

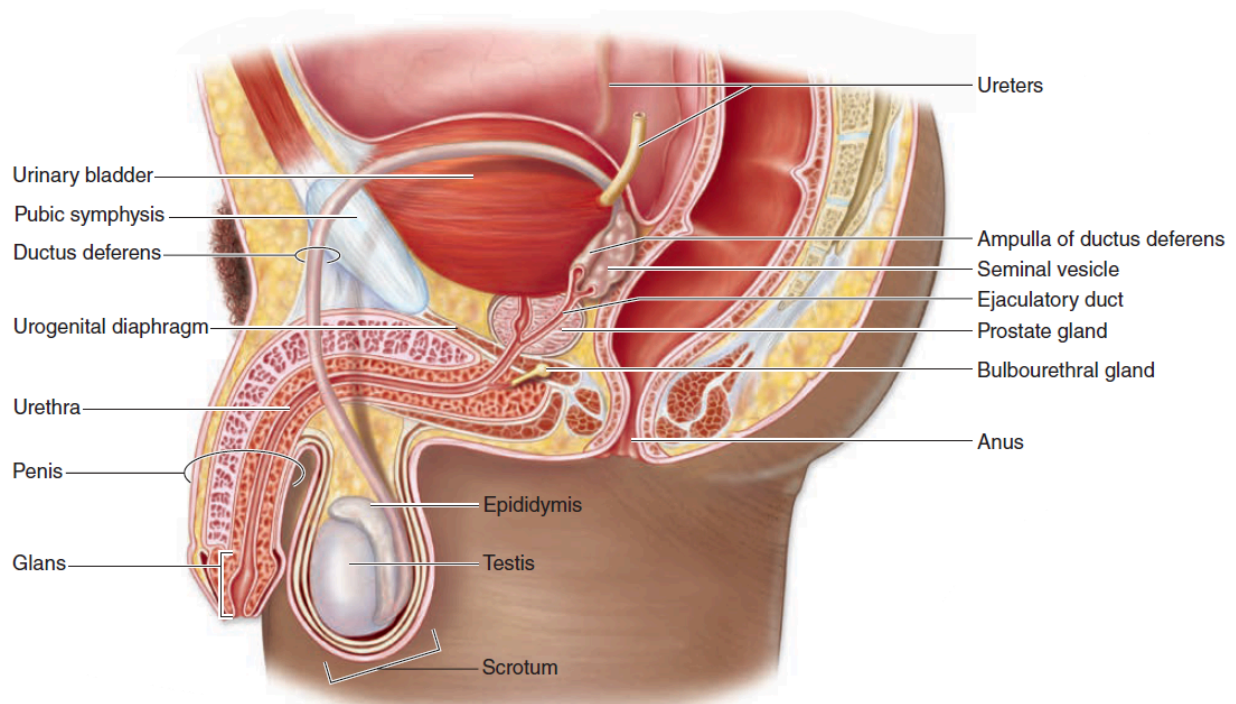
Histology

Male Reproductive System - Part 1

The male reproductive system consists of the 2 **testes**, 2 sets of **genital ducts**, **accessory glands**, and **penis**. Testes produce sperm and contain endocrine cells secreting hormones such as testosterone, which drives male reproductive physiology. The genital ducts and accessory glands produce secretions required for sperm nutrients and activity and conduct spermatozoa and the secretions to the penile urethra. Spermatozoa and the secretions of the accessory glands make up the semen, which is introduced into the female reproductive tract by the penis.

