Spermatogenesis & Spermatozoa

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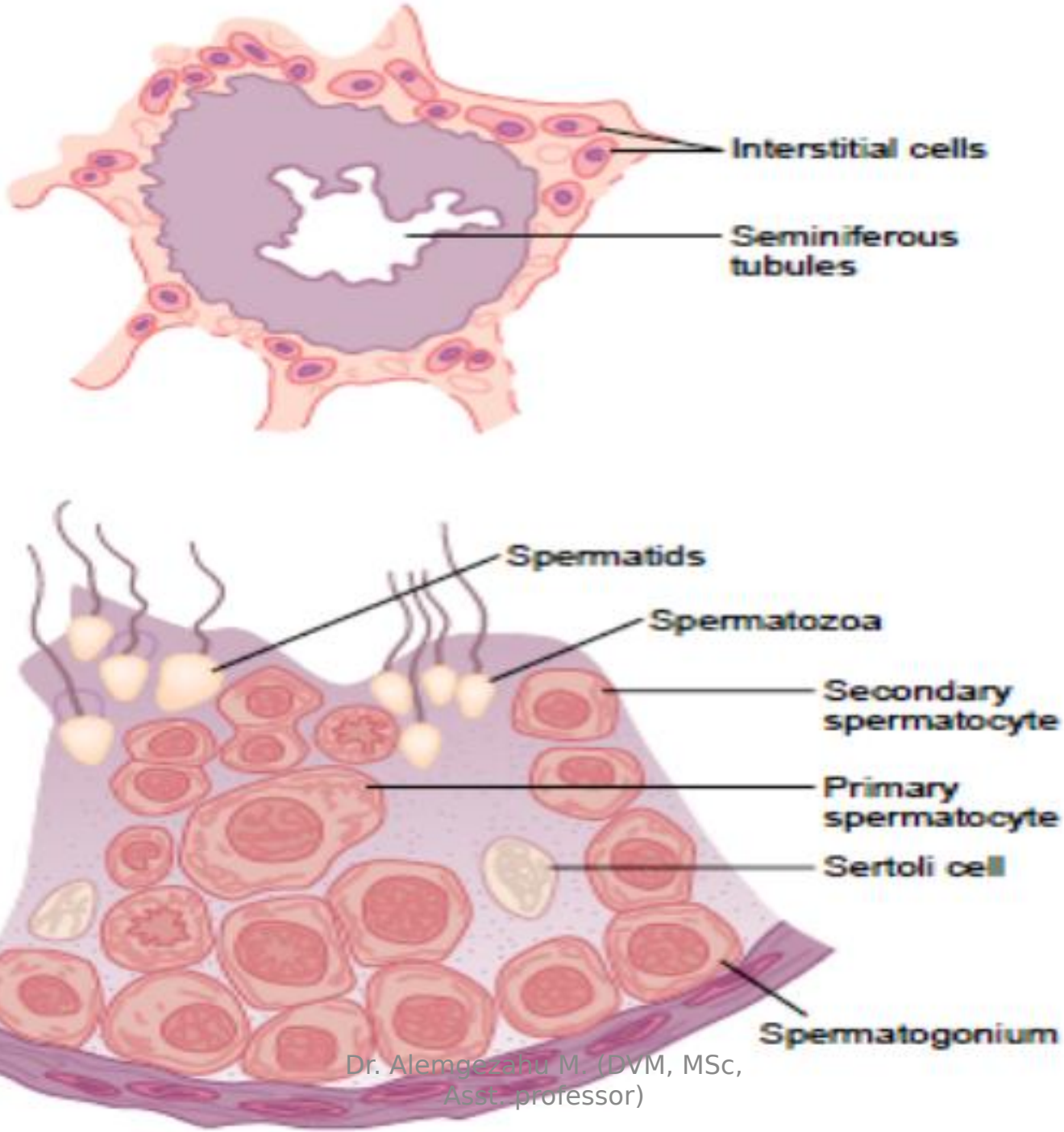
Spermatogenesis

