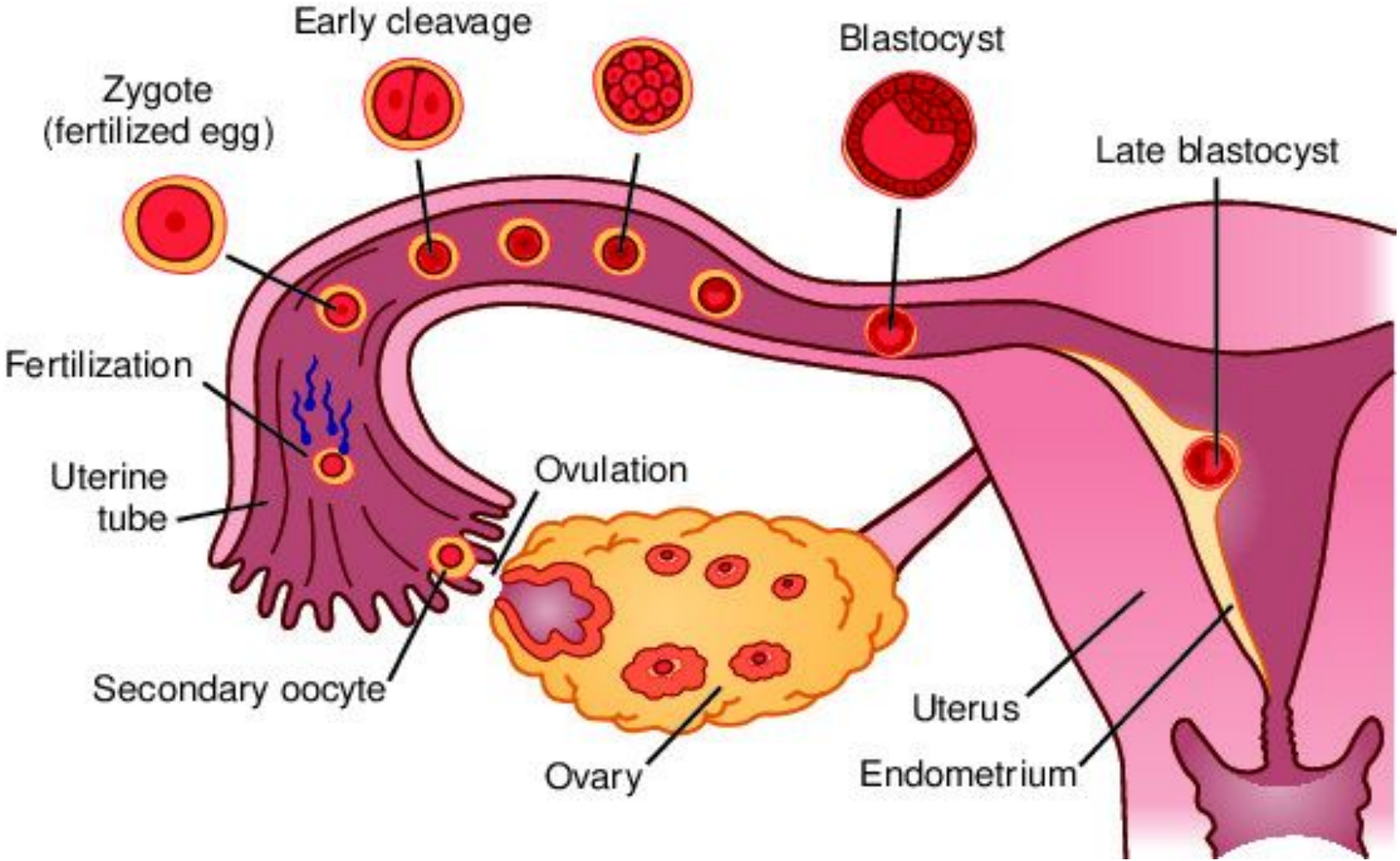
Fertilization

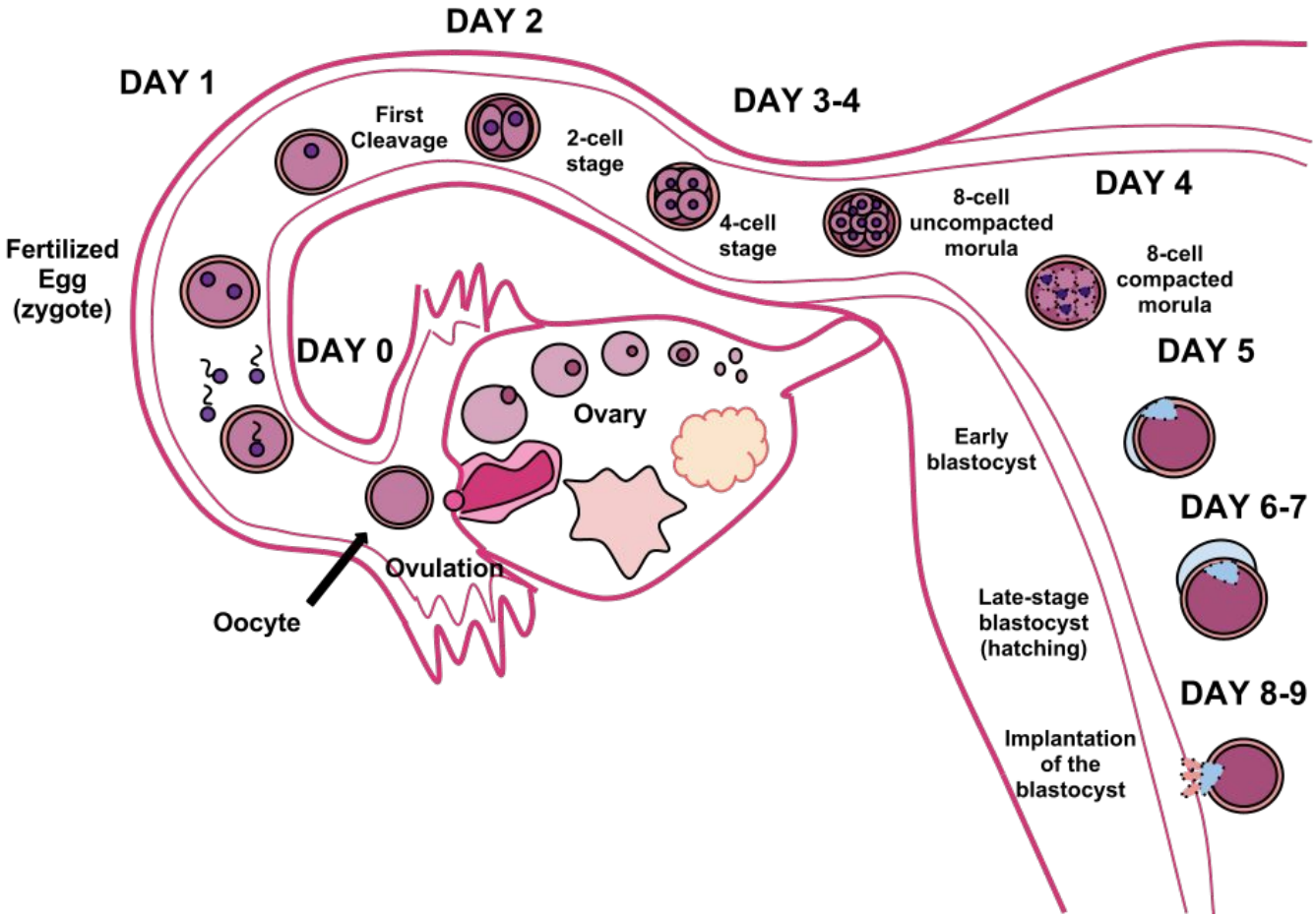
The process whereby a sperm and an ovum fuse to form a single-celled zygote is termed fertilization.