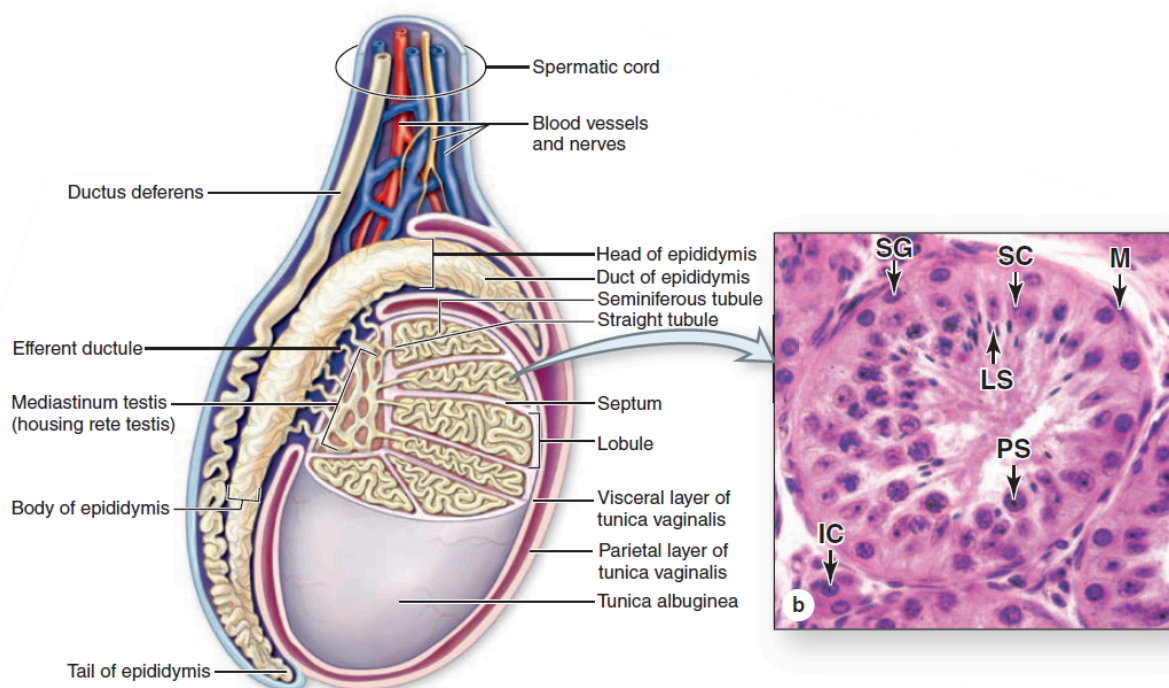
Testes

The testes are oval bodies that are present in the scrotum inside many facial layers, the innermost one is a double-layer of peritoneum called the **tunica vaginalis**. Each testis is surrounded by a dense connective tissue capsule, the **tunica albuginea**, that sends fibrous septa dividing the testis incompletely into about 250 pyramidal compartments called the **testicular lobules**, that may intercommunicate. Posteriorly, tunica albuginea is



thickened to form the **mediastinum testis**, which is rich in blood vessels. Each lobule is occupied by 1-4 **seminiferous tubules** (that produce the spermatozoa) surrounded by a small amount of loose connective tissue. This interstitial connective tissue is rich in blood & lymphatic vessels, nerves & **interstitial (Leydig) cells** that secrete androgens. From each testicular lobule, the seminiferous tubules are drained by a single **straight duct** into a network of channels within the mediastinum testis called the **rete testis**. From the rete testis, about 20 **efferent ductules** convey sperm to the extratesticular passages.

Because certain events in the process of sperm formation cannot occur at the core body temperature of 37°C, a temperature of about 34°C is maintained in the scrotal sac by various mechanisms, including the following: (1) Cooling effect of the pampiniform venous plexus, which radiate heat, (2) Evaporation of sweat from the scrotum, and (3) Contraction & relaxation of the dartos muscle of the scrotum and the cremaster muscles of the spermatic cords move the testes away from or closer to the body, respectively, allowing further control on testicular temperature.



