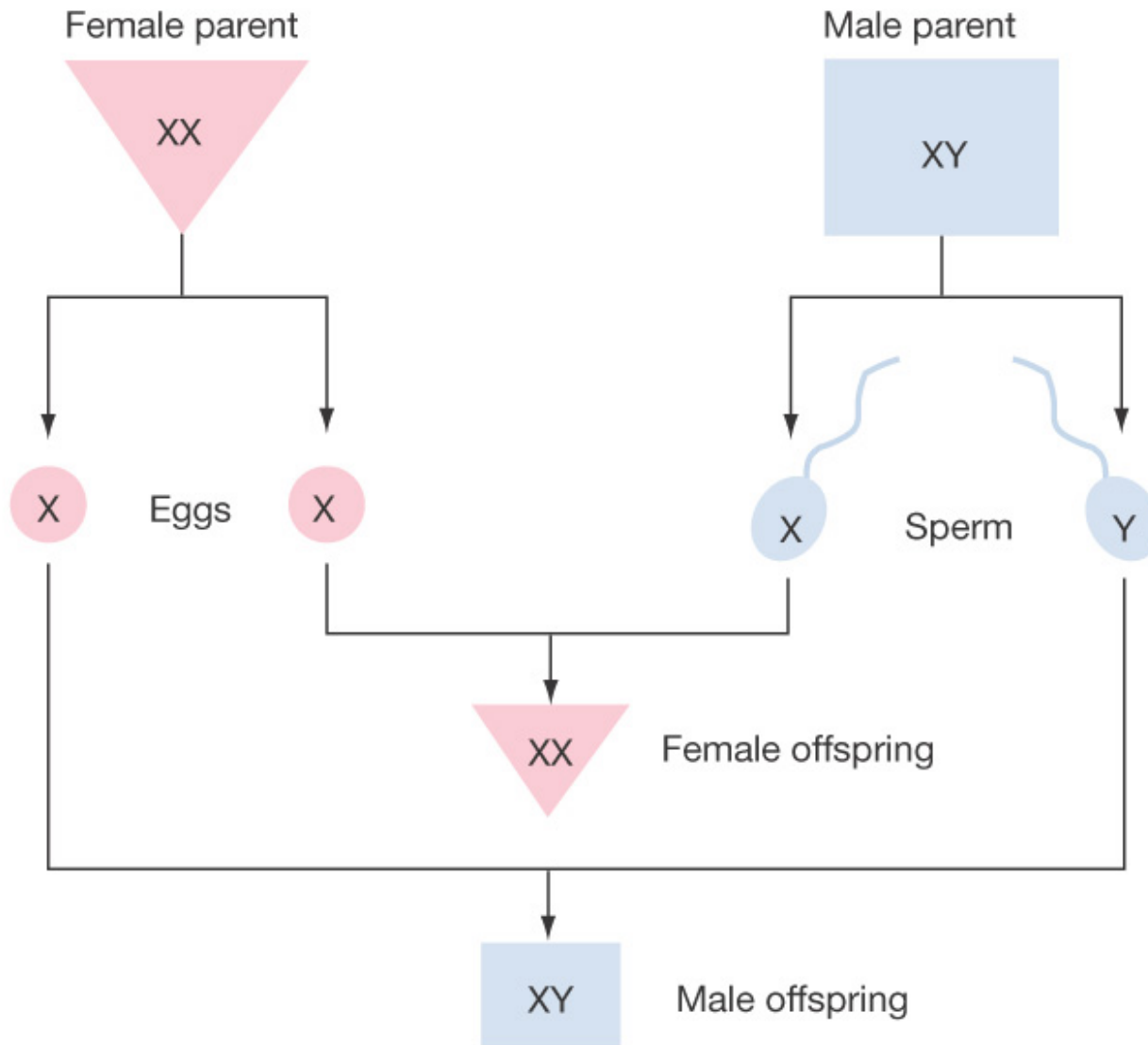


## **Reproductive Physiology**

# **The Male Reproductive System**

*Dr. Khalid Al-Regaiey*

# Sex Determination: Overview



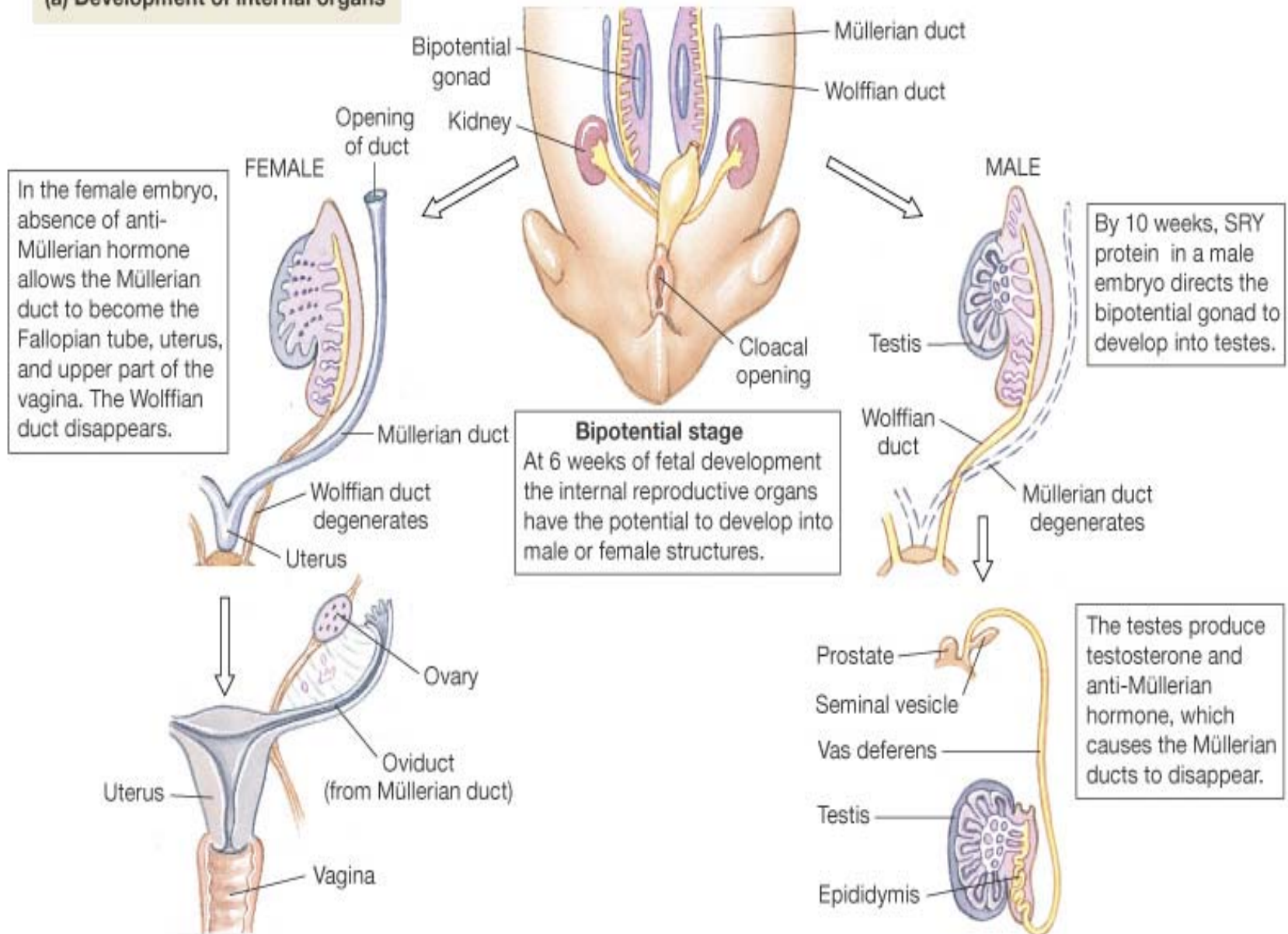
# Sexual Differentiation: Internal Embryonic Development

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- Bipotential tissues: genes & hormones direct differentiation
- Gonad → testis or ovary
- Wolffian duct → Vas deferens,
- Mullerian duct → oviduct

