

# Unit 8 Endocrine and Reproductive Systems

Ms. Randall

# Lesson 1: Hormones

## ***Objective:***

- Describe the functions and mechanisms of hormone action
- Discuss the regulation of hormone levels through positive or negative feedback
- Compare types of endocrine stimuli

# Introduction

- The endocrine and nervous systems function together to regulate body activities
- The endocrine system releases hormones to control body activities and help maintain homeostasis
- In contrast to the rapid communication and control associated with the nervous system, the endocrine system responses are slower and more sustained

# Endocrine System

**TABLE 17.1**

Comparison of Control by the Nervous and Endocrine Systems

<b>CHARACTERISTIC</b>	<b>NERVOUS SYSTEM</b>	<b>ENDOCRINE SYSTEM</b>
<b>Mediator molecules</b>	Neurotransmitters released locally in response to impulses	Hormones delivered to tissues throughout body by blood
<b>Site of mediator action</b>	Close to site of release, at synapse; binds to receptors in postsynaptic membrane	Far from site of release (usually); binds to receptors on or in target cells
<b>Types of target cells</b>	Muscle (smooth, cardiac, and skeletal) cells, gland cells, other neurons	Cells throughout body
<b>Time to onset of action</b>	Typically within milliseconds (thousandths of a second)	Seconds to hours or days
<b>Duration of action</b>	Generally briefer (milliseconds)	Generally longer (seconds to days)

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# Endocrine system

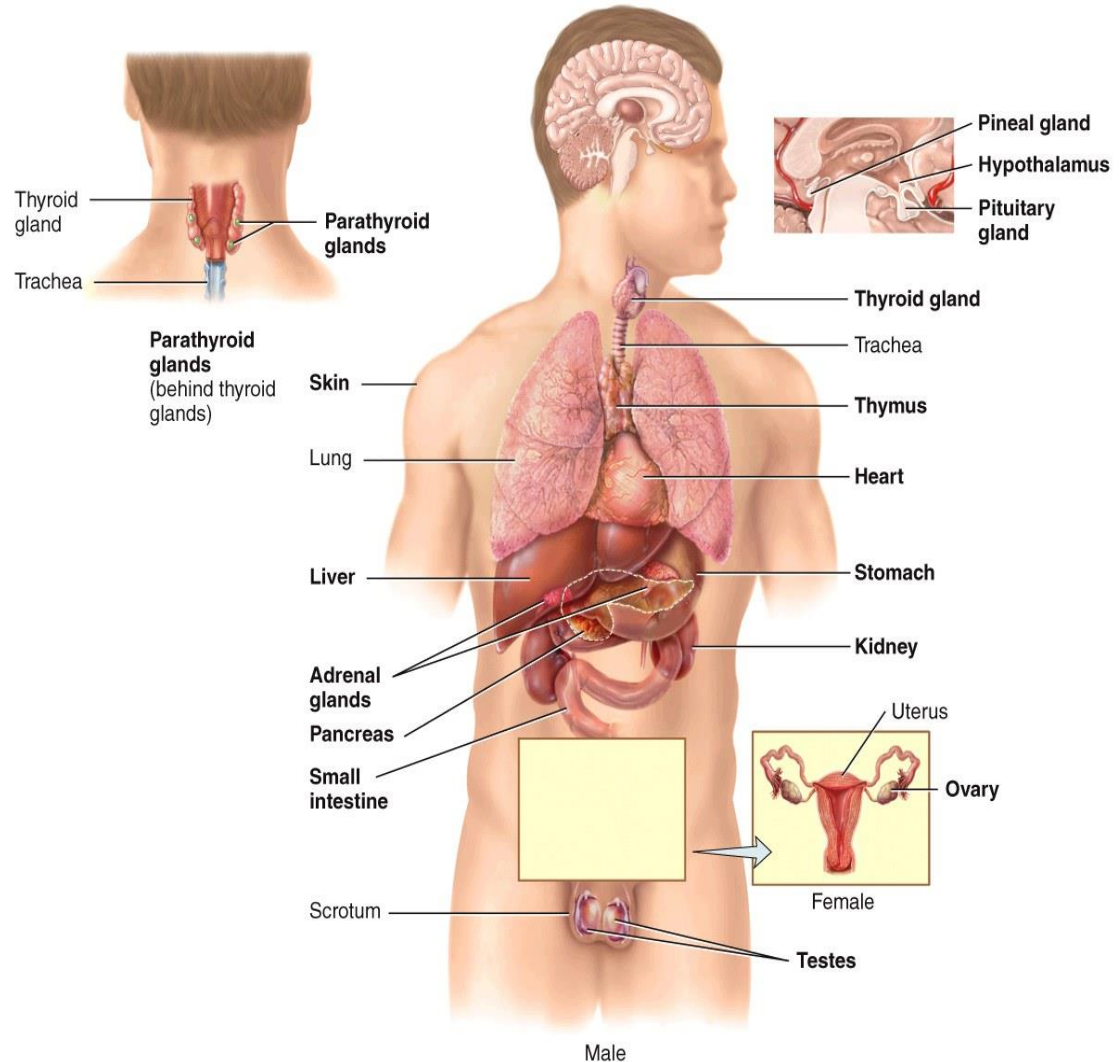
- Made up of the cells, tissues, and organs that secrete hormones into body fluids.
- Regulates a number of metabolic processes within cells, and the whole body.
- Hormones diffuse into the bloodstream to act on target cells some distance away.

Two kinds of glands,

1. *exocrine* (secretes products into ducts) and
2. *endocrine* (secrete products into body fluids to affect target cells).

# Endocrine glands

*Pituitary gland, thyroid gland, parathyroid glands, adrenal glands, pancreas, and other hormone-secreting glands and tissues.*



# Two main classes of Hormones

## 1. Amino acid-based hormones

- Amino acid derivatives, peptides, and proteins

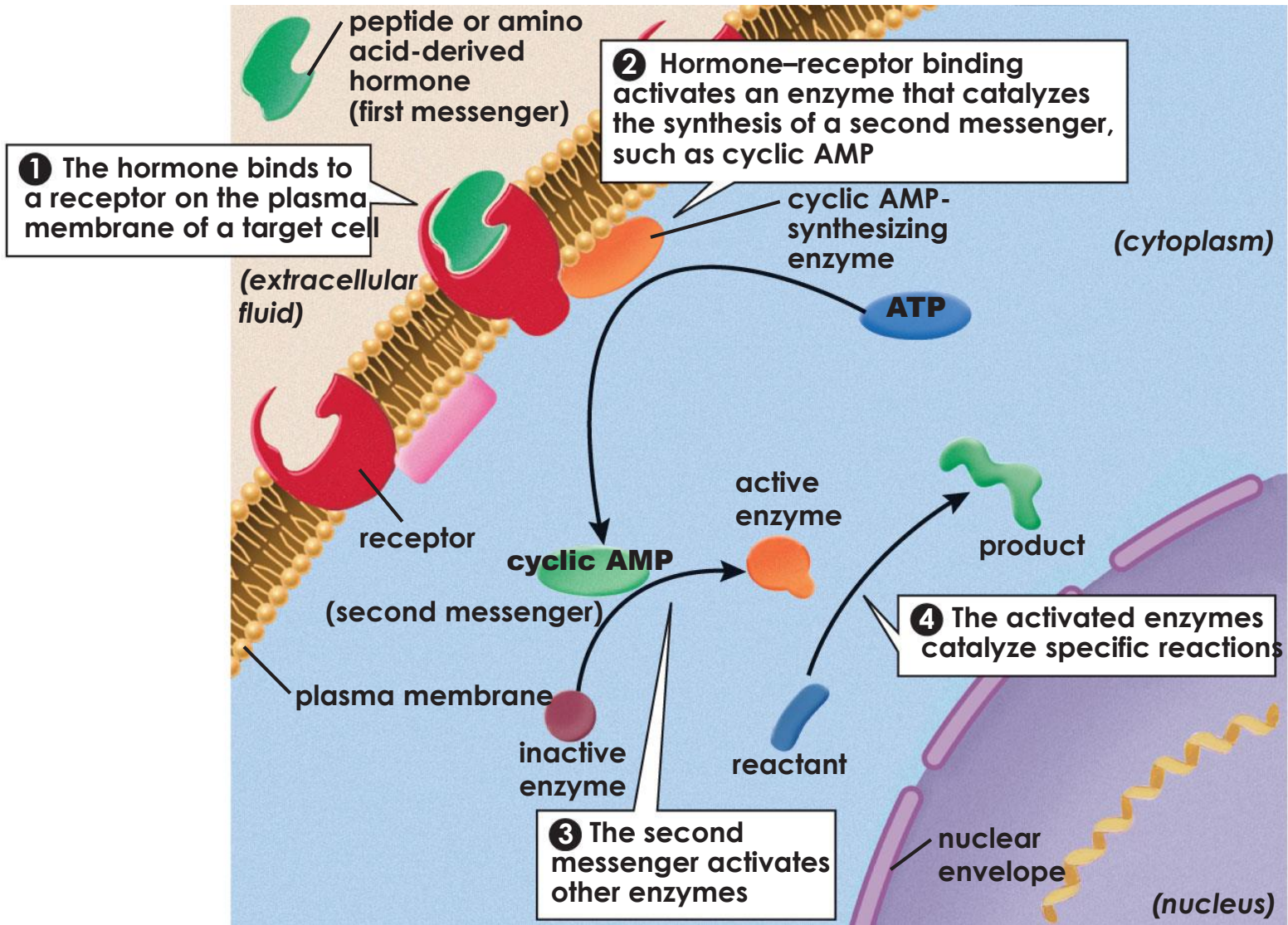
## 2. Steroids

- Synthesized from cholesterol
- Gonadal and adrenocortical hormones

They can influence target cells even if they are present only in small concentrations

# Peptide Hormones(Amino Acid)

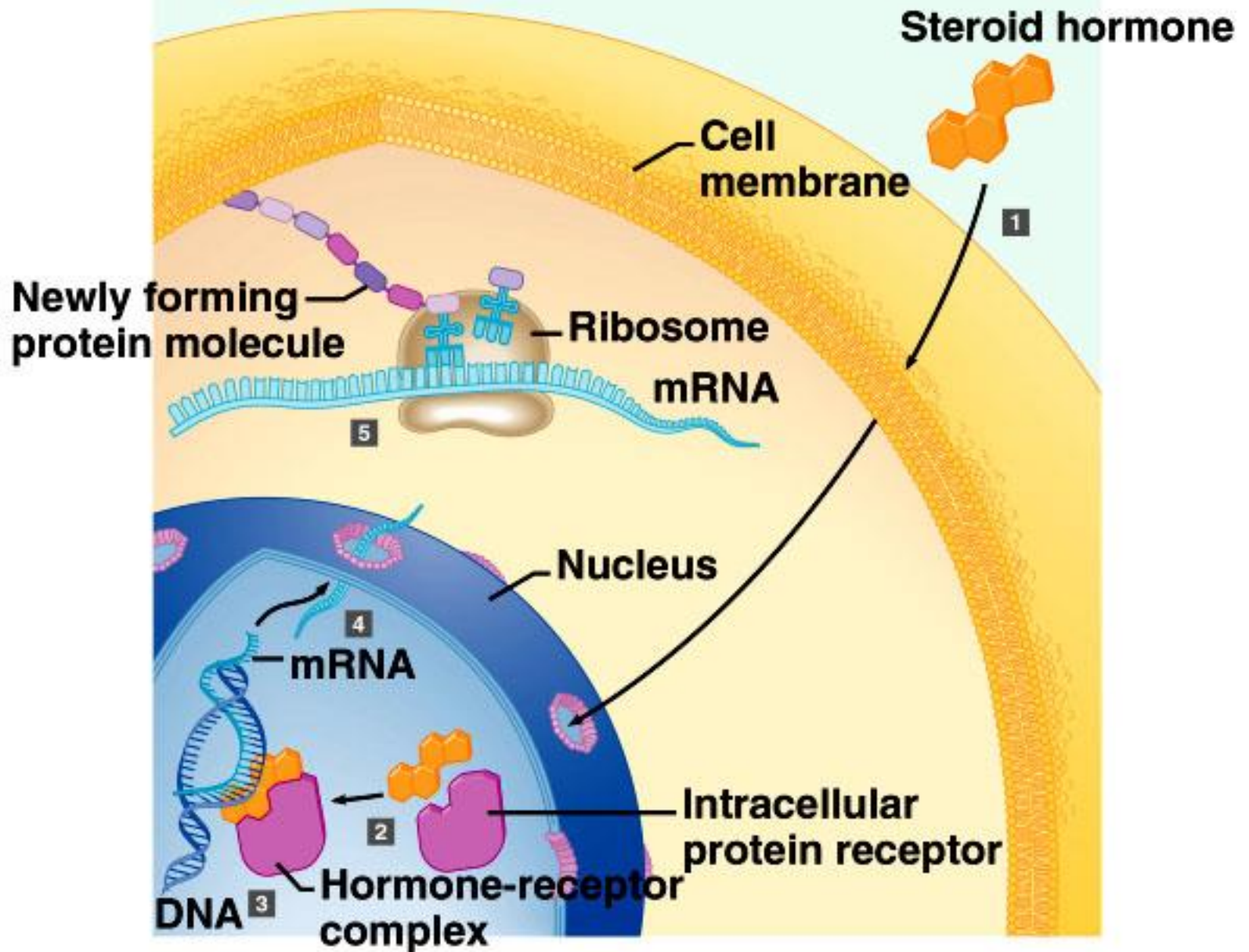
- Peptide hormones do not enter the cell directly. These hormones **bind to receptor proteins in the cell membrane.**
- When the hormone binds with the receptor protein, **a secondary messenger molecule initiates the cell response.**
- Because peptide hormones are water soluble, they often produce fast responses.



# Steroid Hormones

- Steroid hormones **enter through the cell membrane and bind to receptors inside** of the target cell.
- These hormones may **directly stimulate transcription of genes to make certain proteins.**
- Because steroids work by triggering gene activity, the response is slower than peptide hormones.





# Control of Hormonal Secretions

- Hormone levels are very precisely regulated.
- Control Mechanisms
  1. Release of **tropic hormones** from the **hypothalamus** controls secretions of the **anterior pituitary**.
  2. The nervous system influences certain endocrine glands directly.
  3. Other glands respond directly to changes in the internal fluid composition.



# Control of Hormones

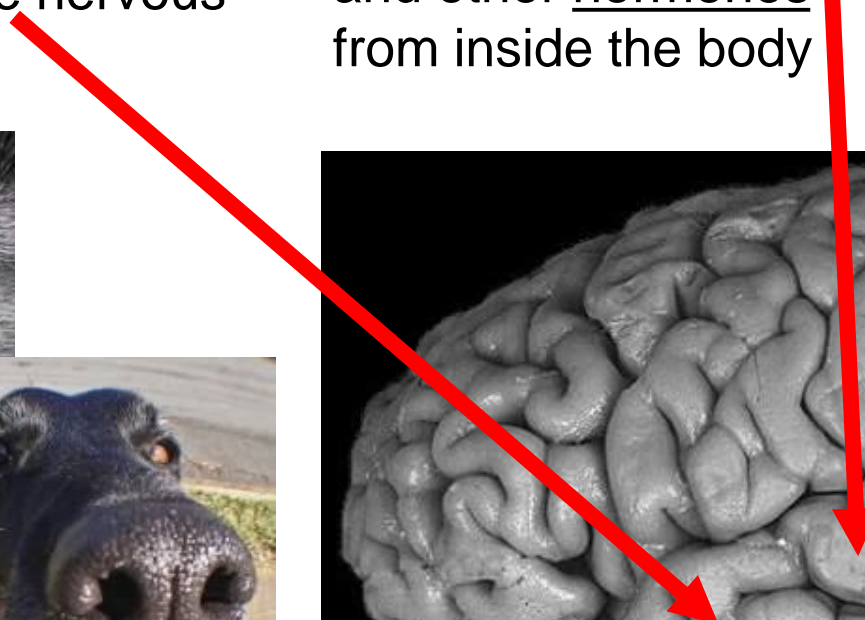
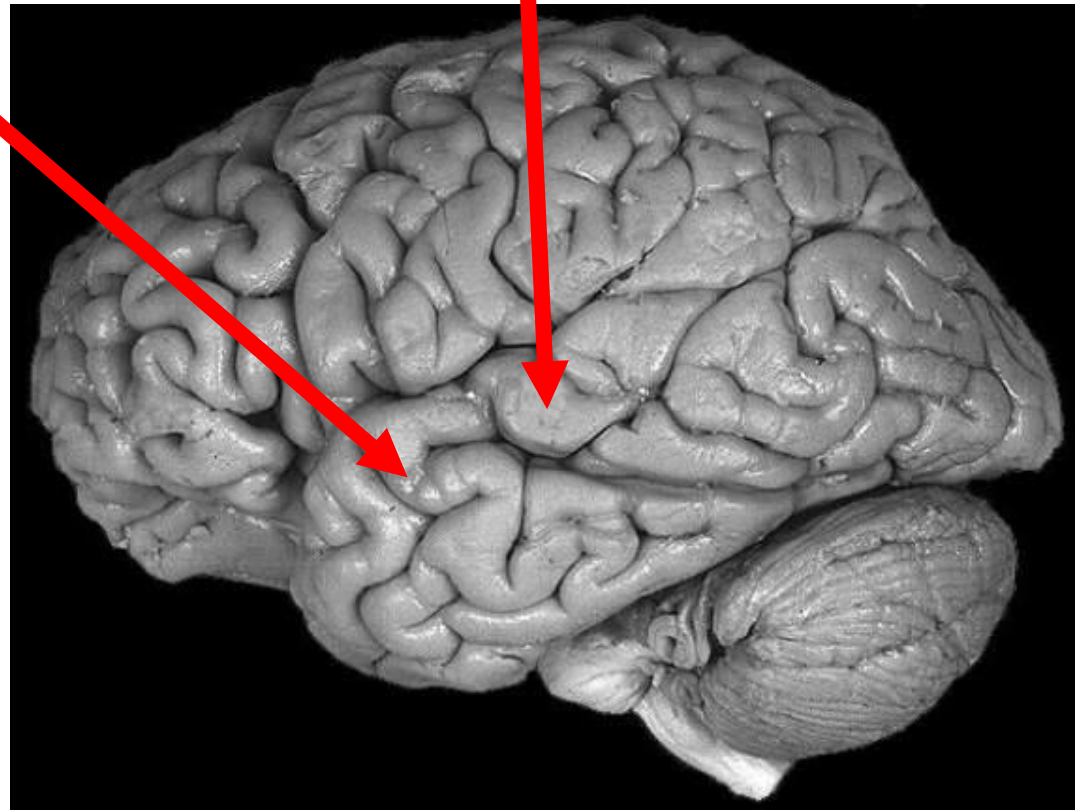
## External stimuli

by way of nerves  
from the sensory  
organs in the nervous  
system



## Internal stimuli

by way of nerves  
and other hormones  
from inside the body



# Negative Feedback Systems

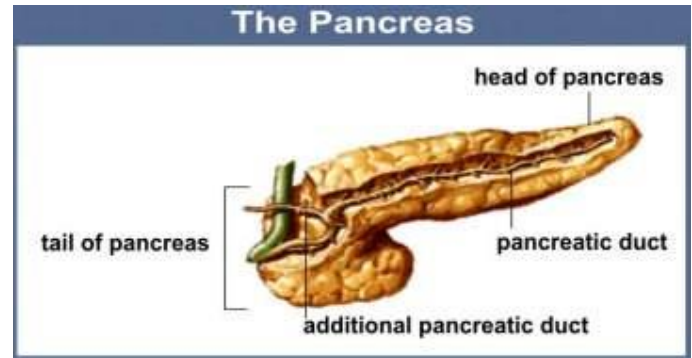
- Commonly, *negative feedback mechanisms* control hormonal releases.
- Gland is sensitive to the concentration of the substance it regulates or which regulates it.
- When the concentration of the regulated substance reaches a certain level (high or low), it **inhibits the gland from secreting more hormone** until the concentration returns to normal.



You eat. Glucose (sugar) in the blood increases.



Increased glucose is detected by receptors that notify the brain. It sends a message to the pancreas to **produce insulin**.

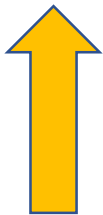


Insulin tells muscle and liver to take up glucose from the bloodstream and use it for energy or store it for later. Brain reduces appetite.

Blood glucose level drops as it is removed by the cells.



Pancreas **stops making insulin**.



# Blood levels of hormones

- Are controlled by negative feedback systems
- Vary only within a narrow desirable range

Hormones are synthesized and released in response to

1. Humoral stimuli
2. Neural stimuli
3. Hormonal stimuli

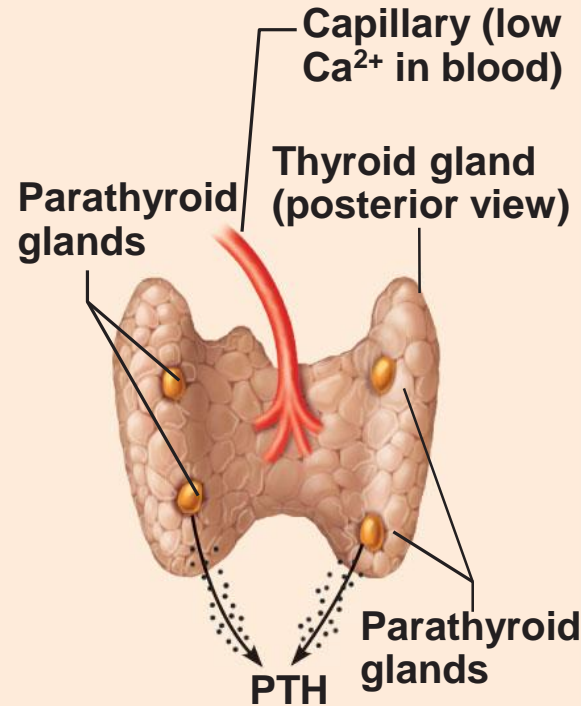
# Humoral Stimuli

*Changing blood levels of ions and nutrients directly stimulates secretion of hormones*

- Declining blood  $\text{Ca}^{2+}$  concentration stimulates the parathyroid glands to secrete PTH (parathyroid hormone)
- PTH causes  $\text{Ca}^{2+}$  concentrations to rise and the stimulus is removed

## (a) Humoral Stimulus

① Capillary blood contains low concentration of  $\text{Ca}^{2+}$ , which stimulates...



② ...secretion of parathyroid hormone (PTH) by parathyroid glands\*

# Neural Stimuli

- **Nerve fibers stimulate hormone release**
  - Sympathetic nervous system fibers stimulate the adrenal medulla to secrete catecholamines

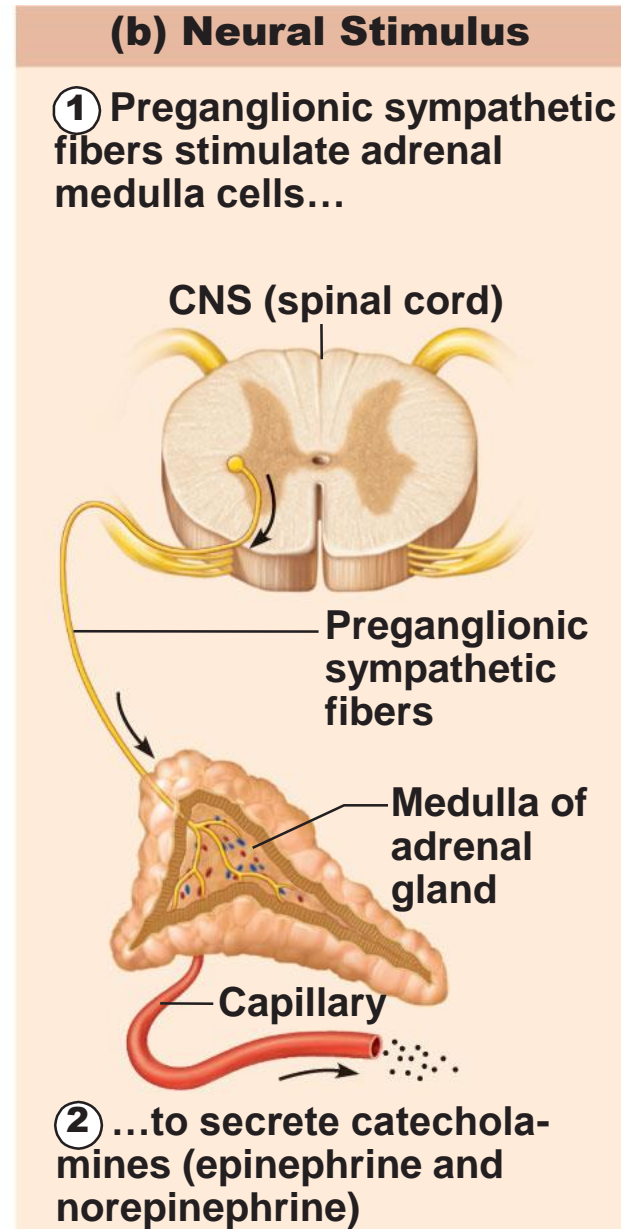


Figure 16.4b

# Hormonal Stimuli

- **Hormones stimulate other endocrine organs to release their hormones**
  - Hypothalamic hormones stimulate the release of most anterior pituitary hormones
  - Anterior pituitary hormones stimulate targets to secrete still more hormones
  - Hypothalamic-pituitary-target endocrine organ feedback loop: hormones from the final target organs inhibit the release of the anterior pituitary hormones

## (c) Hormonal Stimulus

① The hypothalamus secretes hormones that...

② ...stimulate the anterior pituitary gland to secrete hormones that...

