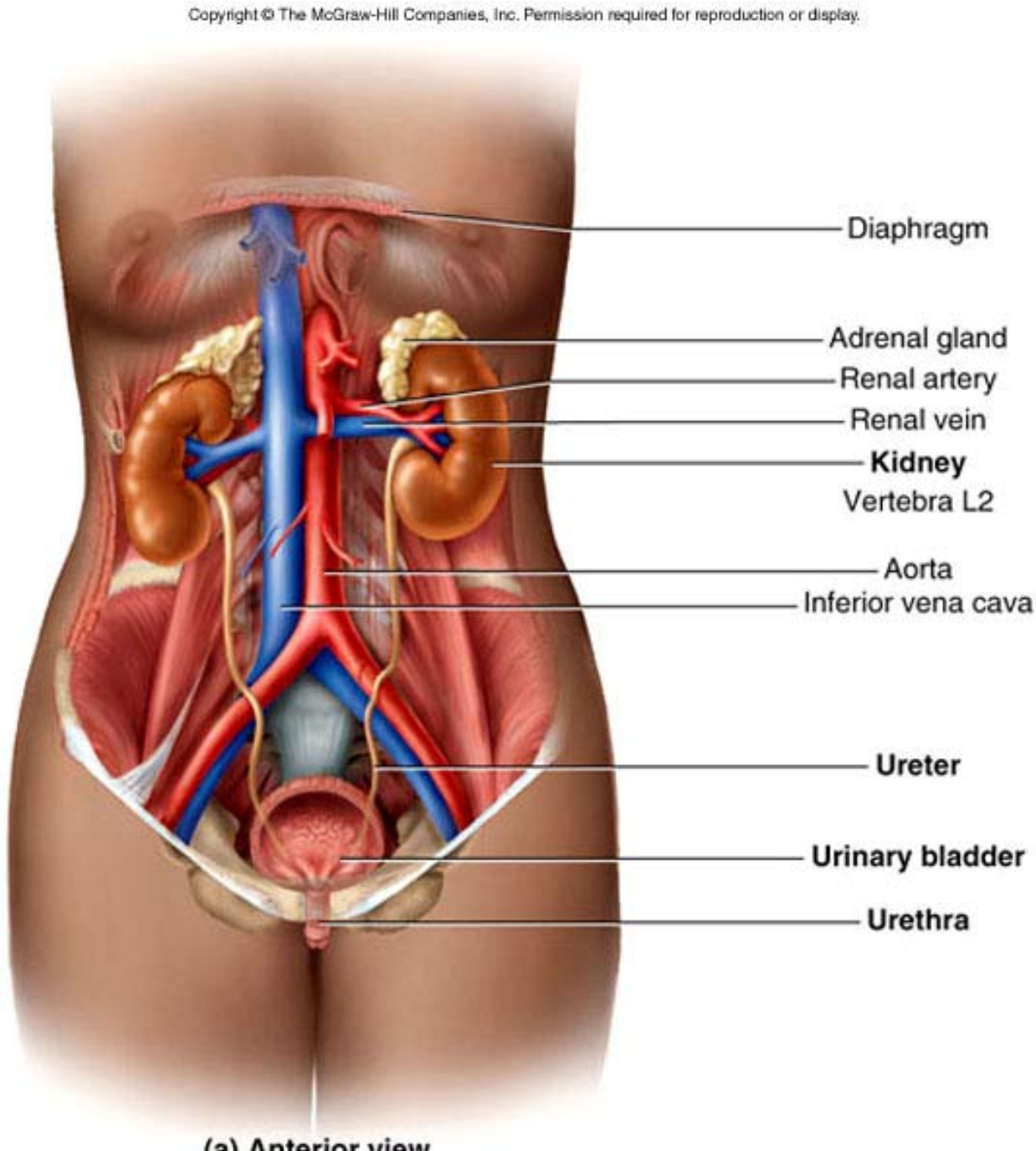
The Anatomy of the Kidney

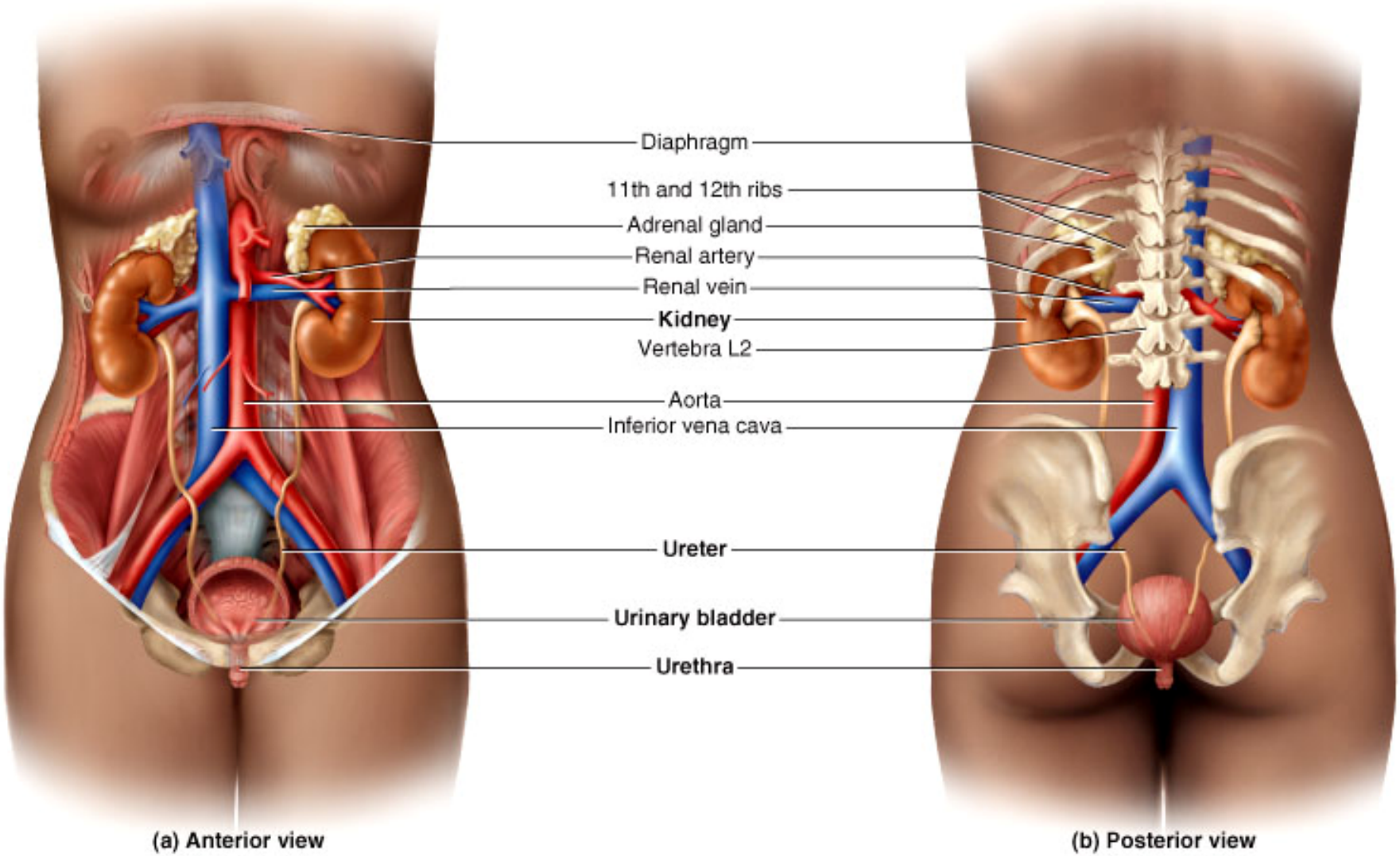
Copyright (c) The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

Urinary System

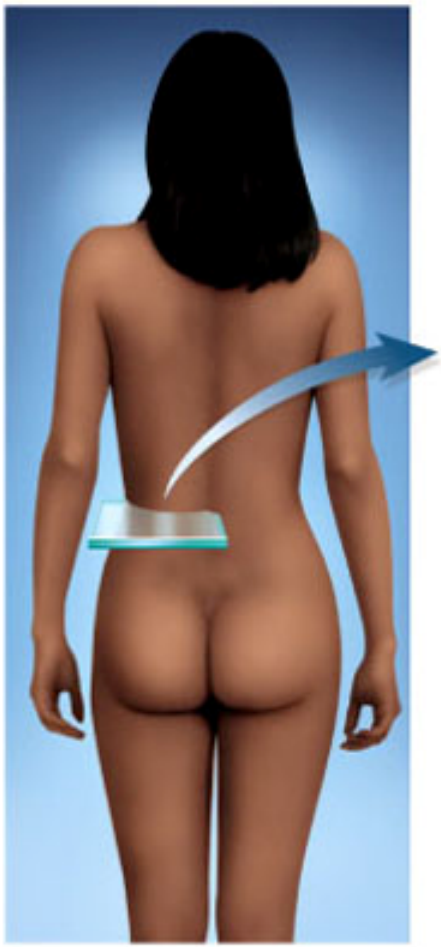
- Two kidneys
- Two ureters
- One urinary bladder
- One urethra

