

Chapter 25

Urinary System

Urinary System

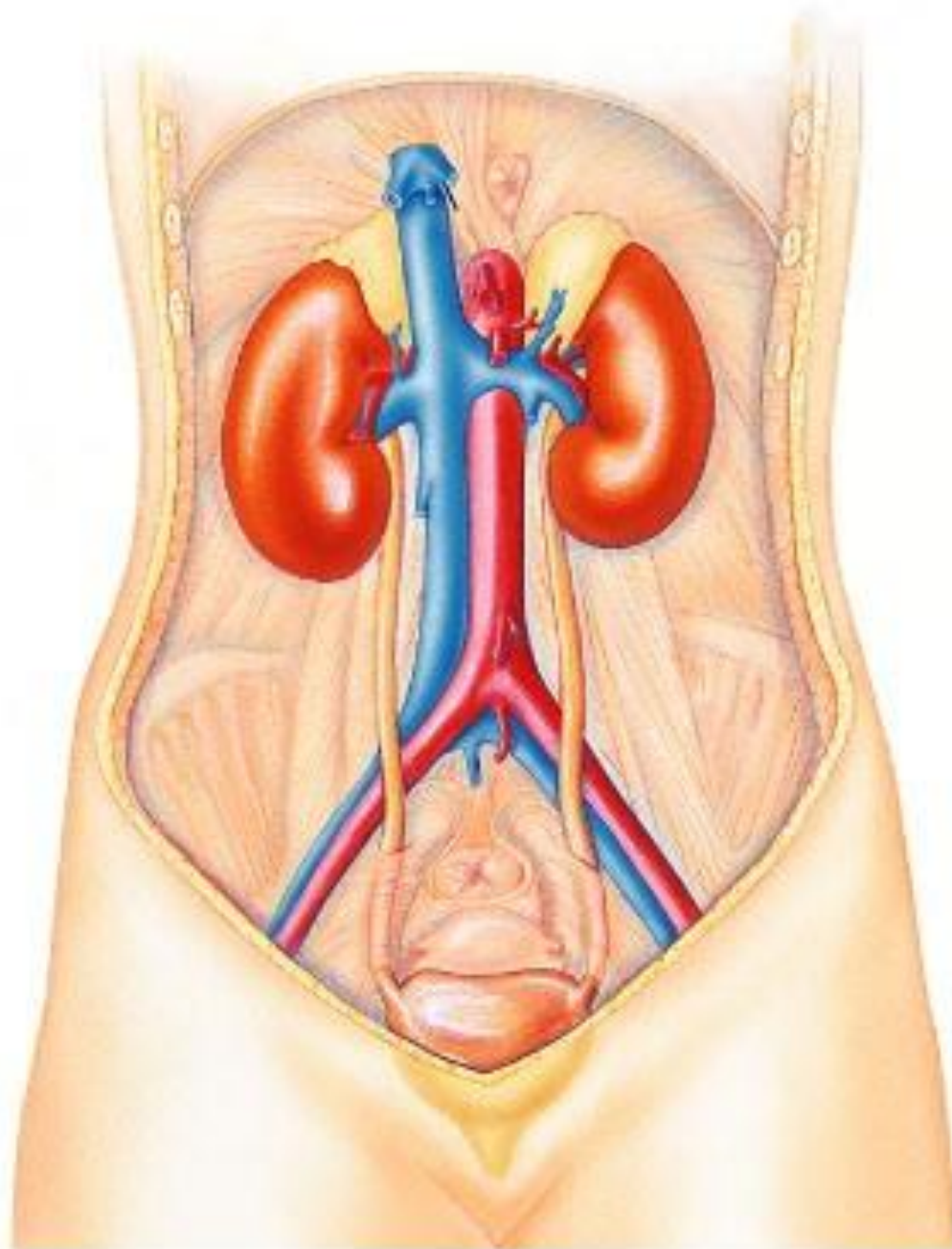
- Includes the
 - Kidneys
 - Ureters – tubes that connect kidneys to the bladder
 - Urinary Bladder – storage of metabolic wastes
 - Urethra – tube that connects bladder to the outside of the body

The Kidneys

- Major urinary organs
- Filter 200 liters of fluid each day
- Produce urine
- Regulate chemical makeup and volume of the blood
- Maintain water, salt and pH balance of the body
- Secrete hormones
- Activate vitamin D