③ ...stimulate other endocrine glands to secrete hormones

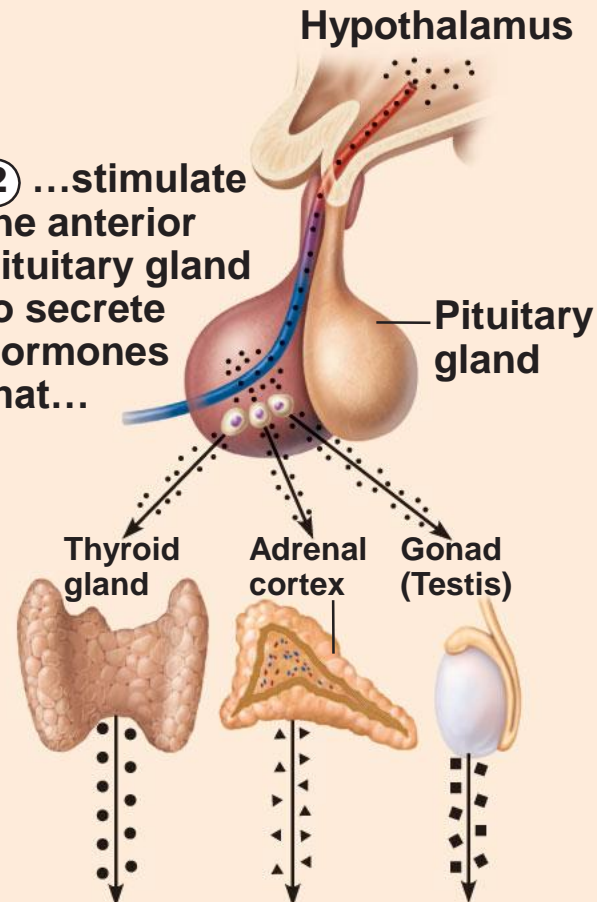


Figure 16.4c

## Lesson 2: Glands

### ***Objective:***

- Summarize the site of production, regulation, and effects of the hormones of the pituitary, thyroid, parathyroid, adrenal, pineal and thymus glands



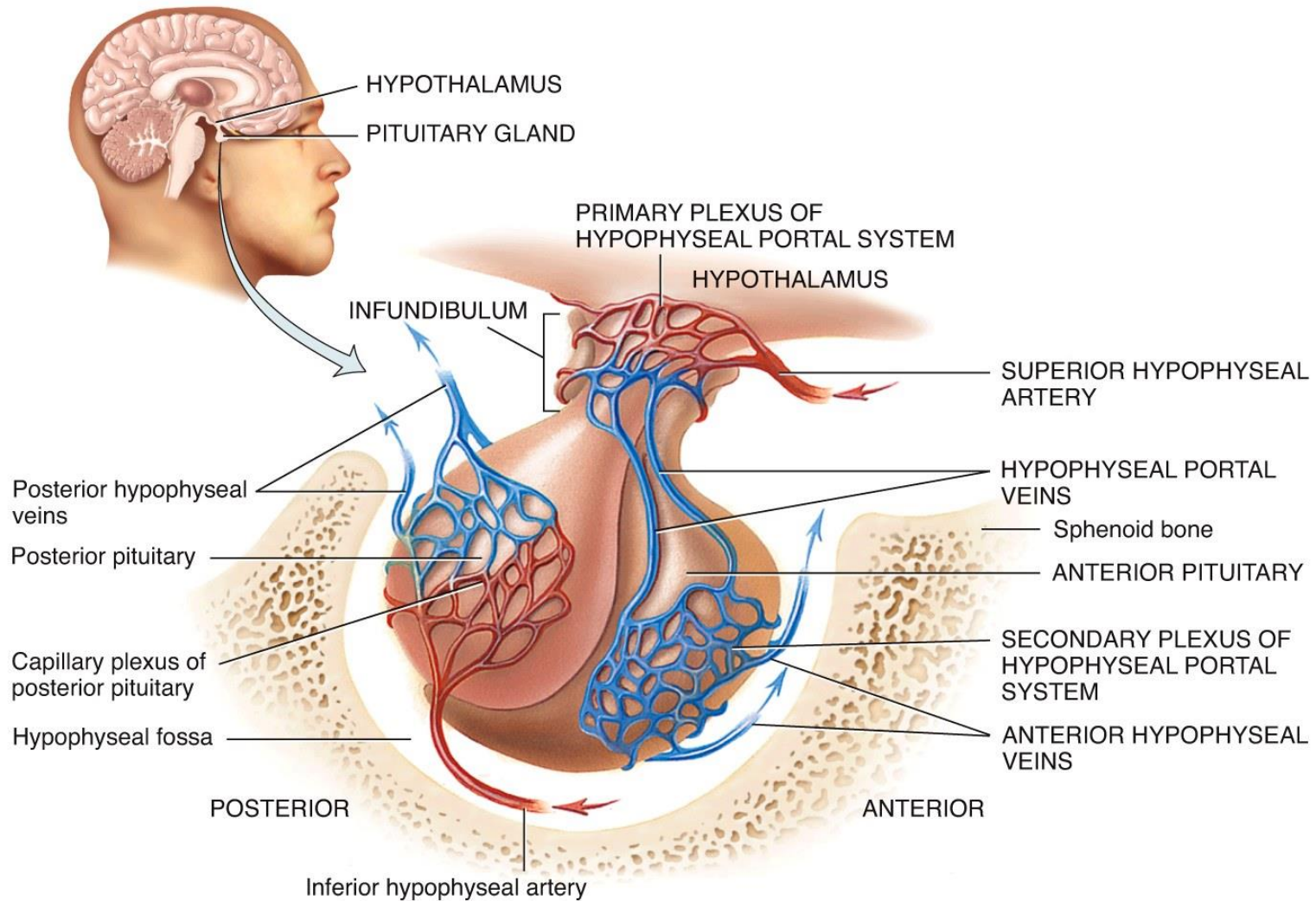
# Hypothalamus

- Major integrating link between the nervous and endocrine systems
  - Region of brain below the thalamus
  - Cell bodies of neurosecretory cells

**Pituitary gland** controls other endocrine glands, but is itself controlled by the hypothalamus

- Some hypothalamic hormones stimulate or inhibit release of anterior pituitary hormones
- Others are stored and released from the posterior pituitary

# Hypothalamus and Pituitary Gland

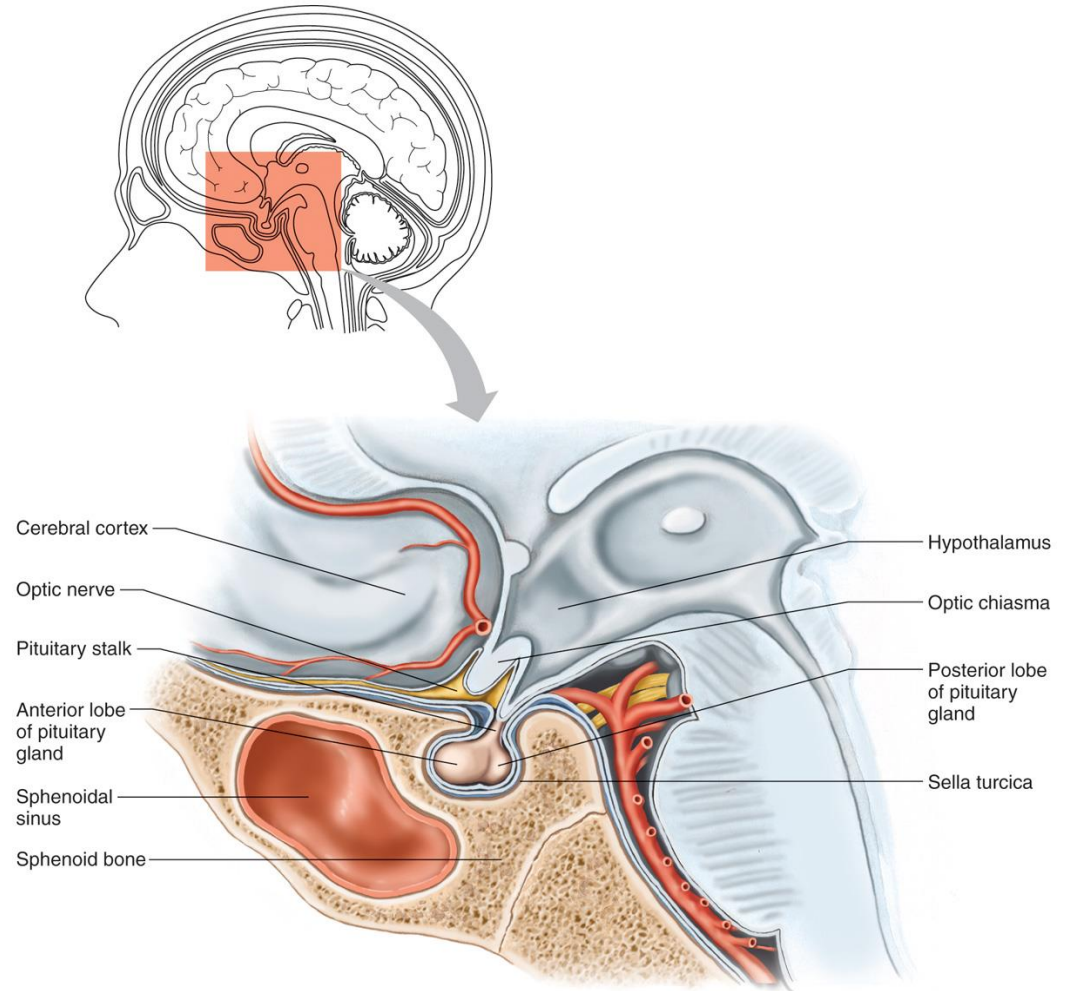


(a) Relationship of hypothalamus to pituitary gland

# Pituitary Gland

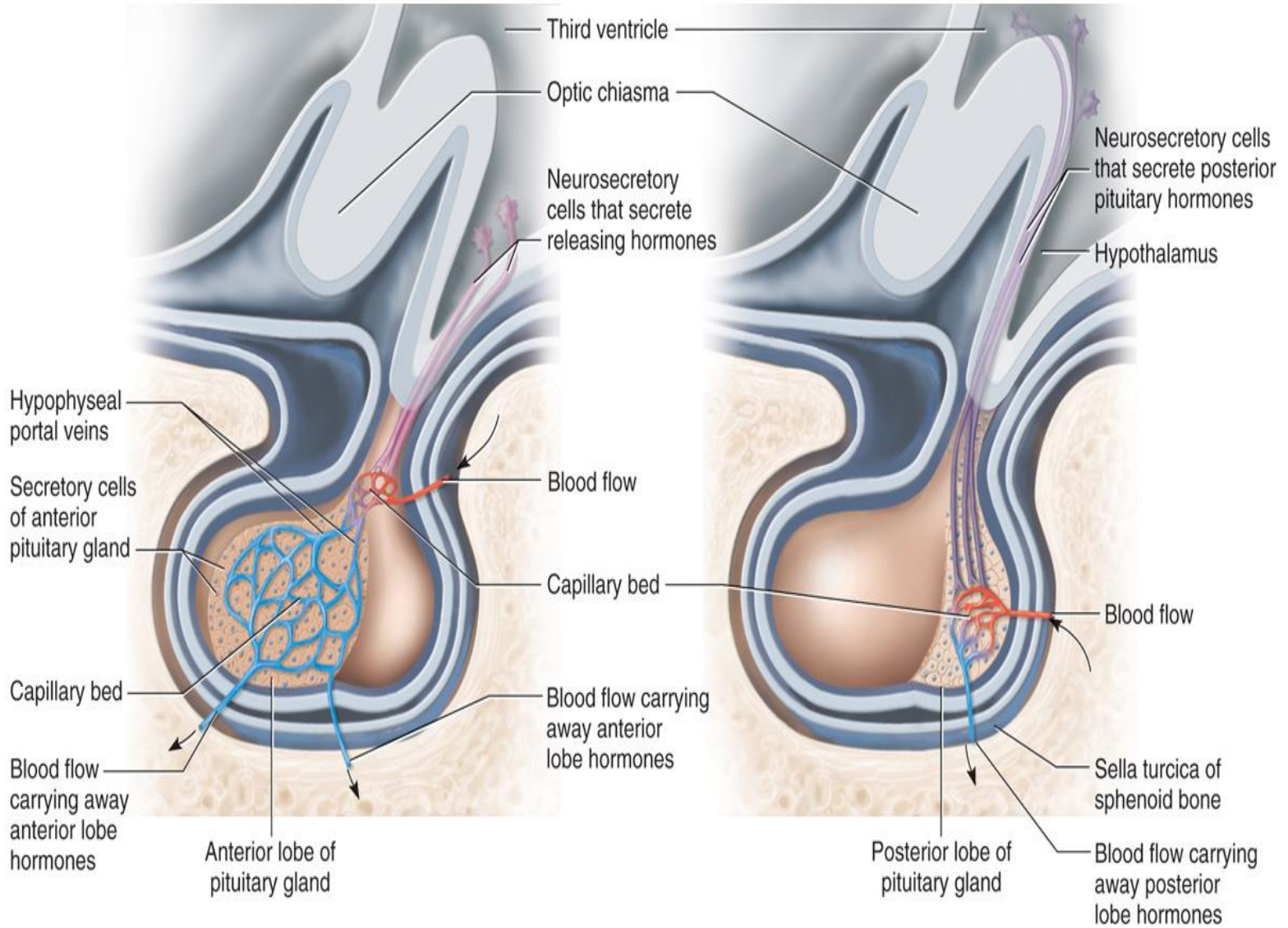
The pituitary gland is attached to the base of the brain and has an anterior lobe (anterior pituitary) and a posterior lobe (posterior pituitary).

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The brain controls the activity of the pituitary gland.

- Releasing hormones from the hypothalamus control the secretions of the anterior pituitary.
- The releasing hormones are carried in the bloodstream directly to the anterior pituitary by hypophyseal portal veins.
- The posterior pituitary releases hormones into the bloodstream in response to nerve impulses from the hypothalamus.





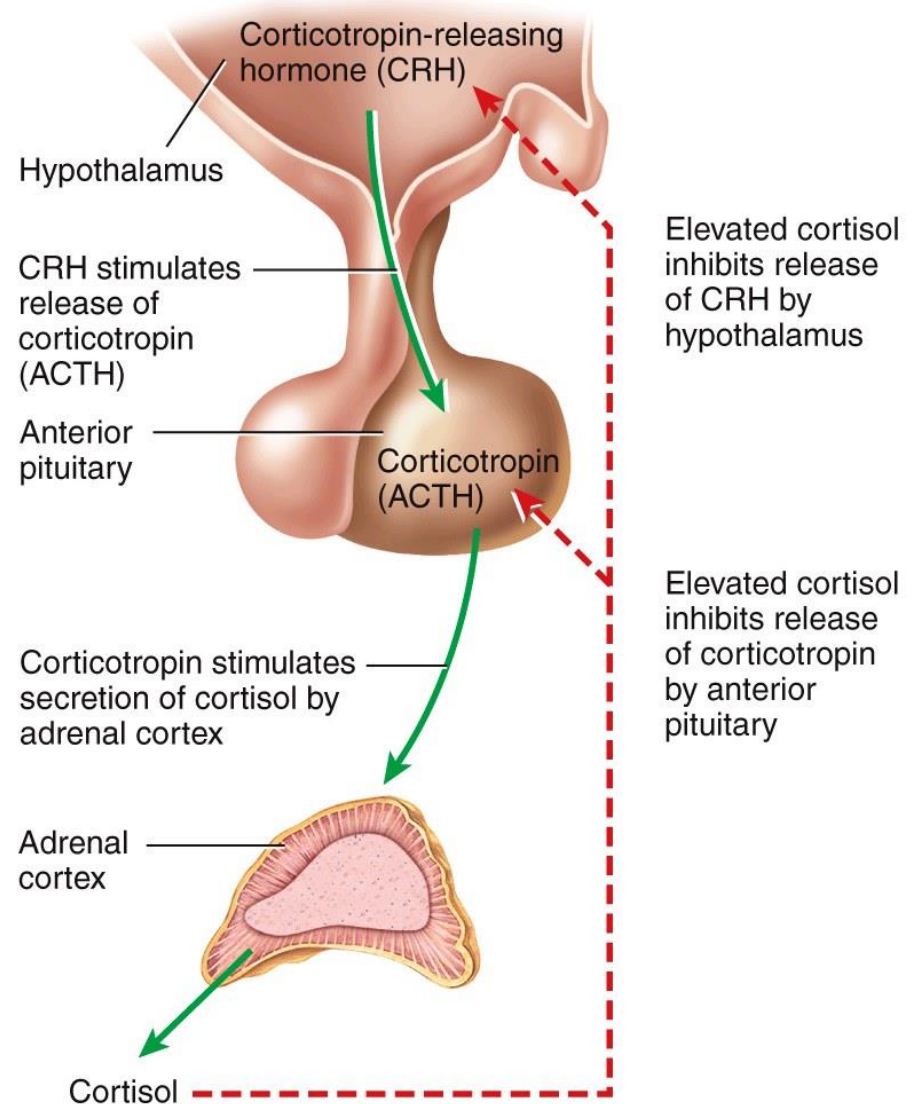
# Anterior Pituitary Hormones

- Adrenocorticotrophic hormone (ACTH)
- Human growth hormone (hGH)
- Thyroid-stimulating hormone (TSH)
- Follicle-stimulating hormone (FSH)
- Luteinizing hormone (LH)
- Prolactin (PRL)
- Melanocyte-stimulating hormone (MSH)

# Adrenocorticotrophic Hormone (ACTH)

- Controls the secretion of glucocorticoids such as **cortisol** from the adrenal cortex
- Secretion stimulated by **corticotropin-releasing (CRH) hormone** from hypothalamus
- Also stimulated by stress-related stimuli
- Rising cortisol blood levels inhibits both ACTH and CRH release by negative feedback

# Adrenocorticotrophic Hormone (ACTH)

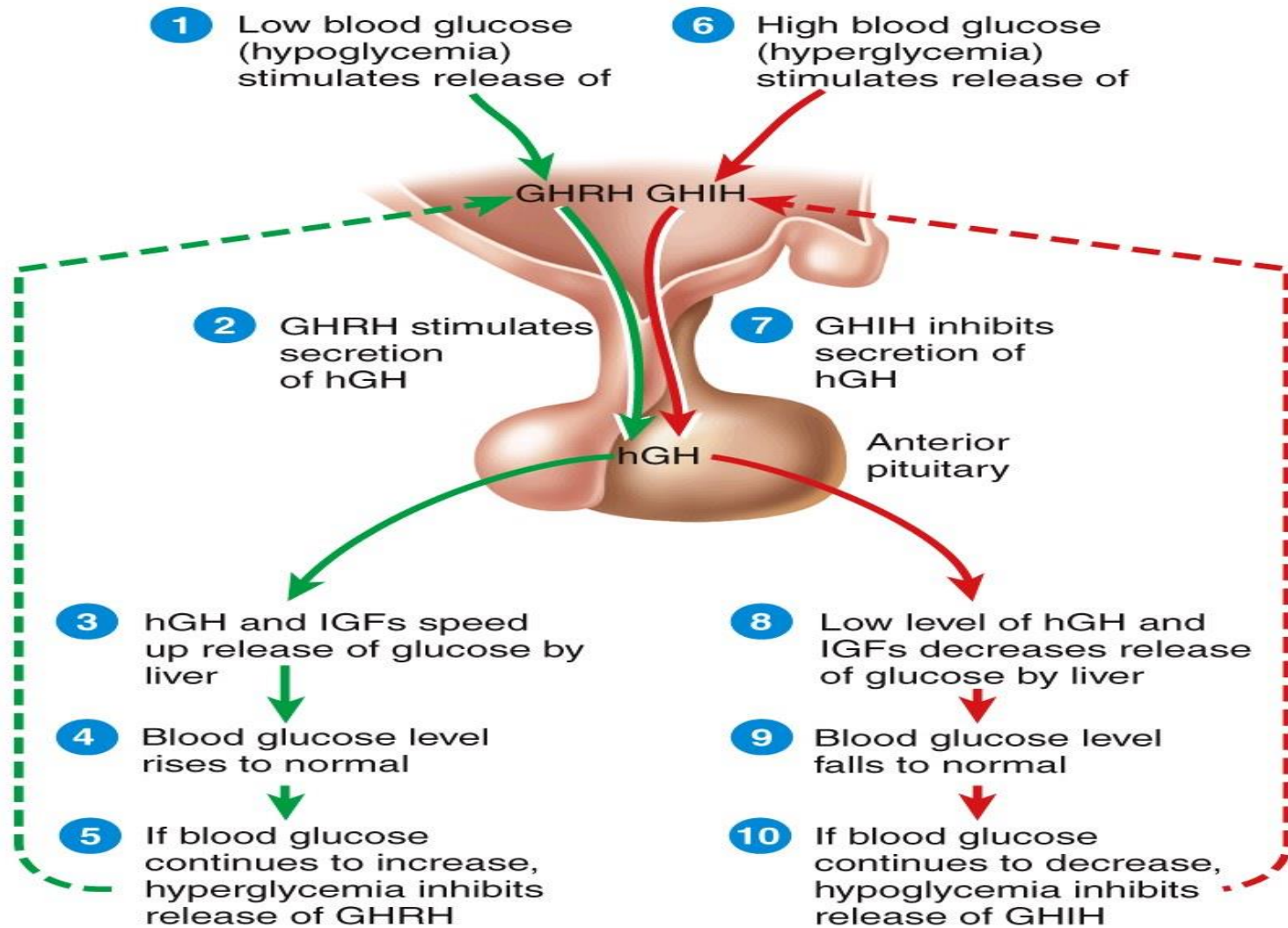




# Human Growth Hormone (hGH)

- Promotes synthesis and secretion of **insulin** like growth factors (IGFs) that stimulate body growth and repair, increase lipolysis, and elevate blood glucose levels
- Secretion stimulated by **growth hormone-releasing (GHRH)** and inhibited by growth hormone-inhibiting (GHIH) hormones from hypothalamus
- Blood glucose level is a major regulator of GHRH and GHIH secretion

# Human Growth Hormone (hGH)



# Thyroid-Stimulating Hormone (TSH)

- Stimulates the thyroid gland to secrete **triiodothyronine ( $T_3$ )** and **thyroxine ( $T_4$ )**
- Secretion stimulated by **thyrotropin-releasing (TRH)** from hypothalamus
- $T_3$  and  $T_4$  blood level is a major regulator of TRH secretion

# Follicle-Stimulating Hormone (FSH)

- In females: **targets ovaries** for monthly development of several ovarian follicles that surround a developing oocyte
- In males: **targets testes** for production of sperm
- Secretion stimulated by **gonadotropin-releasing (GnRH)** hormone from hypothalamus
- Blood **estrogen or testosterone** level is a major regulator of GnRH and FSH secretion

## Luteinizing Hormone (LH)

- In females: triggers **ovulation**, the release of oocyte from ovary, and stimulates secretion of progesterone by ovary after ovulation; also with FSH stimulates secretion of estrogen by ovaries
- In males: stimulates secretion of **testosterone** by the testes
- Secretion stimulated **by gonadotropin-releasing (GnRH)** hormone from hypothalamus

# Prolactin (PRL)

- Initiates **milk production** by mammary glands
- Secretion stimulated **by prolactin-releasing (PRH) and prolactin-inhibiting (PIH) hormones** from hypothalamus
- Sucking action of nursing infant causes a reduction in PIH, therefore increasing PRL secretion
- Function in males not known, but excess causes erectile dysfunction

# Melanocyte-Stimulating Hormone (MSH)

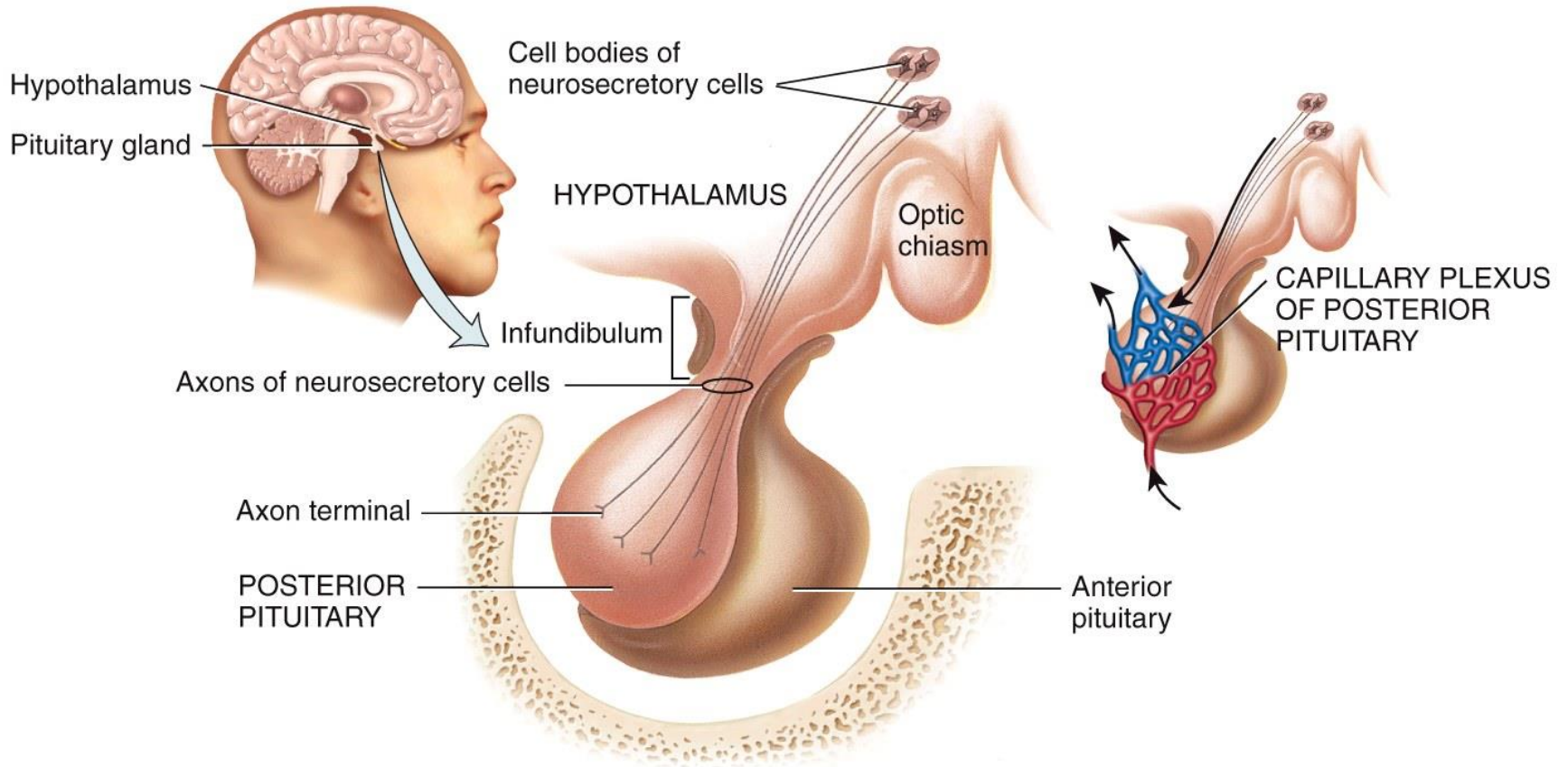
- Function in human is unknown, but receptors in the brain suggests it may influence brain activity
- Secretion stimulated by excessive level of corticotropin-releasing hormone (CRH) and inhibited by prolactin-inhibiting hormone (PIH) from hypothalamus
- Excess can **cause darkening of skin**

# Hypothalamus/Posterior Pituitary

- Posterior pituitary does not synthesize any hormones
  - Stores and releases hormones from hypothalamus neurosecretory cell axons
  - Release triggered by nerve impulses
  - Hormones carried from posterior pituitary blood capillaries through general body circulation to target cells
- Posterior pituitary hormones
  - Oxytocin
  - Antidiuretic hormone



# Hypothalamus/Posterior Pituitary



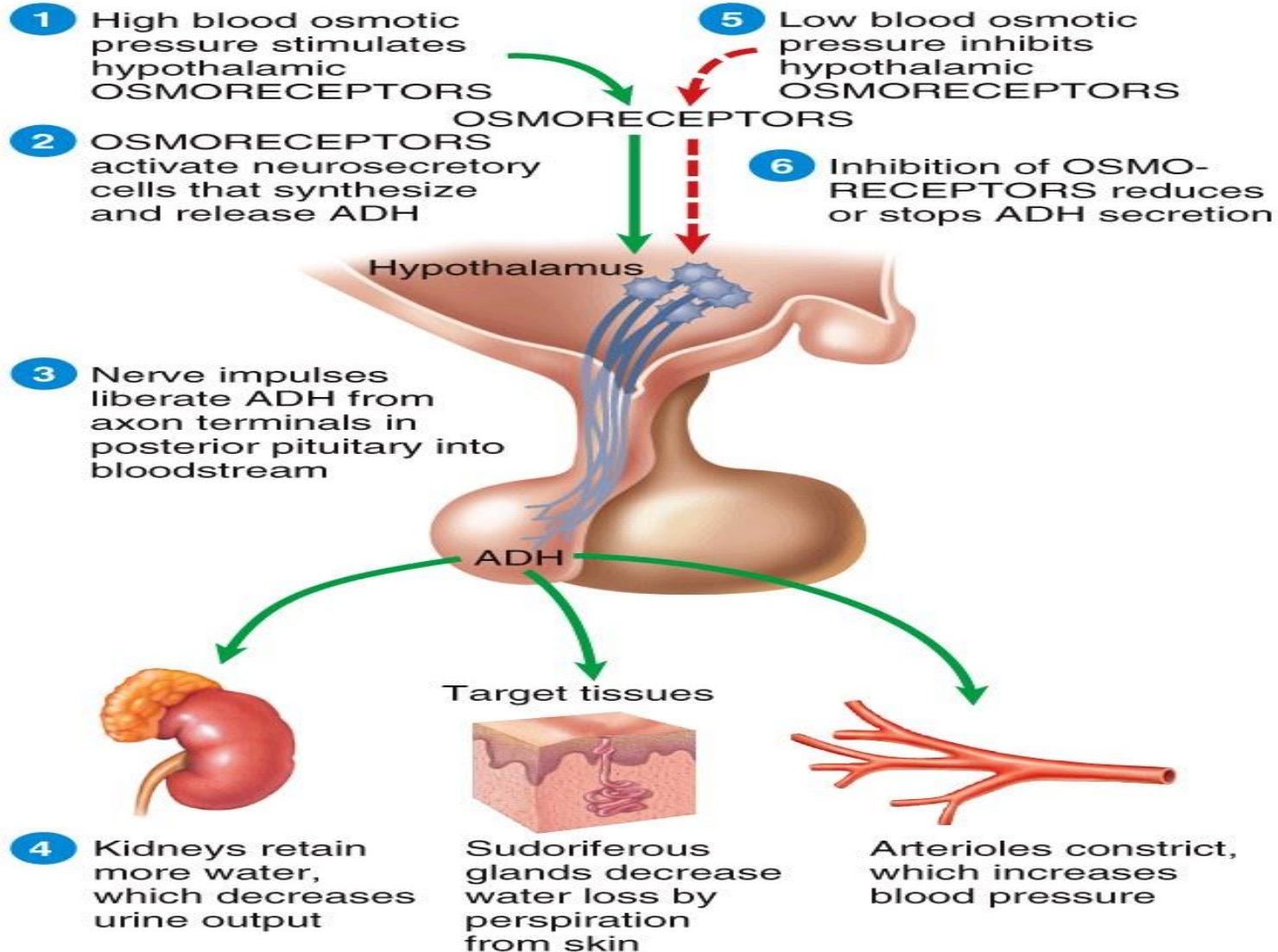
# Oxytocin (OT)

- Enhances smooth **muscle contractions in the uterine wall** to facilitate labor and delivery
- Stimulates milk ejection from mammary glands after delivery
- Secretion stimulated by uterine stretching and suckling during nursing
- Function in males and nonpregnant females not clear, but may foster parental caretaking

# Antidiuretic Hormone (ADH)

- Causes the kidneys to **return more water to the blood** while decreasing urine volume
- Decreases water loss through sweat glands
- Causes **constriction of arterioles to increase blood pressure (also known as vasopressin)**
- Secretion stimulated by high blood osmotic pressure, inhibited by low blood osmotic pressure

# Antidiuretic Hormone (ADH)

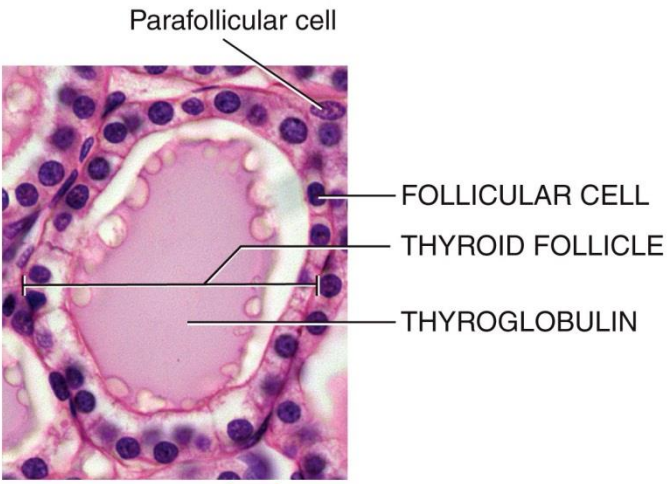
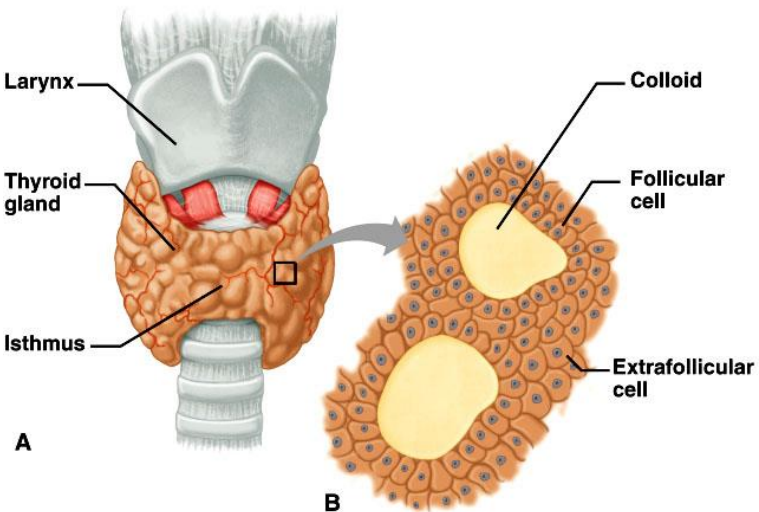


