Learning Outcome C13

URINARY SYSTEM

LEARNING OUTCOME C13

- Analyse the functional interrelationships of the structures of the urinary system

STUDENT ACHIEVEMENT INDICATORS

Students who have fully met this learning outcome are able to:

- Identify and explain the functions of each of the following:
  - kidney
  - ureter
  - urethra
  - urinary bladder
  - renal cortex
  - renal medulla
  - renal pelvis
  - nephron
- Identify and explain the functions of the following components of the nephron:
  - glomerulus
  - Bowman's capsule
  - afferent and efferent arterioles
  - peritubular capillary network
  - proximal and distal convoluted tubules
  - collecting duct
  - Loop of Henle

STUDENT ACHIEVEMENT INDICATORS

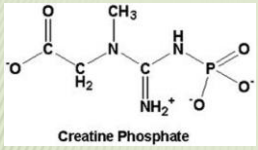
- Describe the production of urine with reference to the following terms:
  - pressure filtration
  - selective reabsorption
  - reabsorption of water following an osmotic gradient
  - tubular excretion
  - metabolic waste
- Describe how the kidneys maintain blood pH
- Compare urea and glucose content of blood in the renal artery with that of the renal vein
- Identify the source glands for antidiuretic hormone (ADH) and aldosterone
- Describe how the hypothalamus, posterior pituitary, ADH, and the nephron achieve homeostasis of water levels in the blood
- Describe how the adrenal cortex, aldosterone, and the nephron achieve homeostasis of water and sodium levels in the blood

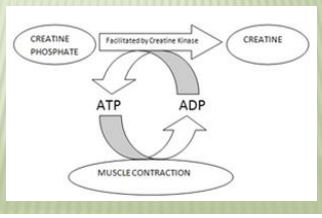
URINARY SYSTEM & EXCRETION

- The kidneys are the primary organ of excretions
- Excretion is the removal of metabolic wastes from the body

FUNCTIONS OF THE URINARY SYSTEM

- Excretion of metabolic wastes
- The kidneys excrete metabolic wastes, notably nitrogenous wastes from amino acids.
- Urea is the primary nitrogenous end product in metabolism
- Humans also excrete ammonium, creatine and uric acid.
- Urea is the by-product of amino acid metabolism
- The breakdown of amino acids in the liver releases ammonia, which the liver readily combines with carbon dioxide to produce urea.
- Ammonia is very toxic to cells, but urea is much less toxic.
- Creatine Phosphate – is a high-energy phosphate reserve molecule in muscles.
- The breakdown of creatine phosphate results in creatine





FUNCTIONS OF THE URINARY SYSTEM

- The breakdown of nucleotides containing adenine and thymine produces uric acid.
- Uric acid is insoluble
- If too much uric acids is present in the blood crystals form and precipitate out.
- Crystals of uric acid sometimes collect in joints resulting in gout.

FUNCTIONS OF THE URINARY SYSTEM

Maintenance of Water-Salt Balance

- Blood volume is related to salt imbalance.
- Salts have the ability to cause osmosis which is the movement of water into and out of the blood.
- The more salts in the blood the greater the blood volume, the greater the blood pressure
- Salts also maintain appropriate levels of other ions such as K^+, $HCO3^-$ and Ca^{2+} in blood.

