FERTILIZATION

The process in which unon of male and female gmetes (formed by gametogenesis) and fusion of pronuclei of sperm and ovum takes place thus diploid ygote is formed, is called fertilization.
Fertillization has following processes : the union of male and female gamets is called Syngamy, where an intermixing of their cytoplasm is called plasmogamy. The funsion of pronuclei of sperm and ovum is called karyogamy. The intemingling of their chromosoems is called amphimisis.
Due to fertilization, diploid zygote is formed by the union of two different types of gamets

SITE OF FERTILIZATION -

(A) INTERNAL FERTILIZATION : Fertilization in the body (i. e. , genital organs of animal) is called internal fertilization. In this type of fertilization, sperms are discharged by male directly into the genital tract of female after coitus.
- Whole process of fertilization takes place within the body of female. This is the most common adaptation in terrestrial animals.
Examples :- Aschelminthes, reptiles, birds and mammlas.

(B) EXERTANL FERTILIZATION - External fertilization takes place outside the body of females i. e. in water Examples : -In most of the invertebrates, some protochordates, amphibia and most of the fishes.

TYPES OF FERTILIZATION -

(a) Self fertilization - This process takes place in the body of single animal i. e. , fusion of male and female gametes produced by male and female organs of the same animal. This is called self-fertilization. This is possible only in bisexual or hermaphordite animals.
Examples : Animals of phylum porifera and most of the secies of Hydra.

(b) Corss - Fertilization - Fertilization takes place between two (male & female) different animals of same species. This is called cross fertilization

- This process is found in all unisexual animals. These animals are also called dioecious animals

- Cross - fertilization is also found in most of the bisexual or hermaphrodite animals because in these animals male genitl organs develop first. This condition is called protandrous condition. In some of the species female organs develop first, this condition is called protogynous condition e. g. sponges.

MECHANISM - We can understand the process of fertilization in following steps.

1. Movement of sperms towards ovum

2. Entrace of sperms in the ovum

3. Activation of ovum

Approach of sperm towards the egg - It is a chance facter, so sperms perform random (directionless) movmenet. To increase the chances of approach of sperm towards egg there are mainly two adaptaion.

(a) Number of sperms in very hig : e. g. In man 20 to 120 million sperms are present per cubic mm of semen.

(b) Egg is 1000 times larger than sperm

- Some special proteins are found on the surface of egg and sperm to help in fertilization.
According to Lillie, chemicals names as “fertilizins” are found on the surface of egg. Fertilizins are glycoproteins or acid mucopolysaccharides. Accordin to Ballinsku, an acidid protein names as Antifertilizin is present on the surface of sperms. “Fertilin” proteins are also present on sperm surface.
- Both the protein are specific for a prticular species. Antifertilizin present on sperm of a particular species will react with fertilizin of present on egg of the same speices of animals.

- If we place some eggs of sea-urchin is sea-awter, this sea water becoems viscous, this is called egg-water. When some sperms come in contact with this egg water, sperms adhere with ecah other. It is called agglutitaioin. Here the reaction of fertilizin (dissolved in water from eg) and antifertilizin of sperm is oberved clearly.

- Fertilizing behave lke lock and antifertilizins behave like keys.

- Fertilization is always intraspecific.

- According to Washerman and Sailing (1989) a specific pair of protein molecules is found on the surface of mammlian sperm, which can recognise specific carbohydrates and proteins in ZP3 regio of zona pellucida. The bindin protein of sperm reacts with these molecuels to initiate the chages in acrosome. A specific suger galacose remain attched wth ZP3 glycoprotein. The sperm fails to recognise the ovum of its own species, if this suger is removed from zona pellucida.

- In addition to these glycopreoteins, there are some hormoens also, which help in fertilization.
The hormones present at the surface of sperm are called androgamones. These are of two types. Androgamone firsdt & androgamone second.

- Androgamones I help in the energy conservation of sperms.

- Androgamones II disolve the gelatnous covering present all over the egg.

- Hormones present at the surface of egg are called gyanogamones these are of 2 t ypes.

(a) Gyanogamones I - this hormone neutralizs Androgamone I and activates sperm to moe

(b) Gynagamones II - It makes sperm head sticky.
Enzyme of acrosome (Hyluronidase and sperm lysins) dissolbe the gg membrane. This is called acrosomal reaction. As the result sperm head make the contct with the plasma membrane of egg, now inner membrane of acrosome evaginates outside and form rigid tube is called acrosomal filament. A crosomal filament provide stimulus to plasma membrane of egg and due to stimulues of sperm, egg is induce for fertilization. Mammalian sperms do not fro this type of filament because mammalian sperms are highly active and provide stimulus to plasma-membrane of egg without and filament. Mammalian sperms acquire activity at two places. First epididymis and secon-vagina. Vaginal secretion make the sperm highly active and sperm acquire capacity of fertilization is called capacitation.

Activation of egg: Due to stimulus of sperm an enzyme is induced in plasma membrane of egg it is called adenly cyclase enzyme and function of this enzyme is to catalyze - C-AMP in agg cytoplasm. C-AMP is the second mesager. Cyclic AMP receives stimulus from plasma membrane of egg and transfer it in egg cytoplasm and induces ald the response of for sperm.

All the response of egg for sperm are collectively called gyanogenesis.
Due to stimulus of sperm, permeability of plasma membrane of egg increases specially for k^+ and Ca^{2+} ions. Function Ca^{2+} ions is to inactivate the cytostatic factors in egg. As a result egg is now ready for cleavage (In egg cytoplasm special type of protein called cytostatic factor are present these prevent the cleavage in unfertilized egg)

Due to stimulus of sperm, H^+ - Na^+ pump activates and induces the plasma-membrane of egg. Function of this pump is to continuosly influx H^+ ions and outflux Na^+ ions. s a result concentration of H^+ ion increases in egg cytoplasm and develops an avidic emdium. In acidic medium, proteolytic enzyme become active and liberate the m-RNA from informosome. The m-RNA become active and rapidly synthesize different types of protein and enzymes. Due to more avilability of protein and enzymes metabolic activity of egg increases.
Response of egg: (1) Due to stimulus of sperm, meiosis-II is induced in human egg by excluding second polar body becoming mature ovum.

(2) At the point of contact with sperm and plasma-membrane of egg a cone-like structure is formed called reception cone. After some time reception cone sink in eg cytoplasm along with sperm (entry of sperm is a type of phagocytosis). With the entry of sperm all the cortical grnuels burts and secrete a membane around the egg if called fertilization membrane (cortical reaction). It is secreted on inner surface of primary egg membrane and perivitelline space become more wide and amount of perivitelline fluid is also increase. Function of pertitelline fluid and fertilization membrane is to prevent tye entry of sperm of in egg. so normally only one sperm enter inside the egg (monospermy). Sometimes more thn one sperm enter inside the eg (polyspermy). Two types of polyspermy are found in nature.

(1) **Pathological polyspermy :** In in the nuclei of all the sperms fuse with egg nucleus. In such type of condition embryo developmen does not occur. (Due to polypolidy condition)

(2) **Plysologicl polyspermy :** In physiological polyspermy nucleus of only one sperm fues with egg nucles and rest of the sperm die in egg cytoplasm. Dead sperm are called merocytes. In physiological polyspermy normal embryo development occurs.

Polyspermy is absent in human beings. Polyspermy mostly occurs in megalecithal eggs.

Fate of serpm in egg - In majority of animals, only head and middle peice enter inside the egg and tail is left outside.

- In mammals, whole sperm entes in the egg.

- In some animals, only head of sperm enters in the egg tail and middle piece remain outside e. g. Hydrda, Neries etc.

After entering inside the egg, sperm rotates by 1800. All the structures of sperm dissolve in egg cytolasm except perm nucleus and proximal centriole.

