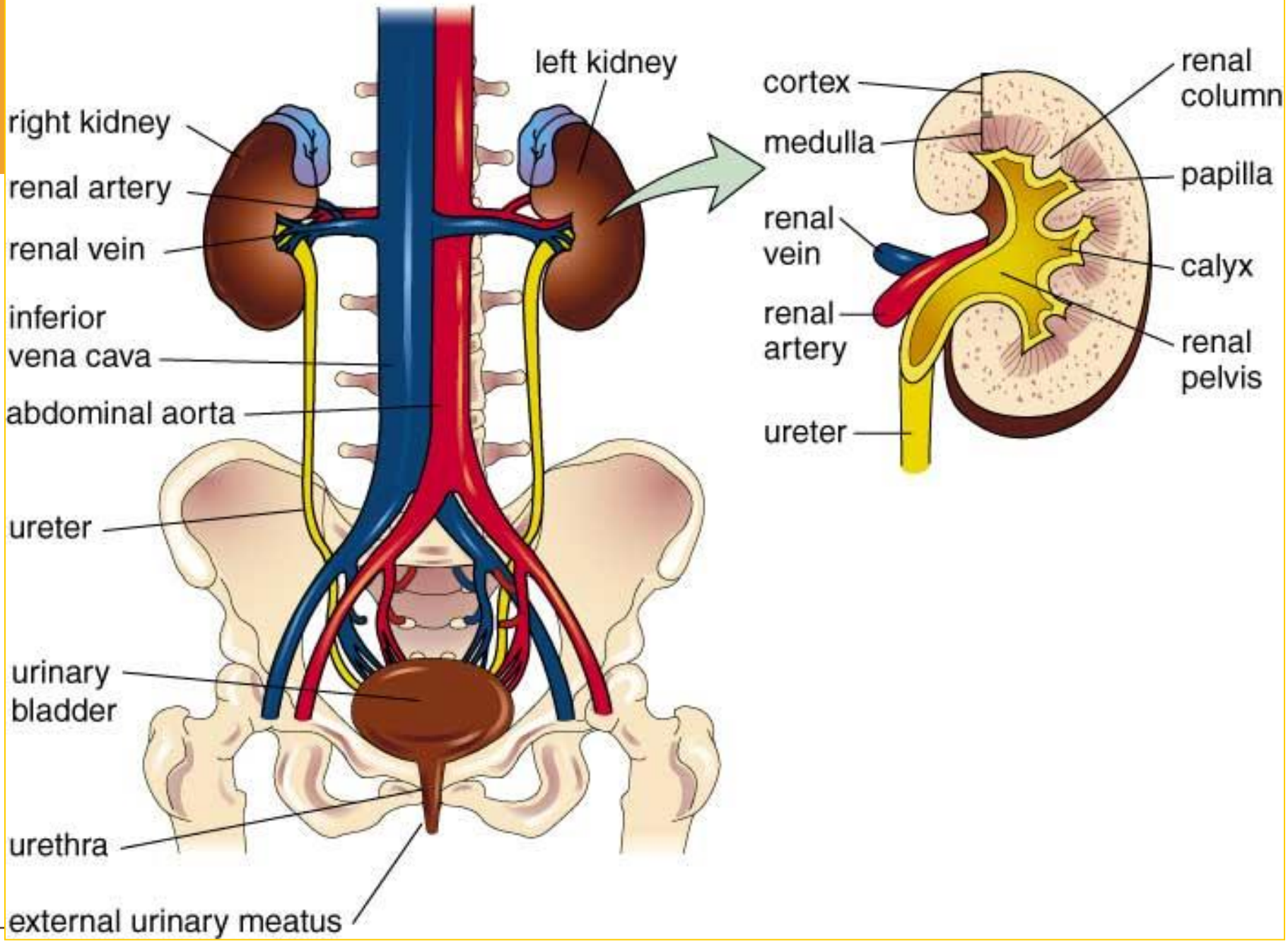
Chapter 14
The Urinary System

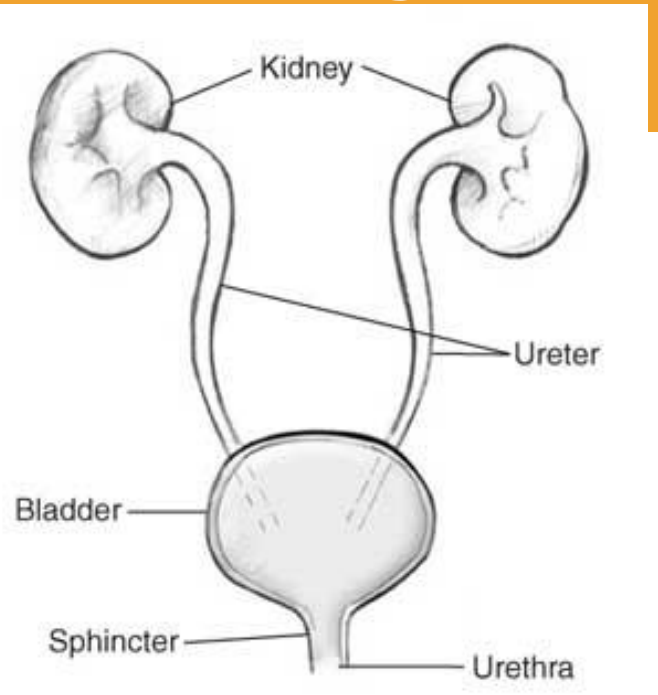
Anatomy

14.1 Overview

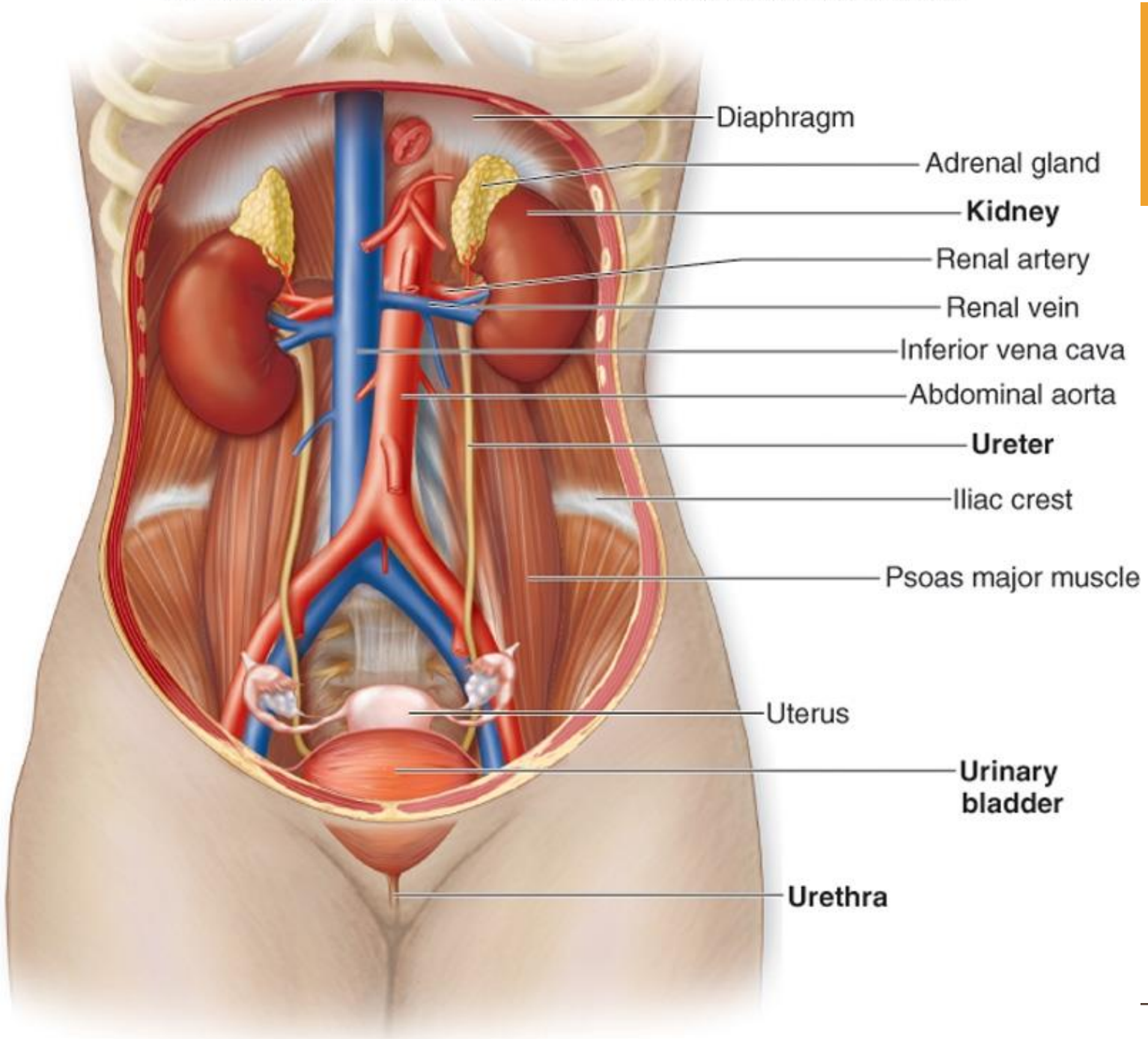
- Role in removal of wastes to maintain homeostasis
  - Acts as filtering system of the blood
    - Produces urine
- Removes wastes, maintains pH, electrolyte composition, and water content of blood


left kidney
right kidney
renal artery
renal vein
inferior vena cava
abdominal aorta
ureter
urinary bladder
urethra
external urinary meatus
cortex
medulla