FUNCTIONS OF THE URINARY SYSTEM

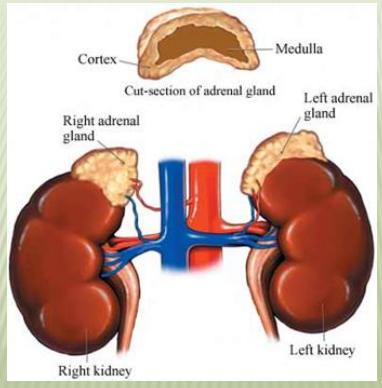
Maintenance of Acid-Base Balance

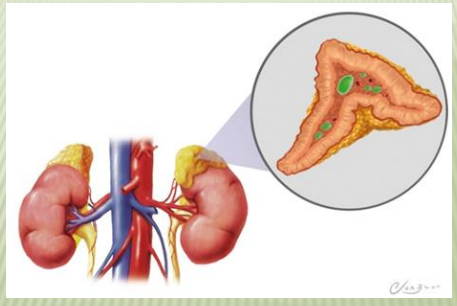
- Blood pH = approx. 7.4
- Kidneys monitor and regulate this pH by excreting H^+ and reabsorbing $HCO3^-$.
- Urine has a pH of 6 or lower because our diet contains acidic food.

FUNCTIONS OF THE URINARY SYSTEM

Secretion of Hormones

- Assist the endocrine system
- The kidneys release renin, which leads to the secretion of aldosterone from the adrenal cortex
- The adrenal cortex is the outer portion of the adrenal gland which lies on the kidney.
- Aldosterone promotes the absorption of Na^+ by the kidneys.
- Kidneys secret the hormone erythropoietin which stimulates RBC production and maturation.

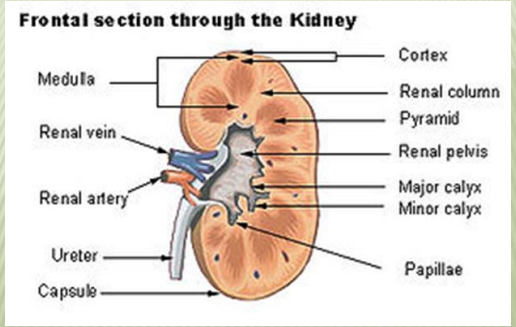




ORGANS OF THE URINARY SYSTEM

Kidneys

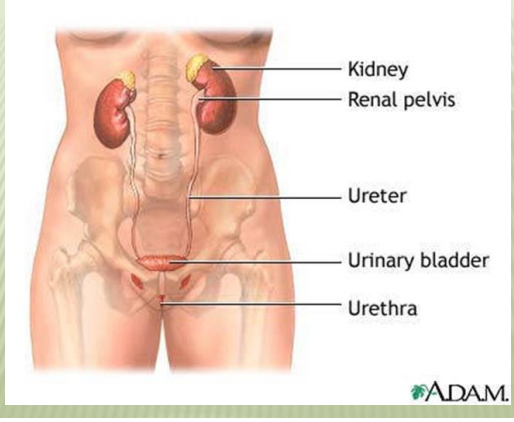
- Kidneys are paired organs
- Located near the small of the back in the lumbar region on either sides of the vertebral column.
- Bean shaped
- Reddish brown color
- Covered by a tough capsule of fibrous connective tissue called the renal capsule.
- Masses of adipose (fat) tissue s are attached to each kidney.
- The concave side of the kidney has depression called the ilium where a renal artery enters a renal veins and ureter exits.



ORGANS OF THE URINARY SYSTEM

Ureters

- Conduct urine form the kidneys to the bladder
- Small muscular tubes
- The walls of ureters have three layers:
  - Inner mucosa (mucous membrane)
  - Smooth muscle layer
  - Outer fibrous coat of connective tissue
- Peristaltic contractions cause urine to enter the bladder, even if the person is lying done.
- Urine enters the bladder in spurts at the rate of 1-5 per minute.



ORGANS OF THE URINARY SYSTEM

Urinary Bladder

- Stores urine until it is expelled
- Located in the pelvic cavity
- 3 openings:
  - 2 for ureters
  - 1 for urinary bladder
- Bladder is expandable.
- Small folds of bladder mucosa act like valves to prevent the backflow of urine to ureters from the urinary bladder.

ORGANS OF THE URINARY SYSTEM

- Two sphincters are located near where the urethra exits the bladder to help control urination:
  - Internal sphincter – opening around urethra
  - External sphincter
- Composed of skeletal muscle that can be voluntarily controlled
- Incontinence – involuntary loss of urine
- Related to changes in urinary bladder and nervous system diseases.
- Usually affects elderly and pregnant women.