- The centriole of egg itself degenerates at the time of second mturation divison. So proximl cenriole of sperm starts division, it divided into 2 daughter centrioles, which migrte towards sopposite pole and start forming spindles.

Fate of sperm nucleus :-

- The nucleus of sperm aborbs water from egg ctyplasm and becomes enlarged. Now it is called male pronulceus.
After meiosis - II egg nucleus occur in the form of scattered vesicles then it is called as kryomeres and after some time all the karyomeres asembeld to form complete nucleus is called emale pronucleus.

- Male pronucleus an female pronucleus migrate through definite routes and come close to each other. These routes are called fertilization path. (It has folloswint parts)

(1) **Sperm penetration path -** Mle pronucleus for some distance, moves at the euator of egg. This is calle sperm penetration path.

(2) **Sperm compultion pth : -**male pronucles starts migrating fowards female pronuleus.

(3) **Egg compulation path : -** Female pronucleus migrates towards male pronucleus. Both the pronuclei come close to each other.

(4) **Cleavage path -** to the pronuclei move together to their final postion which is somewhere of male and female pronuclei form pairs. The mixutre of male and female chromosomes is called amphimixis.
- Amphimixis was discovered by O. Hertwing in the eggs of sea - urchin.

- Newport was of all first observed the entry of sperm into the egg.

Sgnificance of Fertilization

1. Ooctye completes its second maturation division of coming in contact with the sperm.
2. Amphimixis proces leads to the formation of a diploid zygote to restore the normal diploid number of the chromosomes.
3. The centriole of sperm after entering into egg induces the egg to undergo cleavage.
4. The paternal and maternal characters are transmitted to the off springs through the process of fertilization.
5. The peripheral changes occurring in the egg prevent the further entry of sperm into the ovum, thus cheking polyspermy.

PARTHENOGENESIS OF VIRGINAL DEVELOPMENT

- The development of embryo without fertilization if called parthenogenesis. The animals which ware formed by unfertilized eggs are called parthenotes.
- The discovery of parthenogenesis was one by Charles Bonet in the eggs of sea-urchins.
- Parthenogenesis is of two types -

(a) Ntural (b) Artificla

(a) Natural perthenogenesis -

Some animals show parthenogenesis by ature e. g. Honey bees, wasps, ants, grass-hoppers, tick mites and sea-urchins. Natural parthenogenesis is of 2 types -

(1) **Haploid parthenogenesis or Arrhenotoky :-** In this case eggs are formed by meiosis. Eggs are haploid, they have the powr of fertilization sometimes male animals re developed by unfertilized egg. In Honeybees, unfertilized eggs develop into males (drones), and fertilizaed eggs develop into queen and soldiers. Thus male honey bees re always haploid and queen along with soldiers are always diploid.

(ii) **Diploid parthenogenesis or Thelytoky :** In this case, eggs are formed without meiosis division. Eggs are diplod they do not have the power of fertilizaion.
Diploid eggs give rise to female generation only. Male members are absent in these species.
Examples : -Lacerta sexicola armenica (lizard), Caresius aratus gibelio (Fish).
Diploid parthenogenesis may also abe divided into two types -

(A) **Ameiotic Thelytoky -** In this type of parthenogenesis, during oogenesis first meiotic division does not take place but second meiotic division occurs as usual. In this situation the ovum still remains diploid. These ova, when reproduce parthenogenetically give rise to diploid offsprings. For example, Trichoniscus, Daphina pulex etc.

(B) **Meiotic the lytoky -** If the eggs a reformed by normal oogenesis process, but by one or other reasons the eggs retain their diploid chromosomal number, then the parthenogenesis is called meiotic thelytoky. It may happen because of autofertiliztion. Some species of order - Lepidopteta exhibit this type of parthenogenesis.

- In some ainmals parthenogenesis alternates with normal sexual reproductive cycle. This is called cyclic parthenogenesis. e. g. , Honey bee.

- In some animals, development of animals is always by parthenogenesis and sexual reproduction is absent in these species. This is called complete parthenogenesis. Males are absent

Example - Lacerta sexicola armenica (lizard)

(b) Artificial parthenogenesis :-

Thiis type of parthenogenesis is done by artificial methods. Artificial parthenogenesis is done by putting eggs in different atmospheres or by giving special stimules to the eggs. Different articila methods used for this purpose are as follows -

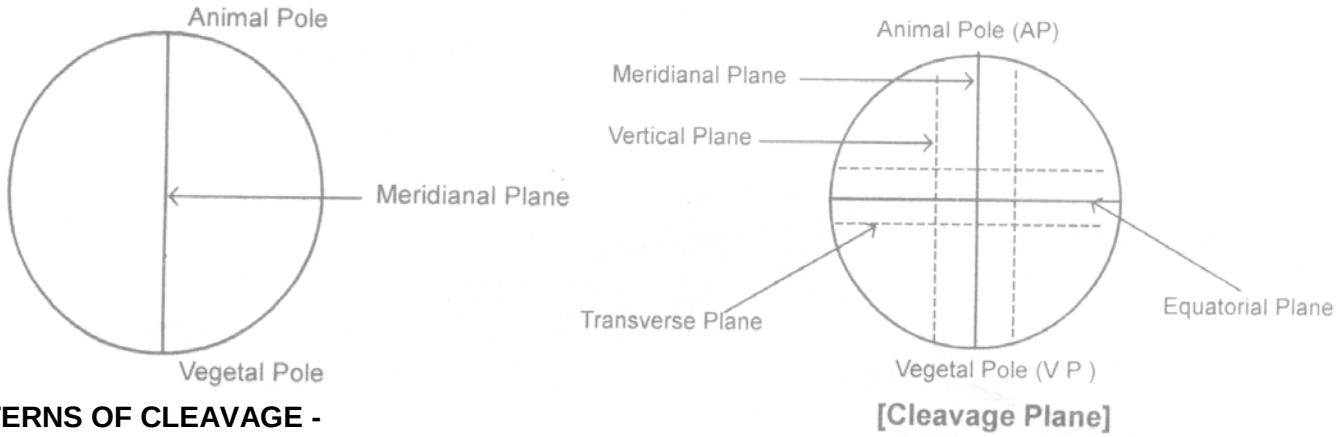
(1) If we place eggs in brine of salt solution, KCI solution. Then eggs who parthenogenesis e. g. eggs of sea urchins.
(2) By short exposure of radiation on eggs or exposure of silk insect egg to sunlight.
(3) If eggs are given shock of temperature.
(4) If eggs are pierced by needle dipped in the blood of some animal. The eggs of frog whof parthenogenesis by this method.

CLEAVAGE

- The term 'Cleavage' was given by "Von Bear"
- In fertilized egg or activated egg, the egg undergoes repeated cell divisions which occur rapidly producing a multicellar structure withut changing its size. all these rapid mitotic cell divisions are collectively called cleavage or segmentation. Due to the process of cleavage, a single celled zygote, through a successive mitotic cell divisions changes into a cmplex multicellular structure. Cells produced as a result of cleavage are termed as blastomeres. The total size of the embryo remain the same. Though the number of blastomeres as a result of mitotic cell divisions increases, the size of blastomeres gradully decreases as complared to parent cell. Interphase stage is very short in cleavage. In interphase only DNA duplication and histone protein synthesis take place up to some exten. t In the inrterphase of cleavage only 'S' phase is present G1 & G2 phases are absent. Protein synthesis and RNA synthesis do not occur during this interphase. Nucleolus is absent in the nucleus of blastomers. Size of blastomers decreases during cleavage. When size of blastomere becomes equal to that of size of somatic cells, the divisions of cleavage. When size of blastomere becomes equal to that of zie of somatic cells, the divisions of cleavage are stopped. Only normal cell divisions take place. Cleavage can be observed till onset of gastrulla stage. After gastrulation, cleavage is completely cheked. Nucleous appears first in gastrulla stage. The consumption of oxygen in increased during cleacage.