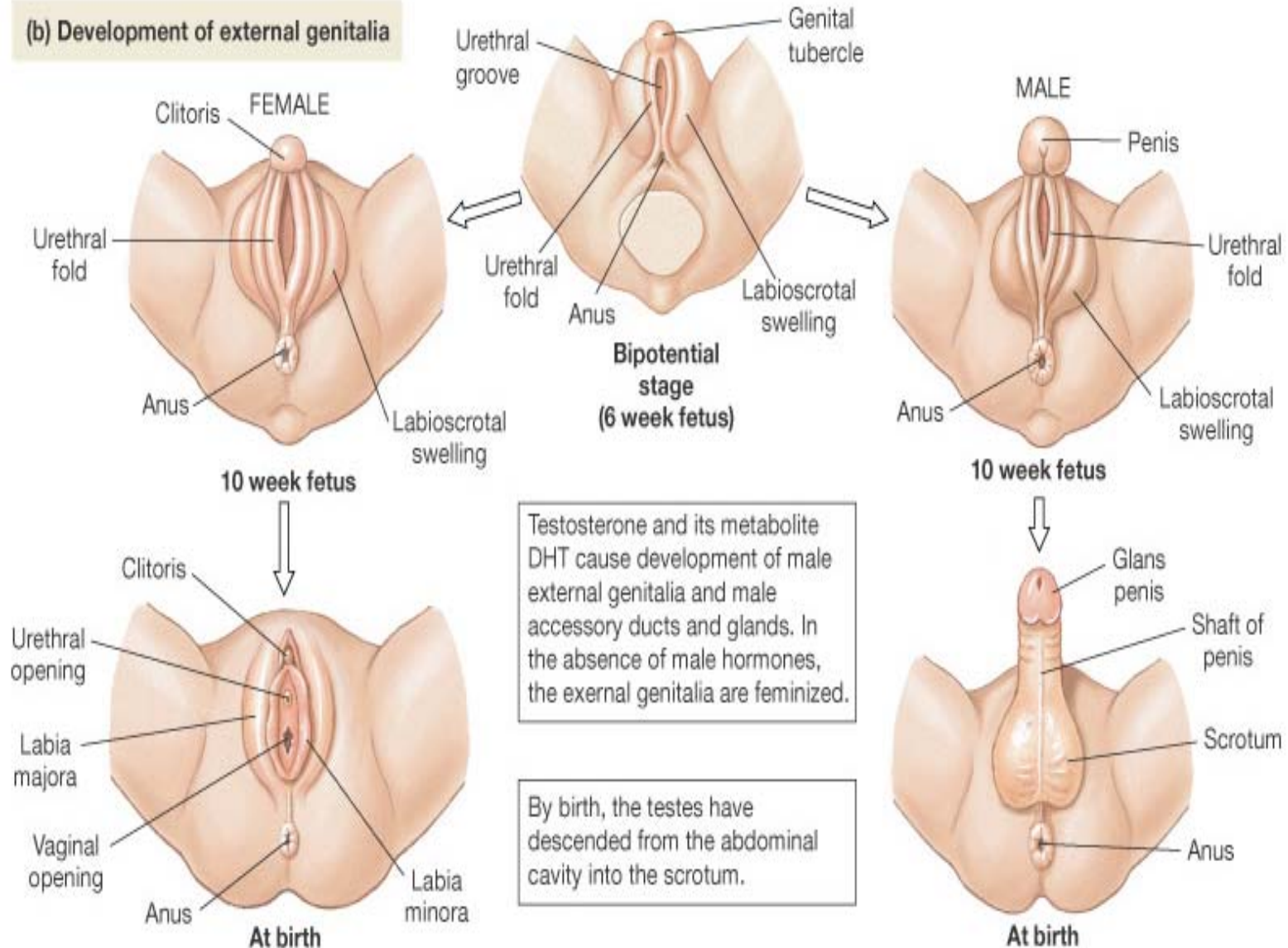
# Sexual Differentiation: Internal Embryonic Development

(a) Development of internal organs

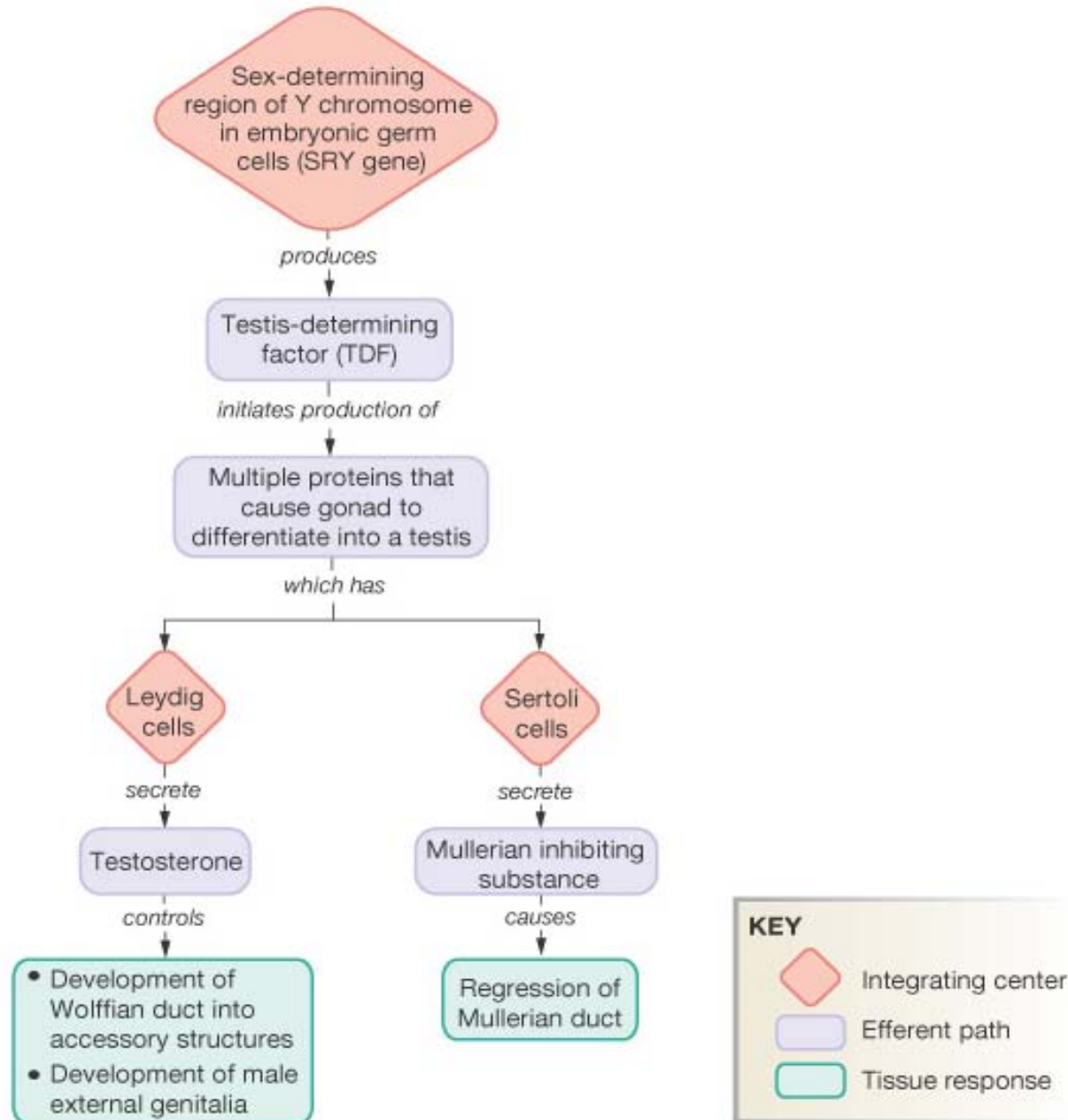


# Sexual Differentiation: External Genitalia

## (b) Development of external genitalia



# Male Development



# Role of hCG in Male Development

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- Human chorionic gonadotropin (hCG) which is secreted by the placenta has LH-like effects
- If the fetus is male, hCG stimulates testosterone production from the testes of the fetus which helps in development of male sexual organs