renal vein
renal artery
ureter
renal column
papilla
calyx
renal pelvis

Gross Anatomy of Urinary System



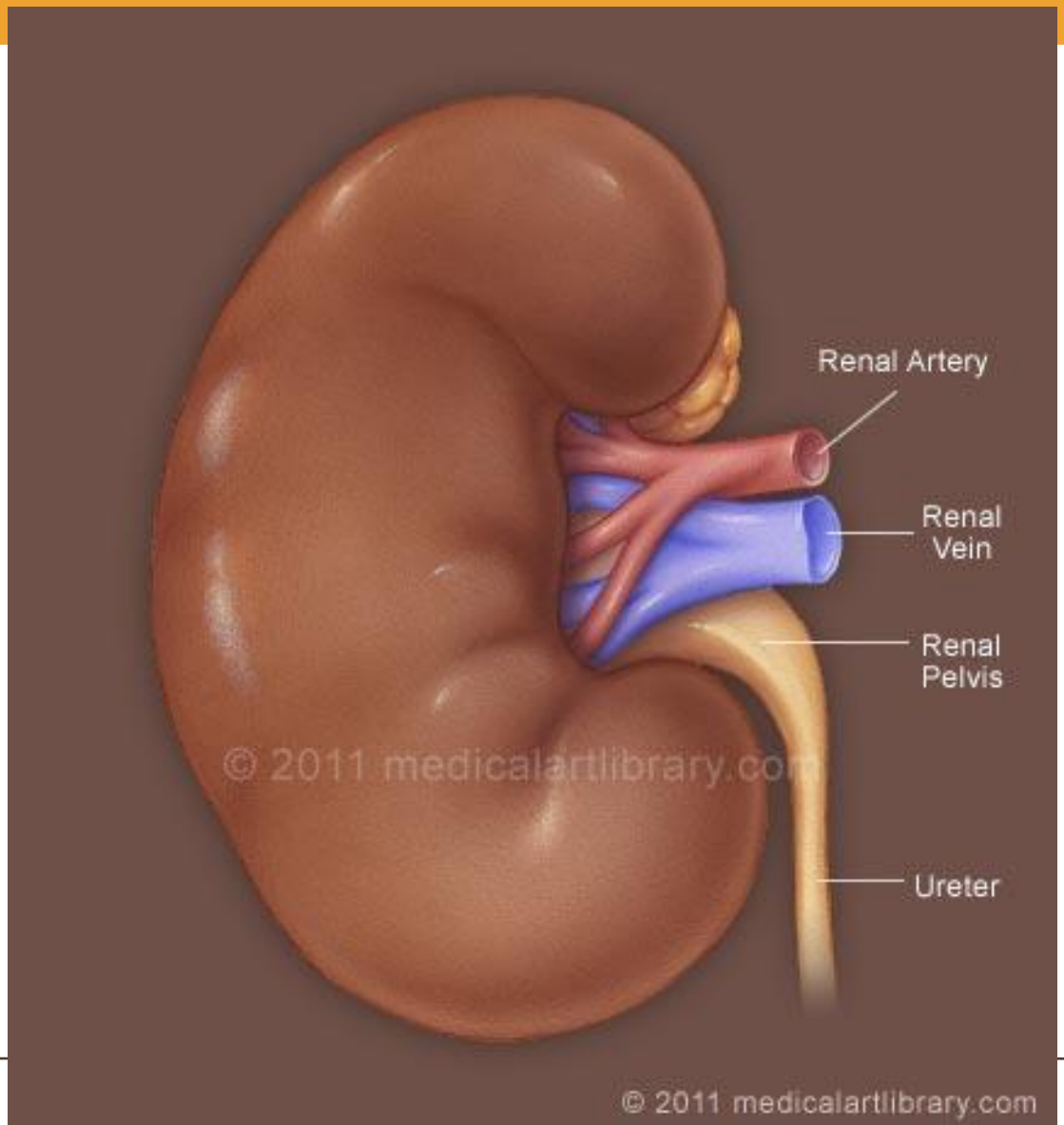
- Kidneys – form urine
  - Pair – true workhorses of system
  - Form in early week 5
  - Early kidneys drain into umbilical cord
    - Not functional until week 9
- Ureters
  - Tubes that send urine from the kidneys to the bladder
- Urinary bladder
  - Sac-like organ that serves as reservoir for urine storage
- Urethra
  - Tube that transfer urine from the bladder to the body's exterior