CLEAVAGE PLANE

The tavelling path of cleavage furrow in fertilized egg is called cleavage plane. Different animal eggs show different cleavage planes :-



[Cleavage Plane]

PATTERNS OF CLEAVAGE -

(a) Radial Cleavage - In this pattern, cleavage furrows are straight and form right angle with each other. In this case I, II cleavages are meridianal, which are at right angle to each other. III cleavage is equatorial. In this ways 8-called octotate is formed. In radial cleavage, 4 blatomeres of upper tier and 4 blatomers of low tier are on same plane i. e, Blastomers are arranged in ratiadl symmetry in the beginning.

Example :- Deutorostomia [Under this group echinoderms & chrodates are included'

(b) Biradial Cleavage - In this pattern first two cleacages are meridianal and at right angle to each other and III cleavage is vertical. In 8- called stage 4 blastomers of central zone are bigger and 4 blastomeres of peripheral region are smaller.

Examples : -In the eggs of Ctenophora.

(c) Bilateral Cleavage - In this pattern, firsdt two cleavages are meridianal in same plane and III cleavage in transverse. i. e. embryo shows bilateral symmetry in 8- called stage. The blatomers of one side are smller and blatomeres of other side are larger.
Examples : In the eggs of tunicata, cephalochordata, amphibia and amphiouxus.

(d) Spiral Cleavage : - The cleavage furrow passes obliquely. In this pattern 4 blastomeres of lower tier rotate clockwise or anticlock wise. If this rotation is clockwise, then it is called dextral spiral cleavage e. g. In Mollusca. In this rotation of lower tier blastomers is anti-clockwise, then this pattern is called sinistral spiral cleavage, e. g. In helminthes and annelida.

CLASSIFICATION OF CLAEVAGE

On the basis of fate of blastomeres :

A. Determinate Cleavage - In this pattern of cleavage, the fate of blastomeres is fixed, determined i. e. each blatomer form a particular portion of embryo. If (by certain reason) any blastomere is damaged or detroyed, then the part of embryo (which would have developed from the blastomere) will be absent e. g. , Nematoda, Annelida, Mollusca and. Some chordates like amphibia & scidina. s

B. Indeterminate Cleavage - In this type of cleavage, the fate of blastomeres is not definite. All the blastomeres form all the parts of embryo. If some blastomeres are lost, no loss observed in this embryo. If in the early stges of cleavage, the embryo is cut into small pieces, then each piece of embryo will develop into a compelte embryo, and all the embryof are identical. So identical twins are monozygous. This is the basis of embryo cloning.

CLASSIFICATION OF CLEAVAGE

On the basis of amount of Yolk :

A scientist named Balfour gave low. According to him, rate of ceavage is inversely proportional to amount of yolk present in the egg. The yolk present in egg, disturbs the rate of cleavage. The rate of cleavage is slow in that part of egg, in which amount of yolk is more, and the rate of cleavage is faster in the portion of egg in which yoklk is in lesser a mount. Mostly cleavage is of 2 types :-

A. Complete or holoblastic : When cleavage furrow passes through the egg completely. As a result of this the whole egg divides. Holoblastic cleavage is found in all the eggs except megalecithal egs. The whole egg divides into blatomeres. No part of egg remains undivided. It is of 2 types :-

(a) Equal holoblastic cleavage - In those eggs, in which amnount of yolk in less and it is distributed evenly in the egg, cleavage occurs in while egg, blastomeres (So formed) are of zame size. All the parts of egg show same rate of cleavage.

Example : It is found in microlecithal and isolecithal eggs.

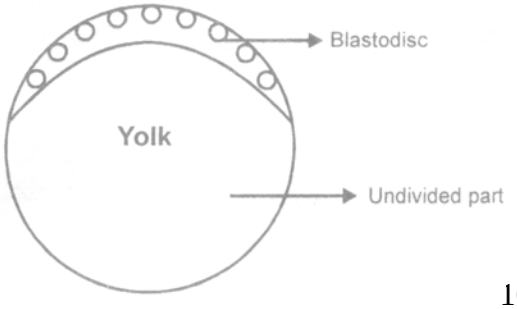
(b) Unequal holoblastic cleavage - In those eggs in which amount of yolk is mediuam and it is distributed unevently in the egg. The blastomeres are bigger and less in number where the concentration of yolk is higher in the egg. The part of egg which contains small amount of yolk, blastomeres here formed are smaller and more in number. The bigger blastomers are called megameres and small blastomeres are called micromeres.

Examples : Unequal holoblastic cleavage in present in mesolecithal and telolecital eggs and human eggs.

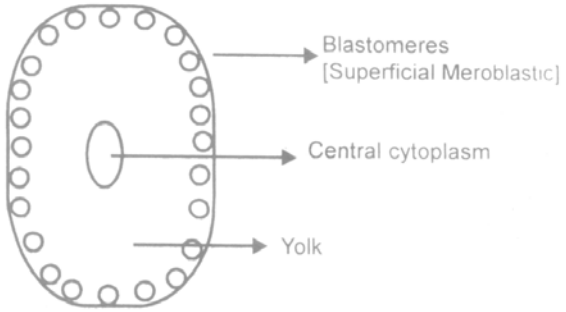
B. Meroblastic cleavage : This cleavage is found in megalecithal eggs, in which amount of yolk is larege. Cleavage does not occur in that part of egg, where yolk is present cleavage occurs only in Cytoplasmic part, yolk remains undivided. Meroblastic cleavage is of 2 types on the basis of distribution of yolk in egg.

(a) Discoidal meroblastic cleavage - Cleavage occurs only in blastodisc of egg. This is mainly found in megalecithal or polylecithal eggs, because in these eggs, cytoplasm is found in the form of a disc.

Example - Reptilian eggs and birds eggs.



(b) Superficial meroblastic cleavage - In insect egg, central cytoplasm shows free central division, due to which so many nuclei are formed. All these nuclei migrates towards peripheral cytoplasm Cleavage occurs only in peripheral region. As a result of this, a superficial layer of blatoemrs is foremd around the yolk. This type of cleave is also called superficial meroblastic cleavage.
Example – In centrolecithal eggs.



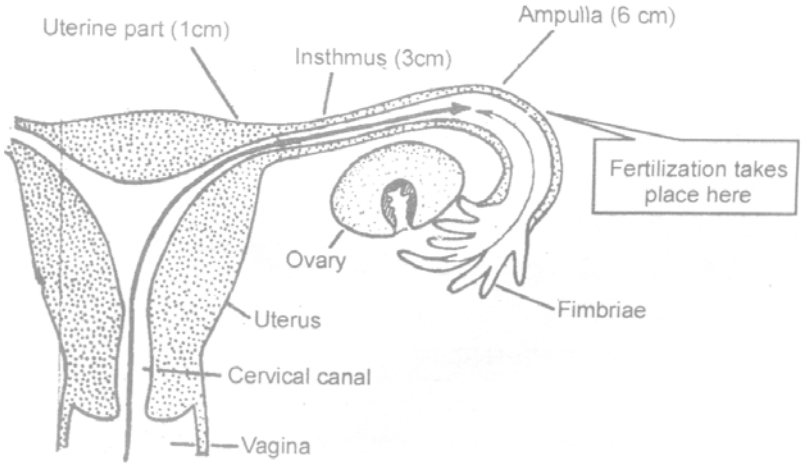
Significance of cleavage -

1. There is no change in shape and size of developing embryo till blastula stage comes. Till then it remains just luke undivided eg in shape.