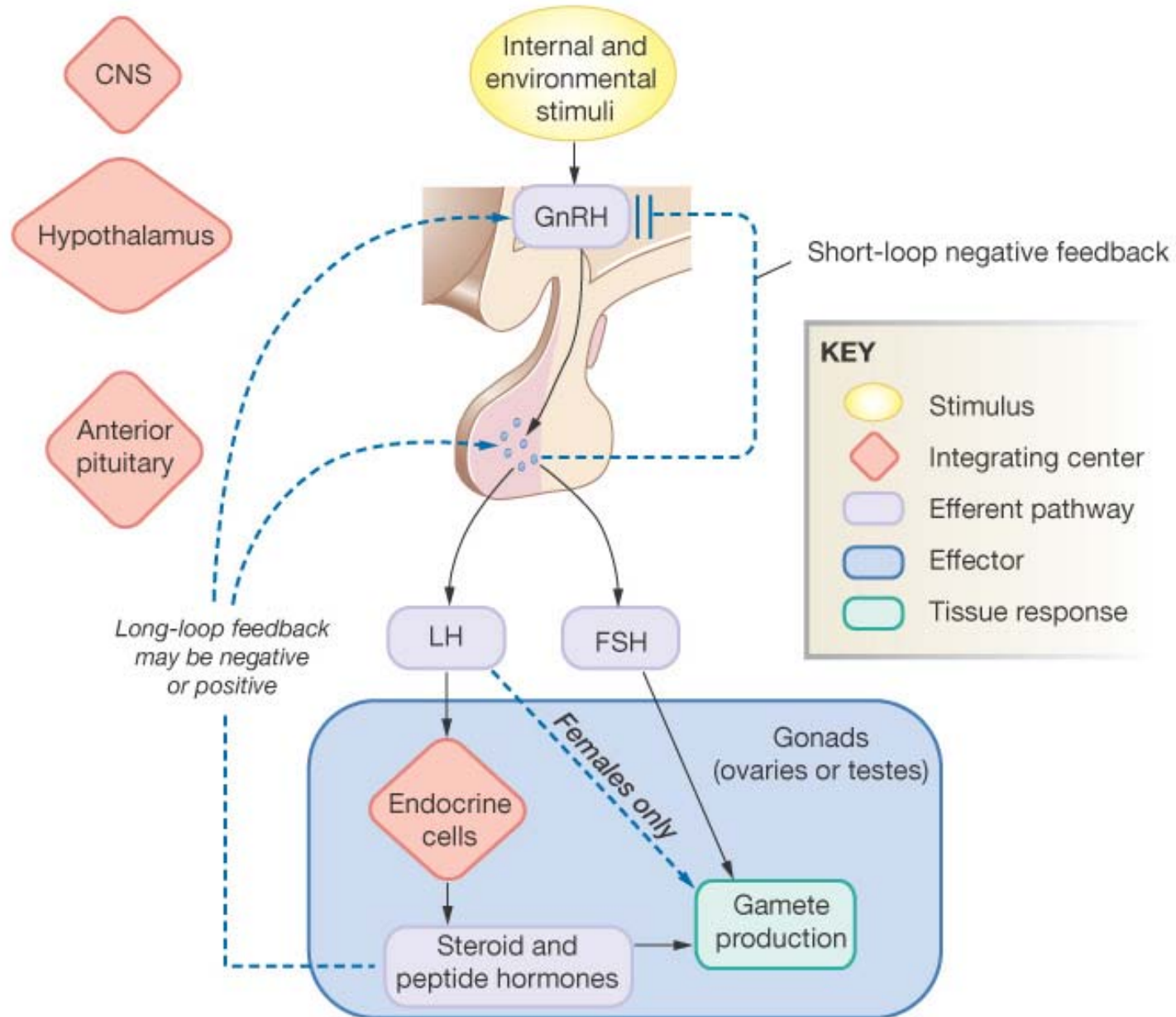
# Regulation of Reproduction: General Pathways

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- Hypothalamus: pulse generator
- Gonadotropin releasing H
  - (GnRH)
- Anterior Pituitary
  - Lutenizing H (LH)
  - Follicle stimulating H (FSH)
- Ovary: progesterone
  - Estrogen, inhibin
- Testis: testosterone



# Regulation of Reproduction: General Pathways



# **Male Reproductive System**

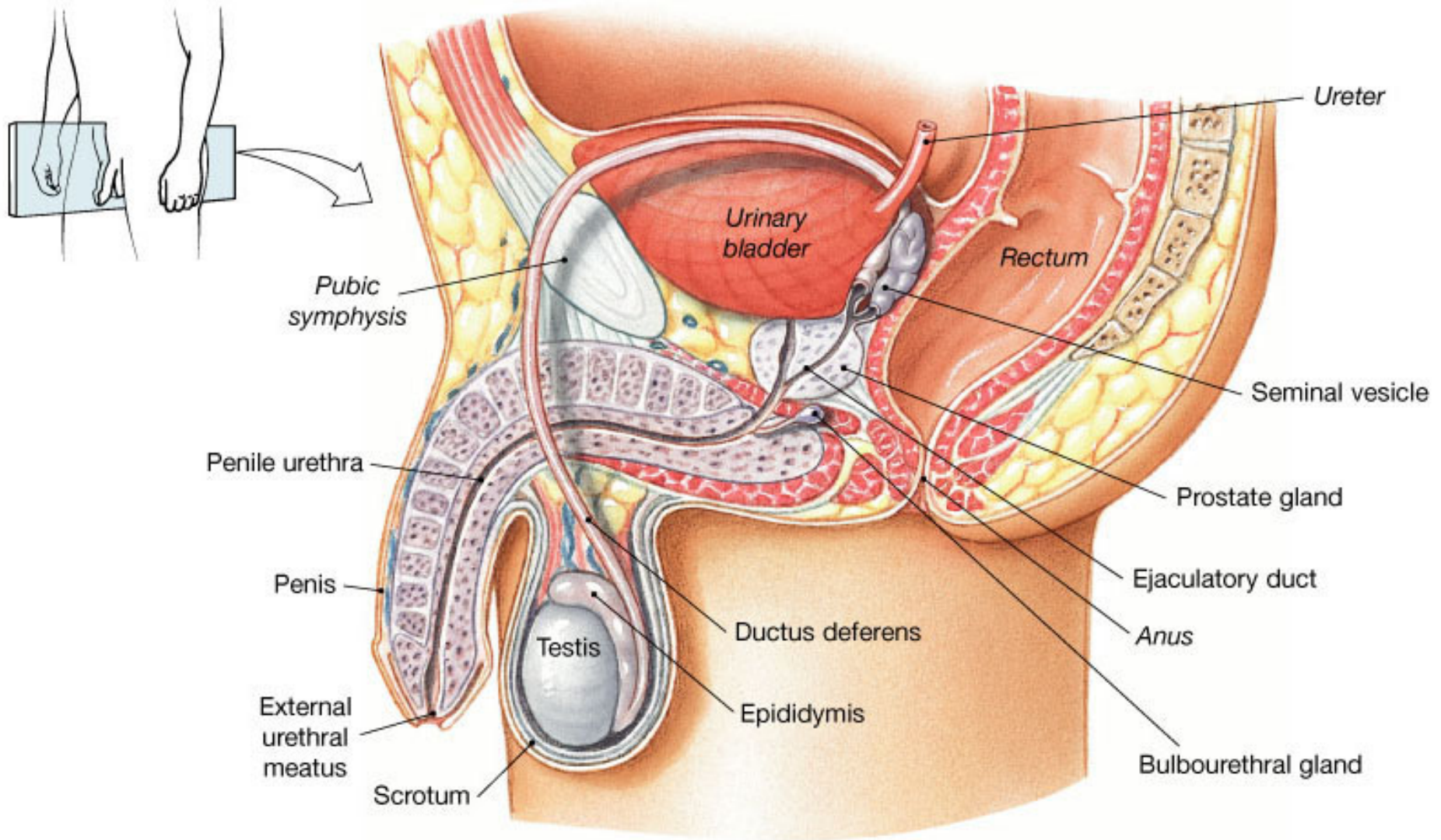
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# Male Reproductive Anatomy and Physiology

