

: Spermatogenesis with respect to mammals :

The transition from mitotically active primordial germ cells to mature spermatozoa is called spermatogenesis, and it involves a sweeping series of structural transformations . Although there is a wide variety in the morphology of mature spermatozoa , the overall process of spermatogenesis is much the same throughout the vertebrate classes . This process can be broken down into three principal phases : 1) mitotic multiplication ,2) meiosis , and 3) spermiogenesis .

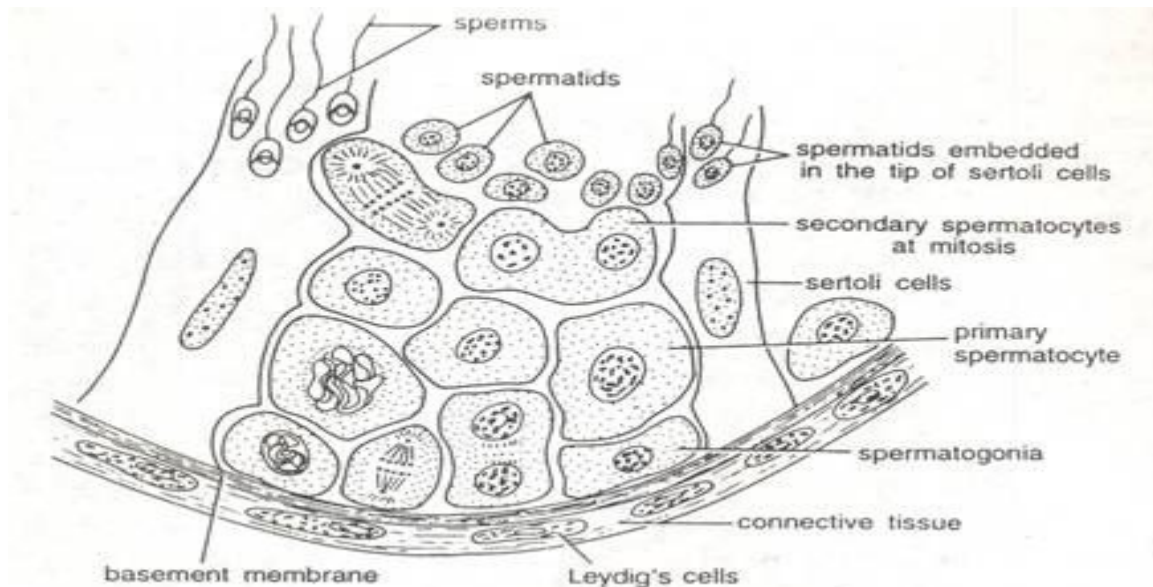


Fig. 2. T. S. of a part of a seminiferous tubule of human testis showing production of sperms.

Fig. no. #1 : Part of a seminiferous tubule showing production of sperms.

Mitosis of sperm - forming cells occurs throughout life , and the mitotically active cells within the seminiferous tubules are known as *spermatogonia*. These cells are concentrated near the outer wall of the seminiferous tubules. Spermatogonia have been subdivided in to two main populations . *Type -A spermatogonia* represent the stem -cell population . Within this population is a group of noncycling dark A cells that may be long- term reserve cells. Some of these cells become mitotically active pale A cells , which ultimately give rise to *type -B spermatogonia* .These are cells that have become committed to leaving the mitotic cycle and which go on to finish the process of spermatogenesis.