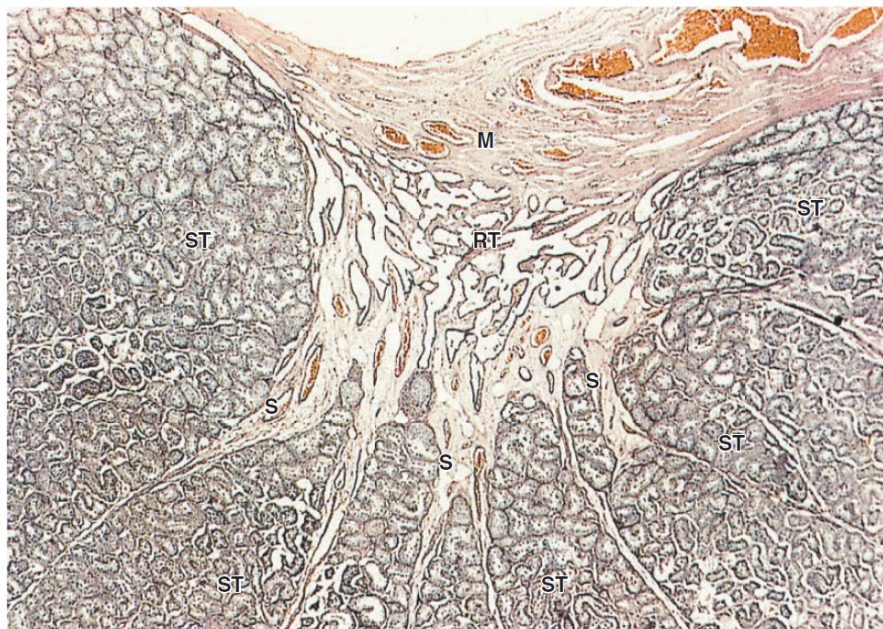
Seminiferous Tubules

Sperm are produced in the seminiferous tubules at a rate of about 2 millions per day in the young adult. Each testis has from 250 to 1000 such tubules in its lobules, and each tubule measures 150-250 μm in diameter and 30-70 cm in length. Each tubule is actually a loop linked (by the very short and narrow straight tubule) to the rete testis.

Each seminiferous tubule is lined with a complex, specialized stratified epithelium called **germinal** or **spermatogenic epithelium**. The basement membrane of this epithelium is covered by fibrous connective tissue containing flattened, smooth muscle-like **myoid cells**, which allow weak contractions of the tubule. The germinal epithelium consists of two types of cells:

- Large nondividing Sertoli cells, which physically and metabolically support developing sperm cell precursors,