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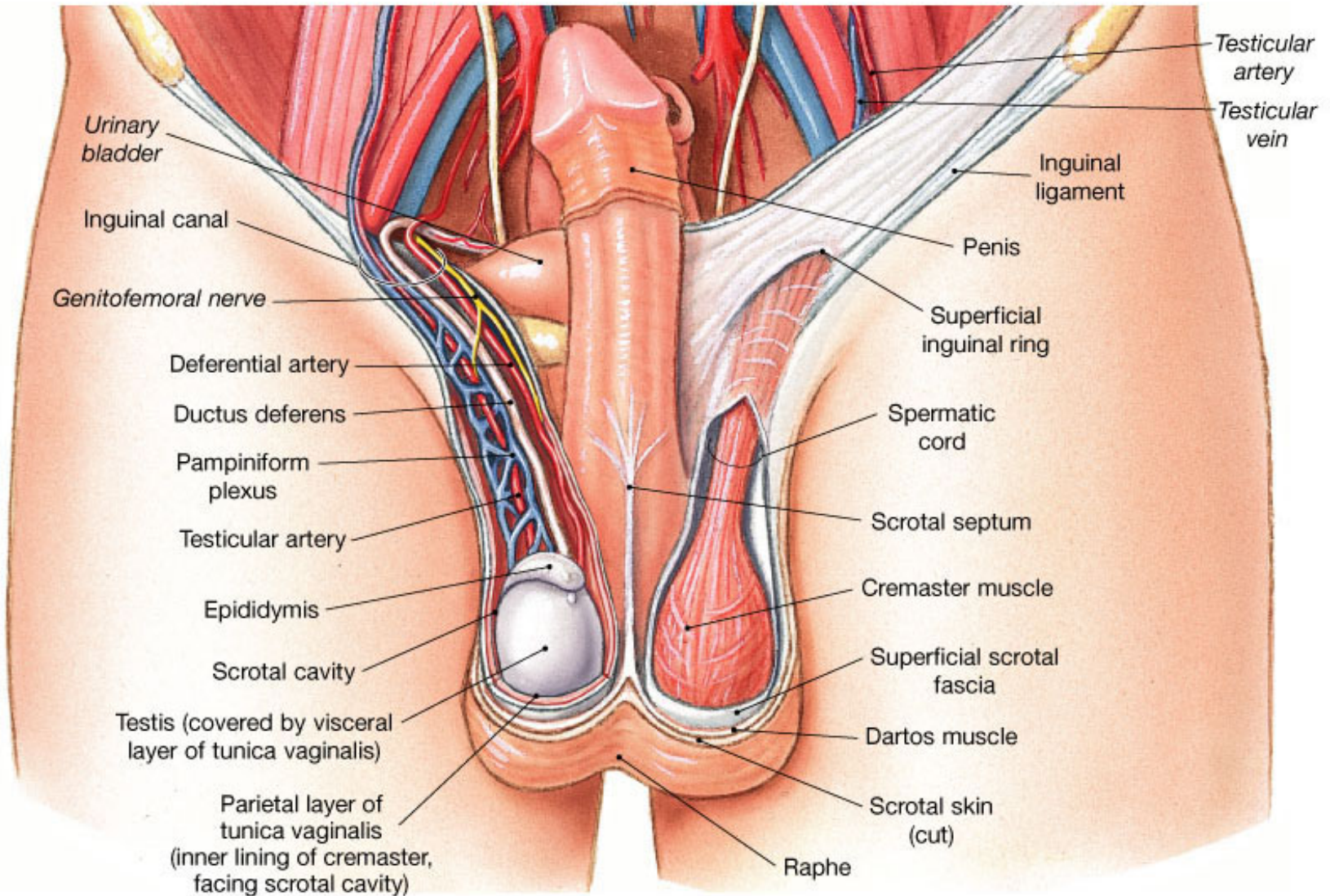
- Testis
- Epididymis
- Vas deferens
- Seminal vesicle
- Prostate
- Bulbourethral
- Ejaculatory duct
- Urethra
- Penis