# Thyroid Gland

- Anatomy
  - Located inferior to the larynx and anterior to the trachea
  - Thyroid follicles with follicular cells that produce triiodothyronine ( $T_3$ ) and thyroxine ( $T_4$ )
  - Parafollicular cells produce calcitonin (CT)
- Only endocrine gland that stores its secretory products in large supply

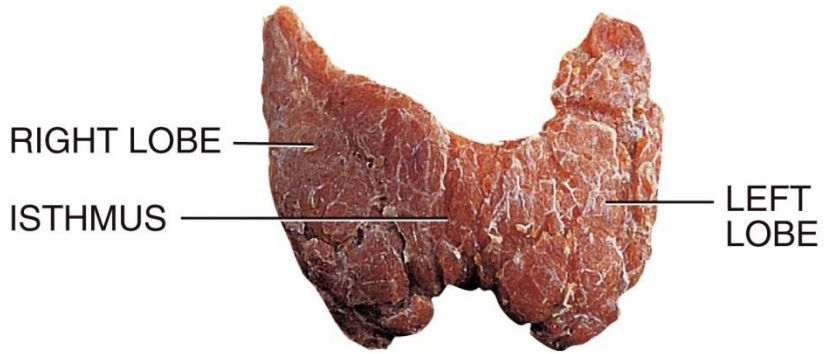
# Thyroid Gland

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**LM** 500x

(b) Thyroid follicles



(c) Anterior view of thyroid gland

Dissection Shawn Miller, Photograph Mark Nielsen

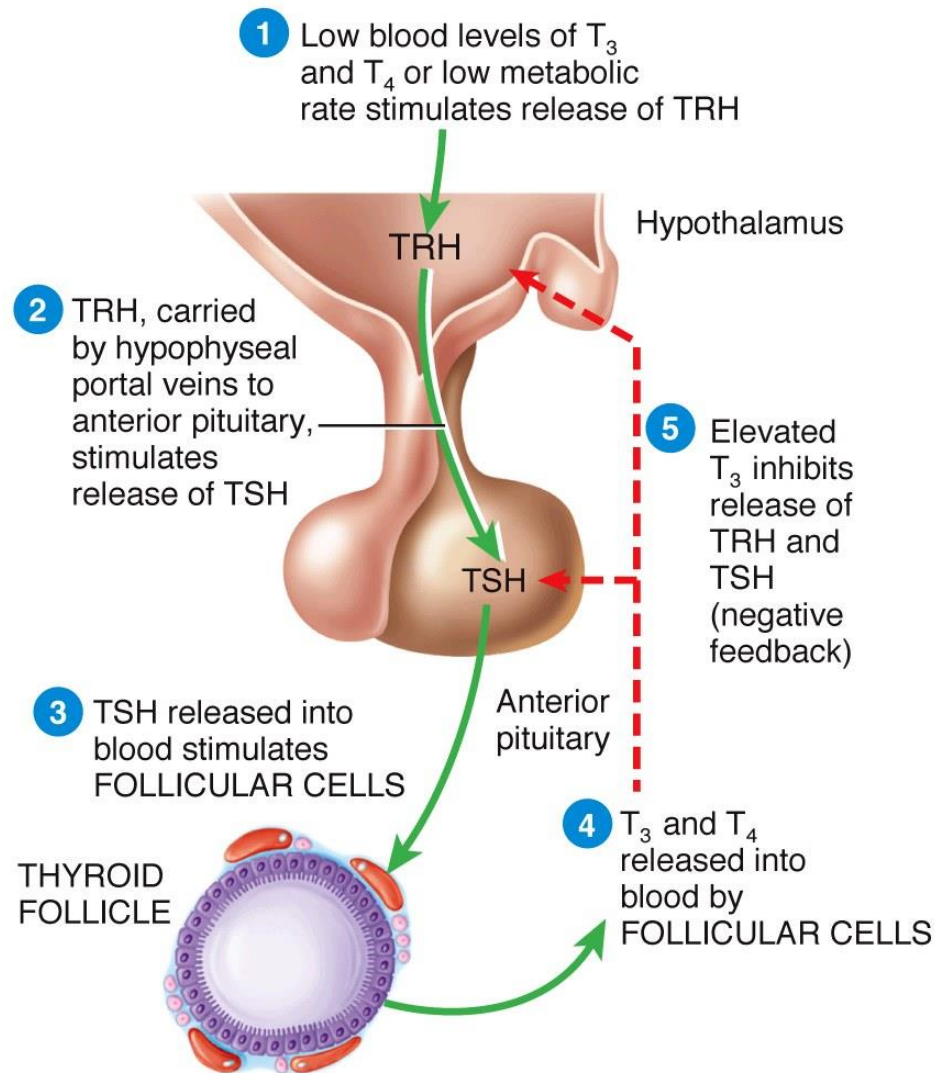
Mark Nielsen

## T<sub>3</sub> and T<sub>4</sub>

- Synthesized from iodine and tyrosine within thyroglobulin
- Transported in the blood bound to thyroxine-binding globulin
- Secretion controlled by thyrotropin-releasing hormone (TRH) from hypothalamus and thyroid-stimulating hormone (TSH) from anterior pituitary



# Thyroid Gland Control



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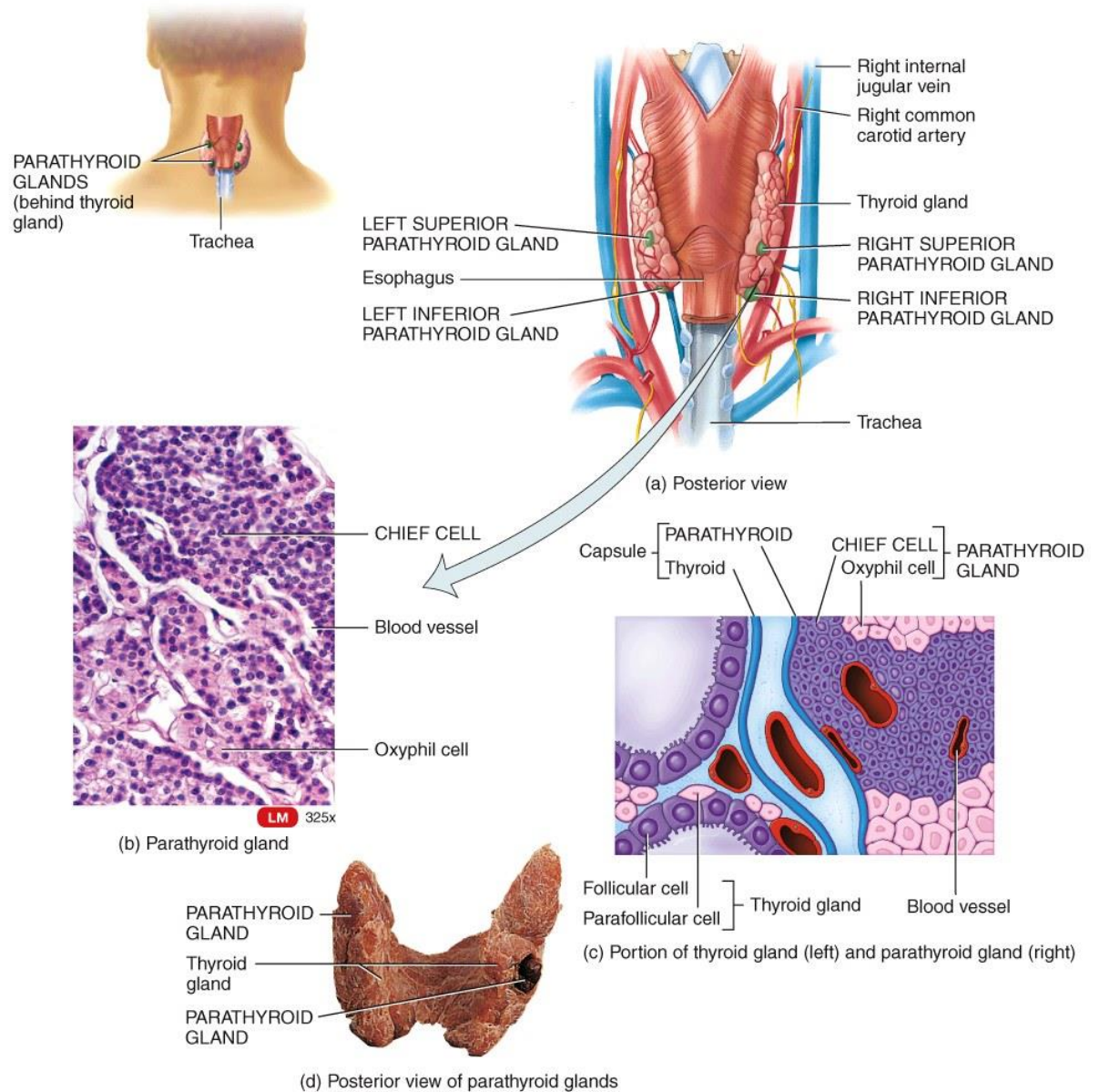
# Calcitonin (CT)

- Lowers the blood levels of calcium and phosphates
- Promotes the up-take into bone extracellular matrix
- Secretion stimulated by high level of calcium in the blood

# Parathyroid Gland and Hormone

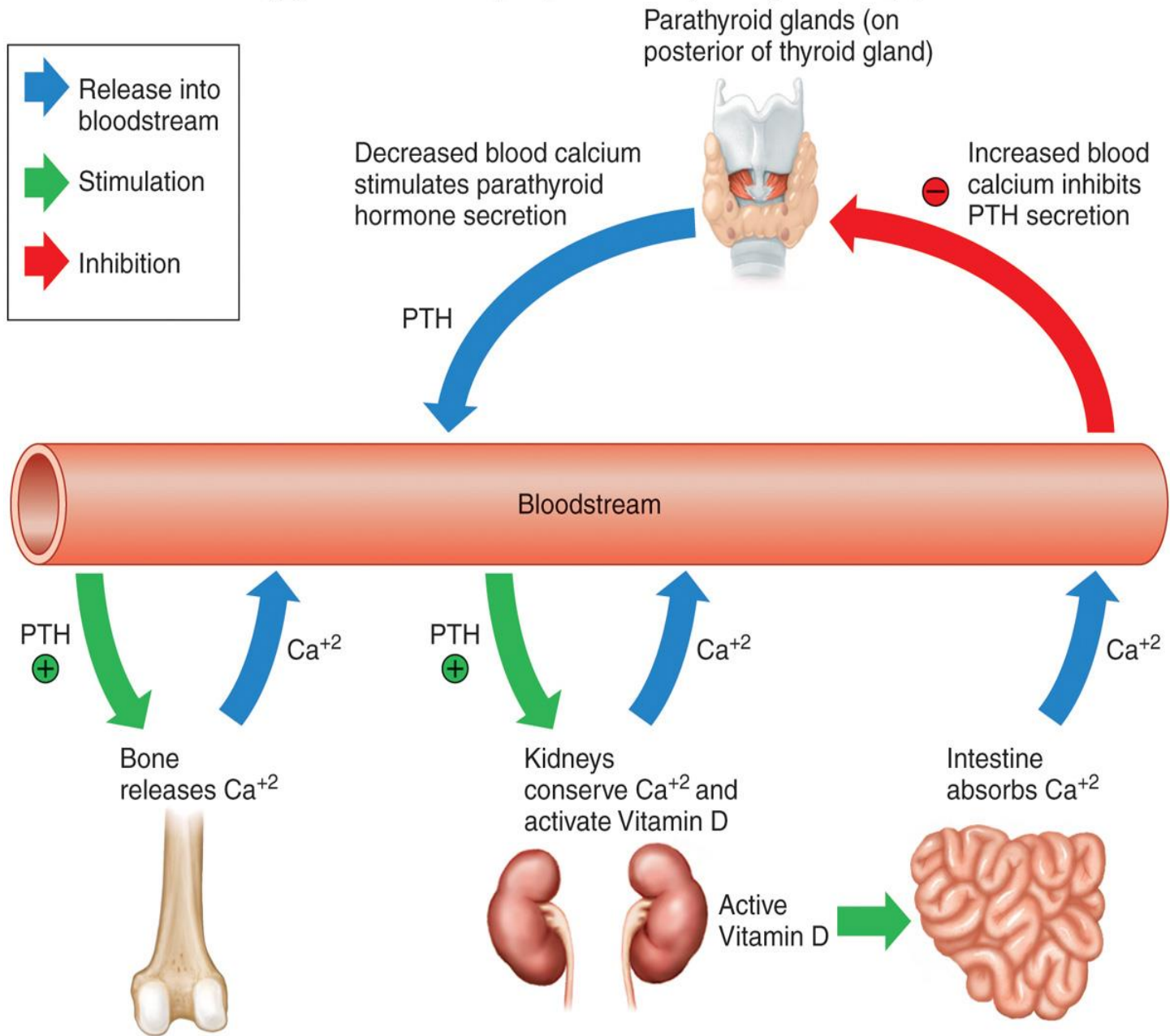
- Anatomy
  - Embedded in the **posterior surface of the thyroid gland**
  - Chief cells produce parathyroid hormone (PTH)
  - Oxyphil cell function not known

# Parathyroid Gland and Hormone



# Parathyroid Hormone (PTH)

- Regulates blood levels of calcium ( $\text{Ca}^{2+}$ ), magnesium ( $\text{Mg}^{2+}$ ), and phosphate ( $\text{HPO}_4^{2-}$ )
  - Causes increased  $\text{Ca}^{2+}$  and  $\text{HPO}_4^{2-}$  release from bones to blood
  - Decreases loss of  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  from blood to urine
  - Increases the loss of  $\text{HPO}_4^{2-}$  from blood to urine
  - Stimulates synthesis of calcitriol by kidneys, that increases absorption of  $\text{Ca}^{2+}$ ,  $\text{HPO}_4^{2-}$  and  $\text{Mg}^{2+}$  from ingested food into blood
- Secretion stimulated by high level of calcium in blood (opposite effect to calcitonin)

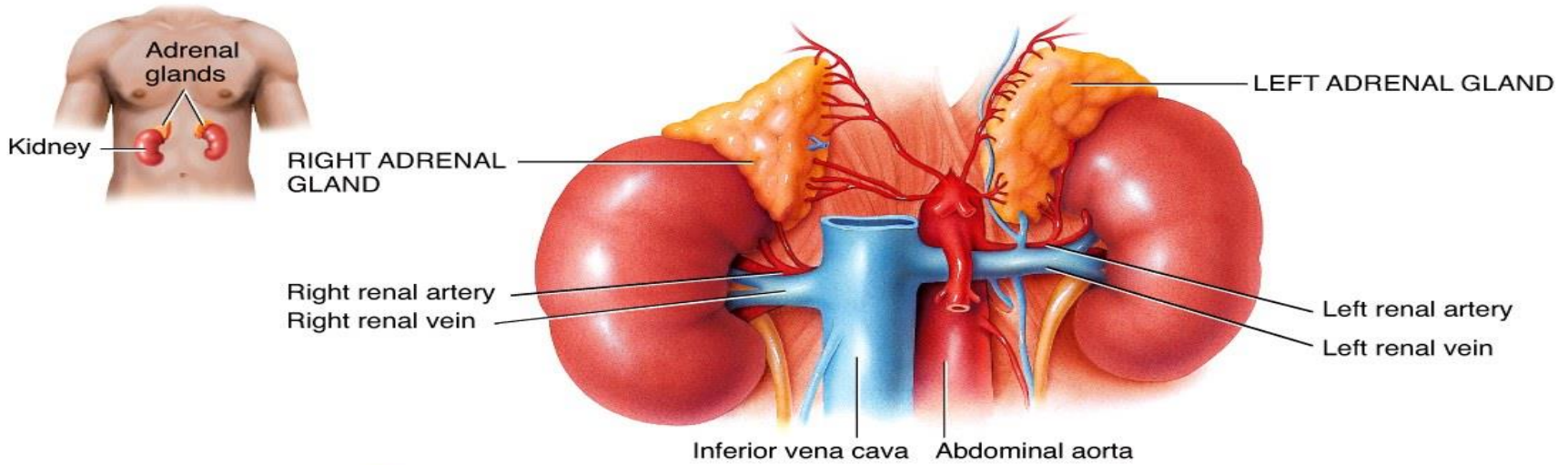


# Adrenal Gland

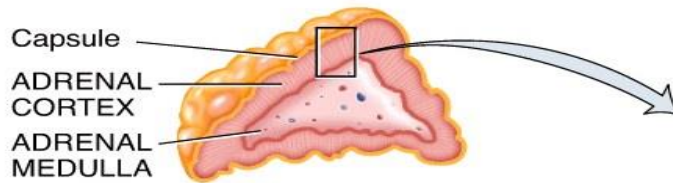
- Anatomy
  - Located superior to each kidney
- Structurally and functionally two distinct regions
  - Adrenal cortex – three zones produce steroid hormones
    - Outer zone: mineralocorticoids
    - Middle zone: glucocorticoids
    - Inner zone: androgens
  - Adrenal medulla – modified sympathetic ganglion of autonomic nervous system secrete hormones
    - Epinephrine and norepinephrine



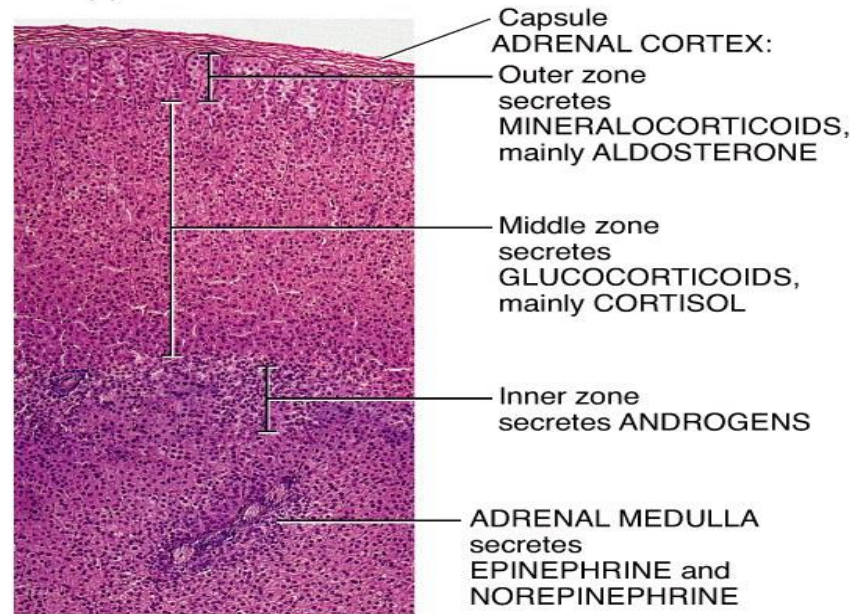
# Adrenal Gland



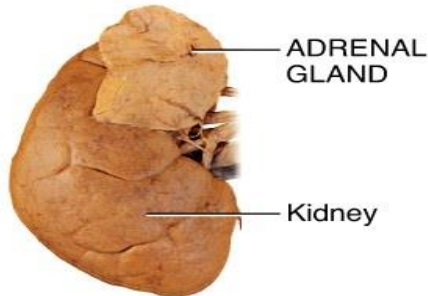
(a) Anterior view



(b) Section through left adrenal gland



(d) Subdivisions of adrenal gland



(c) Anterior view of adrenal gland and kidney

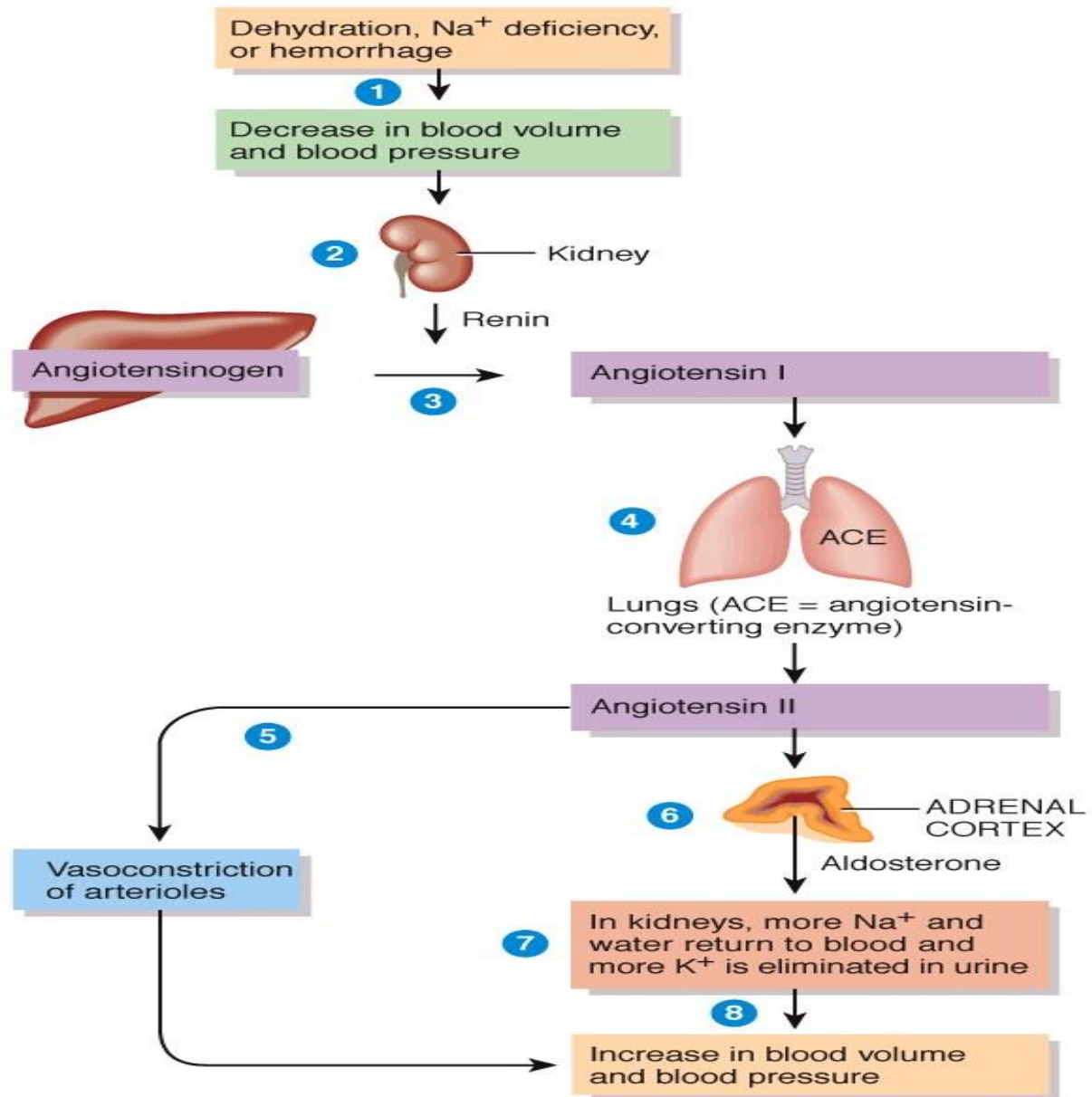
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# Aldosterone

- Major mineralocorticoid produced
- Increases kidney reabsorption of sodium ( $\text{Na}^+$ ) and water from urine to the blood
- Increases excretion of potassium ( $\text{K}^+$ ) into urine
- Helps adjust blood pressure and blood volume
- Secretion is controlled by the renin-angiotensin-aldosterone pathway

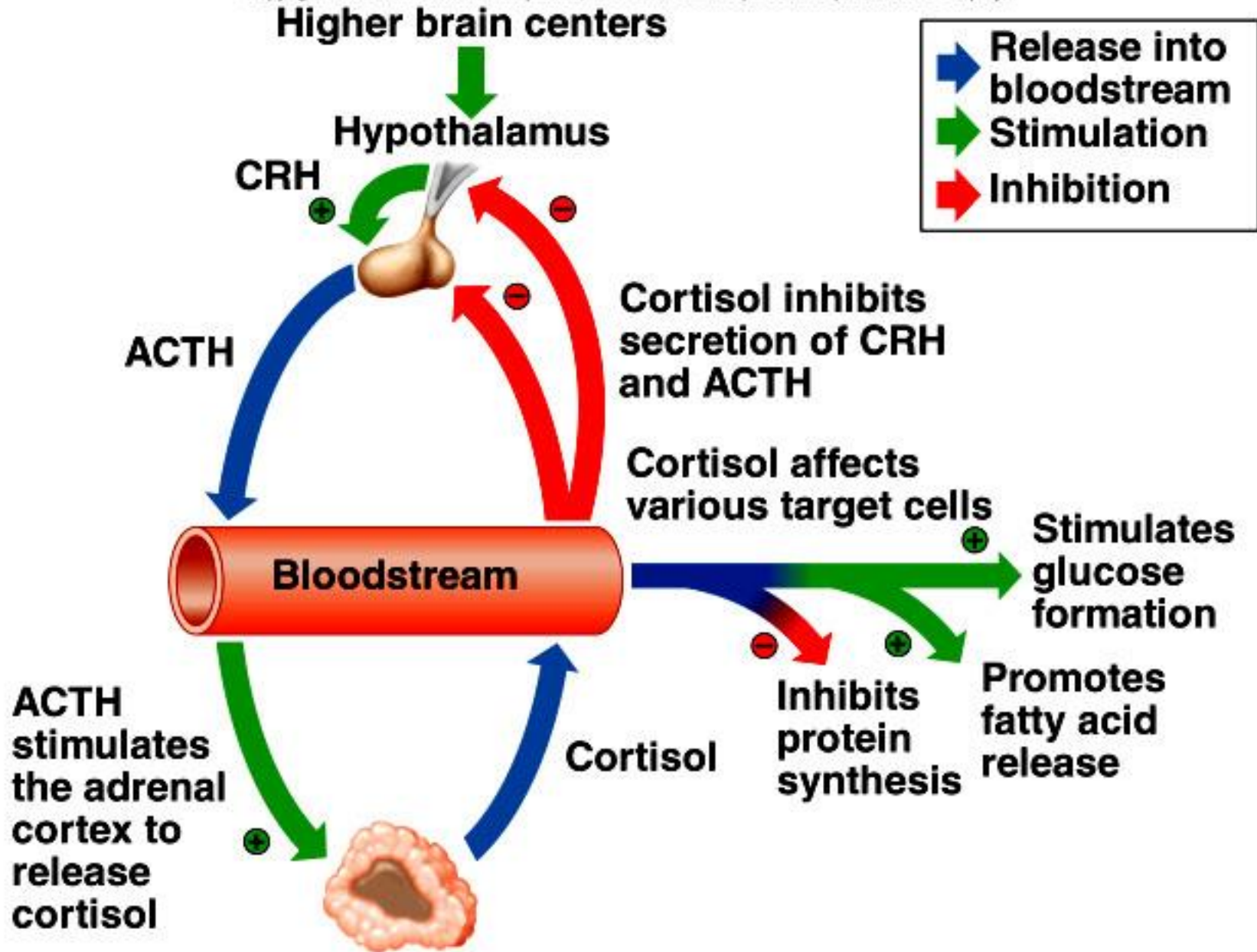


# Aldosteror



# Cortisol

- Major glucocorticoid produced
- Regulates metabolism and resistance to stress
  - Increases protein breakdown
  - Enhances glucose formation
  - Breaks down triglycerides
  - Inhibits inflammation and immune system response
- Secretion is controlled by corticotropin-releasing hormone (CRH) from the hypothalamus and adrenocorticotrophic hormone (ACTH) from the anterior pituitary



# Androgen

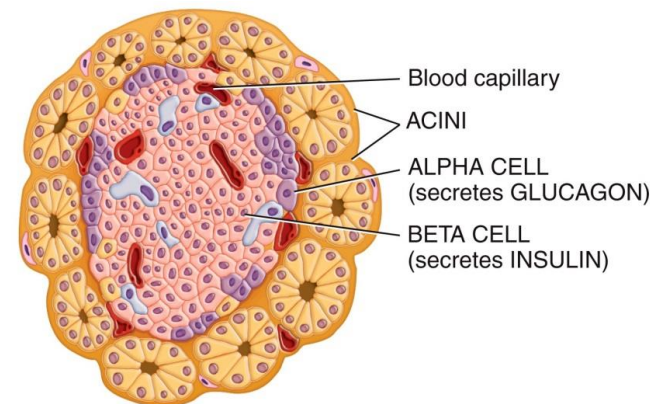
- Produced in both males and females, but more significant effect in females
- Stimulate growth of axillary and pubic hair, aid prepubertal growth spurts, and contribute to libido in females
- Secretion is not well understood, but controlled by adrenocorticotrophic hormone (ACTH)

# Epinephrine and Norepinephrine

- Augment the sympathetic nervous system  
**fight-or-flight response**
  - Increase heart rate and force of contraction
  - Increase blood flow to heart, liver, skeletal muscles, and adipose tissue
  - Dilate airways to lung
  - Increase blood levels of glucose and fatty acids
- Secretion is controlled directly by the autonomic nervous system during stressful situations and during exercise

