

Random Collision

The egg and sperm are brought together by random collision. This is favoured by the large size of the egg and the enormous number of sperm.

Mechancical juxtaposition of gametes

Animals provide a number of mechanical agencies to bring together the eggs and spermatozoa. In mammals the spermatozoa are injected deep into the female genital duct by copulation. In birds, the spermatozoa are introduced into the cloaca of female by a process called “cloacal kiss”. In cephalopds (Sepia, Loligo etc) one of the arms in the male is modifies to transfer the spermatozoa into the female gential duct. This arm is said to be hectocotylus. During courtship, the male carries a bundle of spermatophores from the genital duct in his hectocotylus arm and places it either in the mantle cavity or in the seminal receptacle of the female.

Synchrony in production and release of gametes

The male and female gametes are produced at a particular time. In certain animals eggs are released only after ovulation. This prevents wastage of sperms.

2.CAPACITATION

Capacitation is a process where the spermatozoa acquire the capacity to fertilize the eggs. After capacitation, the spermatoza develop the ability to penetrate the membranes surrounding the egg. The spermatozoa obtains capacitation of the following methods.

1. By remaining in the female genital tract for some time. The duration of this time is six hours in man and one hour in mouse.

2. In some animals sperms obtain capacitation by passing through epididymis.
3. During capacitation the coating substances on the surface of the sperm are removed. This helps the receptor sites on the sperm to recognize signals coming from the egg.

