

SPERMATOGENESIS

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Site of occurrence - Spermatogenesis takes place in seminiferous tubules of the testis. The seminiferous tubules are lined (germinal) by germinal epithelium. The latter consists largely of cuboidal primary germ cells but contains certain tall somatic cells called Sertoli or nurse cells here and there.

(Primary germ cells) Sertoli

Spermatogenesis is a continuous process but, for convenience is often divided into two stages -

Germ - spermatid formation of spermatids from the undifferentiated germ cells
spermatid - spermatozoon formation of spermatozoa from the spermatids.

Formation of Spermatids - This process has 3 phases -

a) Multiplication - The undifferentiated germ cells present in the seminiferous tubules of the testis are called spermatogonia or sperm mother cells. They are proliferated by mitotic division from the primary germ cells of the germinal epithelium lining the seminiferous tubules. The spermatogonia have prominent nuclei that contain 2n or diploid number of chromosomes 46 in humans. The spermatogonia increase their population by repeated mitotic divisions so that each nearly formed spermatogonium possesses the same number of chromosomes i.e. 46.

b) Growth phase - On sexual maturity of the animal, some spermatogonia stop dividing and grow in size by accumulating cytoplasm and replicating DNA and are then termed the primary spermatocytes. The growth phase →

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→ is also called spermatocytogenesis as it give rise to the spermatocytes. The latter are about twice in size of the spermatogonia. Other spermatogonia continue to divide mitotically and produce more spermatogonia for later spermatogenesis.

③ Maturation phase - The primary spermatocytes

Primary
Secondary
Spermatocytes (1MP)
Spermatids (2MN)

undergo first mitotic division and produce secondary spermatocytes. This division is reductional so that each secondary spermatocyte contain half number of chromosomes i.e. 23 in humans. The secondary spermatocytes soon undergo the second meiotic division and produce spermatids. This division is equational. Therefore each spermatid contains to possess the haploid number of chromosomes, which is 23 in human. The spermatids resemble other cells in the testis in their form.

In the cell division producing secondary spermatocytes and spermatids, the cytoplasmic division is not complete so that daughter cells remain interconnected. It is during spermiogenesis that the gametes separated from each other.



Formation of spermatозоа:

The spermatids do not divide further and modify a metamorphose into spermatозоа, which are also haploid. A spermatogonium thus produces four spermatозоа.

Spermatogenesis is the transformation of spermatids into spermatозоа. It involves the movement of cell organelles to positions characteristic of mature spermatозоа, certain changes in the cell organelles, and loss of a good deal of Golgi apparatus, cytoplasm and water. Development of sperm cell takes about 2 months. The fully formed sperm become ~~free~~ free in the cavity of the seminiferous tubules. The process of release of spermatозоа from seminiferous tubule cells into the cavity of seminiferous tubules is called spermiation. From here they pass via vasa efferentia into the epididymis for temporary storage.

Structure of Spermatозоа:

A spermatозоа consist of 4 parts - head, neck, middle piece and tail.

1) Head - it is a flat and oval in human sperm. It consist of a large posterior nucleus and small anterior acrosome. The nucleus

*Dorsalized
hyaloplasm.
Stirrer
RNA - eliminated
DNA present
histone
proteamine*

①
→ consist only of condensed DNA and basic protein.
Acrosome is formed from lysosome. It contains hydrolytic enzyme and used to contact and penetrate the egg in fertilization.

- a) Neck - The neck is very short and contains two centrioles lying behind and at right angles to the other. The proximal centriole plays a role in the first cleavage of the zygote. A distal centriole give rise to the axial filament of the sperm.
- b) Middle piece - The middle piece is cylindrical in human sperm. It contains many mitochondrial tightly coiled around the axial filament. The mitochondria provide energy for the movement of the sperm in the female's genital tract. Middle piece therefore, is also termed as power house of the spermatogenesis zone. The amount of energy is limited. If a sperm fails to contact contact an ovum within a specific period (24-98h), it exhausts its energy and dies.
- c) Tail - The tail is very long, slender and tapering and is formed of cytoplasm. At fine thread, the axial filament arises from the posterior centriole and transverses the middle piece and tail. It may project briefly behind the tail as an end piece. The entire sperm is enclosed by a plasma membr. The spermatogen



swim about by vibrating their tail in a fluid medium in search of ova.

Function / Role of Sertoli cell -

During spermatogenesis the germ cells are closely associated with the sertoli cells. Spermatogonia lie between the sertoli cells and the basal lamina. Other stages occur in pockets along the sides of the sertoli cells. The sertoli cells provide mechanical support, protection and nourishment to the developing spermatozoa. All nutrient, gases and waste exchange between the developing spermatoza and blood vessels around the seminiferous tubules pass via the sertoli cells.