# Pancreas

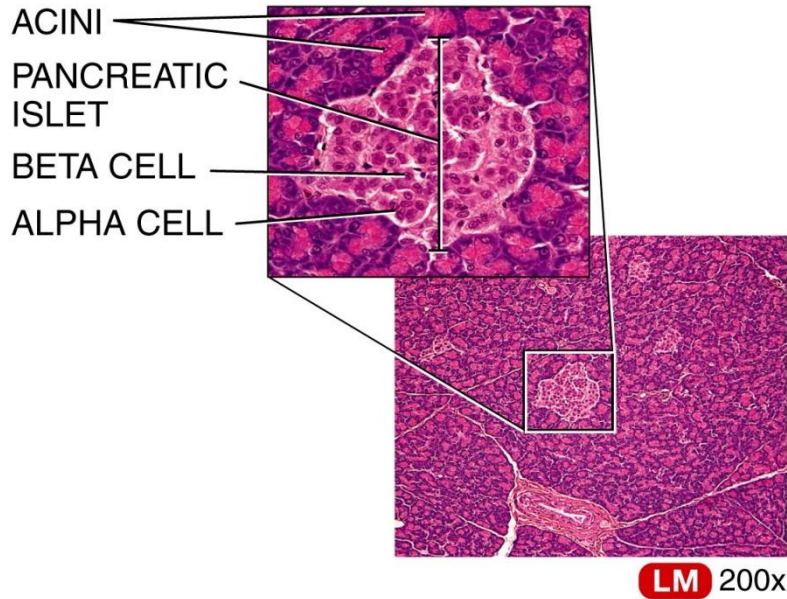
- Anatomy
  - Located in the abdomen near the duodenum of the small intestine
- Both an endocrine and exocrine gland
  - Exocrine – digestive enzymes
  - Endocrine – secrete hormones
- Pancreatic islet of endocrine cells
  - Alpha cells – secrete glucagon
  - Beta cells – secrete insulin



(b) Pancreatic islet and surrounding acini

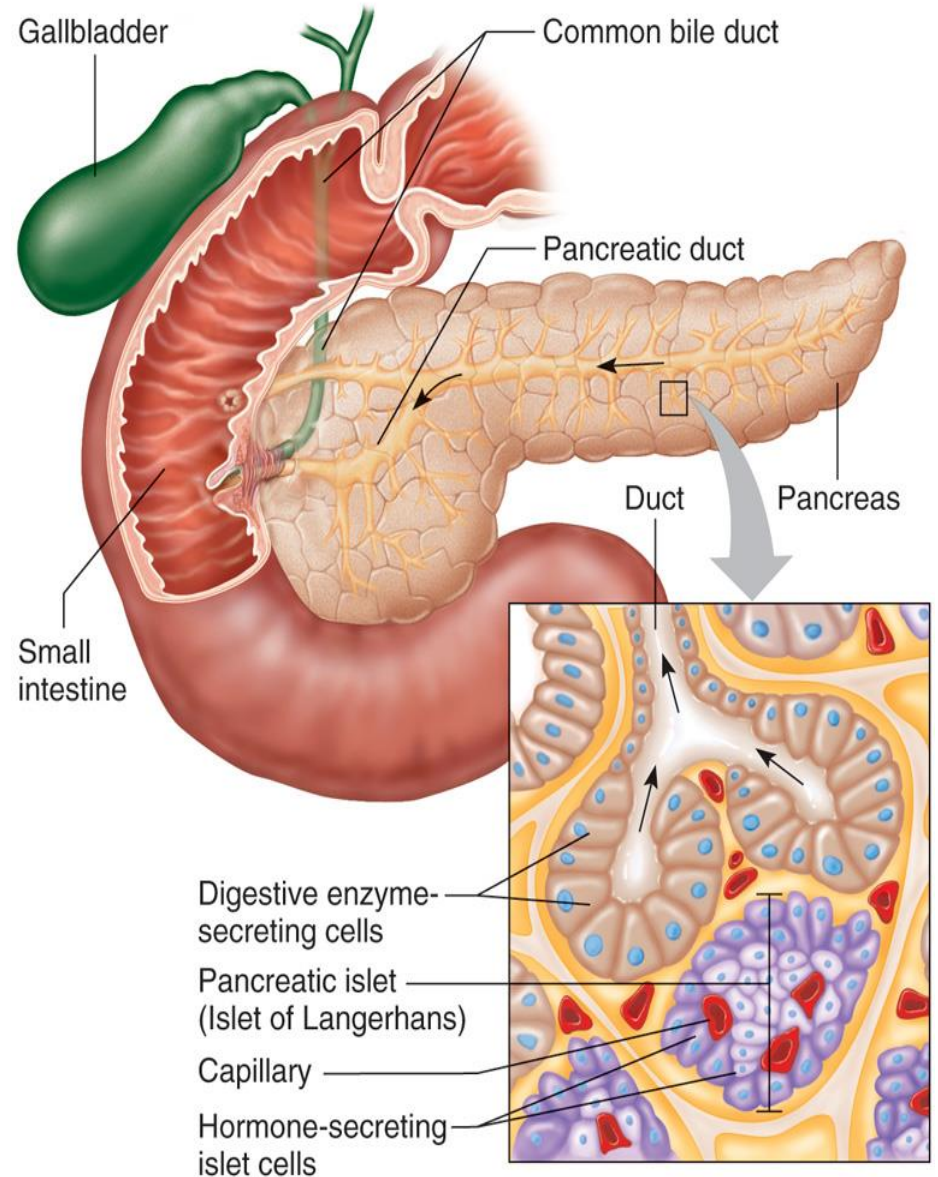


# Pancreas



(c) Pancreatic islet and surrounding acini

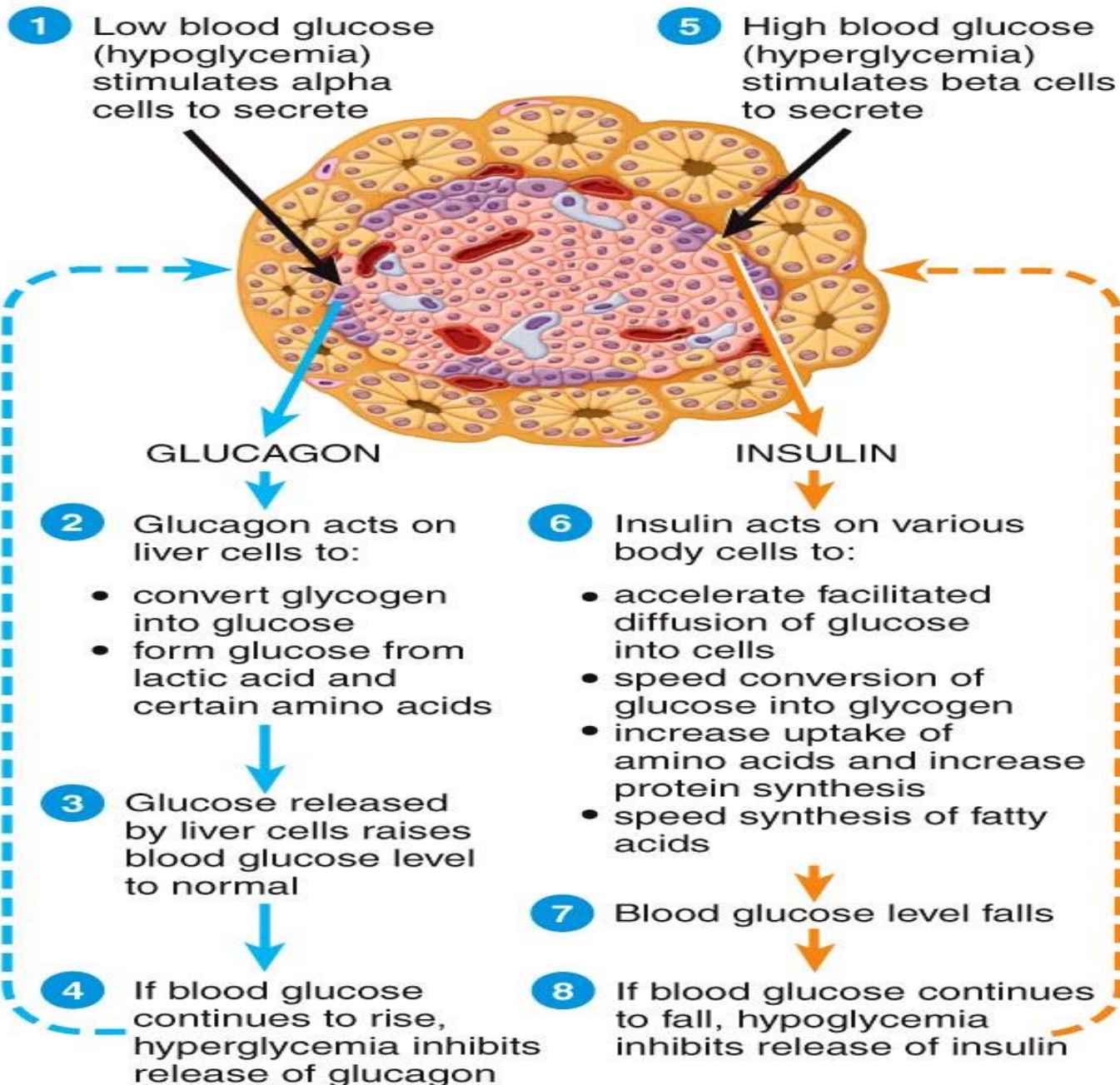
Mark Nielsen



# Glucagon and Insulin

- Low blood glucose level causes secretion of glucagon
  - Acts on liver cells to release glucose into the blood
- High blood glucose level causes secretion of insulin
  - Acts on body cells to increase diffusion of glucose from blood into cells
  - Increases protein and fatty acid synthesis
- Secretion of both also affected by autonomic nervous system, diet, and other hormones





# Other Endocrine Glands

## Pineal Gland

- The pineal gland, near the upper portion of the thalamus, secretes melatonin, which is involved in the regulation of circadian rhythms of the body.

## Thymus Gland

- The thymus gland, lying between the lungs under the sternum, secretes thymosins that affect production and differentiation of T lymphocytes that are important in immunity.

# Reproductive Glands

- The **ovaries** produce **estrogen and progesterone**.
- The **placenta** produces **estrogen, progesterone, and gonadotropin**.
- The **testes** produce **testosterone**.

## Digestive Glands

- The digestive glands secrete hormones associated with the processes of digestion.

## Other Hormone Producing Organs

- The heart secretes **atrial natriuretic peptide** affecting sodium and the kidneys secrete erythropoietin for blood cell production.

# Lesson 3: Female Reproductive System

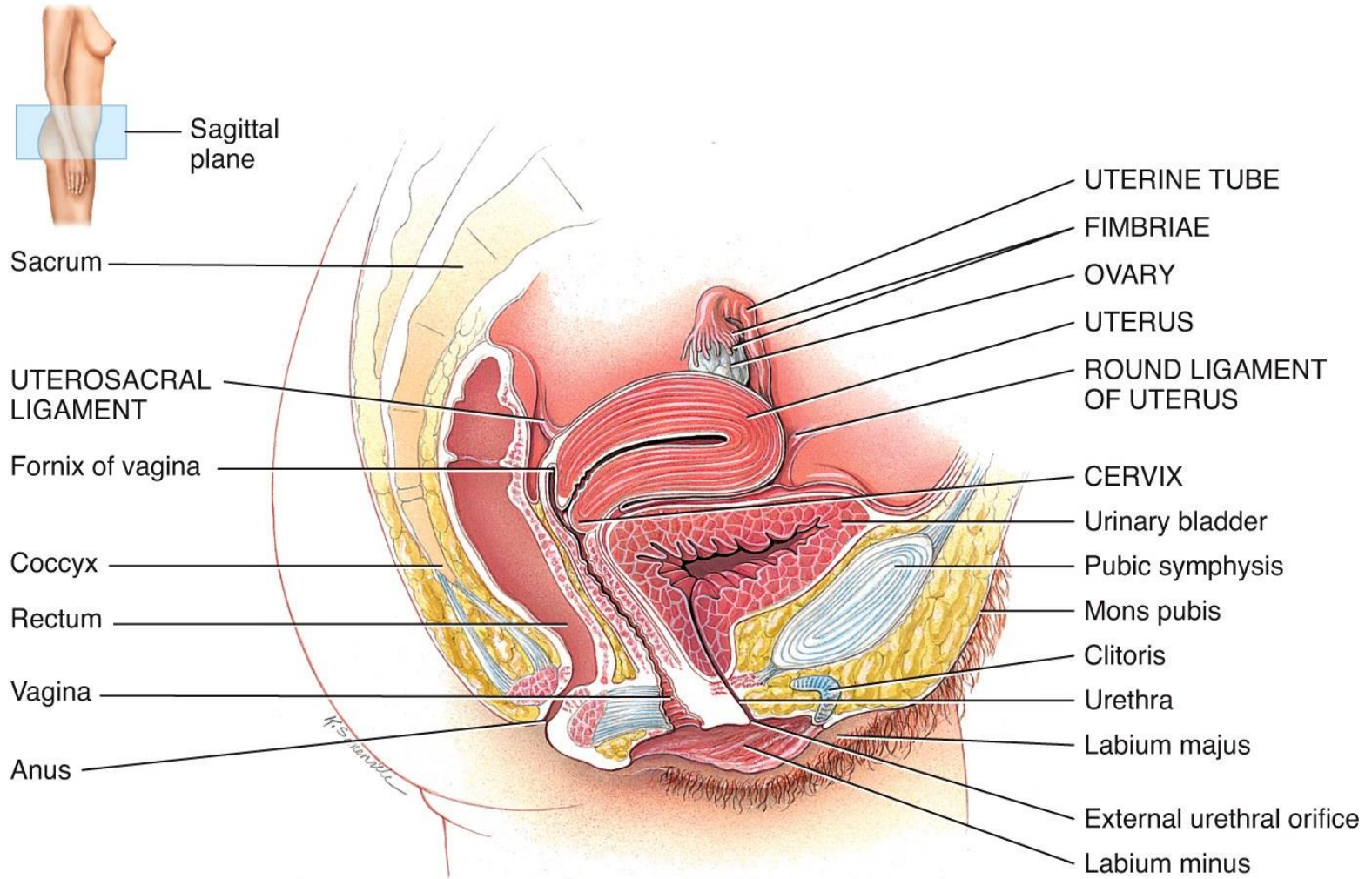
## ***Objective:***

- Describe the structure and function of the organs of the female reproductive system
- List the steps of oogenesis

# Female Reproductive System

- Ovaries
  - Paired female gonads in abdominal cavity
- Uterine tubes or oviducts
  - Tubes transporting secondary oocyte to site of fertilization and zygote to uterus
- Uterus
  - Site of fetal development
- Vagina
  - Passageway from cervix to exterior
- Vulva – collective external structures
- Mammary glands
  - Part of integumentary and reproductive systems

# Female Reproductive System



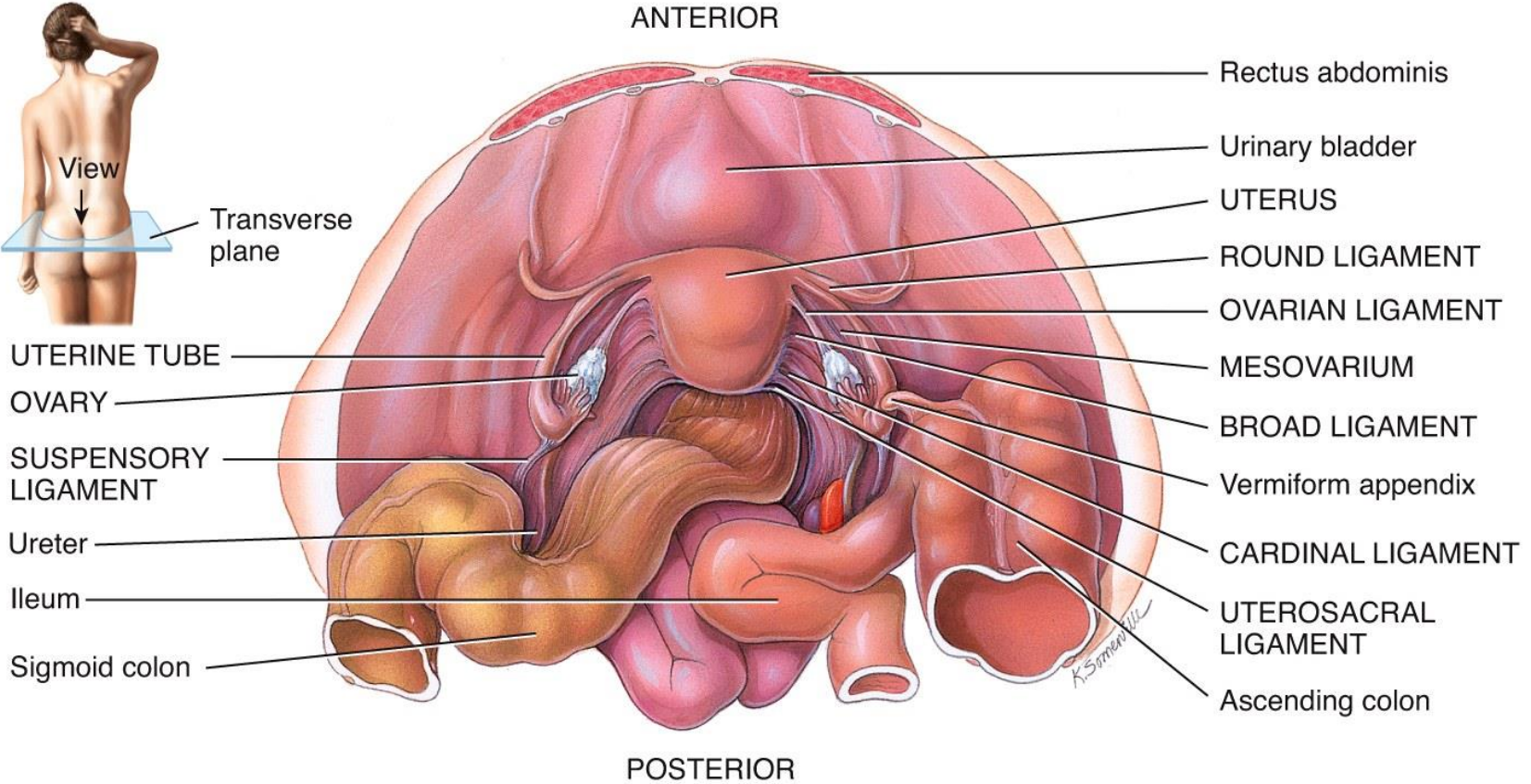
(a) Sagittal section

# Ovaries

- Suspended on either side of uterus in peritoneal cavity, held in position by ligaments
  - Broad ligament, mesovarium, ovarian ligament, and suspensory ligament
- Produce secondary oocytes
  - Follicles in different stages of development surround and nourish developing oocytes
- Also produce and secrete hormones
  - Progesterone, estrogen, inhibin and relaxin

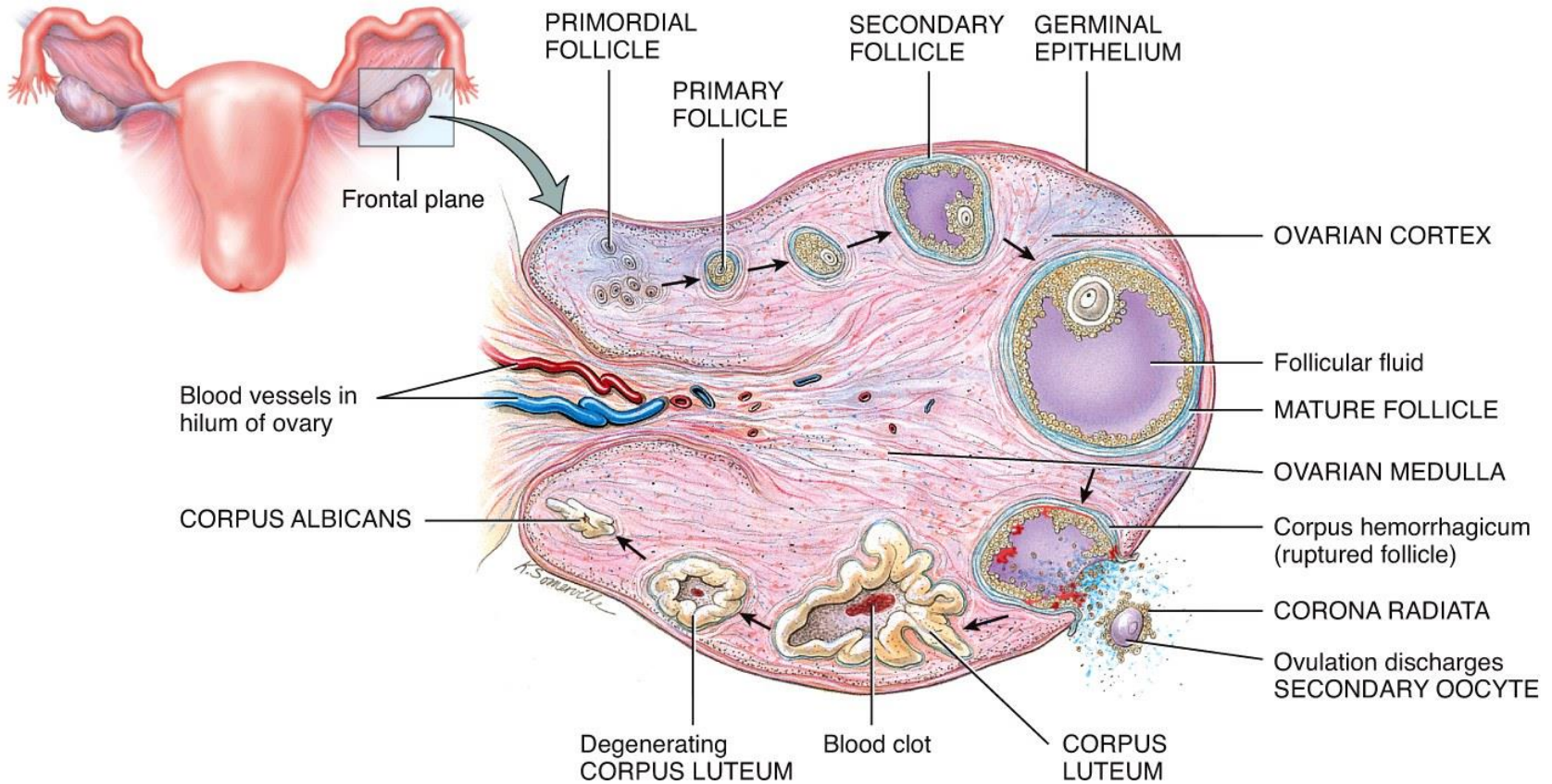


# Ovaries



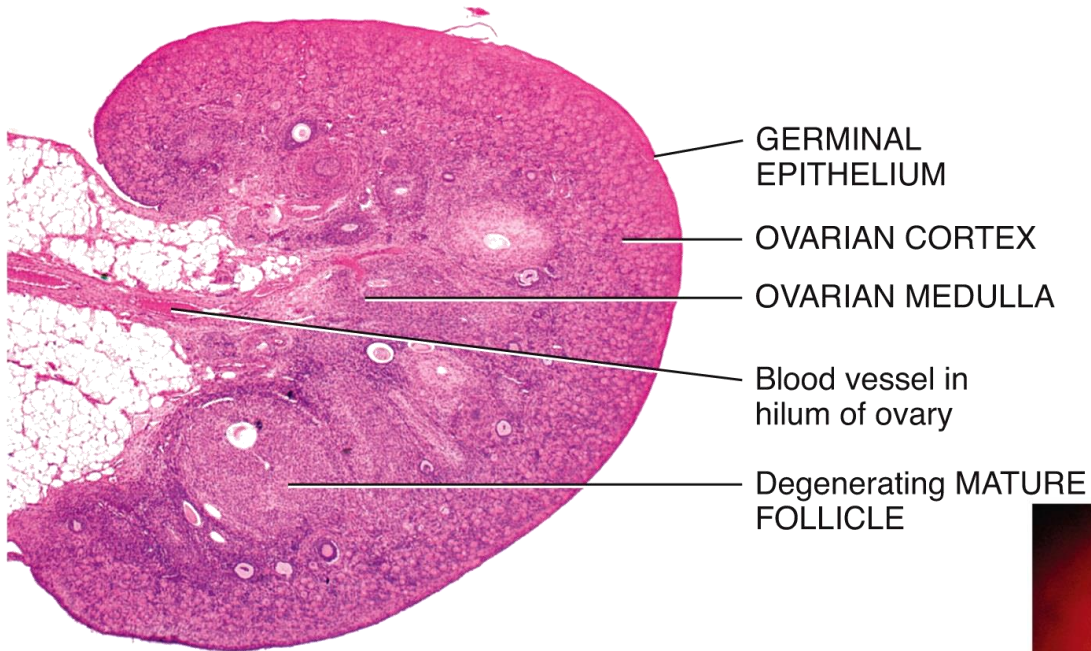
Superior view of transverse section

# Histology of Ovary



(a) Frontal section

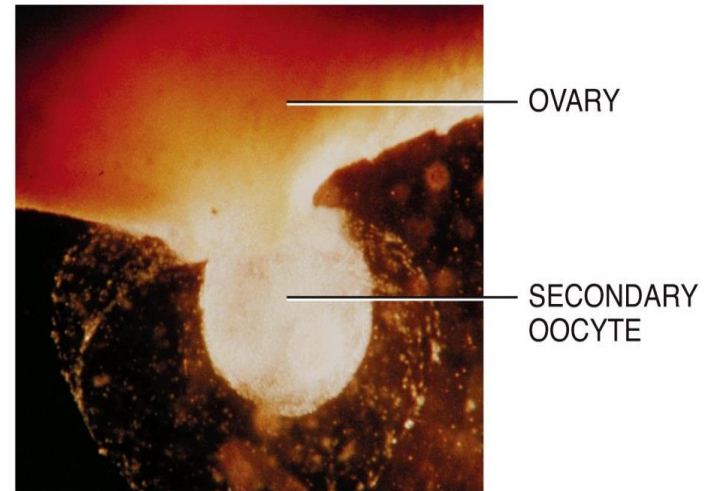
# Histology of Ovary



LM 20x

(b) Hemisection

Courtesy Michael Ross, University of Florida



LM 30x

(c) Ovulation of secondary oocyte

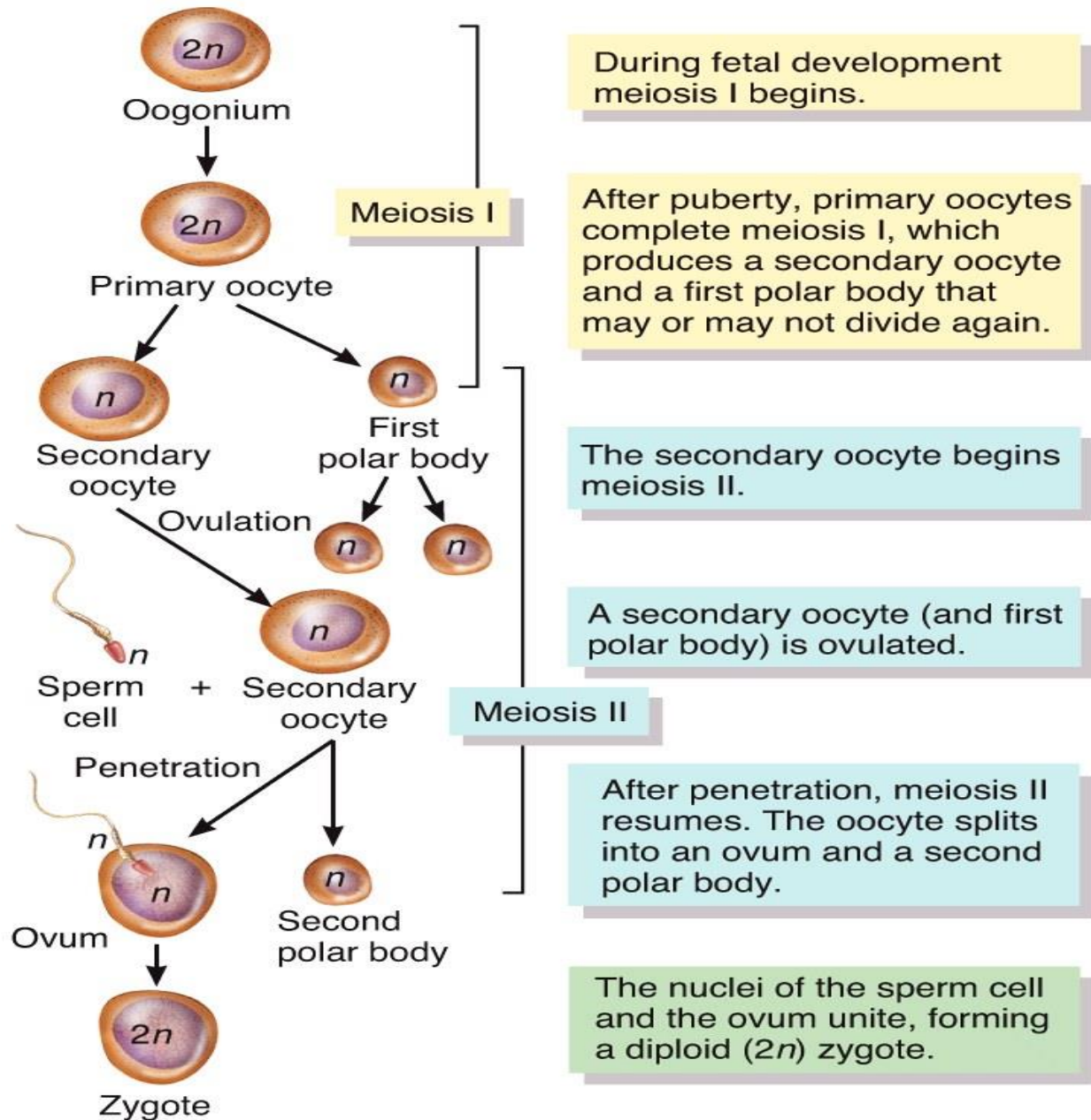
Claude Edelmann/Photo Researchers, Inc.