- During formation of the embryo, the *primordial germ cells* migrate into the testes and become immature germ cells called *spermatogonia* which lie in two or three layers of the inner surfaces of the *seminiferous tubules*.
- The spermatogonia begin to undergo mitotic division, beginning at puberty, and continually proliferate and differentiate through definite stages of development to form sperm.
- The spermatogonia undergo several mitotic cell divisions (where the number of chromosomes remain the same), eventually forming the large primary spermatocytes



Cont…

- **Functions of spermatogenesis**

¬ Produce billions of spermatozoa/day to maximize reproduction

¬ Allow renewal of precursor stem cells to allow continuous production of male gamete for many decades

¬ Facilitate genetic diversity

- **Comprised of three main processes of spermatogenesis**

¬ *Proliferative/ Mitosis Phase* – precursors stem cells (**Spermatogonia**) undergo multiple divisions (increase number of cells). The spermatogonia migrate among *Sertoli cells* toward the central lumen of the seminiferous tubule. The Sertoli cells are very large, with overflowing cytoplasmic envelopes that surround the developing spermatogonia all the way to the central lumen of the tubule.

Meiosis *Phase* – **1º Spermatocyte** undergo two consecutive divisions produce two (2n) **2º Spermatocyte** & four haploid (**n**) **Spermatids** divide - DNA/Genes crossing over – **genetic diversity** (no two sperm cells are genetically identical). Meiosis is the process by which the diploid number of chromosomes present in spermatogonia (the stem cells) is reduced to the haploid number present in mature spermatozoa.

- *Physical Differentiation/Spermiogeneis*– circular **Spermatids** transformed in to a highly specialized **Spermatozoa** having distinct head, neck and tail. Spermatids are non-motile, round, non-specialized.

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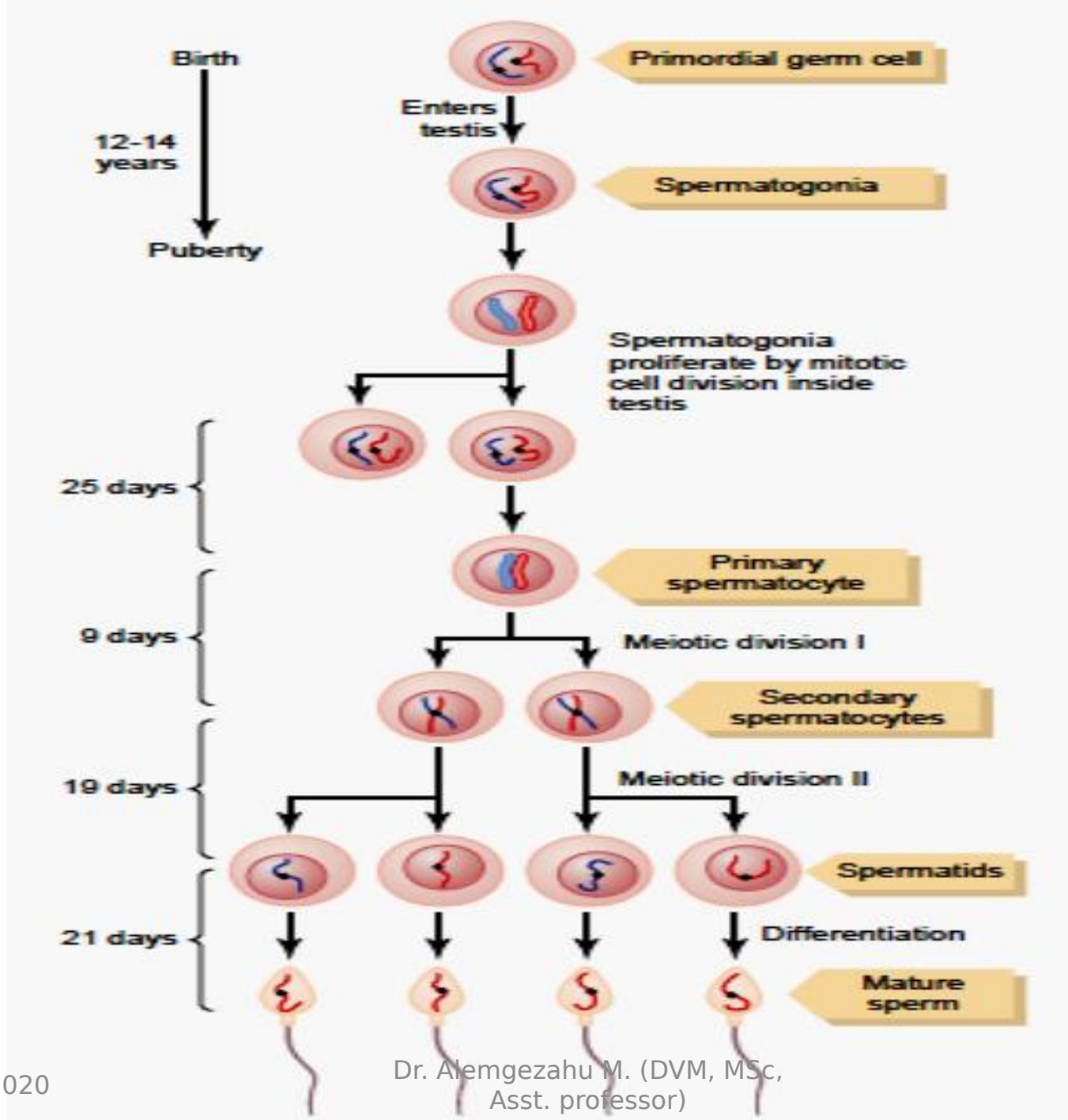