External Kidney Anatomy

- Lies against the back body wall
- About 12 X 6 cm in size (bar of soap)
- Right kidney is slightly lower than the left
- Adrenal gland sits on top of kidneys
 - Function is not entirely related to the kidney



3 Layers Surround the Kidneys

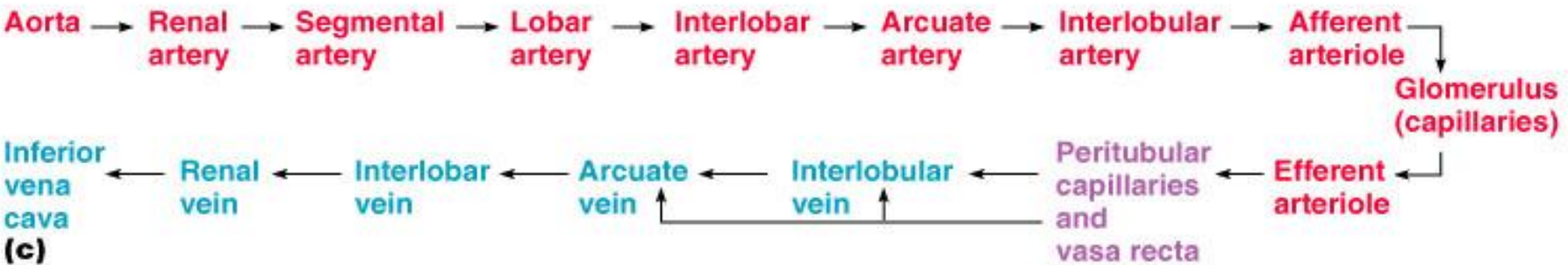
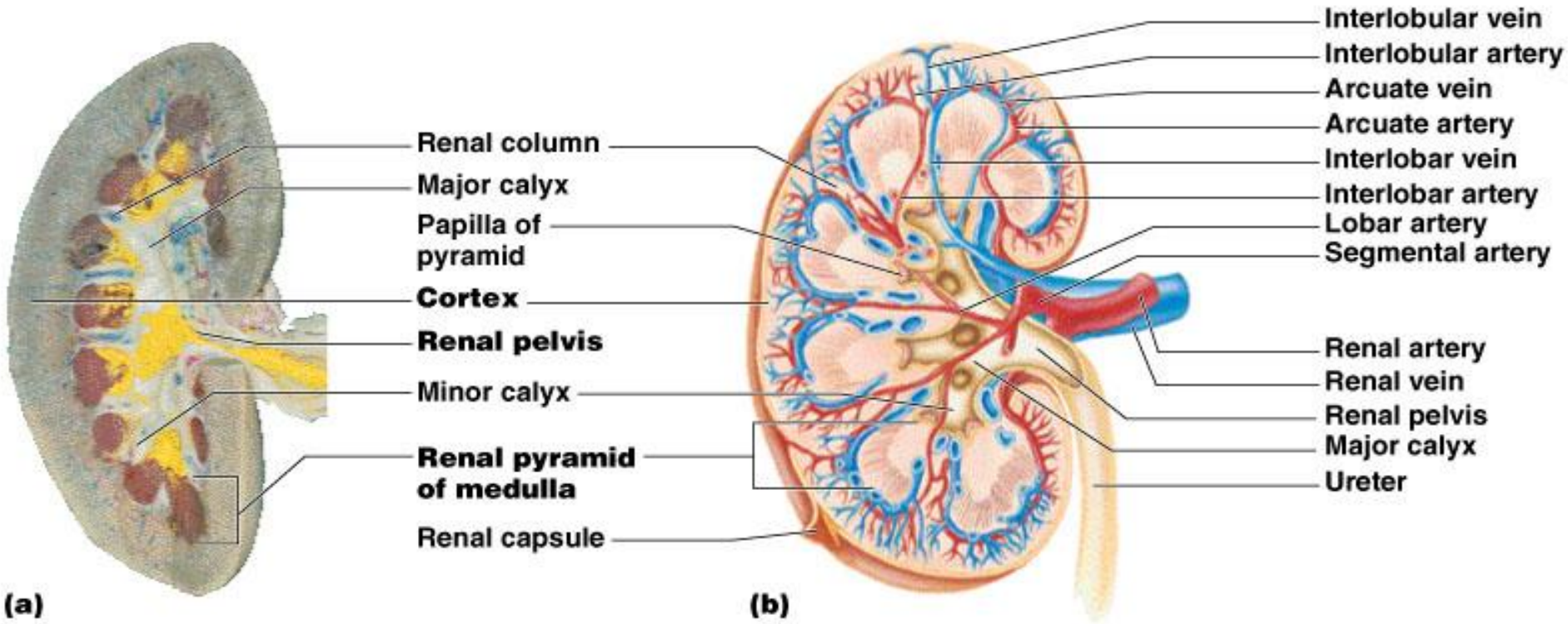
- Renal fascia = connective tissue that anchors the kidney in place
- Adipose capsule = posterior fat layer that cushions the kidneys
- Renal capsule = outer wall that prevents infections

