The Urogenital System

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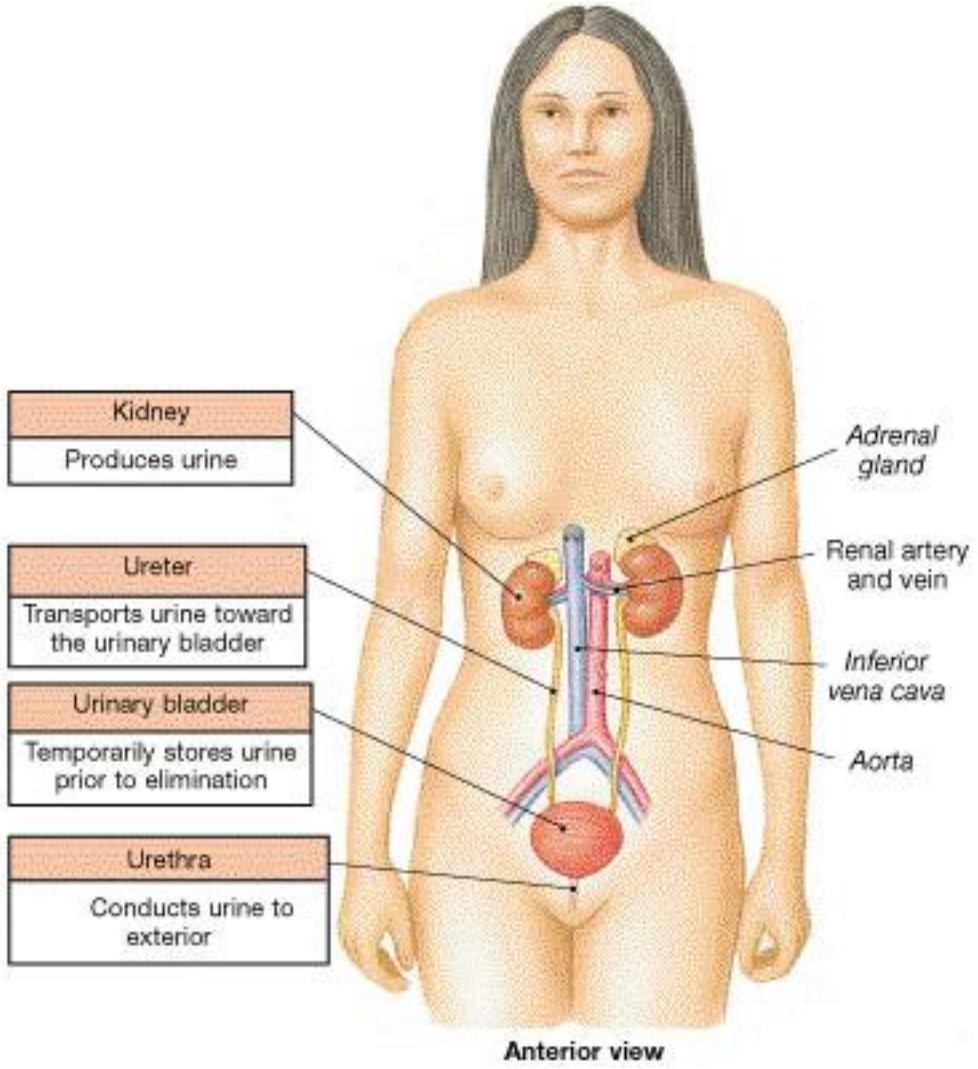
System Functions

- Urinary System
  - Filtering of blood, Removal of wastes and metabolites
  - Regulation of
    - blood volume and composition
    - concentration of blood solutes
    - pH of extracellular fluid
    - blood cell synthesis
  - Synthesis of Vitamin D
- Reproductive System
  - Reproduction and sexual function

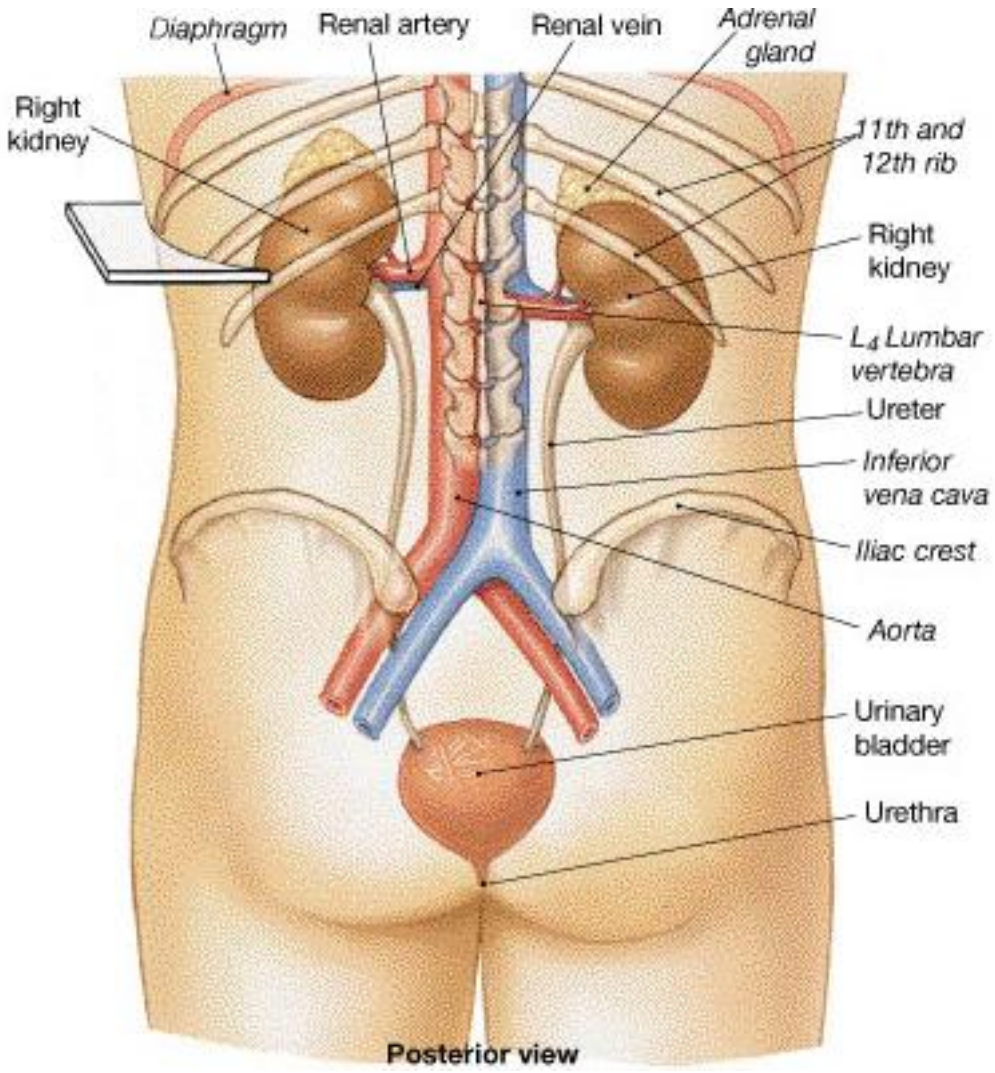
Organs of the Urinary System

- Kidneys (paired)
  - Perform filtering functions and manufacture urine
- Ureters (paired)
  - Transport urine
- Urinary bladder (single)
  - Stores urine
- Urethra (single)
  - Transports urine



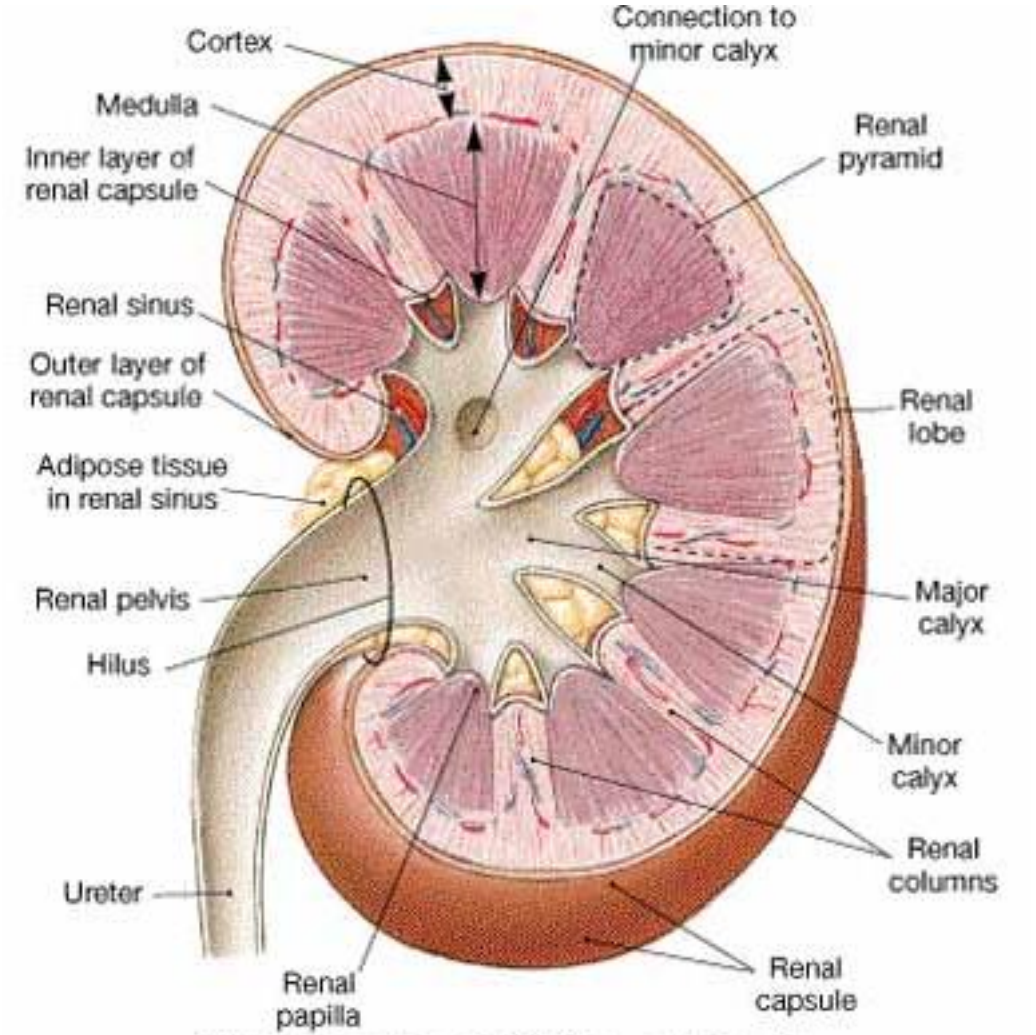
Kidneys

- Location
  - Lie against the dorsal body wall
  - Beneath the parietal peritoneum
  - In the superior lumbar region
    - Protected by the lower part of the rib cage
- External Structure
  - Renal capsule
    - Connective tissue surrounding each kidney
  - Perirenal fat
    - Engulfs renal capsule and acts as cushion and source of energy
  - Renal fascia
    - Anchors kidneys to abdominal wall, separate from abdomen
  - Hilum
    - Renal artery and nerves enter
    - Renal vein and ureter exits



Internal Structure

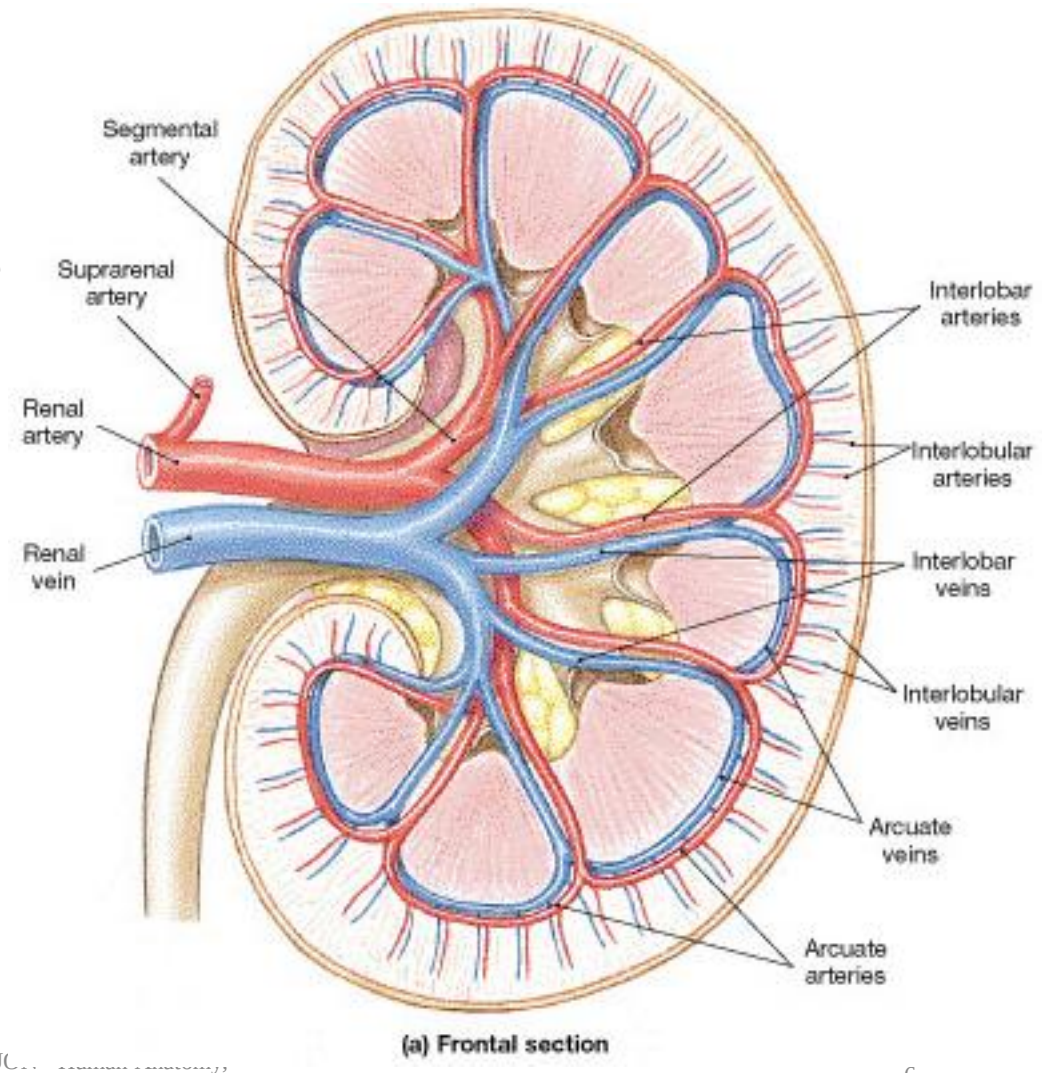
- Renal cortex
- Renal medulla
  - Renal pyramids
- Renal pelvis
  - Continuous with ureter
- Calyces
  - Extensions of the pelvis
  - Function – collect urine



(a) Frontal section of left kidney, anterior view

Blood Supply

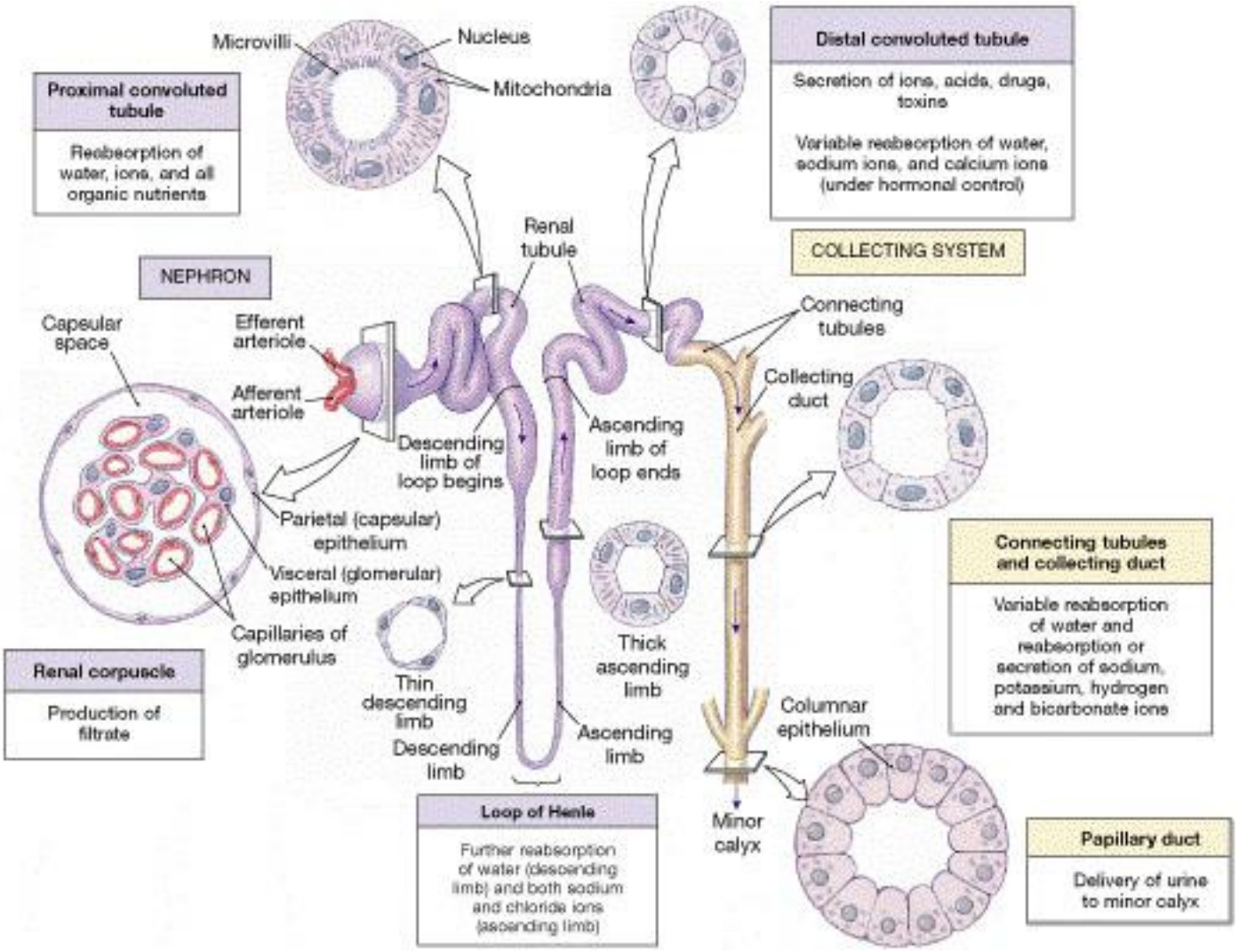
- Approximately ¼ of the total blood supply of the body passes through the kidneys each minute
- Renal artery branches inside the kidney
  - Supplies the pyramids and the cortex
- Venous blood leaves the cortex and medulla
  - Small veins join the renal vein



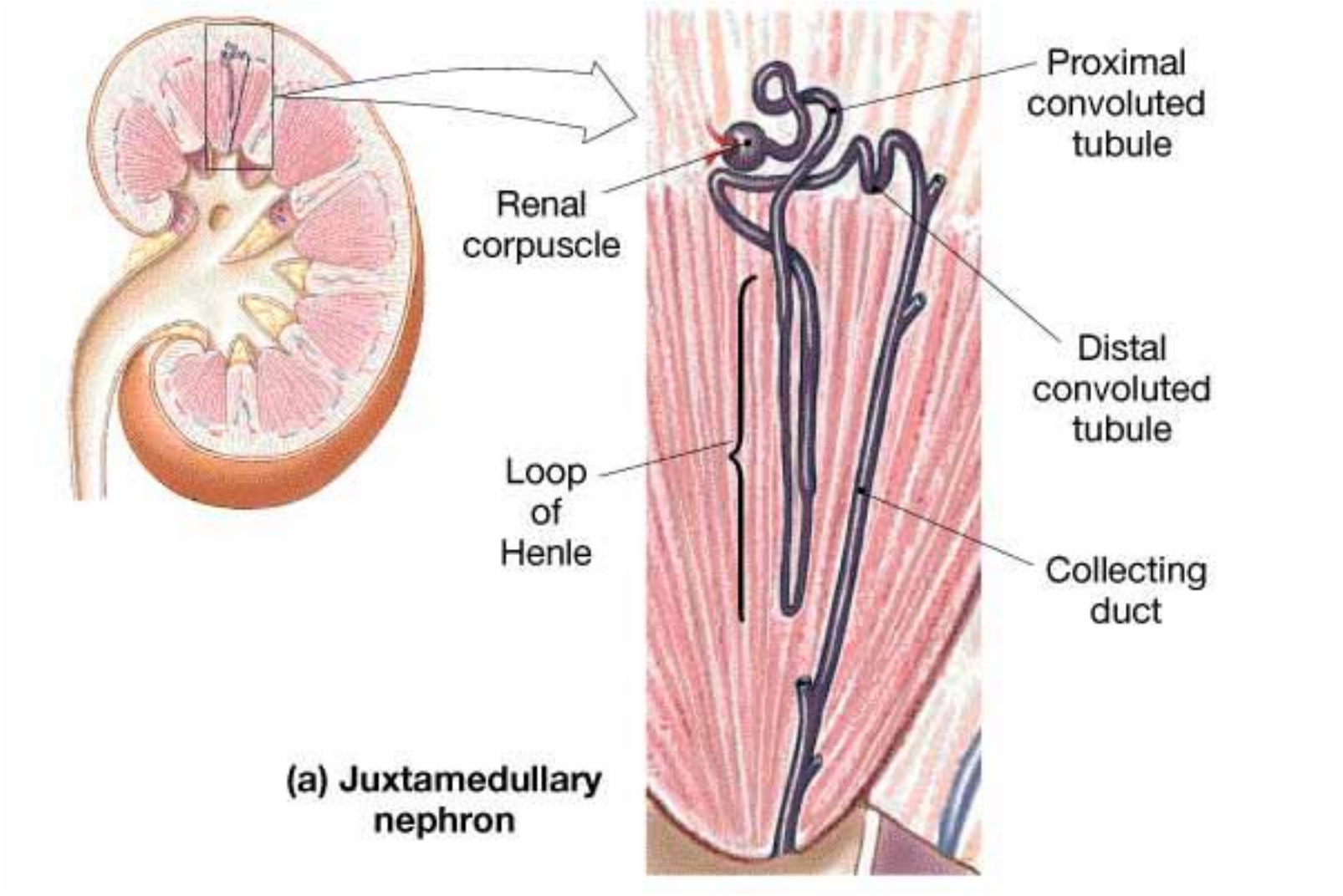
Nephron - Functional Unit of Kidney

- Nephrons form the urine product by processes of
  - Filtration
  - Reabsorption
  - Secretion
- Each kidney contains about 1 million nephrons
- 2 main structures
  - Glomerulus – a knot of capillaries
  - Renal tubule (about 2 inches long)
    - **Bowman's capsule** surrounds the glomerulus
    - **Proximal convoluted tubule**
    - **Henle's Loop**
    - **Distal convoluted tubule**
- Renal tubule enters **collecting duct**
  - Receives urine from nephrons
  - Delivers final urine product into the calyces