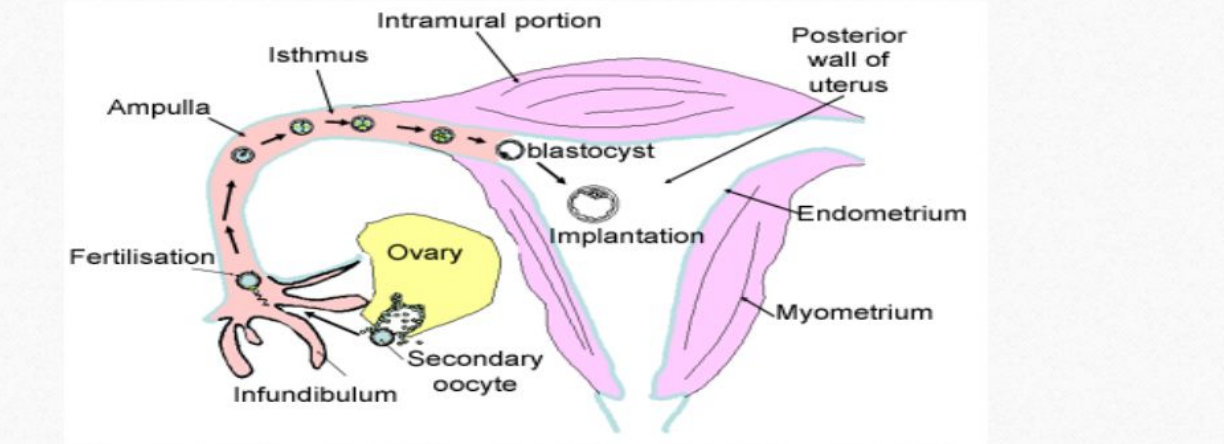
Following penetration of the vitelline membrane by the sperm, the activated ovum completes meiosis and extrudes the second polar body.

The chromosomes contained in the haploid male pronucleus align with their corresponding chromosomes in the female pronucleus.

As a consequence of fertilization, the diploid number of chromosomes is restored, the sex of the individual is determined and biological variation results from the integration of paternal and maternal hereditary characteristics


Early cleavage
Blastocyst
Zygote
(fertilized egg)
Late blastocyst
Fertilization
Uterine
tube
Ovulation
Secondary oocyte
Uterus
Endometrium
Ovary


DAY 2
DAY 1
First Cleavage
2-cell stage
DAY 3-4
DAY 4
8-cell uncompacted morula
4-cell stage
8-cell compacted morula
Fertilized Egg (zygote)
DAY 0
Ovary
DAY 5
Early blastocyst
DAY 6-7
Ovulation
Oocyte
Late-stage blastocyst (hatching)
DAY 8-9
Implantation of the blastocyst



Fertilization occurs in the ampullary region of the uterine tube. This is the widest part of the tube and is close to the ovary.

In mammals, millions of spermatozoa are deposited in the female reproductive tract . Depending on the species, the spermatozoa may be deposited in either the vagina or the uterus.

Volume of ejaculate, number of spermatozoa per ml, and site of deposition of spermatozoa in the female reproductive tract of domestic animals.

Species	Approximate volume of ejaculate (ml)	Number of spermatozoa per ml ($\times 10^6$)	Site of deposition of spermatozoa in the female reproductive tract
Cats	0.5	60	Vagina
Cattle	4.0	800 to 1,500	Vagina
Dogs	10	250	Uterus
Horses	70	150 to 300	Uterus
Pigs	250	200 to 300	Uterus
Sheep	1.0	2,000 to 3,000	Vagina

Internal Fertilization

Internal fertilization occurs most often in land-based animals, although some aquatic animals also use this method.

Internal fertilization has the advantage of protecting the fertilized egg from dehydration on land.

Fewer offspring are produced through this method, but their survival rate is higher than that for external fertilization

There are three ways that offspring are produced following internal fertilization.

1-**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, few types of 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. Chicken eggs are an example of this second type.

2-ovoviviparity: fertilized eggs are remained in the female, but the embryo obtains its nourishment from the egg's yolk and the young are fully developed when they are hatched. This occurs in some bony fish (like the guppy), some sharks, some lizards, some snakes (such as the garter snake), some vipers, and some invertebrate animals (like the Madagascar hissing cockroach).