Kidney – External Anatomy

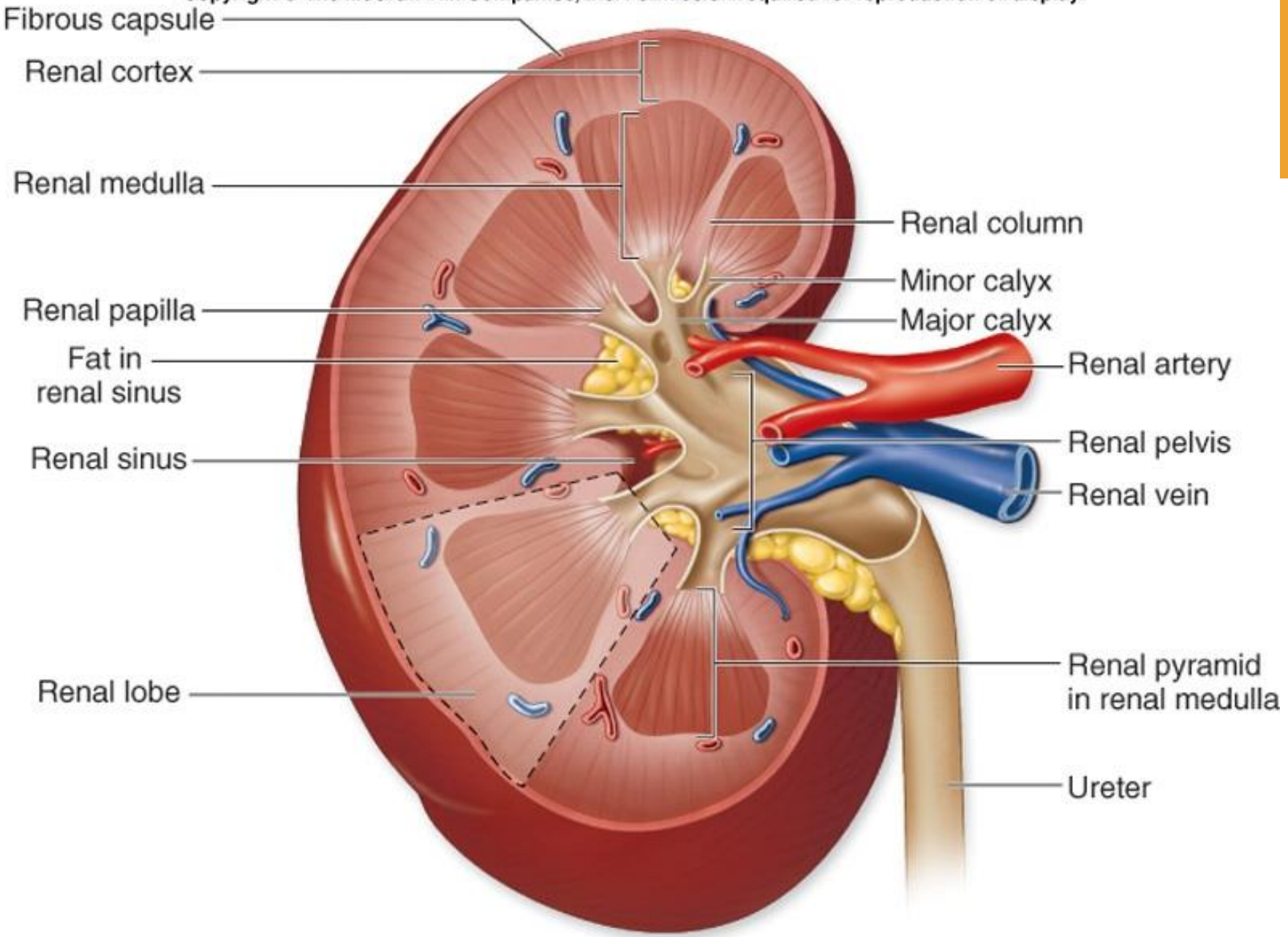
- Bean-shaped – located bilaterally near the midline of abdomen
  - Left a little superior to the right
- Not in the abdominal cavity
  - Lie retroperitoneal – behind peritoneum
- Adipose (fat) – encases each organ
- Renal fascia – CT that secures kidneys to posterior abdominal wall
- Each kidney capped by adrenal gland (produce different steroid)
- Positioned so that the hilus, concave indentation, is medial to the body
  - Entry point for renal artery and exit point for renal vein
    - Artery – carried blood to kidney
    - Vein – blood from kidney to vena cava

Kidney – External Anatomy



Kidney – Internal Anatomy

- 3 easily distinguishable areas (superficial to deep)
  - Renal cortex
  - Renal medulla
    - Soft, marrow-like
      - Renal pyramids
        - Renal columns – separate renal pyramids
          - Collects urine
  - Renal pelvis
    - Where formed urine is collected before it enters the ureter
    - Calcyes (calyx) – extension of renal pelvis; transfers urine from renal pyramids
      - Connected to ureter at each kidney's hilus