Internal Anatomy

- Renal cortex = outermost layer where filtration occurs
- Renal medulla = made of 8 mduallary or renal pyramids separated by extensions of the cortex

Internal Anatomy, cont.

- Renal pelvis = innermost part
 - A flattened, funnel-shaped tube
 - Joins the ureter
 - Inwardly forms about three calyces that connect to the medullary pyramids
- Medulla filters blood and produces urine and passes it into the pelvis



Blood Supply - Arteries

- Renal artery → 5 segmental arteries → lobar arteries → interlobar arteries → arcuate arteries (at the cortical-medullary junction)
- The smallest feed the cortex

Blood Supply - Veins

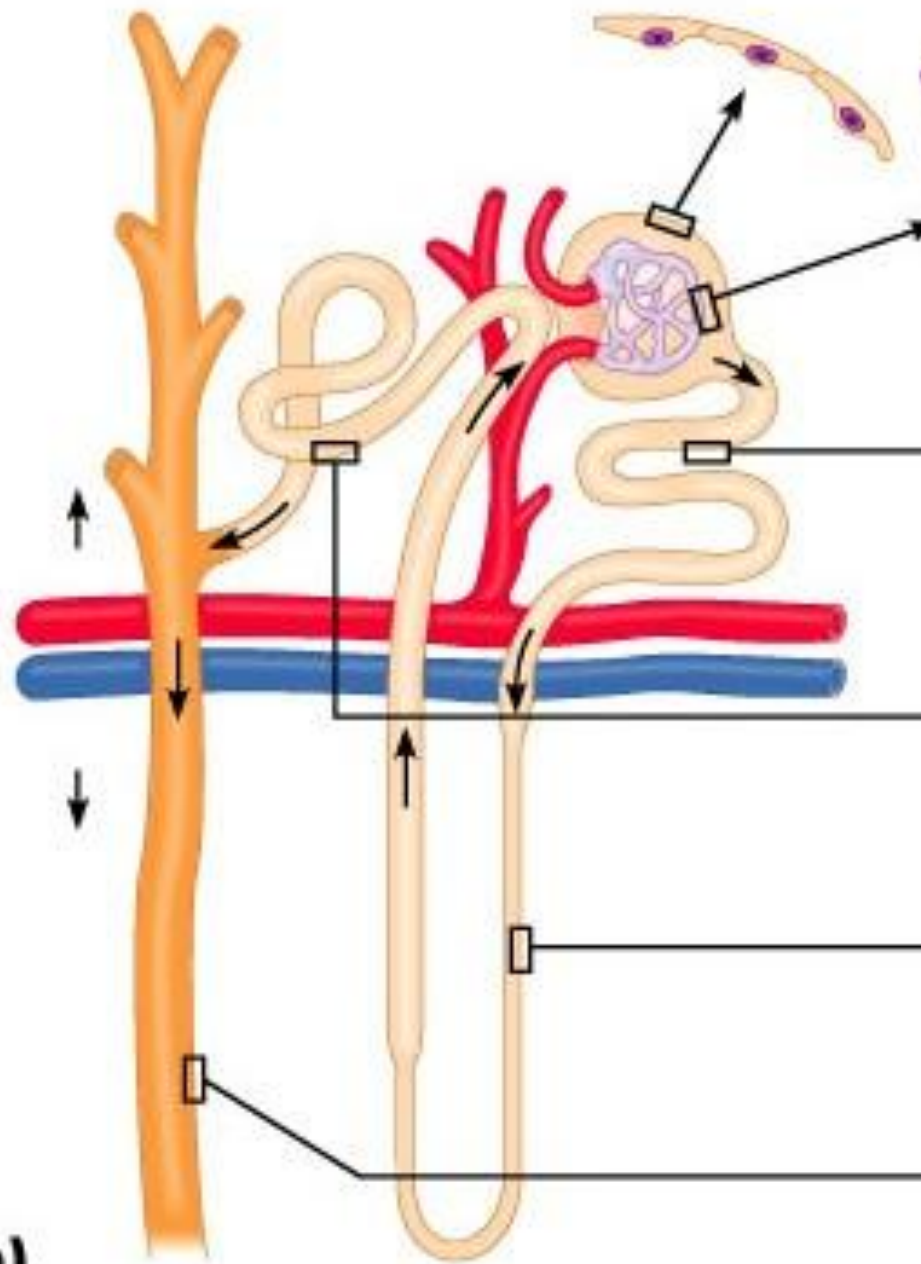
- There are fewer veins than arteries
- Blood from the cortex leaves the kidneys through the veins in the reverse order
- Arcuate veins merge into interlobar veins that merge into renal veins