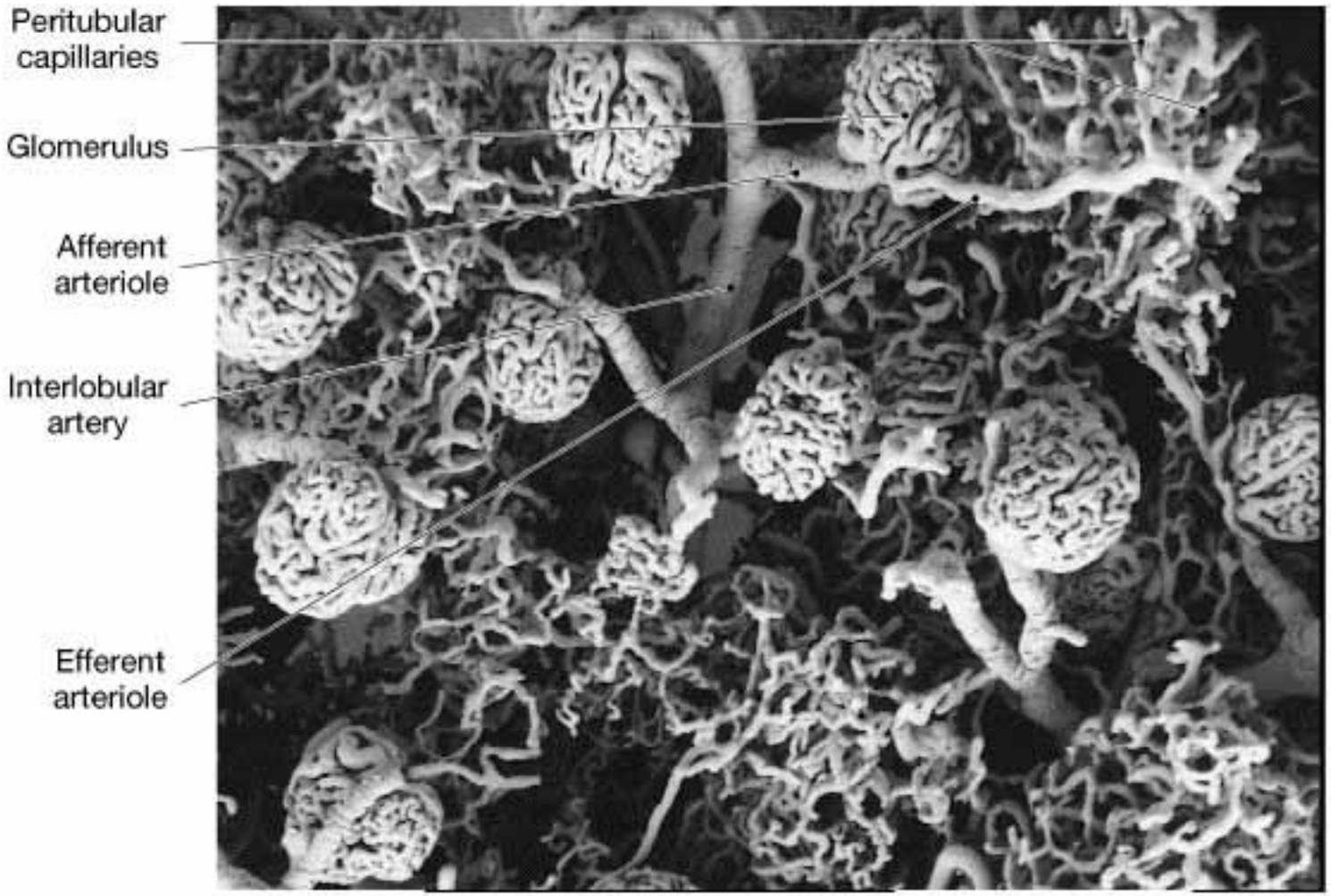
Structure of A Typical (Cortical) Nephron



A Juxtamedullary Nephron

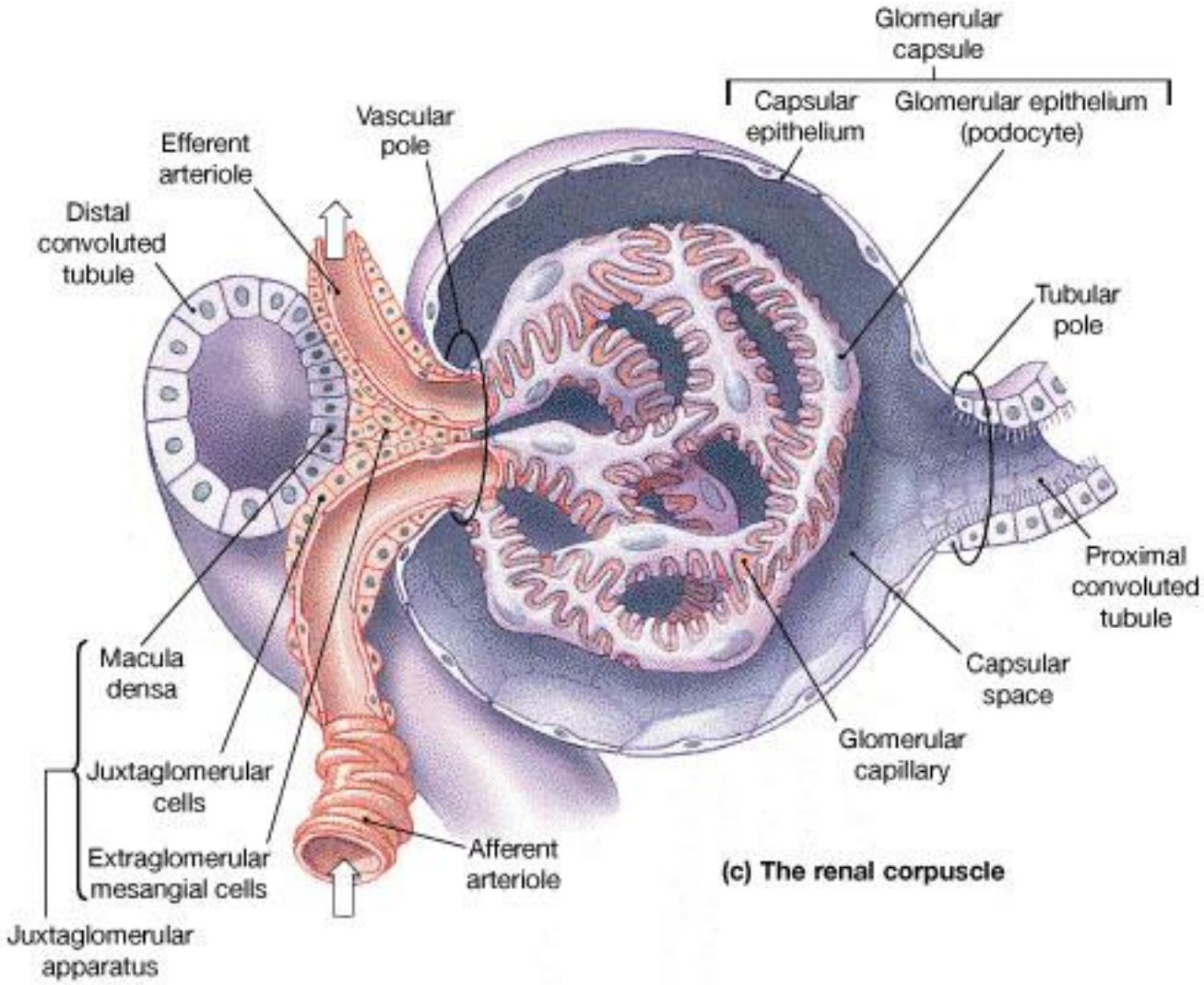


Renal Corpuscles by Electron Microscopy

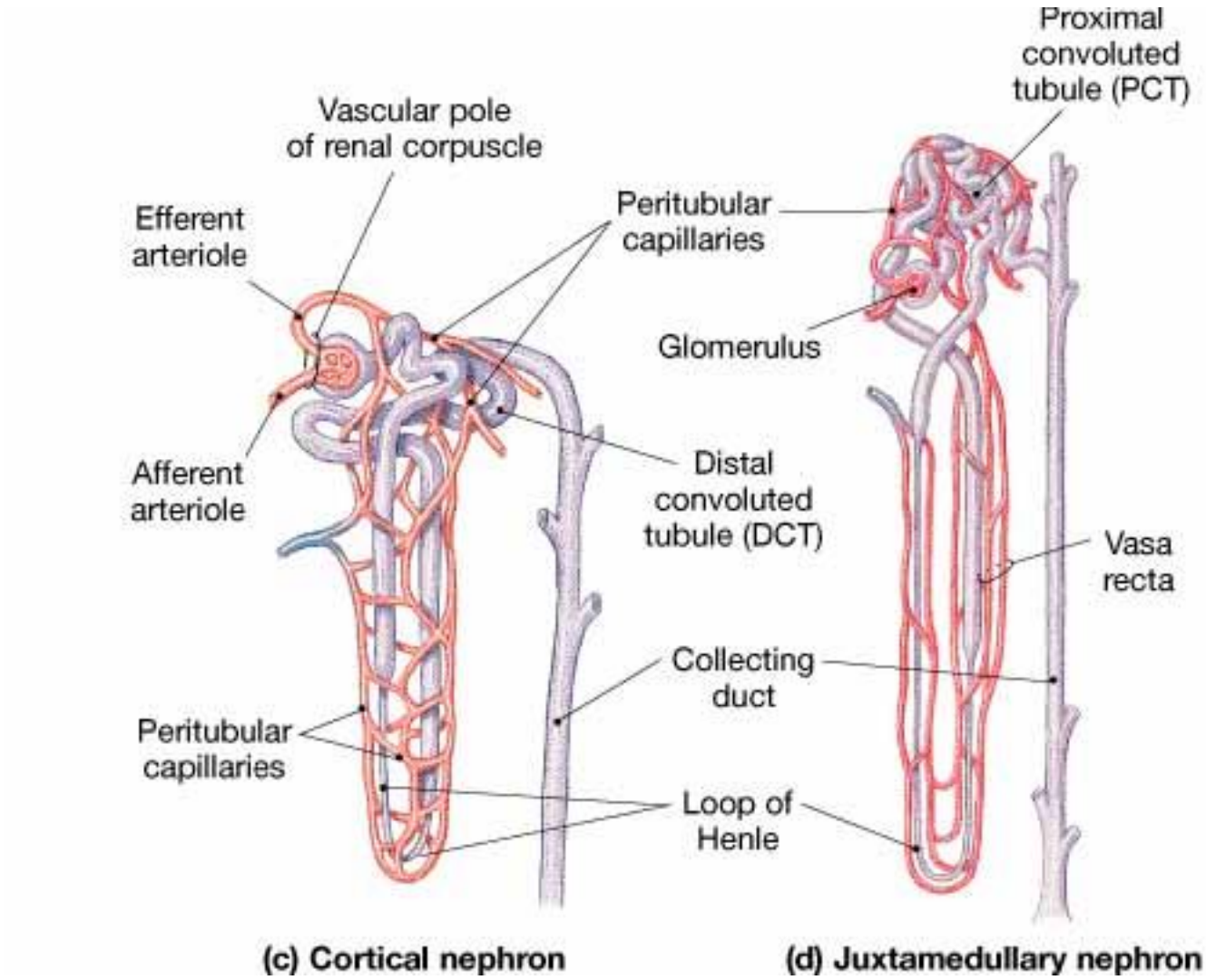


(b) Glomeruli and associated blood vessels (SEM x 94)

A Renal Corpuscle



Blood Supply of the Nephron



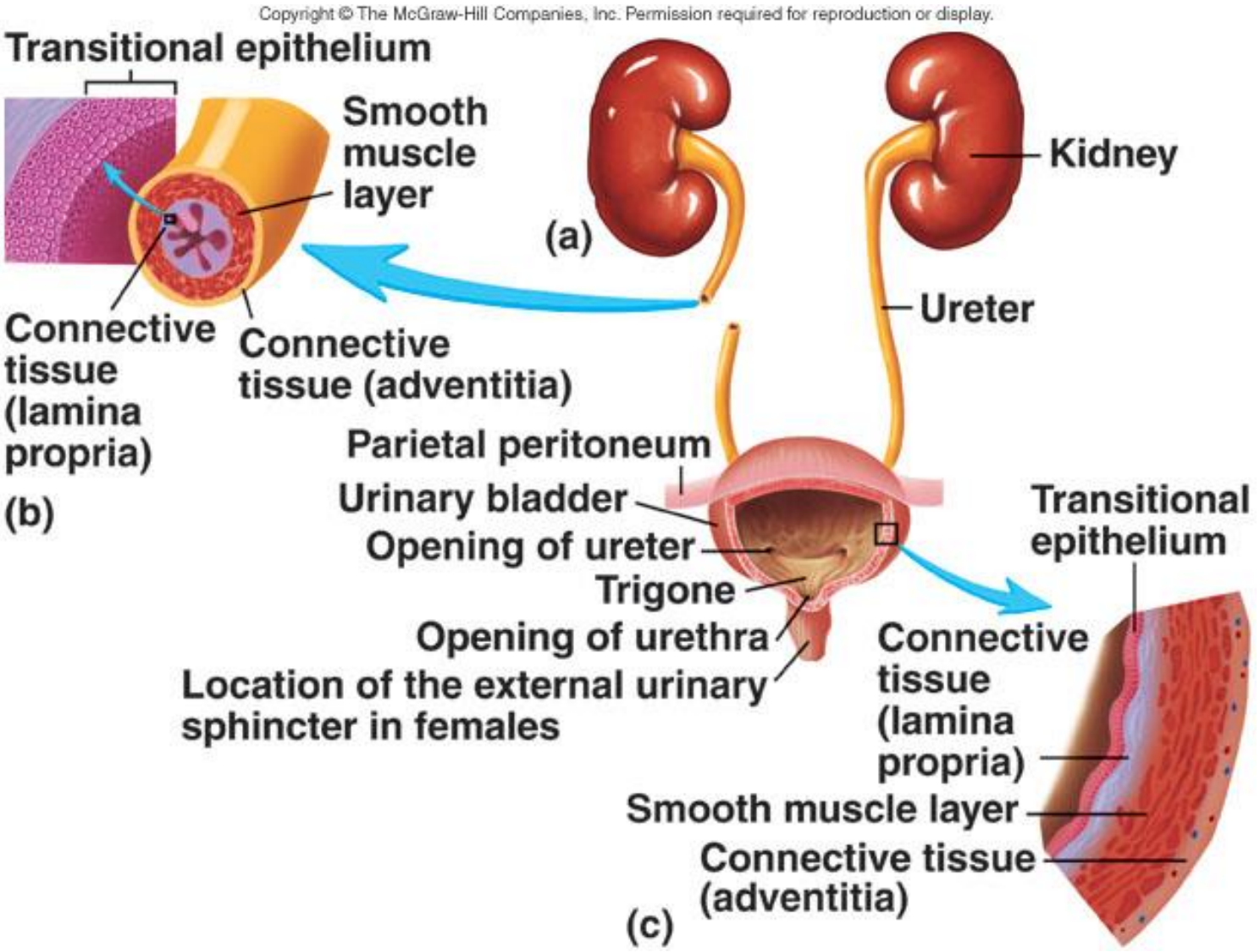
Urine Formation

- Filtration
  - Blood in afferent arteriole is under high pressure
  - Glomerulus acts as a filter
  - **Filtrate** = the substance that is filtered from the blood into the renal tubule
  - Blood leaves the glomerulus through the efferent arteriole
- Reabsorption
  - Filtrate contains useful substances which are returned to the blood
  - Most occurs in the proximal convoluted tubules
- Secretion
  - Substances move from blood (capillaries) into the filtrate
  - Important in controlling pH of blood

Ureters, Urinary Bladder & Urethra

- Ureters
  - Tubes through which urine flows from kidneys to urinary bladder
- Urinary bladder
  - Stores urine
- Urethra
  - Transports urine from bladder to outside of body
  - Difference in length between males and females
  - Sphincters
    - Internal urinary
    - External urinary

Ureters and Urinary Bladder



Urinary Bladder and Urethra - Male

- Males – 20 cm in length
- Three named regions
  - Prostatic urethra - passes through the prostate gland
  - Membranous urethra - through the urogenital diaphragm
  - Spongy (penile) urethra passes through the length of the penis

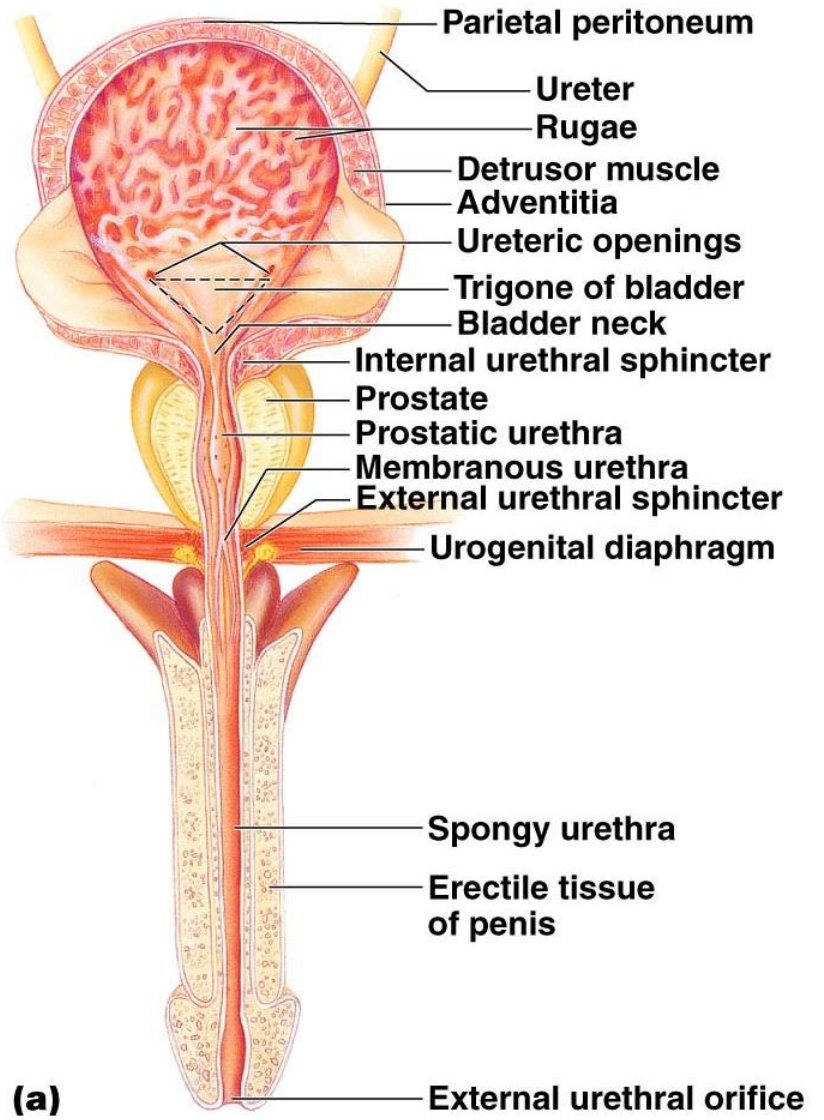
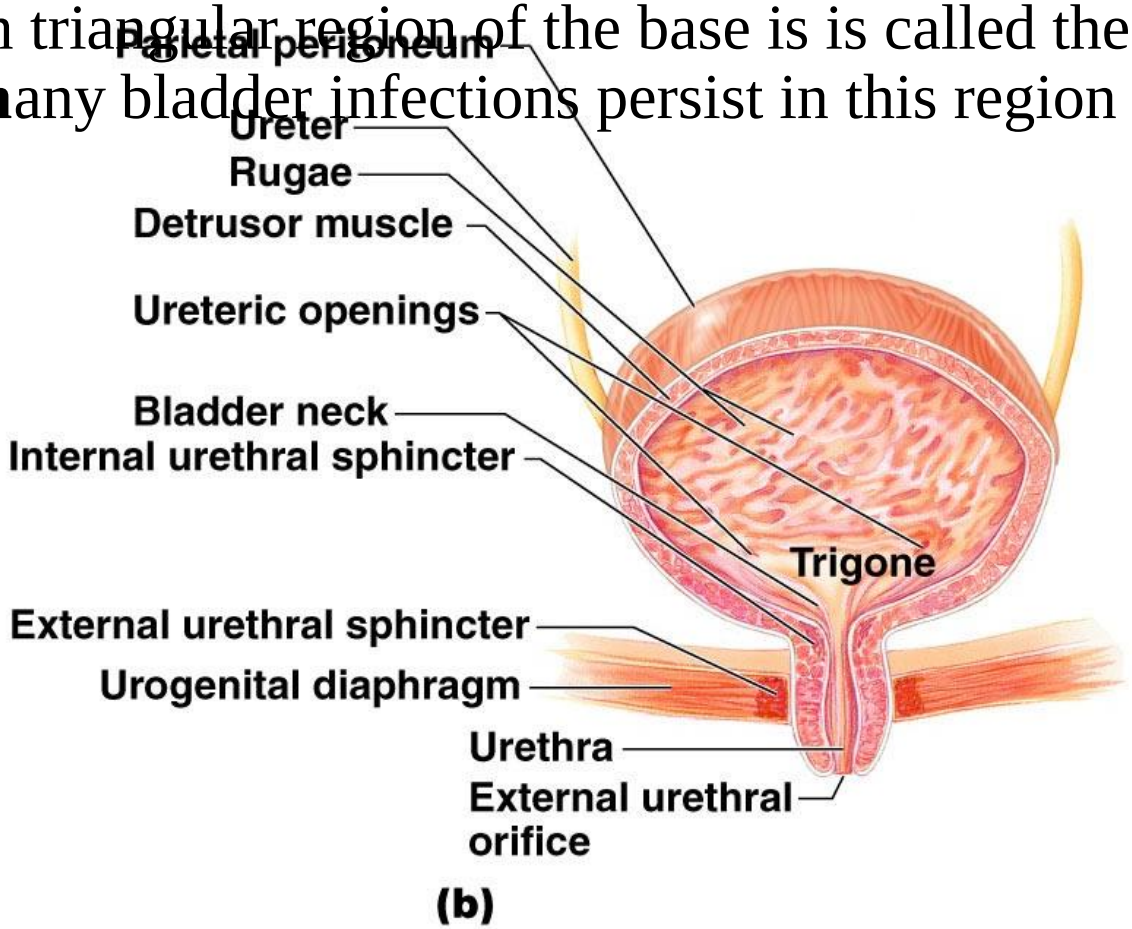