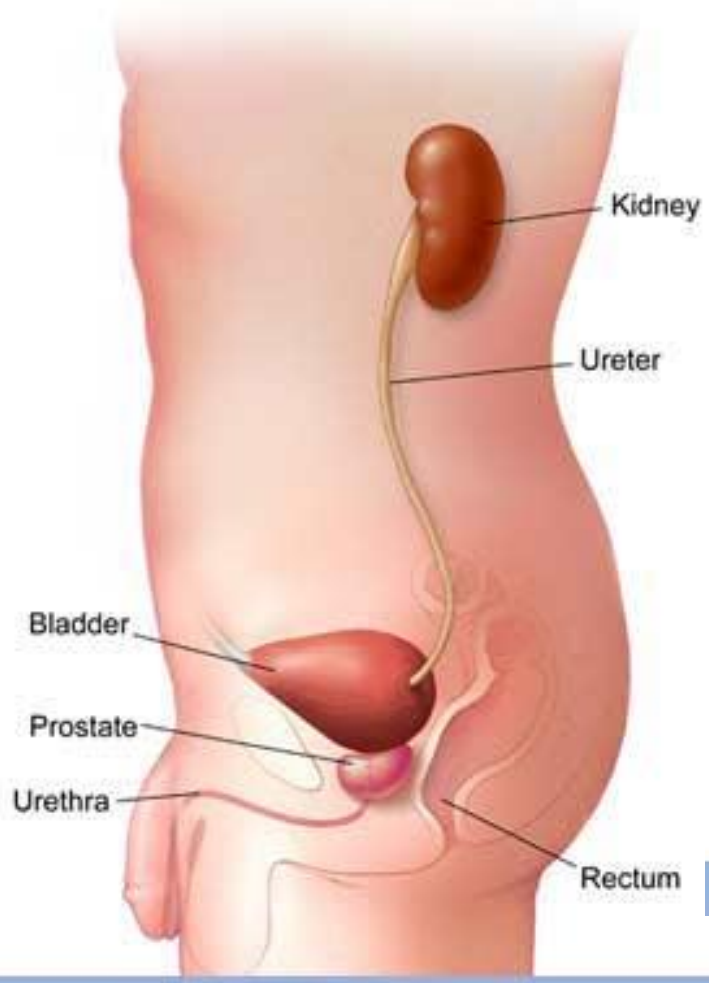


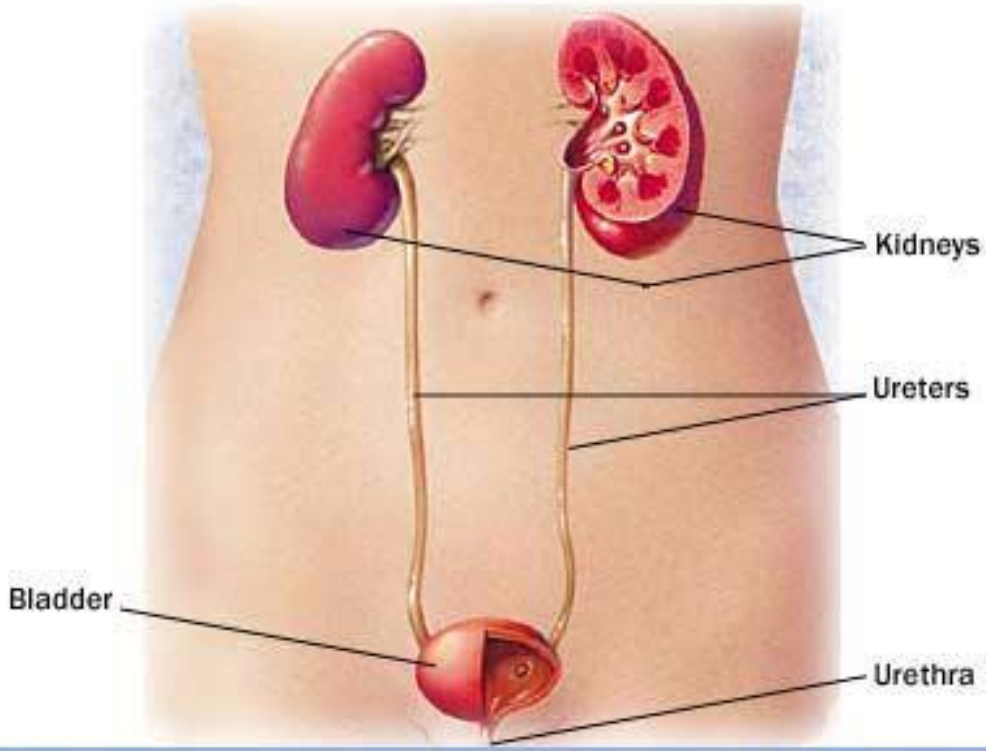
Right kidney, coronal section

Ureters

- Long, thin muscular tubes that are also in retroperitoneal position
  - Extend inferiorly from the hilus and enter the urinary bladder posteriorly at separate locations on bladder floor
- Function only in urine transport
  - Help gravity through peristaltic contractions
- Do not have valves that close to prevent urine from passing into the bladder
  - Bladders exerts upward pressure on them as it fills
    - Pressure pinches tube ends and closes them off