Nephrons

- Structural and functional unit of the kidney
- Over one million in each kidney
- Form urine and secrete hormones into the blood
- Feed into thousands of collecting ducts that feed into the renal pelvis
 - Collecting ducts give the medullary pyramids their striped appearance

Anatomy of the Nephron

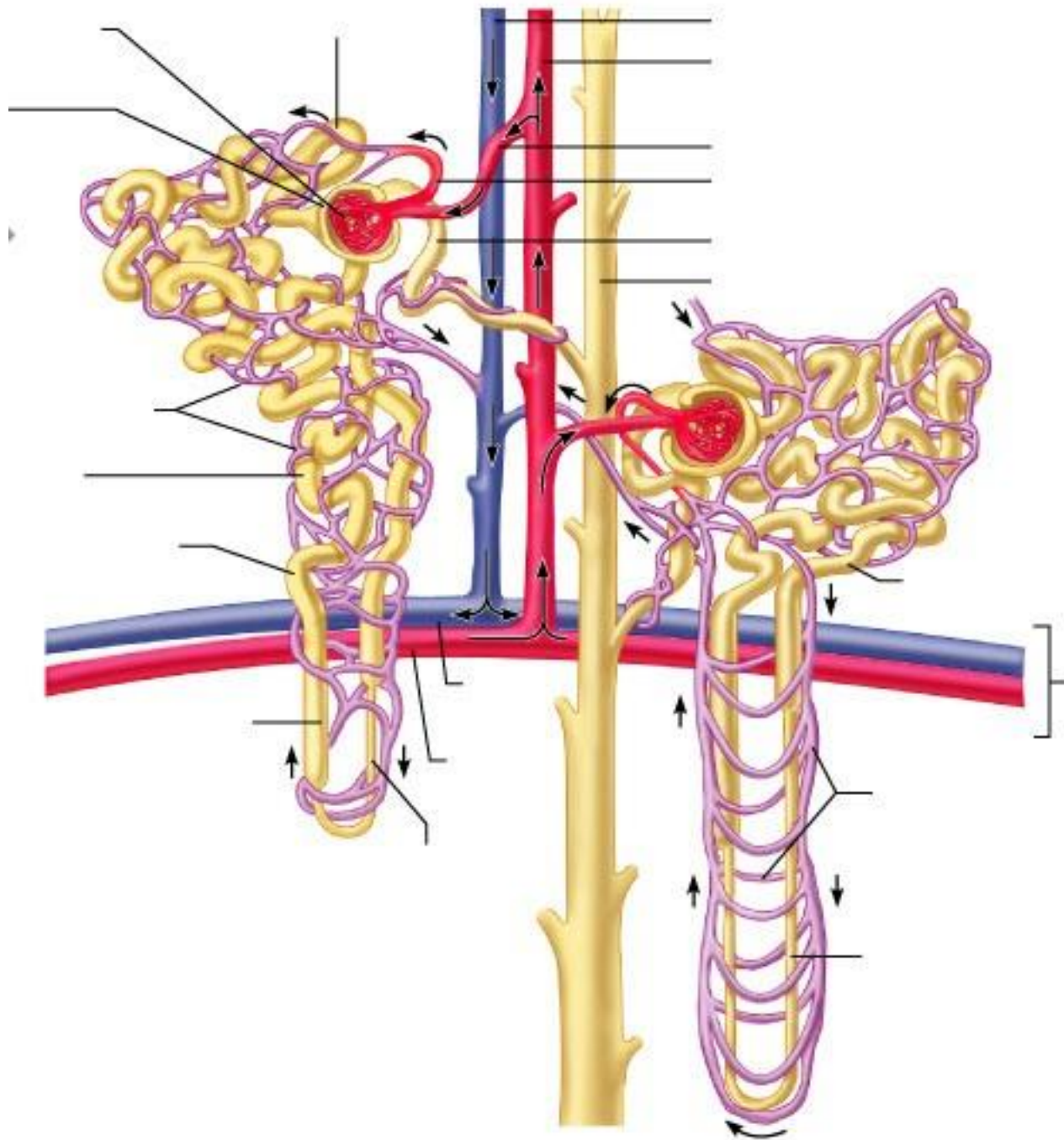
- 2 Major Divisions
 - 1. Glomerulus – A ball of capillaries that filters the blood
 - 2. Renal Tubule – long tube that surrounds the glomerulus and connects to the collecting duct at the other end
 - Glomerular or Bowman's capsule = region where tubule and glomerulus meet



