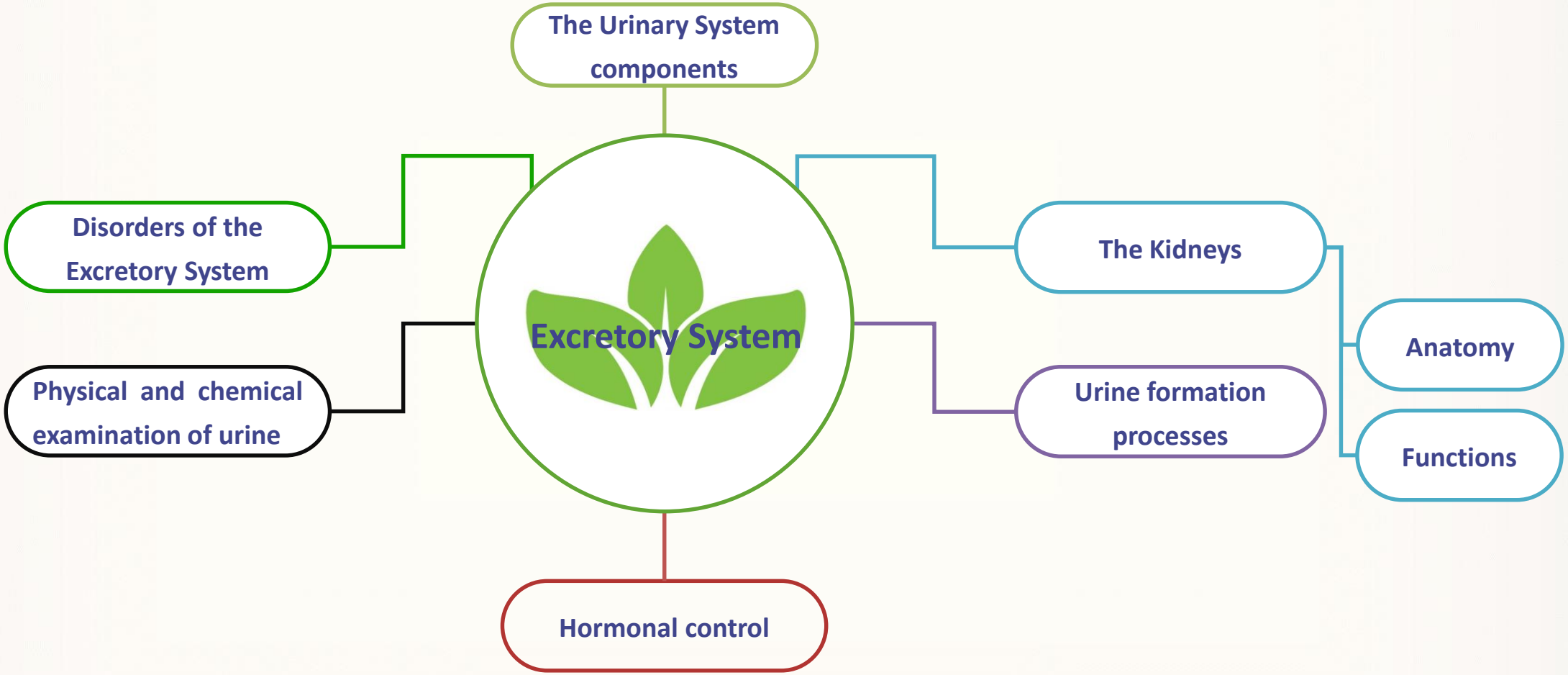
Mind Map


The Urinary System components
Disorders of the Excretory System
Physical and chemical examination of urine
Excretory System
The Kidneys
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Introduction

Wastes can be classified as follows:

- carbon dioxide removed by lungs
- water removed by skin, kidney and lungs
- salts removed by skin and kidney
- ammonia removed by the liver
- urea removed by kidney

The body eliminates cellular wastes through the excretory system. Harmful chemicals made when the body creates energy must be removed from blood to keep you healthy.