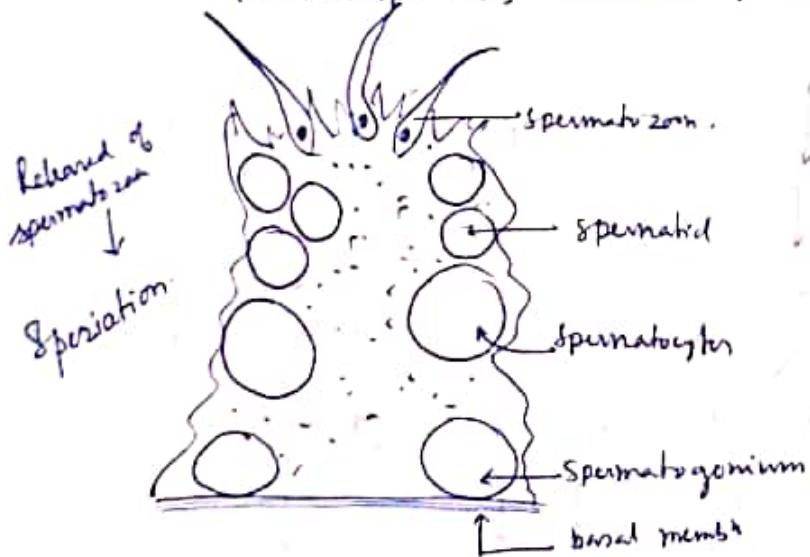
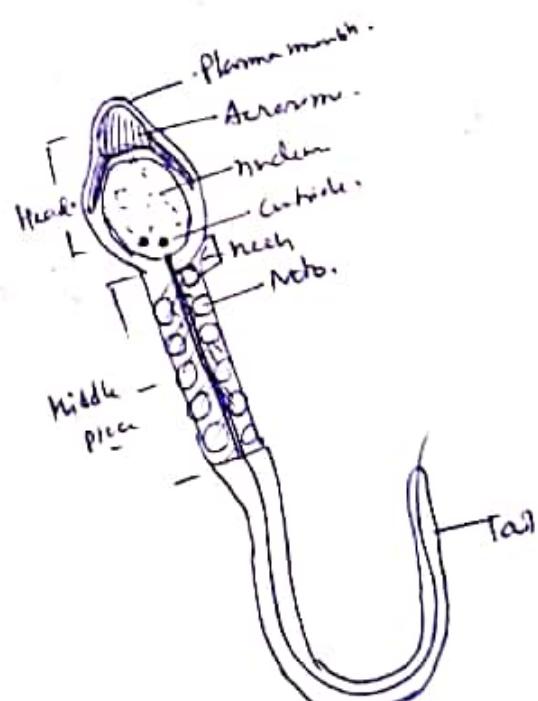
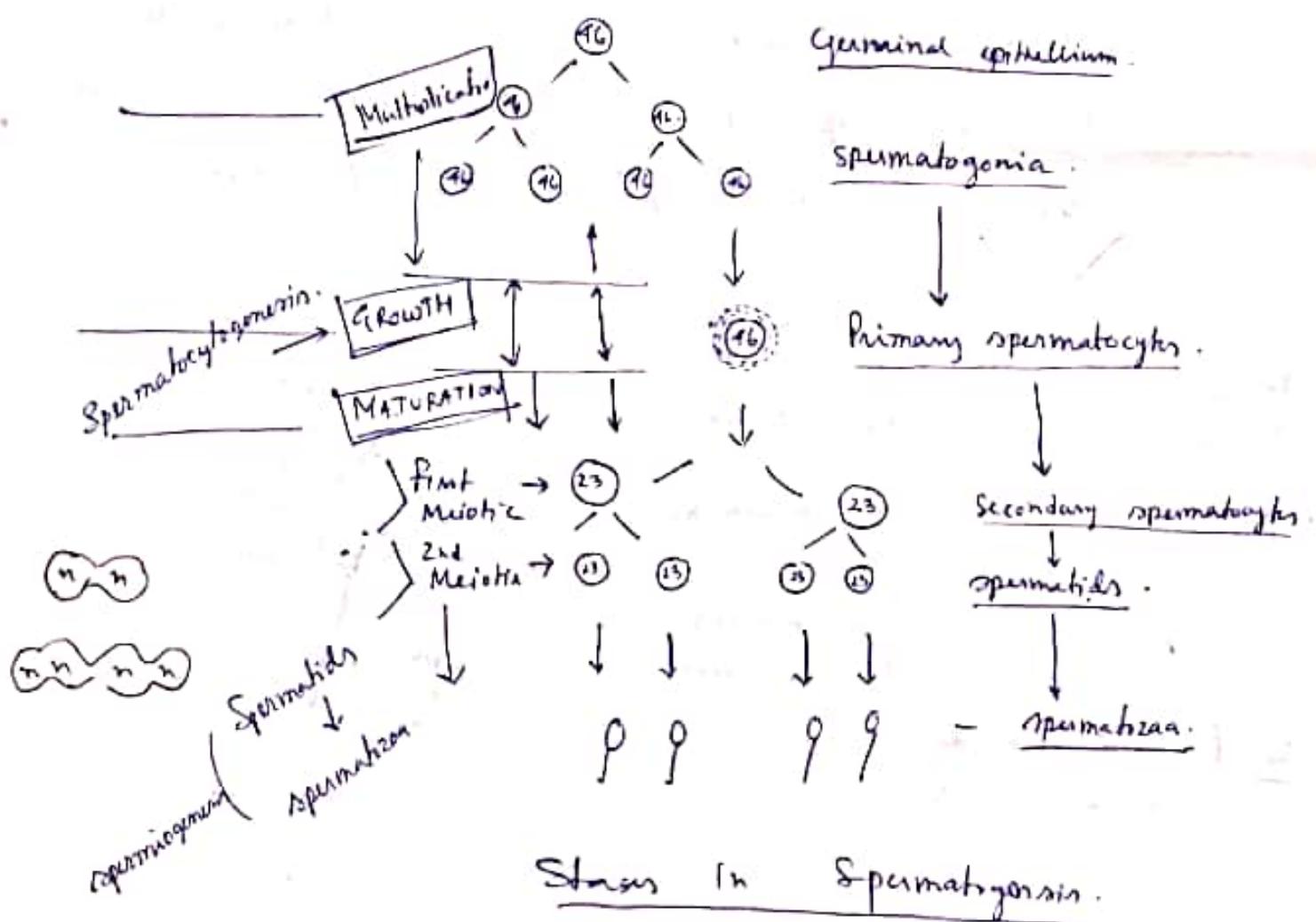