- Dividing cells of the spermatogenic lineage, comprising four or more concentric layers of cells in the germinal epithelium.

Through successive mitotic & meiotic divisions, combined by morphological changes, spermatogenic cells form mature spermatozoa which are released into the lumen of seminiferous tubules. This process takes about 10 weeks and is divided into 2 parts: spermatogenesis & spermiogenesis.



The dense capsule of the testis, the tunica albuginea, thickens on the posterior side as the mediastinum (M) testis, from which many thin septa (S) subdivide the organ into about 250 lobules. Each lobule contains one to four convoluted seminiferous tubules (ST)

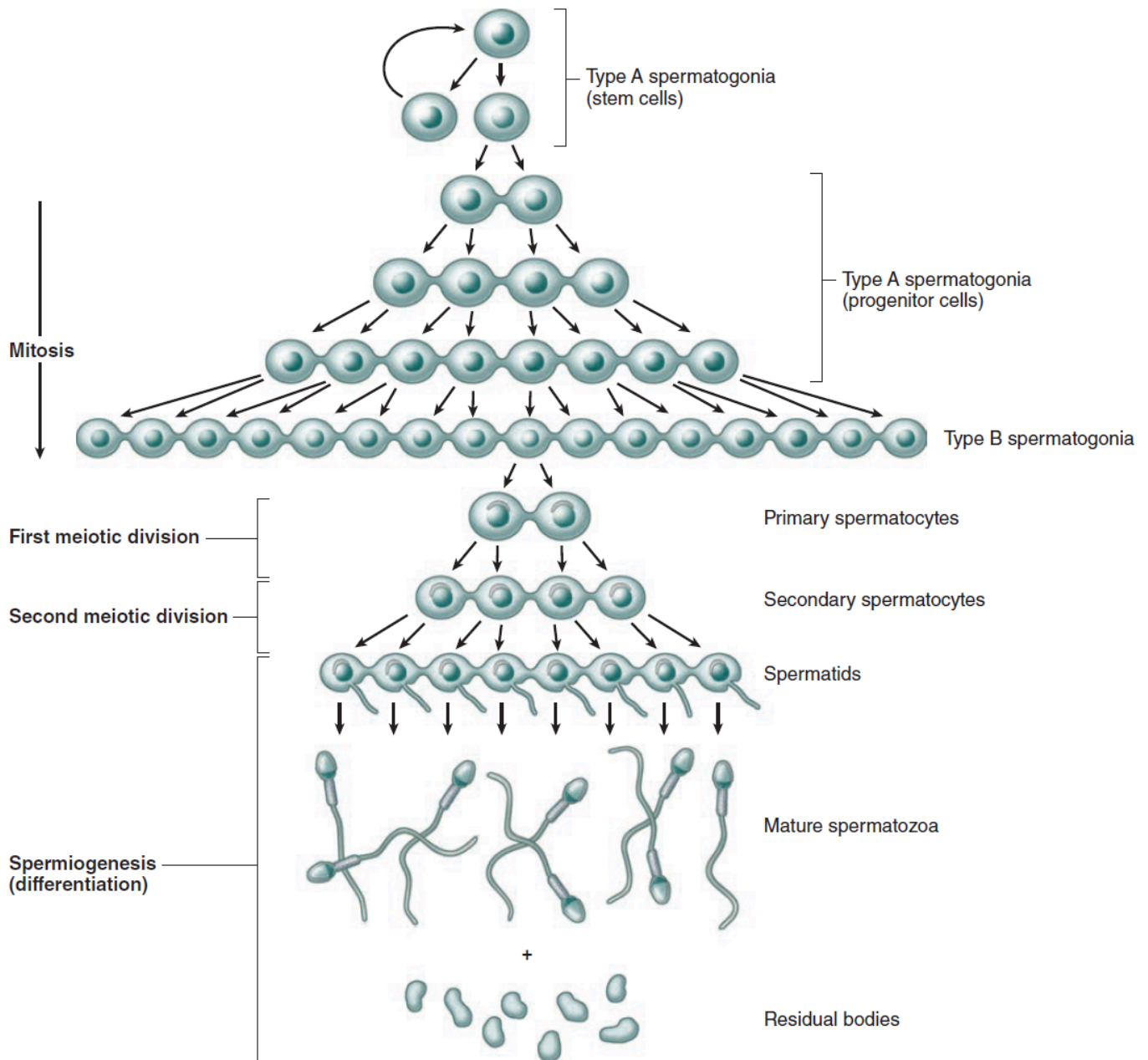
in a sparse connective tissue interstitium. Each tubule is a loop attached by means of a short straight tubule to the rete testis (RT), a maze of channels embedded in the mediastinum testis. From the rete testis, the sperm move into the epididymis. (X60; H&E)

