MALE ENDOCRINOLOGY AND SPERMATOGENESIS (Chapter 10)
AVS 222 (Instructor: Dr. Amin Ahmadzadeh)

I. MALE ENDOCRINOLOGY

(Figure10-1 to 10-3)

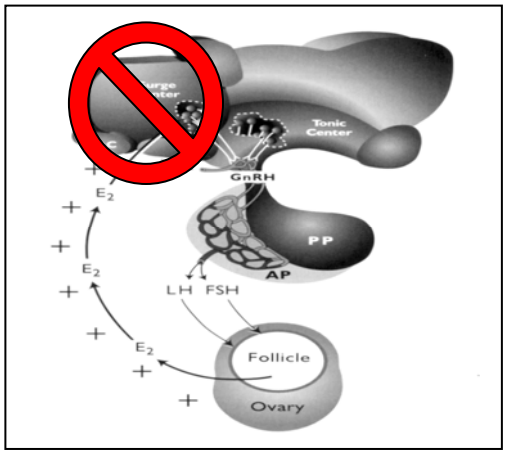
A. Glands and their respective hormones

1) Hypothalamic hormone: GnRH

2) Anterior pituitary: LH and FSH

3) Testes: Testosterone, estradiol, and inhibin

- Testosterone is synthesized by the Leydig cells and estradiol and inhibin by the Sertoli cells
- There is **no surge center** in the hypothalamus of the male and the GnRH tonic center discharges GnRH in a pulsatile manner to stimulate LH and FSH



Adapted from Preg. & Part., Senger ©

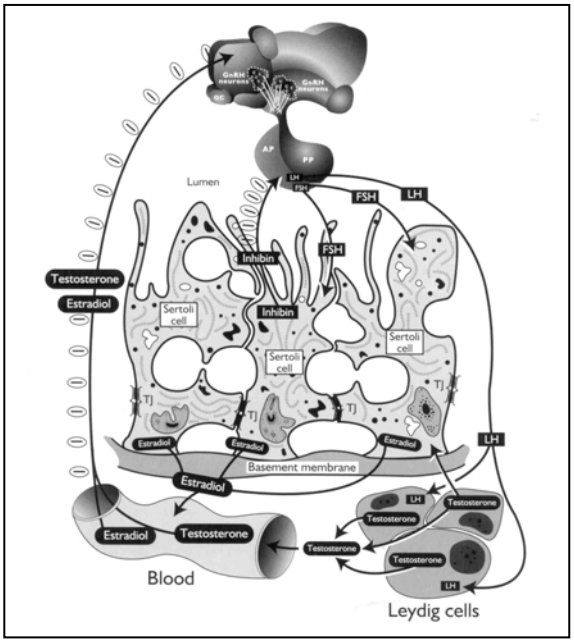
B. Hormones Functions

1) LH (glycoprotein):

- **Acts on the Leydig cells and stimulates the production of testosterone**
- Some testosterone is transported across the basement membrane into the Sertoli cells and some testosterone also goes into systemic circulation

2) FSH (glycoprotein)

- **Acts on the Sertoli cells to stimulate spermatogenesis and Sertoli cell function**
- In the Sertoli cells is responsible for activation of aromatase enzyme for conversion of testosterone into estradiol. If FSH is reduced then Sertoli cell function and spermatogenesis will be impaired



Adapted from Preg. & Part., Senger ©

3) Testosterone (steroid)

***In the Sertoli cells*:**

- Is bound by androgen binding protein and taken into the lumen of the seminiferous tubule, for transport to the epididymis
- Is converted into estradiol by aromatase enzyme and crosses the basement membrane and goes into circulation

In systemic circulation:

Testosterone and estradiol feedback upon the hypothalamus causing a slow down in the release of GnRH, which results in a reduced output of FSH and LH

4) Inhibin (glycoprotein)

The sertoli cells also produce inhibin, which negatively feeds back on the anterior pituitary to selectively suppress FSH.