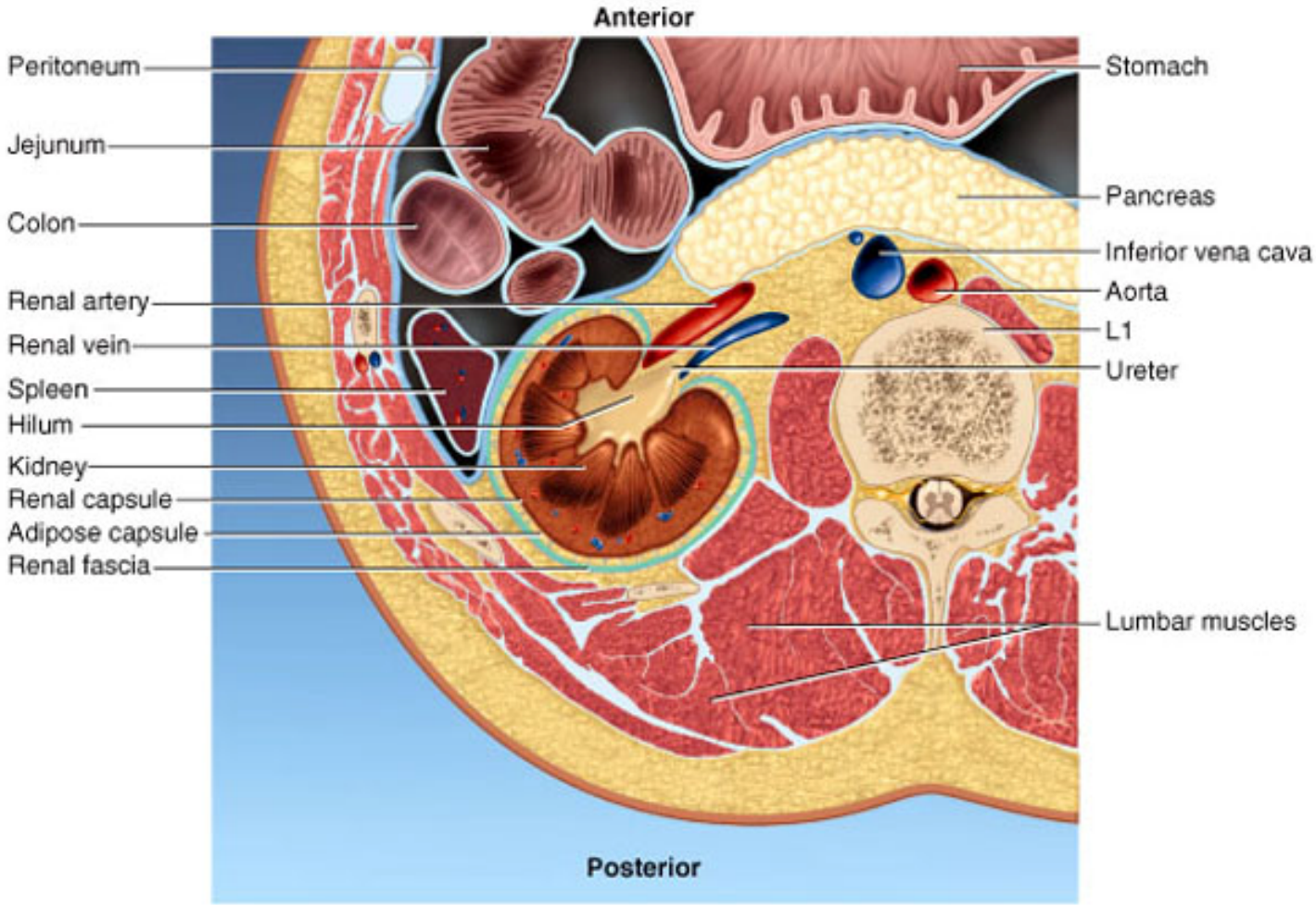


Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

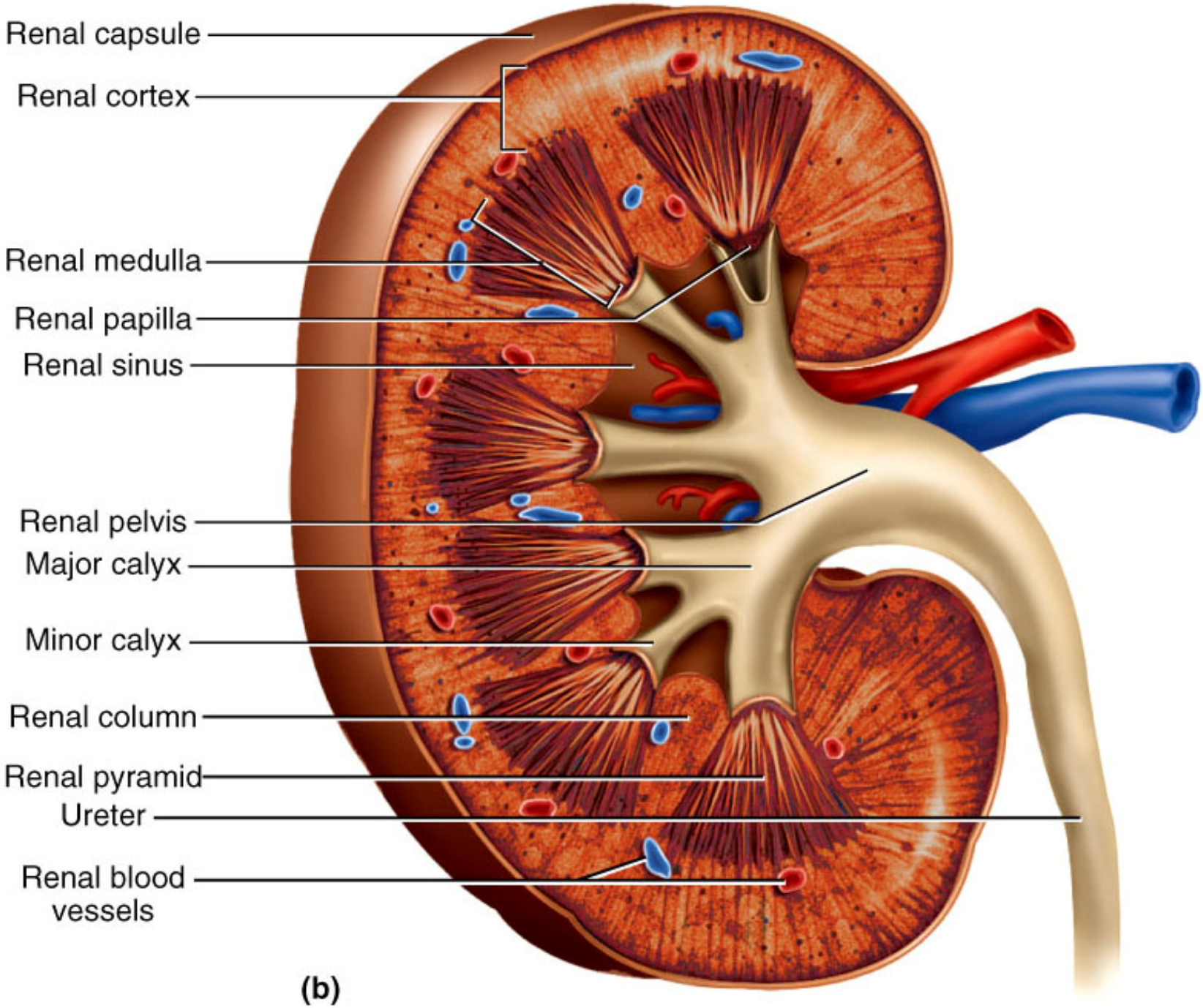


Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

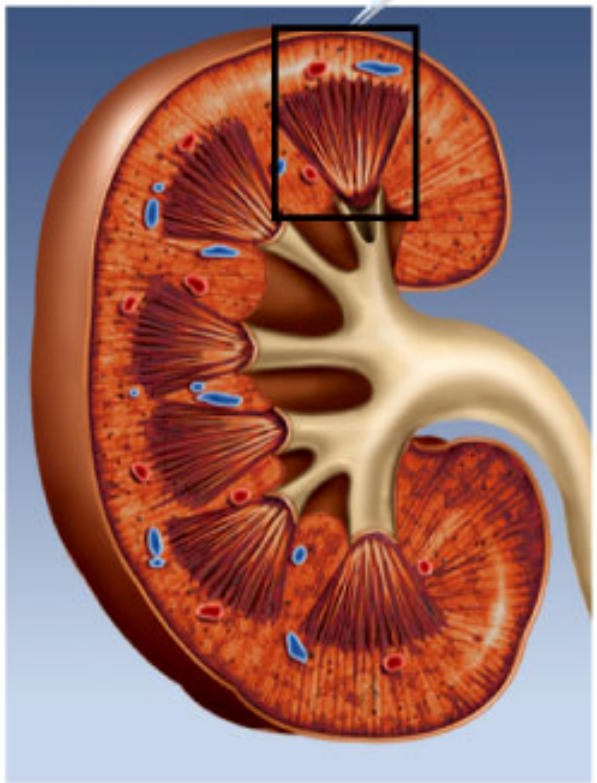


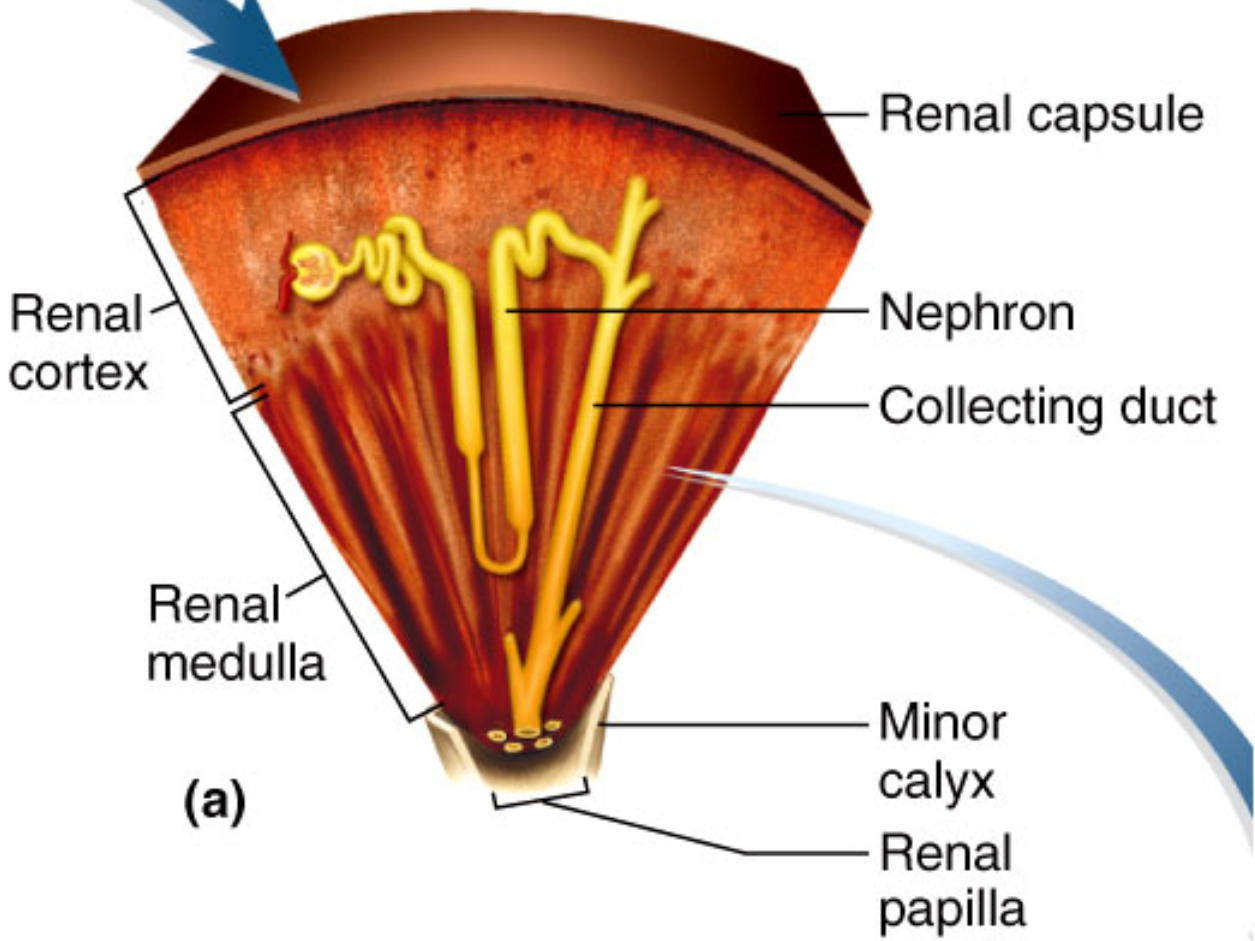


Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

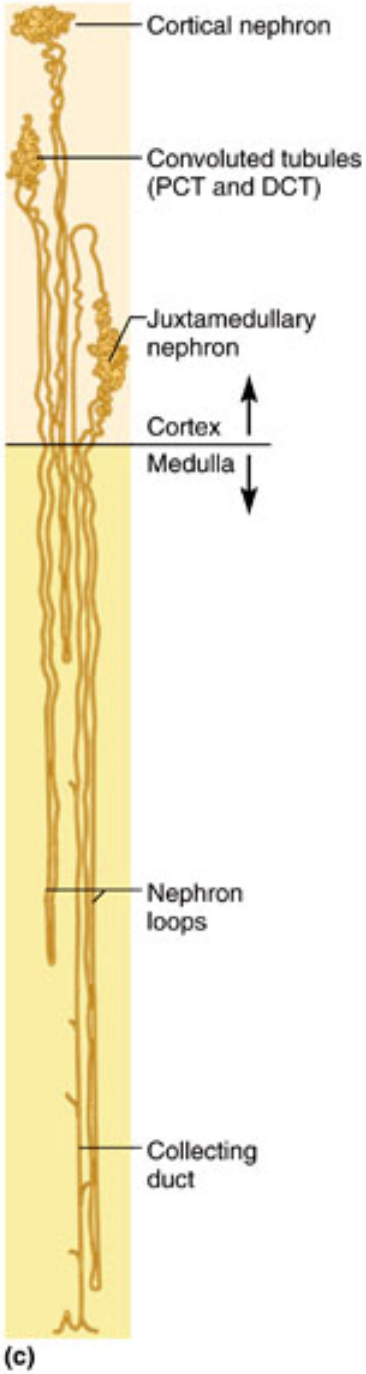


Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.





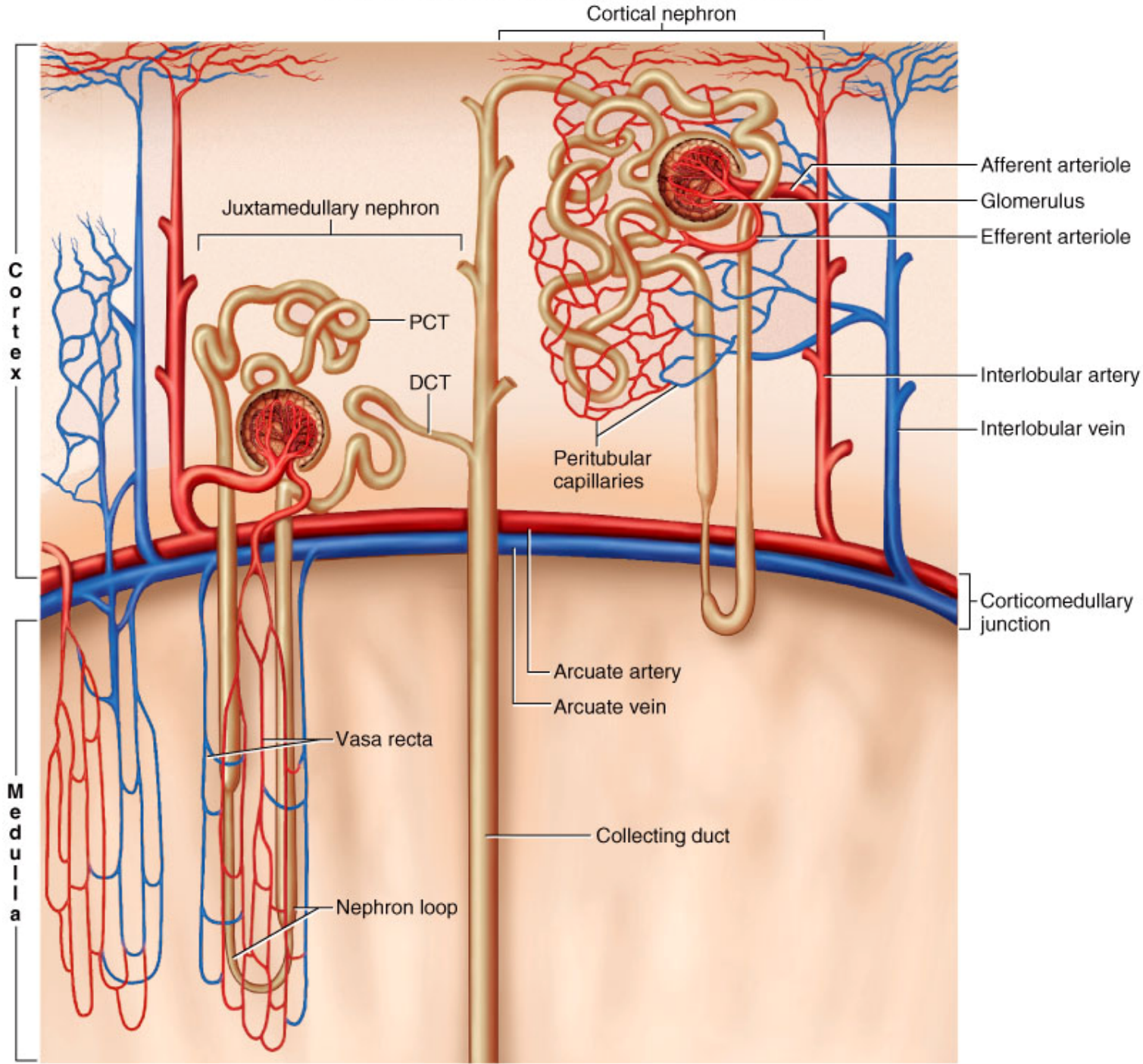
Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