# Oogenesis

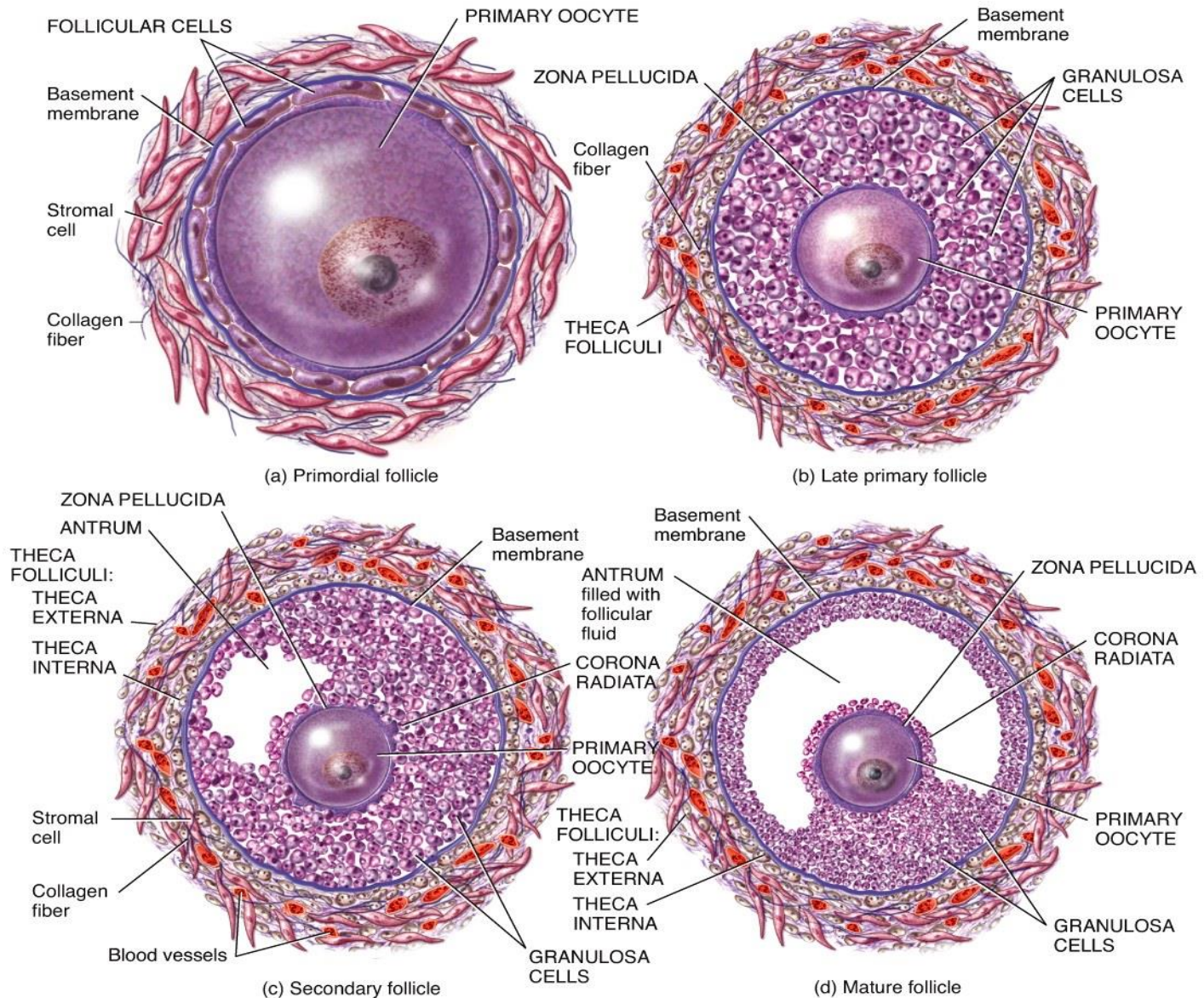
- Oogonia complete mitosis during fetal development
  - Primary oocytes (diploid;  $2n$ ) formed before birth and many begin to degenerate (atresia)
- Meiosis
  - Meiosis I – a few primary oocytes enter prophase
    - But arrested development until after puberty
    - Complete meiosis as follicle develops to produce secondary oocyte and polar body (unequal cytoplasm distribution)
    - Ovulated as secondary oocyte (haploid;  $n$ )
  - Meiosis II – only if fertilized by sperm
    - Second polar body with genetic material

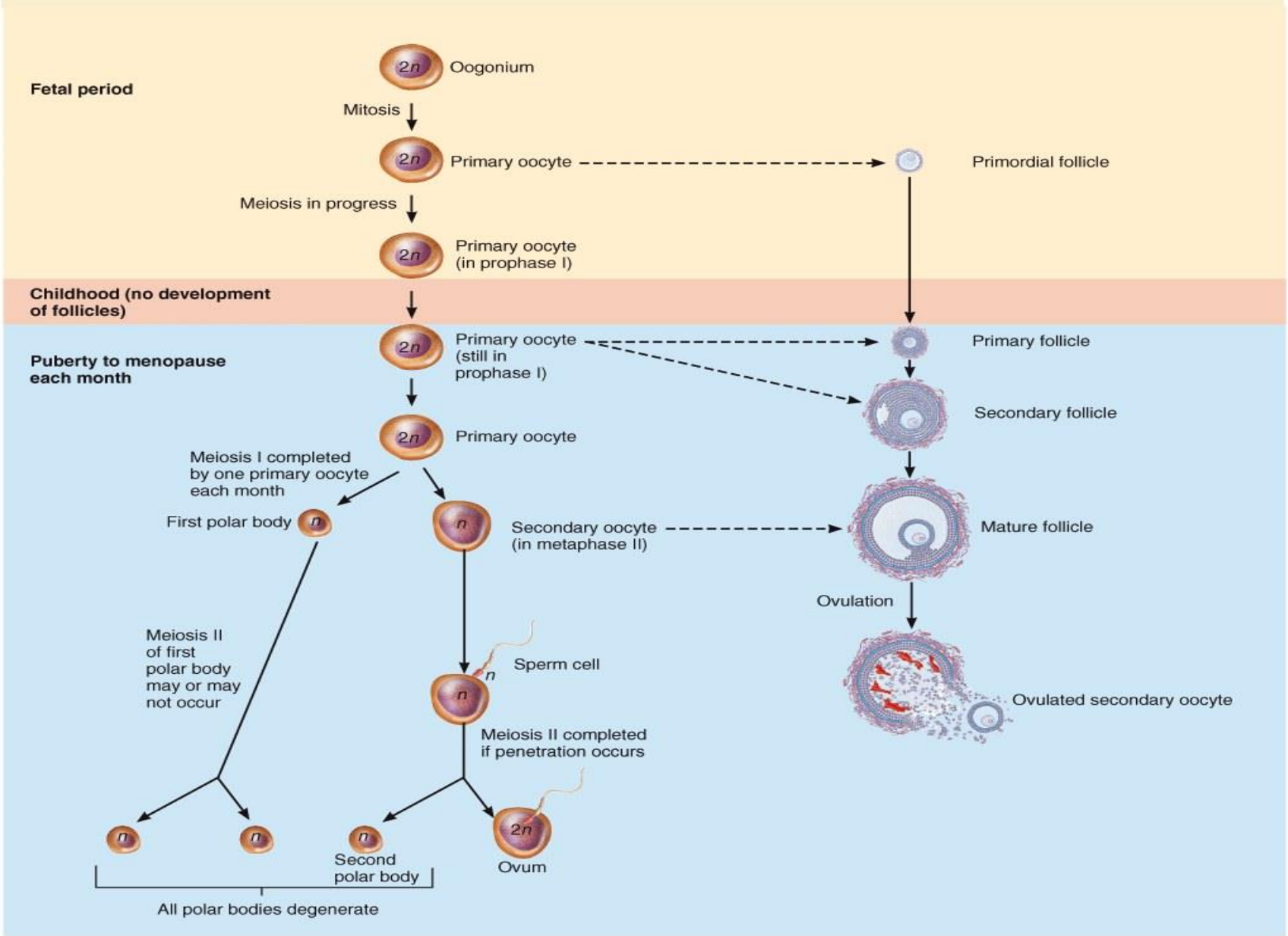


# Oogenesis



# Follicular Development



**TABLE 25.1****Oogenesis and Follicular Development**

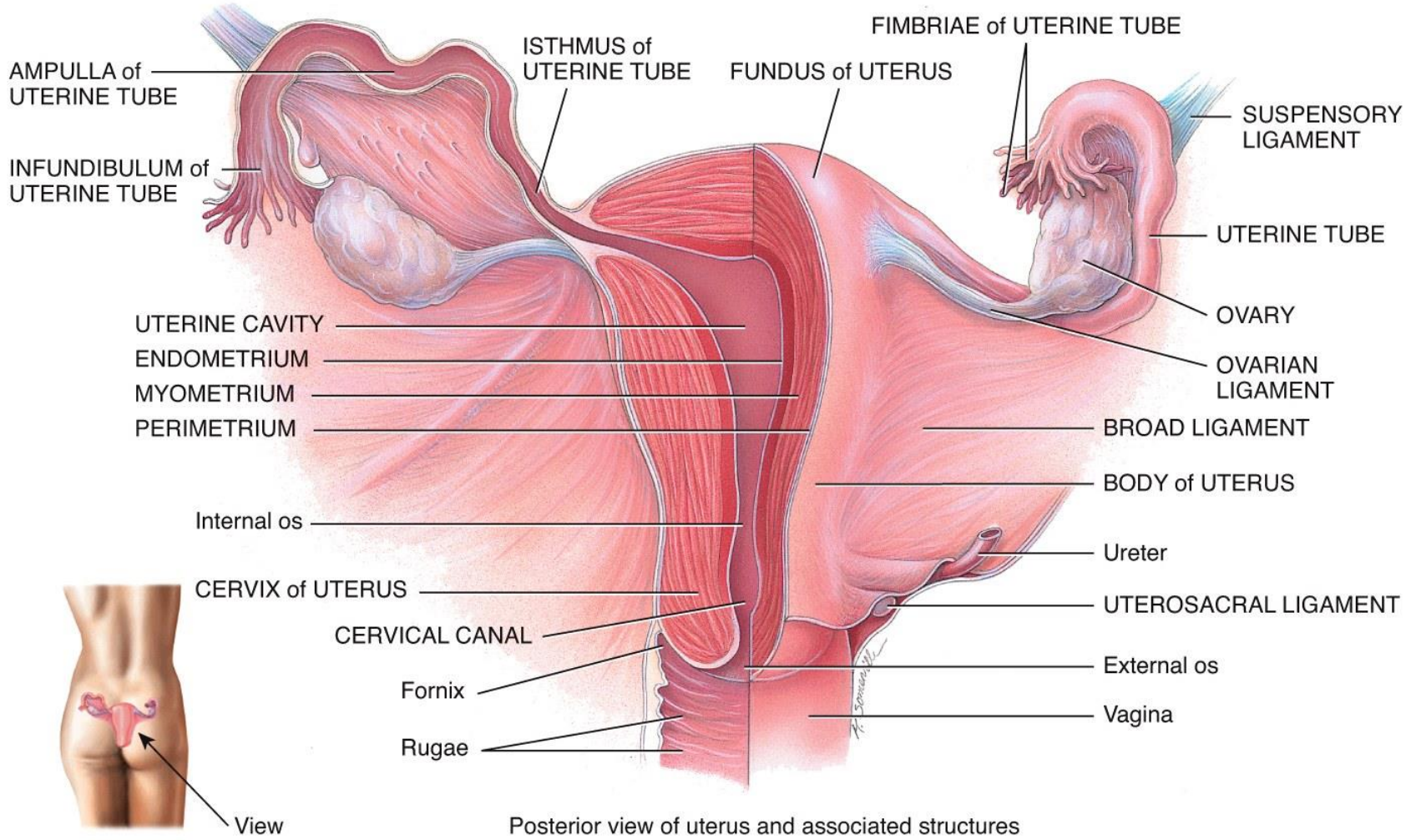


# Uterine Tubes

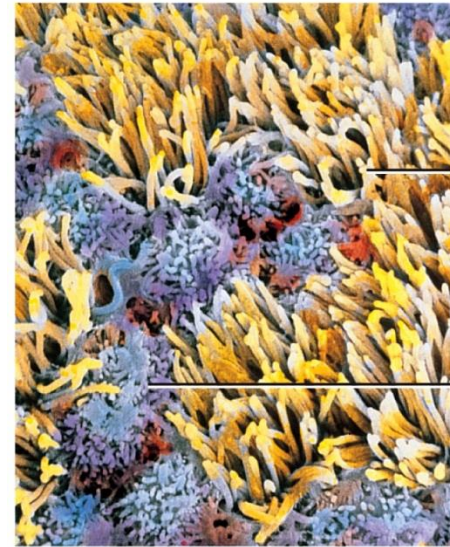
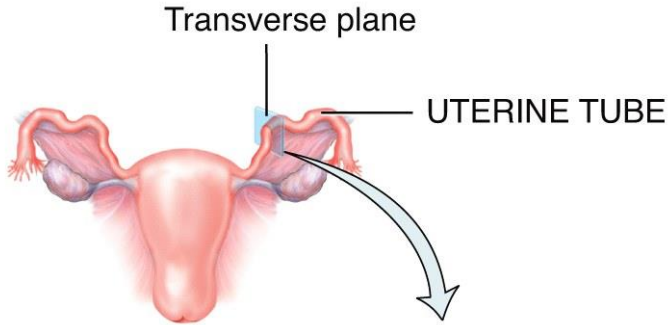
- Extend laterally from uterus
  - Infundibulum – distal funnel shape end of tube, open to serous fluid of peritoneal cavity
  - Fimbriae – fingerlike extensions sweep oocyte into infundibulum
  - Ampulla – widest, longest portion, typically site of fertilization
  - Isthmus – short, narrow connection to uterus
- Ciliated epithelial cells lining tube and peristaltic contractions of smooth muscle transport secondary oocyte or zygote (after fertilization)



# Uterine Tubes



# Uterine Tubes



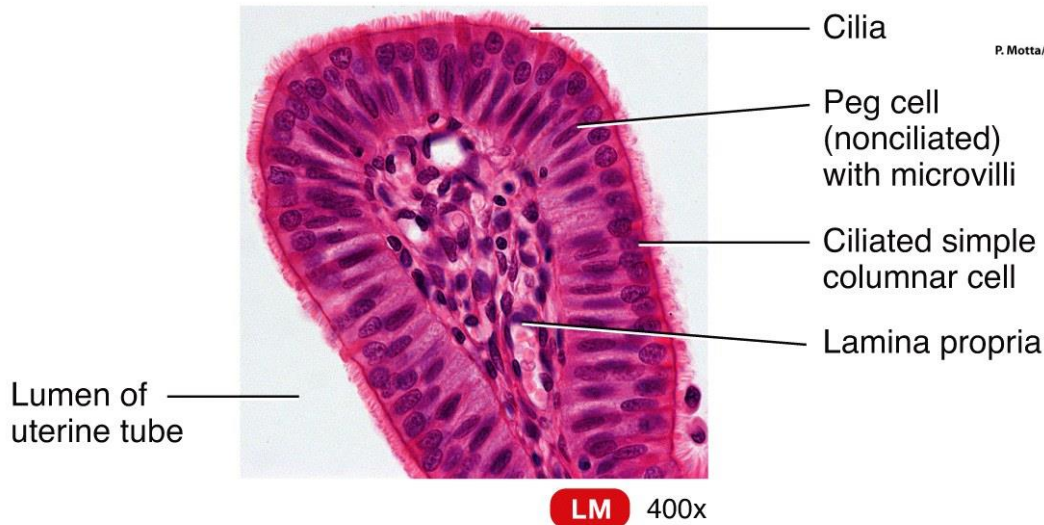
Cilia of ciliated simple columnar epithelial cell

Peg cell (nonciliated) with microvilli

**SEM** 4000x

(b) Details of epithelium in surface view

P. Motta/Photo Researchers, Inc.



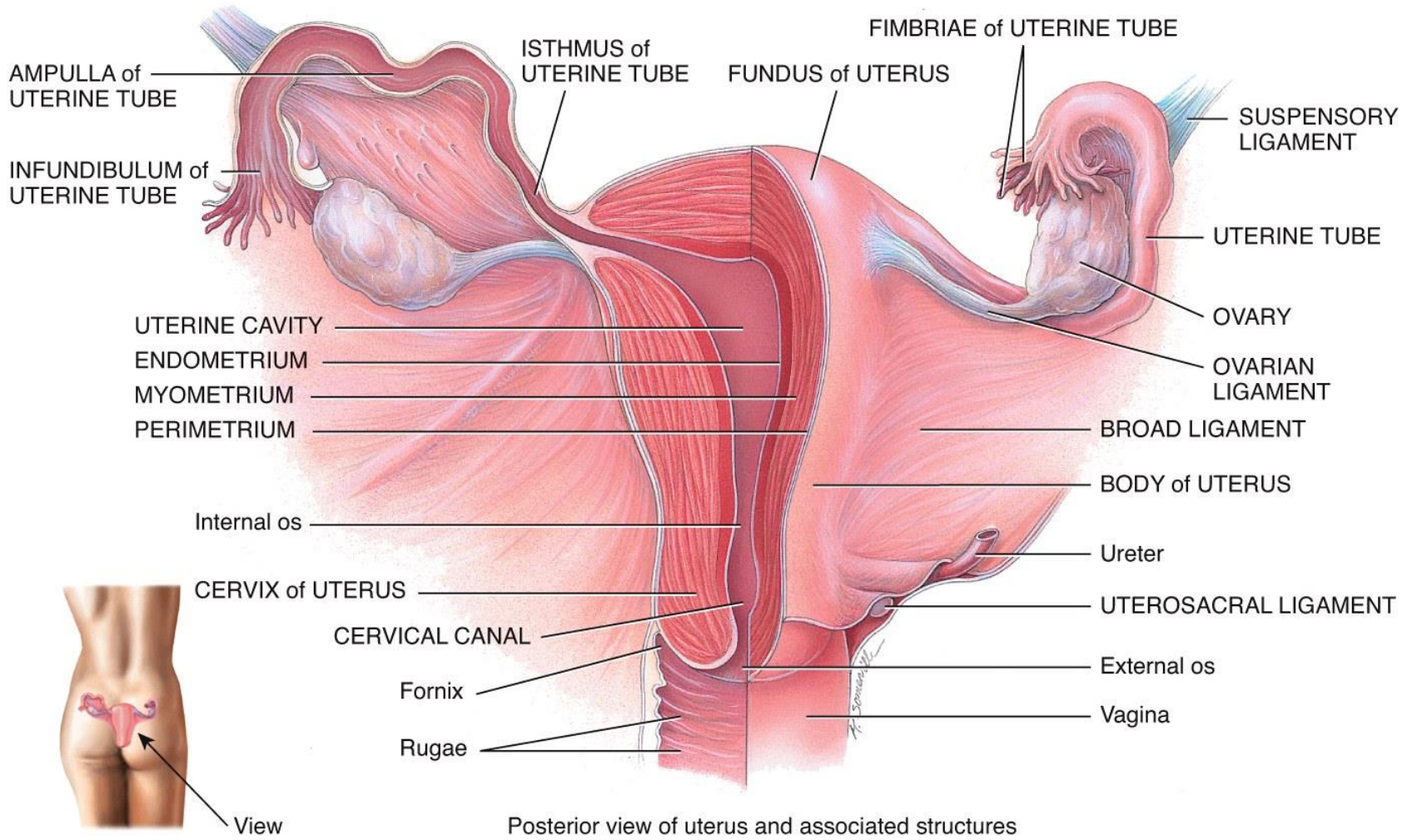
(a) Details of epithelium

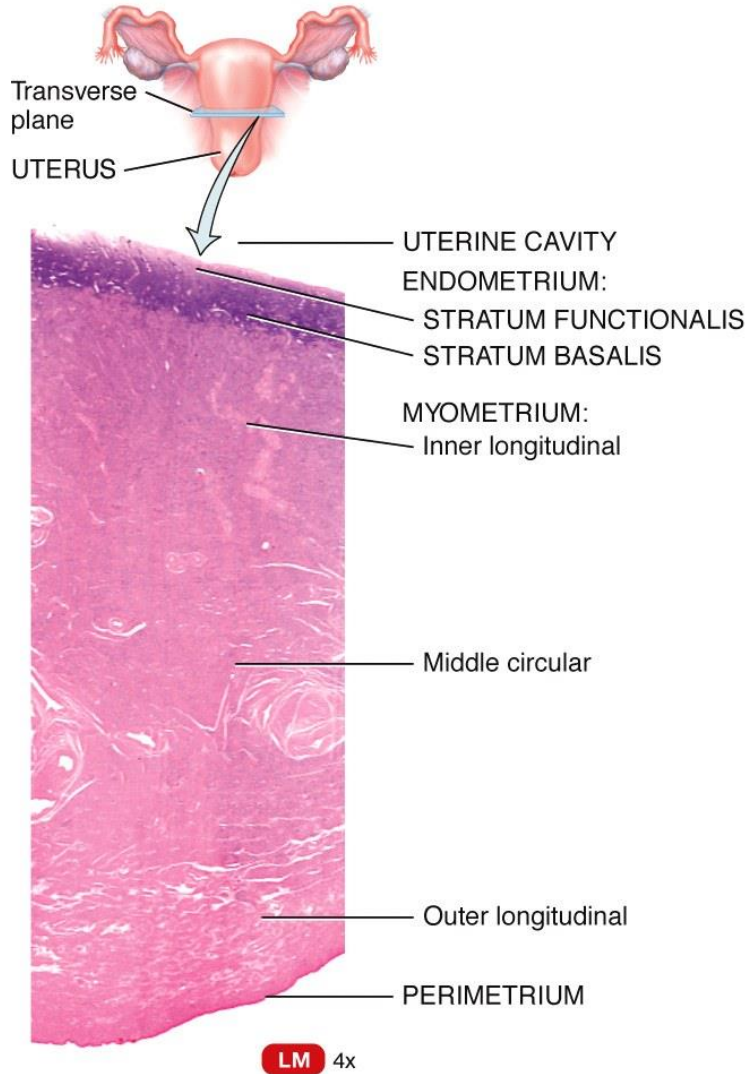
# Uterus

- Major regions
  - Fundus, body, and cervix
- Layers of wall
  - **Perimetrium** – outer protective layer, supported by broad, uterosacral, cardinal and round ligaments
  - **Myometrium** – three smooth muscle layers important during labor
  - **Endometrium**
    - Stratum functionalis - sloughs off
    - Stratum basalis - produces new layer after menstruation

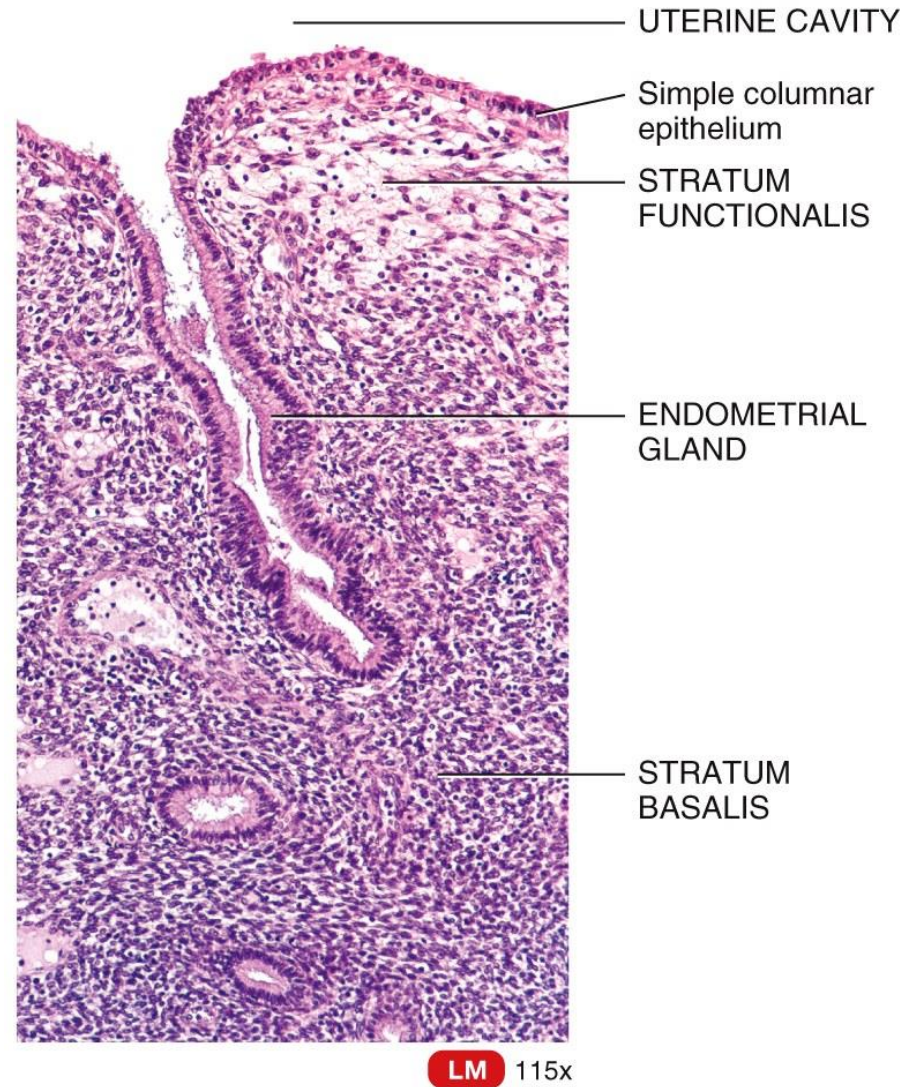


# Uterus





(a) Transverse section through uterine wall



(b) Details of endometrium

Courtesy Michael Ross, University of Florida

# Uterus

- Functions

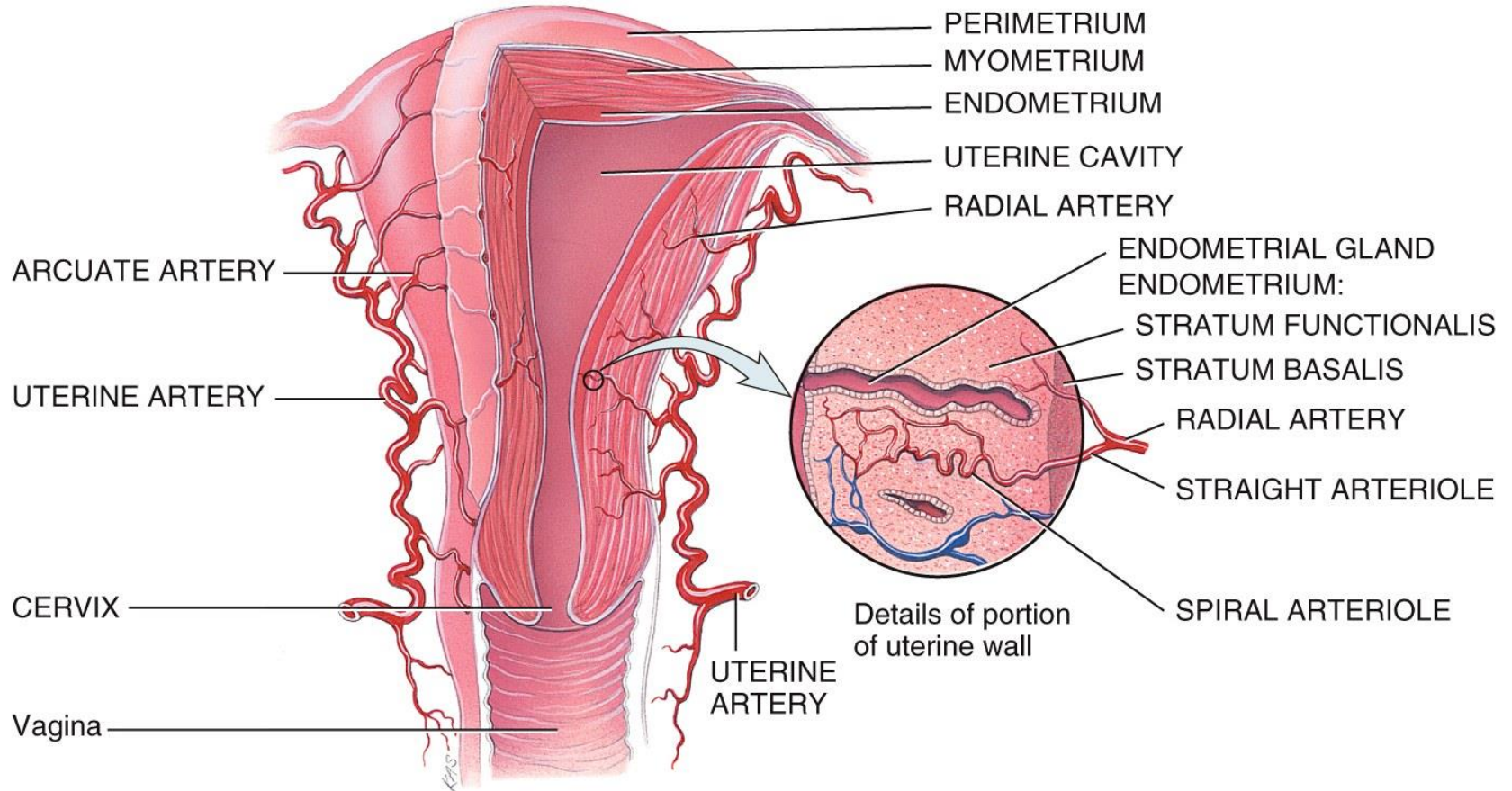
- Menstruation and regrowth of sloughed-off lining
- Implantation of fertilized ovum
- Contribute to structure of placenta
- Support development of fetus during pregnancy
- Labor