Objectives

- Outline the basic macrostructure and function of the urinary excretory system: Kidney, ureters, urinary bladder and urethra
- Explain the role of the excretory system in homeostasis: the ability and necessity to maintain constancy of fluid balance and chemistry.
- Explain the role of Kidney in regulating body fluids.
- Describe the processes of filtration, reabsorption and excretion in the medulla and renal pelvis.
- Describe pathway of urine from kidney to urethra

The Urinary System

The urinary system is composed of :

Kidneys:

The kidney is bean shaped structure that remove urine and excess salts from the blood.

The ureters

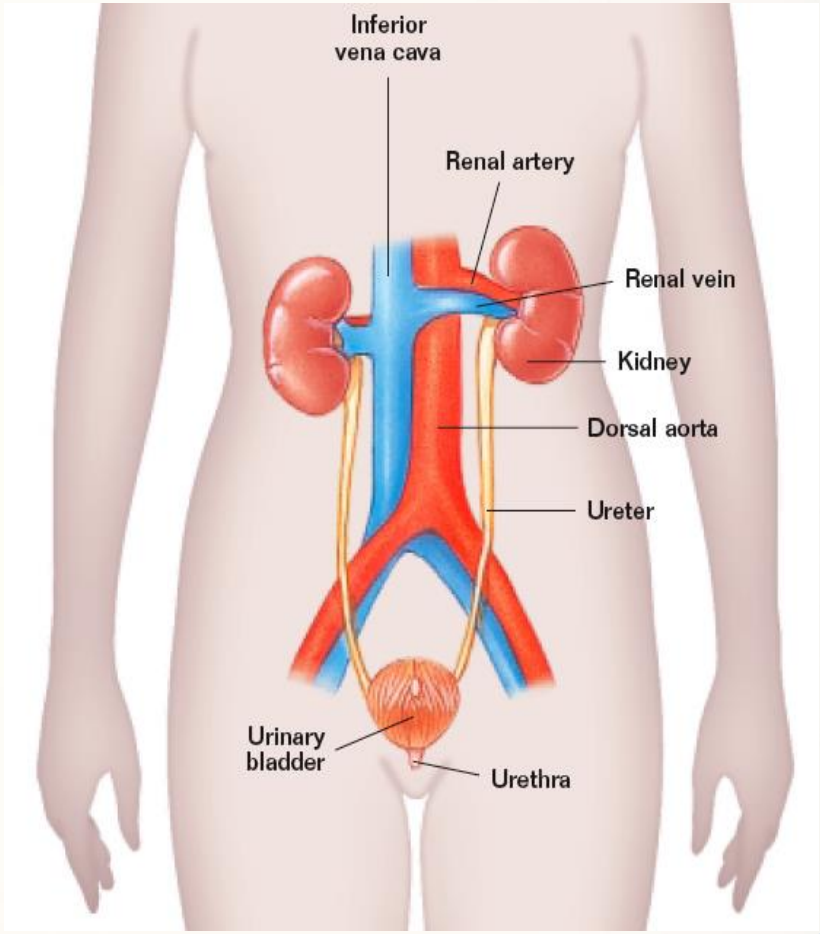
Are tubes that carry urine from the kidneys to the urinary bladder.

The urinary bladder

An elastic muscular sack capable of great expansion and stores urine temporarily until it is released from the body.

The urethra

Is the tube that carries urine from the urinary bladder to the outside of the body. The outer end of the urethra is controlled by a circular muscle called a sphincter.



The Urinary System

Functions of the Kidneys

- The principal function of the kidney is to filter blood in order to remove cellular waste products from the body: urea, uric acid, creatinine, minerals and excess water.
- Every drop of blood in your body is filtered by your kidneys more than 300 times per day. At any given time, 20 % of blood is in the kidneys.
- Kidneys regulate the amount of water we need to maintain in our bodies.
- The kidneys help to maintain homeostasis by filtering the blood: Since the kidneys control what leaves and what remains in the body, they maintain the levels of water, ions and other materials nearly constant and within the limits to maintain homeostasis.
- Humans can function with one kidney. If one ceases to work, the other increases in size to handle the workload.