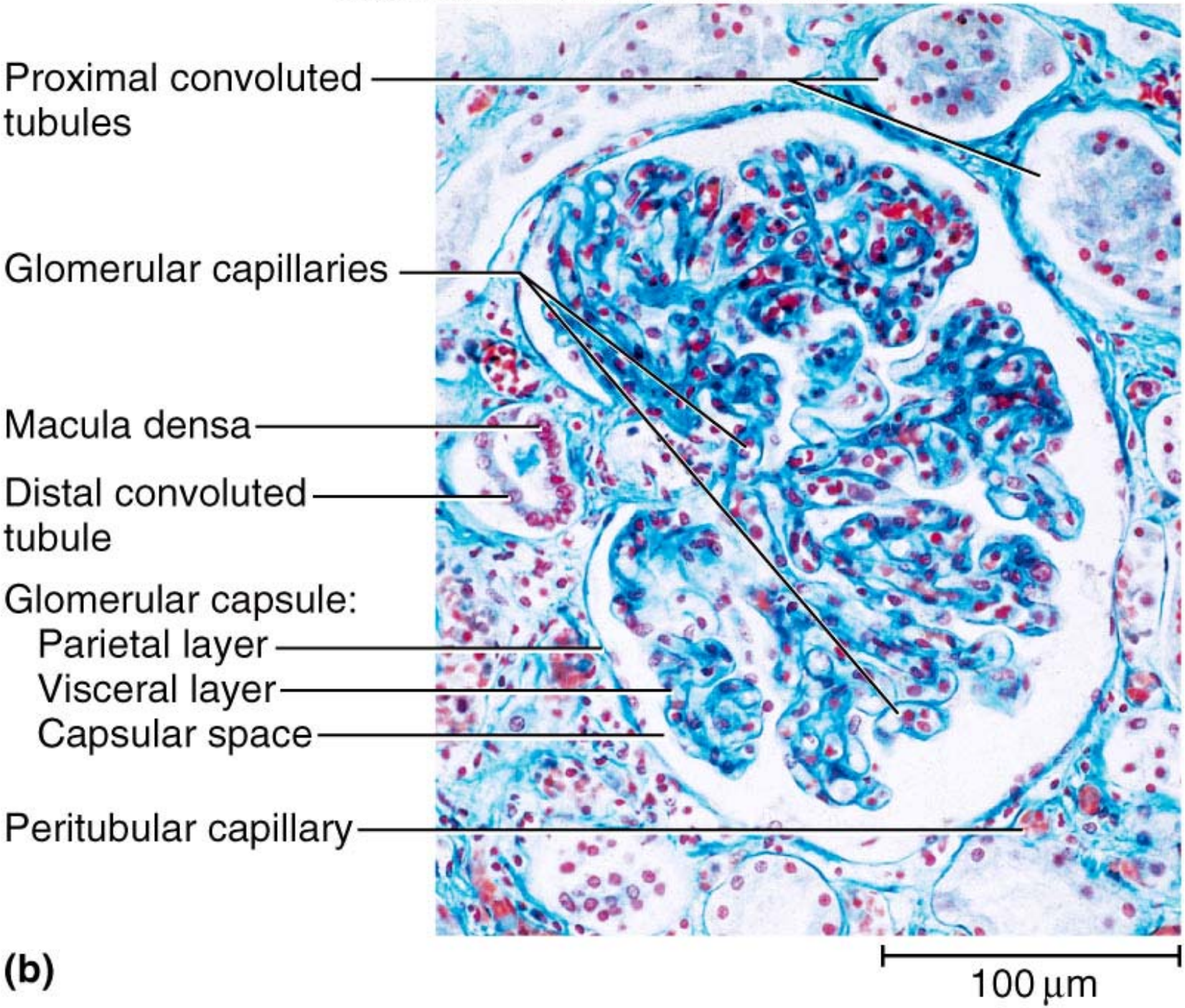
Two Different Type of Nephrons in the Kidneys

- The Cortical Nephrons (85%)
  - short nephron loops
  - efferent arterioles branch off peritubular capillaries
- The Juxtamedullary Nephrons (15%)
  - very long nephron loops, maintain salt gradient, helps conserve water
  - 1 to 2% blood flow
  - establish concentration gradient

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

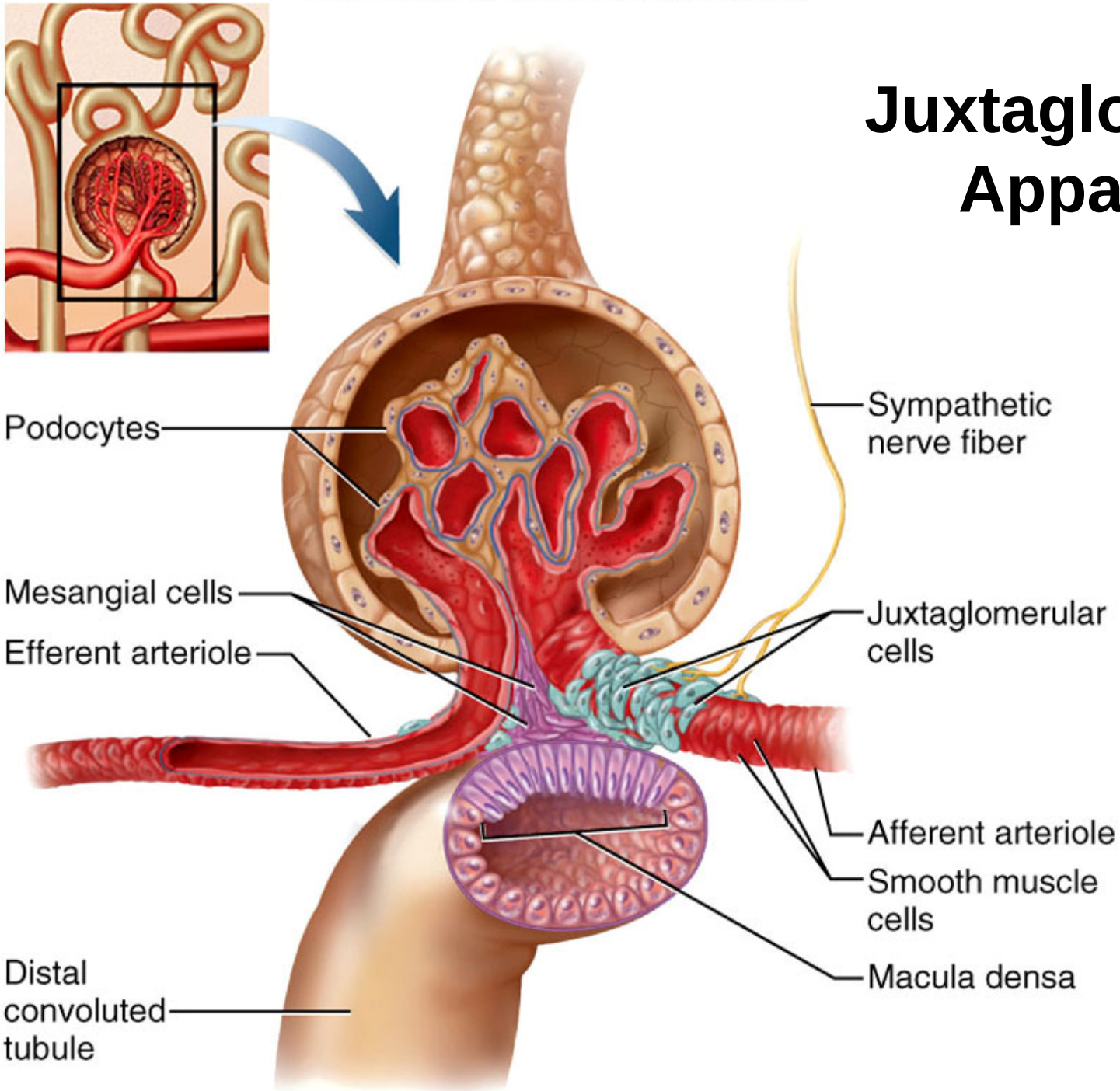


Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

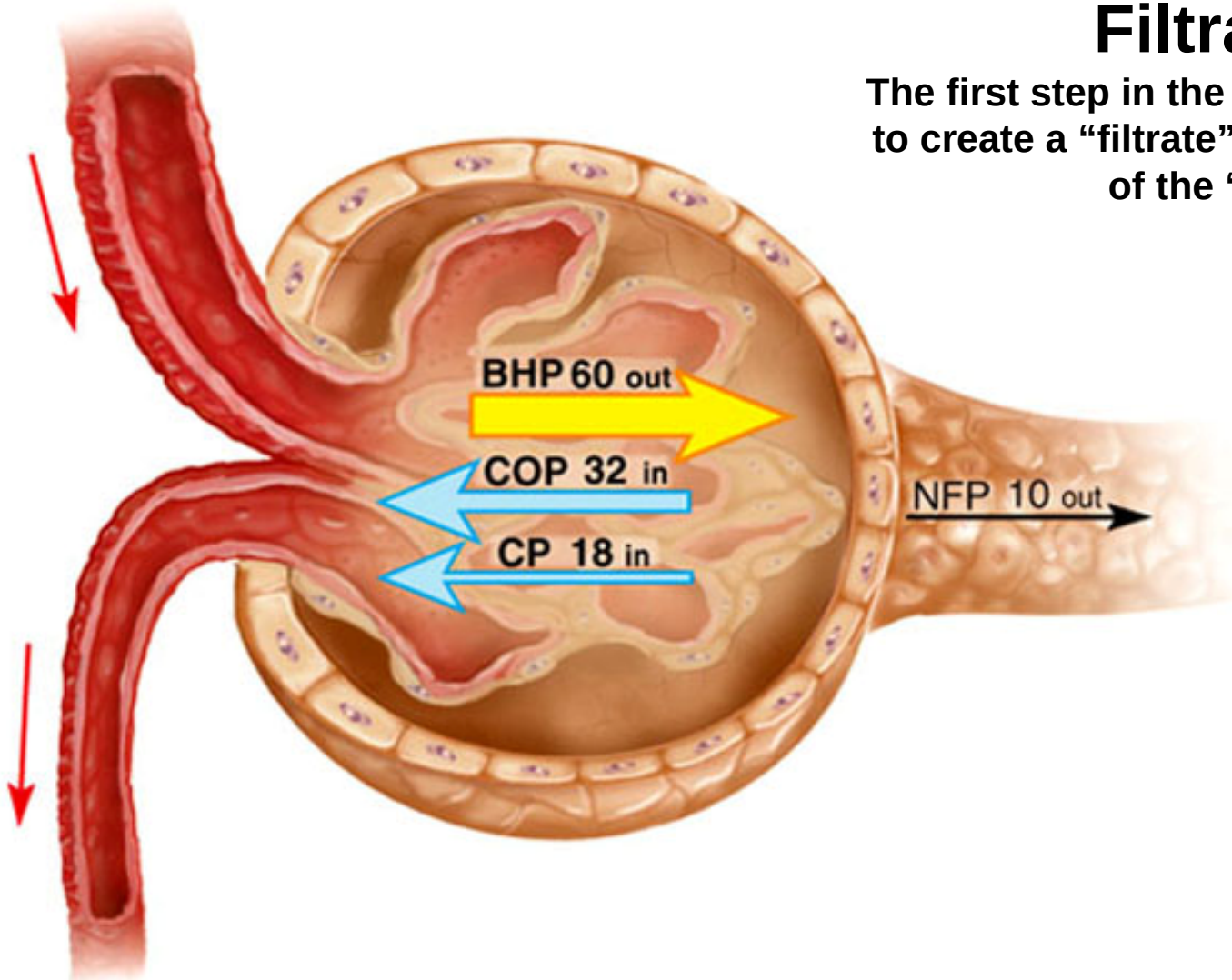
Juxtaglomerular Apparatus



Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

Filtration

The first step in the formation of urine is to create a "filtrate". This is the genisis of the "urine".



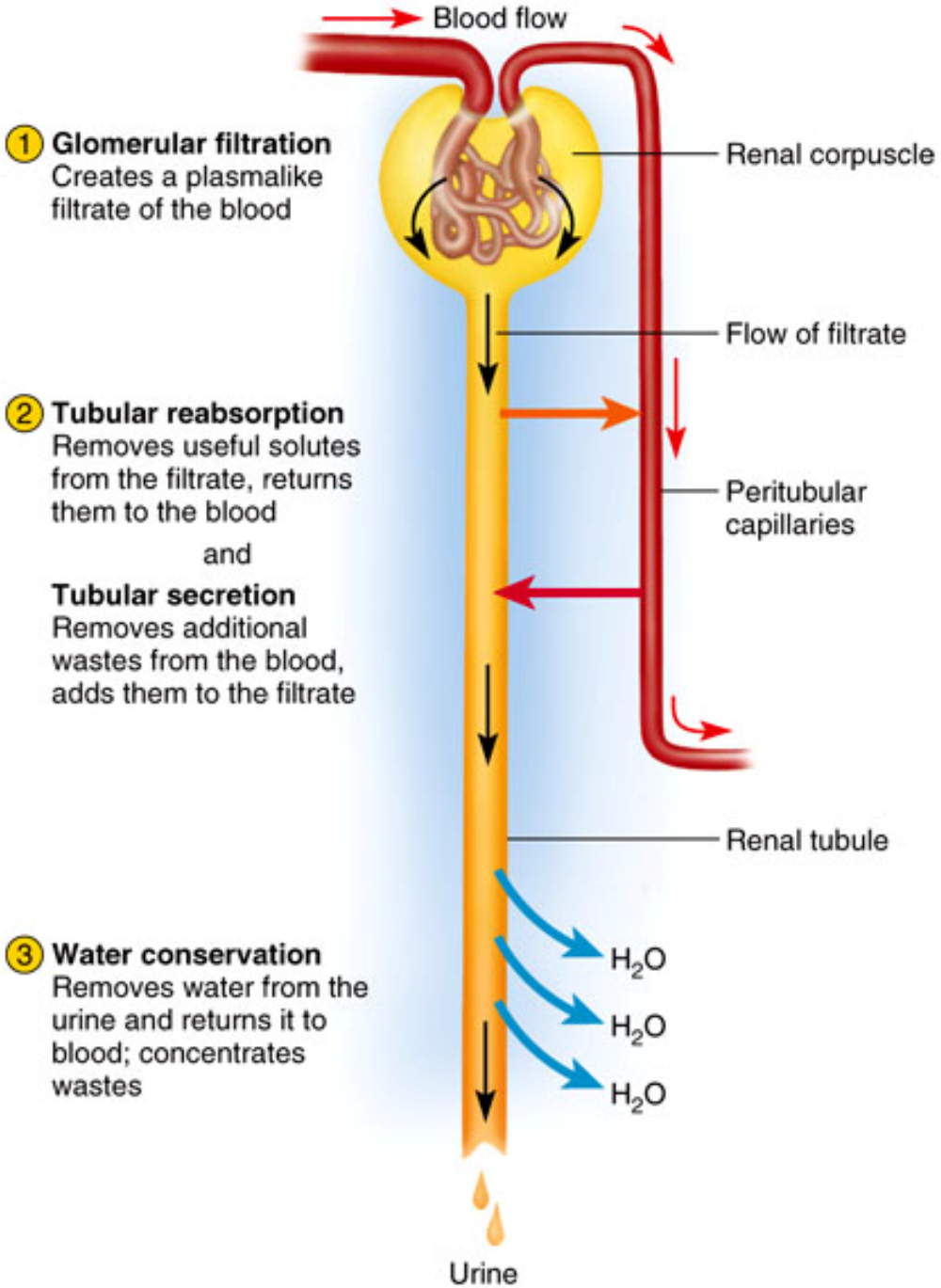
After filtration, the tubular structures (PCT, Loop of Henle, DCT) exchange fluid and solute between the tubules and the peritubular capillaries.

What remains in the Collecting Ducts is the urine.