Ureters





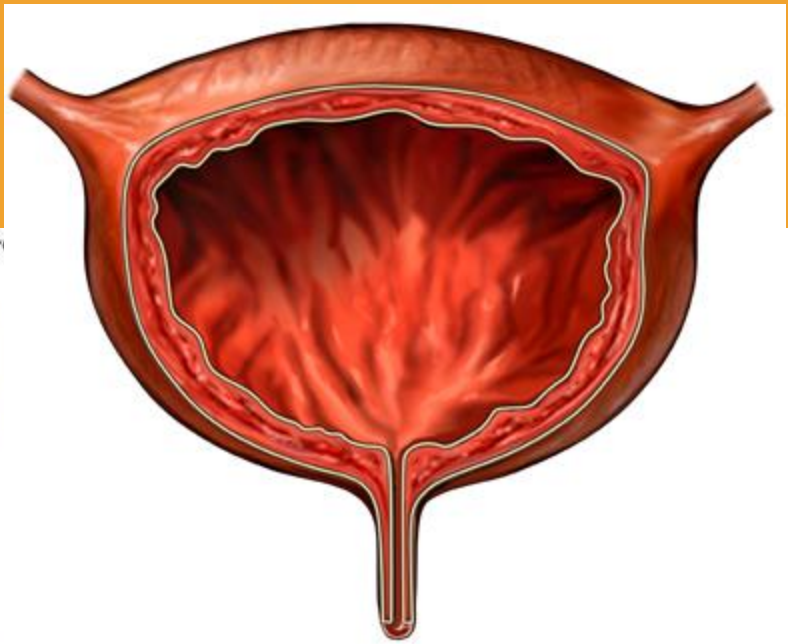
Urinary Bladder

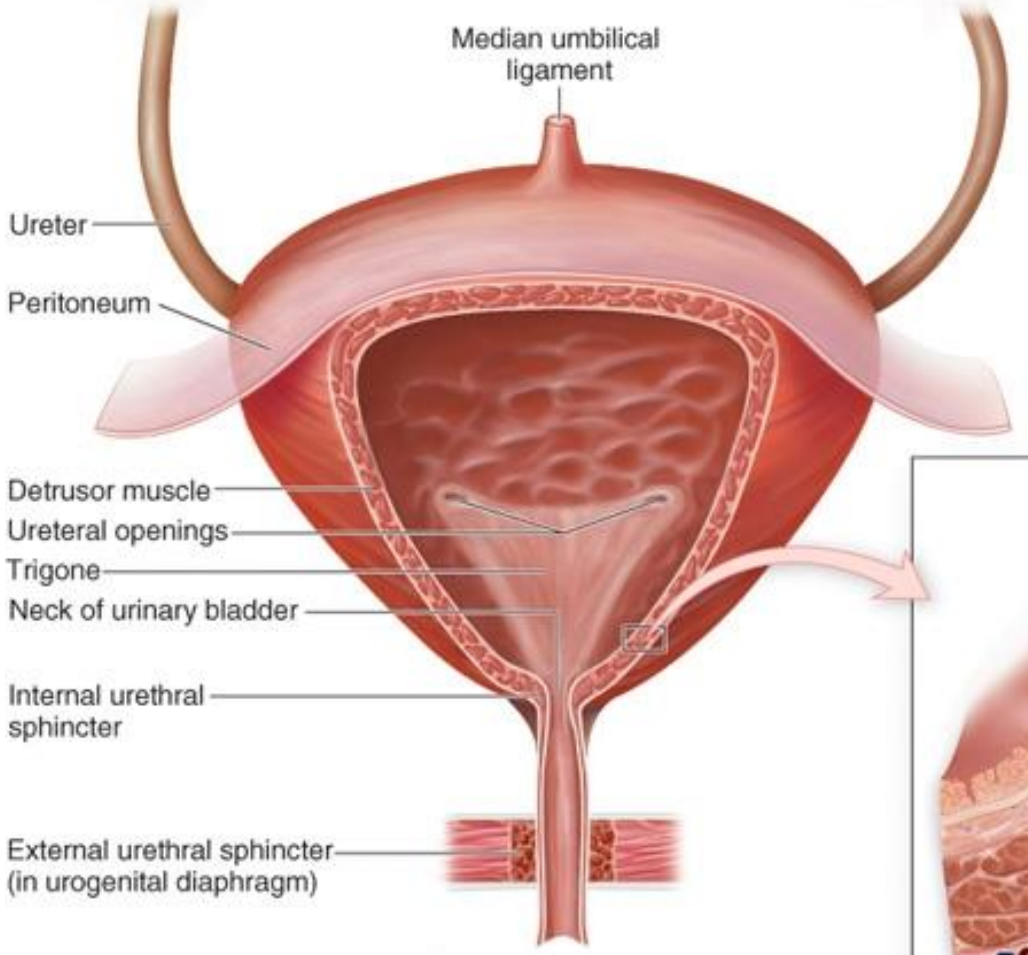
- Inferior in pelvic cavity
- Accumulates and temporarily stores urine
- In females, structure is located anterior and slightly inferior to uterus
  - Explains need for frequent urination during pregnancy
- In males, superior to prostate gland
  - when enlarged, can cause urination problems
- Transitional epithelium – tissue that can change shape with expansion and contraction
  - Lining of bladder

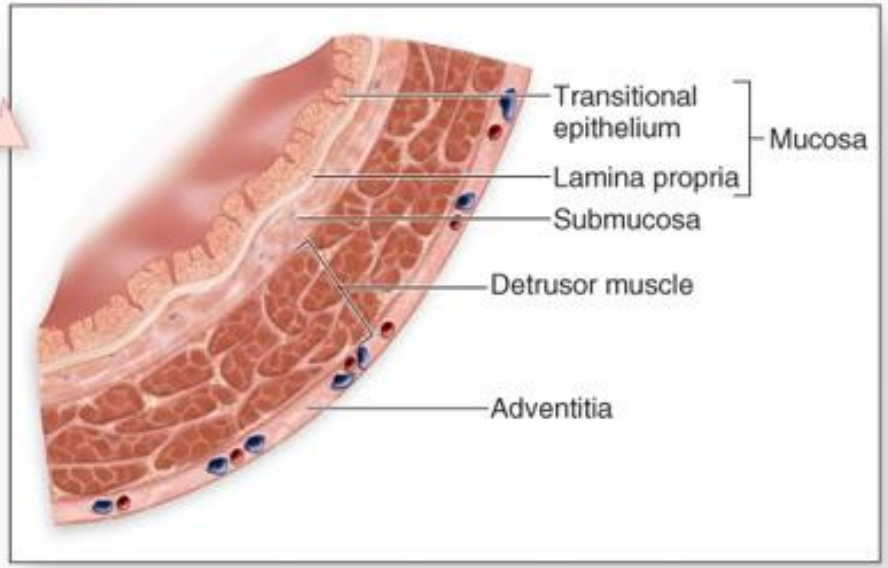
Urinary Bladder, cont.