The Urinary System

Functions of the Kidneys

The kidney can also excrete other waste products, such as :

Ammonia (NH3)

Amino group is removed from amino acid (first step of AA metabolism in the liver) changed to ammonia NH3.

Ammonia is highly toxic to the mammalian body and is changed into urea in the liver (urea cycle).

Urea

A nitrogenous waste moderately toxic, produced in the liver from the breakdown of protein. It is the main component of urine in mammals.

Uric acid

Minimally toxic and usually produced from breakdown of DNA or RNA.

Creatinine

Waste product of muscle action.

The Urinary System

Substance	Blood Plasma (total amount in g)	Urine (amount in g per day)
Urea	4.8	25
Uric acid	0.15	0.8
Creatinine	0.03	1.6
Potassium	0.5	2.0
Chloride	10.7	6.3
Sodium	9.7	4.6
Protein	200	0.1
HCO_3^-	4.6	0
Glucose	3	0

The Urinary System

Anatomy of the Kidney

The kidney is formed of three sections:

- **The cortex**

  The *cortex* is where the blood is filtered

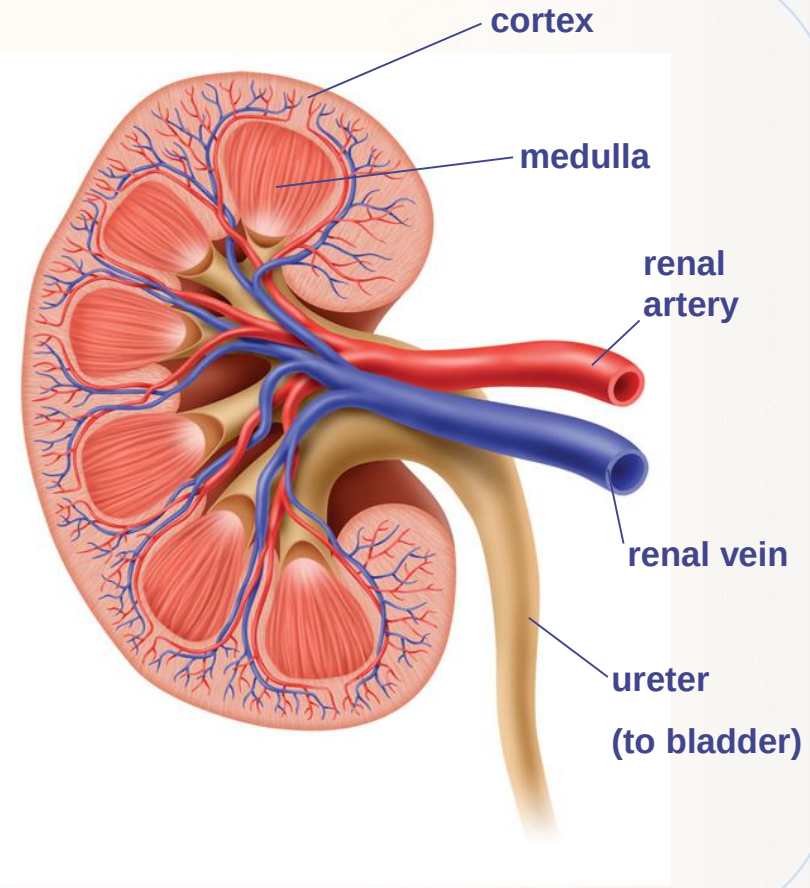
- **The medulla**

  The *medulla* contains the collecting ducts which carry filtrate (filtered substances) to the pelvis. Most of the medulla is made up of renal pyramids.

- **The pelvis**

  The *pelvis* is a hollow cavity where urine accumulates and drains into the ureter.

Blood enters the kidneys via renal arteries, and leaves the kidneys via the renal veins. Wastes removed from the blood leave the kidneys by the ureter.