Birth
12-14 years
Puberty
Primordial germ cell
Enters testis
Spermatogonia
Spermatogonia proliferate by mitotic cell division inside testis
25 days
Primary spermatocyte
9 days
Meiotic division I
Secondary spermatocytes
19 days
Meiotic division II
Spermatids
21 days
Differentiation
Mature sperm

Cont …

- **Temporal pattern –** initiated at puberty & continues without interruption (? Vs Female Oogenesis) for decades of a males life (except in seasonal breeders)
- Development from Spermatogonia to fully formed Spermatozoa in spermatogenesis takes a variable duration of time - species

  Bull = 61 days, Ram = 47 Days, Boar = 39 Days, Stallion = 55 Days

  ****?** – Effect of pathological exposure not observed in semen for up to 4 weeks & Recovery of semen quality may take up to 3 months
- **Site of spermatogenesis** – inside Seminiferous Tubules of adult testis which is comprised of;

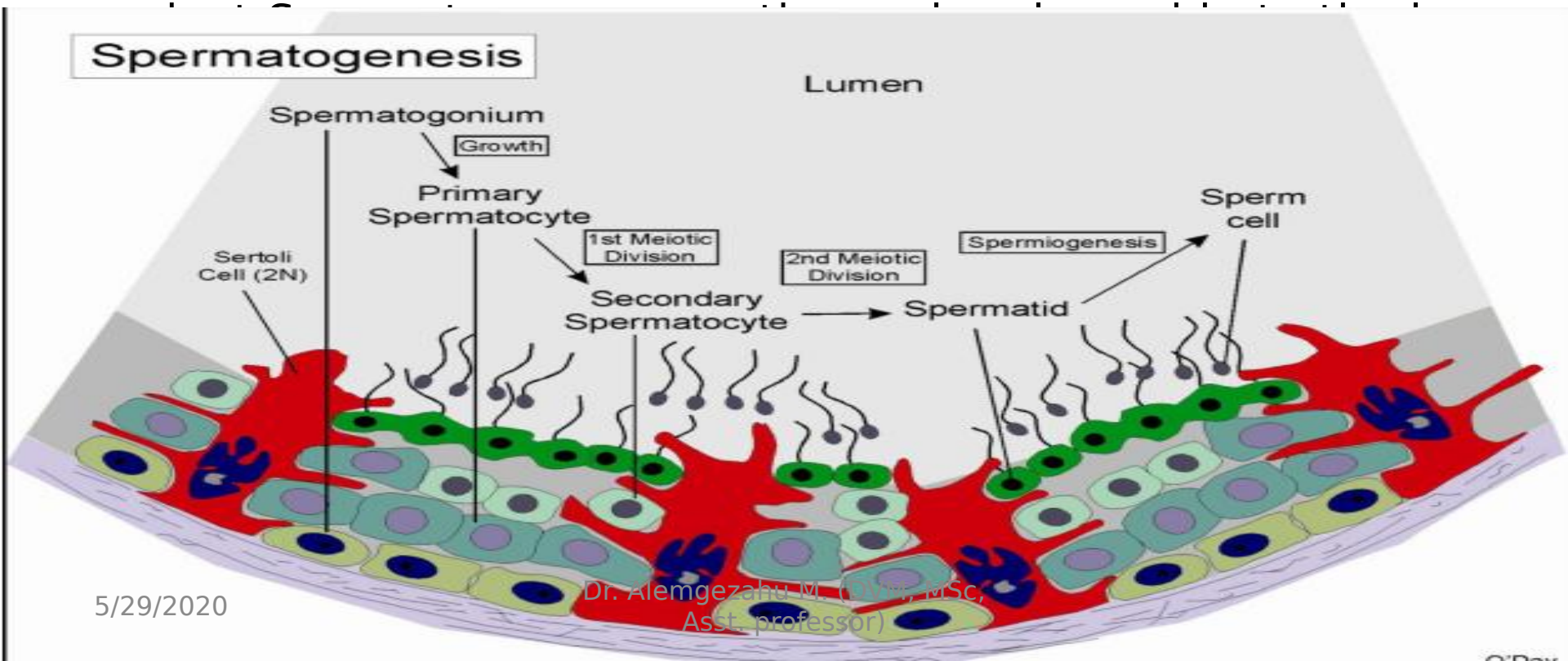
¬ **A Basement Membrane** – *Connective tissue, fibroblasts & myoid cells*