# Male Reproductive Anatomy



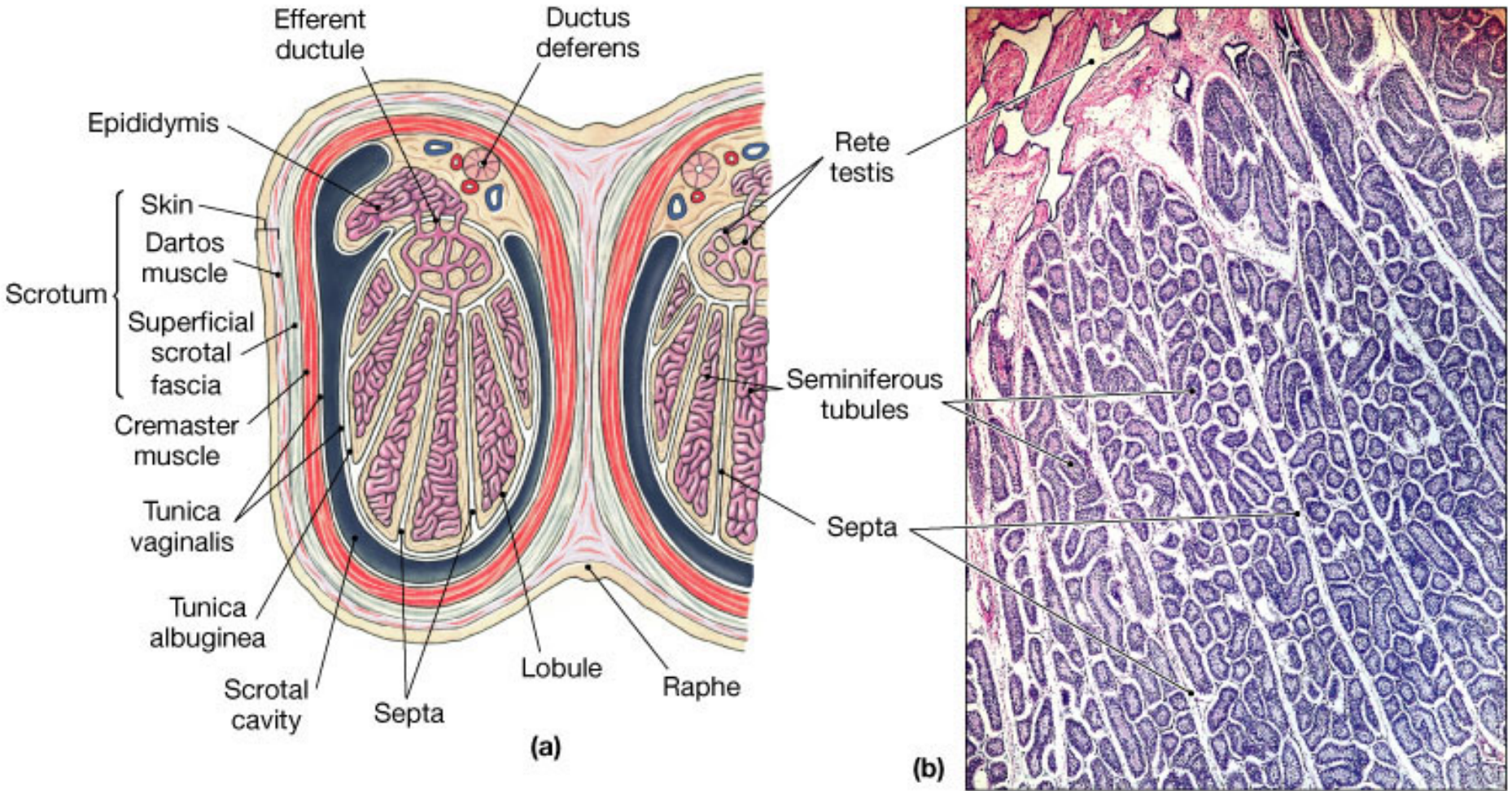


# The Male Reproductive System in Anterior View





# The Structure of the Testes

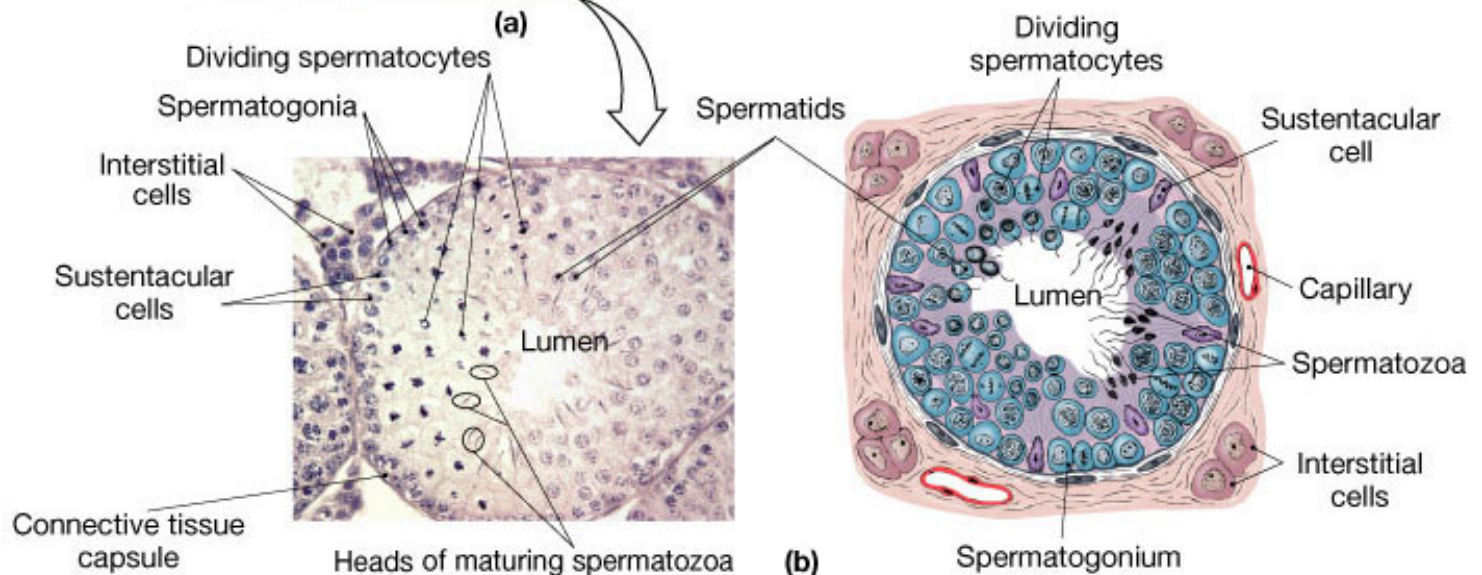
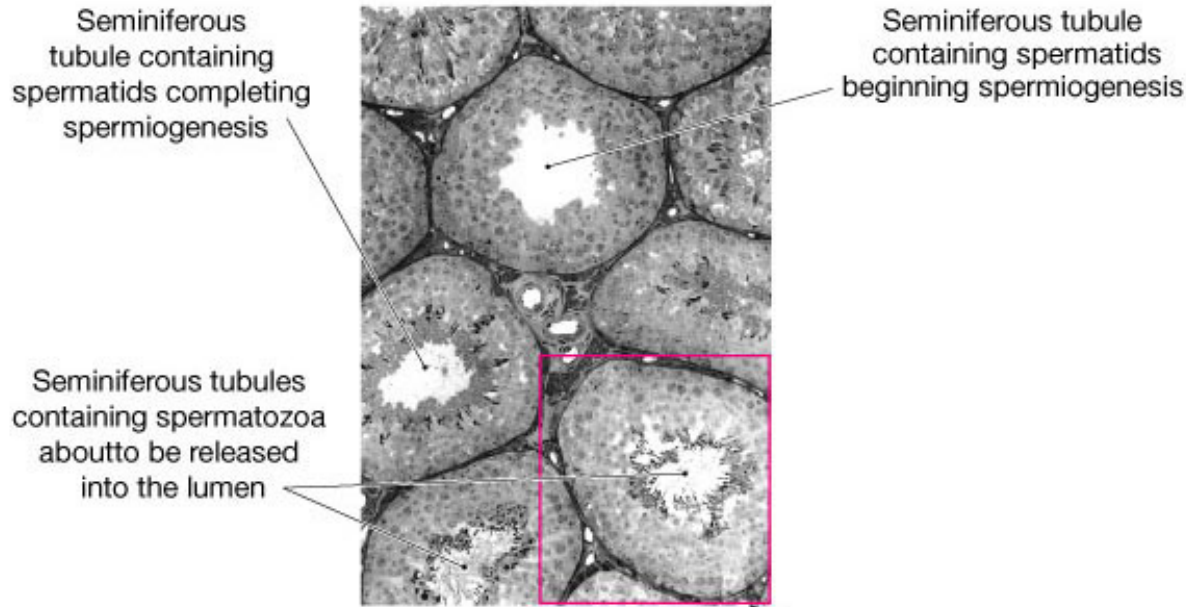


# Spermatogenesis

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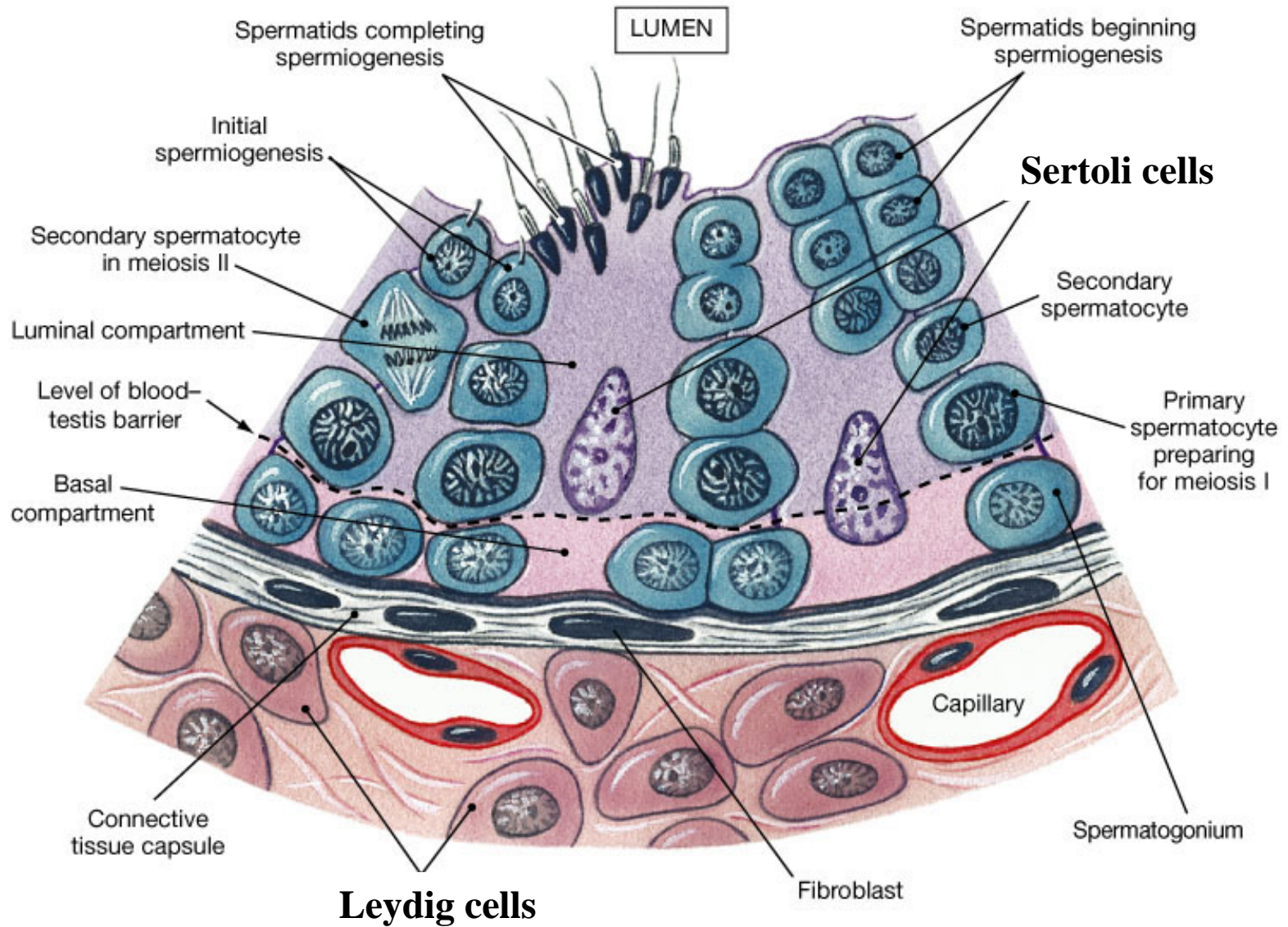
- Takes about 74 days
- Seminiferous tubules
  - Contain **spermatogonia**
    - Stem (germ) cells involved in spermatogenesis
  - Contain **Sertoli** cells
    - Sustain and promote development of sperm