The Urinary System

The nephrons

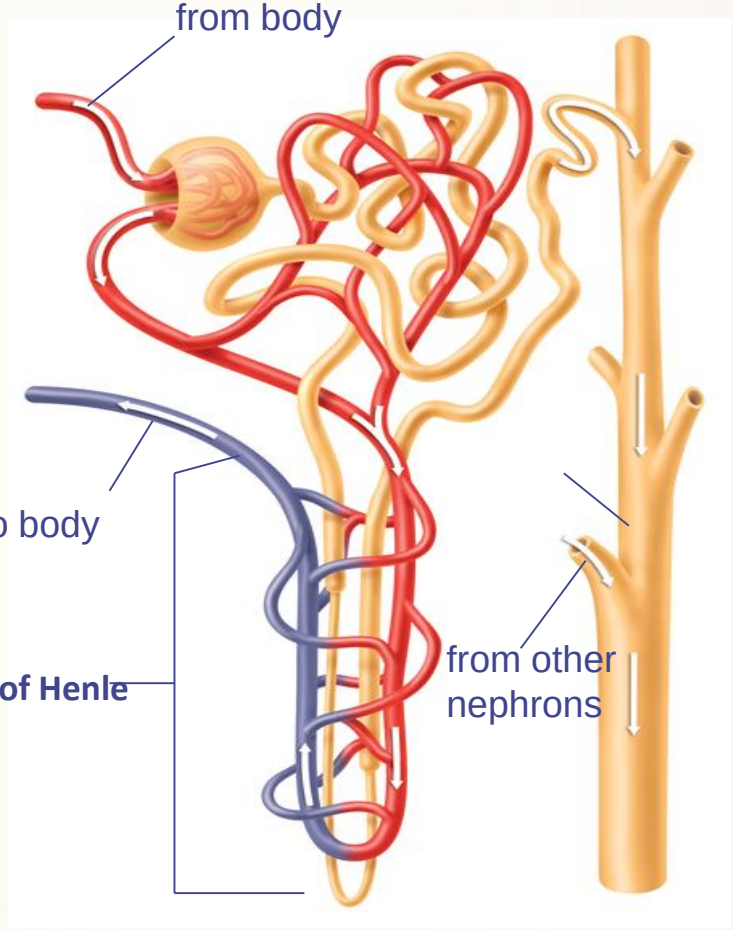
- Nephrons are the filtering units in the kidneys responsible for the actual purification and filtration of the blood.

There are approximately one million nephrons in each kidney.

- The nephrons are located within the cortex and medulla of each kidney.

- The tubes of the nephron are surrounded by cells and a network of blood vessels spreads throughout the tissue. Therefore, material that leaves the nephron enters the surrounding cells and returns to the bloodstream by a network of vessels.

- They clean and rebalance the blood to produce urine (glomerular filtration, reabsorption and secretion).



The Urinary System

The nephrons

Each nephron consists of the following parts:

Glomerulus

The *glomerulus* is a network of thin-walled capillaries arising from an afferent arteriole of the renal artery.

Bowman's capsule

The *Bowman's capsule* is a double-walled, cup-shaped structure that encases the glomerulus.

Proximal tubule (PCT)

The proximal tubule is a convoluted tubule that leads from the Bowman's capsule to the Loop of Henle

