FERTILIZATION AND TYPES OF FERTILIZATION

Fertilization, union of a sperm nucleus, of paternal origin, with an egg nucleus, of maternal origin, to form the primary nucleus of an embryo. In all organisms the essence of fertilization is, in fact, the fusion of the hereditary material of two different sex cells, or gametes, each of which carries half the number of chromosomes typical of the species. The most primitive form of fertilization, found in microorganisms and protozoans, consists of an exchange of genetic material between two cells. The first significant event in fertilization is the fusion of the membranes of the two gametes, resulting in the formation of a channel that allows the passage of material from one cell to the other. Fertilization in advanced plants is preceded by pollination, during which pollen is transferred to, and establishes contact with, the female gamete or macrospore. Fusion in advanced animals is usually followed by penetration of the egg by a single spermatozoon. The result of fertilization is a cell (zygote) capable of undergoing cell division to form a new individual.

Fertilization in Humans

Fertilization is the biological process of fusion of male and female gametes resulting in the formation of a zygote. The fertilization in humans takes place in the fallopian tube. In this process, semen containing thousands of sperms is inseminated into the female vagina during coitus. The sperms move towards the uterus but not all succeed in reaching the opening of the fallopian tube. The secondary oocyte releases from the matured Grafian follicle of the ovary and enters into the fallopian tube, where it is fertilized within 24 hours, after which it is released from the ovary. Though surrounded by several sperms, the oocyte is fertilized by a single sperm. During meiosisII, the sperm enters the secondary oocyte and completes the meiosis. After this, the secondary oocyte is known as the egg. Both sperm and egg can show their vitality only to a limited period. Sperm is alive for 48-72 hours in a female reproductive

system, whereas the egg can be fertilized for 24 hours before it is released 3.2. Steps of Fertilization in Humans The fertilization process in humans takes place in several stages involving both the chemical and physical events. The different stages of fertilization in humans are mentioned below:

1. **Acrosomal Reaction**

The sperms incapacitation undergo acrosomal reactions and release certain chemicals known as sperm lysins present in the acrosome.

Due to the acrosomal reactions, the plasma membrane of the secondary oocyte and the sperm fuse together so that the contents of the sperms can enter. When the plasma membrane of the sperm binds with that of the secondary oocyte, the plasma membrane of the oocyte depolarizes. This prevents polyspermy. Calcium ions play a significant role in the acrosomal reaction. The main factors essential for acrosomal reactions are optimum pH, temperature and calcium and magnesium concentration.

2. **Cortical Reaction**

Soon after the fusion of the plasma membranes, the oocyte shows cortical reactions. Cortical granules found under the plasma membrane of the oocyte, which fuses with the plasma membrane and releases cortical enzymes between the zona pellucida and plasma membrane. The zona pellucida is hardened by the cortical enzymes that prevent polyspermy.

A projection known as the cone of reception is formed by the secondary oocyte at the point of sperm contact. This cone of reception receives the sperm.

3. **Prevention of polyspermy**

Most animal eggs are monospermic; i.e., only one spermatozoon is admitted into an egg. In some eggs, protection against the penetration of the egg by more than one spermatozoon (polyspermy) is due to some property of the egg surface; in others, however, the egg envelopes are responsible. The ability of some eggs to develop a polyspermy-preventing reaction depends on a molecular rearrangement of the egg surface that occurs during egg maturation (oogenesis). Although immature sea urchin eggs have the ability to associate with spermatozoa, they also allow multiple penetration; i.e., they are unable to develop a polyspermy-preventing reaction. Since the mature eggs of most animals are fertilized before completion of meiosis and are able to develop a polyspermy-preventing reaction, specific properties of the egg surface must have differentiated by the time meiosis stops, which is when the egg is ready to be fertilized.

In some mammalian eggs defense against polyspermy depends on properties of the zona pellucida; i.e., when a spermatozoon has started to move through the zona, it does not allow the penetration of additional spermatozoa (zona reaction). In other mammals, however, the zona reaction either

does not take place or is weak, as indicated by the presence of numerous spermatozoa in the space between the zona and egg surface. In such cases the polyspermy-preventing reaction resides in the egg surface. Although the eggs of some kinds of animals (e.g., some amphibians, birds, reptiles, and sharks) are naturally polyspermic, only one spermatozoal nucleus fuses with an egg nucleus to form a zygote nucleus; all of the other spermatozoa degenerate.

4. Karyogamy

After the entry of the sperm, the suspended second meiotic division is completed by the secondary oocyte. This gives rise to a haploid ovum and a second polar body. The head of the sperm containing the nucleus detaches from the entire sperm and is known as male pronucleus. The tail and the second polar body degenerates. The nucleus of the ovum is known as female pronuclei. The male and female pronuclei fuse and their nuclear membranes degenerate. The fusion of the chromosomes of male and female gametes is called karyogamy. The ovum is now fertilized and is known as a zygote.