Figure 23.16a

Urinary Bladder and Urethra - Female

- In females - length of 3–4 cm
- The smooth triangular region of the base is is called the **trigone - m**any bladder infections persist in this region

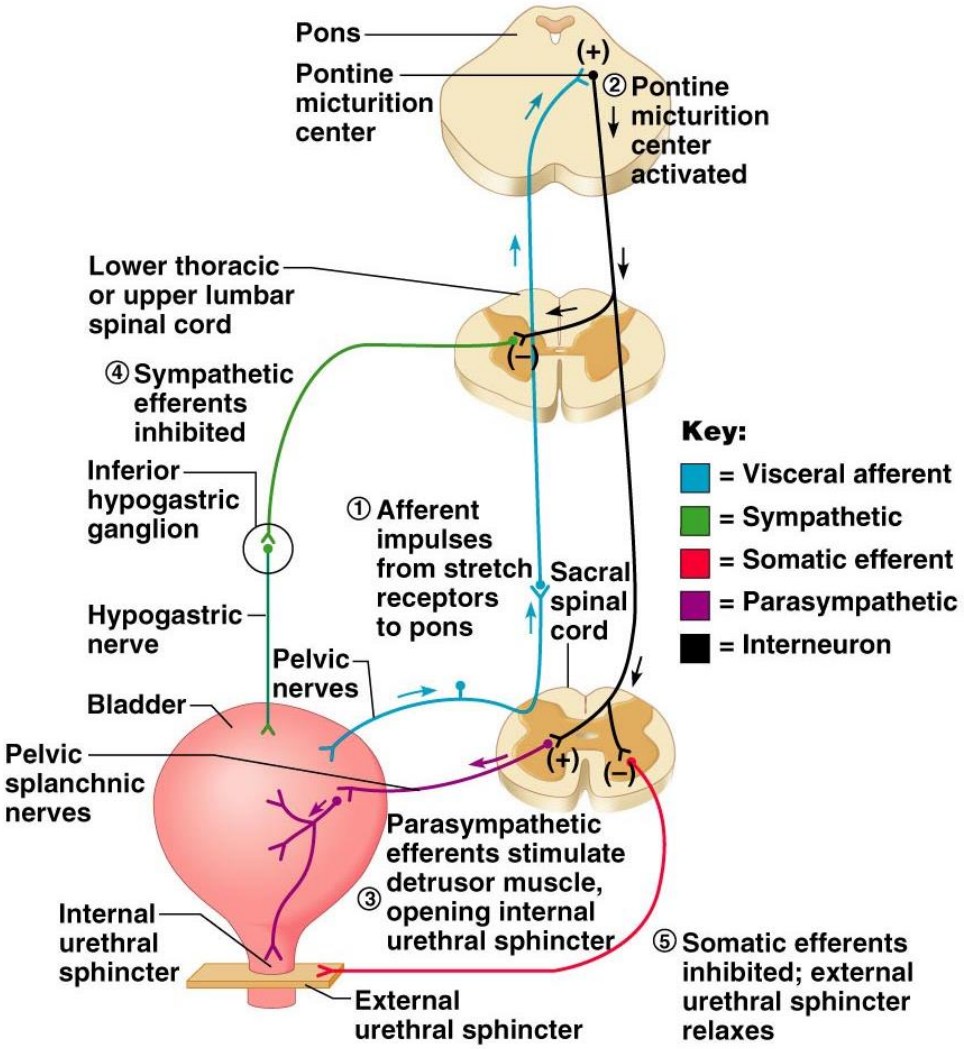


Control of Blood Composition by Kidneys

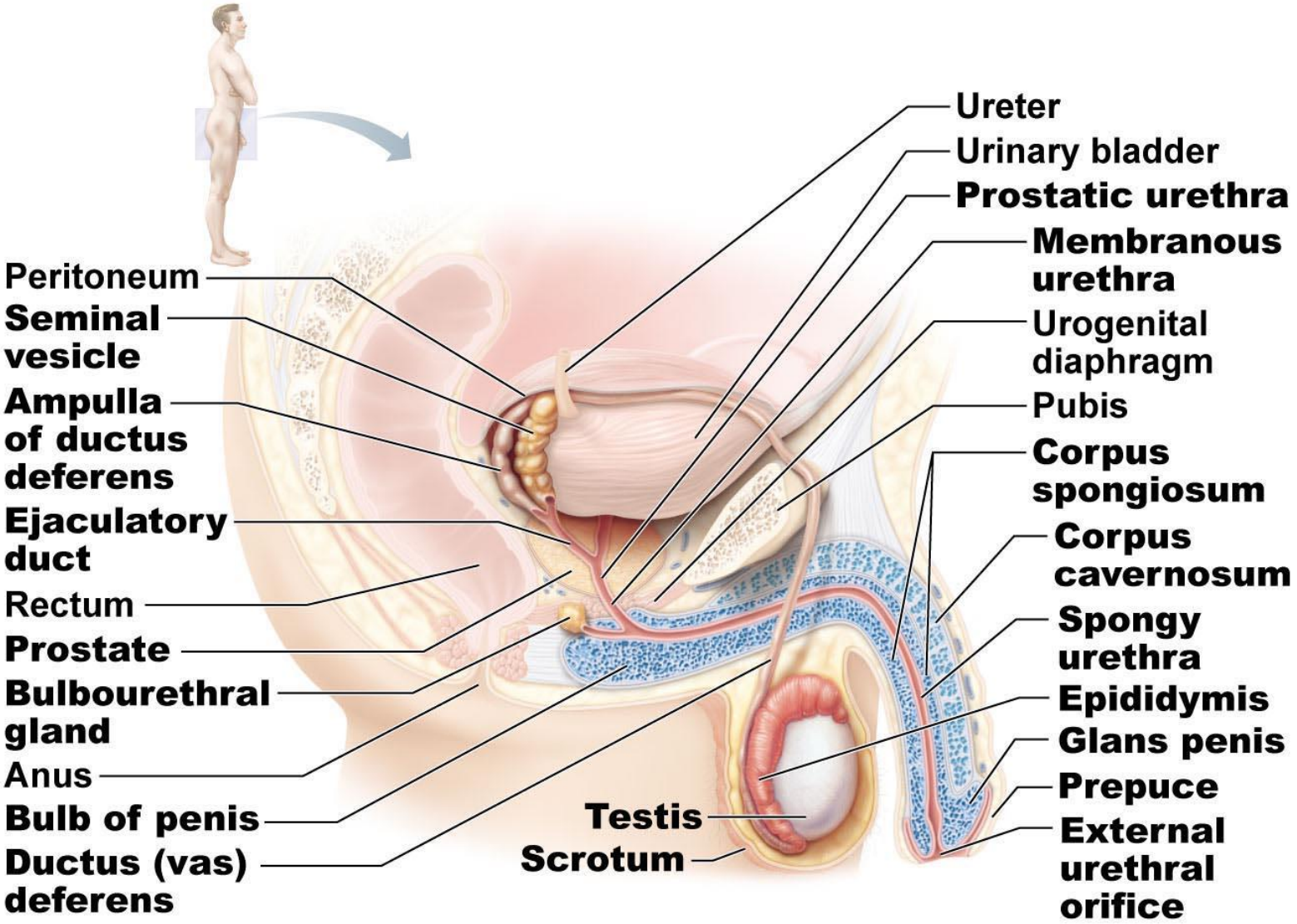
- Excretion of nitrogen-containing compounds
  - Urea
  - Uric acid
- Water and electrolyte balance
  - Regulated by hormones
    - ADH – increases water reabsorption
    - Aldosterone – increases sodium reabsorption
      - Second effect of aldosterone – increase water reabsorption.
    - Acid-base balance of blood
      - Blood pH must be 7.35 – 7.45 (very narrow range)
      - Tubule cells secrete whatever is necessary into filtrate
      - Urine pH = 4.5 – 8.0

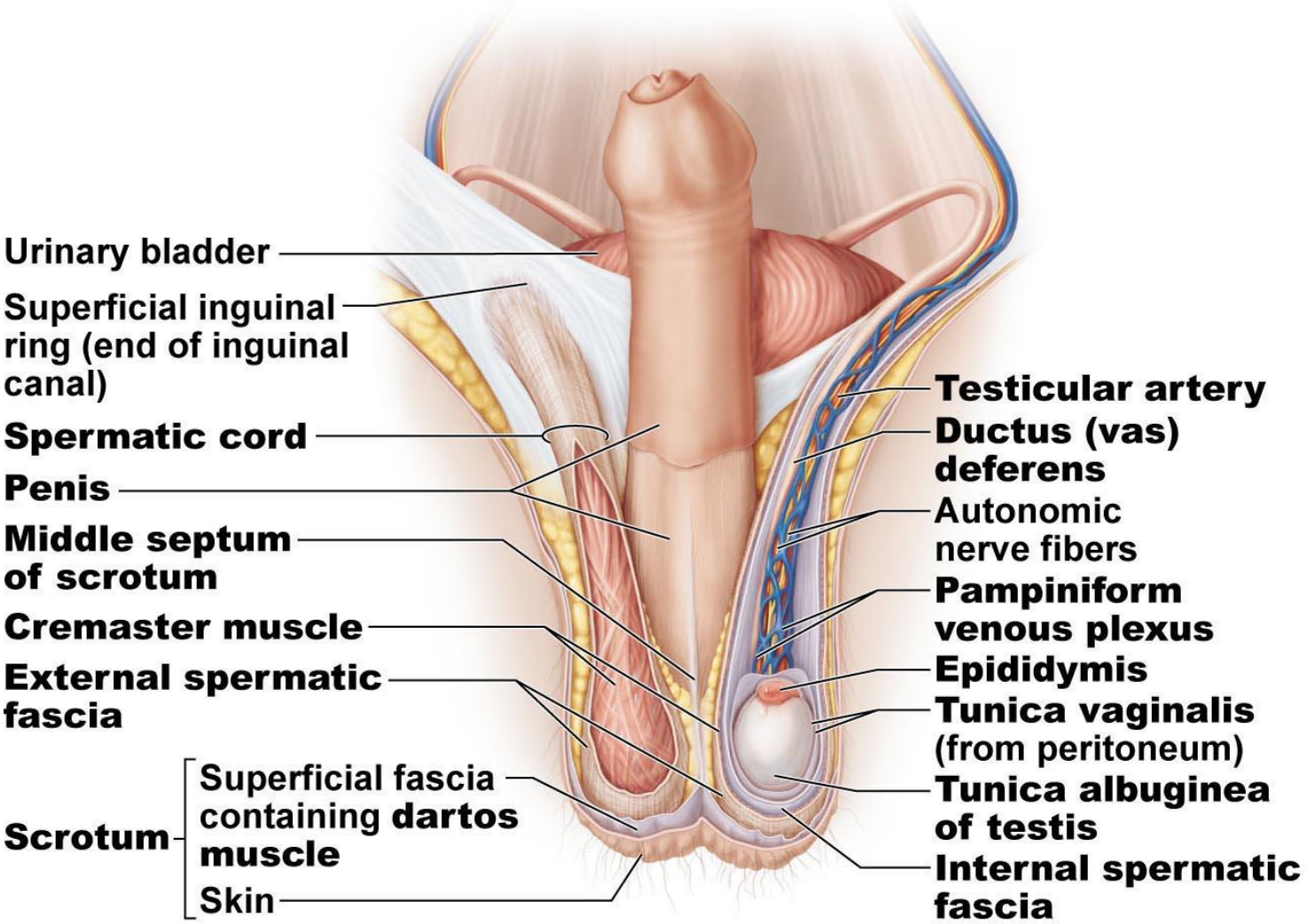
Micturition

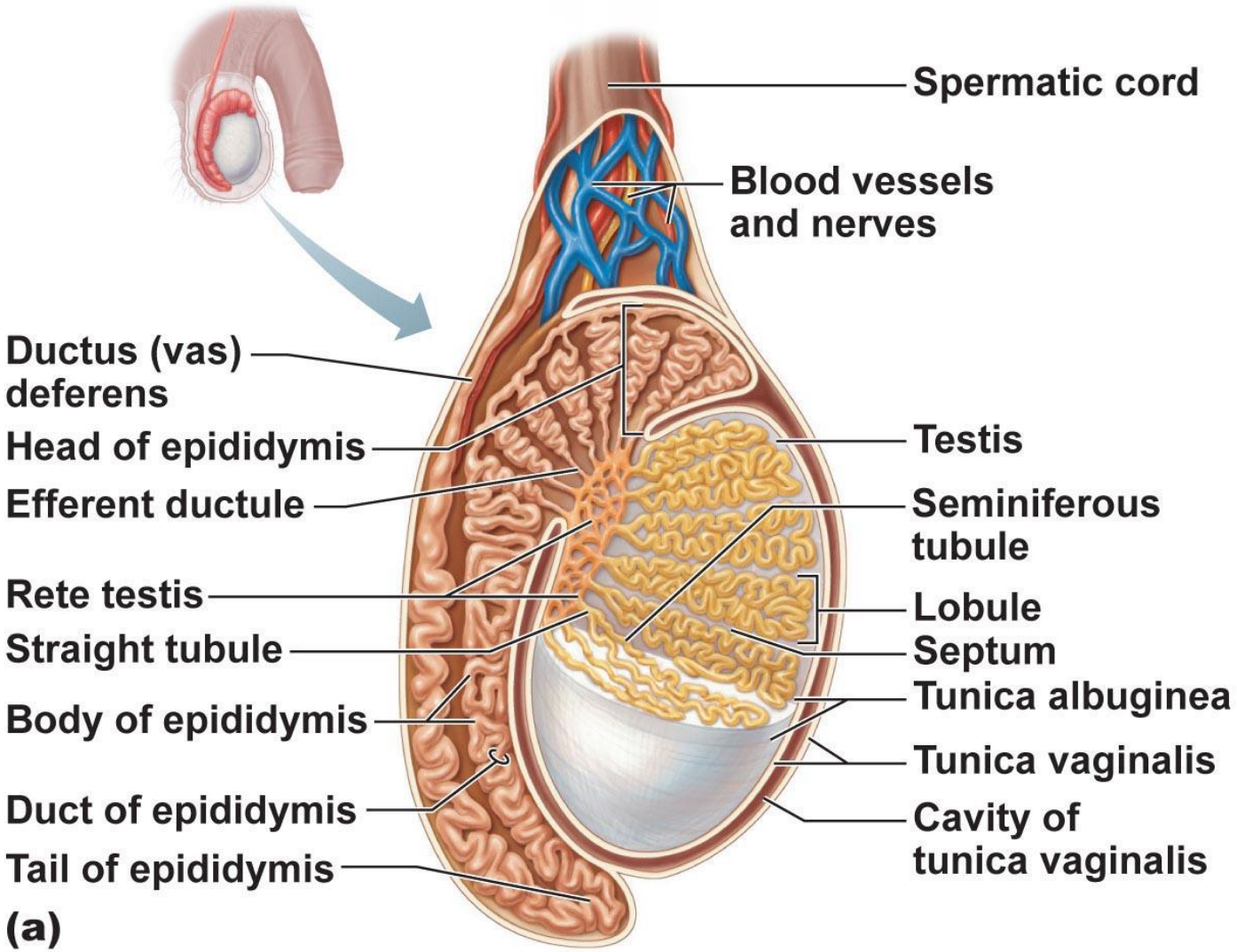
- Bladder can hold 250 - 400ml
- Greater volumes stretch bladder walls initiates micturation reflex:
- Urination coordinated by micturition reflex
  - Initiated by stretch receptors in wall of bladder
  - Urination requires coupling micturition reflex with relaxation of external urethral sphincter

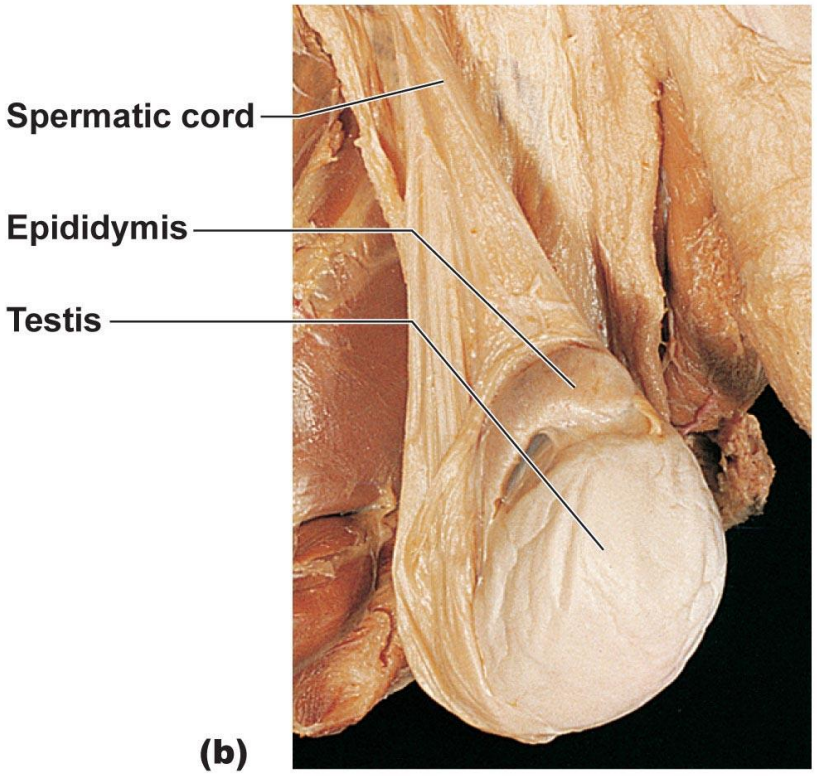


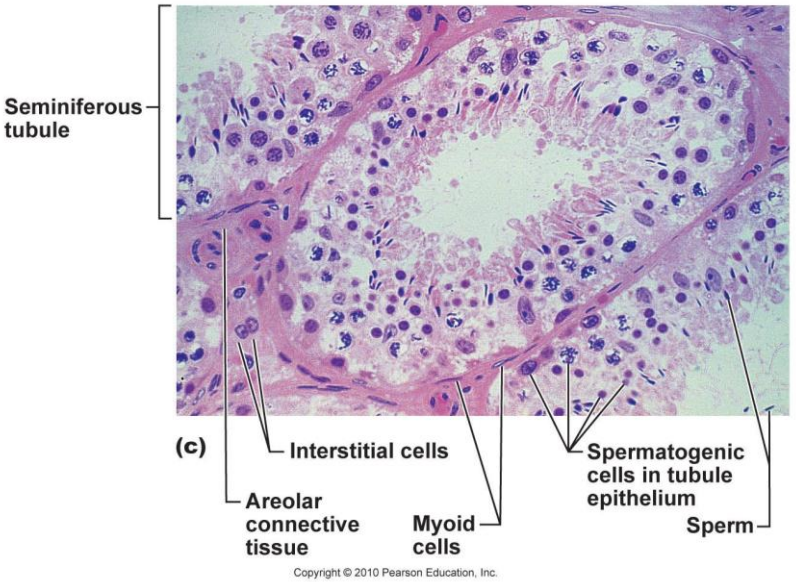
Reproductive System








Spermatic cord
Epididymis
Testis
(b)