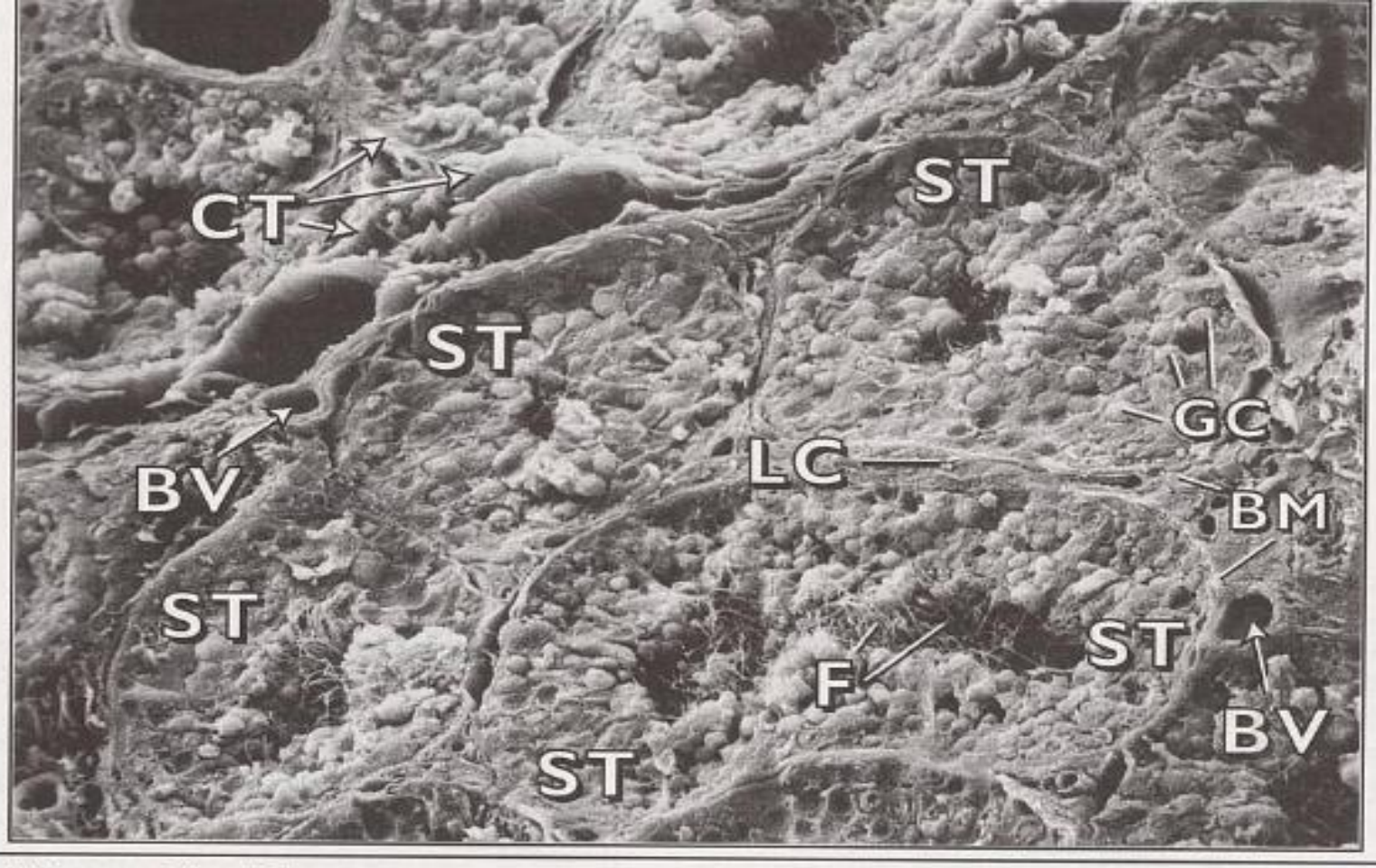
¬ **Seminefrous Epithelium –** consists of