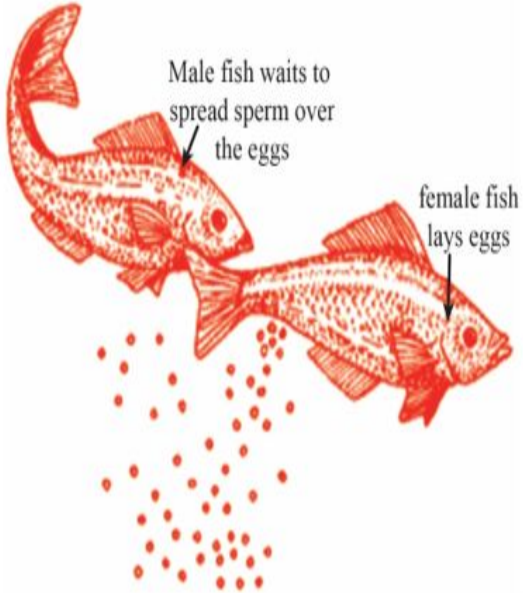
3-viviparity: the young develop within the female, receiving nourishment from the mother's blood through a placenta. The offspring develops in the female and is born alive. This occurs in most mammals, some cartilaginous fish, and a few reptiles

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 takes 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.



Before fertilization, the sperm must gain the ability to disintegrate the various oocyte barriers.

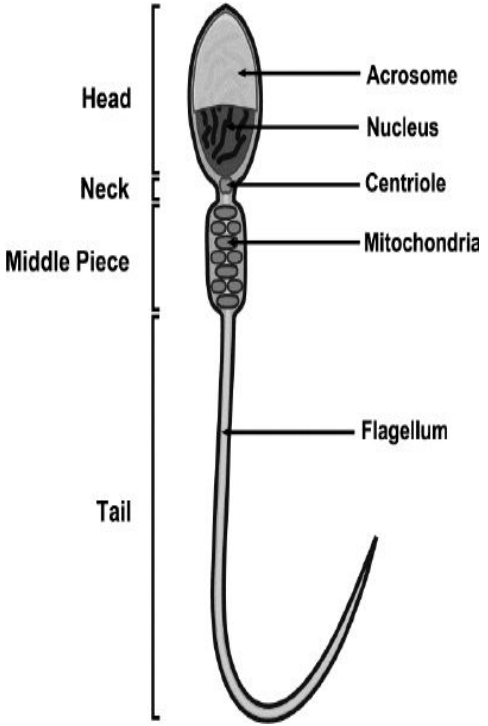
1. First barrier is formed by cells of corona radiata.
2. Second barrier is formed by zona pellucida made of glycoproteins.
3. Third barrier is formed by vitelline membrane of oocyte itself.

This ability is achieved by two processes

(a) capacitation.
(b) acrosome reaction

Capacitation is a period of conditioning in the female reproductive tract. Much of this conditioning, which occurs in the uterine tube, entails epithelial interactions between the sperm and mucosal surface of the tube. During this time a glycoprotein coat and seminal plasma proteins are removed from the plasma membrane that overlies the acrosomal region of the spermatozoa. Only capacitated sperm can pass through the corona cells and undergo the acrosome reaction.

The acrosome reaction, which occurs after binding to the zona pellucida, is induced by zona proteins. This reaction culminates in the release of enzymes needed to penetrate the zona pellucida, including acrosin and trypsin-like substances



Steps/Phases of Fertilization

1. Penetration of corona radiata:
2. Penetration of zona pellucida:
3. Fusion of sperm and oocyte cell membranes
4. Completion of second meiotic division of oocyte and formation of female pronucleus
5. Formation of male pronucleus
6. Formation of zygote

CLEAVAGE (OR CELLULATION)