- Extensive blood supply

- Uterine, arcuate, radial, straight and spiral arteries



# Uterus



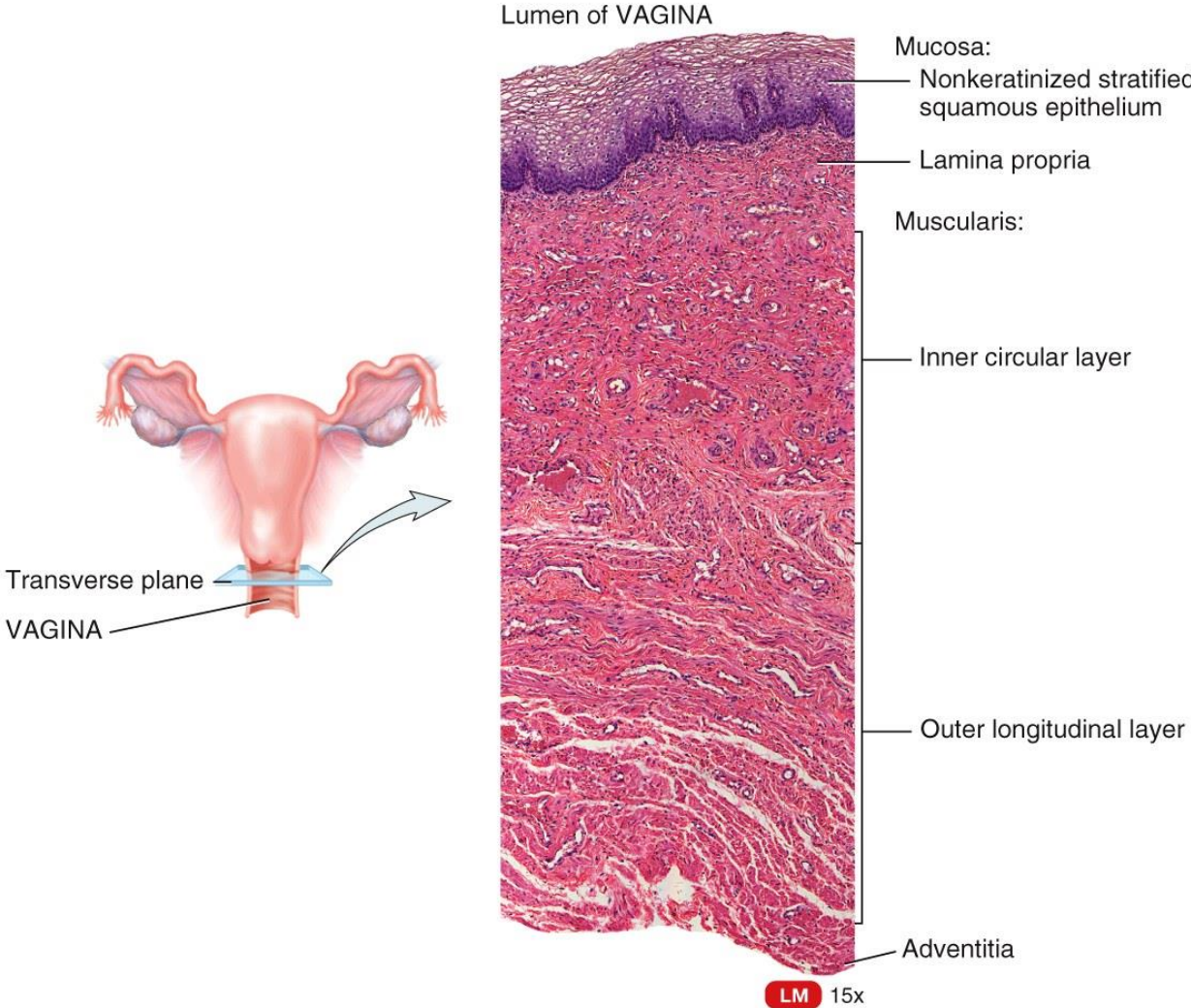
Anterior view with left side of uterus partially sectioned

# Vagina and Vulva

- Vagina
  - Receptacle for penis during sexual intercourse
  - Outlet for menstrual flow
  - Passageway for childbirth
- Vulva
  - External genitals of female
  - Include mons pubis, labia majora, labia minora, clitoris, vestibule, vaginal and urethral orifices (separate in female), bulb of the vestibule, paraurethral glands, and greater vestibular glands
  - Many structures homologous (same embryonic origins) to male structures

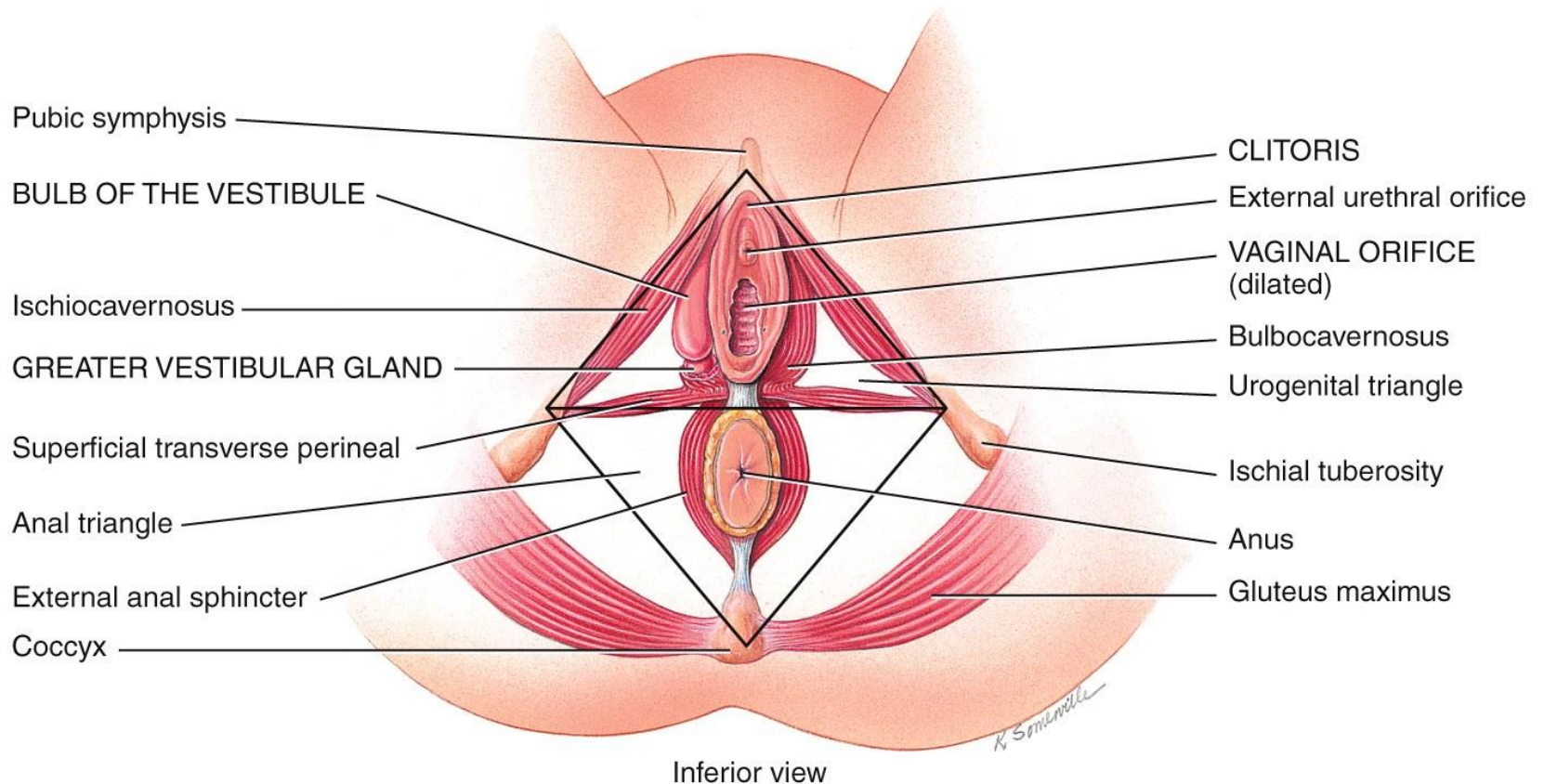


# Vagina and Vulva



(a) Transverse section through vaginal wall

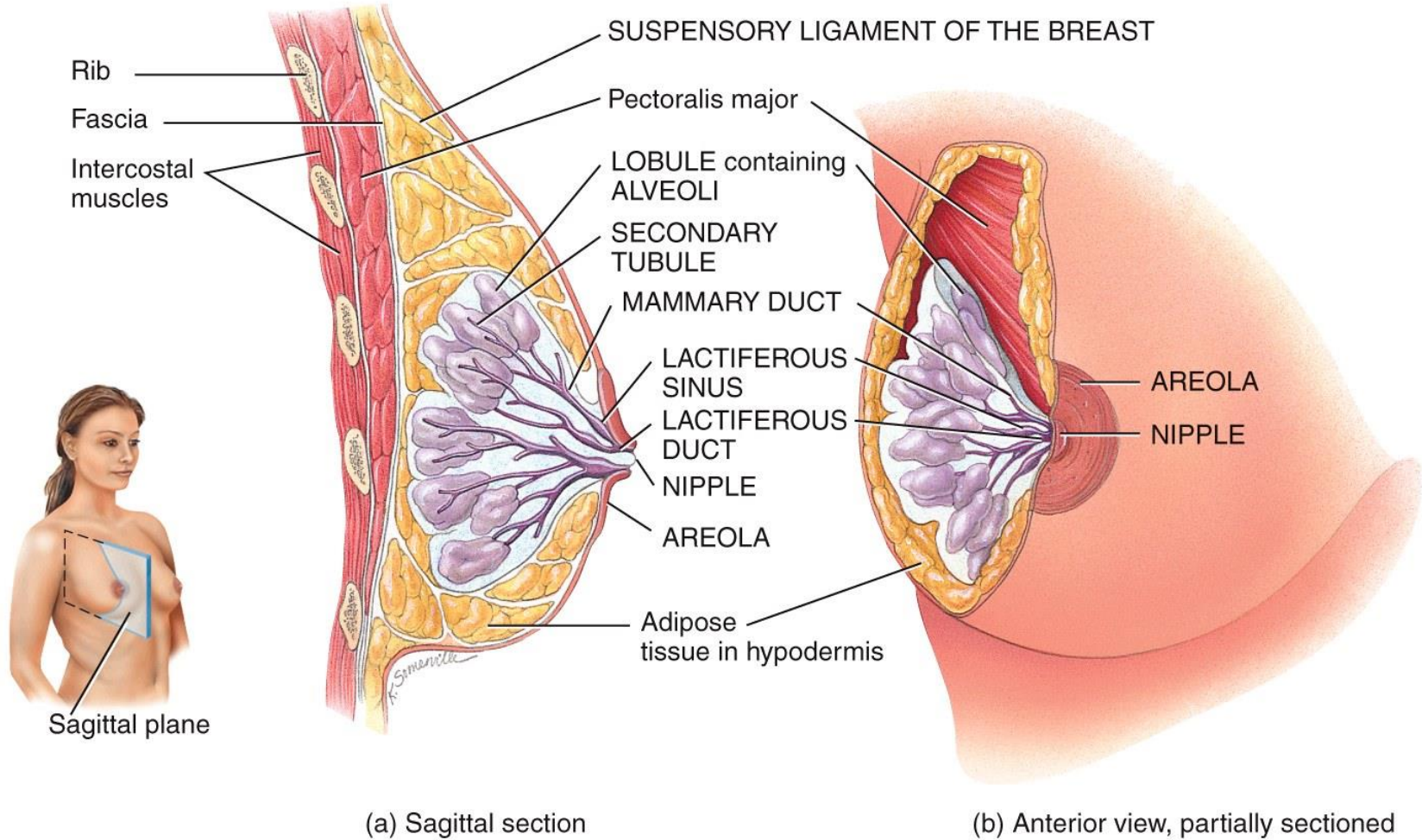
# Vagina and Vulva



# Mammary Glands

- Each breast anterior to pectoralis major and serratus anterior muscles
  - Nipple with lactiferous ducts, areola, and suspensory ligaments
- Mammary gland functions for lactation
  - Modified sudoriferous gland that produces milk
  - Lobules composed of alveoli separated by adipose tissue
  - Myoepithelial cells contract to propel milk through ducts
    - Secondary tubules, mammary ducts, lactiferous sinuses, and lactiferous ducts

# Mammary Glands



(a) Sagittal section

(b) Anterior view, partially sectioned

# Lesson 4: Female Menstrual Cycle

## ***Objective:***

- Describe the structure and function of the organs of the female reproductive system
- Describe the hormonal changes that occur during the ovarian and menstrual cycles
- Trace the path of an oocyte from ovary to fertilization

# Female Reproductive Cycle

- Ovarian cycle
  - Occurs in ovary during and after maturation of oocyte
- Uterine cycle
  - Concurrent changes in endometrium of uterus to prepare to receive fertilized ovum and support its development
- Also related changes in mammary glands and cervix



# Hormone Regulation of Female Cycle

- At puberty, gonadotropin-releasing hormone (hypothalamus)
- stimulates secretion of two anterior pituitary gonadotropin hormones
  - **Follicle-stimulating hormone (FSH)**
    - Initiates follicular growth and estrogen secretion
  - **Luteinizing hormone (LH)**
    - Stimulates further follicular development and estrogen
    - Triggers ovulation and corpus luteum secretion of estrogen, progesterone, relaxin, and inhibin
  - **Inhibin**
    - Inhibits FSH, and LH to lesser extent
  - **Relaxin**
    - Relaxes uterine muscle and pubic symphysis

# Hormone Regulation of Female Cycle

- Estrogen

- Stimulate development and maintenance of female reproductive structures and secondary sex characteristics
- Stimulates protein anabolism
- Decreases blood cholesterol levels

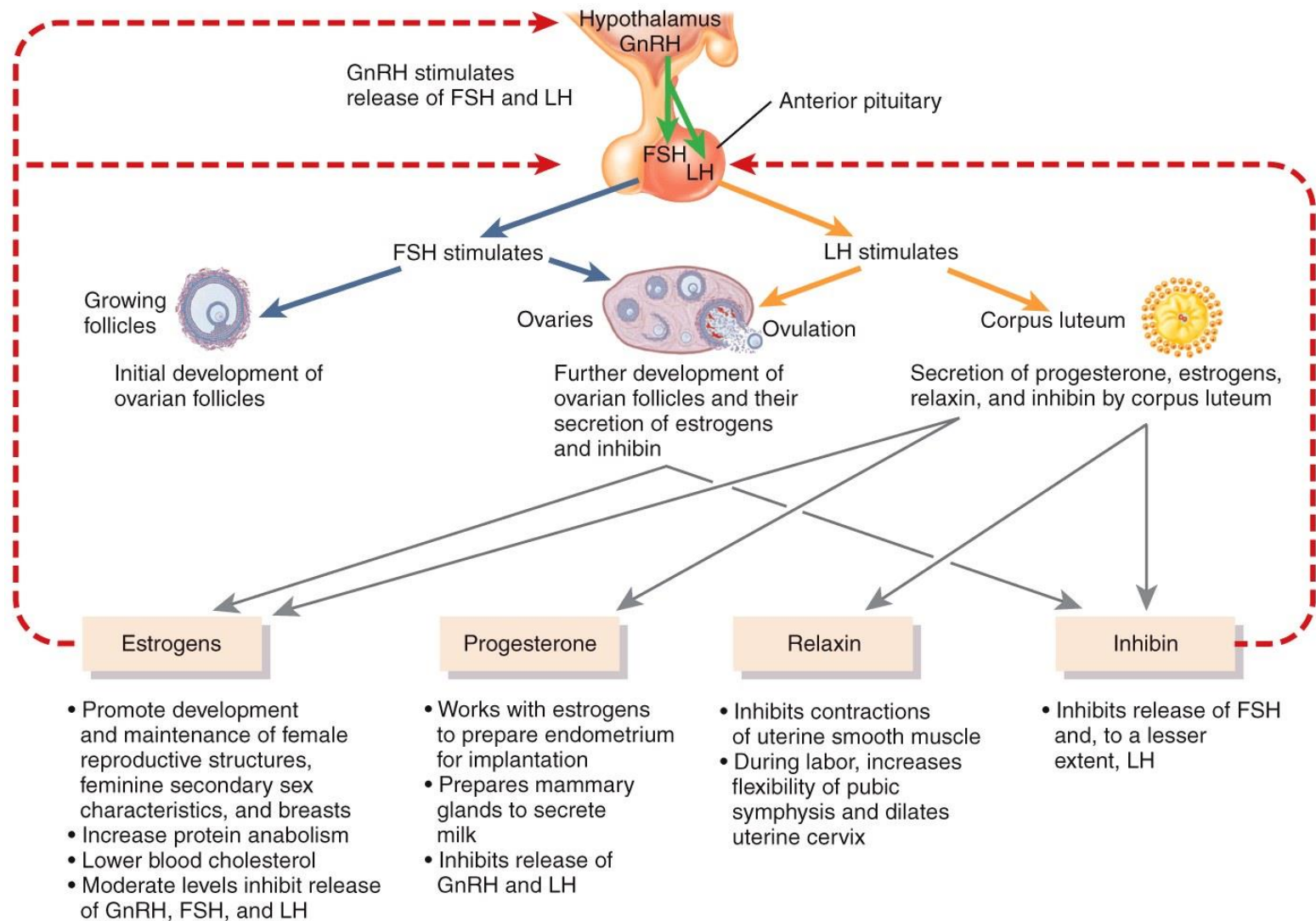
- Progesterone

- Works with estrogen to prepare endometrium for implantation
- Prepares mammary glands for milk secretion

- Negative feedback regulation mechanism



# Hormone Regulation of Female Cycle



# Phases of Female Cycle

- Menstrual phase

- In ovaries, primordial follicle develop into primary, then secondary follicles
- In the uterus, stratum functionalis of the endometrium is shed, discharging blood tissue fluid, mucus, and epithelial cells

- Preovulatory phase

- In ovaries, a group of follicles begins to undergo maturation
  - One becomes dominant, and others degenerate
  - Graafian follicle secretes estrogens and inhibin, which decreases FSH and stops other follicles from growing
- In uterus, estrogens stimulate repair of endometrium

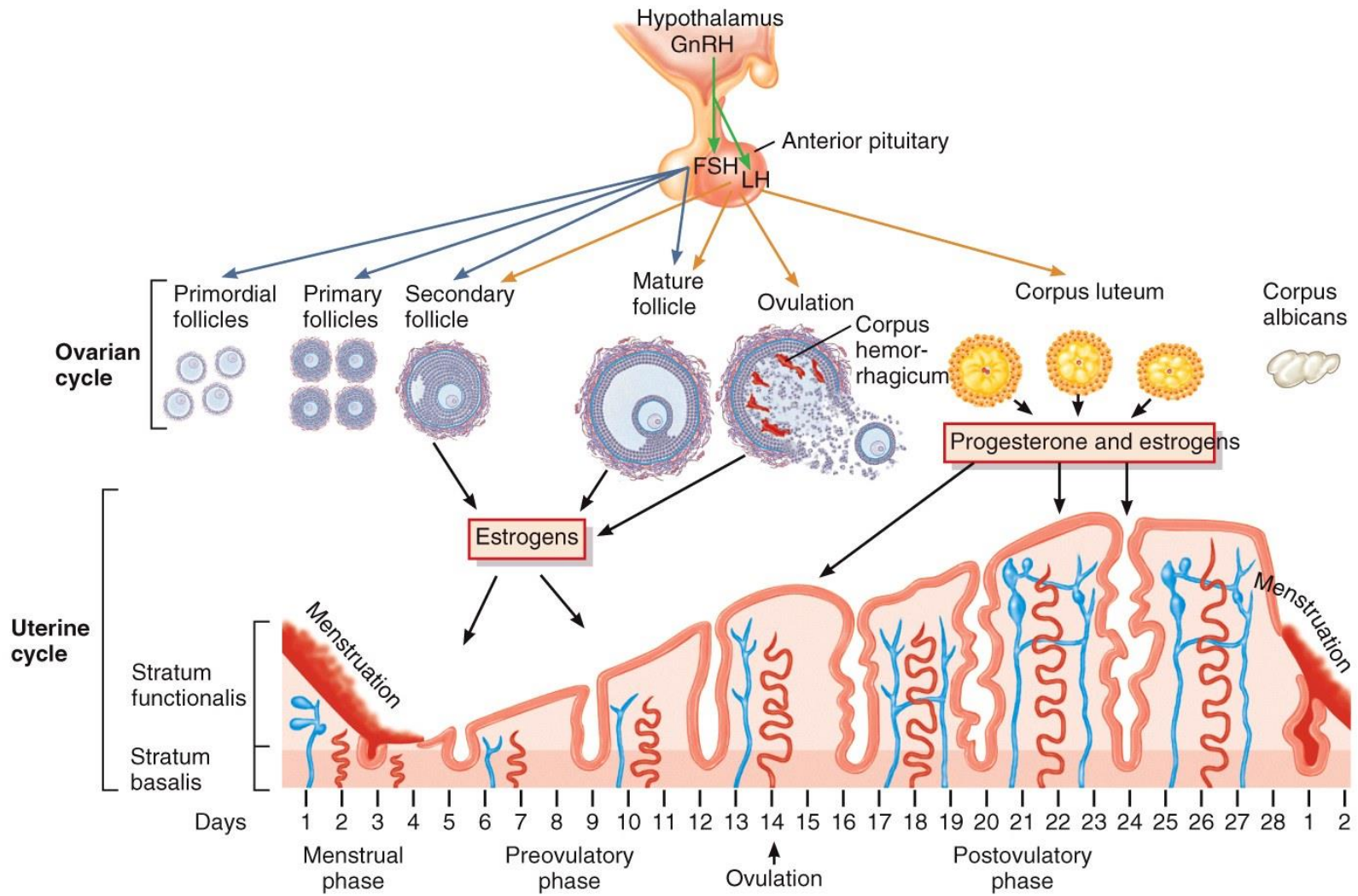
# Phases of Female Cycle

- Ovulation

- High levels of estrogen exert positive feedback effect on anterior pituitary and hypothalamus
- Surge of LH causes rupture of graafian follicle and release of secondary oocyte with zona pellucida and corona radiata cells into pelvic cavity

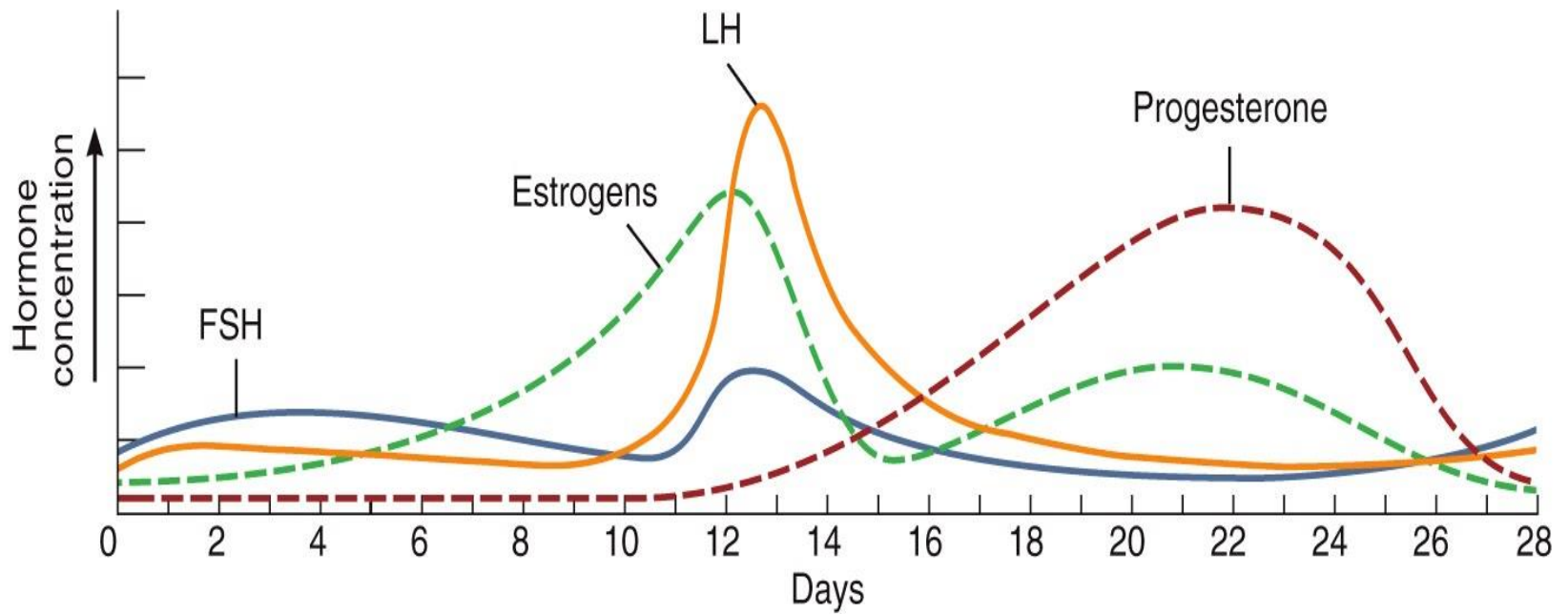
- Postovulatory phase

- In ovaries, the corpus luteum develops from the ruptured follicle
- Stimulated by LH, secretes progesterone, estrogens, relaxin, and inhibin
- In uterus, endometrium thickens in readiness for implantation



(a) Hormonal regulation of changes in the ovary and uterus

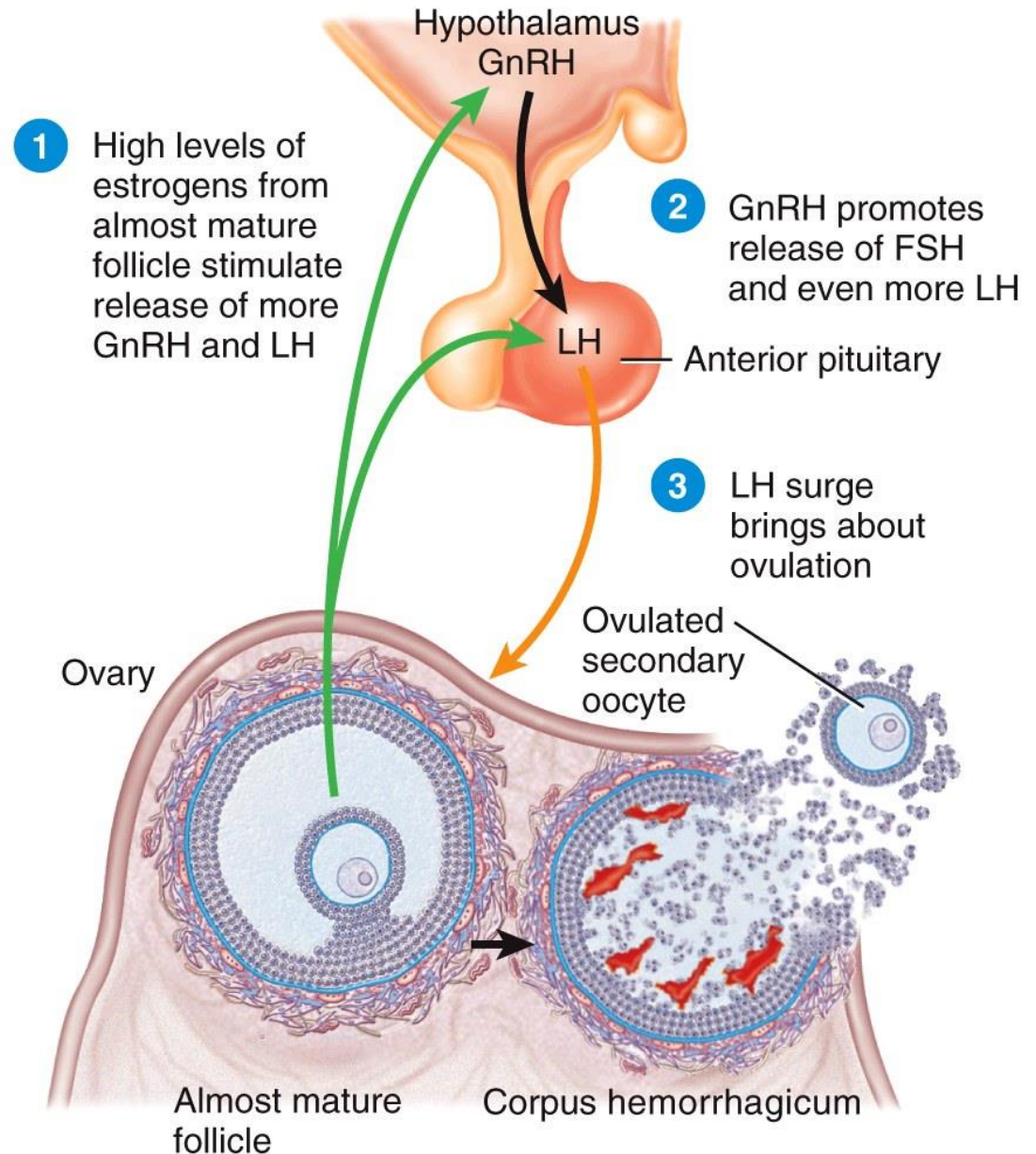
# Phases of Female Cycle



(b) Changes in concentration of anterior pituitary and ovarian hormones



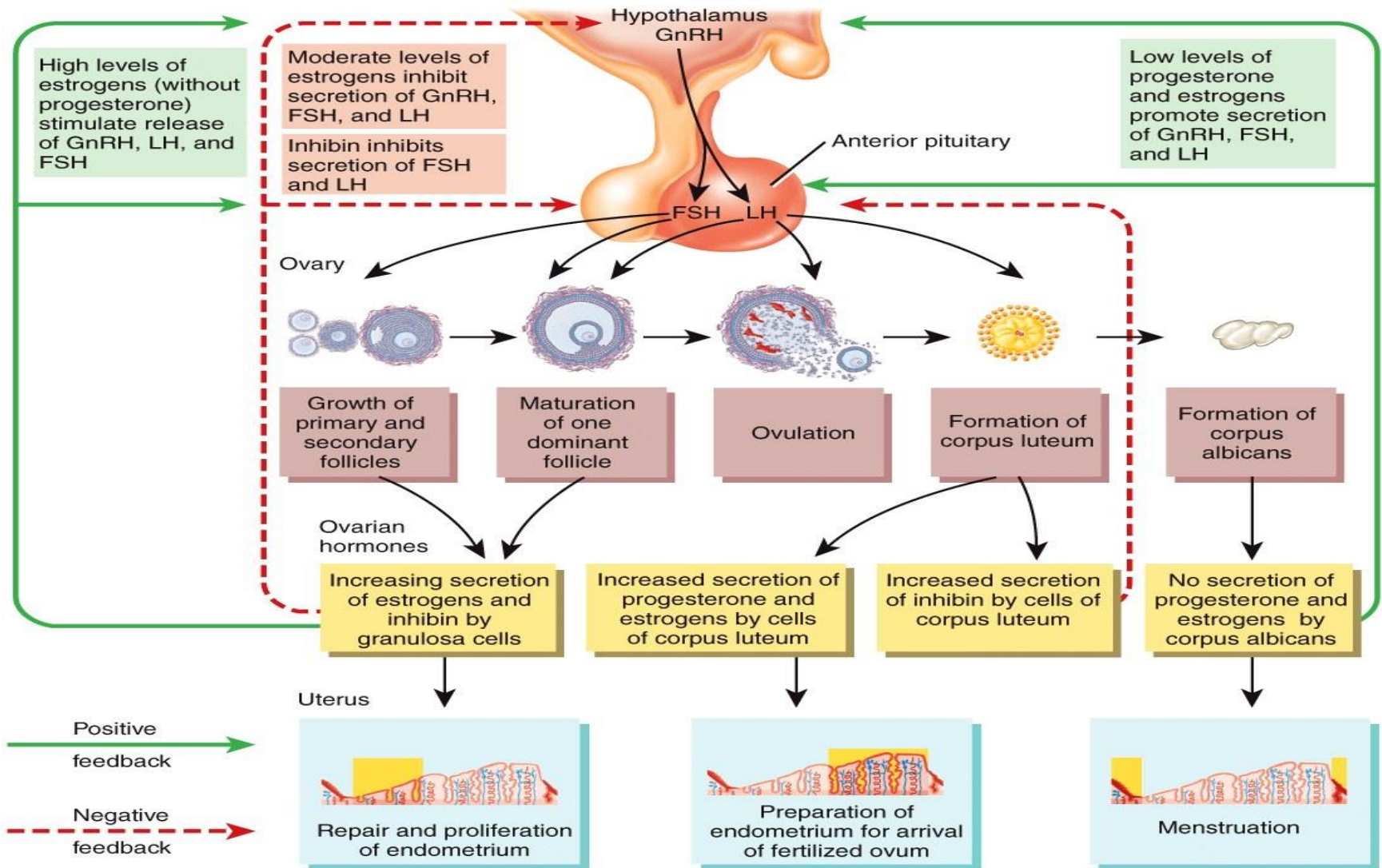
# Positive Feedback Control of Ovulation