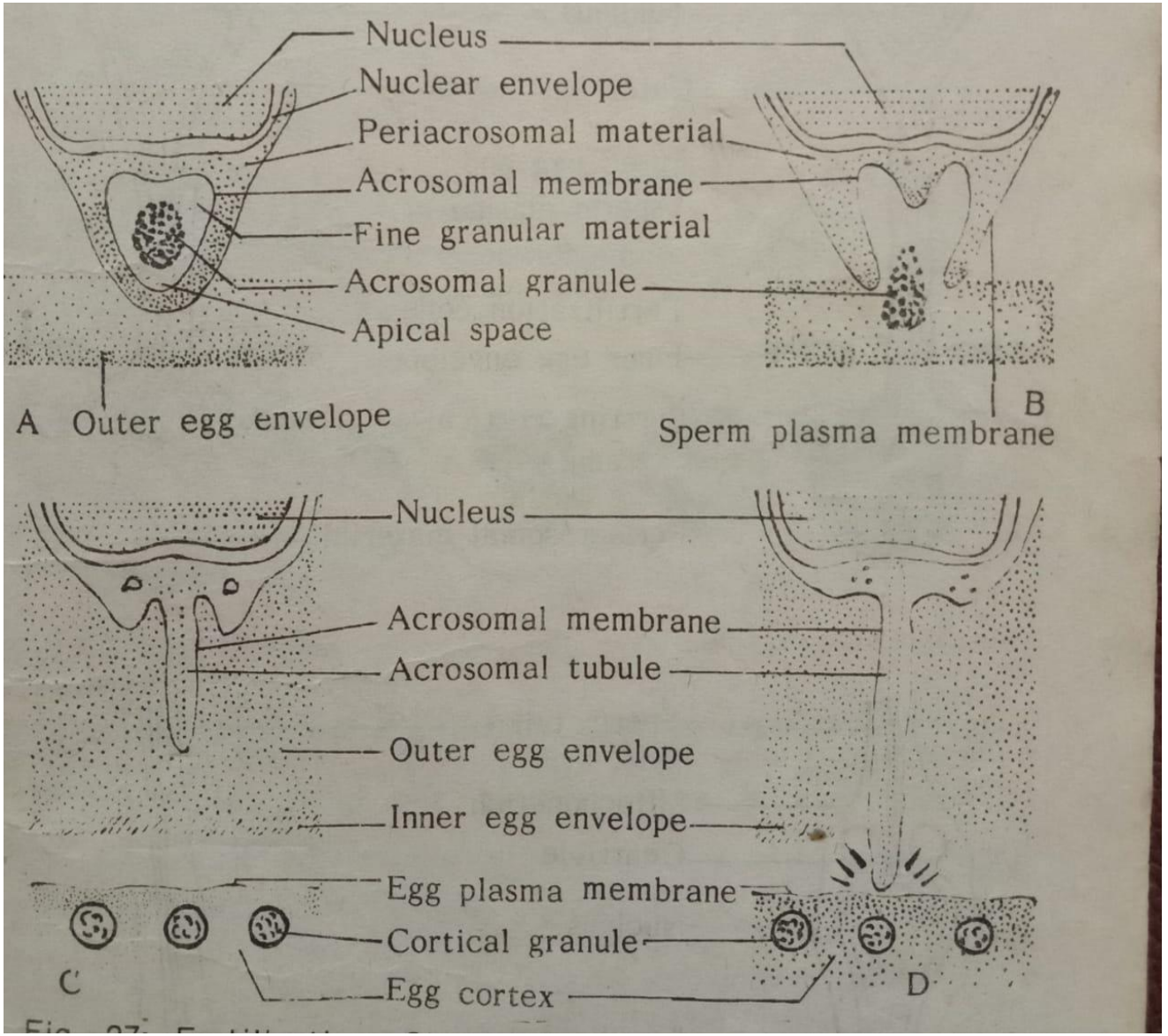
Sperm penetration

- After making contact with the egg, the sperm has to penetrate the egg membranes to reach the surface of the egg.
- In some animals, such as molluscs, echinoderms, insects and fishes, the egg is surrounded by a tough membrane called chorion.
- This membrane cannot be easily penetrated by the spermatozoa. Hence, the eggs are provided with one or more minute opening called micropyles.

- The spermatozoa enter the eggs only through these openings .
- In other eggs are penetration may occur at any place.
- The mechanism of penetration is chemical. The spermatozoa liberates an enzyme called sperm-lysin. It is produced by the acrosome of the spermatozoa.
- It dissolves the egg-membrane and makes way for the entry spermatoza.
- In mammals at the time of ovulation, the egg is surrounded by follicle cells. These cells are cemented together by a substance called hyaluronic acid.
- The mammallan sperm secretes a lytic enzyme called hyaluronidase.
- The enzyme dissolves the hyaluronic acid and the follicle cells are loosened. This paves the way for the entry of spermatozoa.

ACROSOME REACTION

- As the spermartozoon comes in contact with the egg, tremendous changes accur in the acrosome of sperm.
- All these changes constitue the acrosome reaction. The acrosome reaction has been studied extensively in a variety of animals.
- COLWIN(1967) demonstrate the acrosome-reaction in the enteropneust Saccoglossus.
- As spermatozoon's tip makes contact with the egg envelope, the sperm-plasma membrane and the acrosomeal membrane, rupture at the point of contact .
- The around the margin of the opening. The acrosome granule is the sperm-lysin which dissolve the egg-envelope . Thus the egg-surface is exposed at this spot.


Nucleus
Nuclear envelope
Periacrosomal material
Acrosomal membrane
Fine granular material
Acrosomal granule
Apical space
A Outer egg envelope
B
Sperm plasma membrane
Nucleus
Acrosomal membrane
Acrosomal tubule
Outer egg envelope
Inner egg envelope
Egg plasma membrane
Cortical granule
Egg cortex
C
D

- Now, the centre at acrosomal membrane, nearer to the nucleus, grows towards the egg-surface as a thin tube called acrosomal tube .
- As the acrosomal tube grows further, its tip comes in contact with the plasma-membrane of the egg.
- In some cases more than one acrosomal tubes develop. This is true about the polychaete worm Hydroides.

Cytoplasmic Fusion

- As the acrosomal tube comes in contact with the surface, the egg is activated. At the point of contact, the plasma membranes of the egg and sperm fuse and the acrosomal tube opens into the egg-cytoplasm.
- As the fusion is made, the egg-cytoplasm at this point bulges out as a conical projection called fertilization cone .
- In saccoglossus only one fertilization cone develops. But in hydroides many cones develop as there are many acrosomal tubes.
- The fertilization cone gradually engulfs the spermatozoon into the interior of the egg.