Fig :- Relationship b/w developing spermatozae & Sertoli cell -



Additional function of Sertoli cell.

The fluid carrying spermatozoa through the tubules is secreted by the Sertoli cells. Sertoli cell also synthesizes and androgen binding protein, by which it helps maintain a high androgen level in the seminiferous tubules necessary for spermatogenesis. Sertoli cell act as phagocytic too. They consume the residual cytoplasm discarded during spermatogenesis.



Preadultine Growth Period

During this period no synthesis and accumulation of food reserve materials, i.e. yolk takes place but volume of nucleus and cytoplasm increases.

a) Growth of nuclear substances-

The nucleus of the primary oocyte become enlarged mainly because of the rapid production of a large amount of nuclear sap. The large aged nucleus of advancing oocytes is filled with fluid and called germinal vesicle. Homologous chromosomes pair together and each chromosome increases in its length. In the primary oocytes of animals having large eggs (amphibia) the chromosomes assume quite very characteristic appearance - thin threads or loops are thrown out on both sides in transverse plan to the main axis of chromosome making the chromosomes look like lamp brushes - called lampbrush chromosomes. In the loop of chromosomes, histone and non-histone proteins become displaced, so that DNA of loop becomes engaged in active transcription of DNA like ribonucleic acid or mRNA. Thus each lampbrush chromosome transcriptionally manufactures numerous molecules of mRNA, which have copied down the genetic information of DNA. Chromosomal loops and then, ^{tiny} have passed into the oocyte cytoplasm, where proteins are being synthesized in course of

growth of the oocytes. All the mRNA mol. are not utilized in protein synthesis during the oocytes growth period, but some are made inactivated and stored as informeromes to be used during early cleavage of eggs.

Besides mRNA, chromosomal DNA of primary oocytes also synthesizes molecules of tRNA and sRNA, both of which are also transported to the cytoplasm.

Moreover, during growth a period of primary oocytes, the nucleolus increases greatly in size and becomes very conspicuous against the background of the vesicular nucleus.

Gene amplification.