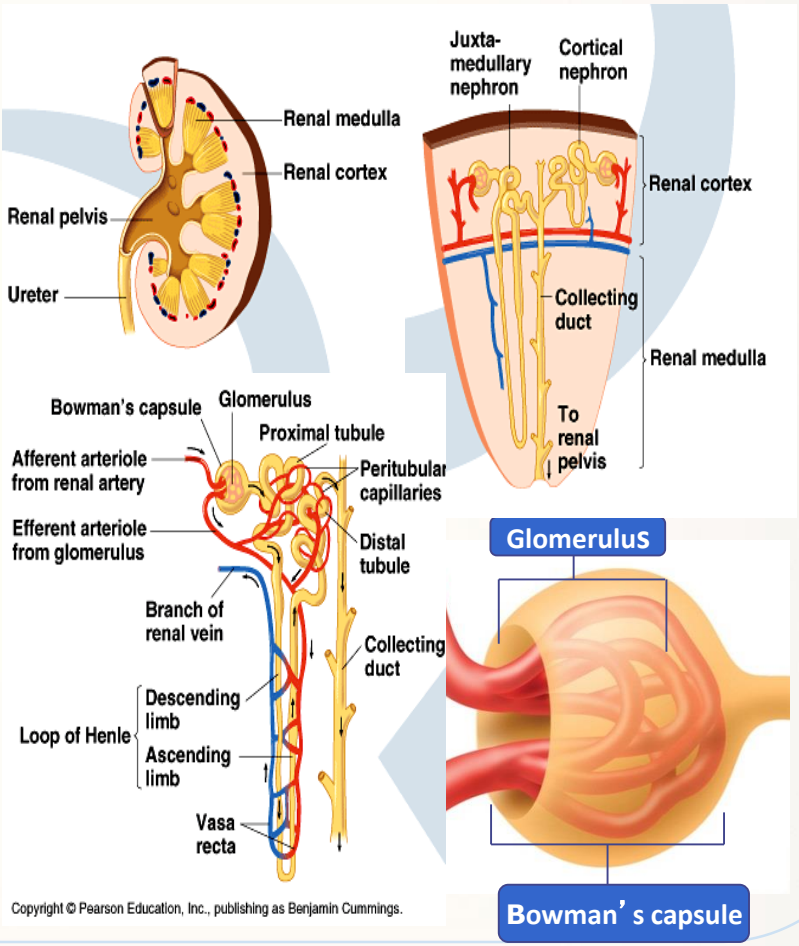
Loop of Henle

The *loop of Henle* is a long loop which extends into the medulla

Distal tubule (DCT)

The distal convoluted tubule connects the loop of Henle to the collecting duct.