- In mammals the entire spermatozoon (nucleus, middle piece and tail) is engulfed by the egg-cytoplasm.
- In majority of animals the nucleus and the middle piece enter the egg and the tail is excluded.
- In Nereis the sperm nucleus along with the proximal centriole alone is engulfed; the tail and the middle piece are discarded.

CORTICAL REACTION

- As the sperm enters the egg, the egg becomes activated. First of all, changes occur in the cortex (surface) of the egg.
- These changes, constitute the cortial reaction. The cortical reaction in the egg of sea-urshin can be summarised as follows:

1. The colour of the egg-surface gradually changes from yellow to white. The changes starts from the point of attachment of the sperm and gradually spreads over the surface of the egg.
2. The vitelline membrane gets lifted off. This membrane is then called fertilization membrane. The space between it and the surface of the egg is called perivitelline space. It is filled with a fluid called perivitelline fluid.
3. The cortical granules swell rapidly and explode. The cortical granules release three important components. They are

    a. **Lamellar folded bodies**

        These are dark and dense bodies. On release, they unfold and fuse with the inner surface of the fertilization membrane. Thus the fertilization membrane is strengthened by the lamellar bodies

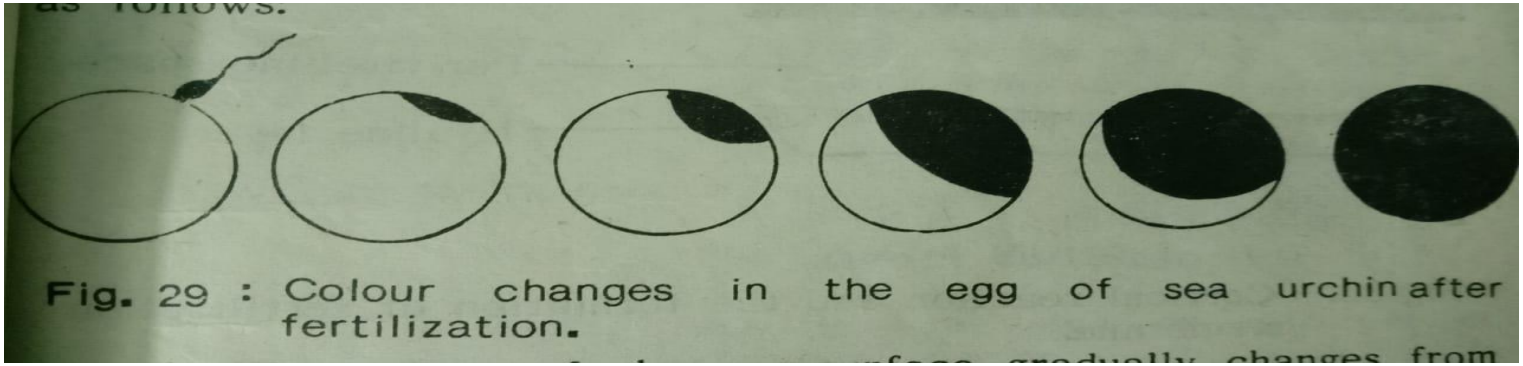


Fig. 29 : Colour changes in the egg of sea urchin after fertilization.