(b)

Glomerulus

- The wall of the renal tubule is filled with pores that allows fluid (filtrate) to cross from the blood to the tubule
- Much of the filtrate is recaptured as it passes through the nephron and is returned to the blood via the peritubular capillaries



Renal Tubule

About 3 cm long

- Parts - location

- Proximal convoluted tubule (PCT) - connects to the glomerular capsule
- Loop of Henle – a hairpin curve
- Distal convoluted tubule (DCT) – connects to the collecting duct

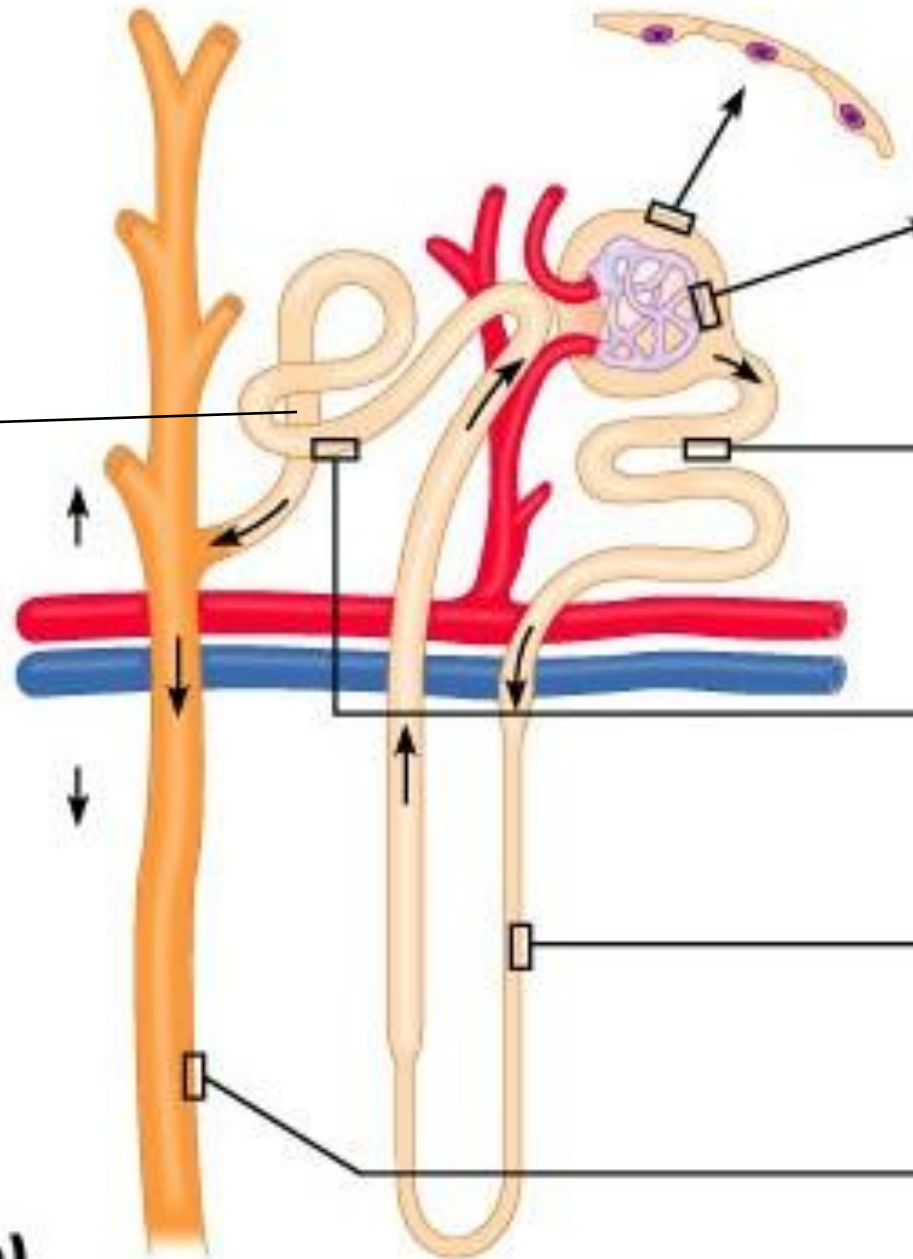
DCT

PCT

Loop of Henle

Collecting Duct

(b)



Parts - Structure

- PCT
 - Filled with microvilli (little extensions)
 - increase the surface area for reabsorption of water and ions
 - Called the brush border

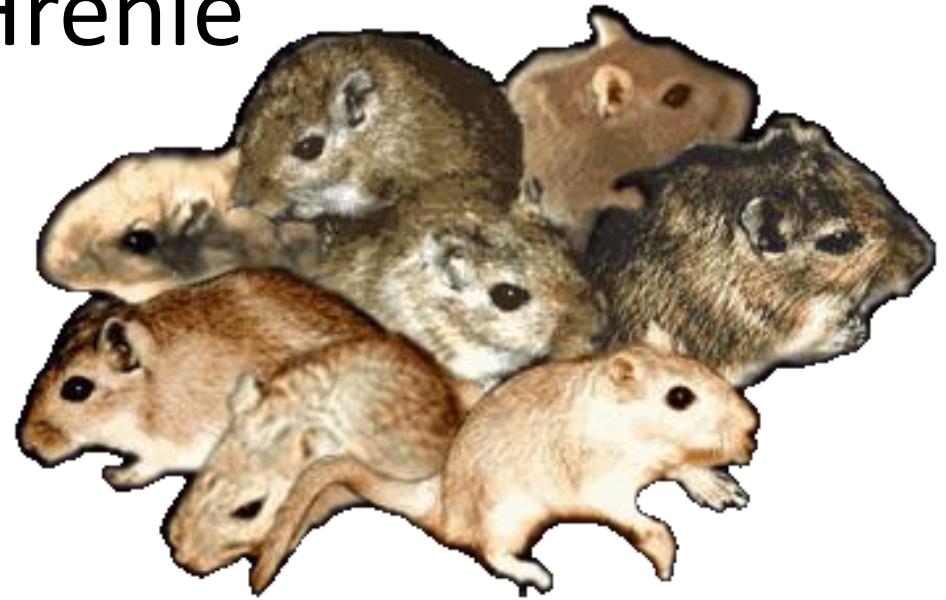
Parts, cont.

- Loop of Henle
 - Specialized for water reabsorption
 - Has two limbs – descending and ascending
 - Descending limb is freely permeable to water
 - Ascending limb reabsorbs salt

Animals with extremely long Loops of Hrenle



Anole



Gerbils



Kangaroo rat

These animals rarely urinate, if ever

Parts, cont.

- DCT
 - Thinner than the PCT and lacks microvilli
 - Impermeable to water and ion reabsorption unless stimulated by hormones to do so
 - Reabsorbs according to the body's needs
 - Hormones and other substances are secreted into the DCT from the peritubular capillaries

Parts, cont.

- Collecting Duct
 - Mainly passes the remaining filtrate on to the renal pelvis to be expelled as urine
 - Can reabsorb additional water when stimulated hormonally

Urine Formation

- All of the body's blood is filtered 60 times per day
- The kidneys use up to 25% of the body's oxygen
- 1% of total fluid filtered out becomes urine

Urine Formation, cont.