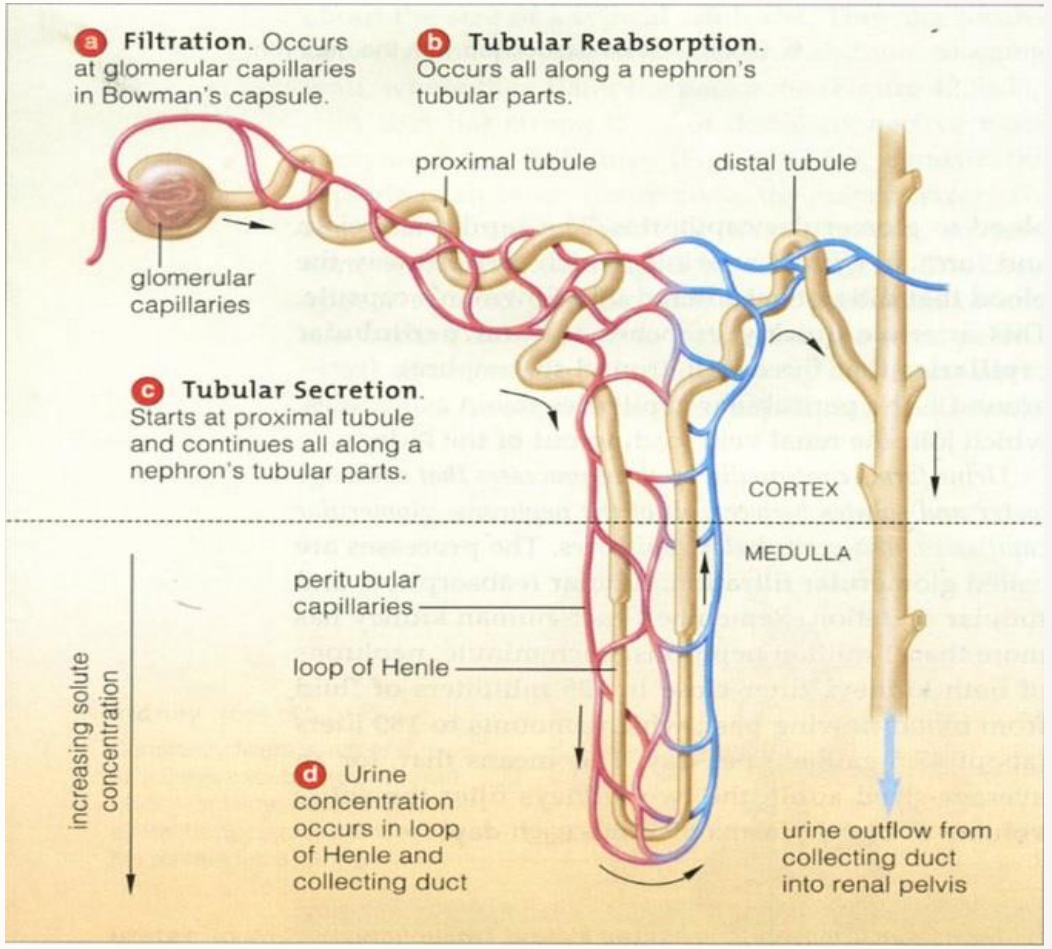
Collecting duct



Urine formation processes

The blood is cleaned and the urine is formed in a three-step processes that take place in successive parts of the nephron:

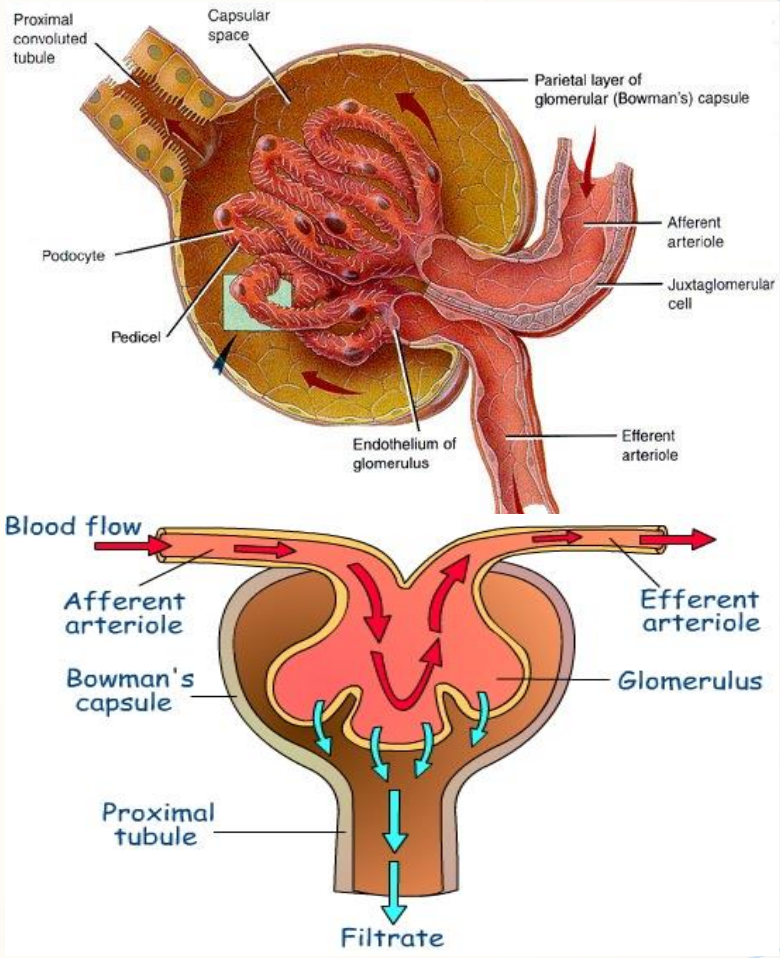
- The first step is **filtration** of the blood
- The second step is **reabsorption** of materials.
- The third step is **secretion** of other metabolic wastes. of materials.