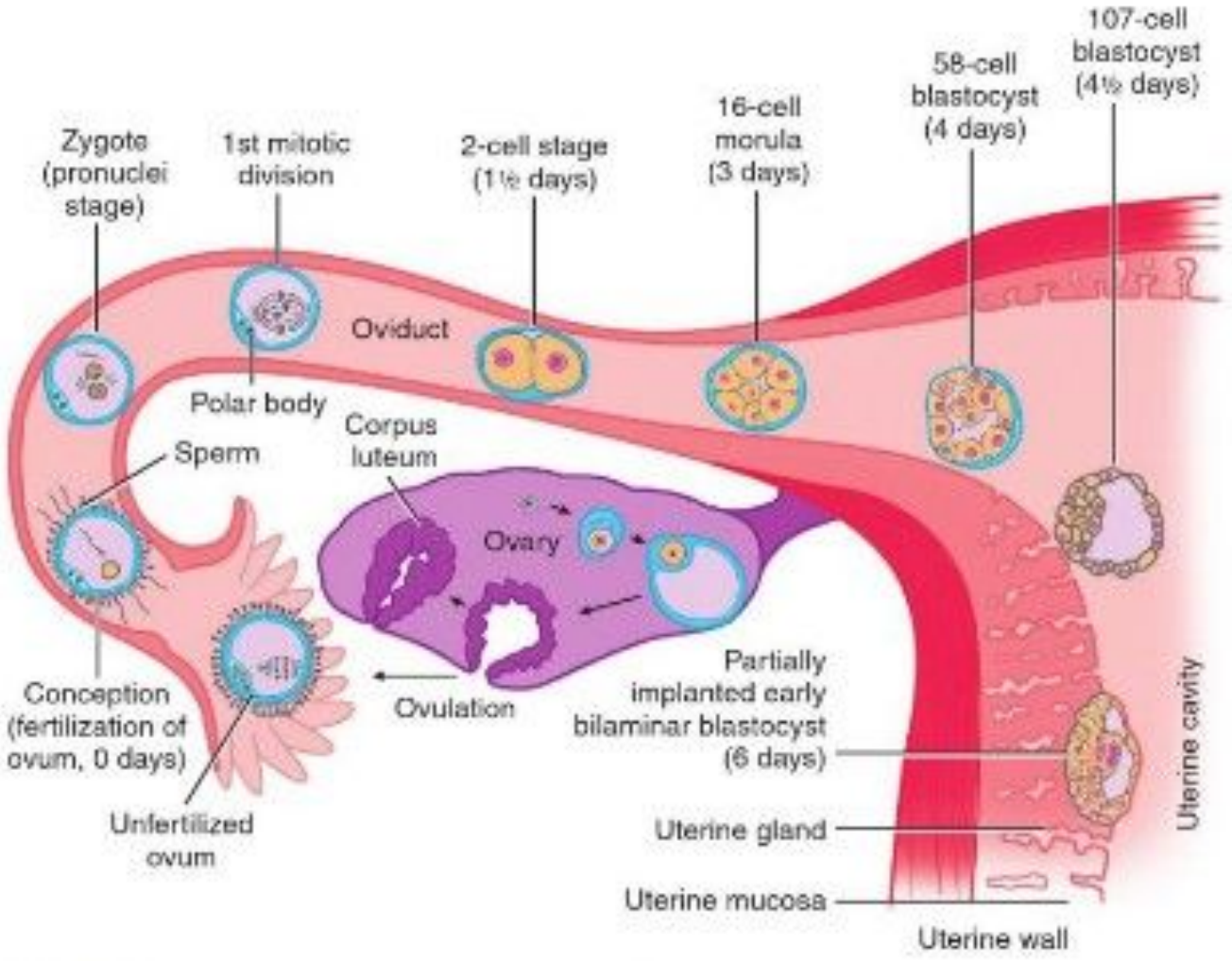
The Cleavage Consists Of Repeated Mitotic Divisions Of The Zygote Into Smaller Units.

This Results In A Rapid Increase In The Number Of Cells. These Cells Are Called Blastomeres.

They Become Smaller With Each Successive Cleavage Division.

The Division Of Zygote Starts Just After Fertilization And Continues As The Zygote Passes Along The Uterine Tube.

During Cleavage The Zygote Is Surrounded By A Rather Thick Zona Pellucida.