- 3 Steps of urine formation
 - 1. Glomerular filtration
 - 2. Tubular reabsorption
 - 3. Tubular Secretion

Glomerular Filtration

- Passive
- High blood pressure in the glomerulus forces liquid and ions through the triple-layered filtration membrane
 - Each layer allows the passage of different molecules

Glomerular Filtration, cont.

- Small molecules pass freely into the renal tubule
 - Water, AA, nitrogenous wastes, glucose
 - Concentration of these in the filtrate is similar to the blood
- Larger molecules pass with difficulty or not at all
 - Proteins in the urine usually indicate a problem

Glomerular Filtration Rate

- Glomerular pressure is kept constant despite constant changes in systemic blood pressure
- Known as renal autoregulation
 - Cells within the DCT sense the rate of flow and the osmotic content of filtrate
 - Arterioles can contract or relax to keep the blood flow constant
 - Can be overridden by nervous stimulation or hormones in emergency situations

Tubular Reabsorption

- Mainly in the PCT
- Active or passive transport
- Active Transport
 - Sodium, and other molecules are actively “dragged” back into the bloodstream by carrier molecules
 - Rate is limited by the number of carriers available

Tubular Reabsorption, cont.

- Passive Transport
 - Water , glucose, AA, vitamins, and ions are reabsorbed this way
 - Most of the urea and uric acid is reabsorbed into the blood at this point
 - The dragging of sodium back into the blood creates two gradients

Passive Transport, cont.

- Electrical gradient – attracts oppositely charged ions
- Concentration gradient – water follows salt
 - Called obligatory water reabsorption
 - This increases the concentration gradient, so the other ions follow the water

Tubular Secretion

- Peritubular capillaries or tubule cells secrete chemicals into the PCT, DCT, and collecting ducts
- Secretion allows the body to:
 - Dispose of wastes not found in the filtrate
 - Drugs and potassium
 - Eliminate products that are passively reabsorbed
 - Urea, uric acid, and others
 - Control blood pH

Chemicals that affect Urine Output

- Diuretics
 - Chemicals that enhance urinary output
 - Alcohol – inhibits hormone secretion that slows urine formation
 - Caffeine and other drugs inhibit sodium reabsorption which also inhibits water reabsorption
 - Others readily pass into the renal tubule, inhibiting water reabsorption

Chemicals that affect Urine Output, cont.

- Antidiuretics
 - Antidiuretic hormone (ADH)
 - Chemicals that decrease urinary output
 - When released, it makes the collecting ducts absorb more water
 - Increases the blood volume, and decreases urine formation

Urine

- Color – yellow = urochrome
 - A byproduct of the breakdown of hemoglobin
 - The more yellow, the more concentrated the urine
- Odor
 - Ammonia odor results from bacteria processing urea

Urine, cont.

- Composition

- 95% water, 5% nitrogenous wastes and ions

- Urea and uric acid

Ureters

- Urine entering the ureters stretches the walls
- Stimulates peristalsis
 - Rhythmic smooth muscle contractions
- Pushes the urine to the bladder