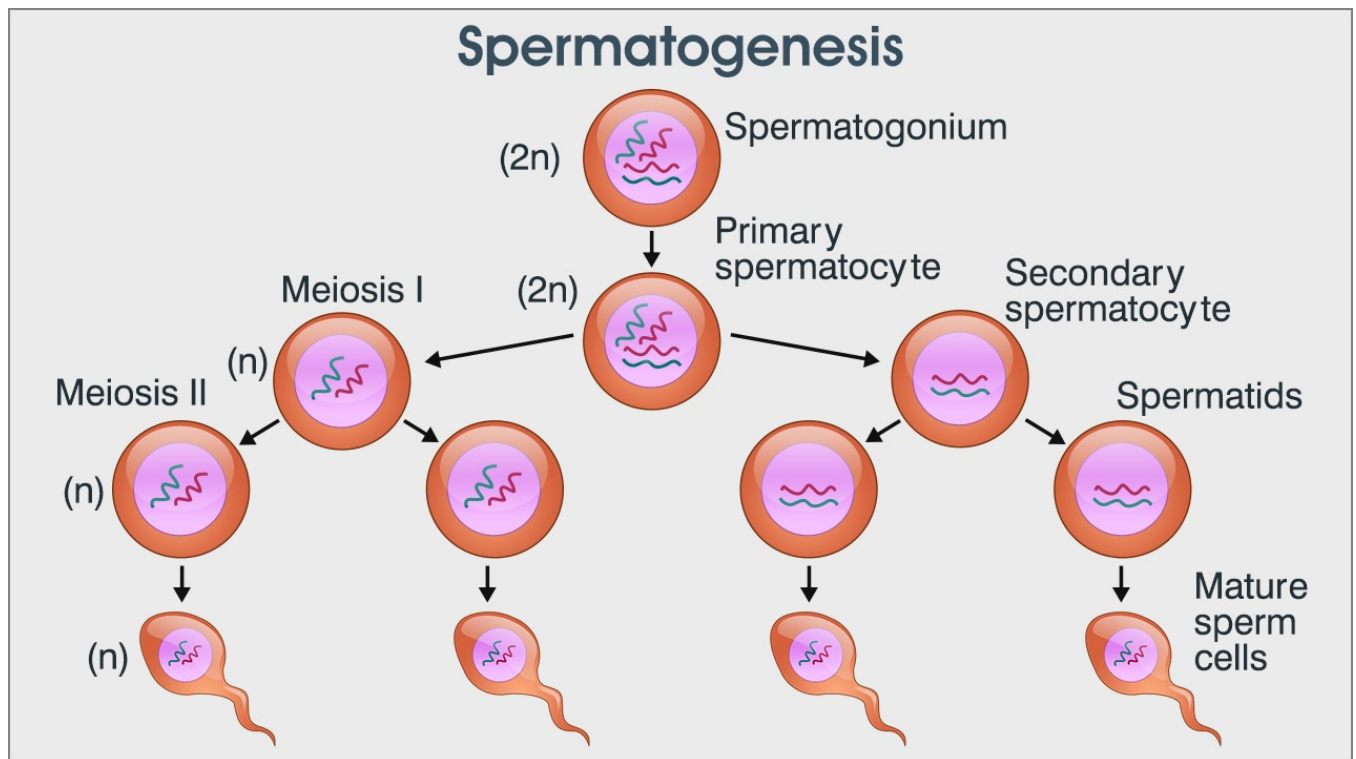


Fig no. #2 : Process of Spermatogenesis.

After the final round of DNA duplication, type-B cells are called preleptotene spermatocytes and are ready to pass through the meiotic phase of spermatogenesis. During the first meiotic division each primary spermatocyte divides into two equal daughter cells. With the onset of the second meiotic division these cells are known as secondary spermatocytes. In the human the first meiotic division lasts for several weeks, whereas the second one is completed in about 8 hours. For *haploid spermatids* result from the meiotic phase of spermatogenesis.

Although they no longer divide, the spermatids undergo a profound transformation from relatively ordinary looking cells to extremely specialized spermatozoa. The third phase in spermatogenesis is called *spermiogenesis*, or *spermatid metamorphosis*.

In the metamorphosis of a spermatid many radical changes occur. At the end of the second maturation division the nucleus is in typical interphase condition, with dispersed, finely granular chromatin and a reconstituted nuclear membrane. Almost immediately the nucleus begins to lose fluid, with a resultant decrease in its size and a concentration of its chromatin. This continues until the compacted chromatin comes to constitute the bulk of the head of the spermatozoon.