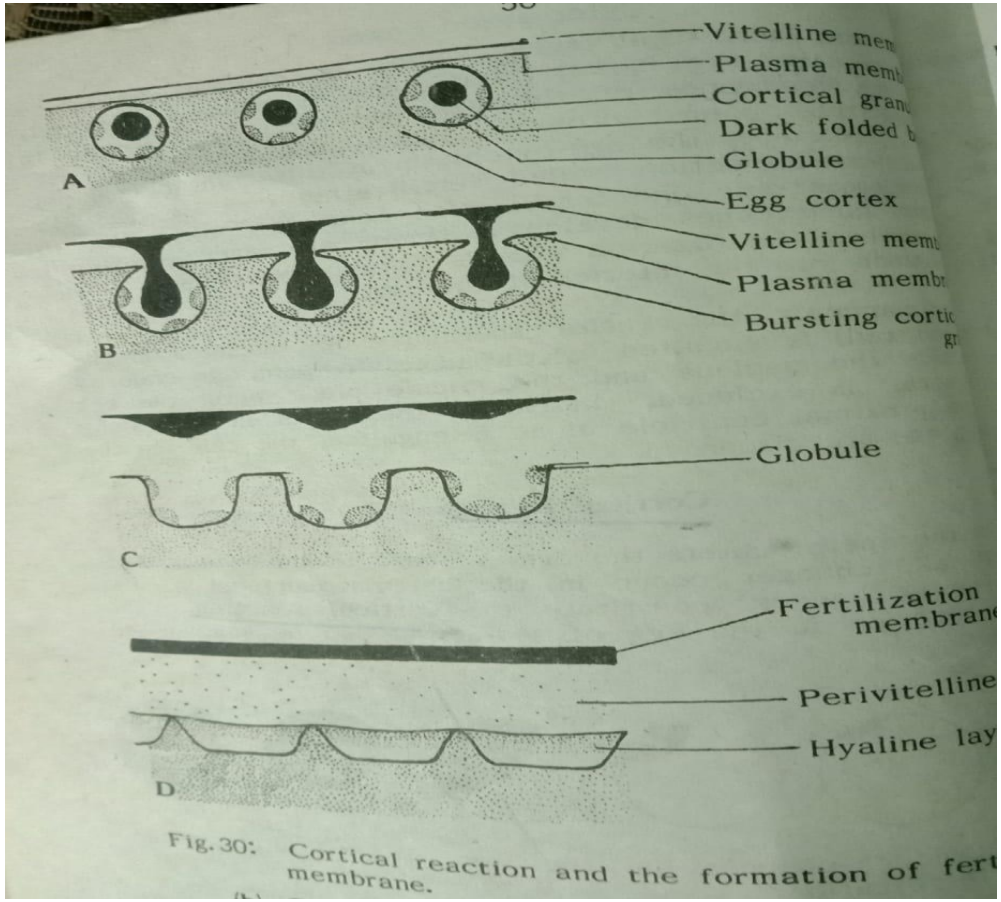


Fig. 30: Cortical reaction and the formation of fert membrane.

a. **Globules**

The globular structures fuse together and form a new surface layer just outside the plasma membrane . This layer is called hyaline layer . It helps to keep the blastomeres intact during clevage.

a. **Liquit component**

the cortical granules contain mucopolysaccharides. They absorb water and become liquified called perivitelline fluid. By imbibing more and more water, it assist in lifting the fertilizaion membrane still further.

AMPHIMIXIS

- Amphimixis refers to the fusion of male and female pronuclei.

In sea-urchin and in all vertebrates the two nuclei come in contact, he nuclear membrance a the point of contact disappear and the contents of the two nuclei unite into one mass surrounded by commo nuclear membrane.

- In ascaris, molluscs and annelids, only after the completion of first cleavage, the male and female pronuclei fuse together.
- In Cyclops the paternal and maternal nuclear components remain separate even after cleavage has started.
- As a result, each blastmere has a double nucleus consisting of two parts lying side by side, each surrounded by its own nuclear membrane.

ACTIVATION

The process of initiating development in an egg is called activation. It is initiated or stimulated by the sperm. The egg responds to the sperm by forming fertilization cone and by undergoing the various surface and internal changes. All these changes collectively constitute activation. During activation the following changes occur in the egg:

1. The egg surface produces fertilization cone.
2. The vitelline membrane is lifted and is converted into fertilization membrane.
3. The cortical granules explode
4. The cytoplasm exhibits movements.

5. The permeability of plasma membrane increases.
6. The coenzyme NAD is phosphorylated.
7. The rate of protein synthesis increases.
8. Mitosis is initiated.
9. The breakdown of polysaccharide occurs.
10. The enzyme dehydrogenase increases.