II. SPERMATOGENESIS

(Figure 10-5, see below)

It takes place in the seminiferous tubule and consists of the sum of all cellular transformation in developing germ cells

A. Spermatogenesis consists of three distinct phases

Spermatocyctogenesis, meiosis, and spermiogenesis

1) Spermatocyctogenesis (Proliferation)

- It takes place in the **basal compartment** of the somniferous tubule
- Mitotic cell division and proliferation and maintenance of spermatogonia
- Spermatogonia undergo several mitotic divisions with the last division resulting in primary spermatocytes
- Three types spermatogonia found in the basal compartment are spermatogonia A, spermatogonia intermediate, spermatogonia B
- Duration of spermatocytogenesis varies in different species:

  bull ~21 days, ram ~18 days, stallion ~21 days

2) Meiosis

- It takes place in the **adluminal compartment** of the seminiferous tubule
- Reduction of the number of chromosomes in the gamete in half (from diploid to the haploid state)
- Primary spermatocytes undergo meiosis I and become secondary spermatocytes and subsequently undergo meiosis II resulting in round spermatid
- The lifespan of spermatocytes is the longest of all sperm cell types
- Secondary spermatocytes is short-lived (1-2 days)

3) Spermiogenesis (Differentiation; Figures 10- 6 and to 10- 7, see below)

- It takes place in the **adluminal compartment** of the seminiferous tubule
- Round spermatids mature and become elongated spermatids
- DNA becomes highly condensed, the acrosome is formed, flagellum (tail) is formed, and cells become potentially motile
- Elongated spermatids move closer to the lumen of the seminiferous tubule

4) Four phases of spermiogenesis (Figure 10-7)

I) Golgi phase: acrosomic vesicle formation

II) Cap phase: acrosomic vesicle spreads over the nucleus of the round spermatid and the flagellum starts to form

III) Acrosomal phase: the spermatid nucleus and cytoplasm elongates, acrosome covers the majority of the anterior nucleus

IV) Maturation phase: Mitochondria are assembled around the flagellum and the flagellum is completely formed

III. SPERM CELL ANATOMY

A. Consists of 3 Parts **(Figures and 8 & 10-9)**

1. Head (nucleus + acrosome + post-nuclear cap)
2. Capitulum
3. Tail [a. Middle piece; b. Principal piece; c. Terminal piece]

B. Sperm Head **(Figure 10-8)**

1. Nucleus
    a. Contains genetic material
    b. Haploid chromosome number
    c. Whole purpose of cell
2. Acrosome
    a. Located at tip to head
    b. Essentially a bag of enzymes
    c. Used to help sperm enter the egg
3. Apical Ridge
    a. Ridge formed at tip of sperm
4. Perforatorium
    a. Located in apical ridge
    b. Large and hooked in rodent sperm
    c. Is not a battering ram
    d. True function unknown
5. Post nuclear cap
    a. Located below acrosome and lateral to nucleus
6. Plasma membrane
    a. Cell membrane that surrounds head

C. Capitulum

Attachment of the head to the tail

D. Sperm Middle piece

1. Mitochondria
    a. Provide energy to move axial filaments
2. Annulus
    a. Junction of mid piece and principal piece

E. Principal piece

1. The largest part of the tail and provide motility to the sperm of middle piece

IV. SEMINIFEROUS EPITHELIUM CYCLE

It is progression through a complete series of cellular associations (stages) at one location along the seminiferous tubule.

A. A series of steps to convert spermatogonia into spermatozoa

B. Called a cycle because it repeats and the time required for this progression is duration of the cycle and is unique for each species **(Table 10-1)**

- Bull = 13.5 days; Ram = 10.4 days; Stallion = 12.2 days; Boar = 8.3 days

C. Each cycle can be divided into several stages **(Usually 8 stages)**

- Stage = specific cellular associations
- Each stage consists of 4-5 germ cell generations **(Figure 10-10 & 10-11)**
- Germ cell generations are cells of the same

The cycle of seminiferous epithelium is similar to a university (Figure 10-12)

- Every year, freshmen (spermatogonia) enter and seniors (spermatozoa) graduate (arrive to the lumen). Each class is analogous to a generation of germ cells found in the seminrferous epithelium.