# The Seminiferous Tubules



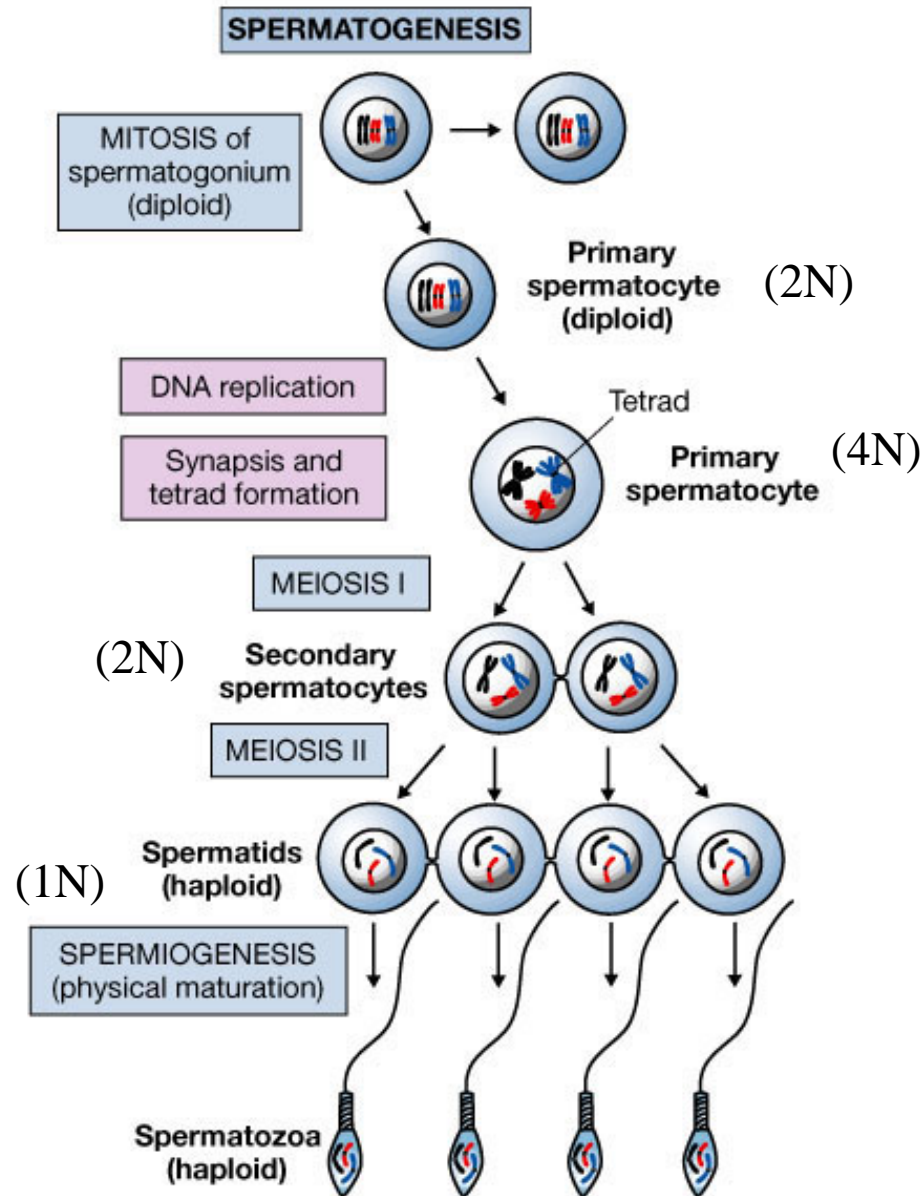


# The Seminiferous Tubules

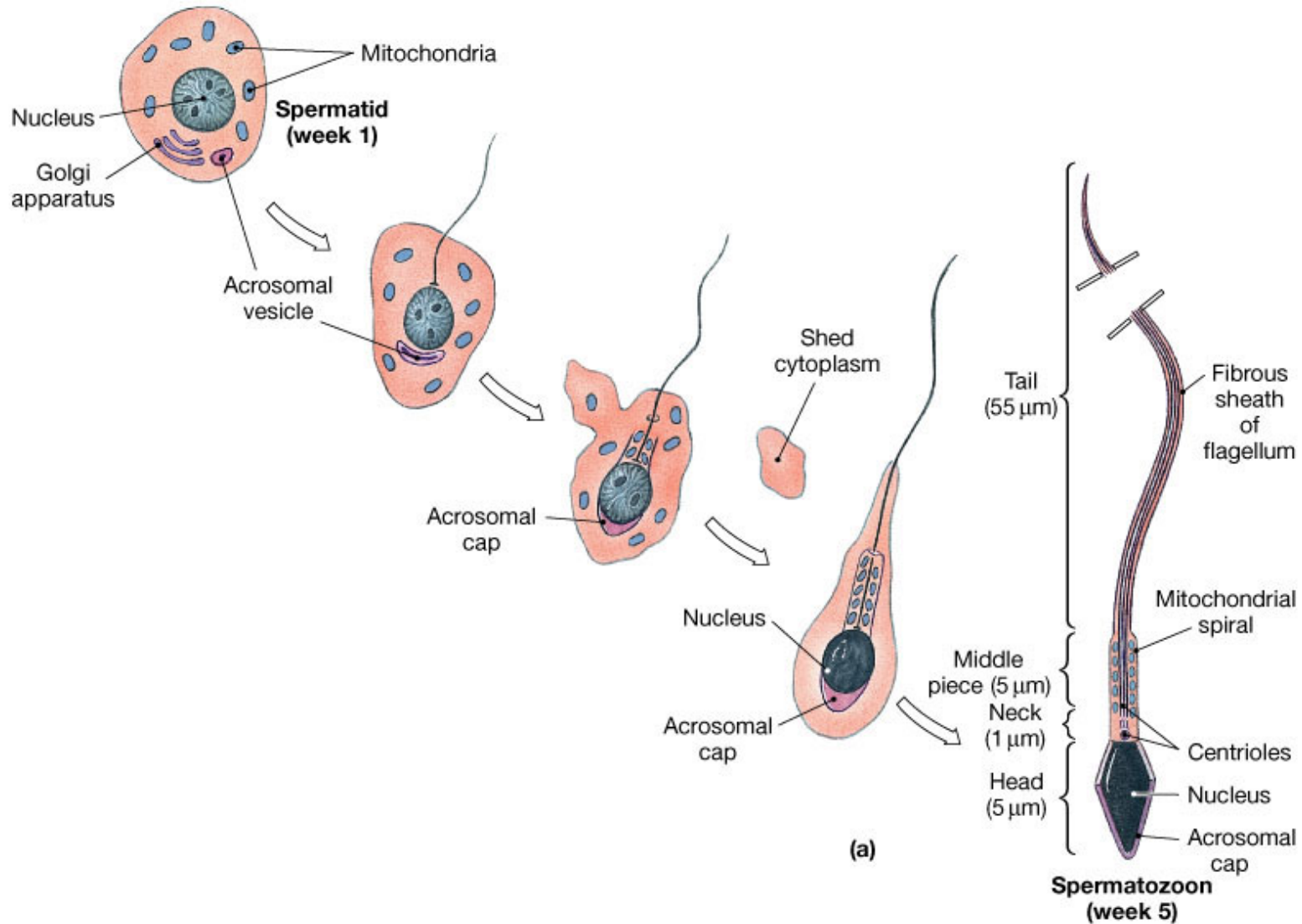


(c)

# Spermatogenesis

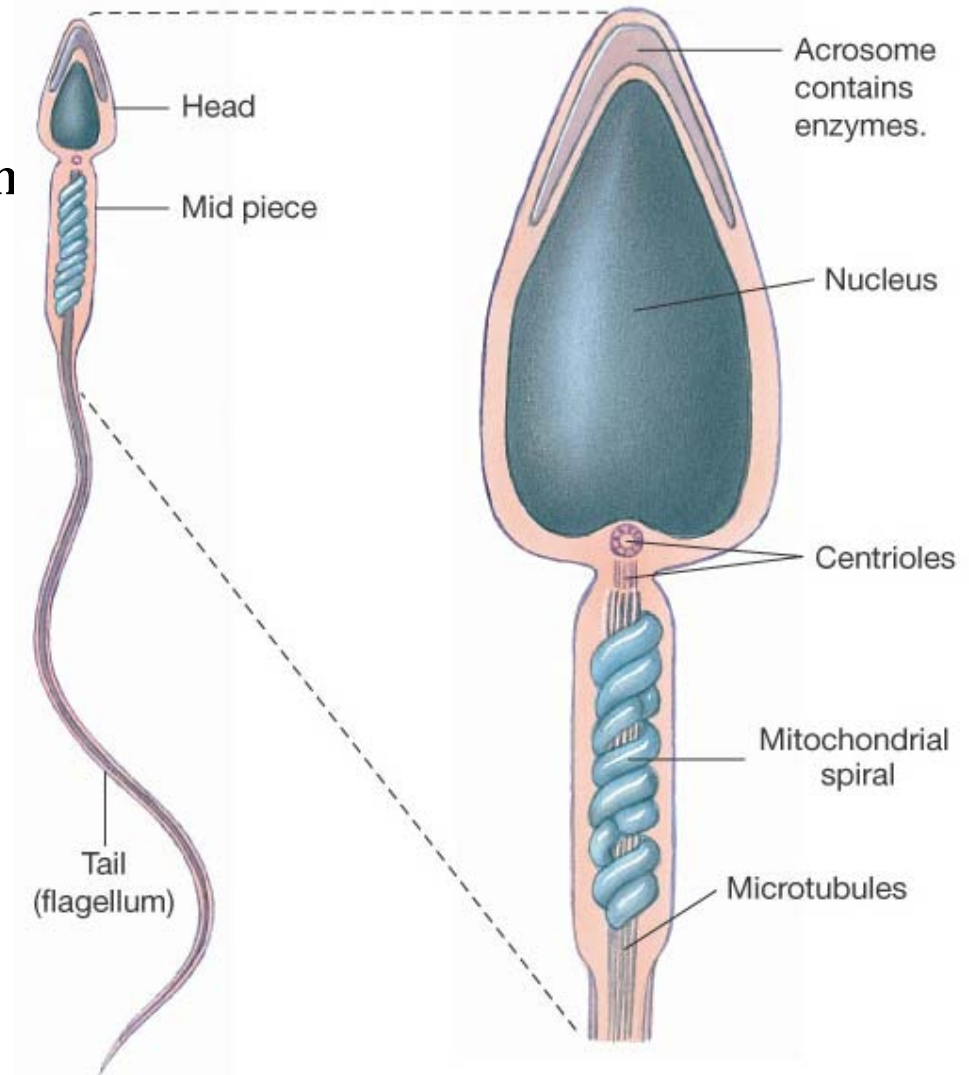


# Spermiogenesis and Spermatozoon Structure



# Spermatozoa Structure and Functions in Review

- **Head**
  - **Acrosome:** formed from Golgi apparatus, contains proteolytic enzymes
  - **Nucleus**
- **Midpiece**
  - **Centrioles:**
  - **Mitochondria:**
- **Tail: flagellum**
  - **Microtubules:**