Sertoli Cells – Rest on basement membrane & project towards the seminiferous tubules lumen, interconnected by tight junctions

Cont …

- Most immature germ cells (spermatogonia) found near basement membrane
- As spermatogonia proliferate and mature (Spermatocytes and Spermatids) they move towards the lumen
- Groups of adjacent developing germ cells are interconnected by **Interacellular Bridges**
- Germ cells develop in contact with Sertoli cells and the final





Seminiferous tubules (ST) containing developing germ cells (GC) are surrounded by a basement membrane (BM). Flagella (F) from developing spermatids can be observed protruding into the lumen of some tubules. The interstitial compartment contains Leydig cells (LC), blood vessels (BV) and connective tissue (CT).

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Spermatozoa

- Mammalian spermatozoa are elongated motile cells specialized to deliver haploid male genomes to oocytes.
- Length is about 50 µm, Shape is mostly compressed/ spatulated
- A spermatozoon comprises a **head and tail**

Sperm Head

- **Nucleus** with a highly compact, hypercondensed chromatin
- **Acrosome** carries enzymes (Hyaluronidase, acrosin, etc) that help the spermatozoon to penetrate the oocyte vestments (Zona Pellucida)

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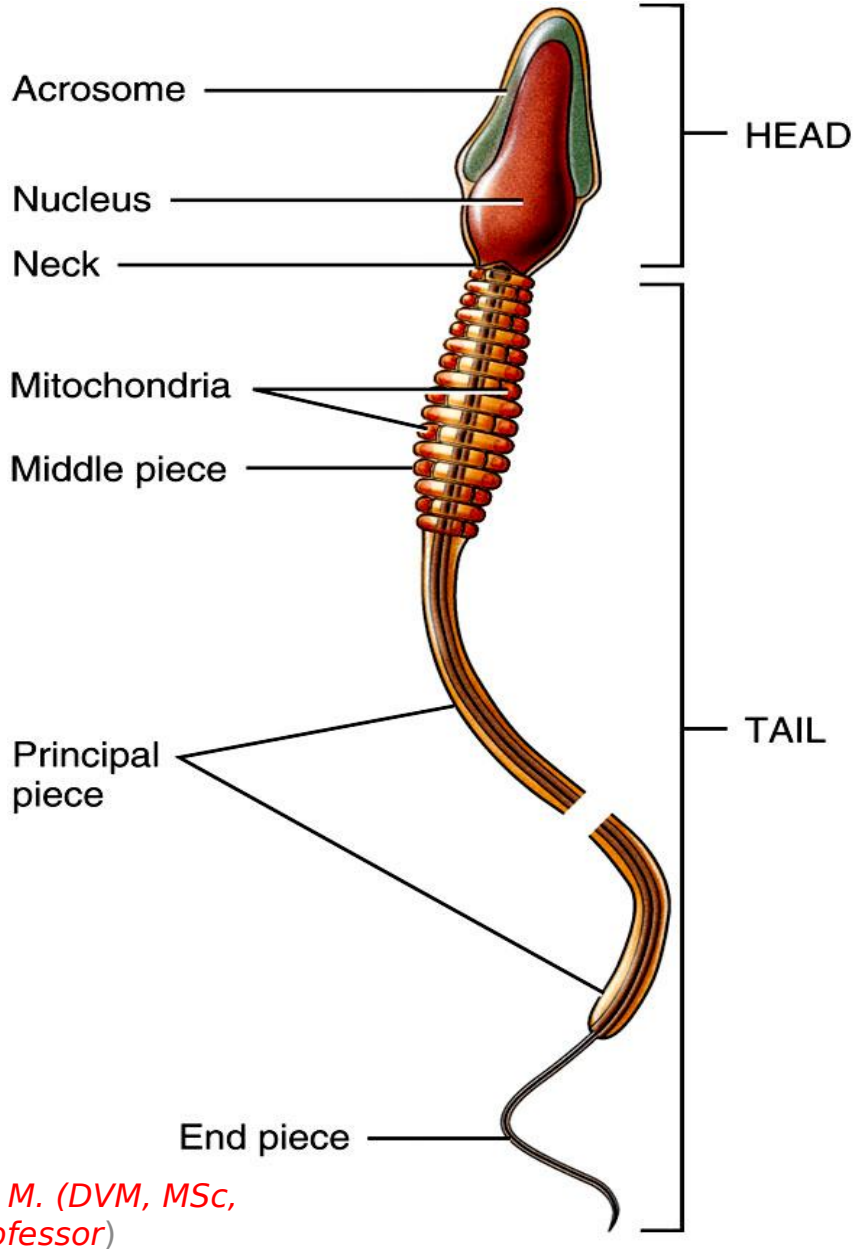
Spermatozoa Functional Morphology

Sperm Tail

- The functions of the tail are to propel spermatozoa forward by a whiplash-like movement and to generate energy for the movement.
- The tail can be divided into a connecting piece, mid-piece, principle piece, and end-piece



Hormonal Control of Testes

- At puberty, secretion of gonadotropin-releasing hormone (GnRH) increases
- Stimulates anterior pituitary to increase secretion of luteinizing hormone (LH) and follicle-stimulating hormone (FSH)
- LH stimulates Leydig cells to secrete testosterone Testosterone stimulates spermatogenesis
  - Synthesized from cholesterol in testes
  - Suppresses secretion of LH and GnRH via negative feedback
  - Enzyme 5 alpha-reductase converts testosterone into dihydrotestosterone (DHT) in external genitalia and prostate
- FSH acts indirectly on spermatogenesis
  - FSH and testosterone act on Sertoli cells to promote spermatogenesis and stimulate secretion of androgen-binding protein (ABP)
  - ABP binds testosterone keeping concentration high
  - Sertoli cells release inhibin which inhibits FSH