2. As a result of cleavage, unicellular zygote changes into multicellular structure.

HUMAN EMBRYOLOGY

Fertilization : -



Fertilization is the union of two opposite types of gametes, spermatozoa and ova. The semen ins a mixture of spermatozoa and accessory fluids. Once deposited within the vagina, the spermatozoa proceed on their journey into and through the uterus and on up into the oviducts. Although spermatozoa can swim several millimeters each second, this trip through the uterus and to the oviducts requires an increase in their motility.
On the first hand, ejaculation of semen in the vagina triggers motility of spermatozoa. This is aided further by muscular contraction of the walls of the uterus and the oviducts. An additional increase in sperm motility occurs due to activation of the sperm by t he viscous liquid secreted from the secretory cells of the ephithelial lining of oviduct mucoca. This penomenon of sperm activation in mammals is known capacitation. It take about 5-6 hours for capacitation.
Before fusion of a spermatozoan with the gg, the spermatozoa are the penetrate a few barriers, the egg membranes, which cover the egg. The acitvated spermatozoa undergo crosomal reaction and release various chemicals, like hyaluronidase that acts on the ground substances of follicle cells, corona penetrating enzyme tht dissolves corona radata, and zona lysine which perforates the zona pelluciada. All these chemicals are contained in the acrosome, located at the tip the sperm head, and are collectively termed sperm lysins. An average human ejaculate of 3-4 ml of semen contains 80-10 million spermatozoa. Out of these, only one will success in entering the egg and fertilizing it. Fertilisation of egg with only one spermatozoan is known as monospermy.

While the ovarian follicle is growing. the oogonium within it undergoes maturation. The oogonium enlrges to form a perimry oocyte. The primary Oocyte undergoes the first meiotic division to shed off the first polar body and becomes a secondary occyte (fig. 5. 2A). At the time of ovulation, the second meiotic division is in progress and a spindle had formed for separation of the second polar body (fig. 5. 2B).

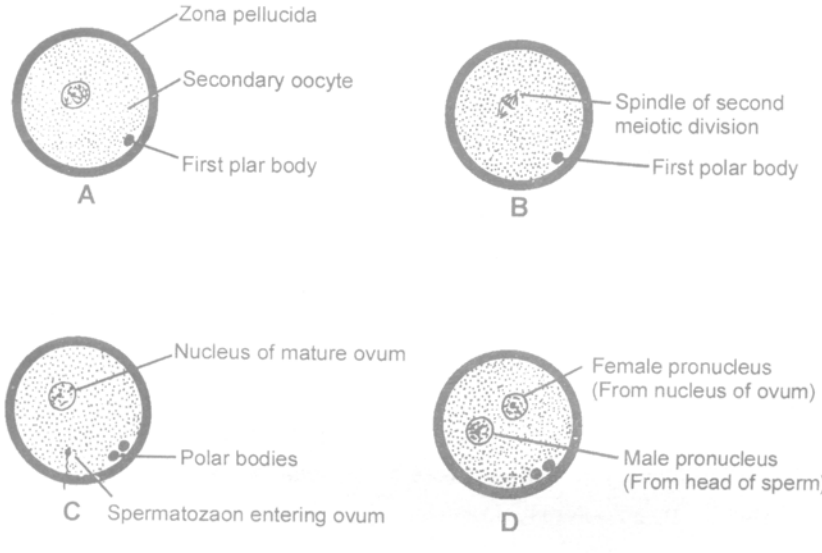


Fig 5.2

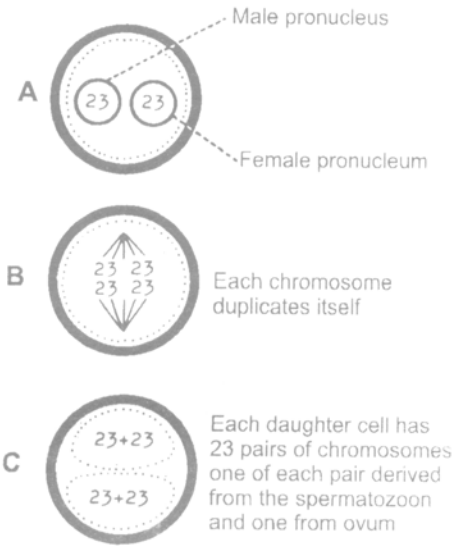


Fig 5.3

At this stage the 'ovum' enters the infundibulum of the uterine tube and passes into the ampulla (fig. 5)

Fertilization of the ovum occurs in the ampulla of the uterine tube. One spermatozoon pierces the zone pellucida and enters the ovum. In response to egg sperm biding two things happen (1) depolatisation of egg mambrane (2)cortical reaction ie. , formation of fertilization membrane to prevent polyspermy. (After one spermatozoon has entered the ovum other spermatozoa cannot enter it). After the entry of the spermatozoon, the second polar body is extruded. The chromosomes of the ovum now assume the shape of a nuelus called the female pronucleus. At the same time the head of the spermatozoon (which it will be membeed is formed from the nucleus) separates from the middle piece and tail, and transforms it self into the mle pronucleus (fig. 5. 2D).

The male and female pronculei meet, but they do not fuse on enucleus. Their nuclear membrane disappear and their chromosomes become distinct. It will be recalled that each pronucles has 23 chromosomes so that the fertilized ovum now has 46 chromosomes in all (fig 5. 3A)

Each of these 46 chromosomes splits into two (fig. 5. 3B). Meanwhile, a spindle has formed and one chromosome of each pair moves to each end of the spndle (as in mitosis), leading to the formation of wo daughter cells fig. (5. 3C). This is called the two-cell stage of the embryo. Note that strictly speaking there is no one-cell stage of the embryo (fig, 6A).

Important points to note a this stage are that :

(i) the two daughter cells are still surrounded by the zona pelluicida:

(ii) each aughter cell in much smaller than the ovum. As subsequent division occur the cell become smaller and small until they acquire the size of most cells of the body.

CLEAVAGE

The two cells formed as described above undergo a series of division. One cell divides from so that we have '3-cell' stage of the embryo (fig. 6B) followed by a '4-cell' stge (fg. 6C), a 5 - cell' stage etc. This process of subdivision of the ovum into smaller cells is called cleavage. These cells are called blastomeres.

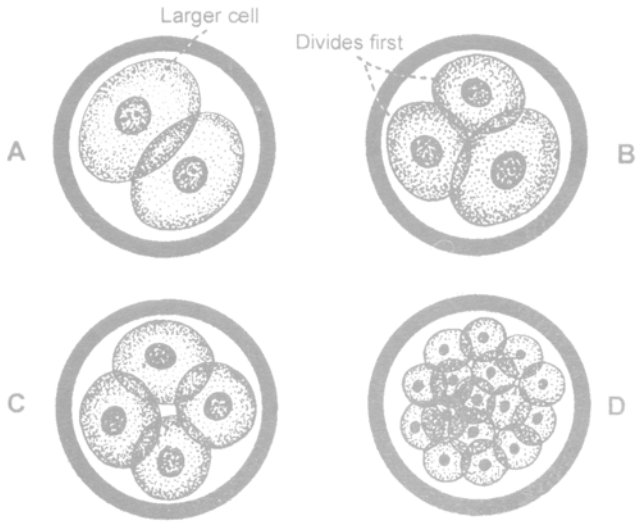


Fig 6

As cleavage proceeds the ovume comes to have 16 cell. It know look s like a mulberry and is called the morula (fig. 6D). It is still surrounded by the zona pellucida. If we cut a section across the morula we see that it consists of an inner cell mass that is completely surrounded by an outer layer of cells, (Compaction). The cells of the outer layer will later give rise to a structure called the trophoblast (fig. 7A). The inner cell mass gives rise to the embryo proper, where as the cells of the trophoblast help to provide nutrition to the embryo.

Some fluid now passes into the morulla from the uterine cavity, and partilly separates the cells of the inner cell mass from those of the trophoblast (fig. 7B). As the quantity of fluid increases, the morula acquires the shape of a cyst. The cells of the trophoblast become flattened and the innter cell mas comes to be attached to the inner side of the trophoblast on one side only (fig. 7C). The morula has now become a blastocyst. That side of the blastocyst to which the inner cell mass is attached is called the embryonic or animal pole. While the opposite side is the vegetal or obembryonic pole.