Seminiferous tubule
(c)
Interstitial cells
Areolar connective tissue
Myoid cells
Spermatogenic cells in tubule epithelium
Sperm
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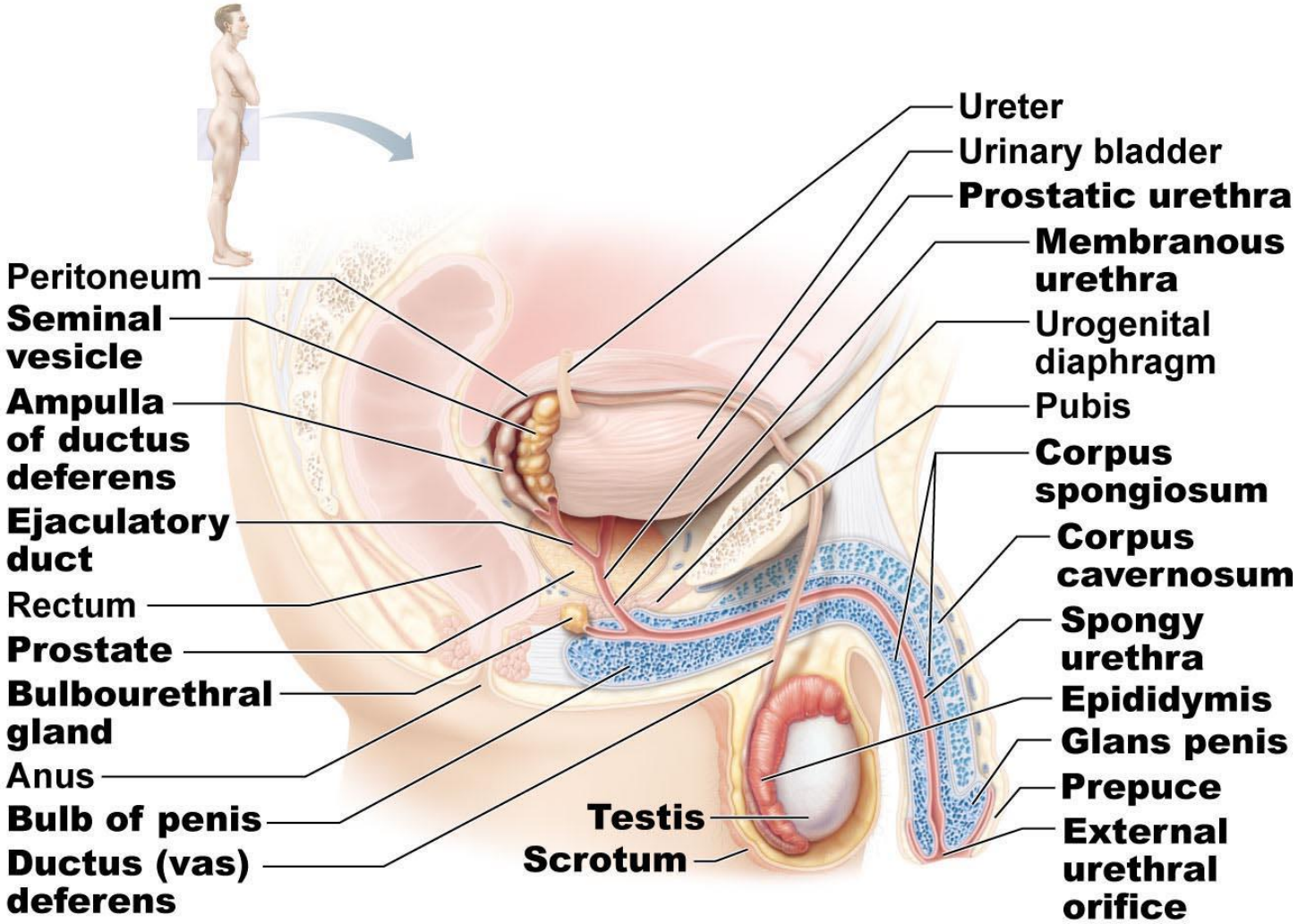
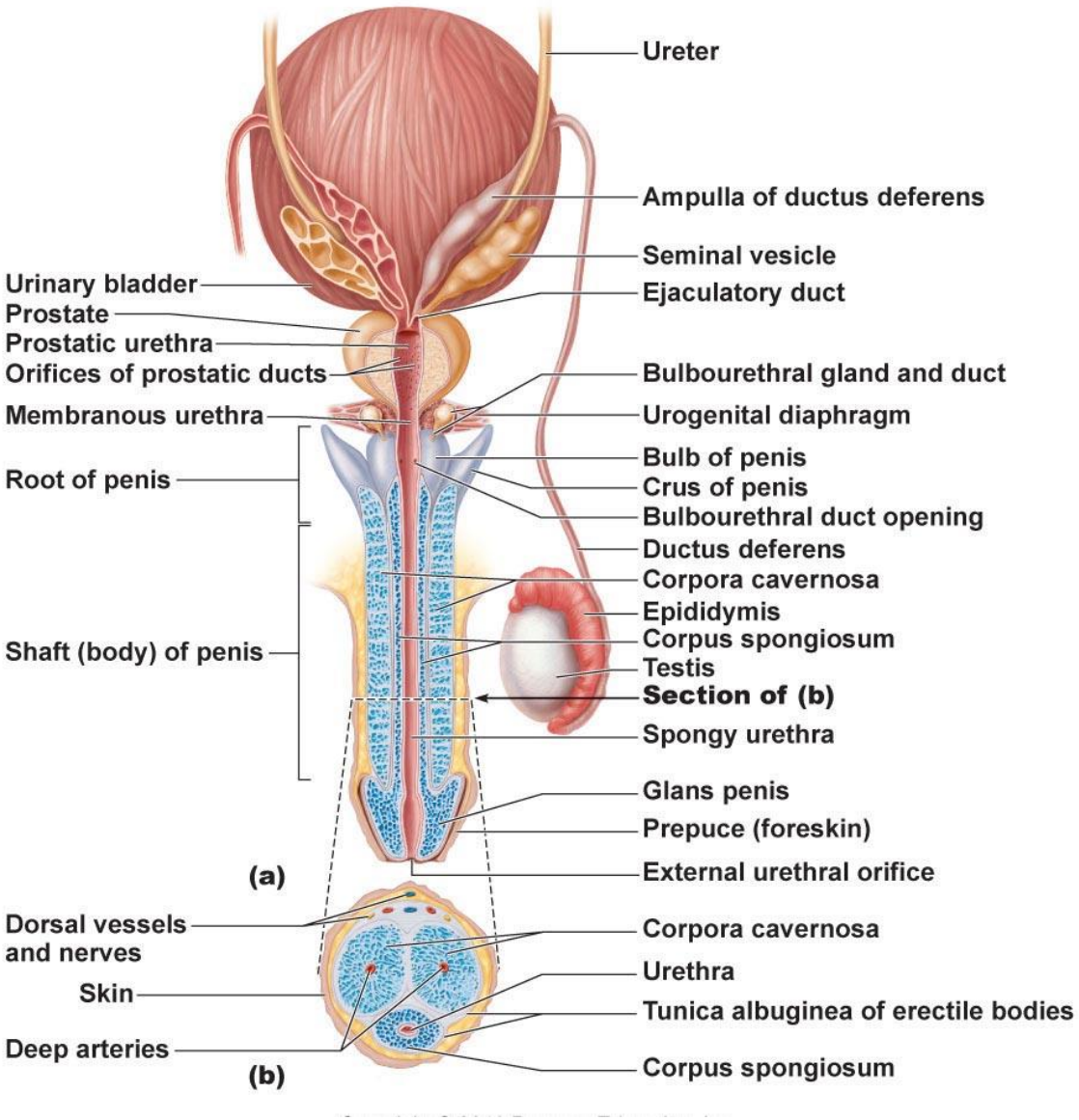
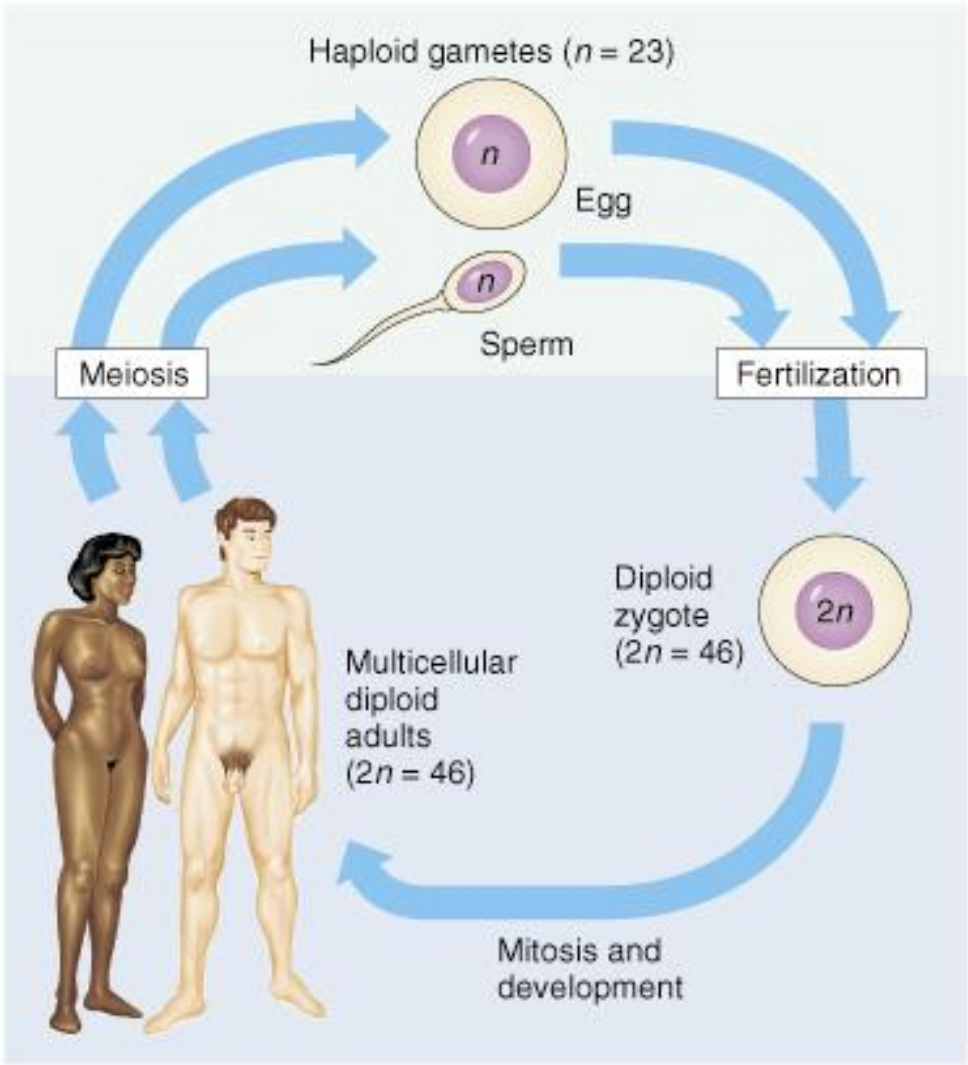
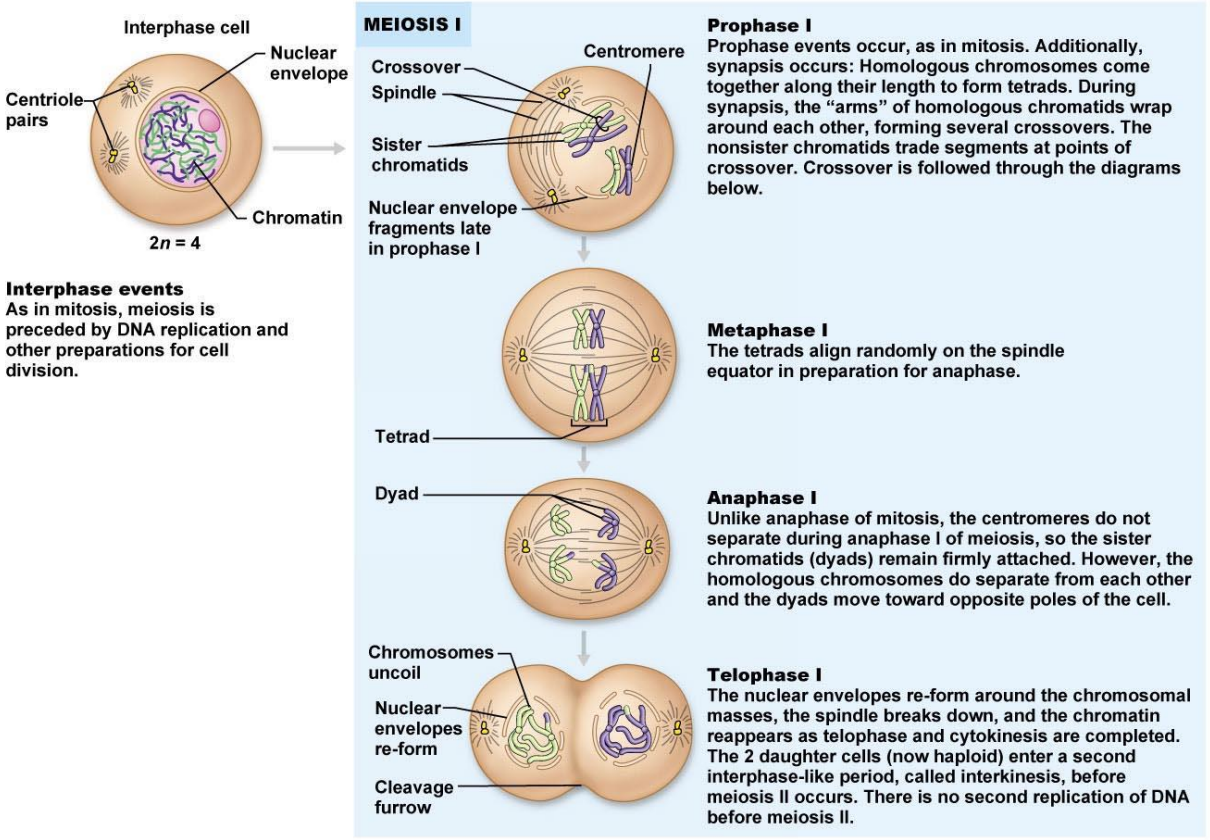
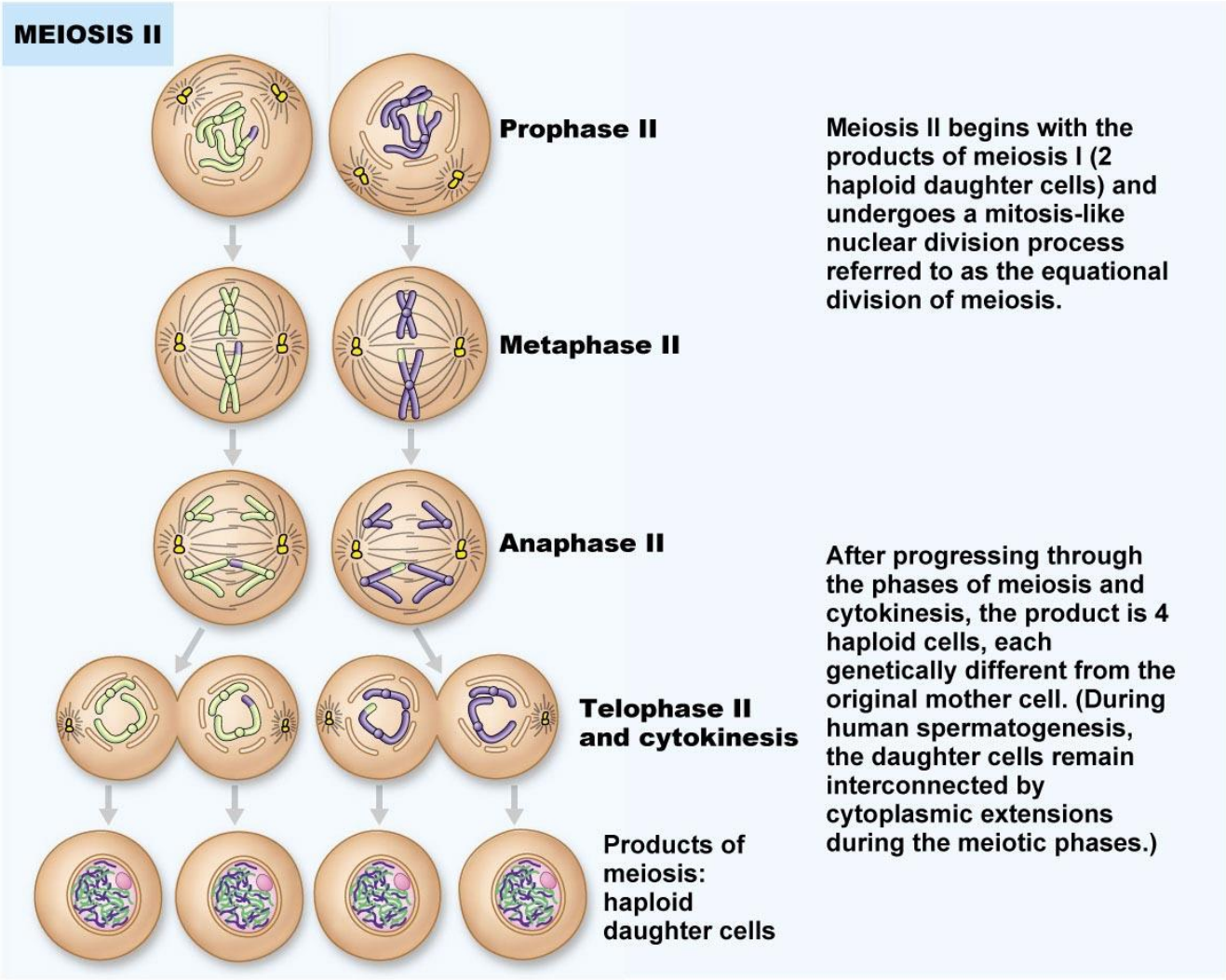

Peritoneum
Seminal vesicle
Ampulla of ductus deferens
Ejaculatory duct
Rectum
Prostate
Bulbourethral gland
Anus
Bulb of penis
Ductus (vas) deferens
Ureter
Urinary bladder
Prostatic urethra
Membranous urethra
Urogenital diaphragm
Pubis
Corpus spongiosum
Corpus cavernosum
Spongy urethra
Epididymis
Glans penis
Prepuce
External urethral orifice
Testis
Scrotum


Ureter
Ampulla of ductus deferens
Seminal vesicle
Urinary bladder
Ejaculatory duct
Prostate
Prostatic urethra
Orifices of prostatic ducts
Bulbourethral gland and duct
Membranous urethra
Urogenital diaphragm
Bulb of penis
Root of penis
Crus of penis
Bulbourethral duct opening
Ductus deferens
Corpora cavernosa
Epididymis
Shaft (body) of penis
Corpus spongiosum
Testis
Section of (b)
Spongy urethra
Glans penis
Prepuce (foreskin)
(a)
External urethral orifice
Dorsal vessels and nerves
Corpora cavernosa
Urethra
Skin
Tunica albuginea of erectile bodies
Deep arteries
Corpus spongiosum
(b)

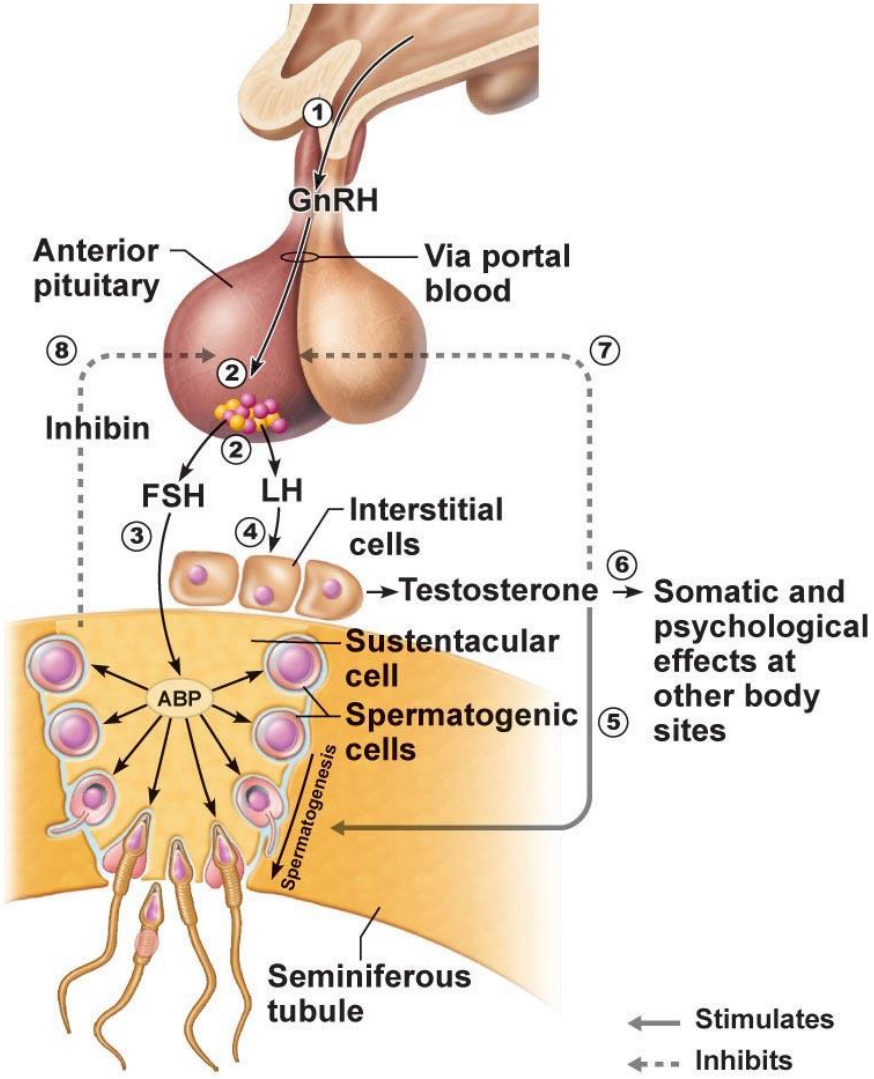
- **Sperm Analysis**
  - One of the first tests done to determine male infertility
  - Sterile if less than 20 million sperm per ml
- **Erection**
  - Controlled by the parasympathetic nervous system
  - Nitric oxide causes the smooth muscles to relax and the blood vessels to dilate
- **Ejaculation**
  - Controlled by the sympathetic nervous system
  - Also called climax or orgasm