D. For completion of spermatogenic cycle (from spermatogonia to elongated spermatid) germ cells have to go through several cycles

For example: (Figure 10-11)

Bull seminiferous epithelium cycle = **13.5 days**

Germ cells have to go through 4.5 cycles in order to become elongated spermatide

So 13.5 X 4.5 = 61 days → this the length of the spermatogenesis in the bull

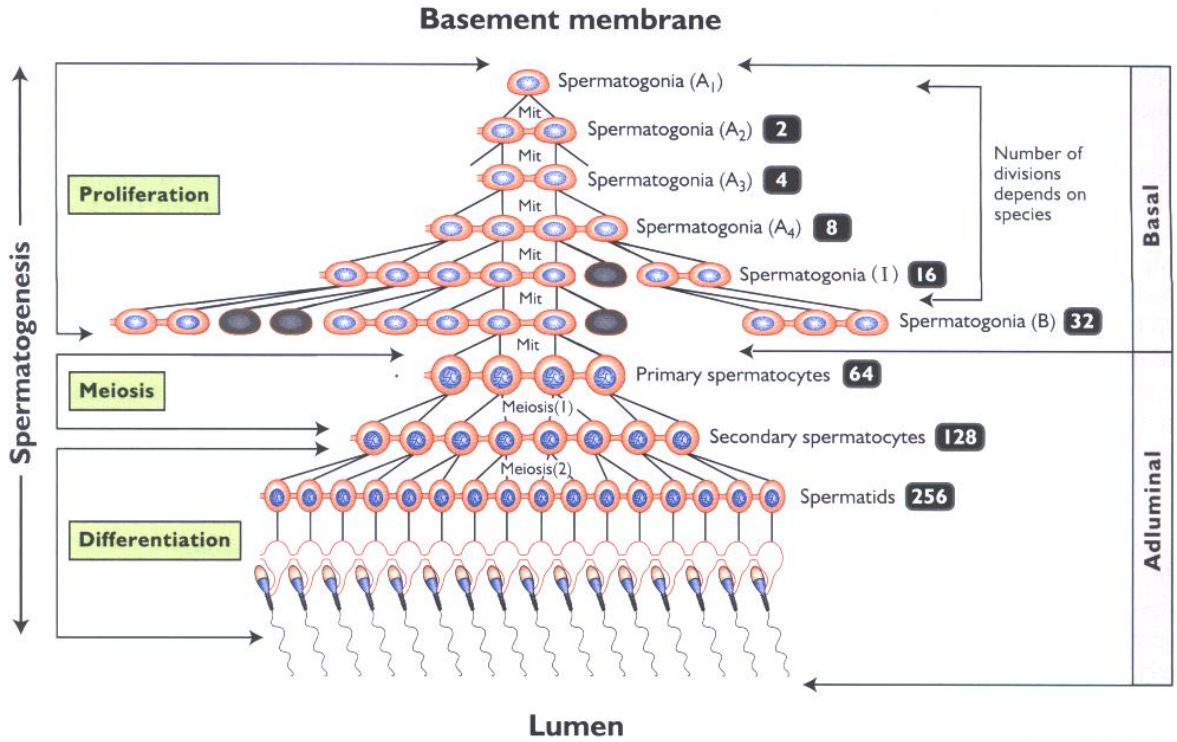
Spermatozoa viability and quality is judged by evaluating motility and morphology

Motility is as an estimate of the percentage of sperm that are swimming in a linear fashion within a given environment as determined microscopically.

There are many types of abnormal spermatozoa **(Figure 10-14)**

Figure 10-5. Typical Sequence of Spermatogenesis in Mammals

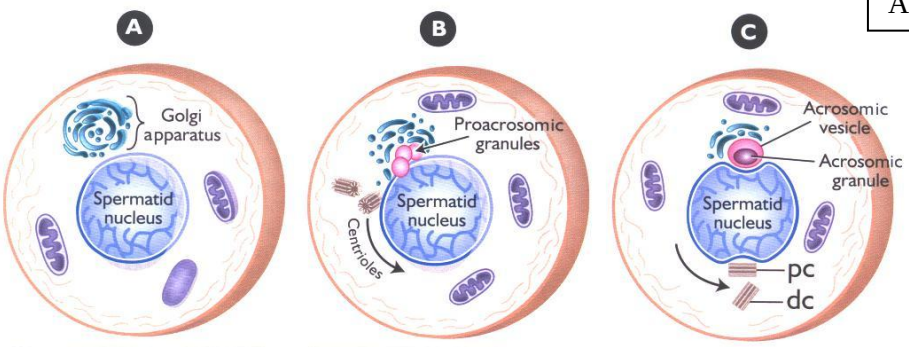
Spermatogonia (A_1-A_4, I and B) undergo a series of mitotic divisions (Mit) and the last mitotic division gives rise to primary spermatocytes that enter meiosis. This series of mitotic divisions allows for continual proliferation of spermatogonia and replacement of A_1 spermatogonia.