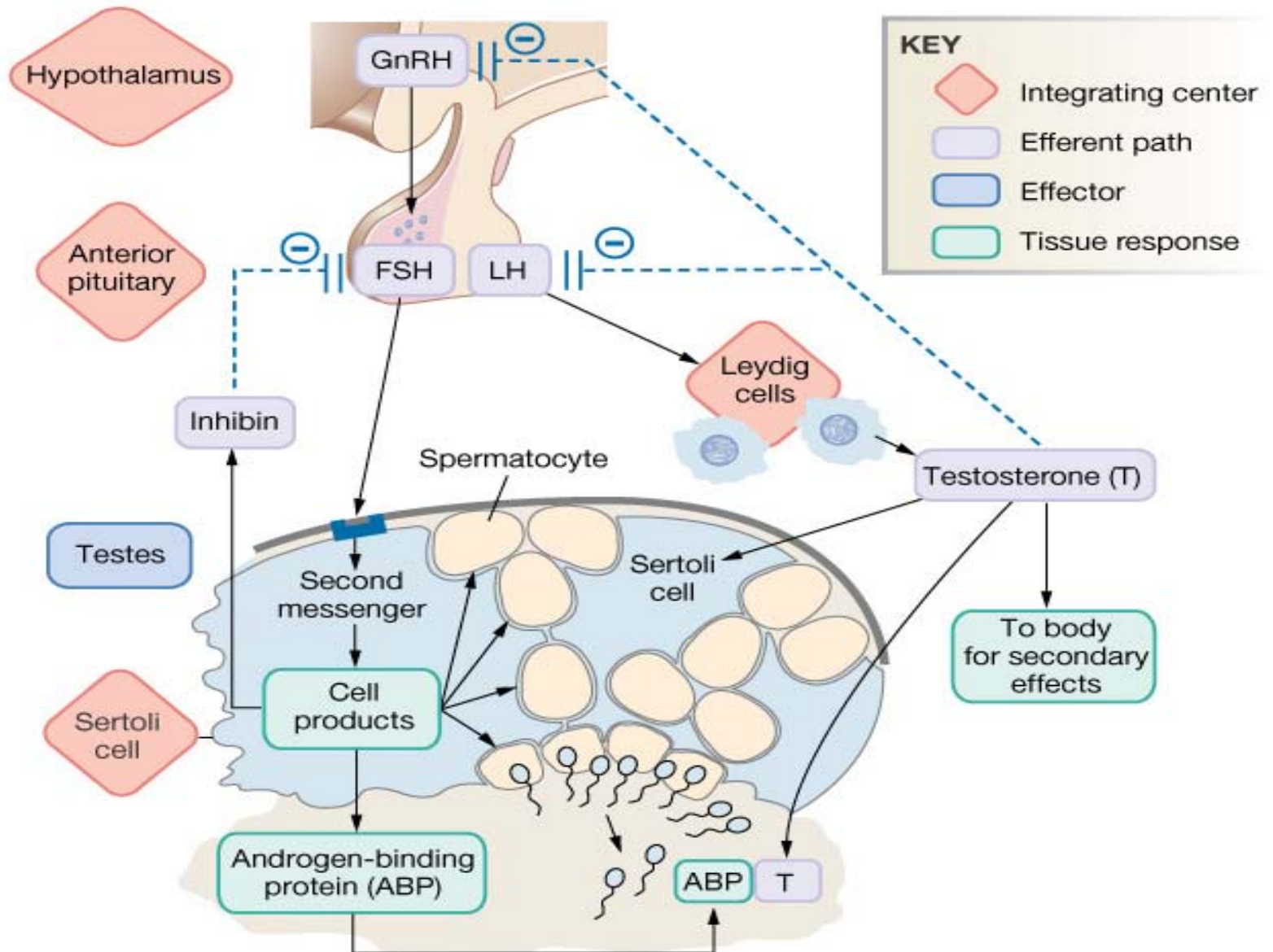
# Regulation of Spermatogenesis

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- GnRH → LH → Leydig cells → testosterone → growth and division of germ cells
- GnRH → FSH → Sertoli cells → spermatocyte maturation
- Inhibin feedback – FSH
- Testosterone – short & long loops



# Regulation of Spermatogenesis



# Maturation of Sperm in Epididymis

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- Sperms in the early portion of epididymis are nonmotile
- After 18-24 h they develop capability of motility
- Most of sperms are stored in vas deferens, maintaining their fertility for at least a month
- After ejaculation they become motile
- Activity of a sperm is greatly enhanced in neutral to slightly alkaline medium and depressed in acidic medium
- The life expectancy of ejaculated sperm in the female genital tract is 1-2 days

---

## **Seminal Vesicles**

- S Vs produce nutrients as well as prostaglandins and fibrinogen

## **Prostate**

- Slightly alkaline milky fluids that help in neutralizing other seminal fluids as well as the vaginal fluids
- Prostates fluids also contain clotting protein and profibrinolysin



# Semen

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- Milky white, sticky mixture of sperm and accessory gland secretions:
  - Sperm and fluid from vas deferens 10%
  - Seminal plasma (70% seminal vesicles, 20% prostate, and small amounts from other glands)
- Provides a transport medium and nutrients (fructose), protects and activates sperm, and facilitates their movement
- Average pH is 7.5

# Semen

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- Prostaglandins in semen:
  - Decrease the viscosity of mucus in the cervix
  - Stimulate reverse peristalsis in the uterus
  - Facilitate the movement of sperm through the female reproductive tract
- Clotting factors coagulate semen immediately after ejaculation, then fibrinolysin liquefies the sticky mass during the next 15-30 minutes
- After ejaculation, sperms can live 24-48 h