# Phases of Female Cycle

- If fertilization and implantation do not occur
  - In the ovaries, corpus luteum degenerates and levels of progesterone and estrogens decrease
  - In the uterus, menstruation triggered by decreasing hormones
  - Initiation of another reproductive cycle
- If fertilization and implantation do occur
  - In the ovaries, human chorionic gonadotropin secreted by embryo maintains corpus luteum , so it continues to secrete progesterone and estrogens
  - In the uterus, endometrium development continues in preparation for implantation by the zygote

# Phases of Female Cycle





# Fertilization

- Union of the genetic material from a haploid sperm and haploid secondary oocyte
  - Male and female pronuclei form a single nucleus
  - Typically occurs in uterine tube 12 to 24 hours after ovulation
- Sperm use flagella to swim from vagina through cervical canal, to uterine tube
  - Capacitation – changes that prepare for penetration of corona radiata to zona pellucida
  - Acrosomal reaction – release of acrosomal enzymes to digest path through zona pellucida
  - Polyspermy block – fast and slow reactions prevent another sperm penetration

# Lesson 5: Male Reproductive System

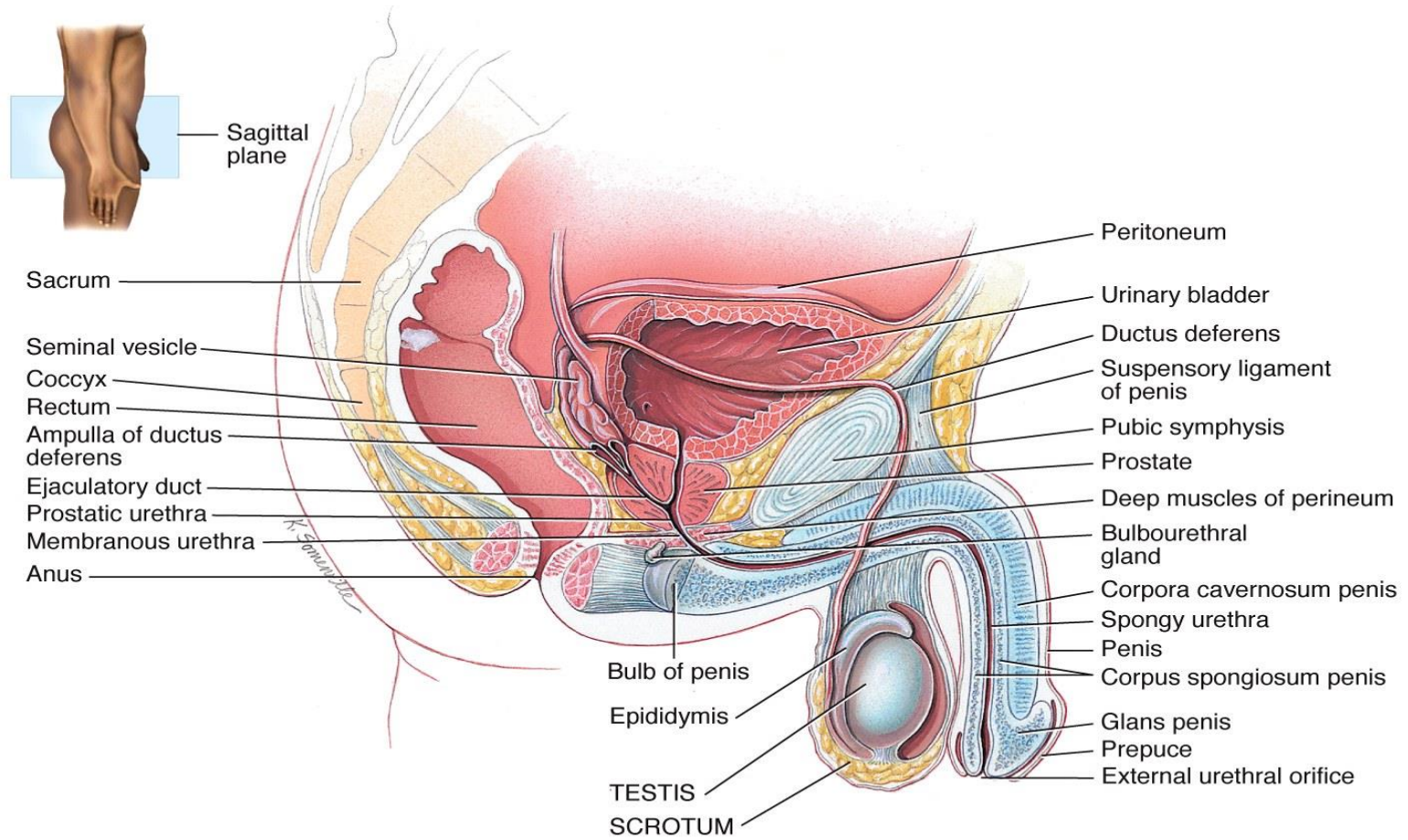
## ***Objective:***

- Describe the structure and function of the organs of the male reproductive system
- Describe the structure and function of the sperm cell
- Explain the events during spermatogenesis that produce haploid sperm from diploid cells
- Identify the importance of testosterone in male reproductive function

# Male Reproductive System

- Testes
  - Paired male gonads in scrotum
- System of ducts
  - Epididymis, ductus deferens, ejaculatory ducts, and urethra
- Accessory glands
  - Seminal vesicles, prostate, and bulbourethral glands
- Supporting structures
  - Scrotum and penis

# Male Reproductive System

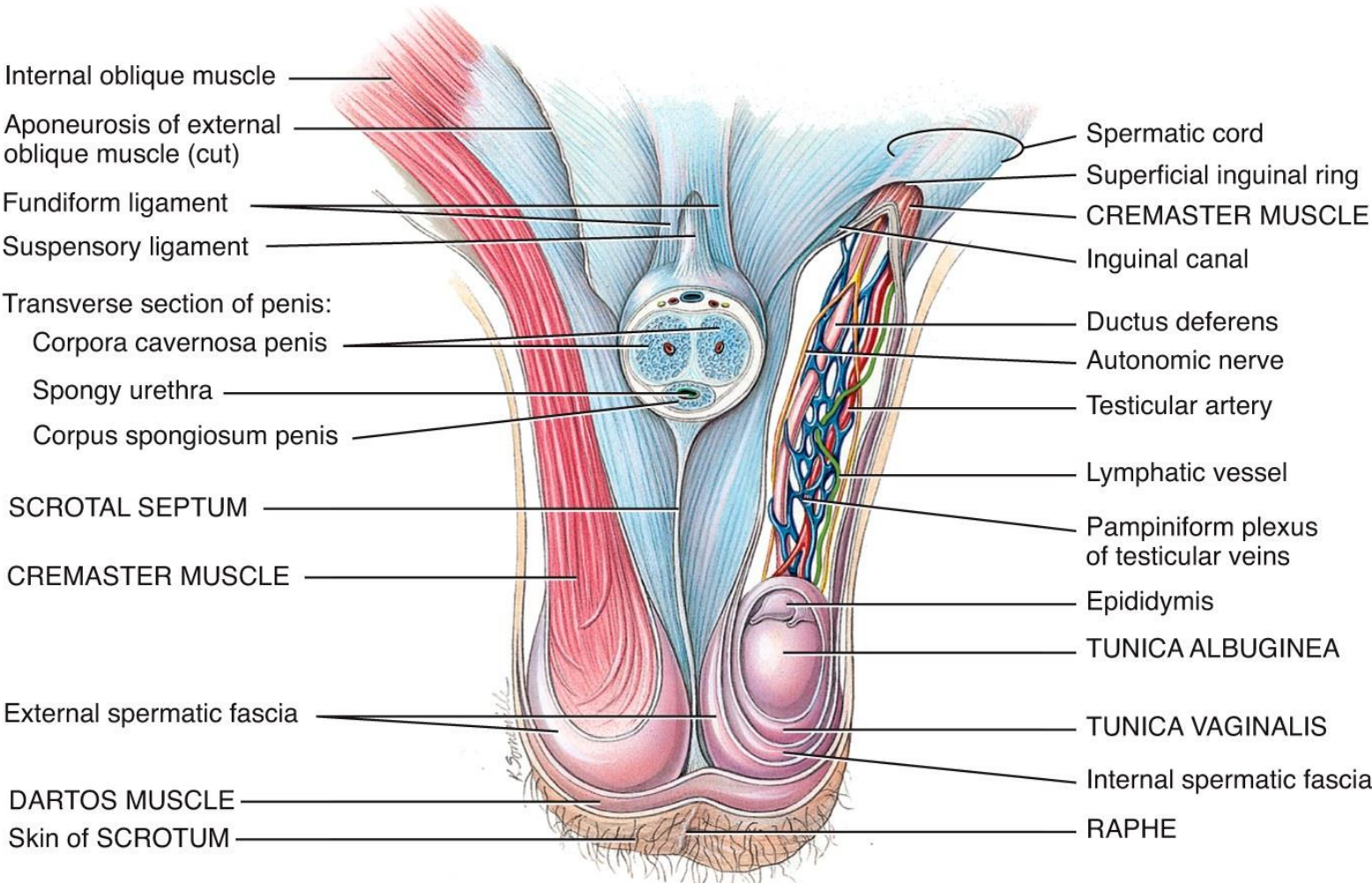


(a) Sagittal section

# Scrotum

- Loose skin and underlying hypodermis support testes in two sacs
  - Normal sperm production in testes occurs at temperature a few degrees below body temperature
  - Testes descend through inguinal canals during fetal development
- Cremaster and dartos muscles in spermatic cord regulate temperature of testes
  - Contract to elevate scrotum, bringing testes closer to warmth of pelvic cavity
  - Relax to move them further away for cooling
  - Spermatic cord also contains blood and lymph vessels, nerves, and ductus deferens

# Scrotum



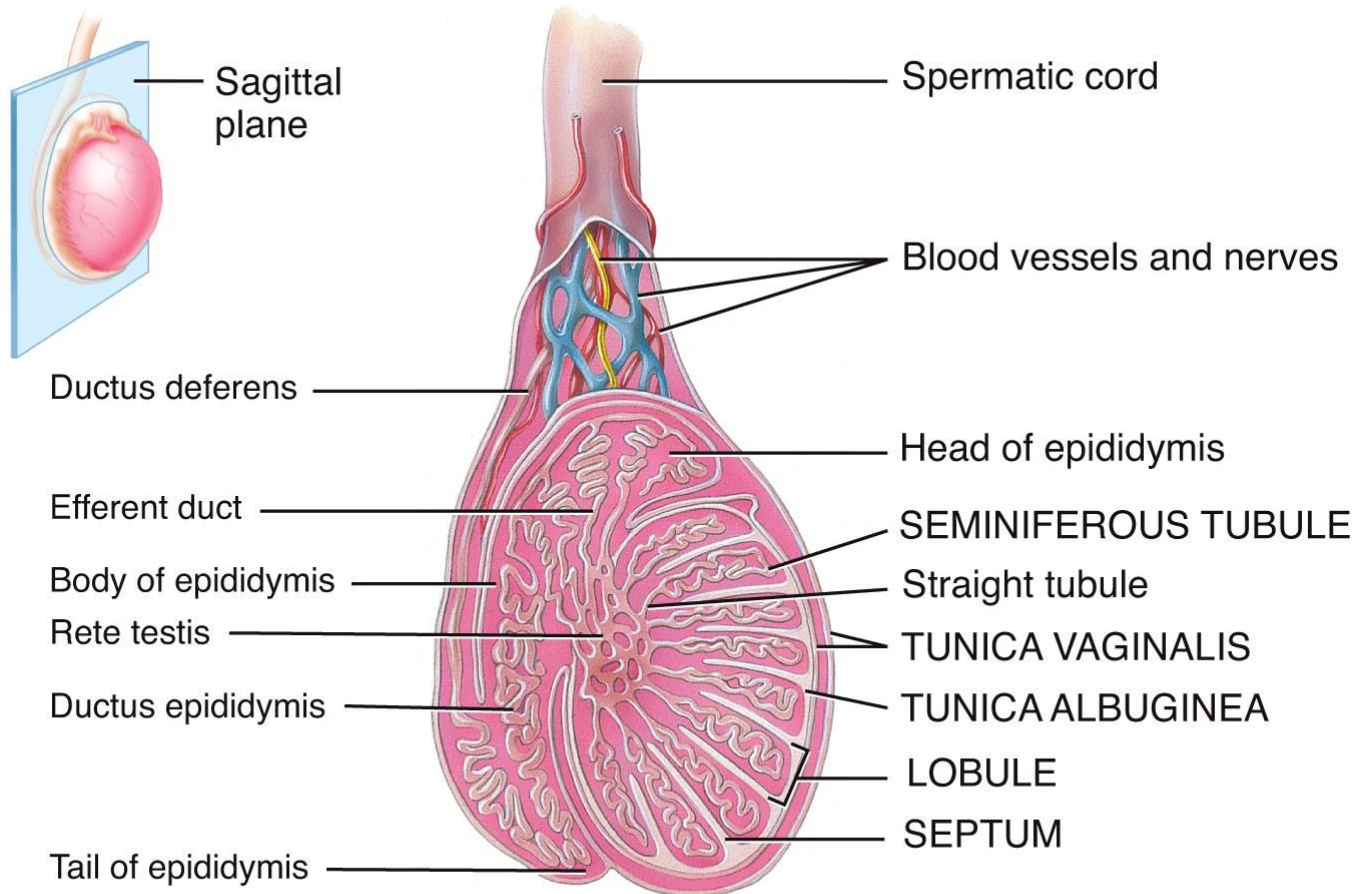
Anterior view of scrotum and testes and transverse section of penis

# Testes

- Contain seminiferous tubules that produce sperm during spermatogenesis
  - Spermatogenic cells
    - Begin sperm production at puberty
  - Sertoli cells
    - Nourish and control movement of developing sperm cells to release in lumen
    - Form blood-testis barrier to prevent immune response
    - Secrete inhibin hormone to decrease spermatogenesis
  - Leydig cells
    - Produce male sex hormone testosterone



# Testes

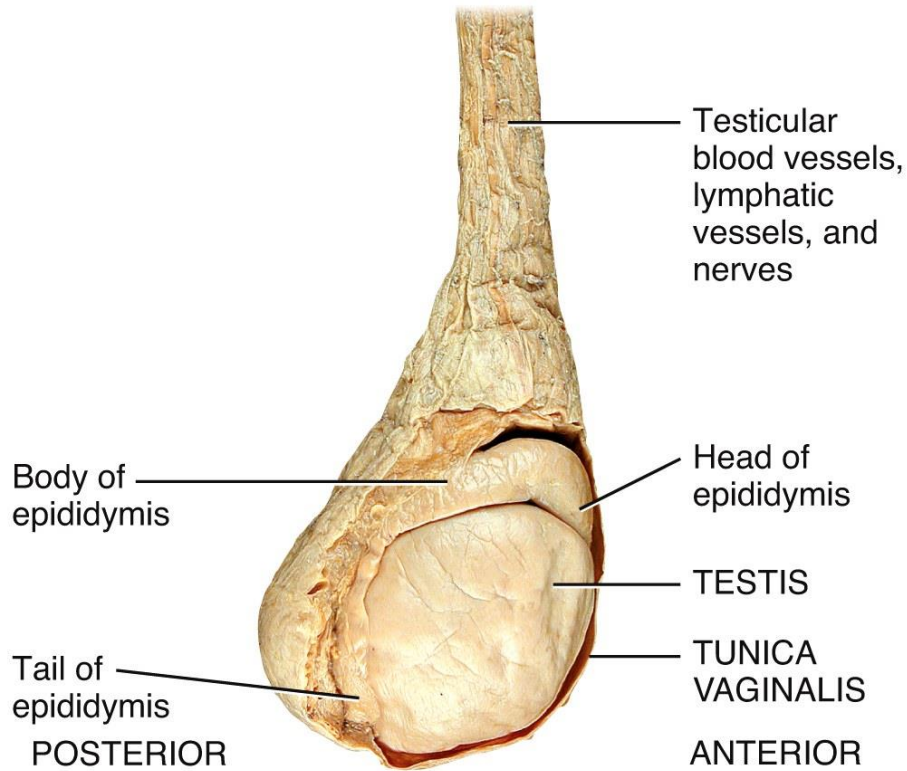


(a) Sagittal section of testis showing seminiferous tubules



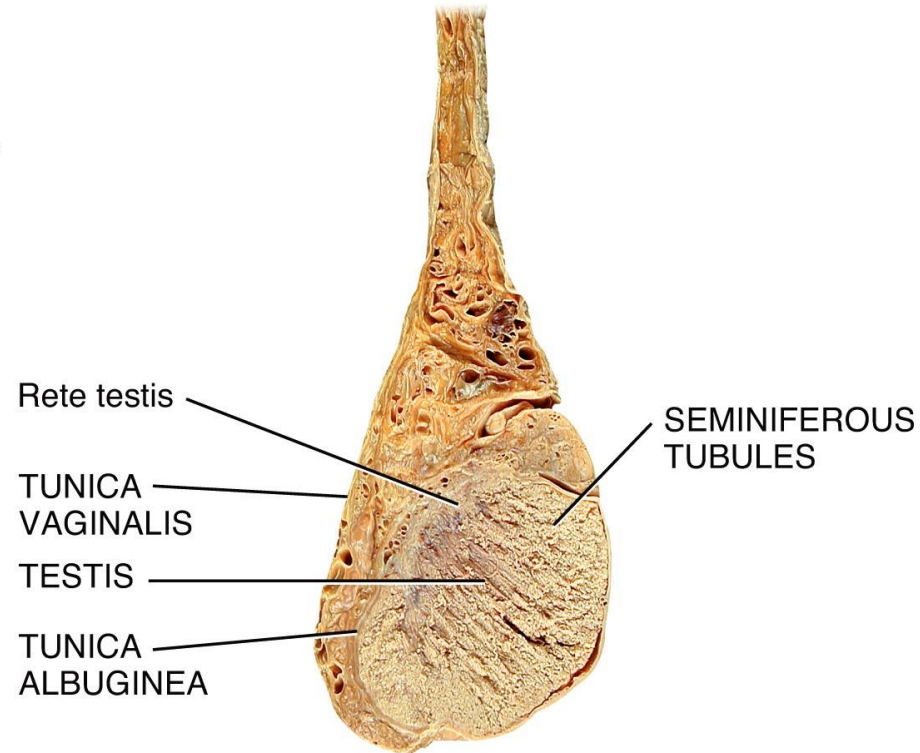
# Testes

SUPERIOR



(b) Lateral view of testis and associated structures

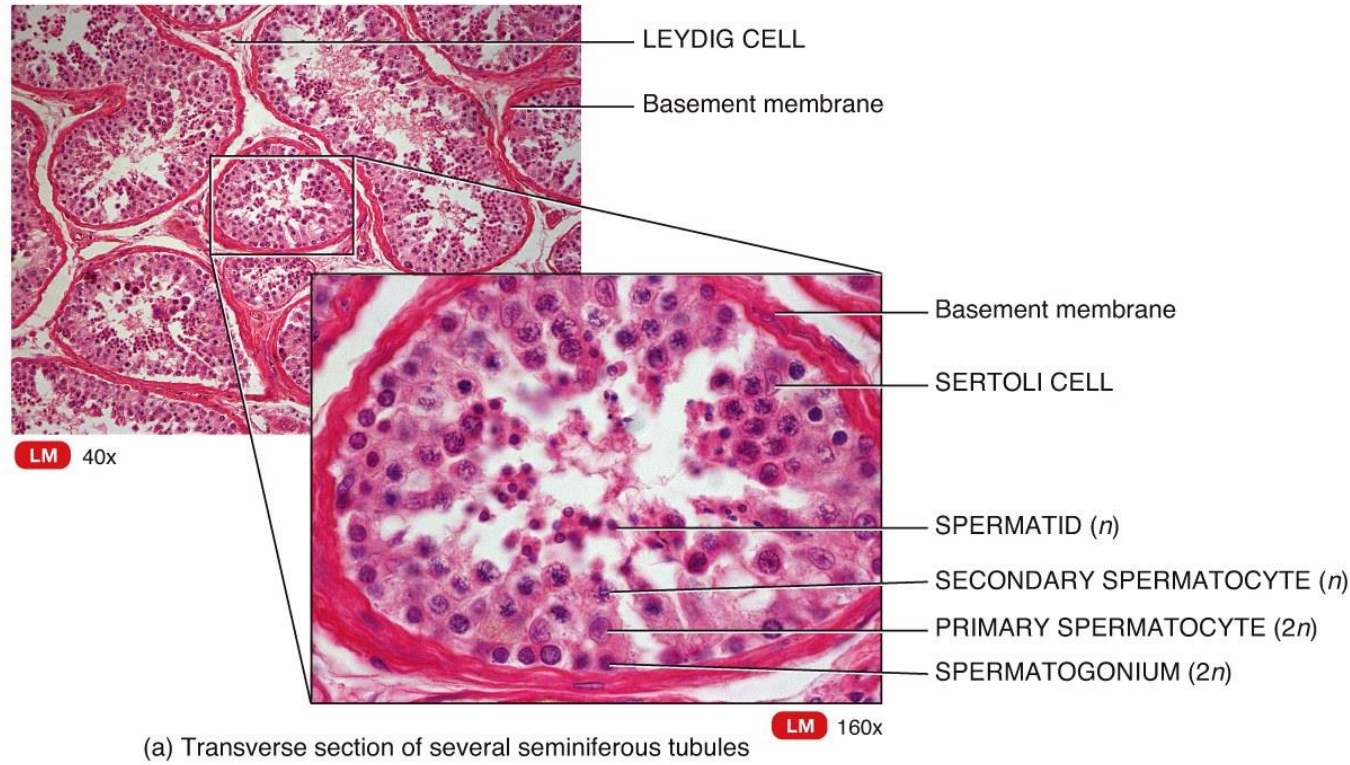
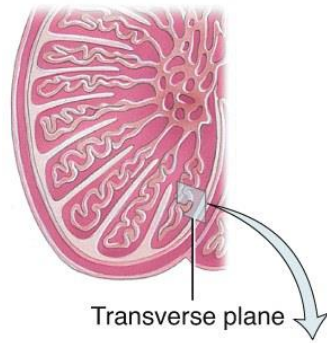
Dissection Shawn Miller, Photograph Mark Nielsen



(c) Sagittal section

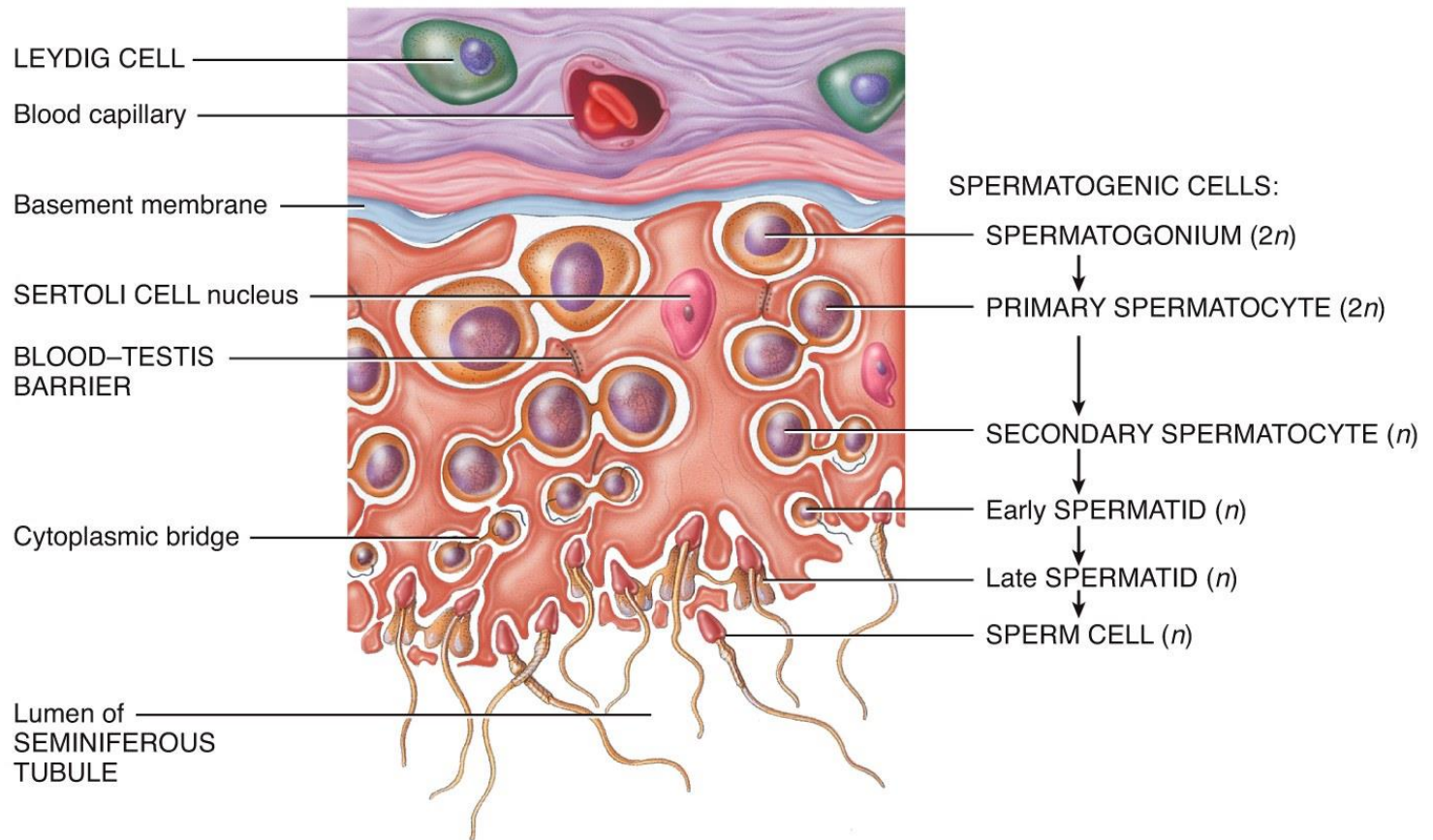
Dissection Shawn Miller, Photograph Mark Nielsen