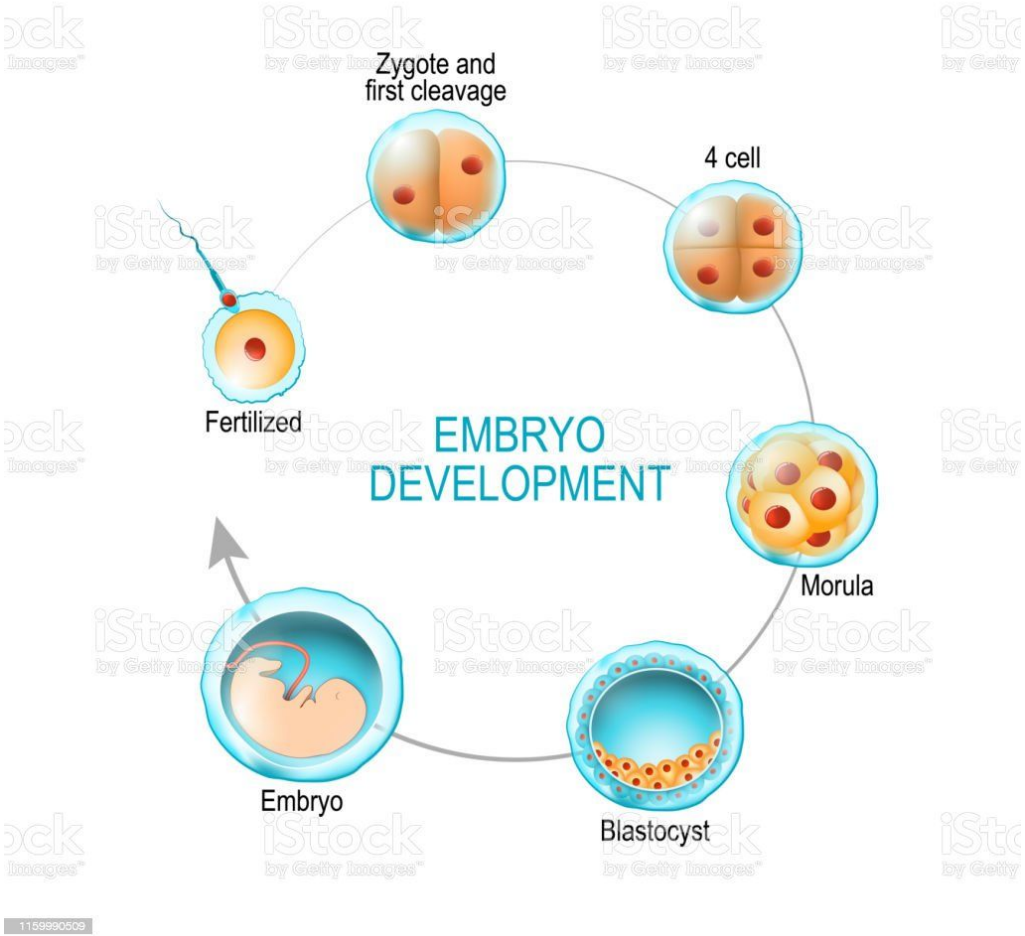

Zygote (pronuclei stage)
1st mitotic division
2-cell stage (1½ days)
16-cell morula (3 days)
58-cell blastocyst (4 days)
107-cell blastocyst (4½ days)
Oviduct
Polar body
Corpus luteum
Sperm
Ovary
Conception (fertilization of ovum, 0 days)
Ovulation
Partially implanted early bilaminar blastocyst (6 days)
Uterine cavity
Unfertilized ovum
Uterine gland
Uterine mucosa
Uterine wall

The process of cleavage remains one of the earliest mechanical activity in the conversion of a single celled egg into a multicellular embryo. It is initiated by the sperm during fertilization.

The zygote divides to form two cells of which one is smaller than the other (twocell stage of embryo). The larger cell divides first giving rise to three-cell stage. The smaller cell divides next and embryo consists of four cells that divide to form eight cells. The 8 cells further divide to form 16 cells