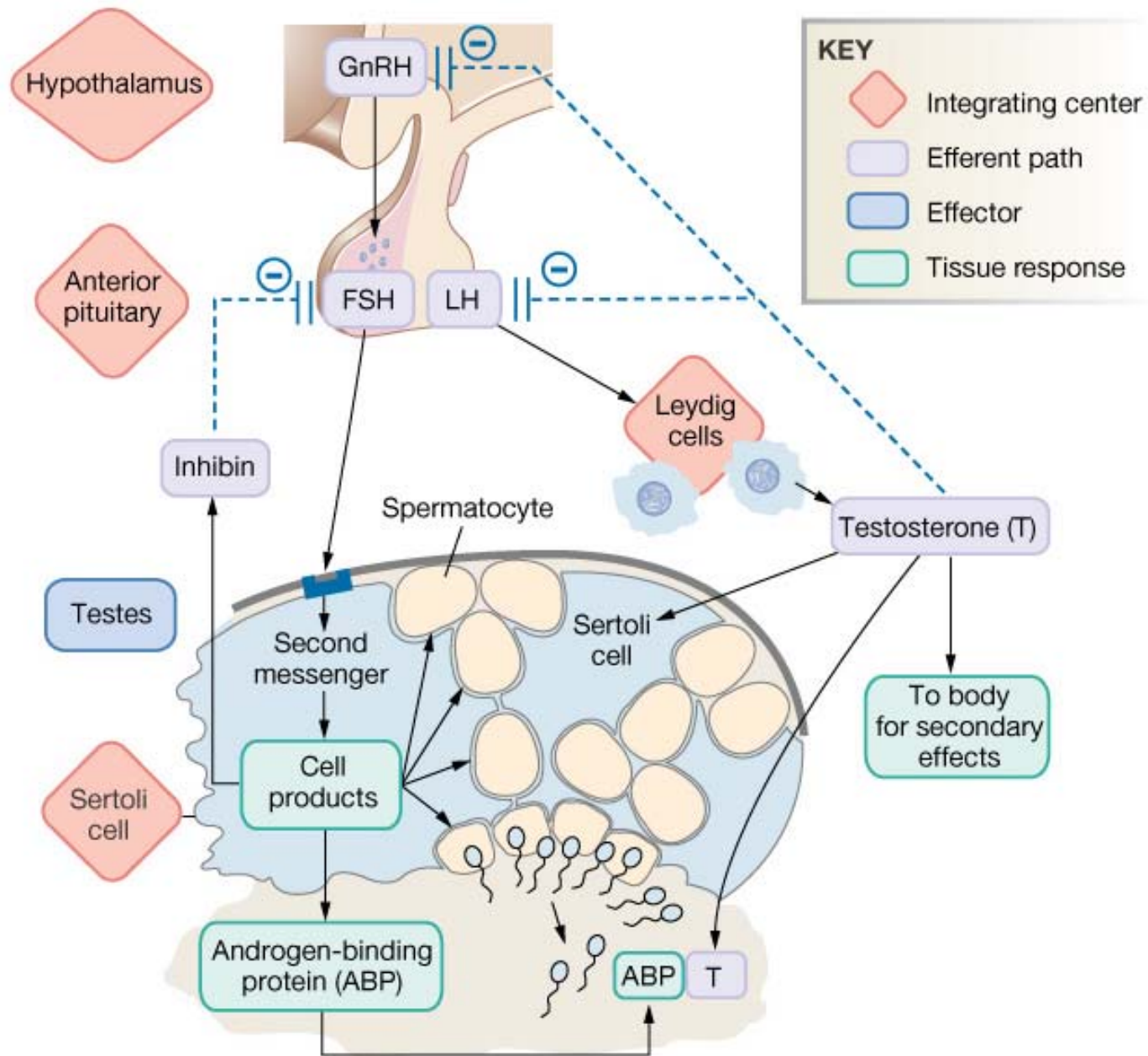
# Semen

- Freshly ejaculated semen undergoes a process called **capacitation**: 1. inhibitory factors are washed out by uterine and fallopian fluids, 2. the sperm swims away from cholesterol vesicles, 3. the membrane of the sperms becomes more permeable to  $\text{Ca}^{++}$
- Only 2-5 ml of semen are ejaculated, but it contains 35-200 million sperm/ml (<20 million  $\Rightarrow$  infertile)
- When the majority of the sperm are morphologically abnormal or nonmotile then person is likely to be infertile

# Hormonal Regulation of Testicular Function

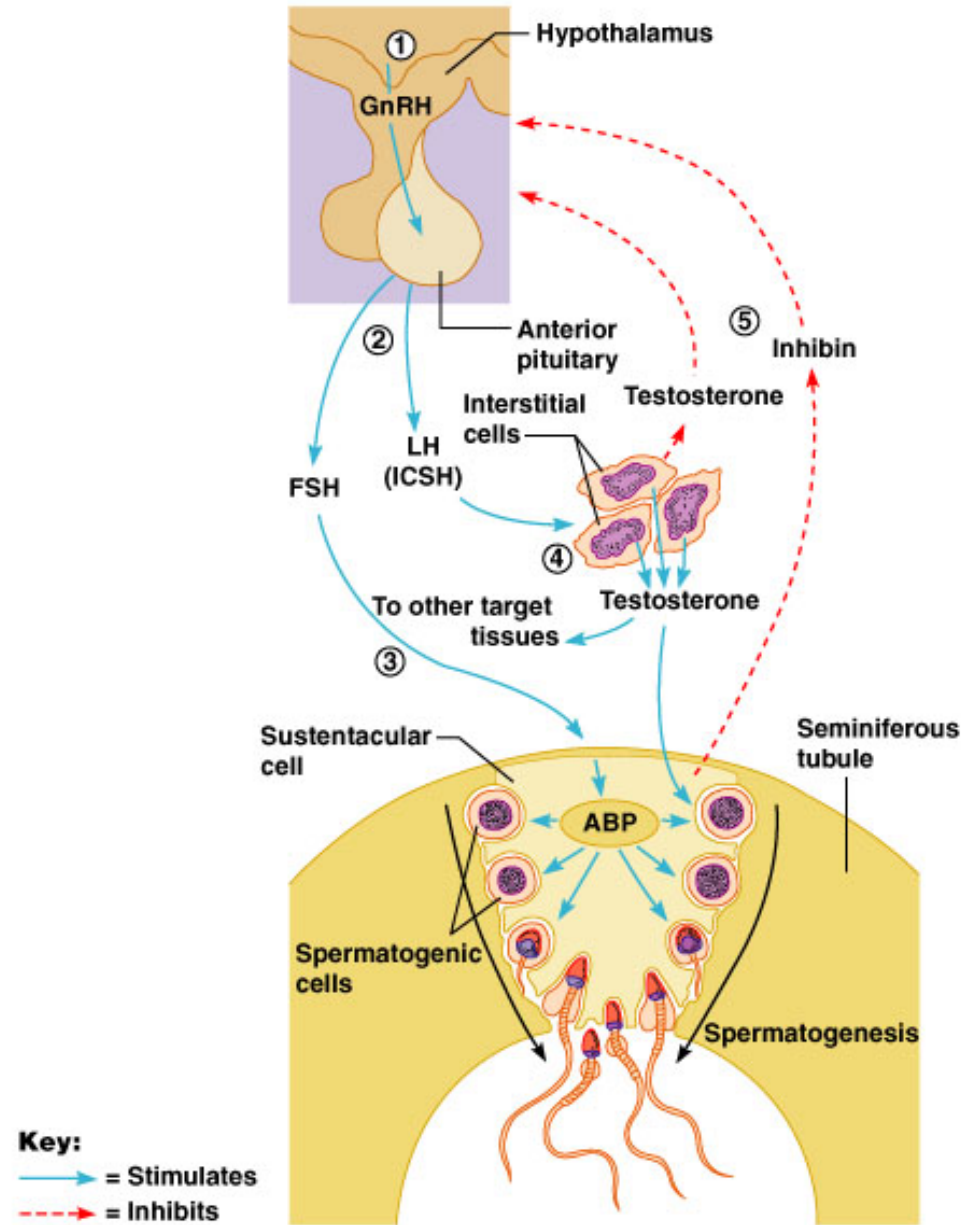
- The hypothalamus releases gonadotropin-releasing hormone (GnRH) in pulses
- GnRH stimulates the anterior pituitary to secrete FSH and LH
  - FSH causes Sertoli cells to release androgen-binding protein (ABP) and help in sperm maturation
  - LH stimulates interstitial (Leydig) cells to release **testosterone**
- Binding of testosterone to ABP enhances spermatogenesis
- GH: promotes early division of spermatogonia

# HPG Axis



# Hormonal Regulation of Testicular Function

- Feedback inhibition on the hypothalamus and pituitary results from:
  - Rising levels of testosterone
  - Increased inhibin



# Mechanism and Effects of Testosterone Activity

- Testosterone is synthesized from cholesterol
- It binds to testosterone –binding globulin (TeBG), serum albumin, or to corticosterone-binding globulin (CBG)
- Once it diffuses to cells it either binds to androgen receptor or converted to DHT which then binds to the androgen receptor
- Testosterone targets all reproductive and accessory organs and its deficiency causes these organs to atrophy
- Increases metabolic rate and red blood cell formation

# Male Secondary Sex Characteristics

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- Male hormones make their appearance at puberty and induce changes in nonreproductive organs, including
  - Appearance of pubic, axillary, and facial hair
  - Enhanced growth of the chest and deepening of the voice
  - Skin thickens and becomes oily
  - Bones grow and increase in density
  - Skeletal muscles increase in size and mass
  - Closure of epiphyseal plates in long bones



# Male Secondary Sex Characteristics

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- Testosterone is the basis of libido in both males and females

# Male Sexual Act

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- Erection is initiated by sexual stimuli including:
  - Touch and mechanical stimulation of the penis
  - Erotic sights, sounds, and smells
- Erection can be induced or inhibited solely by emotional or higher mental activity
- Enlargement and stiffening of the penis from engorgement of erectile tissue with blood

# Male Sexual Act (cont.)

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- During sexual arousal, a PNS reflex promotes the release of nitric oxide
- Nitric oxide relaxes the penis arteries and causes erectile tissue to fill with blood
- Expansion of the corpora cavernosa:
  - Compresses their drainage veins
  - Retards blood outflow and maintains engorgement

# Male Sexual Act (cont.)

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- When the sexual stimulus becomes extremely intense, spinal cord begins to send sympathetic impulses to initiate emission
- Filling of the internal urethra with semen elicits signals that promotes ejaculation
- After orgasm, the excitement disappears within 1-2 minutes (resolution)

# The Erection Reflex