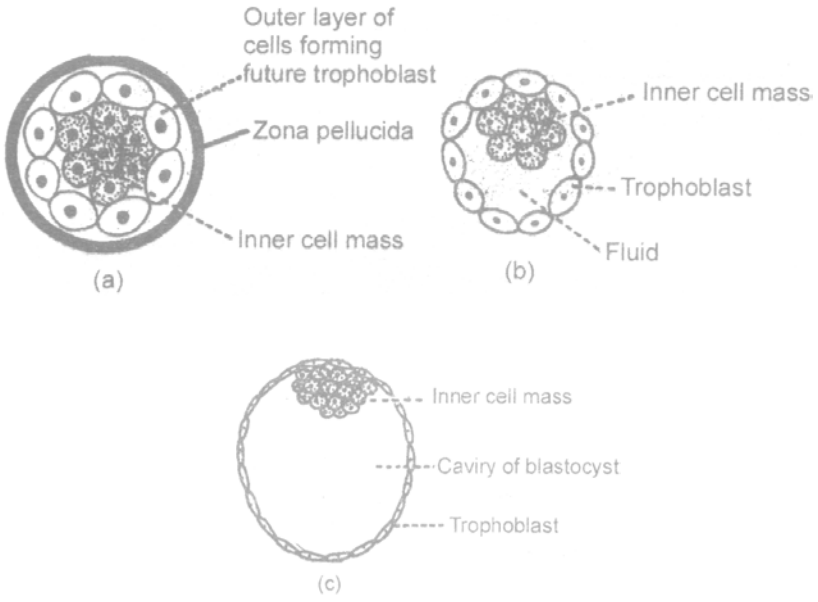


Fig 7

Function of the zona pellucida

The trophoblast has the property of being able to stick to the uterine (or other) epithelium and its cells have the capacity to eat up other cells. As the embryo travels down the uterine tube, and the upper most part of the uterine cavity; it is prevented from ‘stickin’ to the empthelium by the zona pellucida.

FORMATION OF GERM LAYERS (GASTRULATION

At the blatocyts develops further, it gives rise not only to the tissues and organs of the embryo, but also to a number of structures that support of the embryo and help it to acquire nutrition. At a very early stage in development the embryo proper acquires the form of a three-layered disc. This is called the embryonic disc (also called embryonic area, embryonic sheild, or germ disc) The three layers the constitute this embryonic disc are.

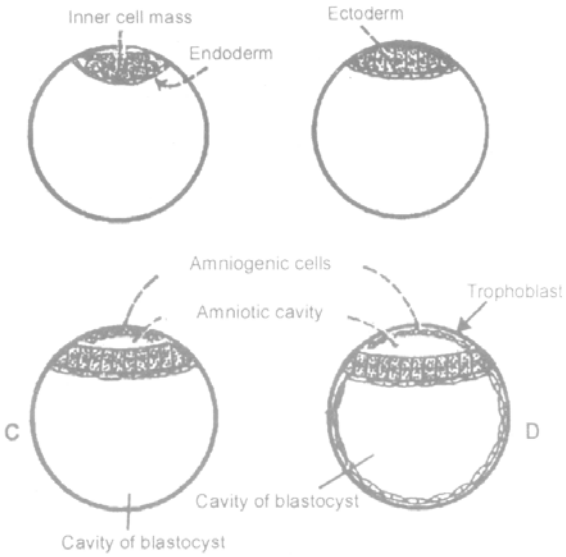
(i) Endoderm (endo = inside)
(ii) Ectoderm (ecto = outside)
(iii) Mesoderm (meso = in the middle)

These are the trhee germ layers. All tisues of the body are derived from one or more of these layers. We have seen that the blastocyts is a spherical cysts lines by flattened trophoblastic cell, and that inside it there is a mas of cell, the inner cell mass, attached eccentrically to the trophoblast. Further changes are as follows.

(a) Some cells of the inner cell mass differentiate (i. e. they become different from others) into flattened cells, that come to line its free surface (fig. 8A). These are called hypoblast and constitute the endoderm, which is thus the first germ layer to be formed.

(b) The remaining cell of the inner cell mass become clumnar (fig. 8B). These cells are called epiblast and form the second germ layer, the ectoderm. The embryo is now in the form of a disc having two layers.

(c) A space appears between the ectoderm (below) and the trophoblast (above). This is the amniotic cavity (fib. 8C), filled by amniotic fluid, or liquor aminii. The rood of this cavity is formed by amniogenic cells (cells of Ruaber) derived from the trophoblast, while its floor is formed by the ectoderm.



(d) Flattened cells arising from the endoderm, speard and line the inside of the blastocystic cavity. In this way, a cavity, lined on all sides by cells of endodermal origin, is formed. This cavity in called the primary yolk sac (fig. 8D).

(e) The cells of the trophoblast give origin to a mass of cells called the extra - embryonic mesoderm (or primary mesoderm). These cells come to lie between the trophoblst and the flattened endodermal cells lining the yolk sac, thus separating them from each other. These cells also separate the wall of the amniotic cavity from the trophoblast (fig. 9A).
This mesoderm is called extra - embryonic because it lies out side the embryonic disc. It does not give rise to any tissues of the embryo itself.

(f) Small cavities appear in the extra-embryonic mesoderm. Gradually these join together to form larger spaces and, ultimately, one large space is formed. This cavity is called the extra-embryonic coelom (fig. 9B). Whit its formation, the exra-embryonic mesoderm is split into two layers. The part lining the inside of the trophoblast, and the outside of the amniotic cavity, is called the parietal or somatopleuric extra-embryonic mesoderm. The part lining the outside of the yolk sac is called the visceral or splanchnopleuric extra-em bryonic mesoderm. (fig. 9B), it will be seen that the extra-embryonic coelom does not extent into that part of the extra-embryonic mesoderm which attaches the wall of the amniotic cavity to the trophoblast. The developing embryo, along with the amniotic cavity and the yolk sac, is now suspended in the extra-embryonic coelom, and is attached to the wall of the blastocyst (i. e. traphoblast) only by this unsplitted part of the extra-embryonic mesoderm. This mesoderm forms a structure called the connecting stalk.

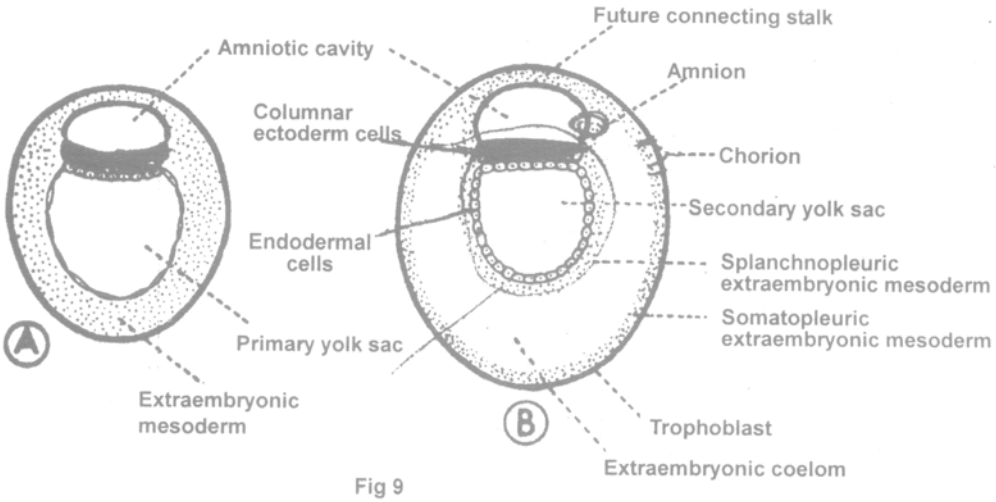


Fig 9

(g) **Formation of chorion and amnion :** At this stage, two very important membranes are formed. One is formed by the pariettal extra-embyonic mesoderm (on the inside) and the overlying trophoblast (on the outside) this is called the chorin (fig. 9B). The other is the amnion which is constituted by the amniogenic cells forming the wall of the amniotic cavity (excluding th eectodermal floor). These cells are derived from the trophoblast. We have already seen that the amnion is sovered by the unsplit exra embryonic mesoderm, and that the connecting stalk is attached to it.