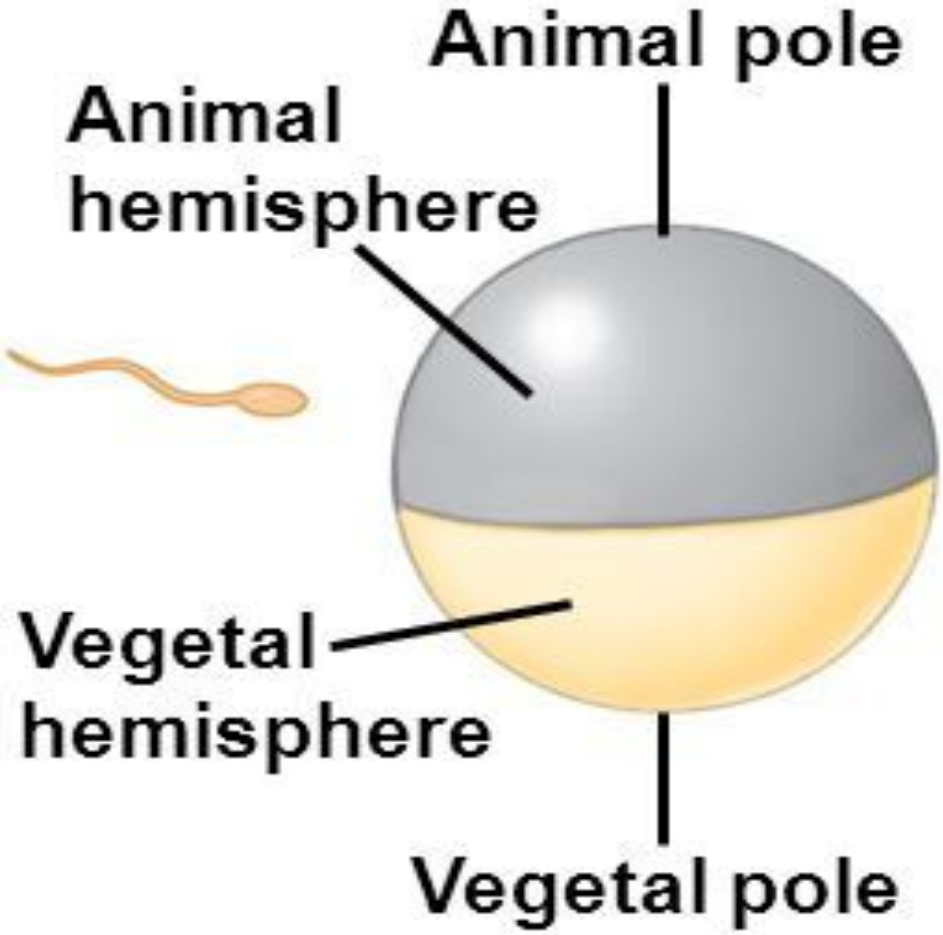
A 16-cell stage embryo is termed morula. In morula, the blastomeres are very small and contain very little cytoplasm to survive.

As the cleavage progresses the resultant daughter cells, namely the blastomeres get reduced in size. During cleavage there is no growth in the blastomeres. The total size and volume of the embryo remains the same



Ovum Poles:

Animal pole is that region of the ovum where polar bodies are extruded and it receives the sperm while Vegetal pole is that pole which is opposite to the animal pole. At one pole, known as the animal pole, the cytoplasm appears to be more active and contains the nucleus (meiotic divisions occur in this region); at the other, called the vegetal pole, the cytoplasm is less active and contains most of the yolk


Animal pole
Animal hemisphere
Vegetal hemisphere
Vegetal pole

Influence of yolk on cleavage

1. Total or holoblastic cleavage - In this type the cleavage cleavage furrow bisects the entire egg. Such a cleavage may be either equal or unequal.

(a) Equal holoblastic cleavage - In microlecithal (The egg has a little amount of yolk compare with cytoplasm) cleavage leads to the formation of blastomeres of equal size. Eg: Amphioxus and placental mammals.

(b) Unequal holoblastic cleavage - In mesolecithal (the amount of yolk is moderate) cleavage leads to the formation of blastomeres of unequal size. Among the blastomeres there are many small sized micromeres and a few large sized macromeres

2. MEROBLASTIC CLEAVAGE :

In this type the cleavage furrows are restricted to the active cytoplasm found either in the animal pole (macrolecithal egg, egg with high amount of yolk) or superficially surrounding the egg (centrolecithal egg, the yolk concentrates in the center of egg).