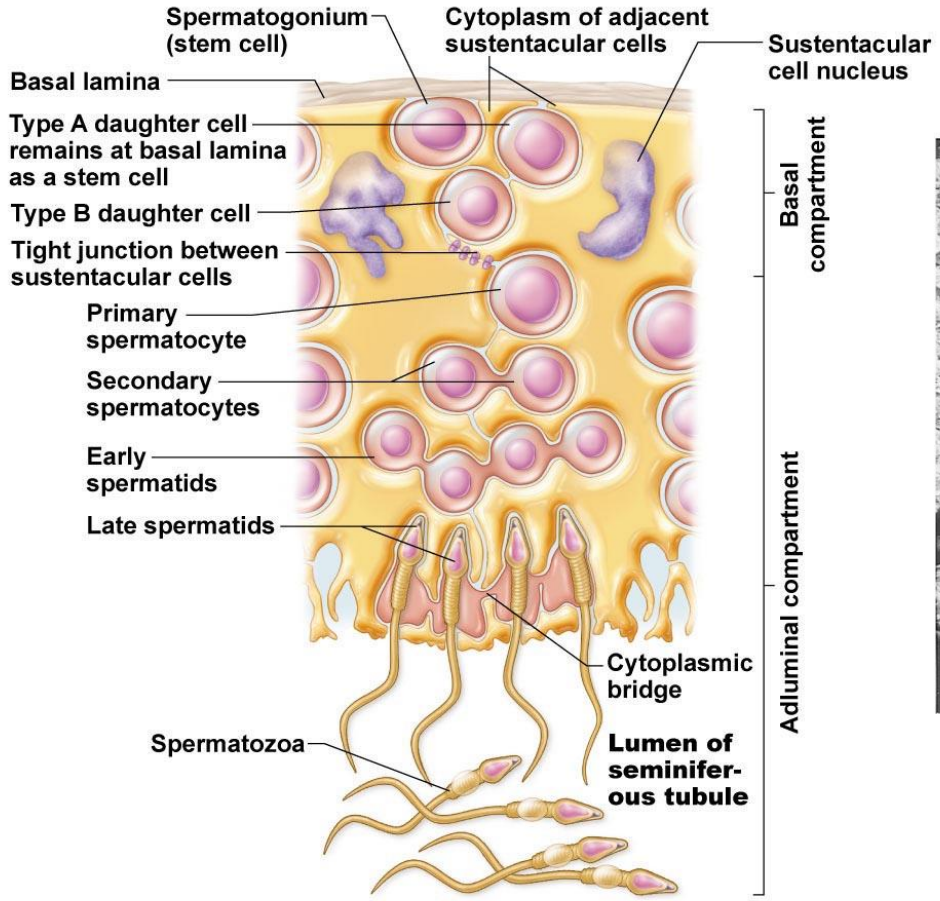

Haploid gametes (n = 23)
n
Egg
n
Sperm
Meiosis
Fertilization
Diploid
zygote
(2n = 46)
2n
Multicellular
diploid
adults
(2n = 46)
Mitosis and
development



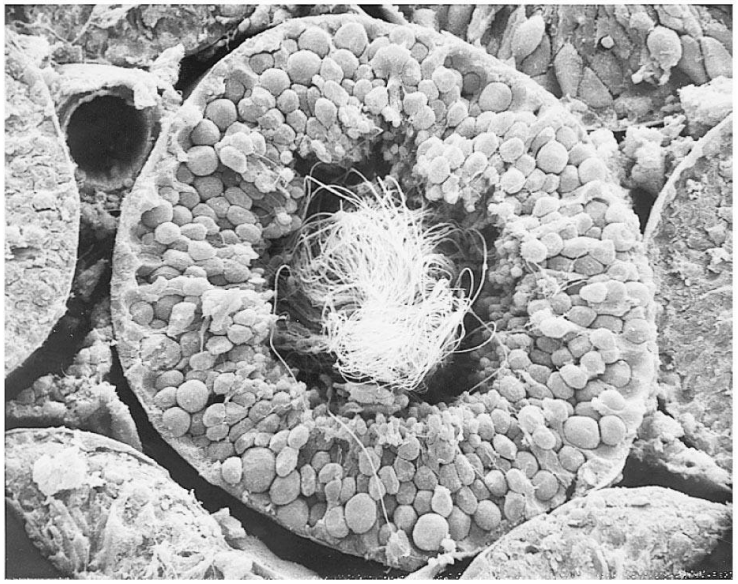


	MITOSIS	MEIOSIS
Number of divisions	One, consisting of prophase, metaphase, anaphase, and telophase.	Two, each consisting of prophase, metaphase, anaphase, and telophase. DNA replication does not occur between the two nuclear divisions.
Synapsis of homologous chromosomes	Does not occur.	Occurs during mitosis I; tetrads formed, allowing crossovers.
Daughter cell number and genetic composition	Two. Each diploid (2*n*) cell is identical to the mother cell.	Four. Each haploid (*n*) cell contains half as many chromosomes as the mother cell and is genetically different from the mother cell.
Roles in the body	For development of multicellular adult from zygote. Produces cells for growth and tissue repair. Ensures constancy of genetic makeup of all body cells.	Produces cells for reproduction (gametes). Introduces genetic variability in the gametes and reduces chromosomal number by half so that when fertilization occurs, the normal diploid chromosomal number is restored (in humans, 2*n* = 46).

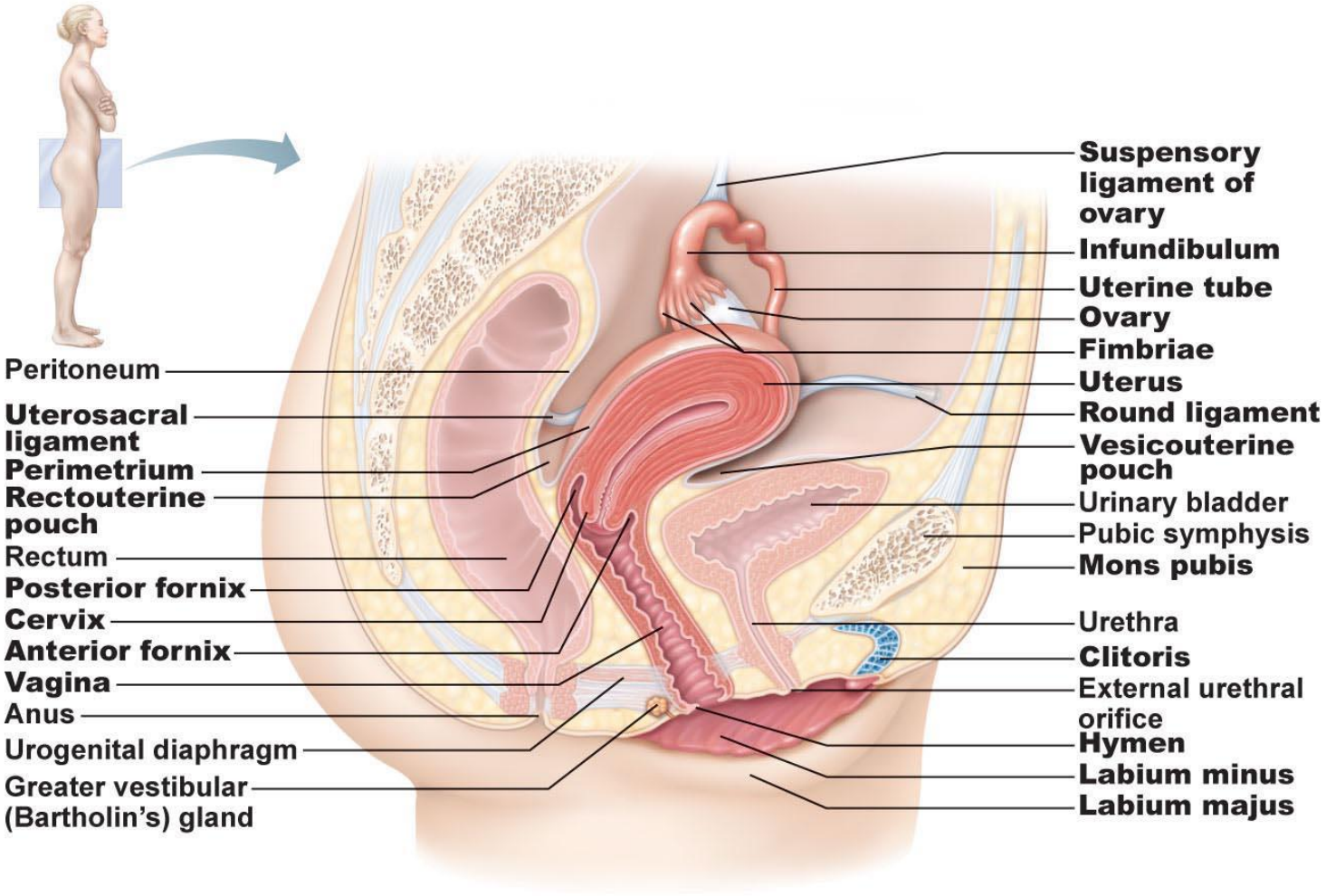

1
GnRH
Anterior pituitary
Via portal blood
8
7
2
Inhibin
2
FSH
LH
3
4
Interstitial cells
6
Testosterone
Somatic and psychological effects at other body sites
Sustentacular cell
ABP
Spermatogenic cells
5
Spermatogenesis
Seminiferous tubule
Stimulates
Inhibits

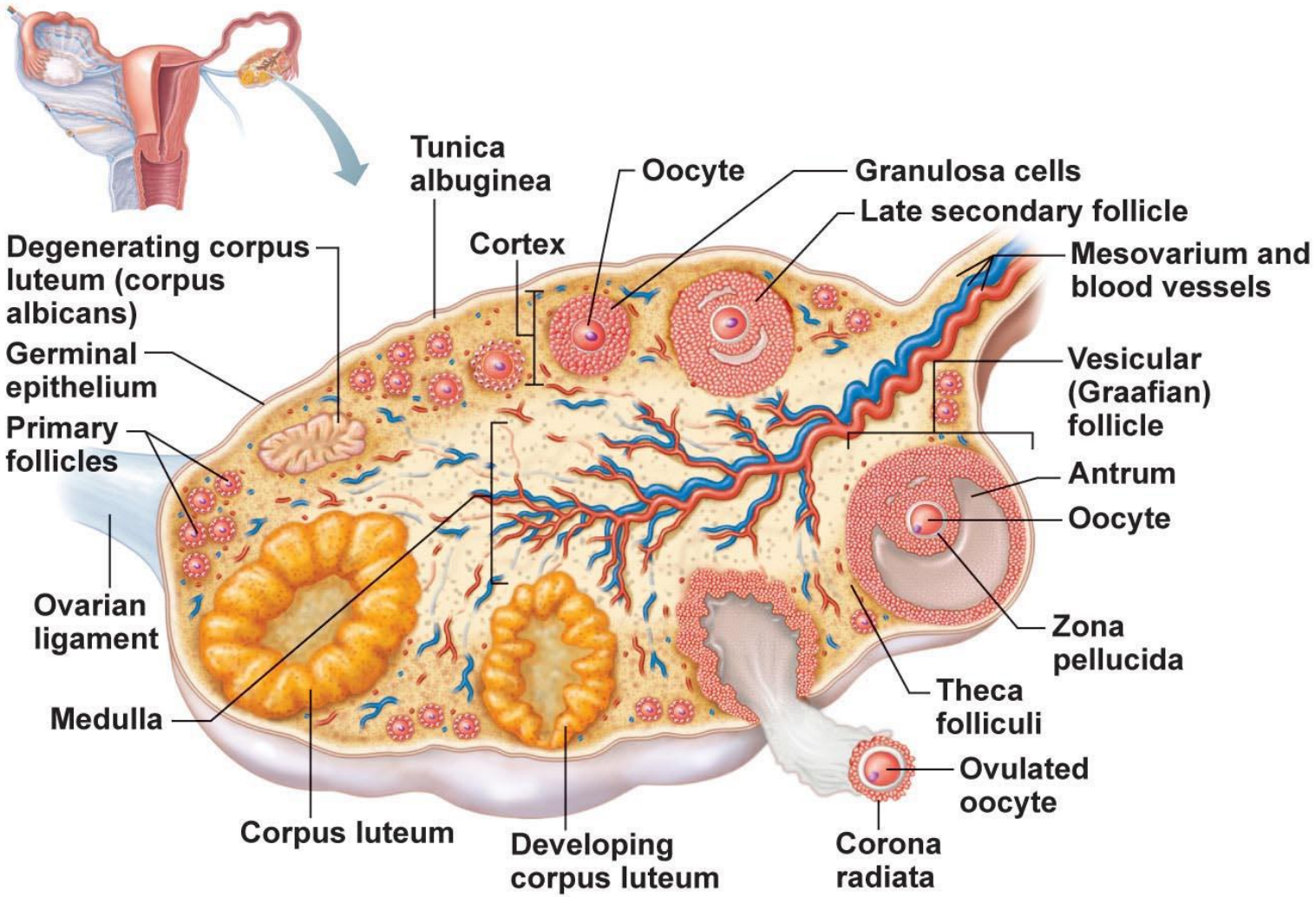


(c) A portion of the seminiferous tublule wall, showing the spermato-genic cells surrounded by sustentacular cells (colored gold)



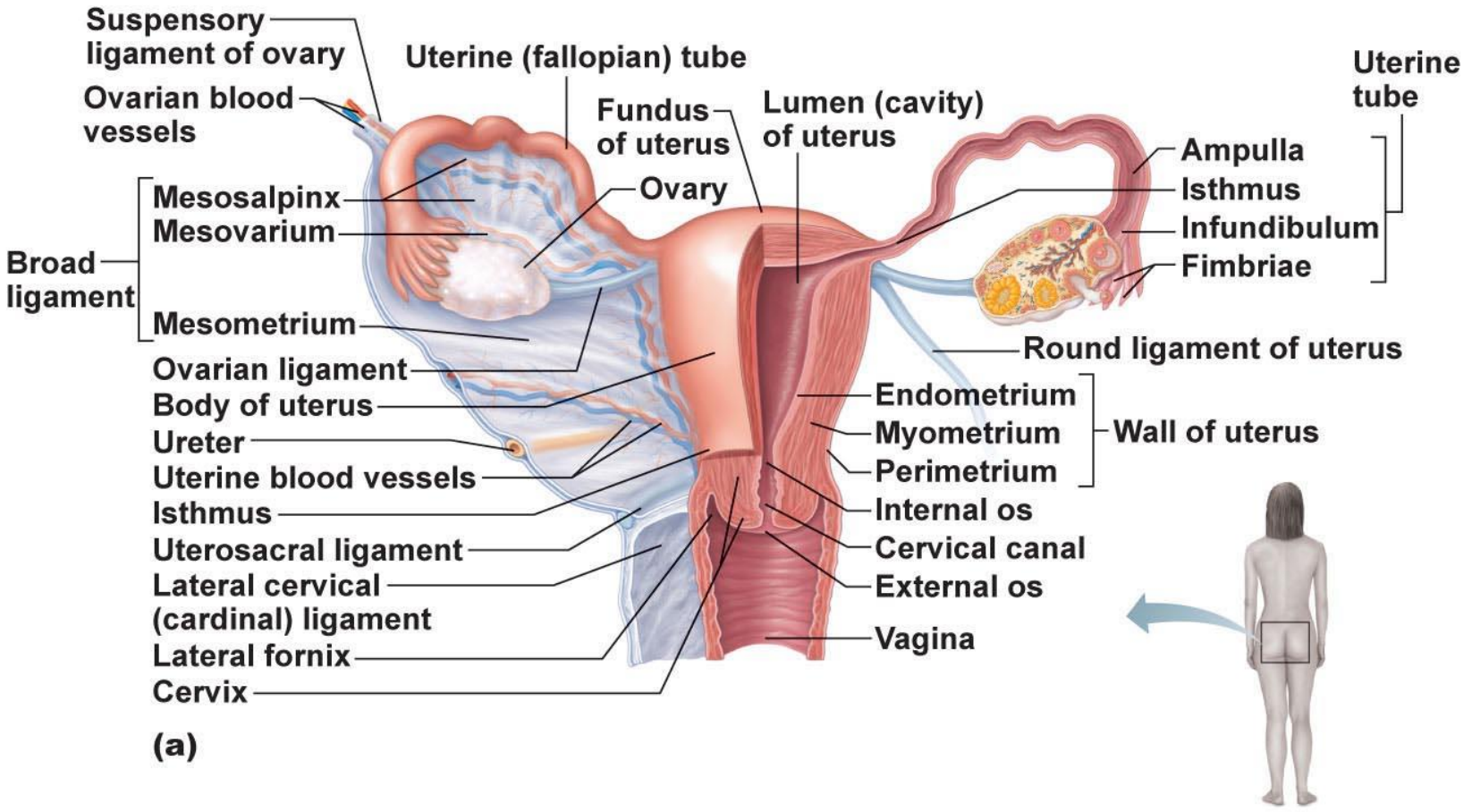
(a) Scanning electron micrograph of a cross-sectional view of a seminiferous tubule (225x)

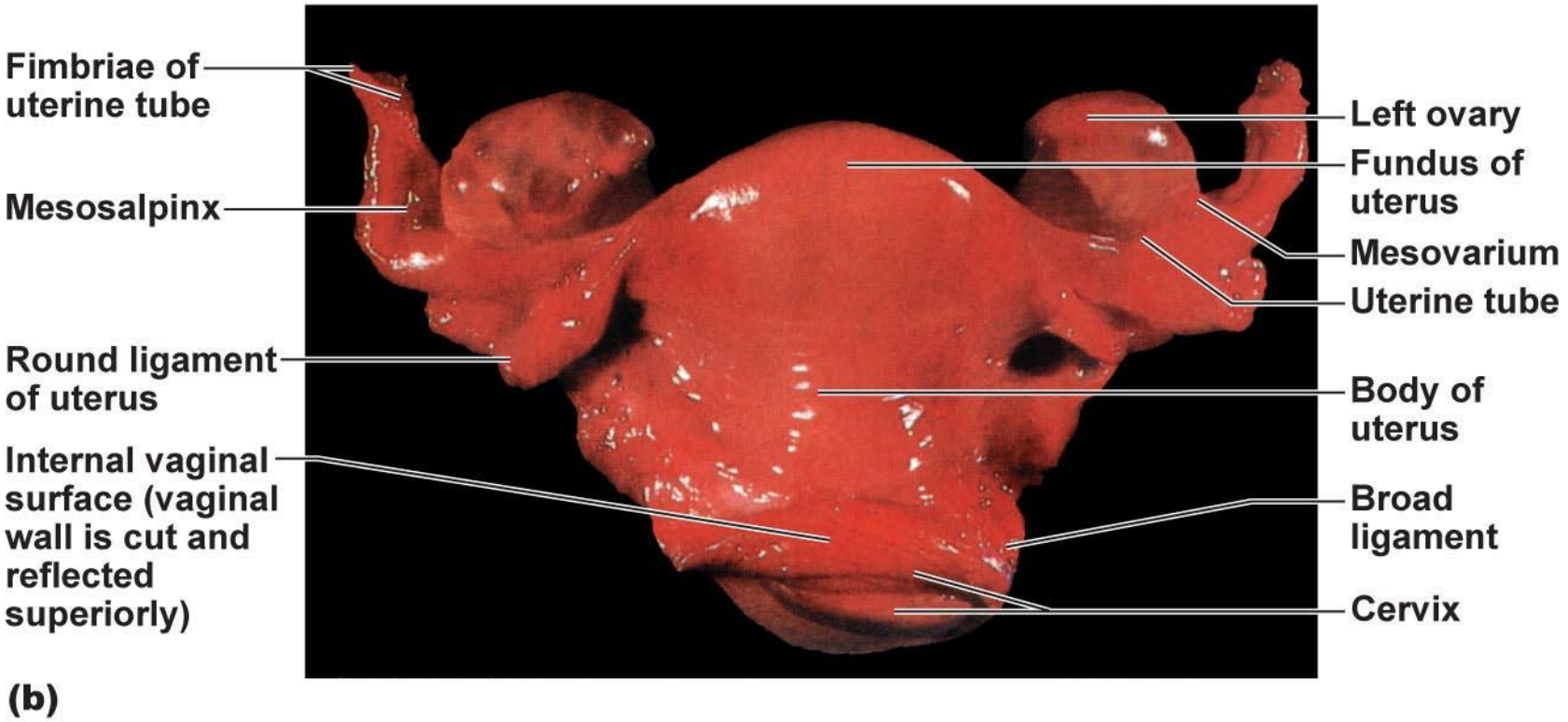

Peritoneum
Uterosacral ligament
Perimetrium
Rectouterine pouch
Rectum
Posterior fornix
Cervix
Anterior fornix
Vagina
Anus
Urogenital diaphragm
Greater vestibular (Bartholin's) gland
Suspensory ligament of ovary
Infundibulum
Uterine tube
Ovary
Fimbriae
Uterus
Round ligament
Vesicouterine pouch
Urinary bladder
Pubic symphysis
Mons pubis
Urethra
Clitoris
External urethral orifice
Hymen
Labium minus
Labium majus