(h) With the appearance of the extra-embryonic mesoderm, and later of the extra-embryonic coelom, the yolk sac becomes much smaller than before and is now called the secondary yolk sac. This alteration in size is accompanied by a change in the nature of the lining cells. They care no longer flattended but cecome cubical (fig. 9B).

(i) At this stage, the embryo proper is a circular disc composed of two layers of cells : the upper layer (towards amniotic cavity) is the ectoderm, the cells of which are columnar, while the lower layer (towards yolk sac) is the endoerm, made up of cubical cells (fig. 10).

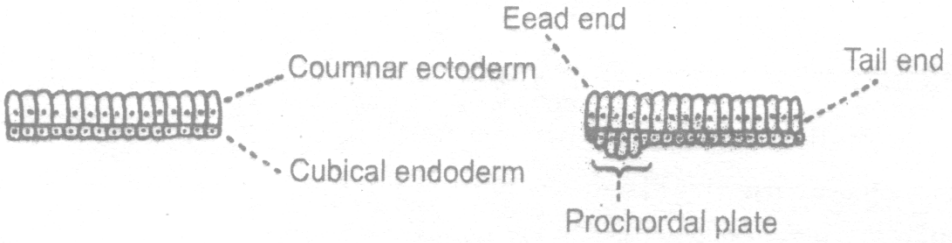


Fig 10

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(j) At one circular area a near the margin of the disc, the cubical cells of the endoderm become columnar. This area is called the prochordal plate. The appearacne of the prochordal plate determines the central axis of the embryo (i. e. anables us to divide it into right left halves), and also enables us to distinguish its head and tail ends (fig. 10).

(k) Soon after the formation of the prochordal plate some of the ectodermal cells lying along the central axis, near the tail end of the disc, begin to proliferate, and form an elevation that bulges into the amniotic cavity. This elevation in called the primitive streak (fig. 11). The primitive streak is at first a rounded or oval swelling, Primitive streak later forms the Henson's node.



(l) The cells that prolliferate in the region of the primitive streak pass sideways. pushing themselves between the ectoderm and endoderm (fig. 11). These cells form the intra-embryoinc mesoderm (or secondary mesoderm) which is the third germ layer.

Notochord

The notochord is a midine structure, that develops from mesoderm in dorsal region.

Importance of the notochord

The notocord is present in all animals that belong to the phylum Chordata. In some of them e. g. Amphioxus, it persists into adult life and forms the central axis of the body. In others, including man. it appears in the embryo but only small remainants of it remain in the adule. Notochord elongates considerably. and lies in the midine, in the position to be later occupied by the vertebral column. However. the notochord does not give rise to the vertebral column.

Neurulation : i. e. formation of neural tube. After neurluation there occur three type of ectoderm.

(i) Somatic ectoderm (ii) Neural tube ectoderm (iii) Neural crest ectoderm.

Anterior part of neural tube differentiates in brain and rest of the neural tube differentiates in spinal cord so central nervous system is formed by neural tube.

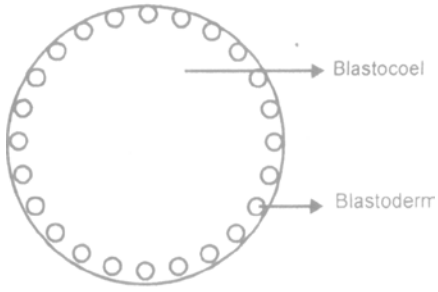
TERTOGENY

During the first 3 months of pregnancy the basic structure of baby is formed. This involves cell divison, cell division, cell migration, and the differentiation of cells into the many types found in the body. During this period, the daveloping baby called foetus is very sensitive t anything that interferes with davelopmental steps. Eg. Virs infeciion of mother by ruella (German measles) virus or exposure to certain chemicals may cause malformation in the daveloping embryo. Such agents are called teratogens (Monster Forming agents).

GENERAL STAGES OF EMBRYONIC DEVELOPMENT

1. Morula-As a result of segmentation or cleavage activities, unicellular zygote changes into a solid ball like multicellular structure. In the later stage f clseavage, clusters of sticky, cohering. protuding (outside) blastomeres are produced, which look like mulberry. This stage is termed as morula stage.

2. Blastulation :-Cleavage continues in solid ball like morula and new formed blastomeres start rearranging themselves. Cell-aggregation starts in blastomeres, due to the movement of these blastomeres a cavity apperrs in the embryo. It is called as blastocoel. This cavity is schizogenous cavity in origin i. e. it is formed by the separation of cells. Fell aggregation is also known as cohesion. Blastomeres arrange themselves in the form of a layer around the blastocoel, this layer is termed as blastoderm. The embryonic stage is now called blastula, and its formative activities is called blastulation.



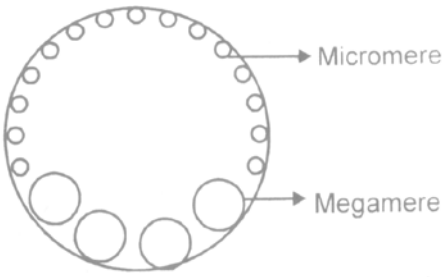
[Coeloblastula]

Types of blastula

The shape of blastula depends on so many factors e. g. size of eggs, amount of yolk, distribution of yolk in the eggs, frequency of cleavage and number of cleavage divisions. According to these factors, we can classify blastula of different animals in different categories.

(a) Coeloblastula (b) Stereoblastula
(c) Discoblastula (d) Blastocyst
(e) Superficial blastula or Periblastula

(a) Coelobastula –Blastocoel is wide and clear in this blastulation, it is completely surrounded by blastomeres on all the sides i. e, blastocoel cavity is situated totally inside the embryo. Blastoneres are very small in size as compared to blastomers

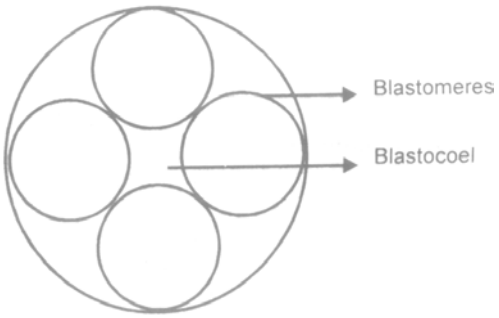


[Amphiblastula]

Example :- eggs of Amphioxs, coelenterata, amphibia, sponges etc.
Coeloblastula of amphibians is called amphiblastula because in it blastocoel cavity is accentaric in position and is more towards the animal pole (amount of yolk is more towards the vegetal pole). Amphiblastula of sponges is a gree swimming larva, its blastomeres are flaggillated. This larva swims frelly with the help of these flagella. it is a unique feature is sponges.

(b) Stereoblastula :- in this blastocoel is very narrow or obliterated. Blastomeres are large as compared to blastocoel. It is almost solid.

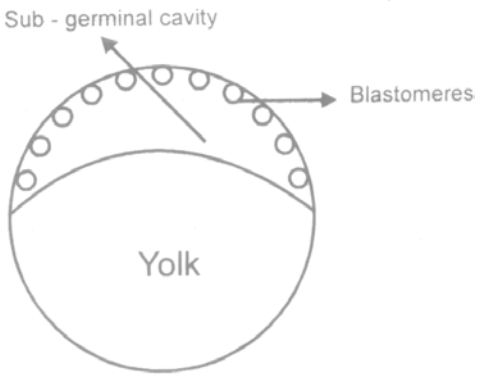
Example- eggs of Neries, and members or phylum Mollusca.