After meiosis, haploid spherical spermatids differentiate into spermatozoa. Meiosis and differentiation take place in the adluminal compartment. Notice that each generation of cells is attached by intercellular cytoplasmic bridges. Thus, each generation divides synchronously in cohorts. Some cells (black) degenerate during the process. Numbers indicate the theoretical number of cells generated by each division.

Figure 10-6. The Golgi Phase of Spermatid Differentiation

Adapted from Preg. & Part., Senger ©

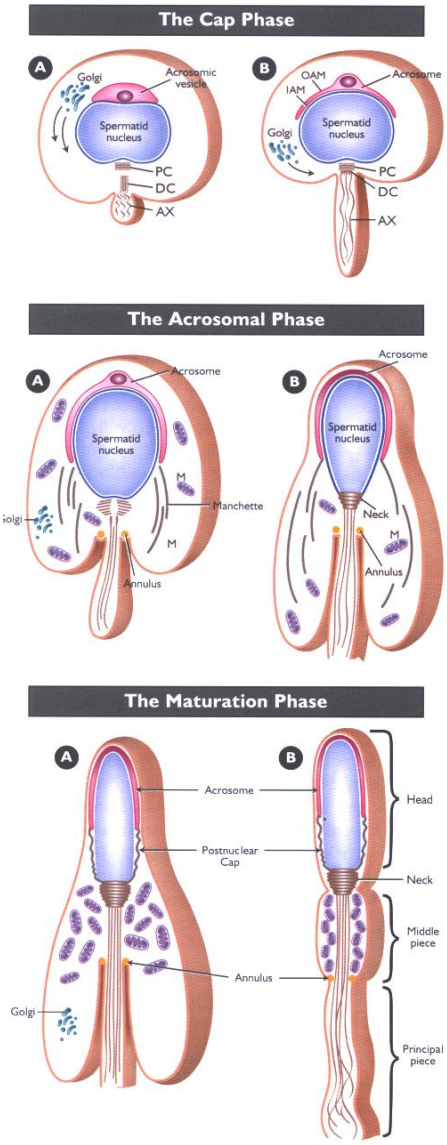


The newly formed spermatid is almost perfectly spherical and has a well developed Golgi apparatus.

Small vesicles of the Golgi fuse, giving rise to larger secretory granules called pro-acrosomic granules. The centrioles start to migrate to a position beneath the nucleus that is opposite the acrosomic vesicle.

Vesicle fusion continues until a large acrosomic vesicle is formed that contains a dense acrosomic granule. The proximal centriole (PC) will give rise to the attachment point of the tail. The distal centriole (DC) will give rise to the developing axoneme (central portion of the tail) inside the cytoplasm of the spermatid.

Figure 10-7. The Cap, Acrosomal and Maturation Phases of Spermatid Differentiation



A

The Golgi migrates toward the caudal part of the cell. The distal centriole (DC) forms the axoneme (AX) or flagellum that projects away from the nucleus toward the lumen of the seminiferous tubule.

B

The acrosomic vesicle flattens and begins to form a distinct cap consisting of an outer acrosomal membrane (OAM), an inner acrosomal membrane (IAM) and the acrosomal contents (enzymes).

A

The spermatid nucleus begins to elongate and the acrosome eventually covers the majority of the anterior nucleus. The manchette forms in the region of the caudal half of the nucleus and extends down toward the developing flagellum.

B

The neck and the annulus are formed and the later will become the juncture between the middle piece and the principal piece. Notice that all components of the developing spermatid are completely surrounded by a plasma membrane. M = mitochondria.

A and B

Mitochondria form a spiral assembly around the flagellum that defines the middle piece. The postnuclear cap is formed from the manchette microtubules. The annulus forms the juncture between the middle piece and the principal piece.

Adapted from Preg. & Part., Senger ©