- Detrusor muscle – smooth muscle of urinary bladder
  - Wall of bladder – crisscross arrangement
- Trigone – smooth triangular area of urinary bladder floor
  - Has three openings
    - 2 for ureters at the corners
    - Urethra at base
- Internal urinary sphincter – involuntary circular muscle
  - Keeps the ureter closed
- Can hold up to 1 liter of urine
  - Causes extremely uncomfortable pressure
    - Need to void typically is felt at 20% capacity

Urinary Bladder



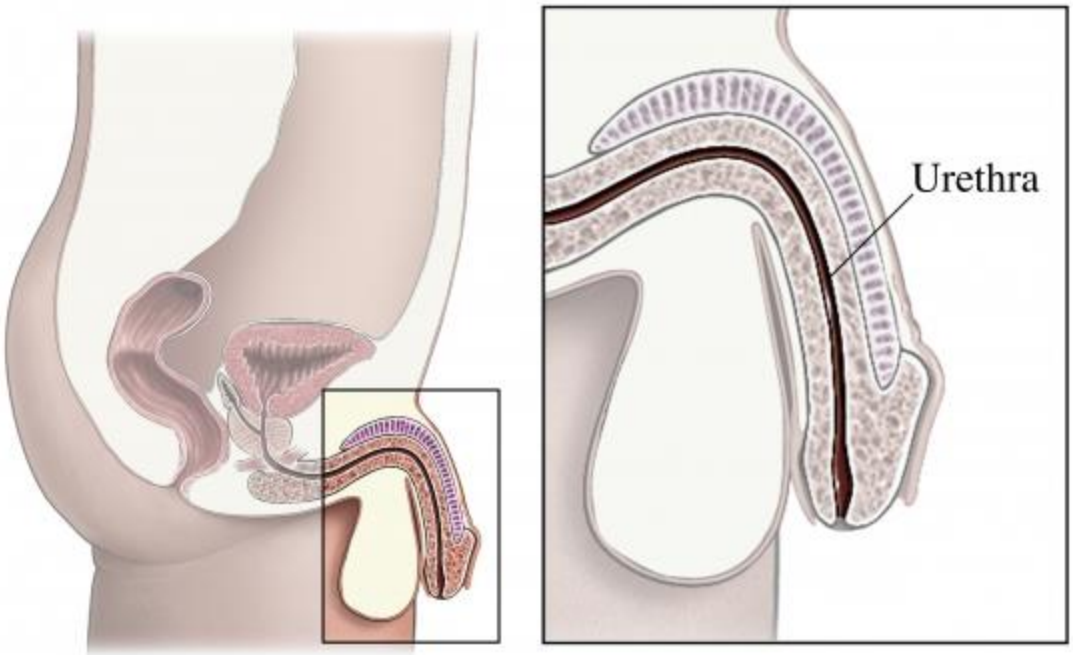


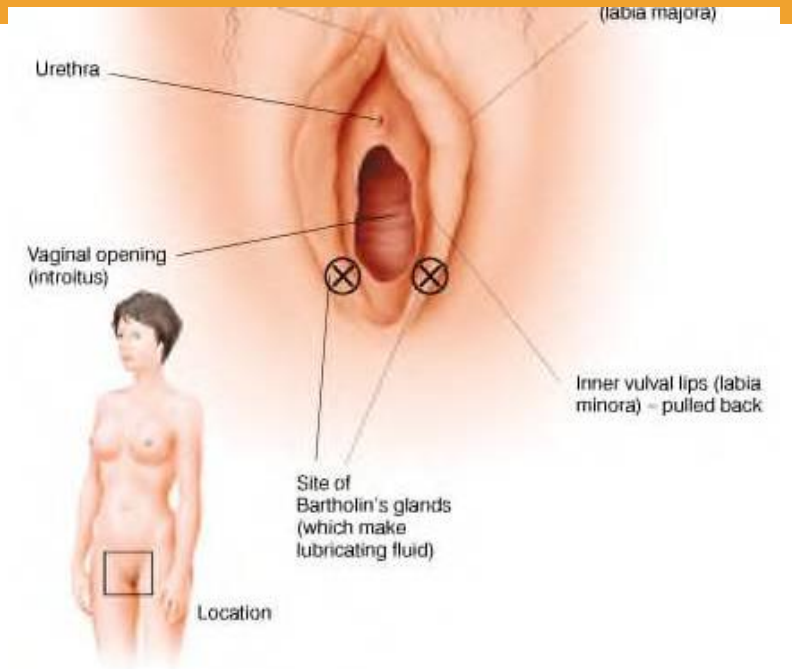


Urethra

- Forms passageway from bladder to body's exterior
- Single muscular tube, closure is controlled by voluntary muscle called external urethral sphincter
- Urethral orifice – external opening when urine exits body
- Male urethra longer than females
  - Descends through prostrate and the full length of penis
  - Also carries semen
- Female – sole function is to carry urine
  - Bladder is closer to body's exterior – more susceptible to entry of bacteria because of proximity to anal area
  - More prone to UTI or urinary bladder infections

Urethra


Urethra


(labia majora)
Urethra
Vaginal opening
(introitus)
Inner vulval lips (labia
minora) – pulled back
Site of
Bartholin's glands
(which make
lubricating fluid)
Location