[Stereoblastula]

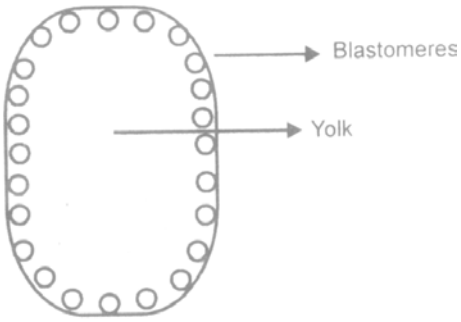
(c) Discoblastula :- It is found in those animals which have discoidal eggs. There is a cavity present in between blastomeres and yolk. it is called subgerminal cavity. It is a type of cavity, which is surrounded by yolk on one side and by blastomeres on the other side.

Examples :- eggs of reptiles, birds and prototheria.



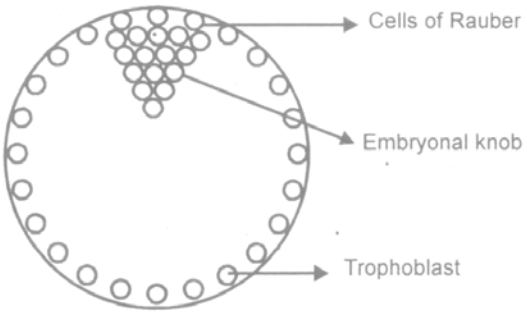
[Discoblastula]

(d) Superficial blastula or periblastula-
In centrolecithal eggs, cleavage occurs only in peripheral region. The layer of blastomeres surroundsthe centrally tuated yolk. Blastocoel is absent in this type of blastula. In place of blastocoel, subgerminal cavity is found.
Example – Eggs of insects.



[Periblastula]

(e) Blastocyst – blastula of Euterian & Metatierian mammals is called blastocyst, because blastula in the form of a cyst.



[Blastocyst]

B;asti;a – of mammals is called blastocyst. In blastocyst all the embryonal cells occur in the form of solid mass called embryonal knob. Embryonal knob(inner cell mass) is covered by protective layer called trophoblast and it 's cell just above the embryonal knob are called cells of Rauber (amniogenic cells). There occurs a cavity in betweem embryonal knob and trophoblast called albumin cavity. it is filled with nutritive fluid absorbed from the wall of uterus. So albumin cavity is also nutritive – cavity.

3. Gastrulation

Gastrula : in astrula stage rate of cleavage division is slow and ultimately stops at the end of gastrula. Gastrula stage is the most important stage in embryonic development because two main events take place during gadytuls stage.

(a) Defferentiation of blatomere: As a result of differentiation of blastomere; three germinal layers i. e. ectoderm, mesoderm and endoderm are formed. Formation of three germinal layers is the significance of gastrula stage. All the preparation of differentiation of blastomere are completed in late blastula stage.

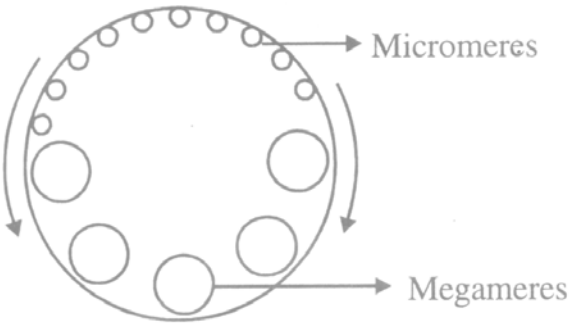
(b) Morhogenetic Movements : During gastrula stage blastomere perform amoeboid movement and reach to their definite place in embryo because after the gastrulation organogenesis has to start I embryo. Morphogenetic movement requires enormous energy. So respiratory activity of egg increases. Embryo consumes maximum O2 during gastrula stage.

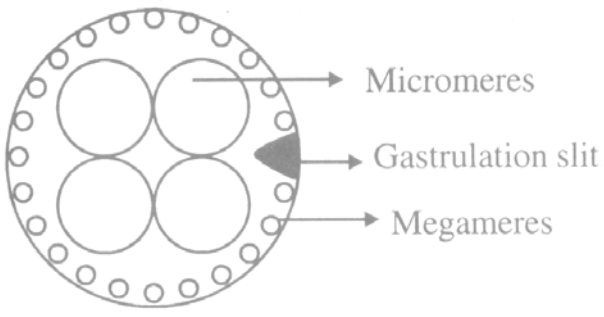
Method of Gastrulation :

(a) Epiboly : Movement of ectoderm forming blastomere

(b) Emboly : Movement of mesoderm and endoderm forming blastomere.

(a) Epiboly : IN epiboly, ectoderm forming blastomere undergo division to form outsise. Epioly is clearly visible in animal with amphiblastula. In amphiblastula ectoderm is derived form outer most layer of dividing micromeres.



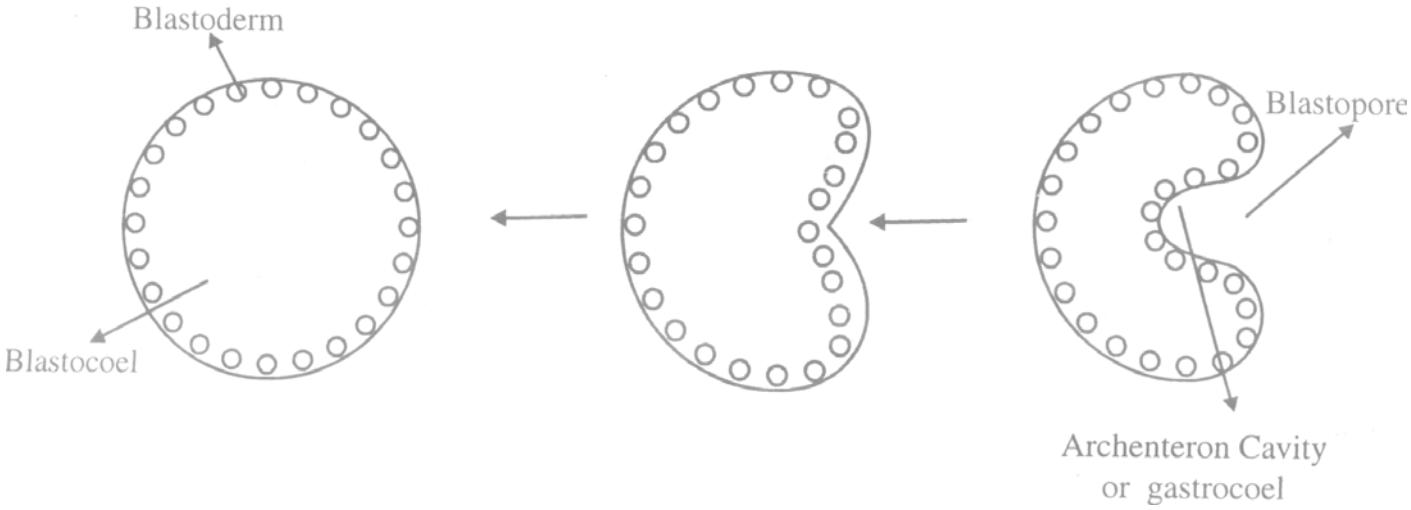


These micromeres perform amoeboid movement and cover the megamer form outside. Megameres without any movement establish inside the embryo because they are heavily filled with yolk. At one definite place in embryo micromeres do not perform any movement to cover the megameres this place occurs in the form of depression is called gastrulation slit or future blastopore. It is formed in grey crescent area.