Blood hydrostatic pressure (BHP)	60 mm Hg $_{out}$
Colloid osmotic pressure (COP)	–32 mm Hg $_{in}$
Capsular pressure (CP)	–18 mm Hg $_{in}$
Net filtration pressure (NFP)	10 mm Hg $_{out}$

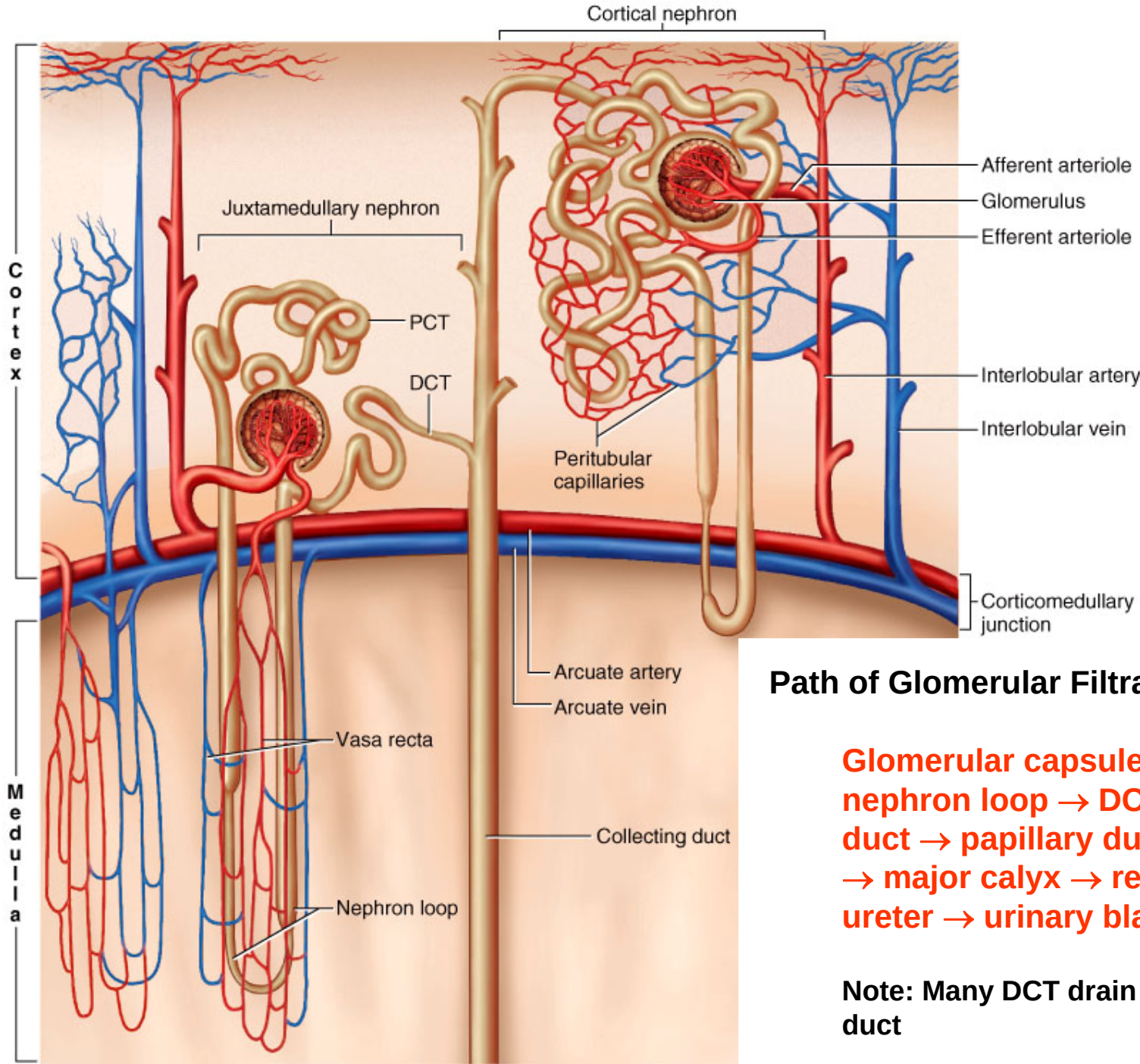
Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

Urine Formation



What term describes the anatomy of two separate capillary beds between an arteriole and a venuole?

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



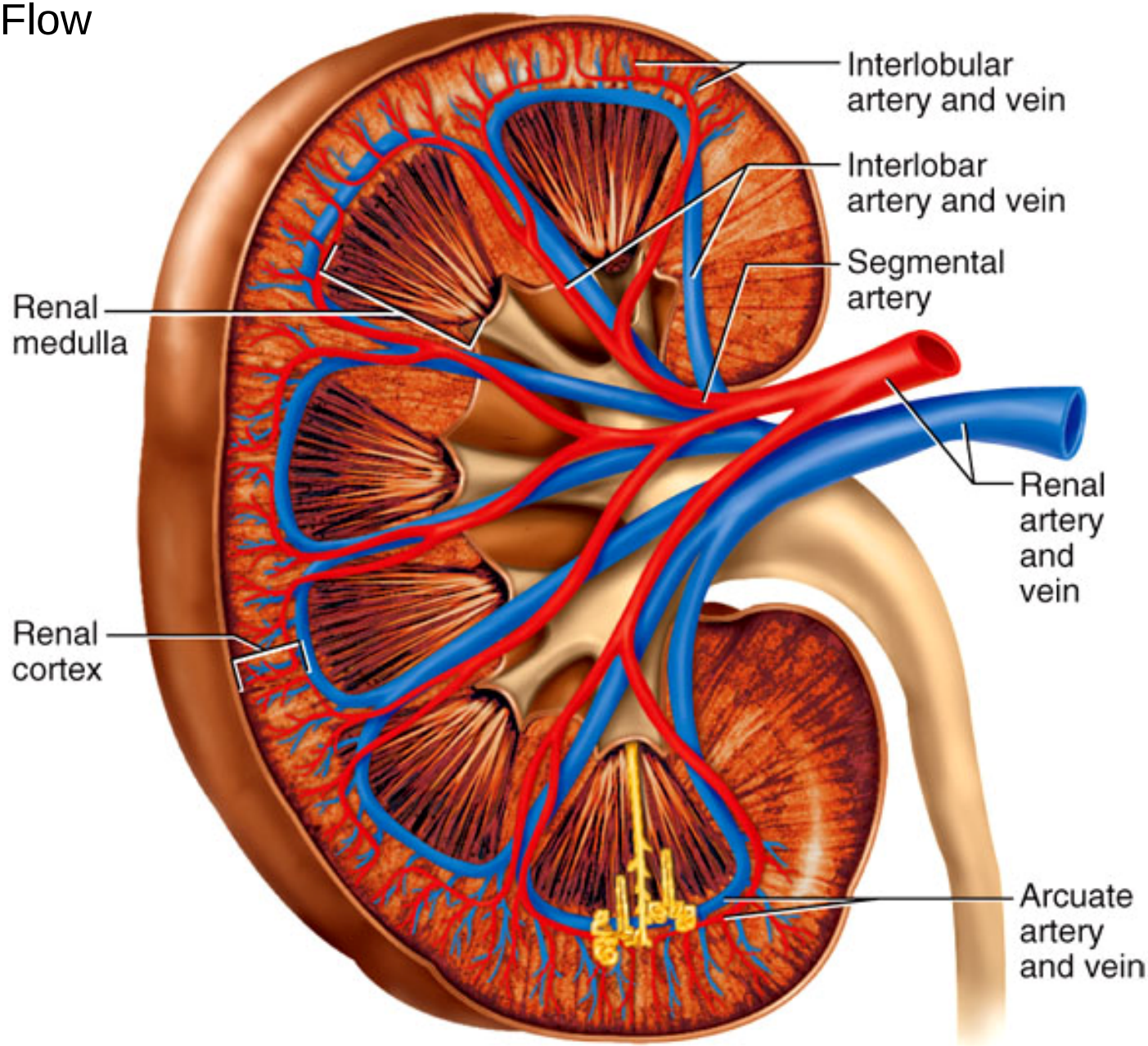
Path of Glomerular Filtrate:

Glomerular capsule → PCT → nephron loop → DCT → collecting duct → papillary duct → minor calyx → major calyx → renal pelvis → ureter → urinary bladder → urethra

Note: Many DCT drain into one Collecting duct

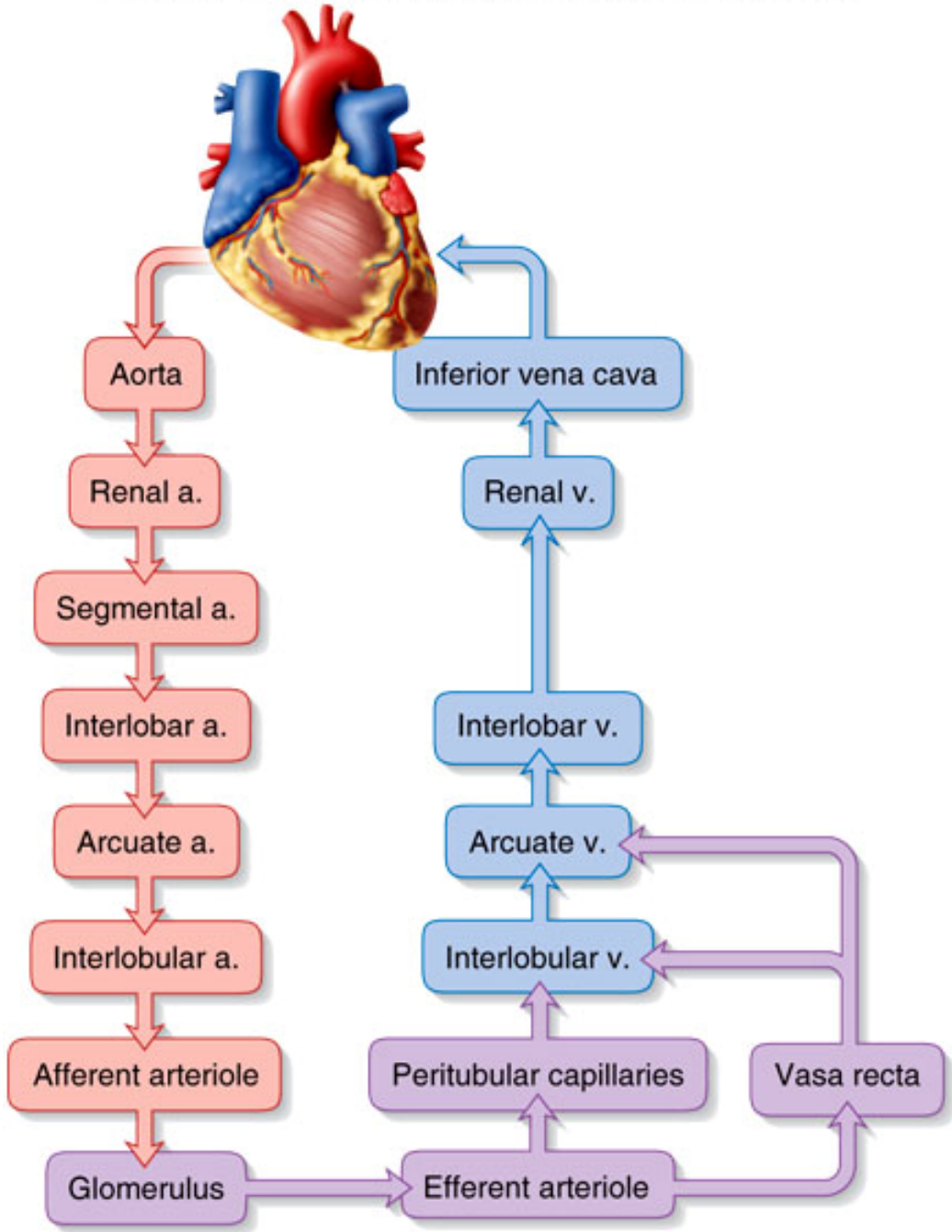
Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

Renal Blood Flow



(a)

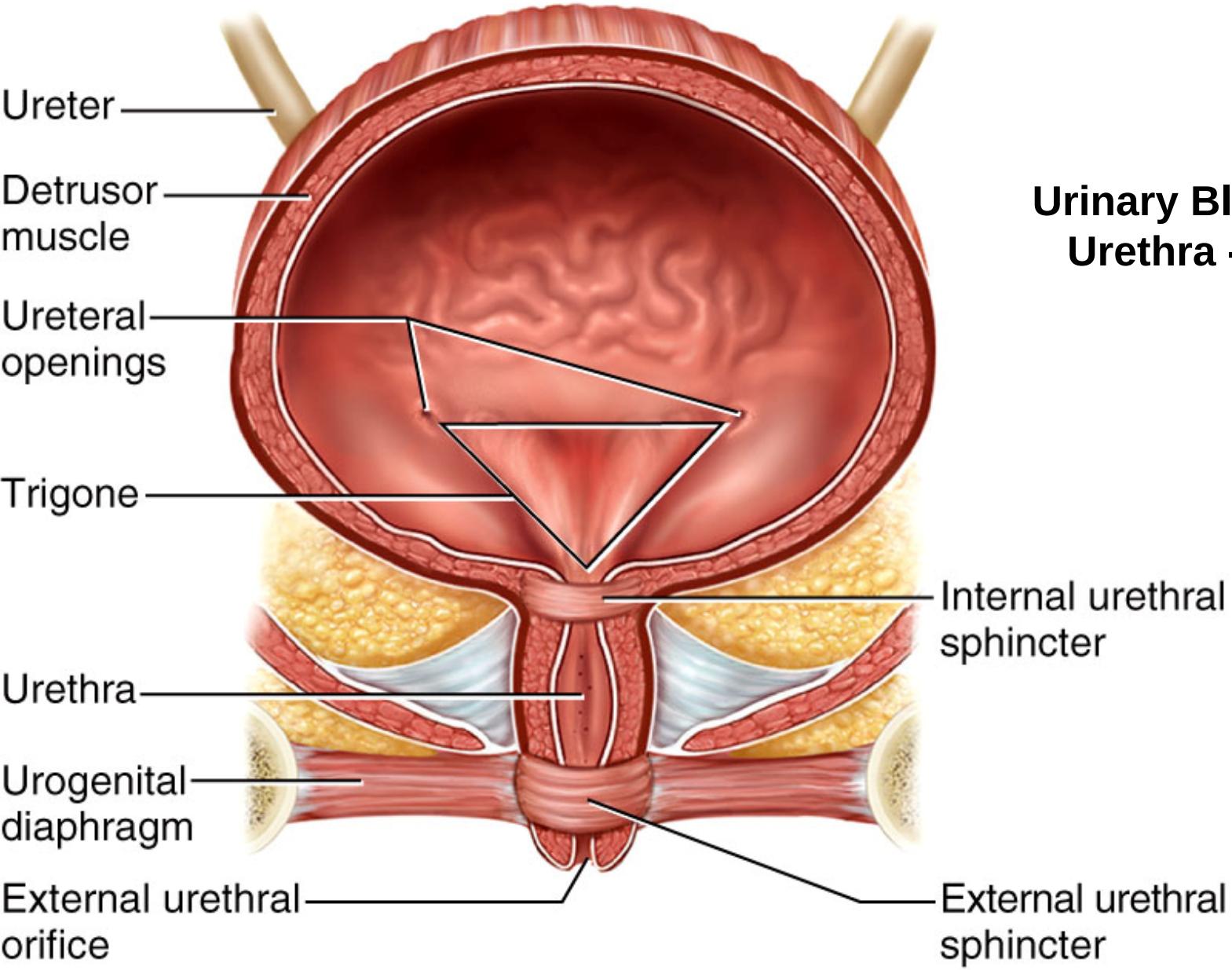
Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