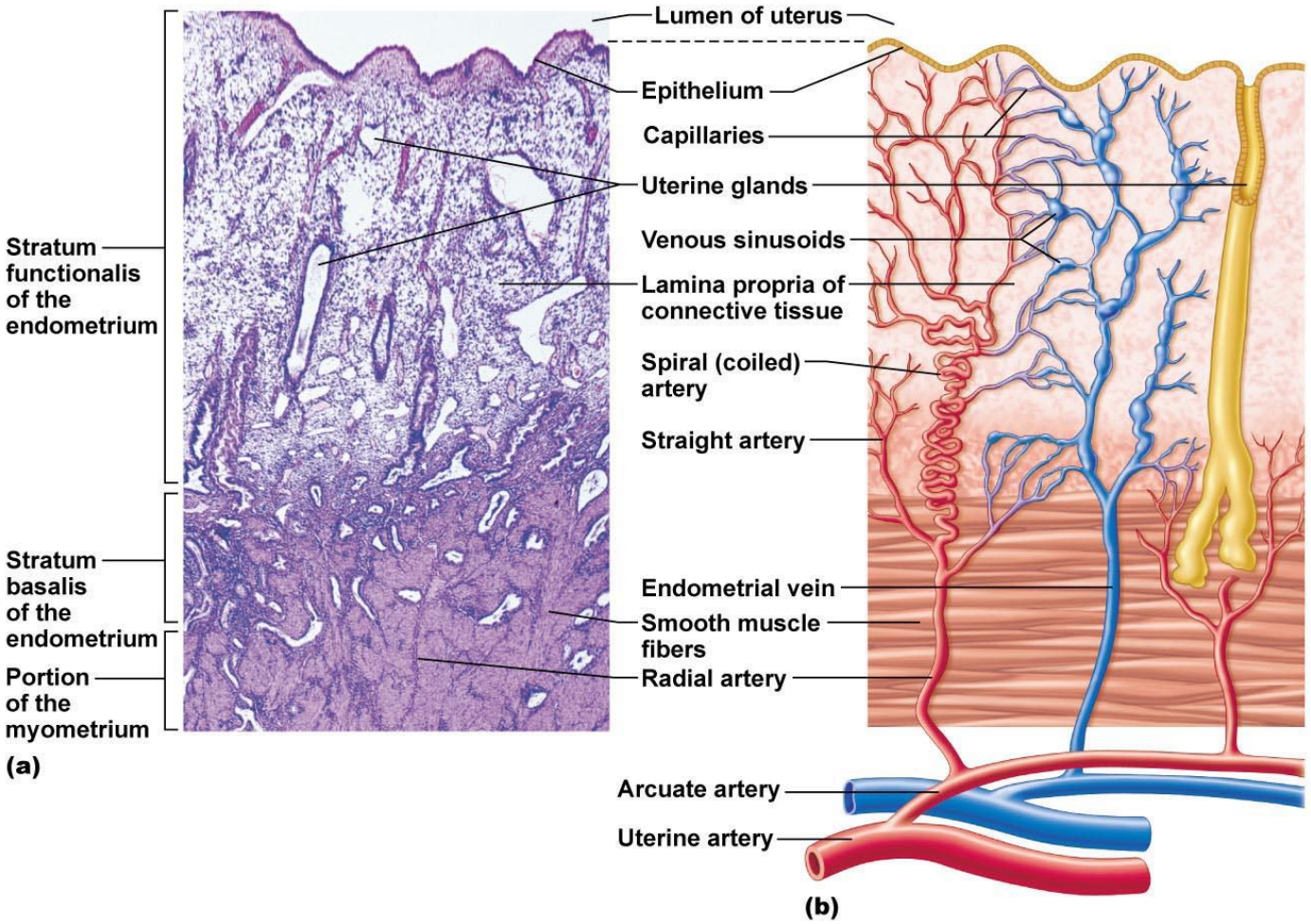


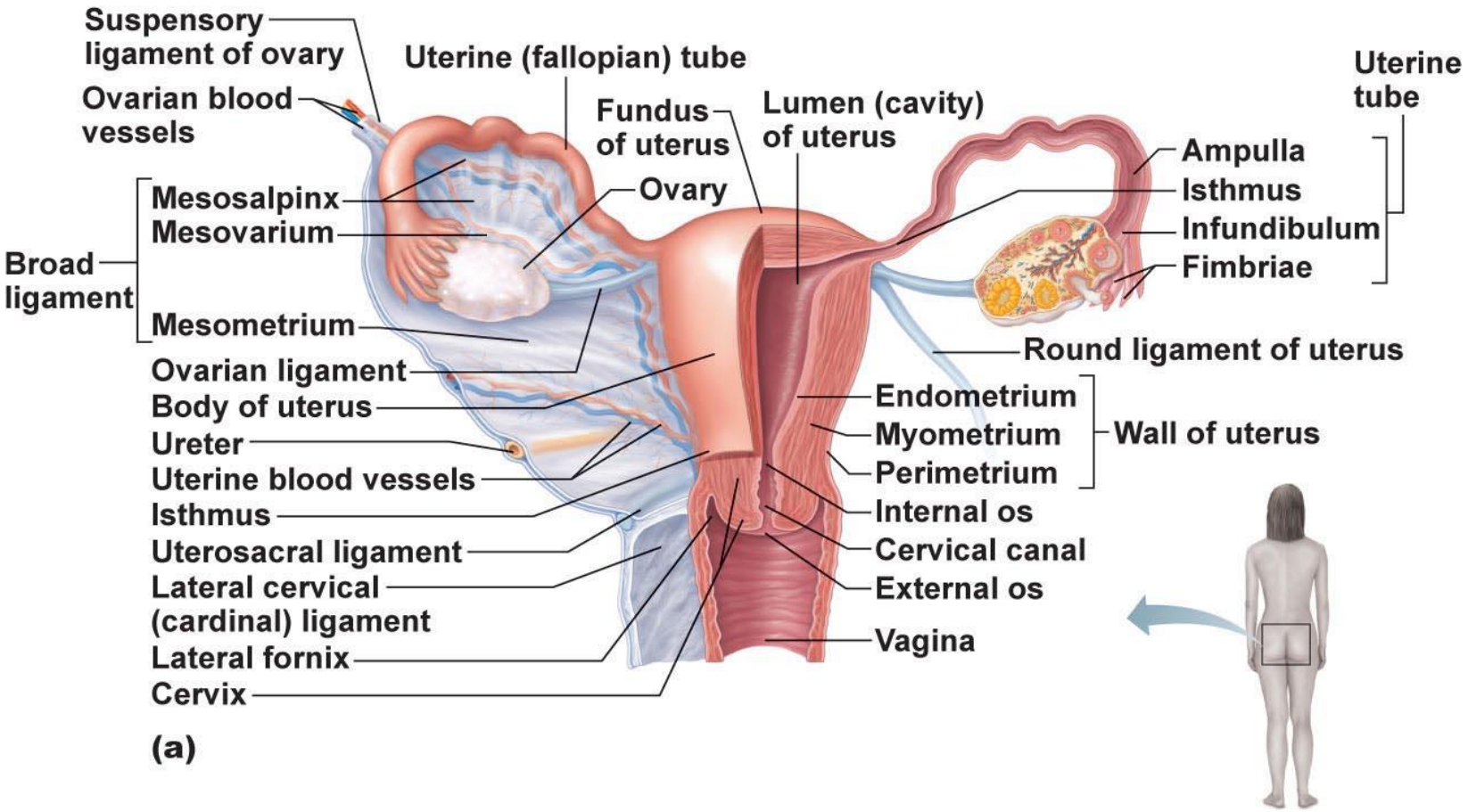
(a) Diagrammatic view of an ovary sectioned to reveal the follicles in its interior

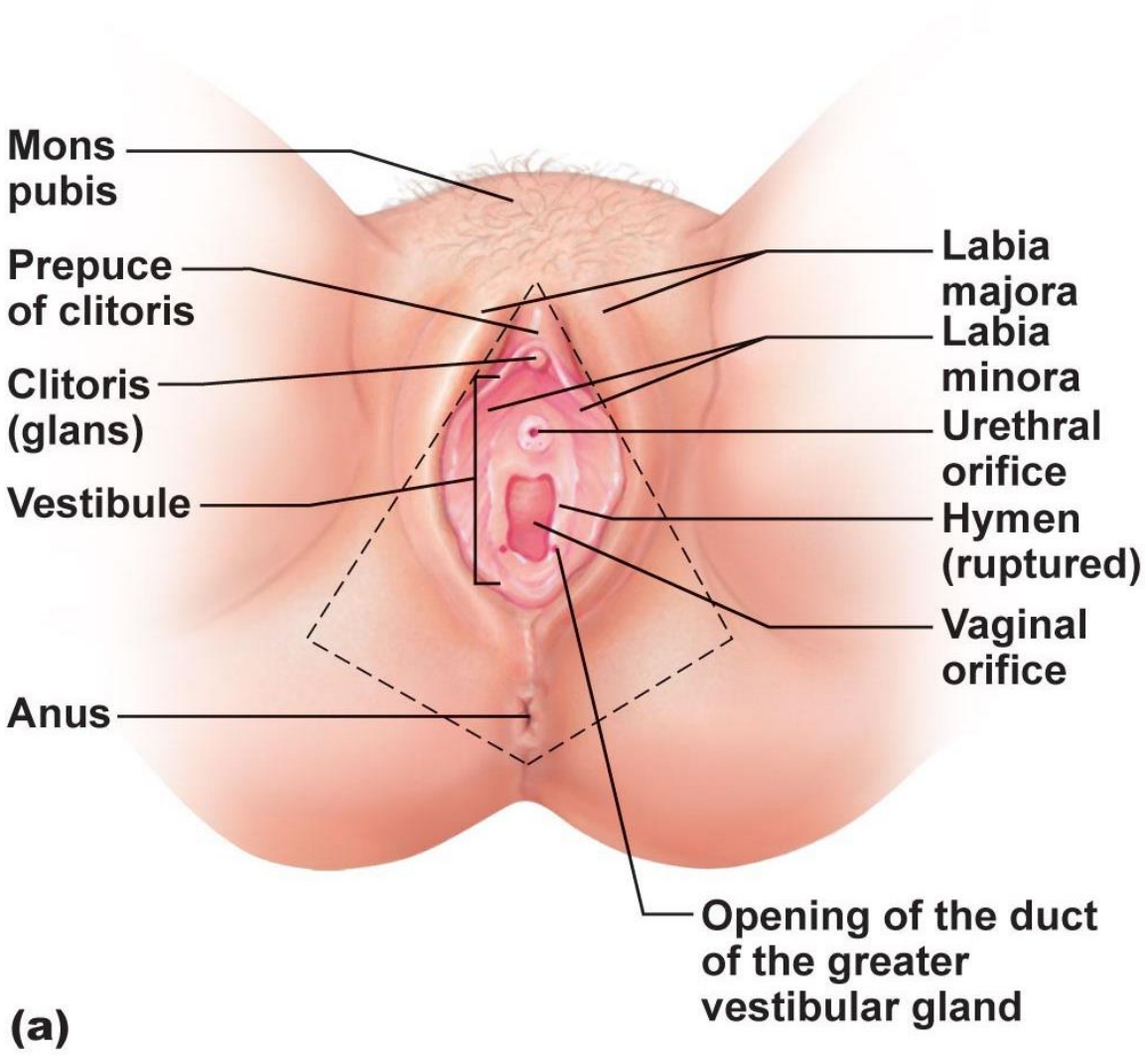
(b) Photomicrograph of a mammalian ovary showing follicles of different developmental phases

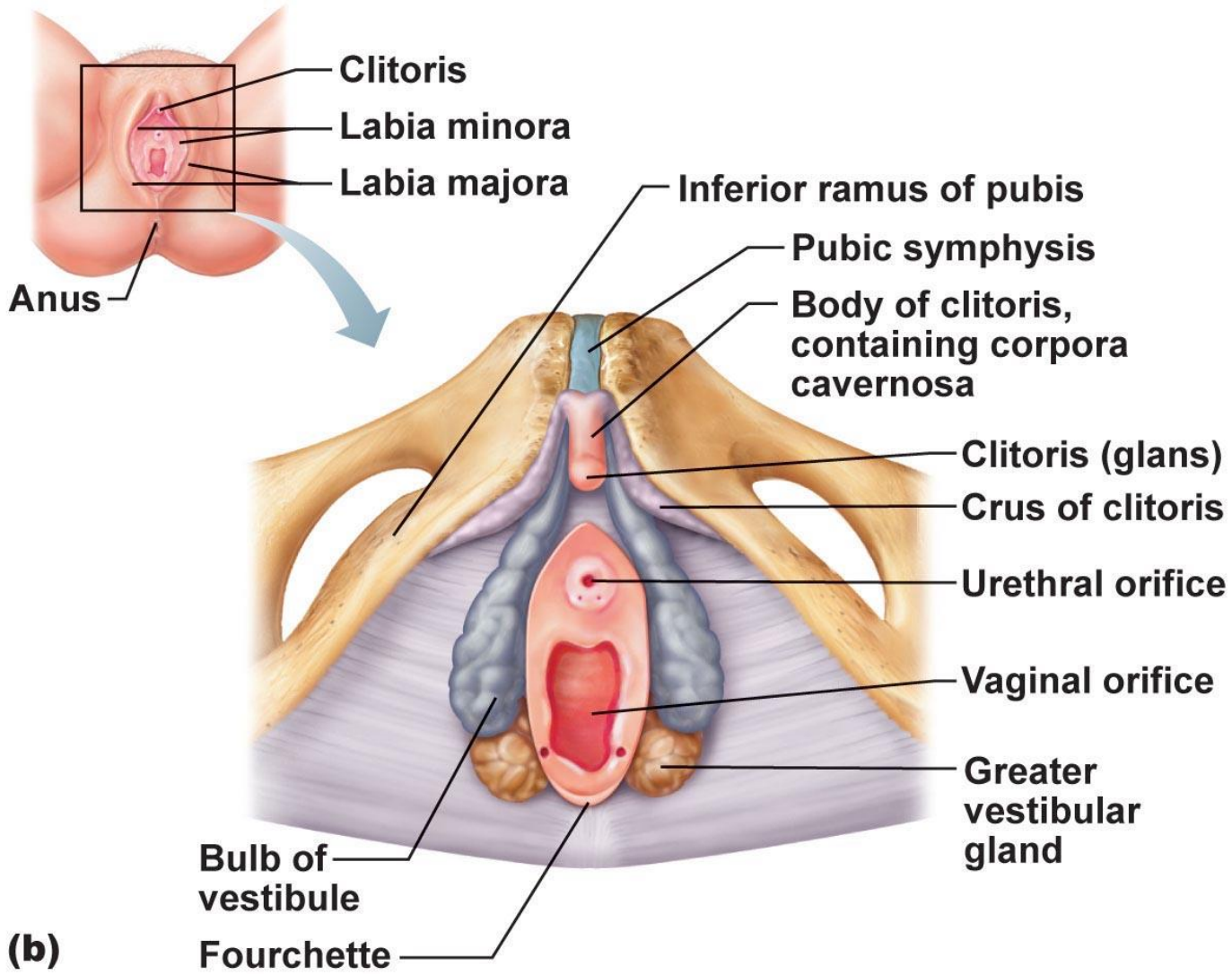

Suspensory ligament of ovary
Ovarian blood vessels
Uterine (fallopian) tube
Fundus of uterus
Lumen (cavity) of uterus
Uterine tube
Ampulla
Isthmus
Infundibulum
Fimbriae
Ovary
Broad ligament
Mesosalpinx
Mesovarium
Mesometrium
Round ligament of uterus
Ovarian ligament
Body of uterus
Ureter
Uterine blood vessels
Isthmus
Uterosacral ligament
Lateral cervical (cardinal) ligament
Lateral fornix
Cervix
Endometrium
Myometrium
Perimetrium
Wall of uterus
Internal os
Cervical canal
External os
Vagina
(a)

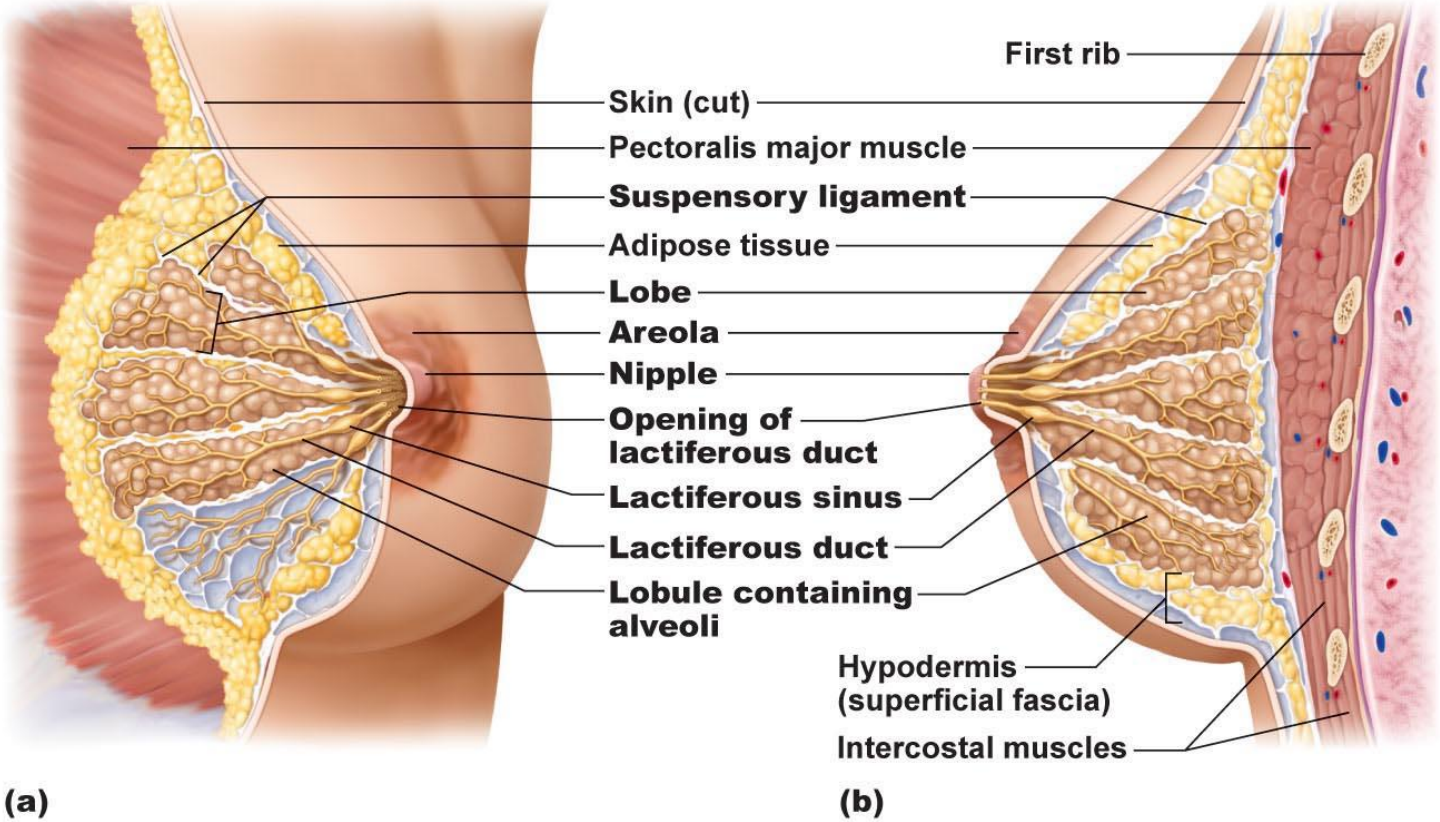

Fimbriae of uterine tube
Mesosalpinx
Round ligament of uterus
Internal vaginal surface (vaginal wall is cut and reflected superiorly)
(b)
Left ovary
Fundus of uterus
Mesovarium
Uterine tube
Body of uterus
Broad ligament
Cervix