ORGANS OF THE URINARY SYSTEM

Urethra

- Small tube carries urine form the bladder to an external opening
- Females - 4 cm
- Males - 20 cm
- In males connected to reproductive functions
- Carries urine and semen
- As the urethra leave the urinary bladder it is encircle by the prostate
- In men over 40 the prostate gland may become enlarged and this may restrict urination.

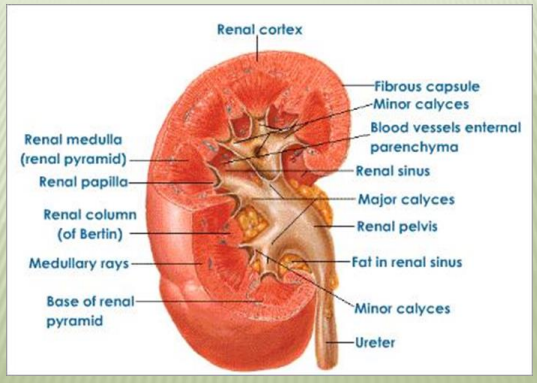
URINATION

- When the urinary bladder fills to about 250 mL with urine, stretch receptors send an impulse to the nerve cord.
- The motor nerve impulses causes the urinary bladder to contract and the sphincters to relax so urination can occur.
- In toddlers, children and adults the brain control this reflex, delaying urination to a suitable time.

ANATOMY OF THE KIDNEY & EXCRETION

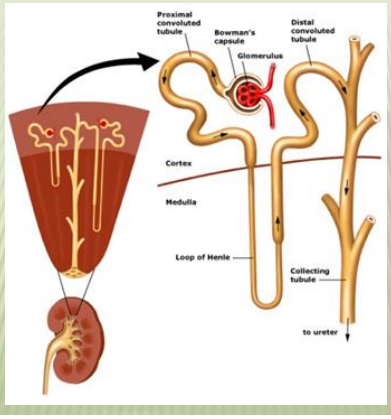
- The kidney has three regions:

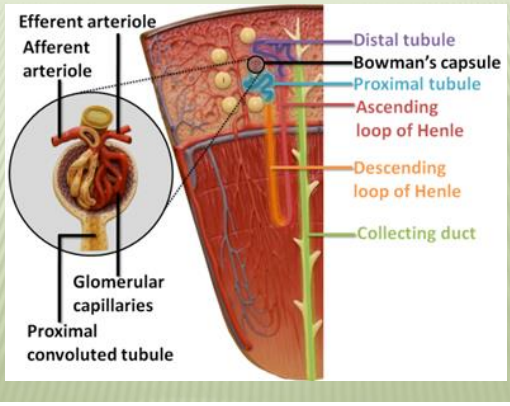
1. renal cortex
   - ✓ Is the outer granulated layer that dips down in between a radially striated inner layer called the renal medulla
2. renal medulla
   - ✓ Consists of cone-shaped tissue masses called renal pyramids
3. renal pelvis
   - ✓ Is a central space or cavity that is continuous with the ureters.

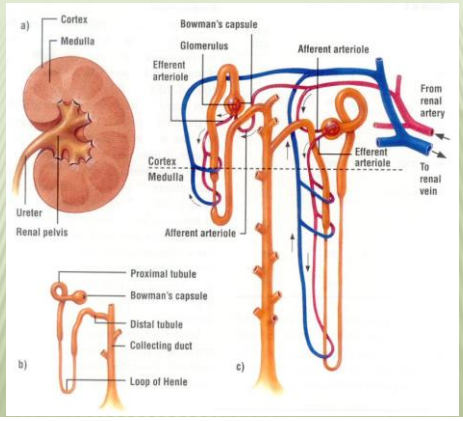


ANATOMY OF A NEPHRON

- Each kidney is compose of over 1 million nephrons (aka renal or kidney tubules).
- Each nephron has its own blood supply including two capillary regions.
- Renal artery →renal arterioles =→ glomerulus/capillary within glomerular capsule
- Blood leaving glomerulus → efferent arteriole→ peritubular capillary network → venules → renal veins