5. Activation of Eggs

The entry of sperm triggers the metabolism in the zygote. Consequently, protein synthesis and cellular respiration increase.

6. Types of fertilization:

1. External and
2. Internal Fertilization

External Fertilization

External fertilization usually occurs in aquatic environments where both eggs and sperm are released into the water. After the sperm reaches the egg, fertilization can then take place. Most external fertilization happens during the process of spawning where one or several females release their eggs and the male(s) release sperm in the same area, at the same time. The release of the reproductive material may be triggered by water temperature or the length of daylight. Nearly all fish spawn, as do crustaceans (such as crabs and shrimp), mollusks (such as oysters), squid, and echinoderms (such as sea urchins and sea cucumbers). Pairs of

fish that are not broadcast spawners may exhibit courtship behavior. This allows the female to select a particular male. The trigger for

egg and sperm release (spawning) causes the egg and sperm to be placed in a small area, enhancing the possibility of fertilization.

External fertilization in an aquatic environment protects the eggs from drying out. Broadcast spawning can result in a greater mixture of the genes within a group, leading to higher genetic diversity and a greater chance of species survival in a hostile environment. For sessile aquatic organisms such as sponges, broadcast spawning is the only mechanism for fertilization and colonization of new environments. The presence of the fertilized eggs and developing young in the water provides opportunities for predation, resulting in a loss of offspring. Therefore, millions of eggs must be produced by individuals. The offspring produced through this method must mature rapidly. The survival rate of eggs produced through broadcast spawning is low.

Internal Fertilization

Internal fertilization occurs most often in land-based animals, although some aquatic animals also use this method. There are three ways that offspring are produced following internal fertilization: oviparity, ovoviparity, and viviparity.

In oviparity, fertilized eggs are laid outside the female's body and develop there, receiving nourishment from the yolk that is a part of the egg. This occurs in most bony fish, many reptiles, some cartilaginous fish, most amphibians, two mammals, and all birds. Reptiles and insects produce leathery eggs, while birds and turtles produce eggs with high concentrations of calcium carbonate in the shell, making them hard. These animals are classified as oviparous.

In ovoviparity, fertilized eggs are retained in the female, but the embryo obtains its nourishment from the egg's yolk; the young are fully developed when they are hatched. This occurs in some bony fish (such as the guppy, Lebistes reticulatus), some sharks, some lizards, some snakes (such as the garter snake, Thamnophis sirtalis), some vipers, and some invertebrate animals (such as the Madagascar hissing cockroach, Gromphadorhina portentosa).

In viviparity, the young develop within the female, receiving nourishment from the mother's blood through a placenta. The offspring develops in the female and is born alive. This occurs in most mammals, some cartilaginous fish, and a few reptiles, making these animals viviparous.

Internal fertilization has the advantage of protecting the fertilized egg from dehydration on land. The embryo is isolated within the female, which limits predation on the young. Internal fertilization also enhances the fertilization of eggs by a specific male. Even though fewer offspring are produced through this method, their survival rate is higher than that for external fertilization.

7. Implantation

Once fertilization happens, the cell starts to divide and multiply within 24 hours in the fallopian tube. This detached multi-celled structure is called zygote. Later, after 3-4 days it travels to the uterus and now we call it as an embryo. The embryo develops and undergoes various stages and gets attached to the endometrial layer of the uterus. This process of attachment is known as implantation. In humans, the initial stage of pregnancy is referred to as implantation.

a. About Implantation In the early stage of pregnancy, the conceptus clings to the walls of the uterus and the conceptus is called as a blastocyst. In order to grow, the fetus receives

oxygen and nutrients from the mother. When the eggs leave the ovary, the fertilization process of the eggs begins. This transportation of eggs is done through the fallopian tubes. When male sperm cells are deposited in the female reproductive tract, they try to unite with the egg and travel to the proximity of fallopian tubes. After getting fertilized, the egg has to go through a series of cell division. It takes 7 days for the egg to reach the uterus. By this time the egg with single cell gets divided and a ball of around 200 cells gets created. b. Fertilization Once the egg reaches the uterus, it remains free for about a day in the uterine cavity and then it gets adhered to the endometrium (i.e. The uterine lining). Once the egg gets in contact with the uterine wall, the cells that are on the outer surface of the egg starts growing. Then the egg distorts the uterine lining and actively dig into the deeper tissue. After the 11th day of fertilization, the egg completely inserts itself into the uterine lining