14.2 Urine Voiding

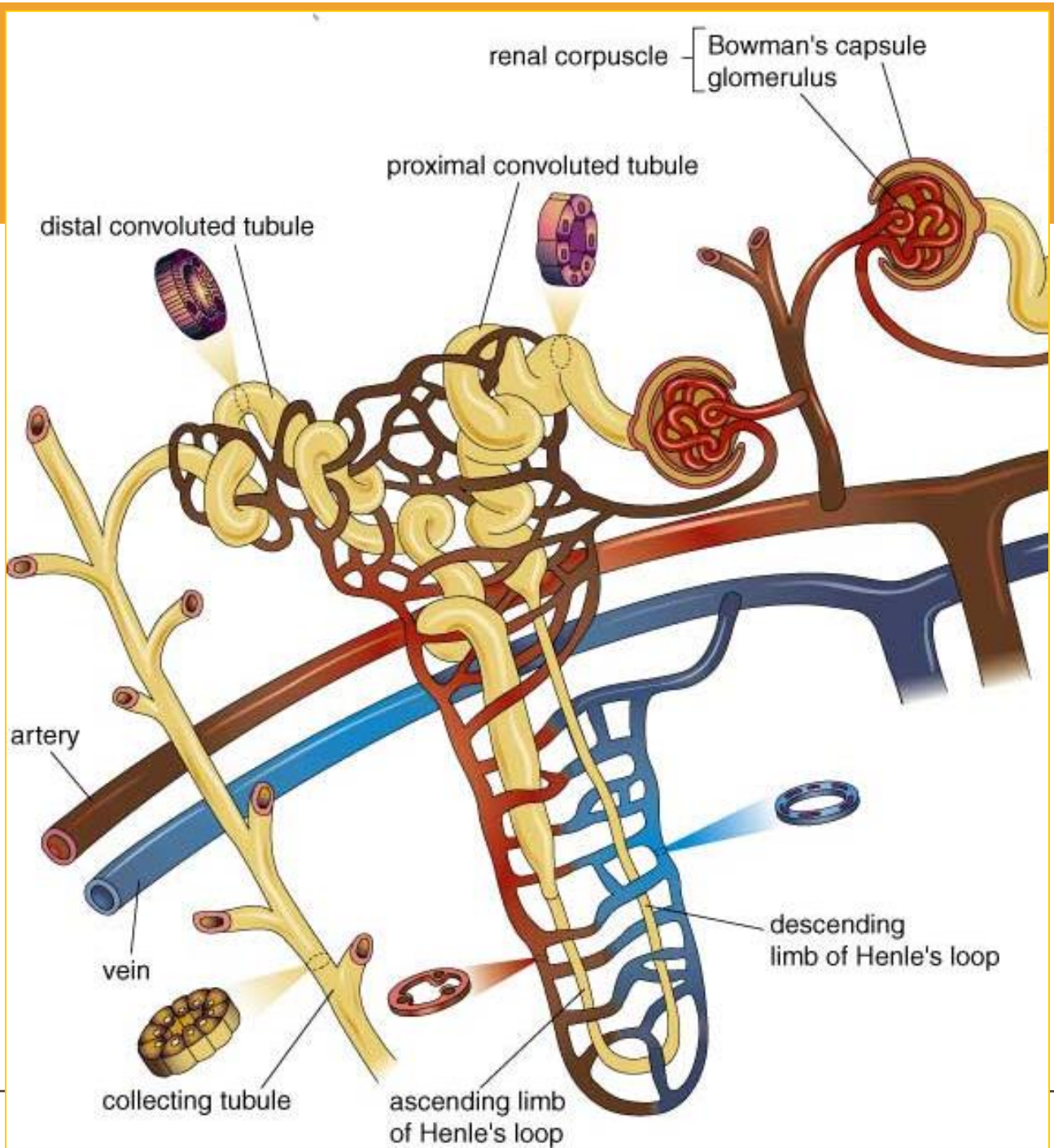
- Urination = emptying the bladder
  - Micturition – medical term for elimination of urine from the bladder
- Infant – immature nervous system – external urethral sphincter not yet under voluntary control
  - Urination occurs reflexively as bladder detected accumulated urine
- As nervous system matures, voluntary control is gained
- Incontinence, inability to hold urine
  - Decrease competence of urinary sphincter muscles

Urine Voiding, cont.

- Anuria – inability to produce urine
  - Can be indicator of health disorders like renal failure
    - Can be fatal if waste is not eliminated from body
- Urinary retention – inability to expel urine from bladder
- Catheter – tube inserted into urethra to expel urine
  - Can relieve urinary retention
- Oliguria – decreased urine production
  - Can indicate kidney damage or ureter obstruction
- Polyuria – production of excess urine
  - Can indicate diabetes mellitus
- Nephrons – tubular structures that filter the urine in kidneys
  - Responsible for many physiological processes involved in urine formation