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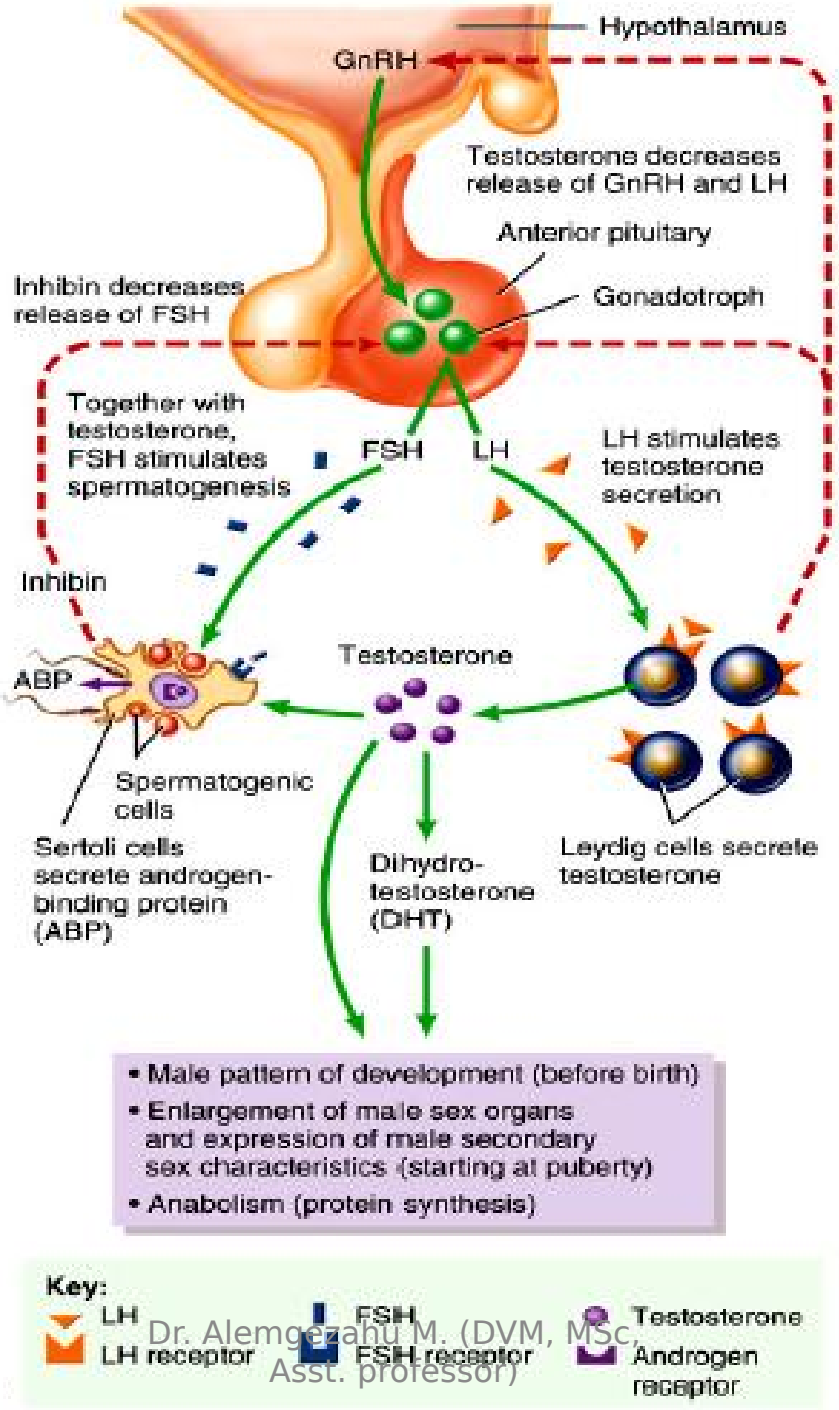
Hypothalamus
GnRH
Testosterone decreases release of GnRH and LH
Anterior pituitary
Gonadotroph
Inhibin decreases release of FSH
Together with testosterone, FSH stimulates spermatogenesis
FSH
LH
LH stimulates testosterone secretion
Inhibin
ABP
Testosterone
Spermatogenic cells
Sertoli cells secrete androgen-binding protein (ABP)
Dihydro-testosterone (DHT)
Leydig cells secrete testosterone
• Male pattern of development (before birth)
• Enlargement of male sex organs and expression of male secondary sex characteristics (starting at puberty)
• Anabolism (protein synthesis)
Key:
LH
LH receptor
FSH
FSH receptor
Testosterone
Androgen receptor