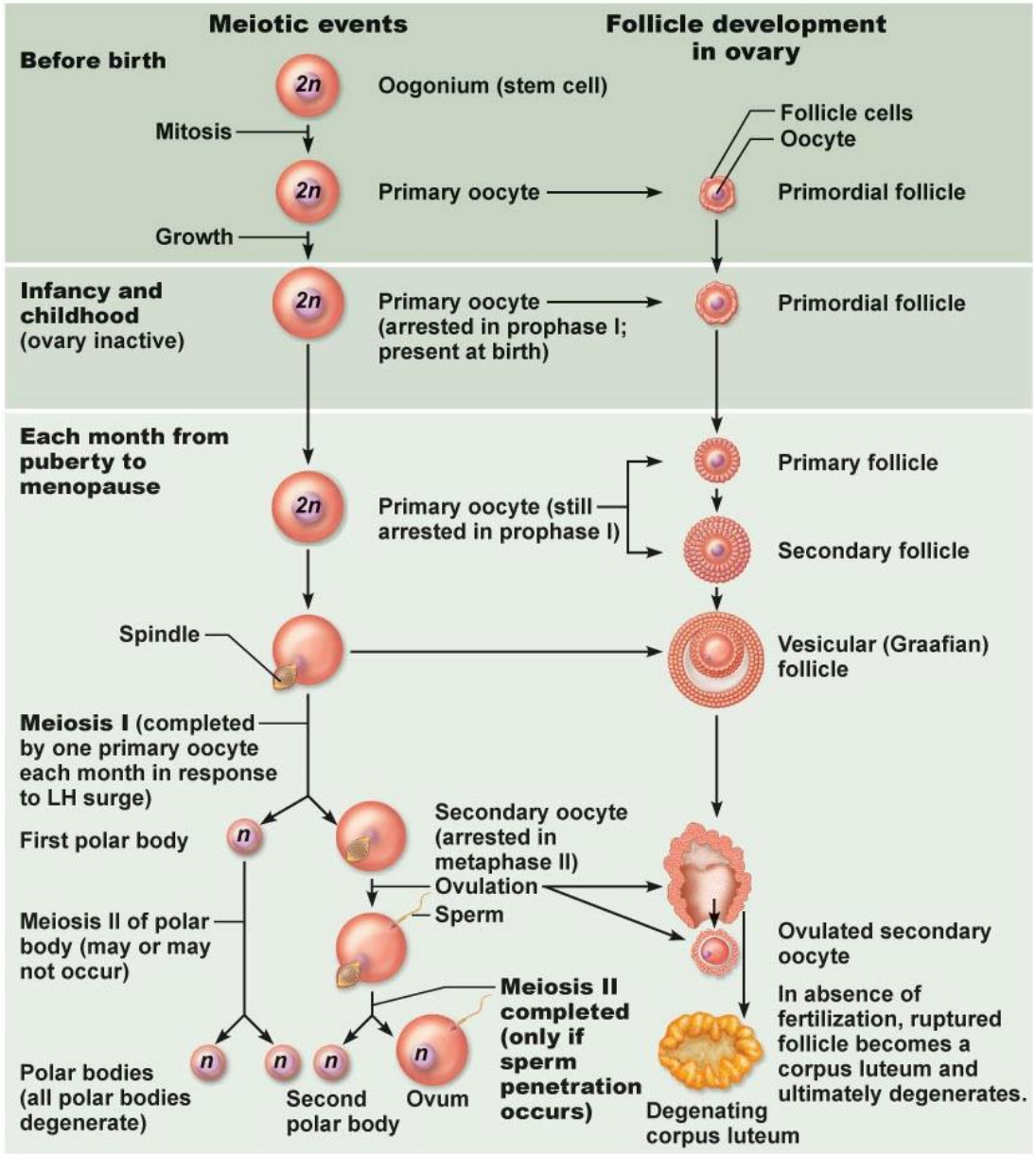

Lumen of uterus
Epithelium
Capillaries
Uterine glands
Venous sinusoids
Lamina propria of connective tissue
Spiral (coiled) artery
Straight artery
Endometrial vein
Smooth muscle fibers
Radial artery
Arcuate artery
Uterine artery
Stratum functionalis of the endometrium
Stratum basalis of the endometrium
Portion of the myometrium
(a)
(b)


Suspensory ligament of ovary
Ovarian blood vessels
Uterine (fallopian) tube
Fundus of uterus
Lumen (cavity) of uterus
Uterine tube
Ampulla
Isthmus
Infundibulum
Fimbriae
Ovary
Mesosalpinx
Mesovarium
Broad ligament
Mesometrium
Round ligament of uterus
Ovarian ligament
Body of uterus
Ureter
Uterine blood vessels
Isthmus
Uterosacral ligament
Lateral cervical (cardinal) ligament
Lateral fornix
Cervix
Endometrium
Myometrium
Perimetrium
Wall of uterus
Internal os
Cervical canal
External os
Vagina
(a)


Mons pubis
Prepuce of clitoris
Clitoris (glans)
Vestibule
Anus
Labia majora
Labia minora
Urethral orifice
Hymen (ruptured)
Vaginal orifice
Opening of the duct of the greater vestibular gland
(a)

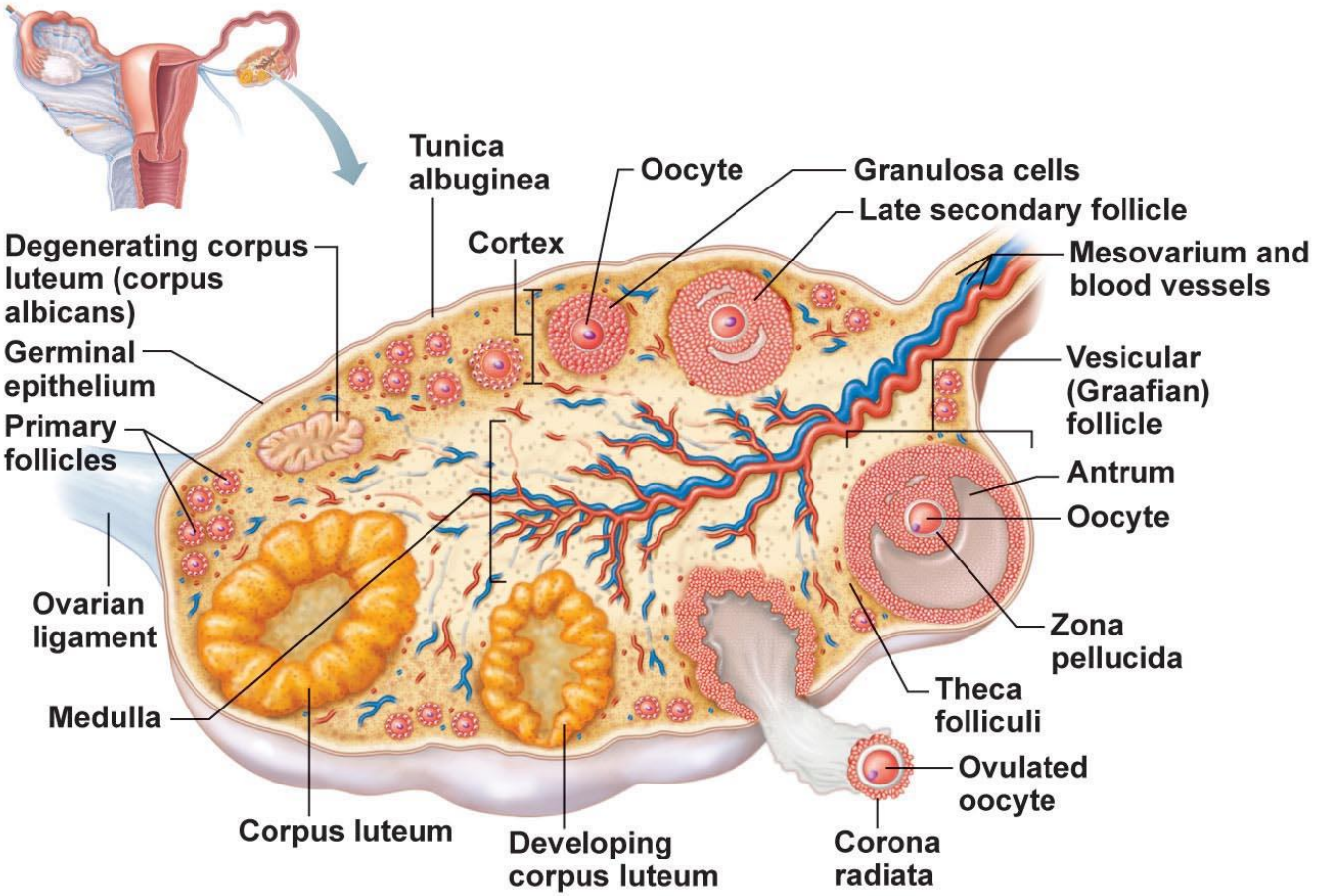

Clitoris
Labia minora
Labia majora
Anus
Inferior ramus of pubis
Pubic symphysis
Body of clitoris, containing corpora cavernosa
Clitoris (glans)
Crus of clitoris
Urethral orifice
Vaginal orifice
Greater vestibular gland
Bulb of vestibule
Fourchette
(b)


Skin (cut)
Pectoralis major muscle
Suspensory ligament
Adipose tissue
Lobe
Areola
Nipple
Opening of lactiferous duct
Lactiferous sinus
Lactiferous duct
Lobule containing alveoli
(a)
First rib
Hypodermis (superficial fascia)
Intercostal muscles
(b)

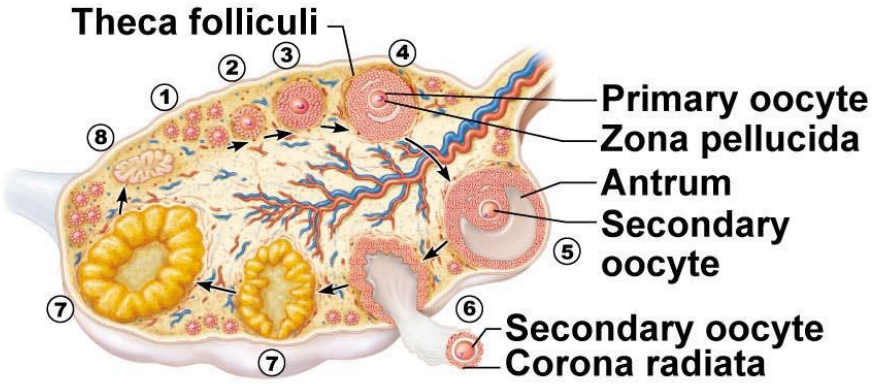

Meiotic events
Follicle development in ovary
Before birth
2n
Oogonium (stem cell)
Mitosis
Follicle cells
Oocyte
2n
Primary oocyte
Primordial follicle
Growth
Infancy and childhood (ovary inactive)
2n
Primary oocyte (arrested in prophase I; present at birth)
Primordial follicle
Each month from puberty to menopause
Primary follicle
2n
Primary oocyte (still arrested in prophase I)
Secondary follicle
Spindle
Vesicular (Graafian) follicle
Meiosis I (completed by one primary oocyte each month in response to LH surge)
First polar body
n
Secondary oocyte (arrested in metaphase II)
Ovulation
Sperm
Meiosis II of polar body (may or may not occur)
Ovulated secondary oocyte
Meiosis II completed (only if sperm penetration occurs)
In absence of fertilization, ruptured follicle becomes a corpus luteum and ultimately degenerates.
Polar bodies (all polar bodies degenerate)
n
n
n
n
Second polar body
Ovum
Degenating corpus luteum

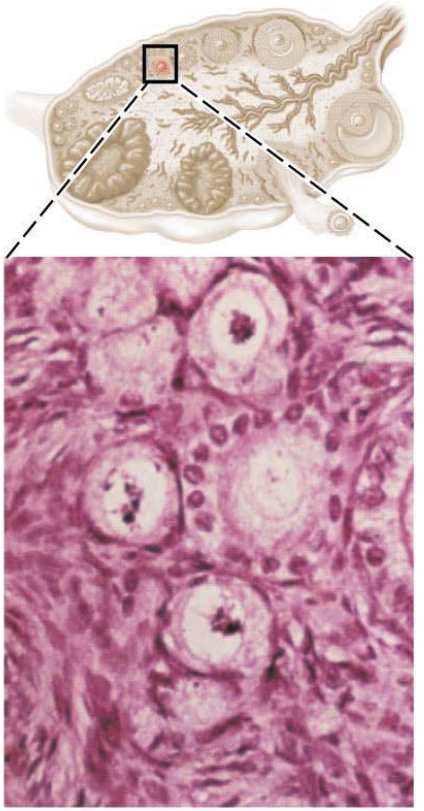
- Follicular phase
- Ovulation
- Luteal phase

3 Phases: Follicular, ovulation & Luteal phase

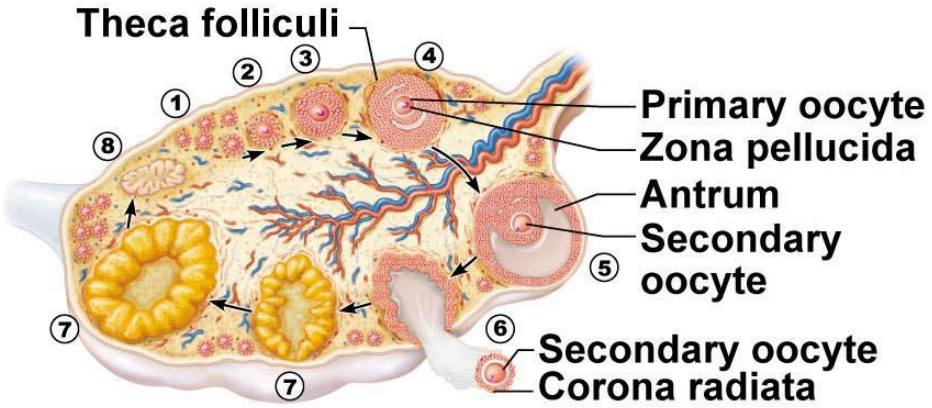


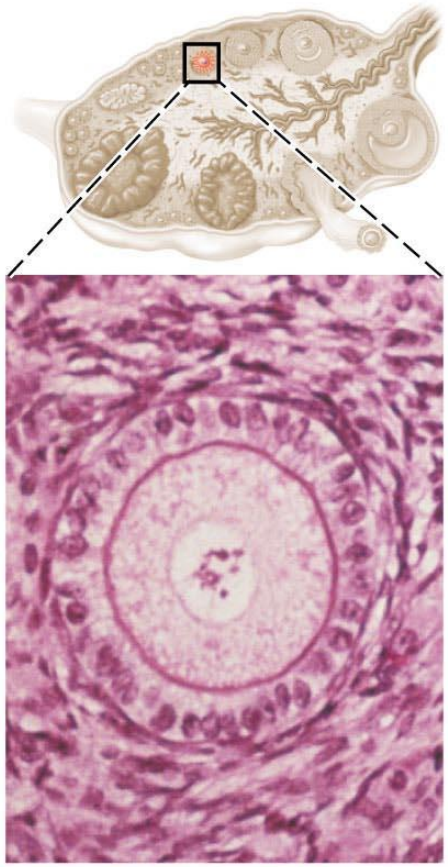
(a) Diagrammatic view of an ovary sectioned to reveal the follicles in its interior



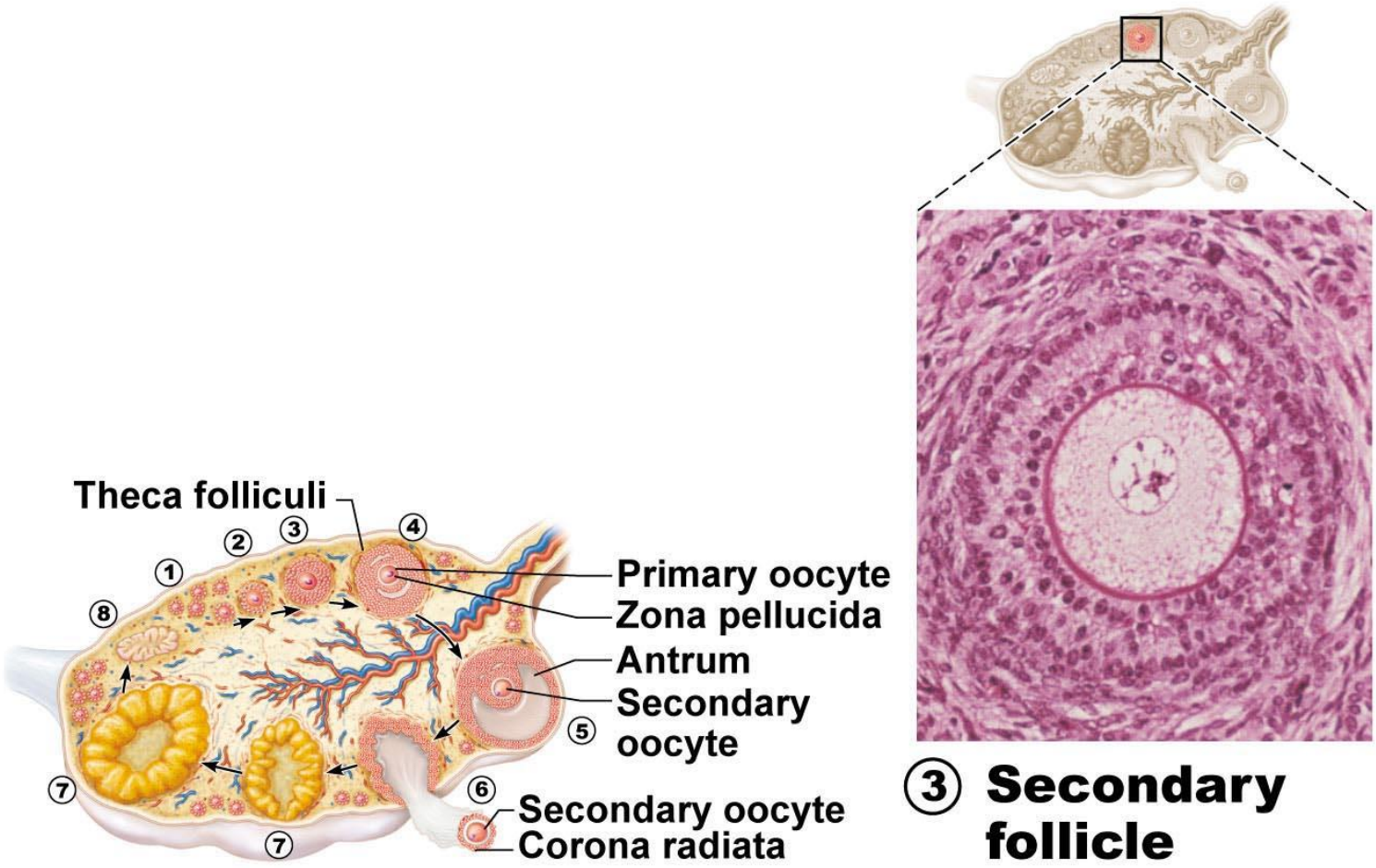


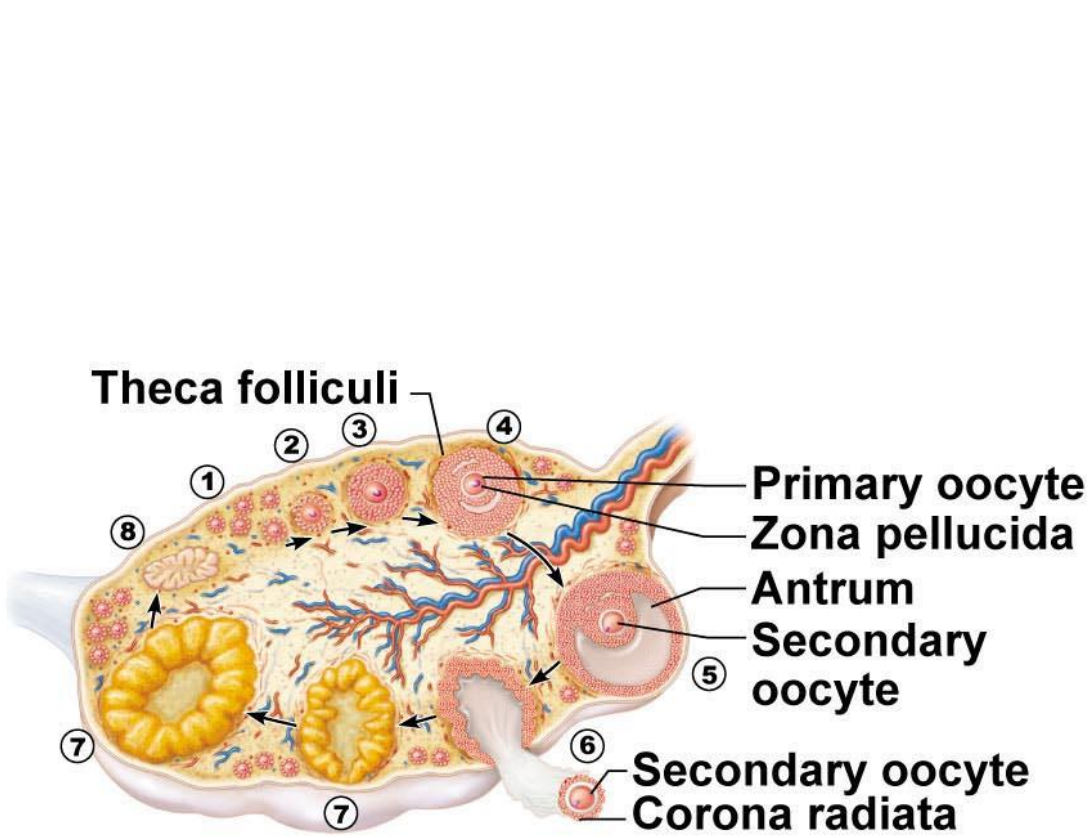
① **Primordial follicles**

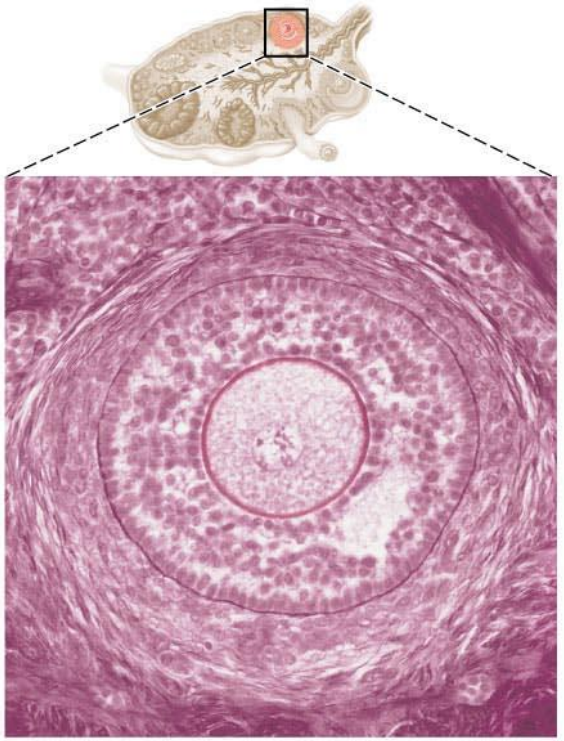




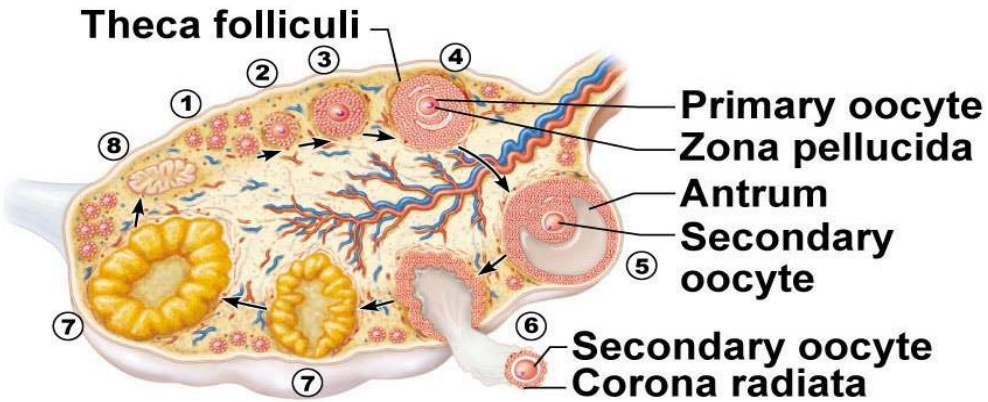
② Primary follicle

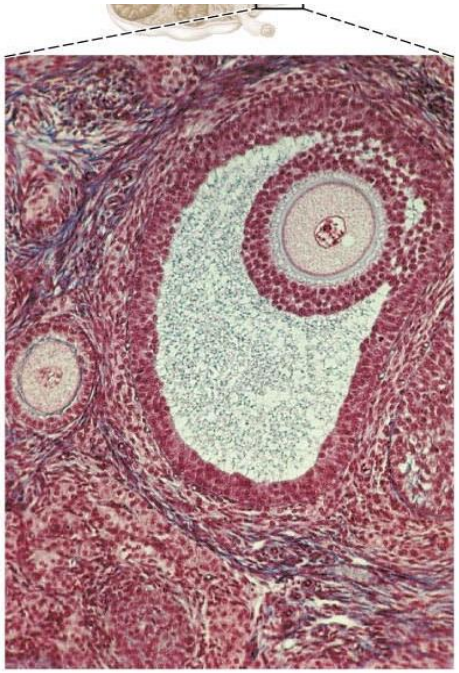

Theca folliculi
1
2
3
4
5
6
7
7
8
Primary oocyte
Zona pellucida
Antrum
Secondary oocyte
Secondary oocyte
Corona radiata
③ Secondary follicle