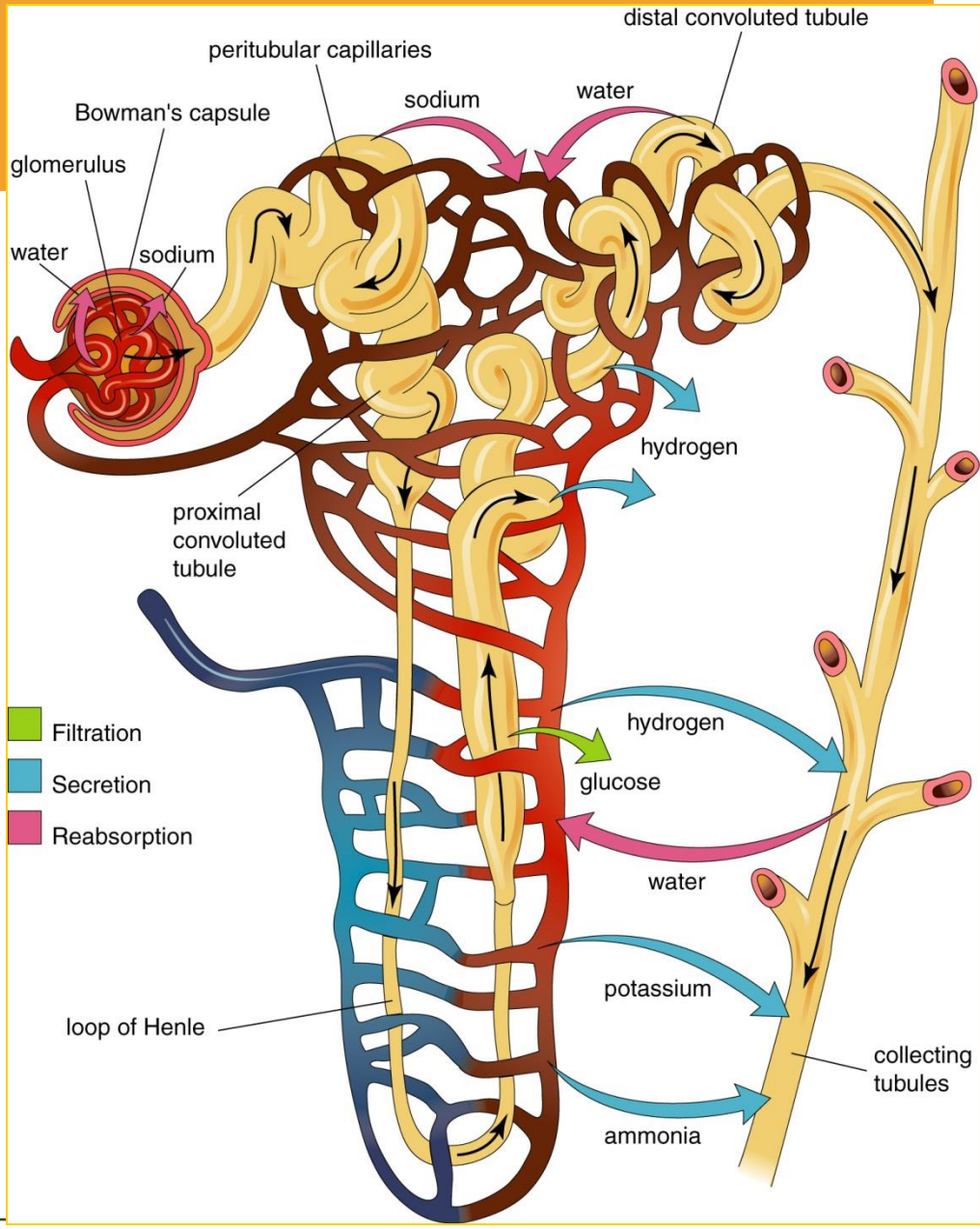
The Nephrons

- Thousands are present in each kidney
- Carry out several of kidney's many jobs
- Each is composed of an arrangement of renal tubules – has intricate vascular network
- Consists of uniquely folded capillary network called the glomerulus
  - Originates from the afferent arteriole (blood vessel that narrows to become glomerulus)
- Glomerulus is surrounded by Bowman's capsule
  - Expanded portion of renal tube
- Bowman's capsule and the glomerulus are tucked within a structure called the renal corpuscle
- Distal end exits efferent arteriole – formed by glomerulus


renal corpuscle
Bowman's capsule
glomerulus
proximal convoluted tubule
distal convoluted tubule
artery
vein
collecting tubule
ascending limb
of Henle's loop
descending
limb of Henle's loop

Urine Formation

- Three Stages
  - Glomerular filtration
  - Tubular reabsorption
  - Tubular secretion



Urine Formation definitions

- Glomerular Filtration
  - The process by which plasma and many dissolved substances are moved from the blood into Bowman's capsule
- Tubular Reabsorption
  - A process in the peritubular capillary system in which water, nutrients, and electrolytes travel back into the blood
- Tubular Secretion
  - The process by which certain waste products and ions are removed from the blood into the tubular fluid

Hormonal Regulation of Urine Formation

- Various hormones involved in controlling rate and volume of urine production
  - Release of hormone is elicited by specific change detected in body
- Anti-diuretic hormone (ADH)– produced by pituitary gland in response to dehydration
  - Greatly influences diuresis, or excretion of water from body
- Aldosterone – adrenal cortex steroid
  - In response to high levels of blood potassium ions, is produced to increase water movement out of distal tubule
    - Creates concentration gradient for outward movement of water

Hormones, cont.

- Atrial natriuretic factor (ANF) – secreted by special cardiac cells
  - Lowers blood volume and blood pressure
  - Antagonistic to aldosterone
  - Lowers sodium ion reabsorption
- Angiotensis II elevates blood pressure through *vasoconstriction*
  - the consequent increase in pressure within the glomerular capillaries increases filtration and elevates urine output.

14.3 Pathology

- **Most urinary system disorders fall under one or more of the following categories:
  - Congenital disorders
  - Infection and inflammation
  - Immune disorders
  - Hormonal disorders
  - Degenerative disorders
  - Tumors

Congenital Disorders

- *Present @ birth
- Polycystic kidney disease – inherited disease that causes the growth of kidney cysts
  - Can require hemodialysis – allows for artificial filtering of the blood
    - Has risks such as infection, but is better than the alternative which is renal failure, then death
- Glycosuria – presence of glucose in blood
  - Increases solute of urine
  - From failure of renal absorption of glucose
- Aminoaciduria – presence of amino acids in the urine
  - Can result in crystallization and subsequent formation of painful “stones” of calculi, in the kidney or bladder
  - Nephrolith – alternate name for a calculi

Infection and Inflammation

- Urinary tract infection (UTI) – inflammation caused by bacteria
  - Can be anywhere in urinary tract
- Urethritis – inflammation of urethra
- Cystitis – inflammation of urinary bladder
- Pyelitis – inflammation of the renal pelvis
- Pyelonephritis – inflammation of the nephrons
- Dysuria – painful urination
  - Accompanies UTIs
- Pyuria – presence of white blood cells in urine
  - Indicates UTI
  - In addition to WBC (leukocytes), also high in nitrate levels

Immune Disorders

- Glomerulonephritis – autoimmune disorder causing inflammation and deterioration of the glomerular membranes
  - Can be caused by streptococcal bacteria infection
  - Causes edema – accumulation of fluids in the body tissues
- Hematuria – presence of red blood cells in urine
- Proteinuria – presence of abnormal protein levels in the urine
- Cast – abnormal aggregate of cells found in urine

Hormonal Disorders

- Addison's disease – abnormally low aldosterone
  - Causes sodium excretion, excess water loss, dehydration, and hypertension
- Diuretics – increase volume of water in urine
  - Due to decrease in sodium absorption
  - Can be used to treat hypertension because increased water loss decreases blood volume and lowers blood pressure
  - Can also treat edema

Degenerative Disorders

- Chronic renal failure – irreparable nephron damage and loss of kidney function
  - causes buildup of urea in the blood
- Acute renal failure – temporary loss of kidney function
  - Proper nephron function in only 1/3 of a single kidney can keep a person alive
  - Still need hemodialysis
- Renal cell carcinoma – malignancy of the cells of the renal tubular lining
  - Most common form of kidney cancer
- Bladder cancer – malignancy of the tissue of the bladder
  - Hard to detect without medical imaging and symptoms present as a UTI.

Aging of Urinary System

- Nephroptosis – movement of the kidneys from its proper anatomical position to an inferior position
  - Due to forces of gravity and loss of fat – usually in elderly
- Cystocele – herniation of the bladder into the vagina
  - From continual pressure of the bladder on the structural connections that hold it in place
  - Pregnancy and multiple pregnancies increases this risk
- Incontinence due to degradation of the sphincter muscles surrounding urethra
- Urinary retention is seen in males due to hypertrophy of the prostate gland as early as 40
  - Restricts urethral passageway