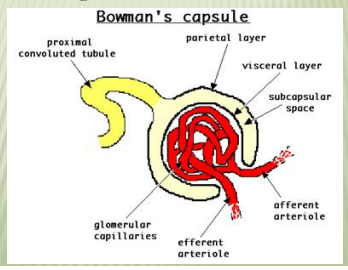


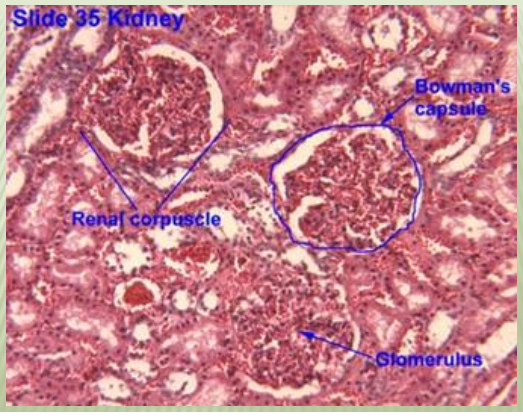


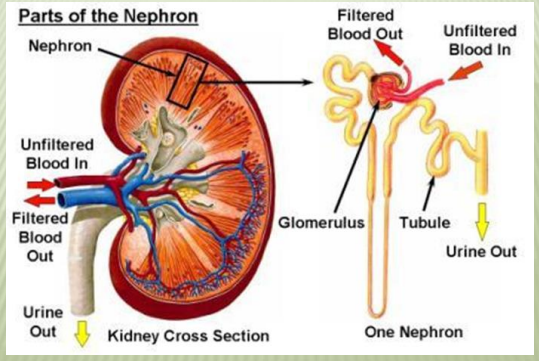


PARTS OF A NEPHRON

- Cup-like structure: glomerular capusule (aka Bowmans' capsule)







PARTS OF A NEPHRON

- Connects to proximal convoluted tubule
- Composed of cuboidal epithelial cells and tightly packed microvilli form a brush border to increase surface area for reabsorption.
- Narrow tube takes a U-turn and becomes the Loop of Henle which is lined with simple squamous epithelial cells.
- The Loop of Henle becomes the distal convoluted tubule which is composed of cuboidal epithelial cells that have many mitochondria but do not have microvilli.
- PCT not specialize for reabsorption.
- DCT of several nephron enter one collecting duct.
- Many collecting ducts carry urine to the renal pelvis.

URINE FORMATION

1. *Glomerular Filtration*
   - Occurs when blood enters the afferent arteriole and the glomerulus (capillary)
   - Due to the glomerular blood pressure, water and small molecules move from the glomerulus to the inside of the Bowman's Capsule
   - This is a filtration process because large molecules are formed and elements are not able to pass through the capillary wall.
   - The glomerular filtrate contains small dissolved molecules in approximately the same concentration as plasma.
   - Any molecule that escapes being filtered as well as the non-filterable components leave the glomerulus via the efferent arteriole.

URINE FORMATION

2. Tubular Reabsorption
   - Occurs when ions are being reabsorbed from the nephron into the blood from the peritubular capillary network.
   - The osmolarity of blood is maintained by the presence of plasma proteins and salt.
   - When Na^+ are actively reabsorbed Cl^- flows passively
   - The reabsorption of NaCl increases the osmolarity of blood compared to filtrate so water moves from the tubule to the blood.
   - Nutrients such as glucose and amino acids also return to the blood at the PCT.
   - This is a selective process because only molecules recognized by carrier proteins can be transported