Urinary Bladder

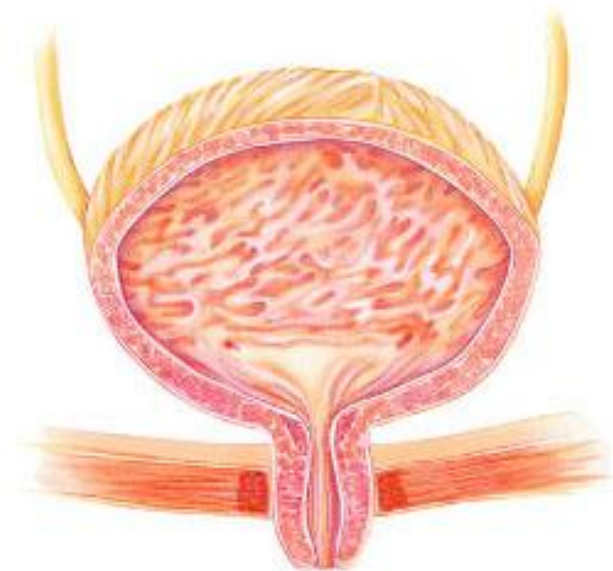
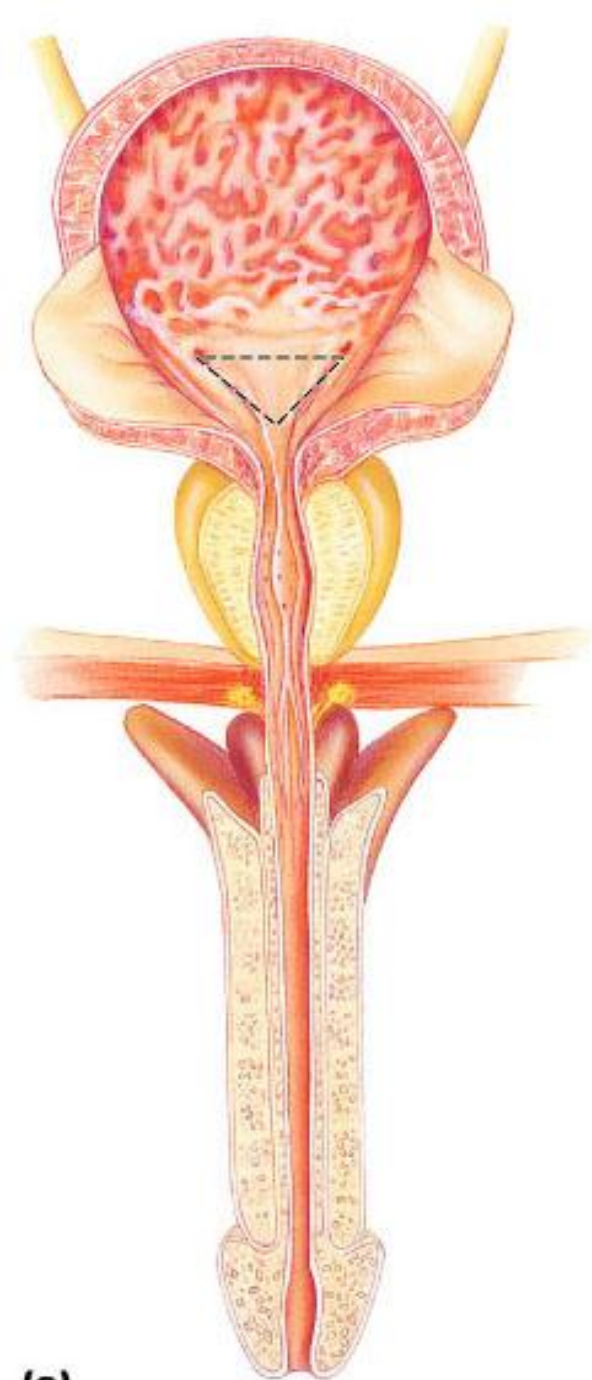
- A muscular sac for urine storage
- Both ureters and the urethra connect to it
- Walls thin as it expands to keep internal pressure low
- Can hold up to 1 L of fluid (in an emergency)
- Urination = micturition or voiding
- Can rupture if overextended

Urethra

- Internal urethral sphincter
 - Involuntary
 - Keeps urethra closed when urination is not occurring

Urethra, cont.

- External urethral sphincter
 - Skeletal muscle sphincter that provides voluntary control of urination
- Females – 3 -4 cm long
- Males – 20 cm long



(b)

(a)

Kidney Disorders

- Kidney Stones
 - Calcium, magnesium, or uric acid salts crystallize in the renal pelvis
 - Forced through the ureters into the bladder

Kidney Stones, cont.

- Causes
 - Recurrent urinary tract infections
 - Urine retention
 - High blood levels of calcium
 - Alkaline urine
- Now mainly treated by zapping the stones with ultrasonic shock waves

Kidney Disorders, cont.

- Anuria – low urine production
 - Caused by nephron failure or low glomerular pressure

Kidney Disorders, cont.

- Incontinence

- Inappropriate expulsion of urine

- Stress related – because of laughing, coughing, or pregnancy

- Overfill – related – Occurs anytime the bladder is too full

Kidney Disorders, cont.

- Urinary Retention

- Inability to void the bladder
- In males, can be caused by enlargement of the prostate gland
- Normal after general anesthesia
- Prolonged retention can be alleviated with the use of a catheter