(b)

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

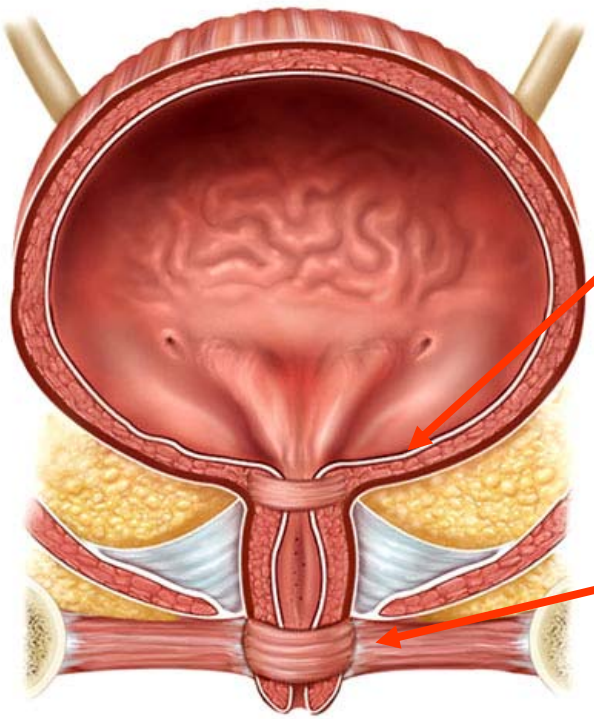
Urinary Bladder and Urethra - Female



(b) Female

Urethral Sphincter Muscles

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



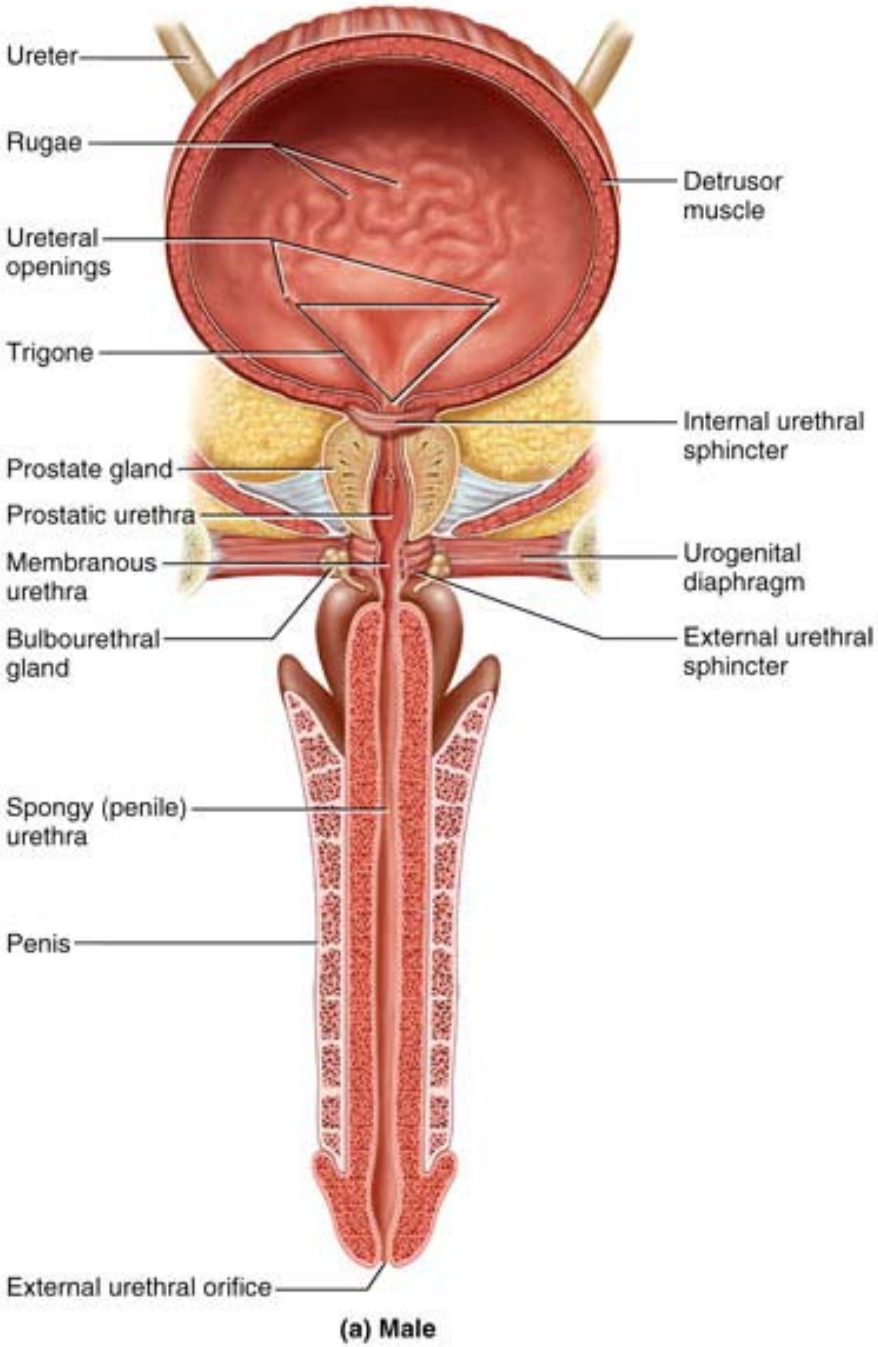
(b) Female

- 3 to 4 cm long
- External urethral orifice
  - between vaginal orifice and clitoris
- Internal urethral sphincter
  - detrusor muscle thickened, smooth muscle, involuntary control

External urethral sphincter
skeletal muscle, voluntary control

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

Male Bladder and Urethra



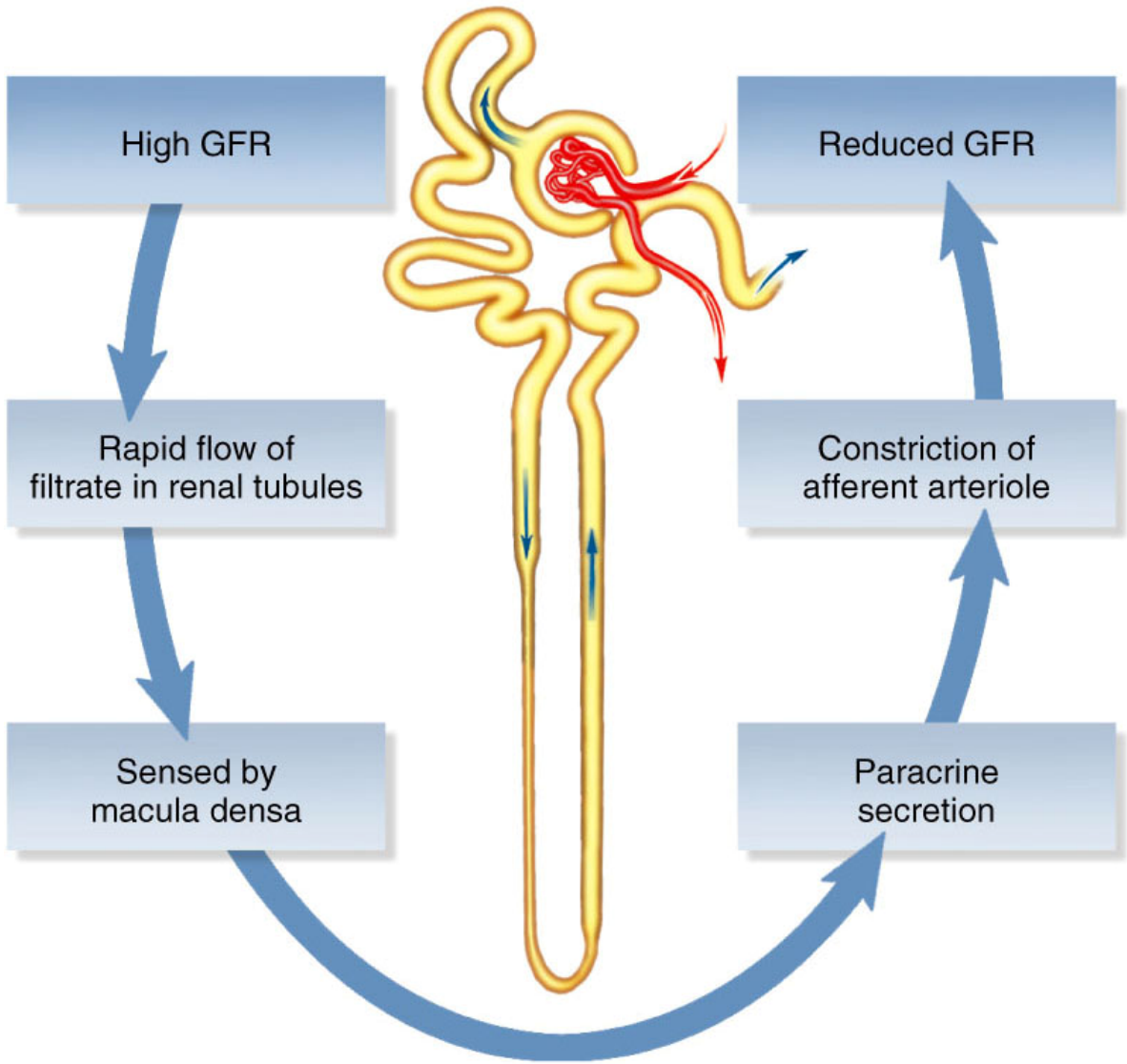
(a) Male

- 18 cm long
- Internal urethral sphincter
- External urethral sphincter

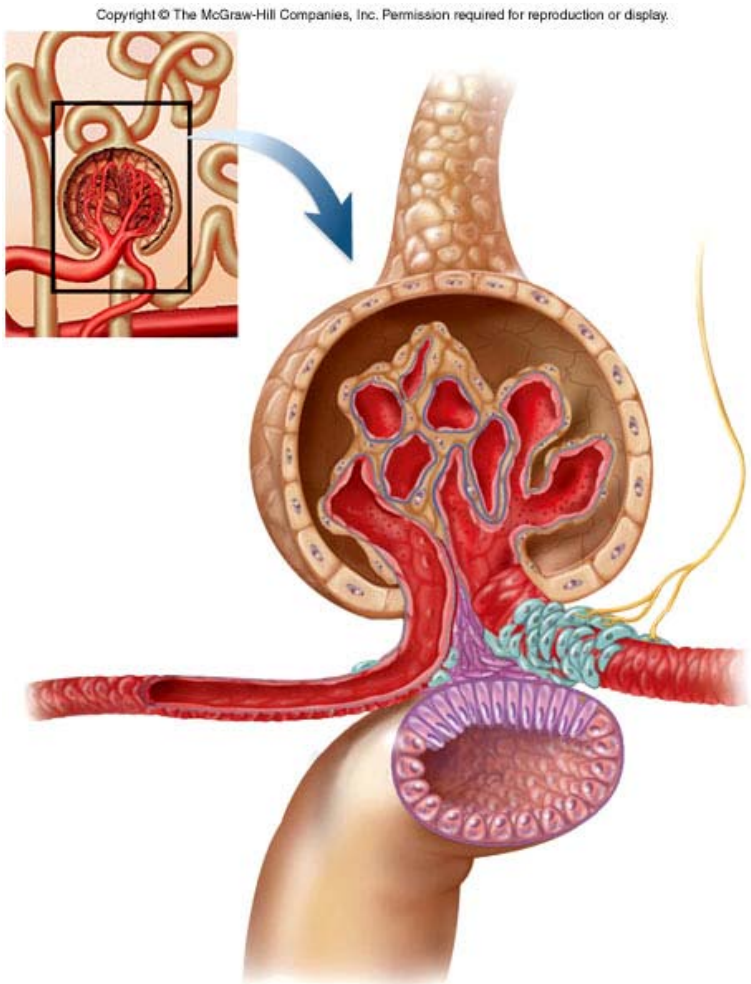
3 regions
- prostatic urethra
  - during orgasm
  - receives semen
- membranous urethra
  - passes through
  - pelvic cavity
- spongy urethra

Negative Feedback Control of GFR

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



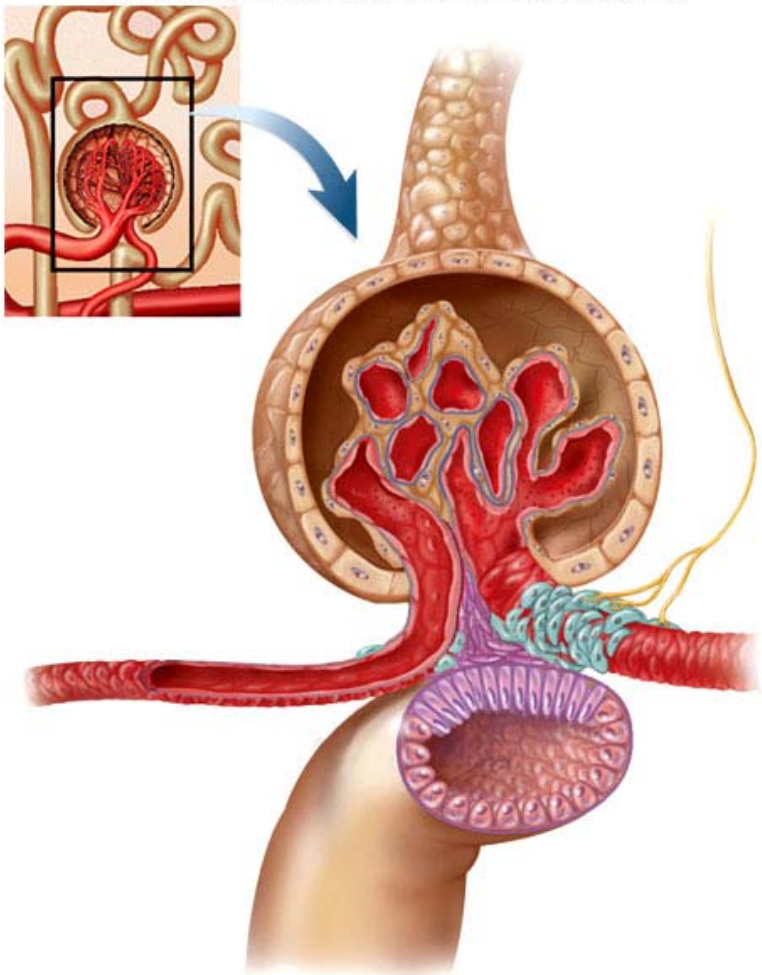
Renal Autoregulation of GFR (1 of 2)