Concurrently, the cell organization changes. The cytoplasm streams away from the nucleus, which will become sperm head, leaving only a thin layer covering the nucleus. At the apical end of the developing sperm head, the golgi complex forms proacrosomal granules, which fuse to form acrosome. Within the cytoplasm centrioles become more conspicuous and appear to be a point of

anchorage for the developing flagellum. The distal centriole moves away from the proximal one, and microtubules from it become continuous with microtubules in the flagellum. Mitochondria begin to form a spiral investment around the proximal part of the flagellum. As spermiogenesis continues, the remaining cytoplasm becomes aggregated into a remnant, or residual body, which is sloughed off and phagocytised by the Sertoli cells. This leaves the mature spermatozoon stripped of all nonessential parts. It consists of 1) a head containing the nucleus and acrosome; 2) a neck containing the proximal centriole; 3) a middle piece containing the proximal part of the flagellum, the centrioles, and the mitochondrial helix, which acts as an energy source; 4) the tail, a highly specialized flagellum.

As early as the mitotic divisions of the type -A spermatogonia, the daughter cells are connected to one another by fine intercellular bridges of cytoplasm that are the result of incomplete cytokinesis (cell division) after mitosis. Clusters of interconnected cells are found throughout spermatogenesis until the late spermatid stage.