Spermatogenesis

The male is born with his testes containing millions of progenitor cells called spermatogonia (Gr. sperma + gone, generation). These are small round cells (about 12 μm in diameter) in the epithelial wall of the tubules, next to the basement membrane, closely associated with Sertoli cells.

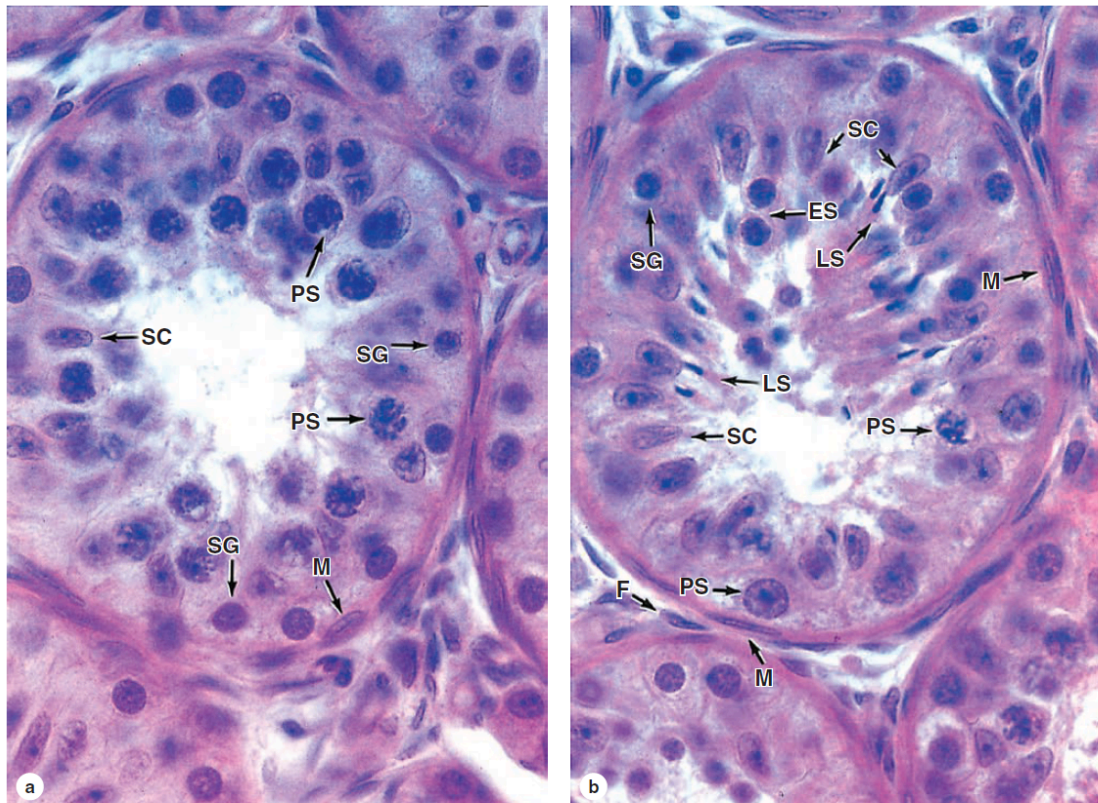
- Spermatogenesis begins at puberty with proliferation of spermatogonia.
- Spermatogonia with dark ovoid nuclei (stem cells) divide infrequently and give rise both to (1) new stem cells, and (2) progenitor cells with more pale-staining, ovoid nuclei that divide more rapidly. These type A spermatogonia each undergo several clonal divisions that leave most of the cells interconnected as a syncytium.
- Progenitor type A spermatogonia give rise to type B spermatogonia, which have more spherical and pale nuclei.
- Each type B spermatogonium then undergoes a final mitotic division to produce two cells that grow in size and become primary spermatocytes.
- **Primary spermatocyte** is a large spherical cell (actually the largest spermatogenic cell) with euchromatic nucleus. Primary spermatocyte replicates its DNA, so each chromosome consists of 2 chromatids, and enters meiosis-I, during which homologous chromosomes come together in synapsis, DNA recombination occurs during prophase-I. The primary spermatocyte is a diploid cell that has 46 (44 + XY) chromosomes and a DNA content of 4N. Soon after their formation, these cells enter the first meiotic prophase that lasts about 3 weeks, during which the nucleus is characterized by the presence of partially condensed chromosomes in various stages of synapsis and recombination. Primary spermatocytes are the most commonly seen spermatogenic cells within the germinal epithelium.
- Homologous chromosomes separate in the first meiotic division, which produces 2 smaller (haploid) cells called **secondary spermatocytes** with only 23 chromosomes (22 + X or 22 + Y), but each still consists of two chromatids so the amount of DNA is 2N. Secondary spermatocytes are rare in testis sections because they are very short-lived cells that remain briefly in interphase & quickly have the second meiotic division.
- Division of each secondary spermatocyte separates the chromatids of each chromosome and produces two smaller haploid cells called

spermatids each of which contains 23 chromosomes. Because no S phase (DNA replication) occurs between the first and second meiotic divisions, the amount of DNA per cell is reduced by half when the chromatids separate and the cells formed are haploid ($1N$). With fertilization, a haploid ovum and sperm produced by meiosis unite and the normal diploid chromosome number is restored in the zygote.



The Clonal Nature of Male Germ Cells

The stem cells produced by mitotic divisions of spermatogonia remain as separate cells. However, all subsequent divisions of the daughter cells, which become progenitor cells, have incomplete cytokinesis (cytoplasmic division) and the cells remain attached to one another by intercellular bridges of cytoplasm. These allow free cytoplasmic communication among the cells during their remaining mitotic and meiotic divisions. Although some cells may separate, clones of approximately a hundred cells may remain linked through meiosis. The complete significance of this spermatogenic syncytium is not clear. The germ cells finally become separated from one another during differentiation. Meiotic division takes about 2 months. Cells at different stages of development are typically grouped together along the tubule, with the intercellular bridges helping to coordinate their divisions and differentiation.



(a, b) In these cross sections of seminiferous tubules, most of their cell types can be seen. Outside the tubules are myoid cells (M) and fibroblasts (F). Inside near the basement membrane are many prominent spermatogonia (SG), small cells that divide mitotically but give rise to a population that enters meiosis. The primary spermatocytes (PS) remain for 3 weeks in prophase of the first meiotic division during which recombination occurs. Primary spermatocytes are the largest spermatogenic cells and are usually abundant at all levels between the basement

membrane and the lumen. Each divides to form two secondary spermatocytes, which are rarely seen because they undergo the second meiotic division almost immediately to form two haploid spermatids. Newly formed round, early spermatids (ES) differentiate and lose volume in becoming late spermatids (LS) and finally highly specialized sperm cells. All stages of spermatogenesis and spermiogenesis occur with the cells intimately associated with the surfaces of adjacent Sertoli cells (SC) that perform several supportive functions. (Both X750; H&E)