- **Myogenic mechanism**
  - **increase in BP = increase filtration pressure = increase in GFR**
  - **change in blood pressure changes the "tension" within the smooth muscle of the afferent and efferent arterioles**
  - **restores normal GFR**
- **↑ BP → constrict afferent arteriole & dilate efferent**
- **↓ BP → dilate afferent arteriole & constrict efferent**
- **Stable for BP range of 80 to 170 mmHg (systolic)**
- **Cannot compensate for extreme BP**

Renal Autoregulation of GFR (2 of 2)

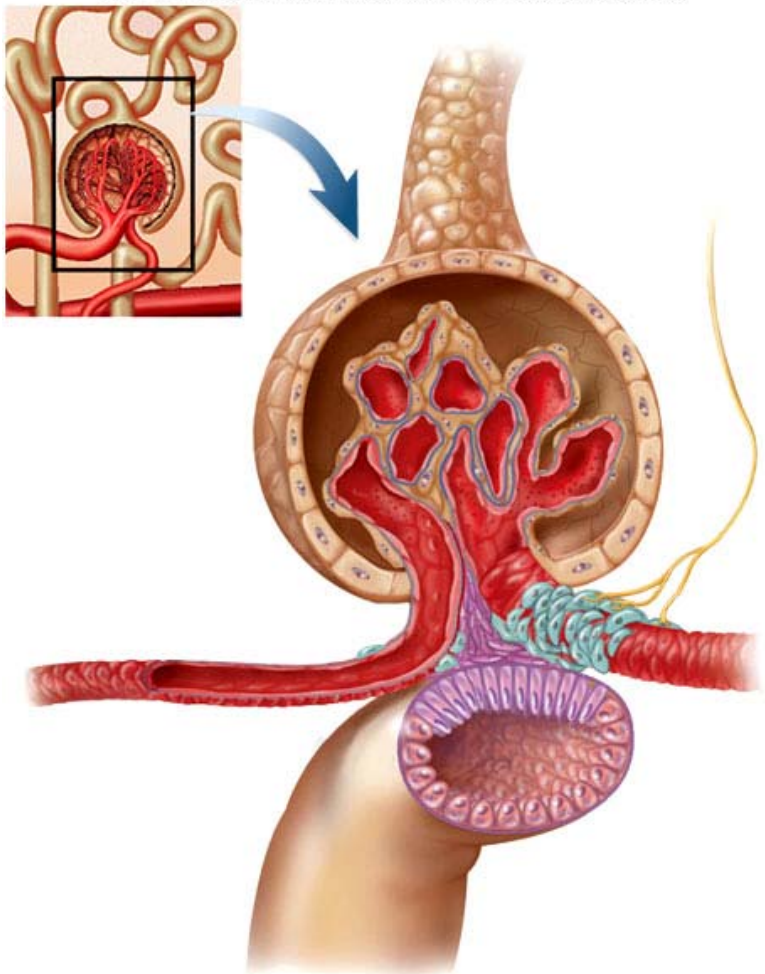
Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



- **Tubuloglomerular Feedback**
  - **Macula densa on DCT monitors tubular fluid**
  - **Uses paracrine messengers**
  - **signals juxtaglomerular cells (enlarged smooth muscle cells, surrounding afferent arterioles and lesser extent efferent arterioles) to constrict afferent arteriole to ↓ GFR**

Sympathetic Control of GFR

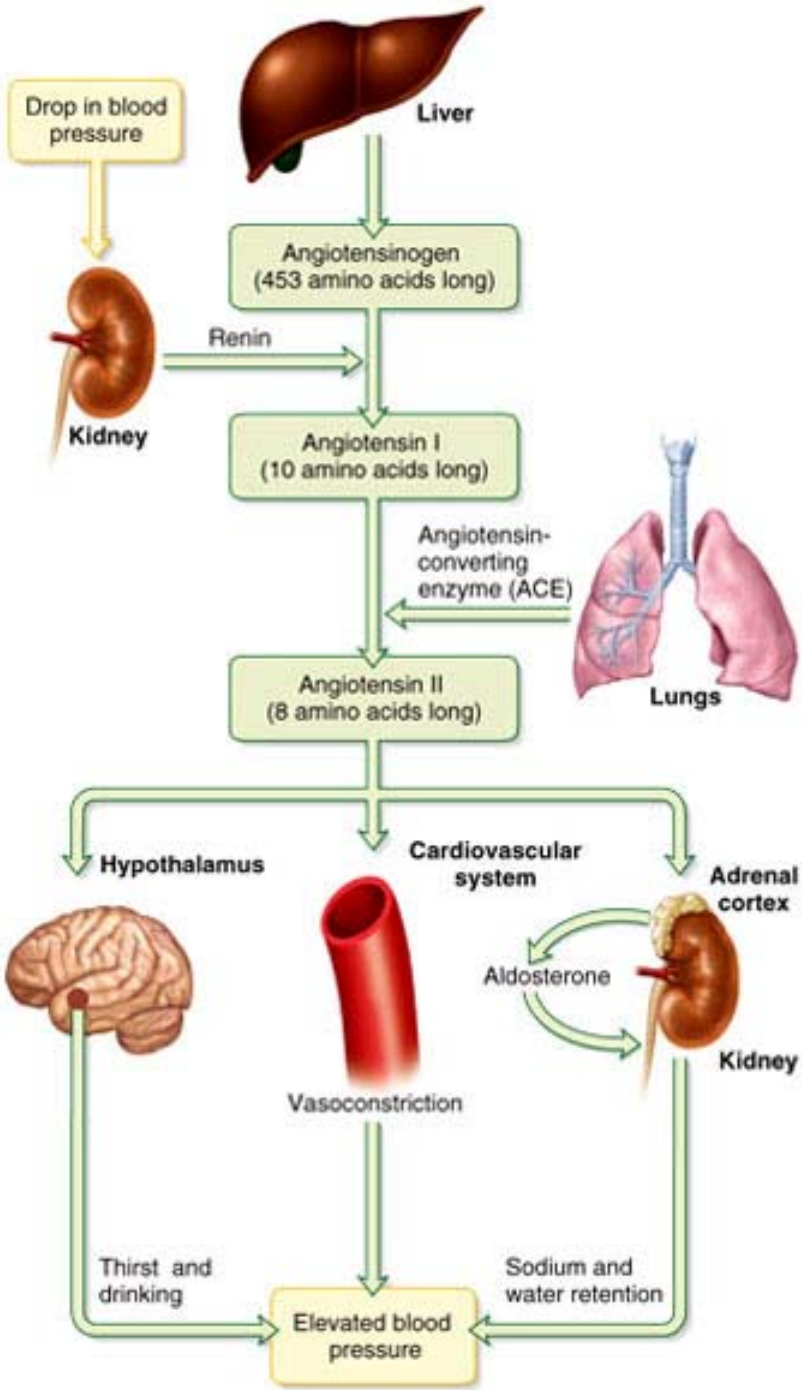
Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



- **Strenuous exercise or acute conditions (circulatory shock) stimulate afferent arterioles to constrict**
- **↓ GFR and urine production, redirecting blood flow to heart, brain and skeletal muscles**
- **Kidney = 4% body wt but receives 21% of cardiac output under normal resting state**

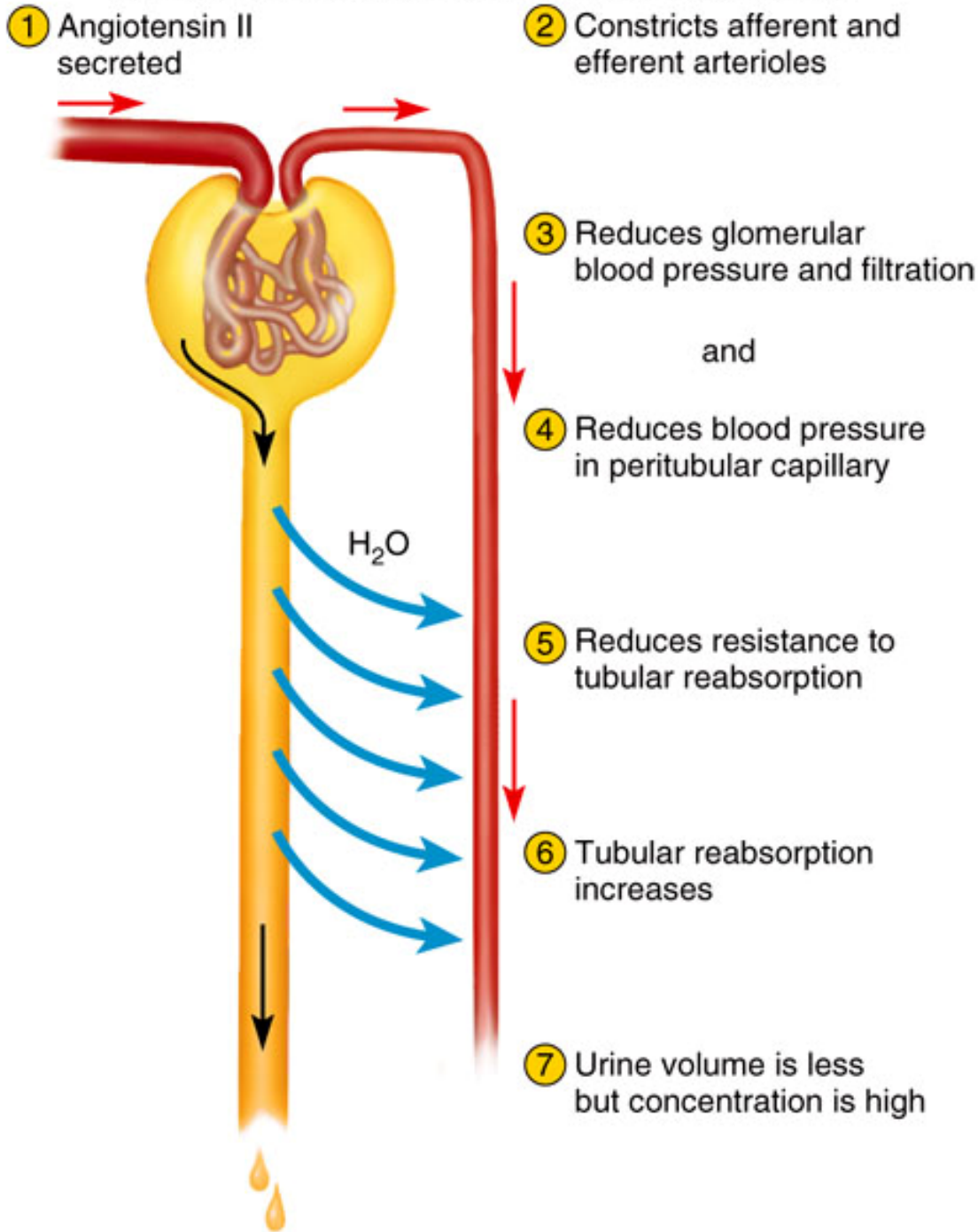
Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