The increased transcription activity (RNA synthesis) of chromosomal genes during growth period of oocytes is called gene amplification or ~~the~~ redundancy. It is evident by following fact -

- The oocyte chromosomes give out loops and become lampbrush chromosomes to make more gene transcriptionally active for rRNA or mRNA synthesis.
- Several mRNA mol. can be transcribed from each gene.
- Each mRNA mol. in turn can be translated several times into the corresponding proteins.
- ^{rRNA} mol. are synthesized in such a large number that mol. either becomes large sized or the number greatly increases to per nucleus.

b) Growth of cytoplasmic substances

During this period, the amount of cytoplasm of oocyte increases in quantity as well as in quality by the elaboration and regular distribution of various cell inclusions. The mitochondria, number is less in young oocytes but may increase in number very considerably during the growth of primary oocytes and in some animals (Birds, amphibia) be aggregated to in the form of "mitochondrial clouds". The ER in the young oocytes in the form of small vesicles but the developing oocytes also contain annulated lamellae in their cytoplasm. In young oocytes Golgi complex is found around the centrosome, but in mature it either becomes well developed and forming large spherical mass in some mammals and functions as manufacturing the cortical granules.

Vitellogenesis Growth period.

Synthesis and deposition of yolk in the oocyte is called Vitellogenesis.

The vitellogenesis growth period is the period of rapid growth, because during this period the egg cytoplasm is packaged by reserve food materials such as glycogen, carbohydrates, lipid and proteins, all of which collectively called yolk or Vitellin.

Yolk is the usual form of food storage in the growing oocyte and egg. chemically it is composed of proteins, phospholipids and neutral fats. It may be called 'Protein yolk' when it has more protein than lipids or 'fatty yolk' where it has more fat content than the protein. Both of these kind of yolk occur in following two forms — (form of yolk) 
Yolk formation or Vitellogenesis.

Although in some species, the yolk may possibly be synthesized by the oocytes themselves, but according to most recent embryological investigation, the vitellogenesis or synthesis of different yolk component (Protein & Phospholipid) occurs in some extraovarian tissue, such as fat bodies in insect and liver in most vertebrates.

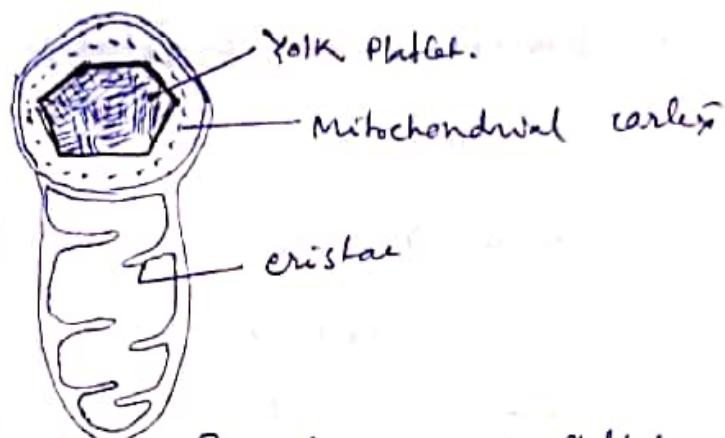
Invertebrate: From the liver, the yolk component are transported in soluble state to some ovarian cells, such as follicle cells, by the blood stream. As a developing oocyte of vertebrate remains surrounded by follicle cells, so from these follicle cells,

— the oocyte takes them through their microvilli by the process of Pinocytosis. The Golgi complex and ER transport these yolk component to the modified mitochondria of oocyte. Inside the mitochondria these yolk component are made insoluble by a mitochondrial enzyme Protein kinase and ultimately yolk granules or yolk platelets are synthesized. During the crystallization process of yolk platelets the mitochondrial cristae become dislodged and their membranes ultimately becomes arranged in concentric layers while the whole mitochondrial space is taken up by the main body of yolk platelet.

In invertebrates mainly insects, the lipid component of yolk first accumulated into follicle cells and then, is transferred from them to the oocytes. The protein component of yolk is either manufactured in midgut and then transferred to ovaries by haemolymph or synthesized in follicle cells. It is either taken directly from the haemoceel or indirectly through the follicle cells by the oocyte, by the process of Pinocytosis. Pinocytic vesicles from the periphery fuse with the ER and these are joined by vesicles from the Golgi



Materials accumulated in the cisternae of ER, and eventually form the protein yolk spheres.



Formation of yolk platelet inside mitochondria.

Type of Yolk. Forms of yolk *

- (1) Granular yolk - In the eggs of invertebrates and lower chordates the protein yolk is found in the form of fine granules which remain evenly distributed in the cytoplasm of oocytes.
- (2) Yolk Platelets - In case of most vertebrate groups, the yolk occurs in the form of large granules called yolk platelets. The yolk platelets of amphibians have an oval shape and are flattened in one plane. The cytoplasm is densely packed with them. Chemically yolk plates (amphibia) contain two main proteinous substances — Phosvitin and Lipovitellin.