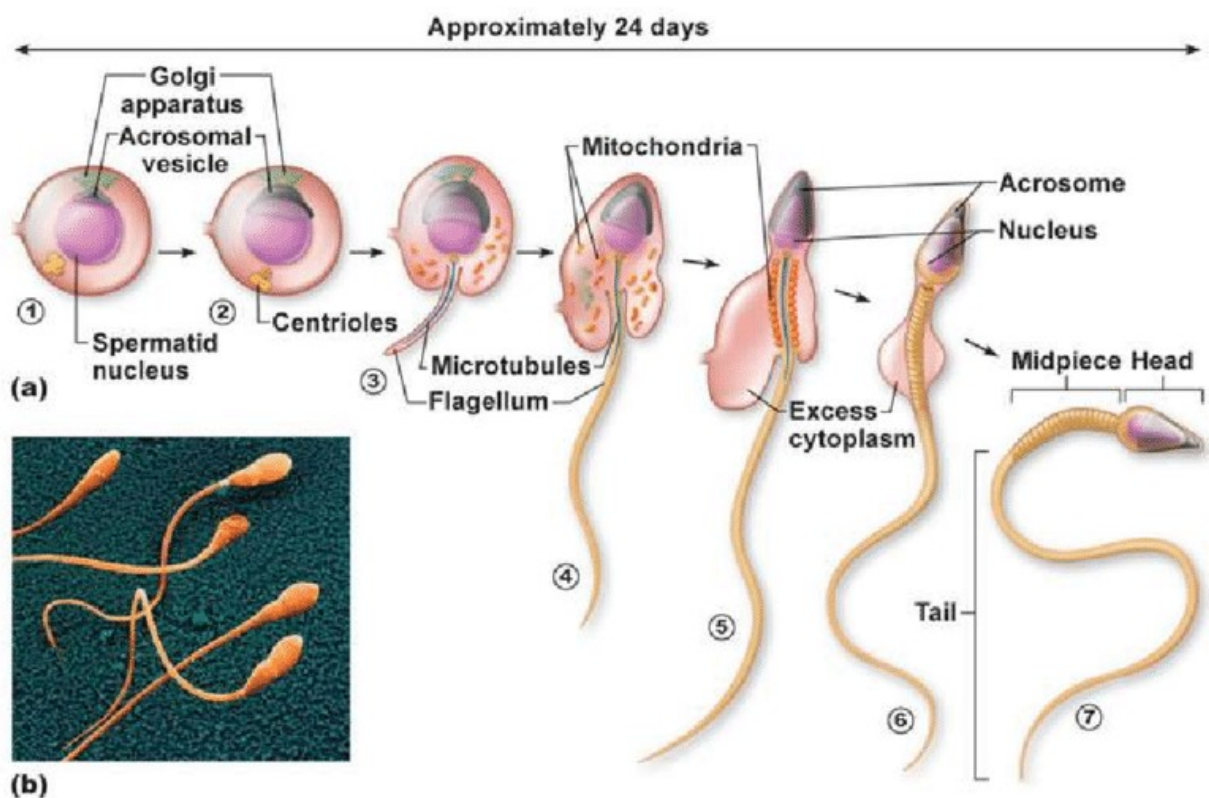


Fig. no.#3 : Process of Spermiogenesis.

During spermatogenesis, the cells are also closely associated with Sertoli cells, which lie at regular intervals along seminiferous tubule. Sertoli cells serve a wide variety of functions, including 1) being the target cells for FSH, 2) synthesizing of an androgen-binding protein that maintains a high concentration of testosterone inside the seminiferous tubule, 3) maintaining the blood-testis barrier, 4) creating an environment that is important in the differentiation of sperm cells, 5) facilitating the

release of mature spermatozoa , and 6) degrading the residual cytoplasm that is shed during spermiogenesis .

The blood testis barrier is necessary to prevent the body's immune system from destroying the maturing sperm cells , which are antigenically different from the rest of the body . The blood -testis barrier consists of a continuously interlocking sheet of sertoli cell processes , which are attached to one another by tight junctions . Outside the barrier are spermatogonia and spermatocytes that are just entering into meiosis .

Spermatocytes in the zygotene stage of meiosis pass through the blood - testis barrier. Passage through the barrier is accomplished by the Sertoli cells' extending processes and forming an impermeable layer on the outer side of the leptotene spermatocytes Concurrently , the original sertoli -cell barrier on the inner side of the cells is disrupted as the sertoli cells withdraw these processes .

Spermatogenesis is not a random process; rather, within the seminiferous tubules it is highly synchronized in regard to both time and location . The earliest stages of spermatogenesis occur at the periphery of the tubule, and progressively later stages are encountered closer to the lumen . However , all stages of spermatogenesis are not seen in the same section of the seminiferous tubule . Typically , several generations of developing sperm cells are present along any radial line drawn in a cross section of a tubule , and all cells within a given generation are in the same stage . In many mammals , such as the rat, well-defined waves of spermatogenesis can be delineated along the length of the seminiferous tubule . The distribution of cell associations in the human testis is more patchy than wave like in nature . In human , the time required for a spermatogonium to develop into a spermatozoon is about 64 days.

Gene Expression during spermatogenesis :

In mammals , postmeiotic gene expression was long considered impossible , but molecular techniques have clearly shown the production of proteins during virtually all stages of spermatogenesis , both during and after meiosis . Almost 100 proteins in the mouse are formed after completion of the second meiotic division.

Sperm Maturation :

Although in many invertebrates and vertebrates that rely on external fertilization, sperm taken directly from the testes are capable of fertilizing eggs, those of mammals are not. Despite their appearance of morphological maturity, newly formed mammalian spermatozoa are minimally functional. During their leisurely transit from the seminiferous tubules to the tail of the epididymis, where they are retained until their ejaculation, the spermatozoa are exposed to a series of different humoral environments within the male genital duct system. The metabolic apparatus of the spermatozoa becomes more capable of translating chemical energy into a certain degree of motility. In addition, the head of the sperm becomes covered with a glycoprotein coating which must be removed in the female reproductive tract before fertilization can occur. A final phase of sperm maturation in the male reproductive tract might better be called activation, after ejaculated spermatozoa have come into contact with the seminal fluid secreted by the seminal vesicle and prostate gland. The seminal fluid provides the functionally mature sperm with an external energy source which allows it to gain full motility.

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Ref. Book : (1) "Foundations of Embryology" - by Bruce M Carlson.

(2) General Zoology in Bengali by Chandra Sekhar Chakraborty.

(3) "Introduction to General Zoology" - by Chaki & Kundu & Sarkar.