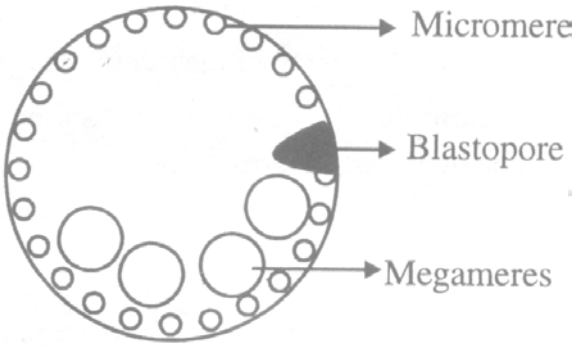
In some animals there occur special type of epiboly is called Apiauxis. in this process ectoderm forming micromere are received from two sources.
(1) By the division of micromere
(2) By budding of megamere. (Eg, - Ctenophora. Annelida, Molllusca and Fishes).

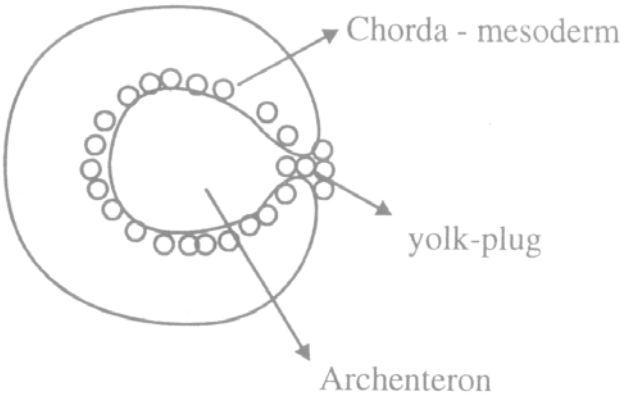
(b) Emboly : Mesoderm and endoderm forming blastomere perform movement and establish inside the embryo. there are three methods of emboly.

(i) I nvagination : emboly mainly takes place by invagination in animal with simple coeloblastula. In coelblastula a part of blastoderm invaginate in embryo. as a result blastocoel cavity degenerates and new cavity forms outside to inside called archenteron. Opening of archenteron is called blastopore. Archenteron forms alimentary canal. Blastopore forms mouth in protostomia animals ans anus in deuterostomia animal. As a result of invagination blastomer which fill the blastocoel form mesoderm and endoderm. Blastomere of outer layer form ectoderm i. e. all the three germinal layer are formed by emboly in coeloblastula. Epiboly is absent in coeloblastula.

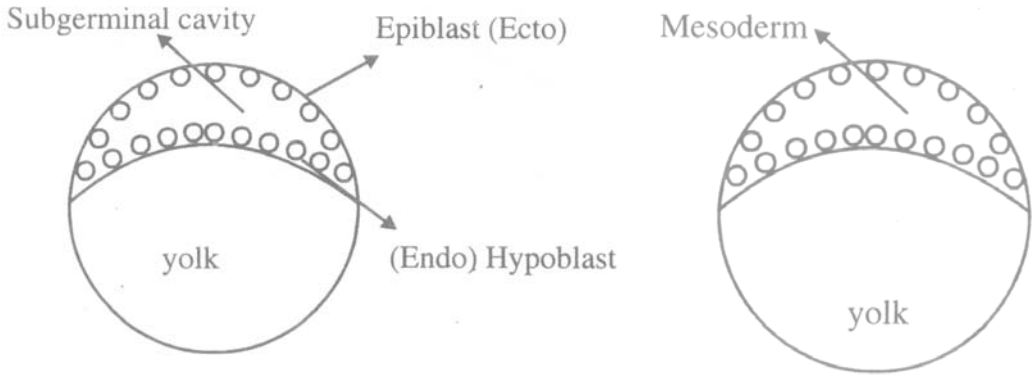


(ii) Involution : i. e. rolling movement of blastomere. Emboly mainly takes place by involution in animal with amphiblastula. In amimal with amphiblastula. In amphiblastula micromeres move from different directions towards future blastopore, this movement is called covergence. After convergence, second step is involution (i. e. blastomere perform rolling movement and enter in blastocoel with the help of future blastopore) now all the blastomeres move in different direction in blastocoel, this is called divergence. As a result of divergence blastocoel cavity degenerates and new cavity called archenteron is formed. Opening of archenteron is called blastopore. All the involuted blastomeres are collectively called 'Chorda mesoderm'. At the end of gastrula, outgrowth occurs in some megamere i. e. megameres evaginate outside andclose the blastopore temporarily (yolk –pluge stage) yolk-pluge stage indicates completion of gastrulation.





(3) **Poly-invagination or ingression :** Emboly mainly takes poly – invagination in discoblastula, peniblastula.



Gastrulation in discoblastula :

In discoblastula, gastrulation takes place by two methods :

(i) **Delamination :** In delamination all the blastomere of blastoderm undergoes division. As a result new mlastomere form and new blastomere fall on the floor of subgerminal cavity. So embryo become doublelayered. Upper layer of blastomere is called epiblast and lower – layer of blastomere is called hypoblast. Hypoblast differentiates in endoderm.

(ii) **Polyinvaginations :** All the blastomere of epiblast undergo to form new blastomere and new blastomere fall insubgerminal cavity form different direction and fill the subgerminal cavity. blastomere which fill the suberminal cavity are collectively called chorda-mesoderm. (chorda mesoderm forms mesoderm) Blastomeres which are left outside i. e. blastomere of epiblast form ectoderm. in such blastulas no new cavity is formed during gastrula stage i. e. archenteron formation does not occur during gastrula stage.

SPECIAL POINTS

1. The growth phase is the longest phase during male gametogenesis. But in human oogenesis, maturation phase is longest.
2. The acrosome of sperm are produced by golgibodies.
3. The smallest sperm is of crocodile and its size is 0. 02 m & largest sperm is of Discoglossus (2mm)
4. 74 days are required to complete the cycle of spermatogenesis in human being.
5. In 1 ml of semen, 20 to 120 millions of sperms are present in being.
6. Deficiency in the number of sperms result in sterility which is known as oligospermia.
7. Absence of sperms in semen is known as azoospermia.
8. Formation of yolk in oogenesis takes place in the growth phase.
9. Largest egg is of Ostrich (16 cm long with its shell).
10. Althouh normal number of sperm are present in semen but if these are completely non mothile. This condition is known as necrospermia.
11. Smallest eggin birds is of humming bird.
12. Due to high mortality rate in lower animals, the production of egg is more.
13. Sequence of egg production is as follows.
    Mammals<Aves<Reptiles<amphibian<Pisces.
14. Cat and rabbit both are induced ovulator.
15. The life span of eggs in female reproductive organs in human being is 48 hrs.
16. The nucleus of egg is known as germinal vesicle.
17. At the age of 45-50 yrs. In female the ovulation process will stop which is known as mwnoause.
18. The spermiation (release of sperms from sertoli cells) in all sertoli cells occurs simultaneously.
19. Cortical granules are absent in rat.
20. Mosaic type of cleavage is found in the parasite Echinococcus granulosus.

Special features of some animals :

(a) Sperms of some animals are not having flagella:

eg. (1) Ascaris – sperm is amoeboid

(2) Cray fish – star shaped. tail les sperm

(3) In crab and lobuster the sperm are tail less and have three sharp processes.

(b) Biflagellated sperm :

eg. In toad fish (Opsanus) head of many sperms unite together and form sperm boats.

In Gastropods, the sperms are hexaflagellated.

Smallest sperm- Crocodile (0. 02mm)

Largest sperm- Discoglossus (2mm) in chordates and Drosophila in entire animal kingdom.

Shape of head part of sperms :

(i) Spherical – eg teleostel

(ii) Lance shaped –eg amphibia and Reptiles

(iii) Spiral end –eg. Birds

(iv) Spoon shaped – eg. Mammals (in man)

(v) Hook like – eg. Rat.