Negative feedback regulates T production

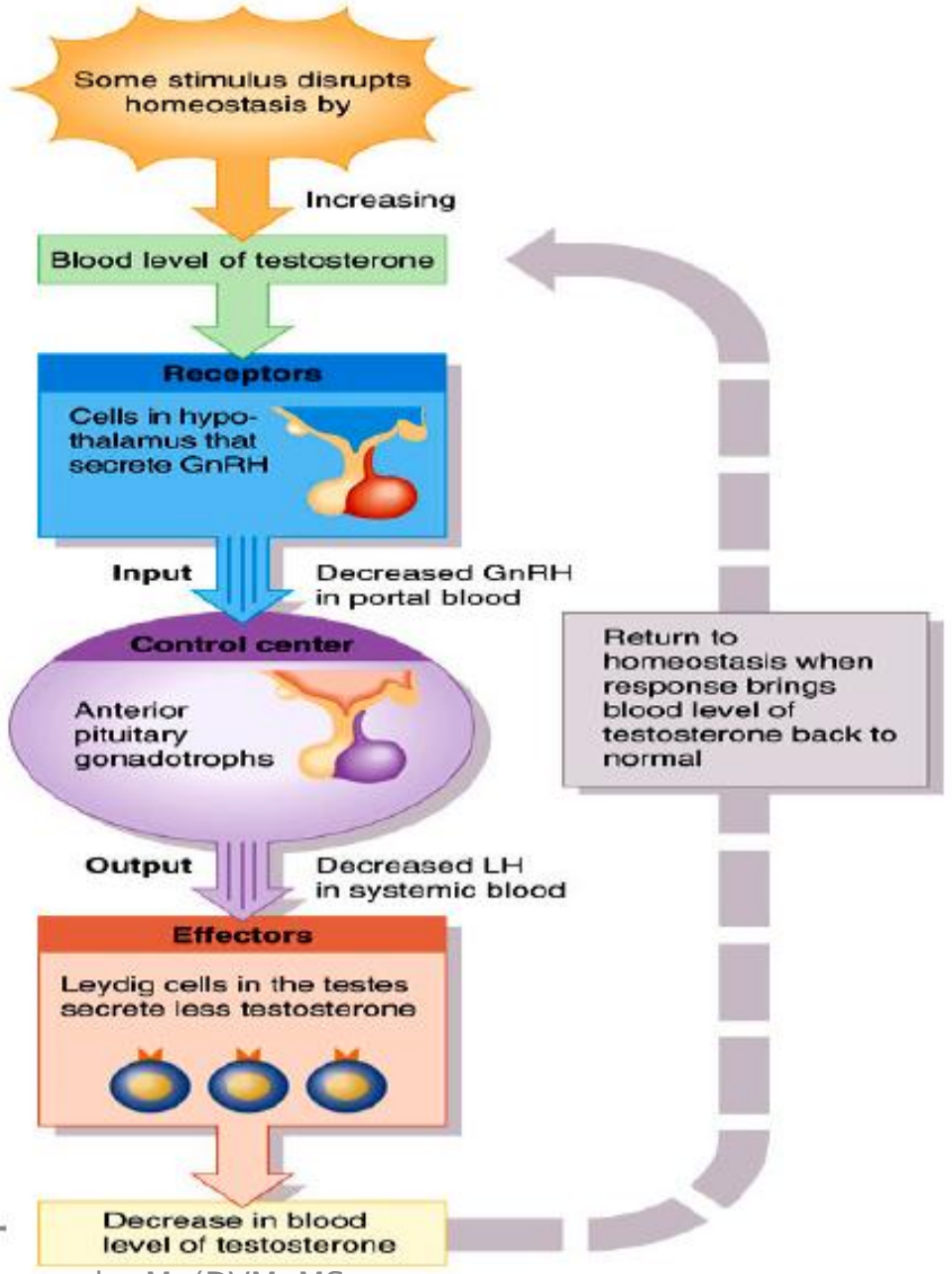

Figure 28.08 Tortora - PAP 12/e

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- Endocrine control of reproduction shows some species and seasonal variation Eg. LH may have a direct role in supporting spermatogenesis in Rams, levels of FSH and LH in the horse are higher in summer because sperm production is at it highest level.

- **PRACTICAL IMPLICATIONS**
- **Clinical application –** determining duration and origin of pathological events
- **Artifical manipulation of reproduction –** scheduling AI in seasonal breeders, designing male contraceptives
- Others ….

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Thank You!!!

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