Renin-Angiotensin-Aldosterone

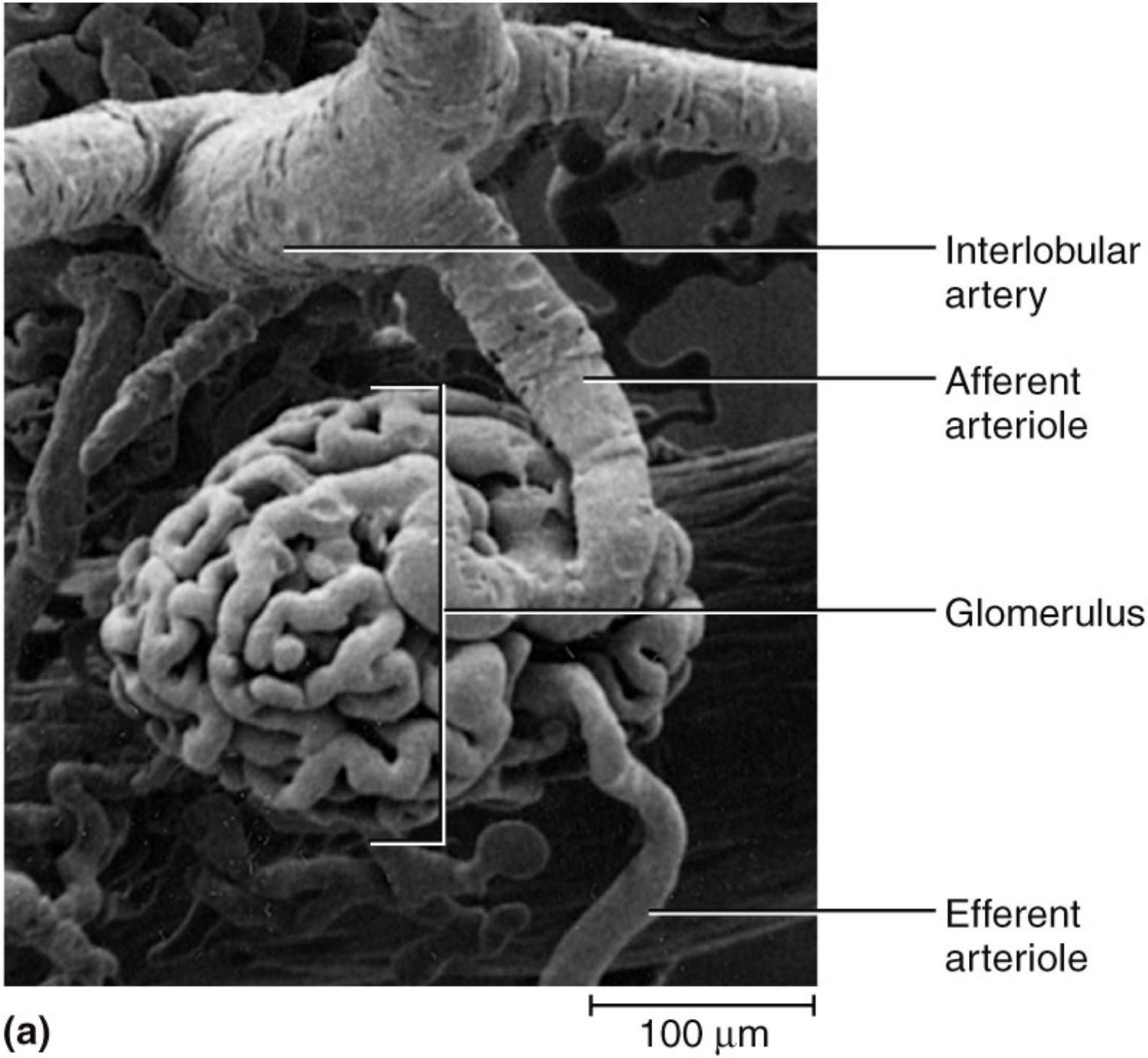


Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

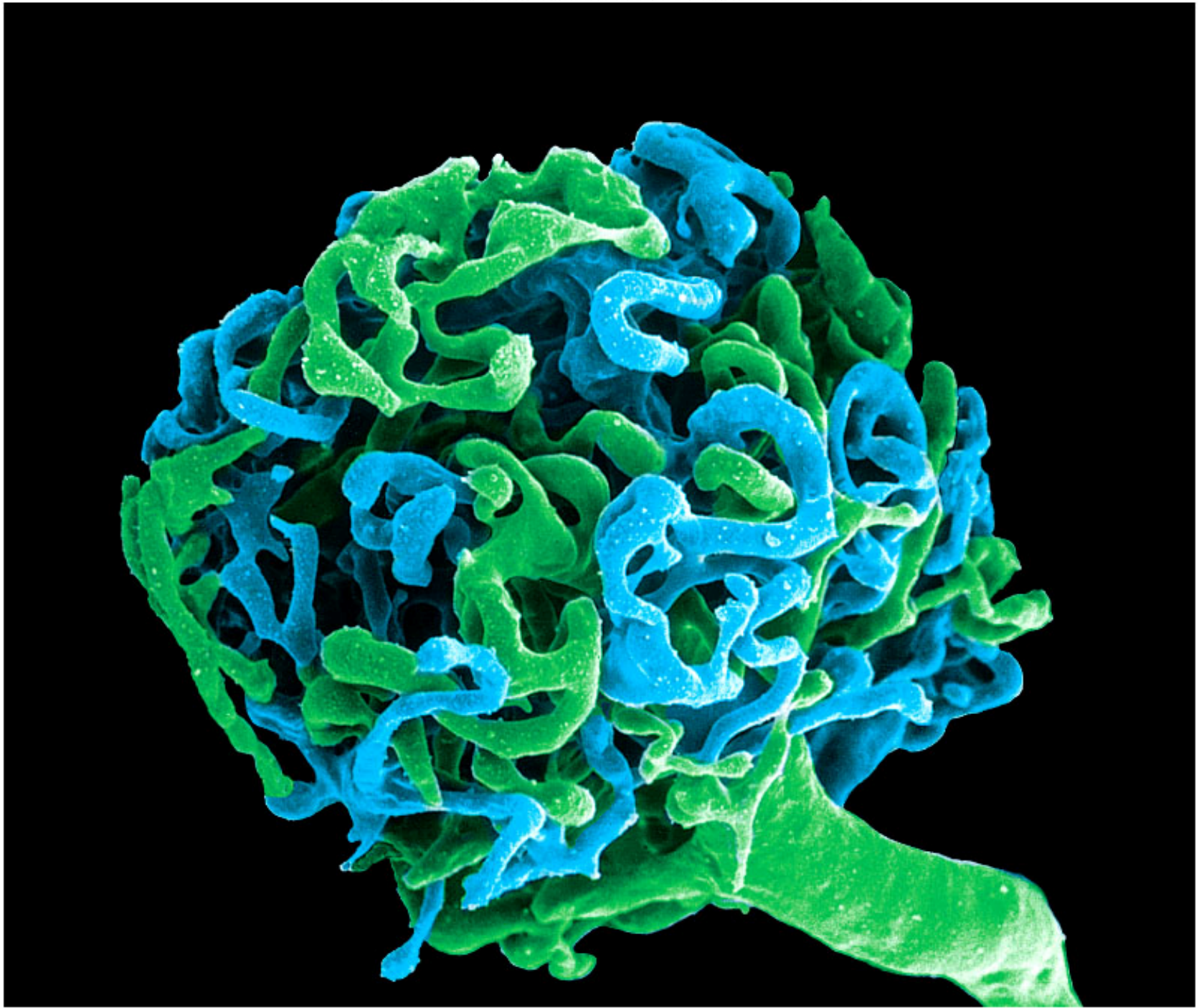
Effects of Angiotensin II



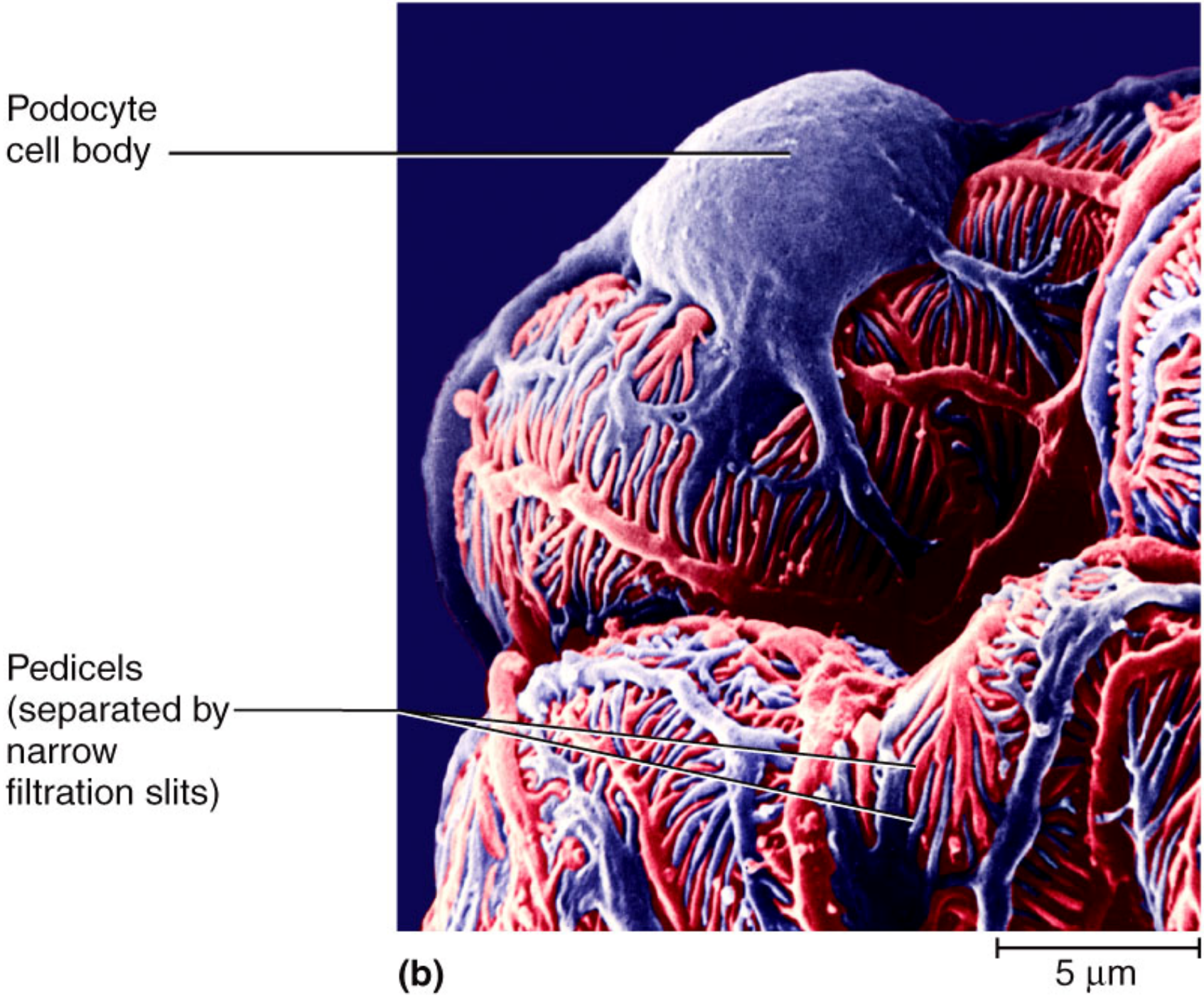
Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

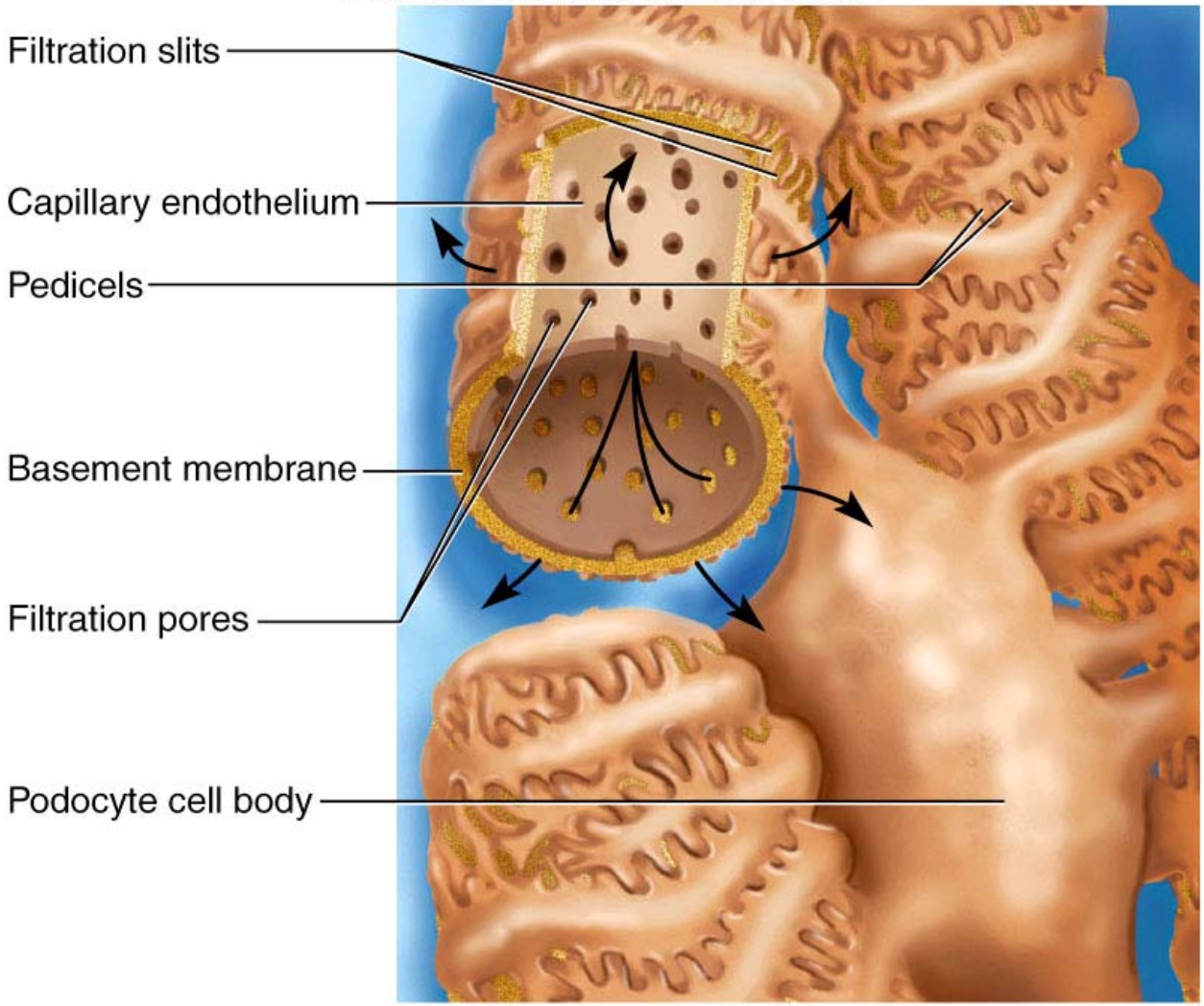


Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



Filtration Membrane

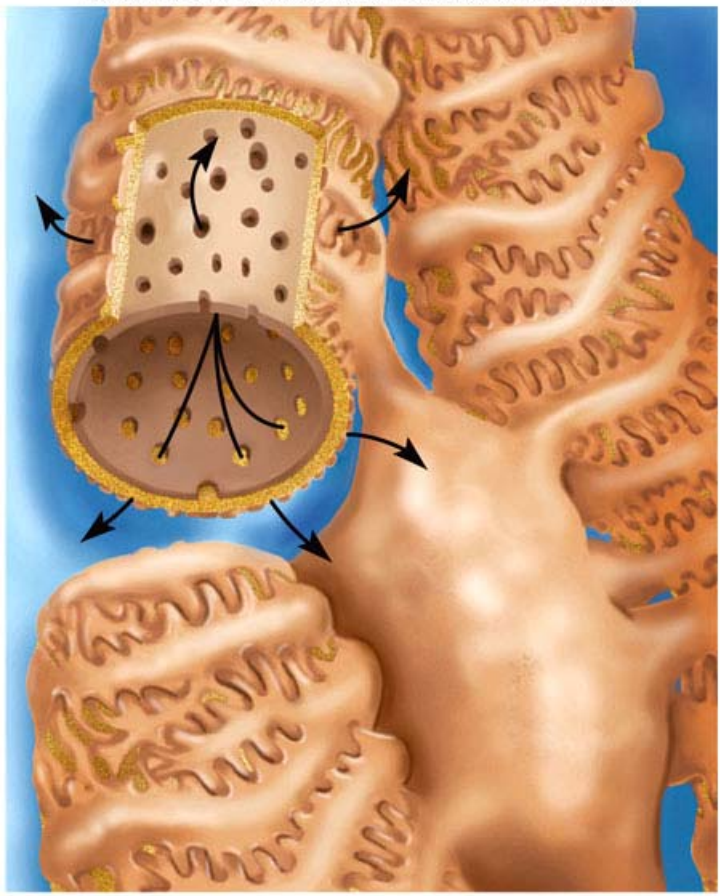
Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



(d)