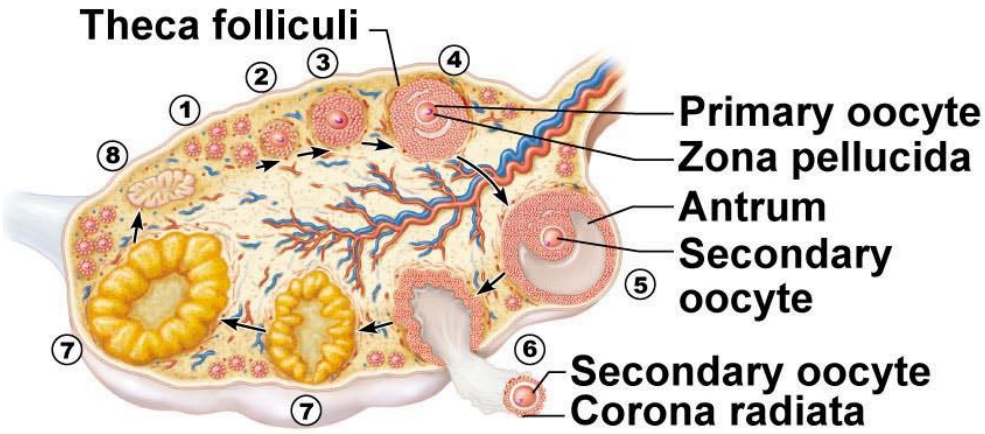


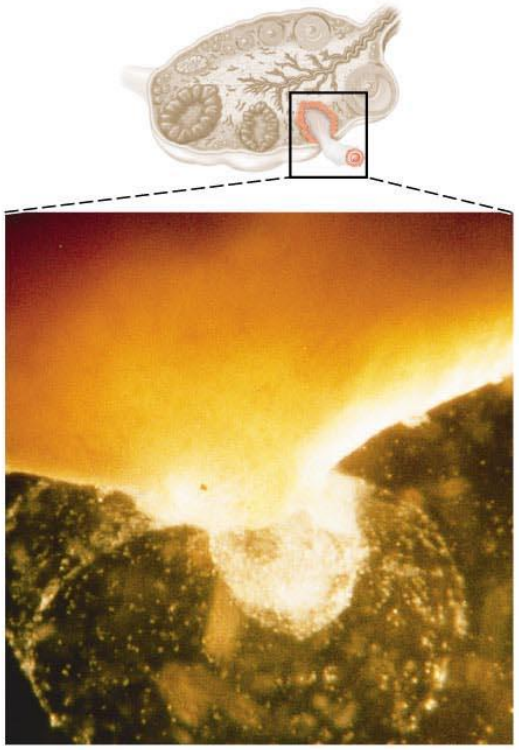
④ Late secondary follicle



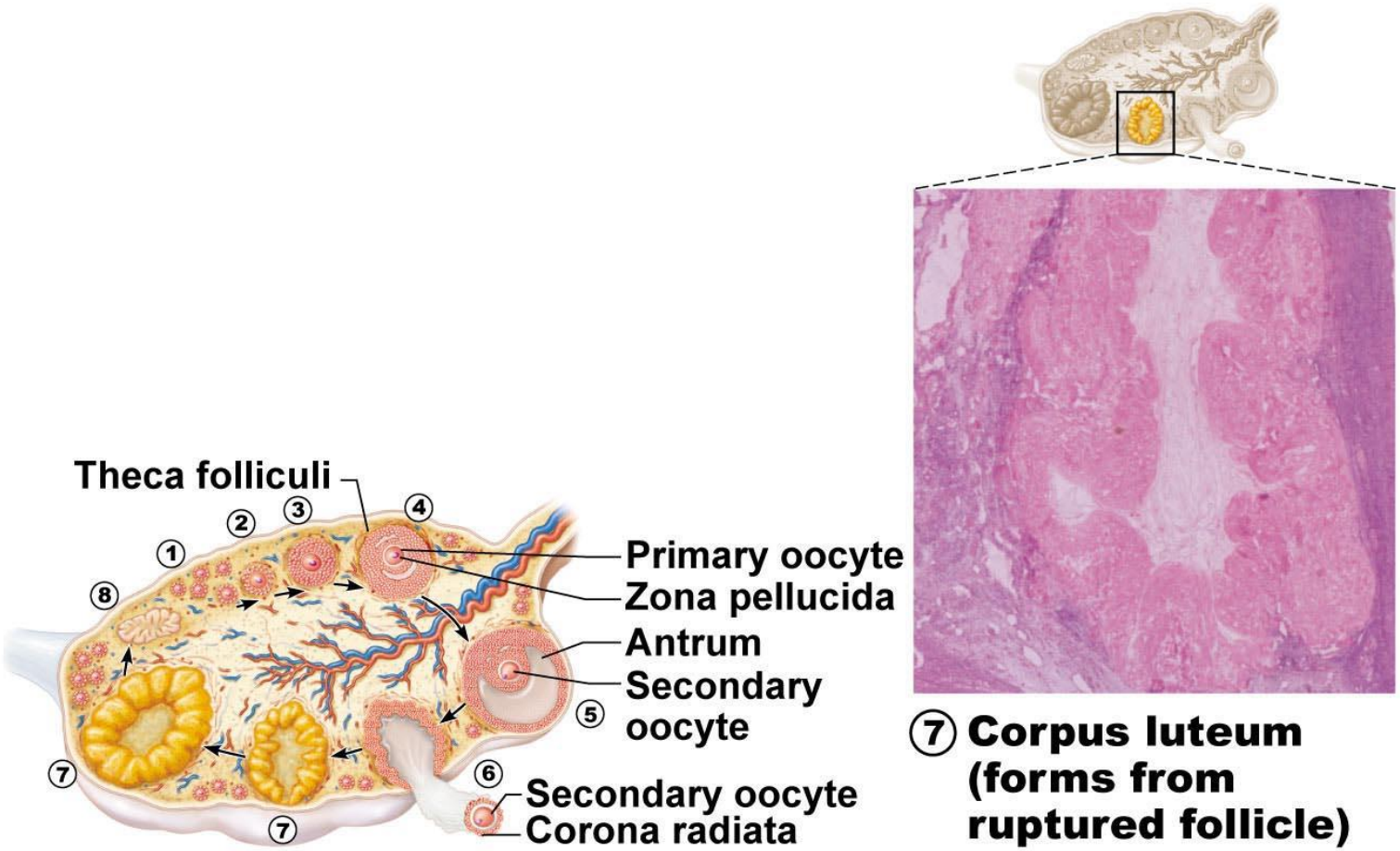


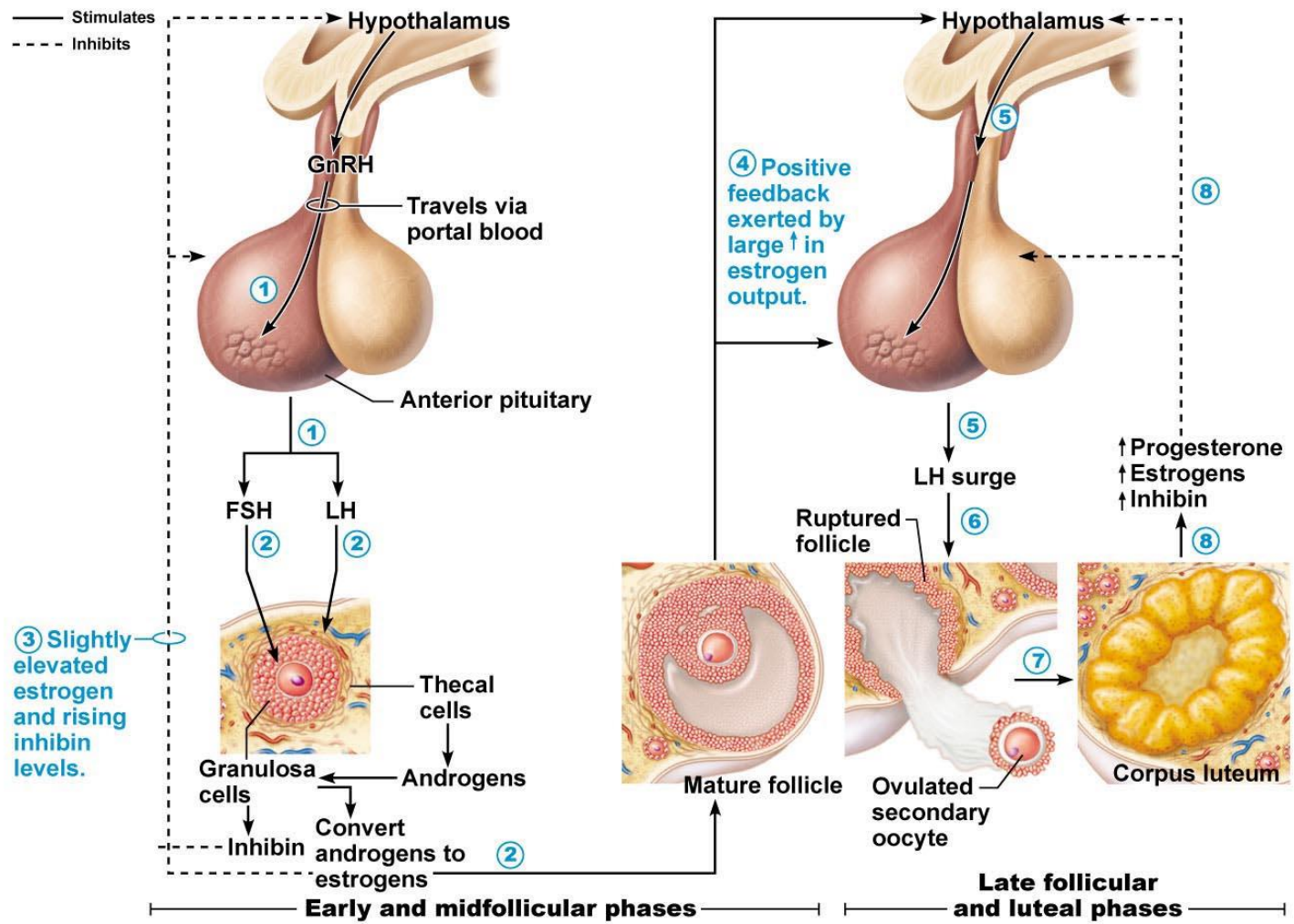
⑤ Mature vesicular follicle carries out meiosis I; ready to be ovulated



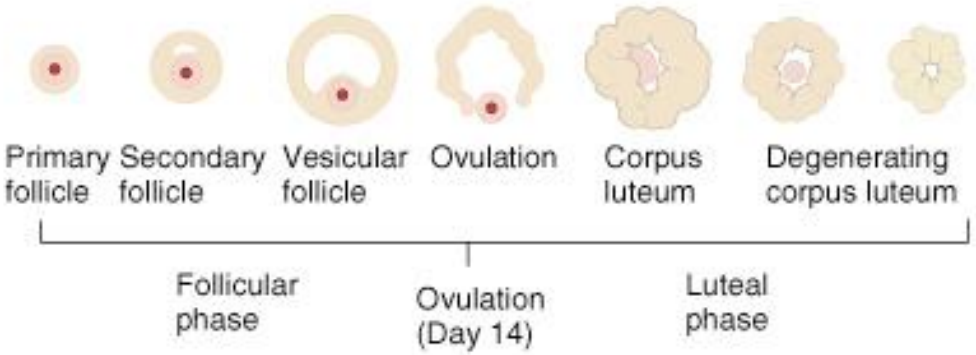


⑥ Follicle ruptures; secondary oocyte ovulated

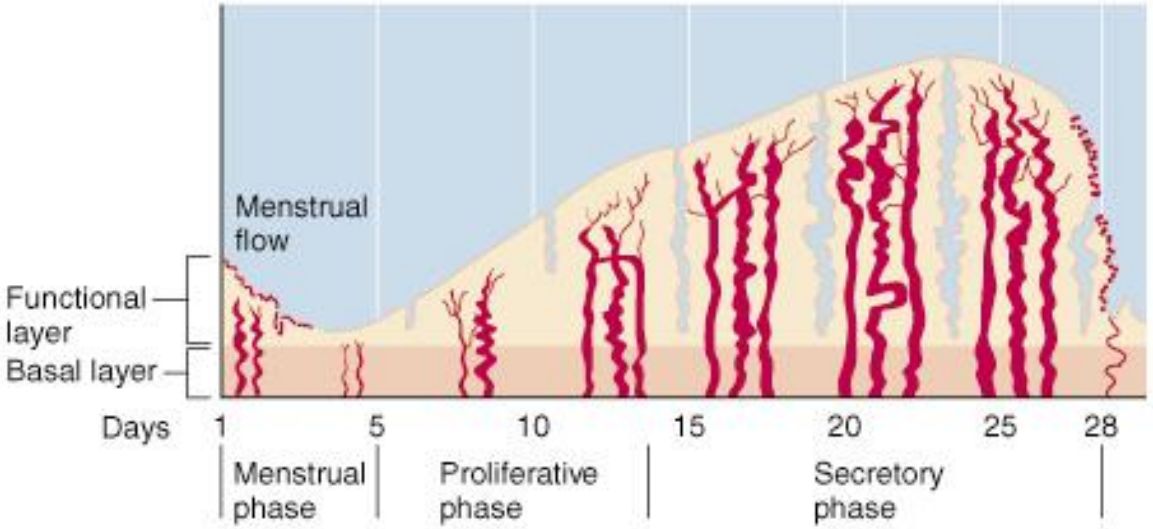

Theca folliculi
1
2
3
4
5
6
7
8
Primary oocyte
Zona pellucida
Antrum
Secondary oocyte
Secondary oocyte
Corona radiata
⑦ Corpus luteum (forms from ruptured follicle)


Stimulates
Inhibits
Hypothalamus
GnRH
Travels via portal blood
1
Anterior pituitary
1
FSH
LH
2
2
3 Slightly elevated estrogen and rising inhibin levels.
Thecal cells
Granulosa cells
Androgens
Inhibin
Convert androgens to estrogens
2
Early and midfollicular phases
Hypothalamus
5
4 Positive feedback exerted by large ↑ in estrogen output.
8
5
LH surge
↑Progesterone
↑Estrogens
↑Inhibin
Ruptured follicle
6
8
Mature follicle
7
Ovulated secondary oocyte
Corpus luteum
Late follicular and luteal phases

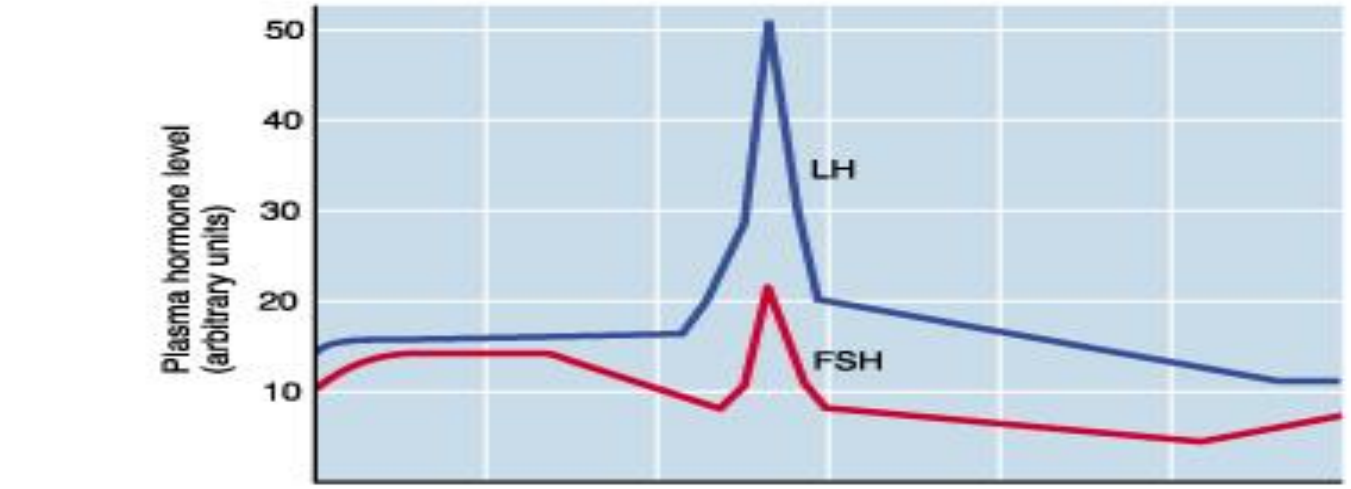
- Menstrual stage (menses)
- Pre-ovulatory stage (proliferative)
- Post-ovulatory stage (secretory)



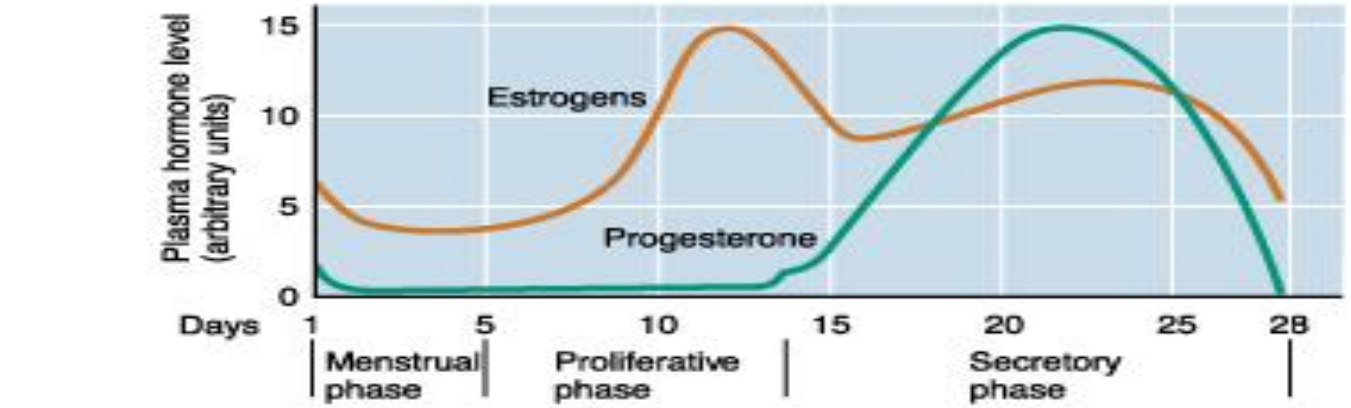
(c) Ovarian cycle



(d) Uterine cycle



(a) Fluctuation of gonadotropin levels



(b) Fluctuation of ovarian hormone levels

ALL THE BEST!