# Testes



(a) Transverse section of several seminiferous tubules

# Testes



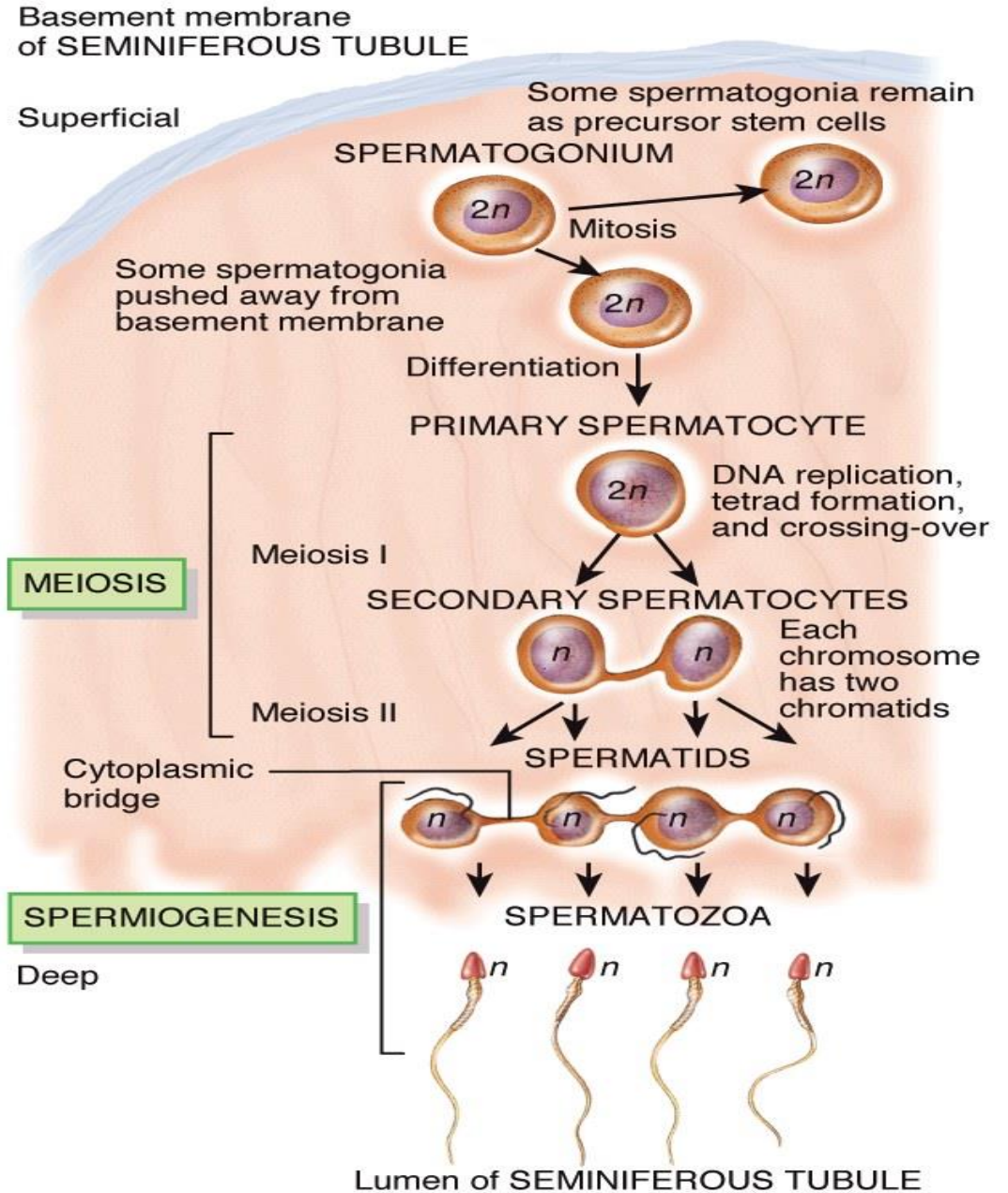
(b) Transverse section of portion of seminiferous tubule

# Spermatogenesis

- Spermatogonia begin mitosis at puberty
  - Some remain near basement membrane as stem cells
  - Others move between Sertoli cells to become primary spermatocytes (diploid;  $2n$ )
- Meiosis
  - Meiosis I – two secondary spermatids (haploid;  $n$ ) with two chromatids of one of each pair of chromosome
  - Meiosis II – four spermatids ( $n$ ) still linked by cytoplasmic bridge



# Spermatogenesis



# Spermatogenesis

- Spermiogenesis

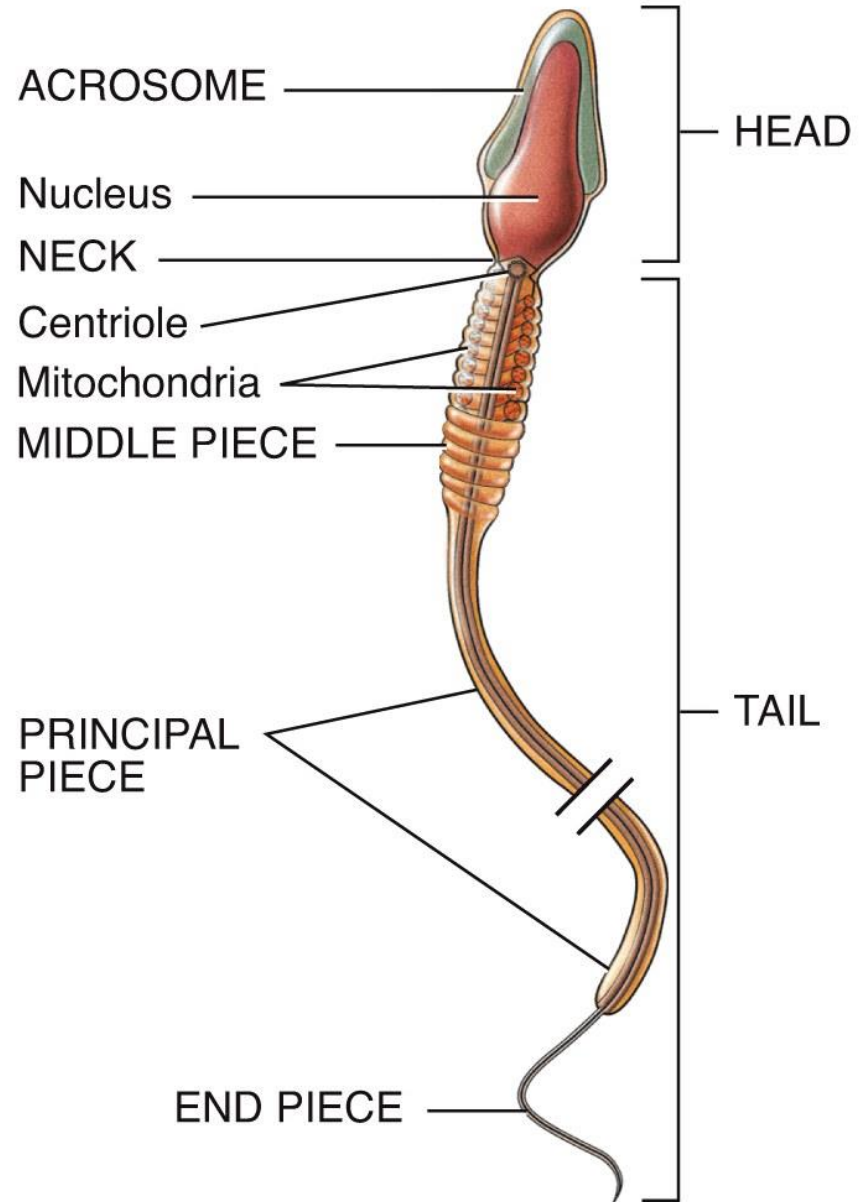
- Developing sperm form an acrosome and flagellum, shed excess cytoplasm, and increase mitochondria
- Elongated sperm cells are released into lumen of seminiferous tubule
- Sertoli cells secrete fluid to push sperm toward the ducts of the testes

# Mature Sperm

- 300 million per day produced
- Once ejaculated, survive 48 hours in female reproductive tract
- Mature sperm structures
  - **Head** – contains nucleus and haploid DNA
  - **Acrosome** – enzymes for penetrating secondary oocyte
  - **Middle piece** – mitochondria produce ATP
  - **Tail** – flagellum for locomotion



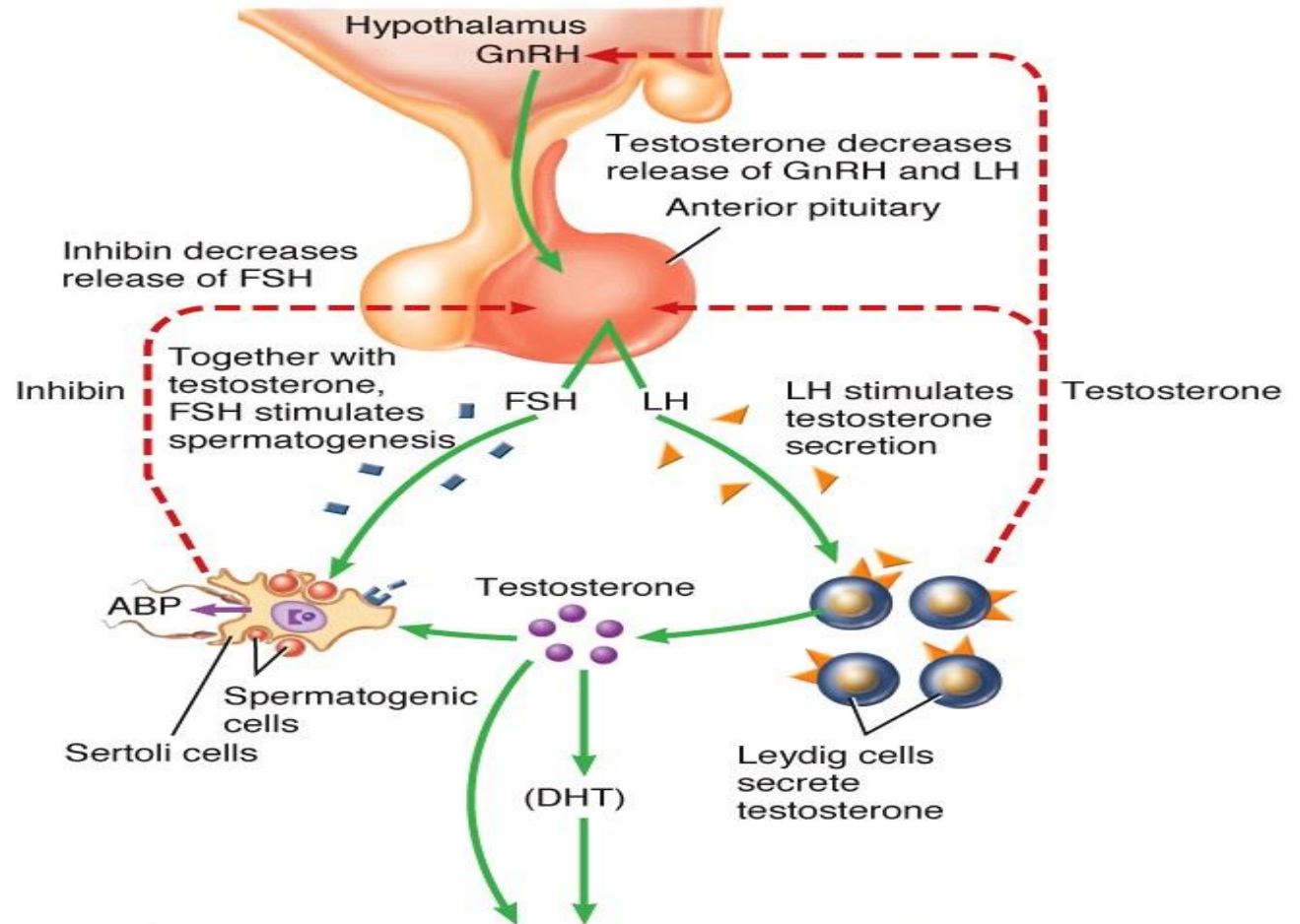
# Mature Sperm



# Hormone Control of Testes

- At puberty, gonadotropin-releasing hormone (hypothalamus) stimulates secretion of two anterior pituitary gonadotropin hormones
  - **Luteinizing hormone (LH)**
    - Stimulates Leydig cells to secrete testosterone
  - **Follicle-stimulating hormone (FSH)**
    - With testosterone, stimulates Sertoli cells to secrete androgen-binding protein which keeps testosterone level high in seminiferous tubules
  - **Inhibin (from Sertoli cells)**
    - Inhibits FSH to help regulate the rate of spermatogenesis
- Negative feedback regulation mechanism

# Hormone Control of Testes

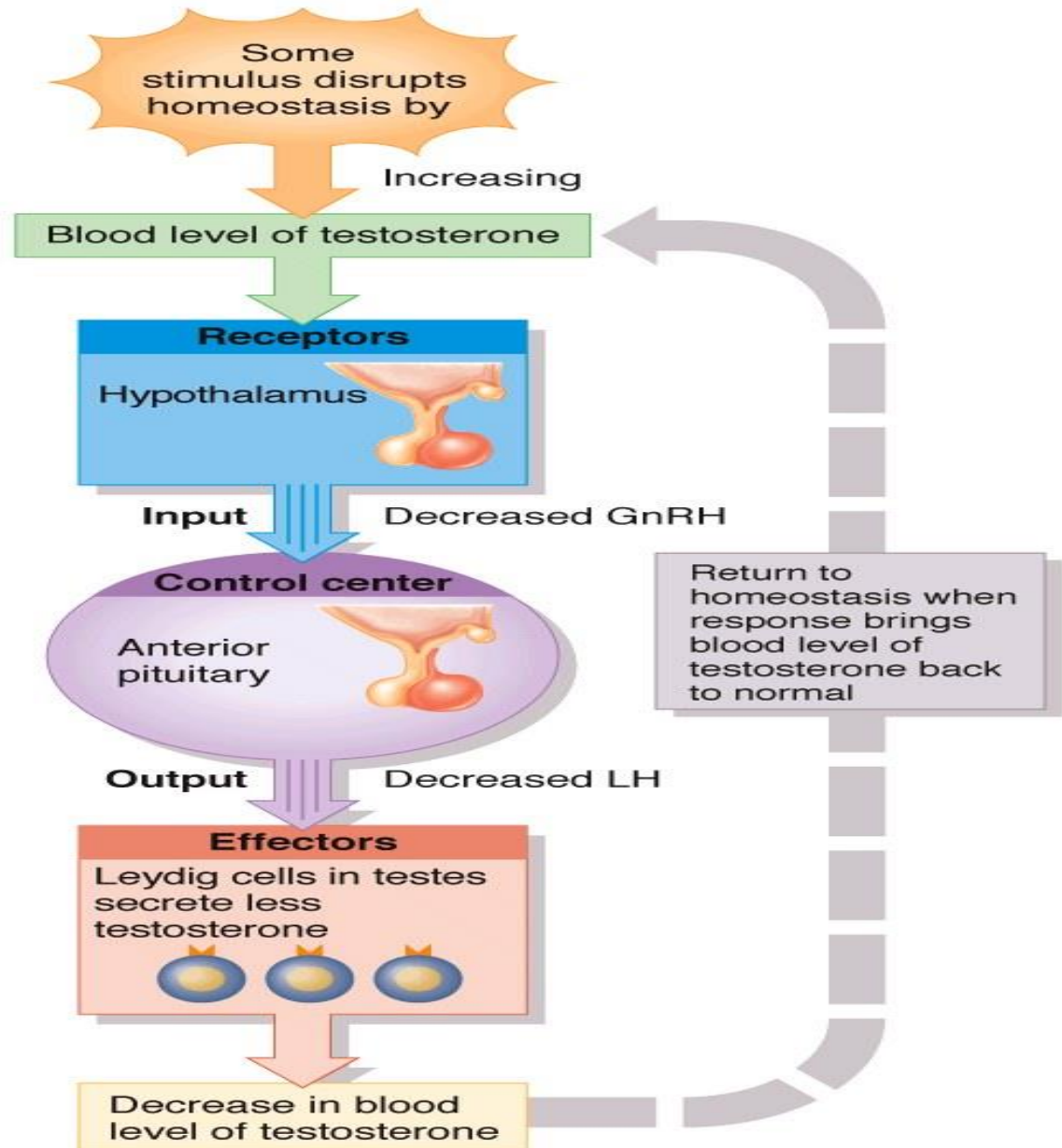


- Male pattern of development (before birth)
- Enlargement of male sex organs and expression of male secondary sex characteristics (starting at puberty)
- Anabolism (protein synthesis)

**Key:**

 LH	 FSH	 Testosterone
 LH receptor	 FSH receptor	 Androgen receptor

# Hormone Control of Testes



# Testosterone

- Converted to **dihydrotestosterone (DHT)** in some target cells, such as in prostate
- Both bind to same androgen receptors within nuclei of target cells for several effects
  - Prenatal development
  - Development of male sexual characteristics
  - Development of sexual function
  - Stimulation of anabolism

# Male Reproductive System of Ducts

- Ducts of the testes
  - Seminiferous tubule lumen, straight tubules, rete testis
- Epididymis
  - Efferent ducts, ductus epididymis
  - Site of sperm maturation
- Ductus deferens (vas deferens)
  - Ascends in spermatic cord, through inguinal canal, loops over ureter, and ends at dilated ampulla
  - Stores sperm and conveys them to urethra



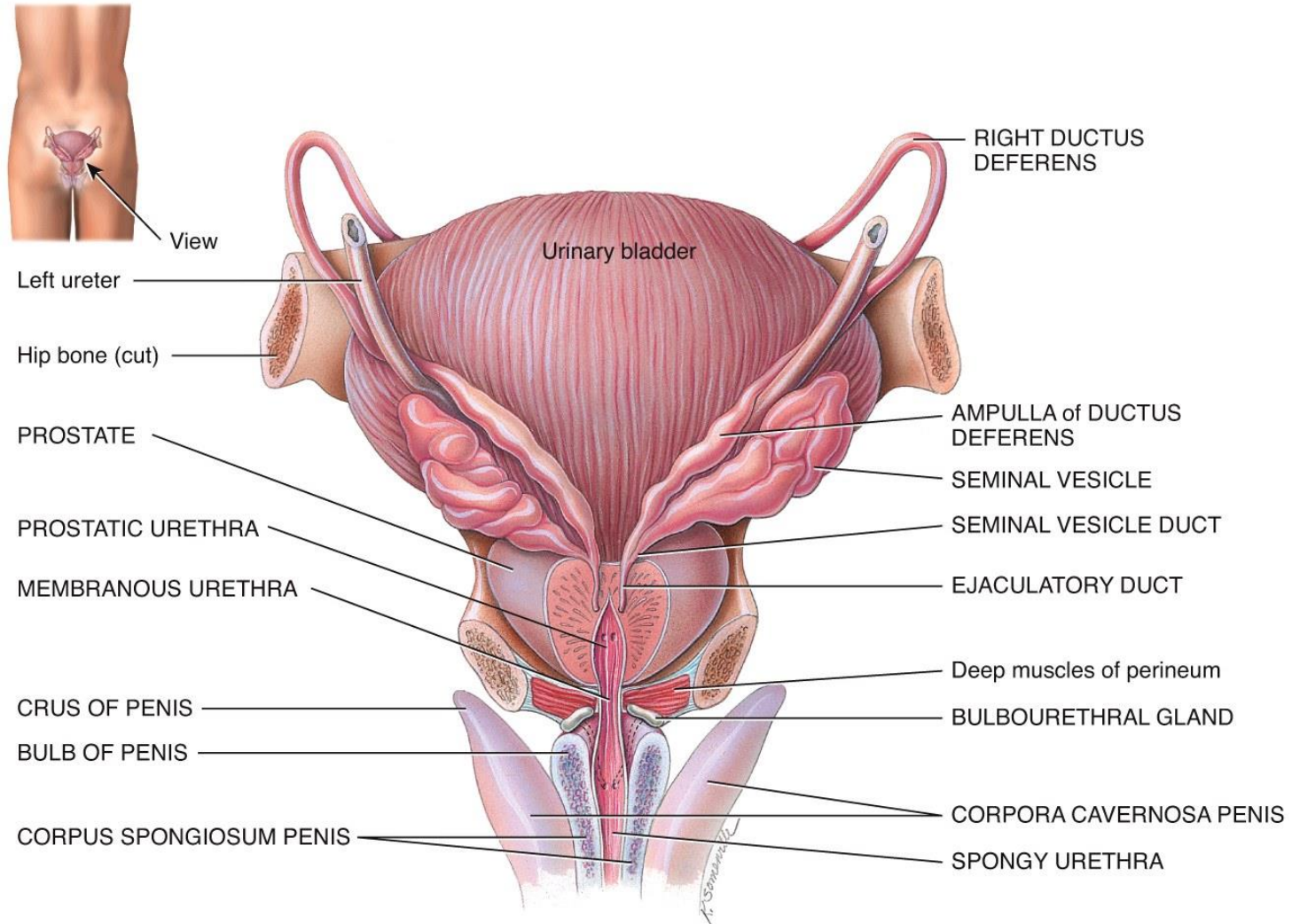
# Male Reproductive System of Ducts

- Ejaculatory ducts
  - Union of ductus deferens and duct of seminal vesicles
  - Empties sperm and seminal fluid into prostatic urethra
- Urethra
  - Shared by reproductive and urinary systems
  - Prostatic urethra
  - Membranous urethra
  - Spongy (penile) urethra
  - External urethral orifice

# Male Reproductive Accessory Glands

- Seminal vesicles
  - Alkaline, viscous fluid with fructose, used by sperm for ATP production
  - Secretion contributes to sperm viability
- Prostate
  - Surrounds prostatic urethra
  - Secretion contributes to sperm motility and viability
- Bulbourethral glands (Cowper's gland)
  - Either side of membranous urethra
  - Mucus for lubrication and alkaline fluid to neutralize acids from urine in urethra

# Male Reproductive Accessory Glands



Posterior view of male accessory organs of reproduction

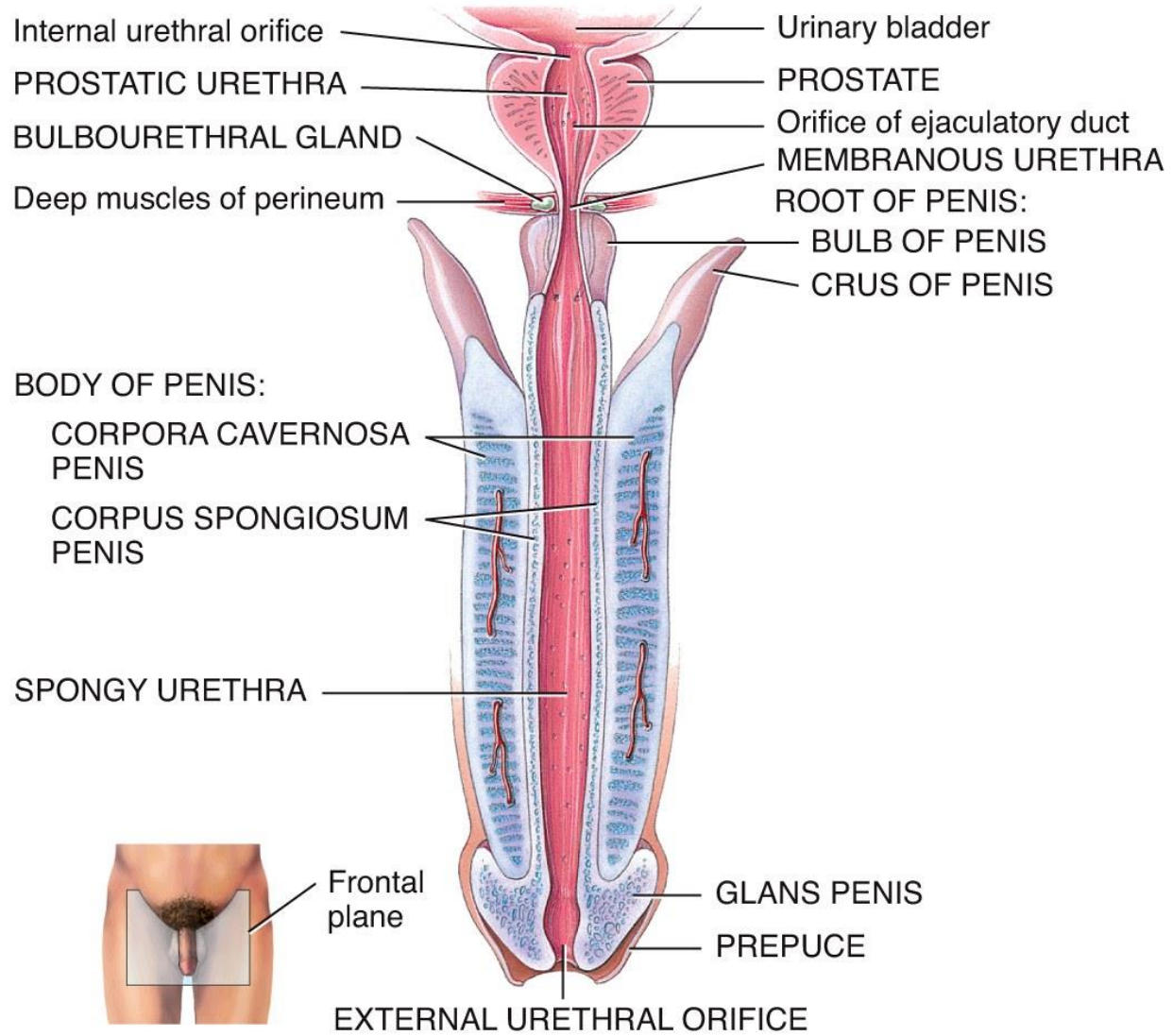
# Semen

- Mixture of fluids
  - Sperm and secretions from seminiferous tubules
  - Secretions from seminal vesicles, prostate, and bulbourethral glands
- Function of semen
  - Fluid in which sperm are transported
  - Supplies nutrients for sperm
  - Neutralizes the acidity of the male urethra and female vagina
- Ejaculation – expulsion of semen from the urethra to the exterior of the body

# Penis

- Support structure
  - Contains urethra
  - Passageway for ejaculation of semen and excretion of urine
- Body of penis
  - Three erectile tissue masses
    - Two corpora cavernosa penis
    - One corpus spongiosum penis around urethra
  - Glans penis expanded distal tip with sensory receptors
- Erection – engorgement of penile blood sinuses under influence of sexual excitement

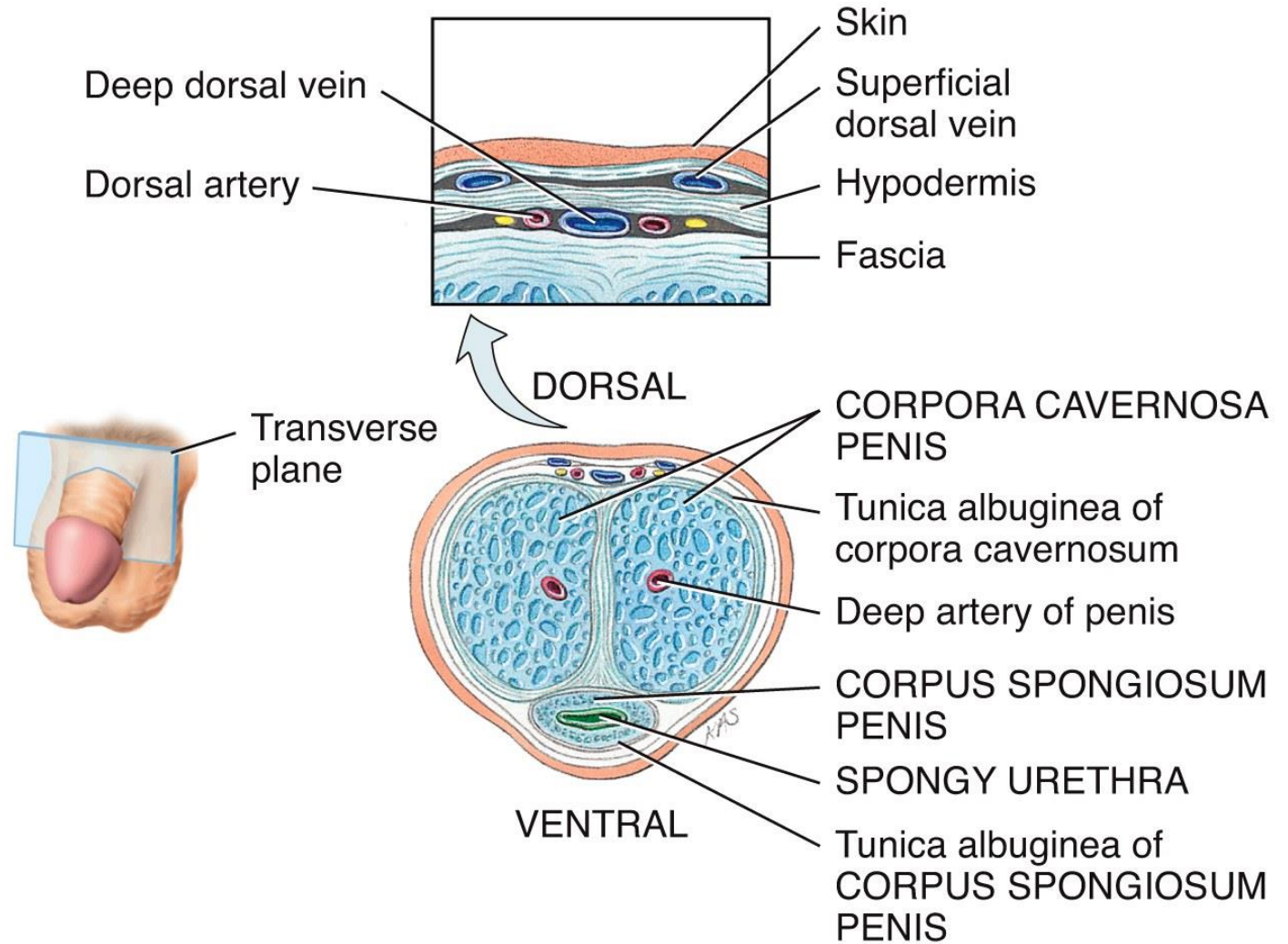
# Penis



(a) Frontal section



# Penis



(b) Transverse section