Filtration Membrane

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

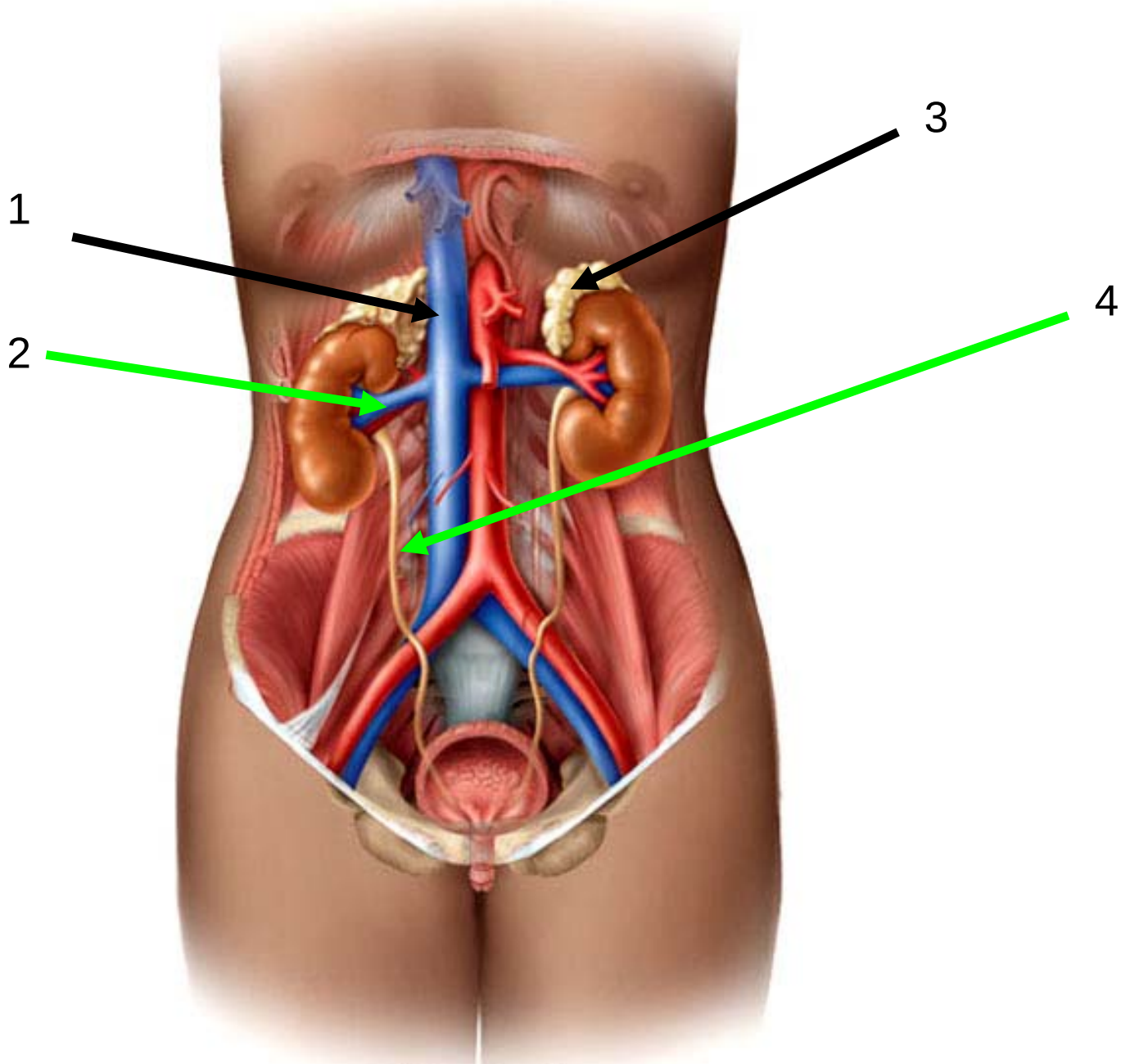


(d)

- **Fenestrated endothelium**
  - **70-90nm pores exclude blood cells**
- **Basement membrane**
  - **proteoglycan gel**
  - **negative charge**
  - **excludes molecules > 8nm**
  - **blood plasma 7% protein**
  - **glomerular filtrate 0.03%**
- **Filtration slits**
  - **podocyte arms have pedicels**
  - **negatively charged filtration slits**
  - **allow particles < 3nm to pass**

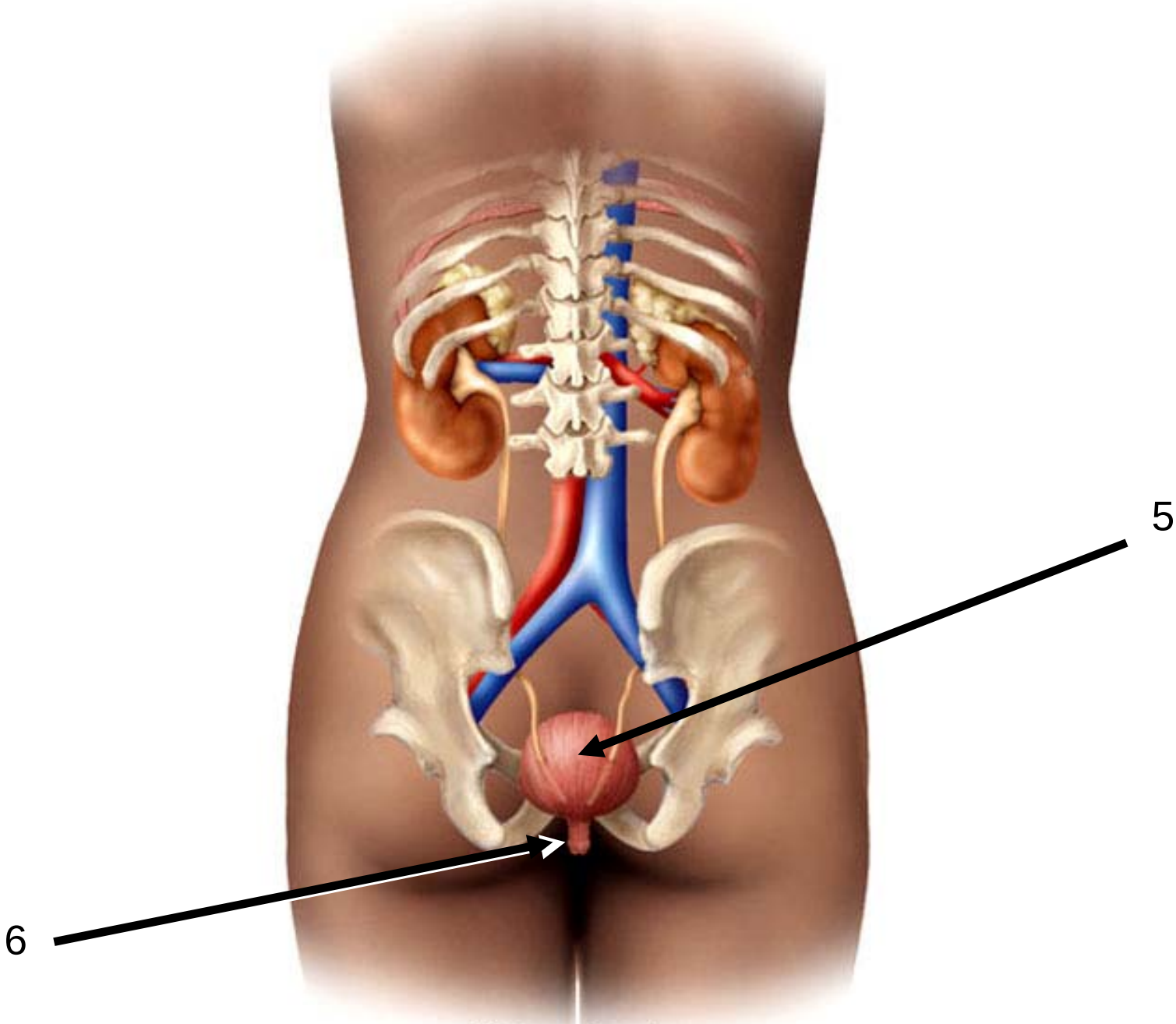
Quiz

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



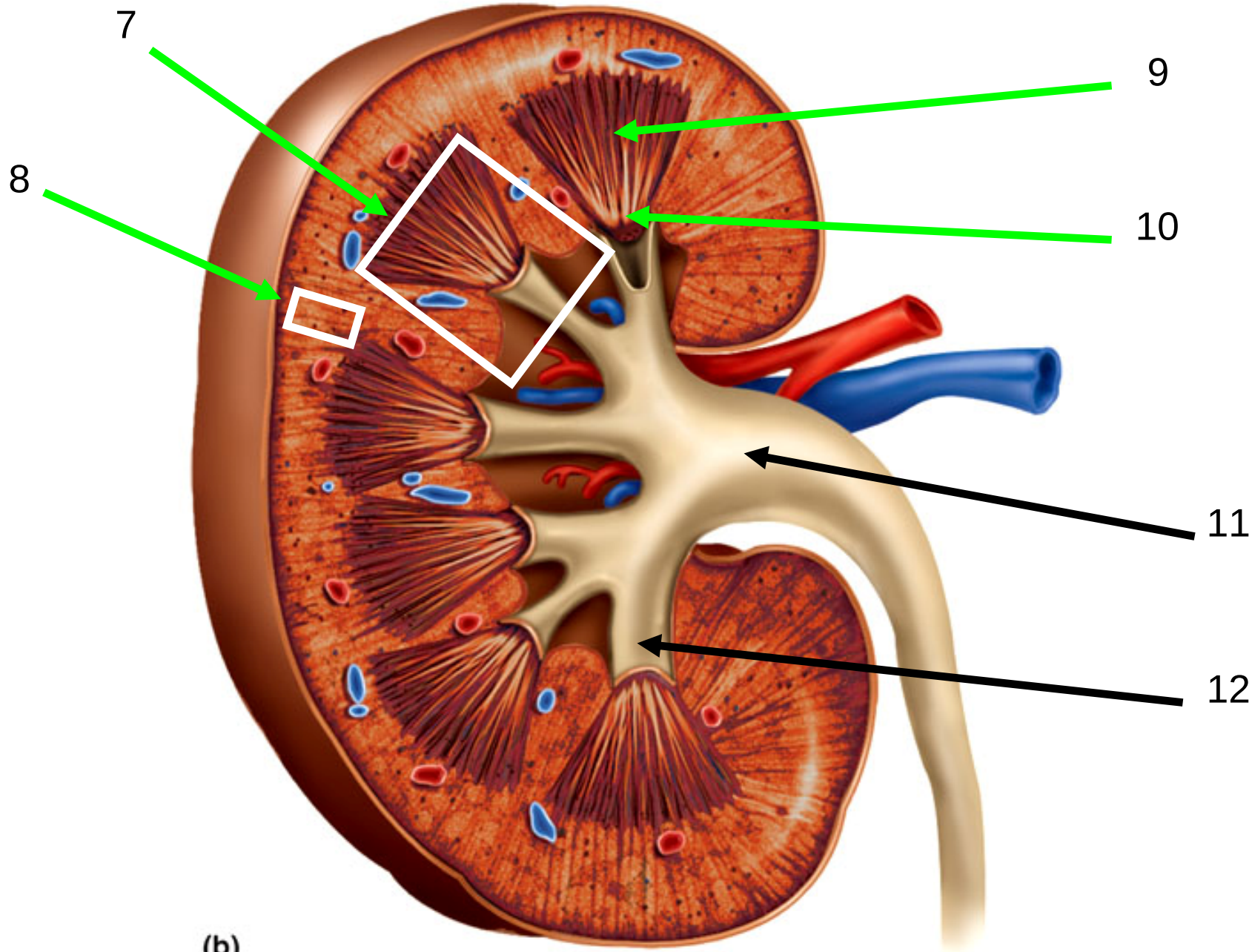
(a) Anterior view

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

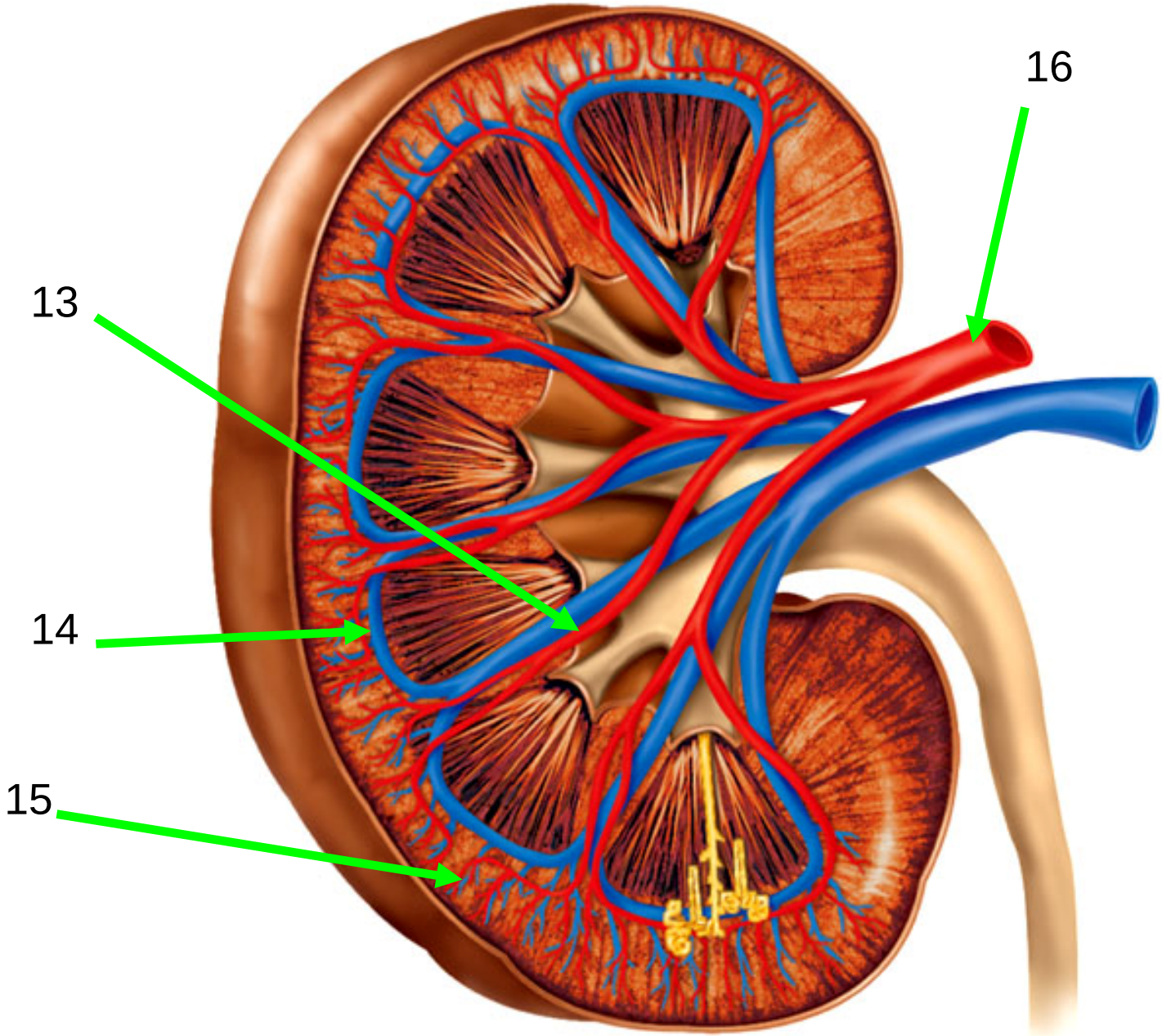


(b) Posterior view

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



(a)

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.