Urine formation processes

The first step is filtration of the blood

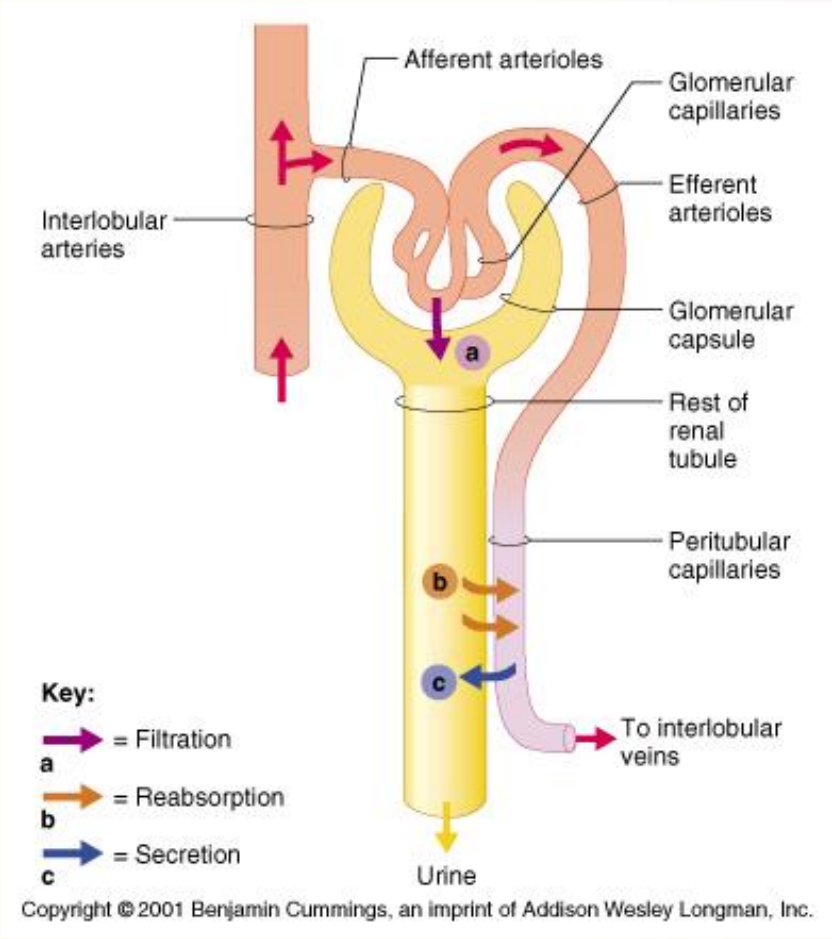
- Blood enters Bowman's capsule through a tiny artery — (the renal artery). The artery branches to form a glomerulus.
- Blood pressure in Bowman's capsule forces some blood plasma and small particles into the surrounding capsule. Water, electrolytes, amino acids, glucose, urea, and other small molecules diffuse out of the blood, creating the filtrate. This is called the nephric filtrate.
- Large particles such as blood cells (RBCs, WBCs, platelets) and proteins remain in capillaries.
- The nephric filtrate is pushed out of the capsule into the proximal tubule. This is where the next step of reabsorption begins. An efferent arteriole leaves the glomerulus and forms the peritubular capillaries, where reabsorption takes place.
- The body's entire volume of blood is filtered every 45 min. (Glomerular filtration rate GFR in normal adult human = 125 ml/ min).= 180 liter/day.



Urine formation processes

The second step is reabsorption of materials.

- The peritubular capillaries contain blood in a hyperosmotic state, so much of the water filtrate reenters (reabsorption) the blood by osmosis. Active transport also returns sodium (chloride following passively), glucose, and amino acids to the blood.
- Only materials needed by the body are returned to bloodstream. For example, 99 % of water, all glucose and amino acids and many salts (such as Na ions) are reabsorbed.
- Materials not reabsorbed make up the urine, which flows into the loop of Henle whose primary function is to remove water from the filtrate by osmosis.



Urine formation processes

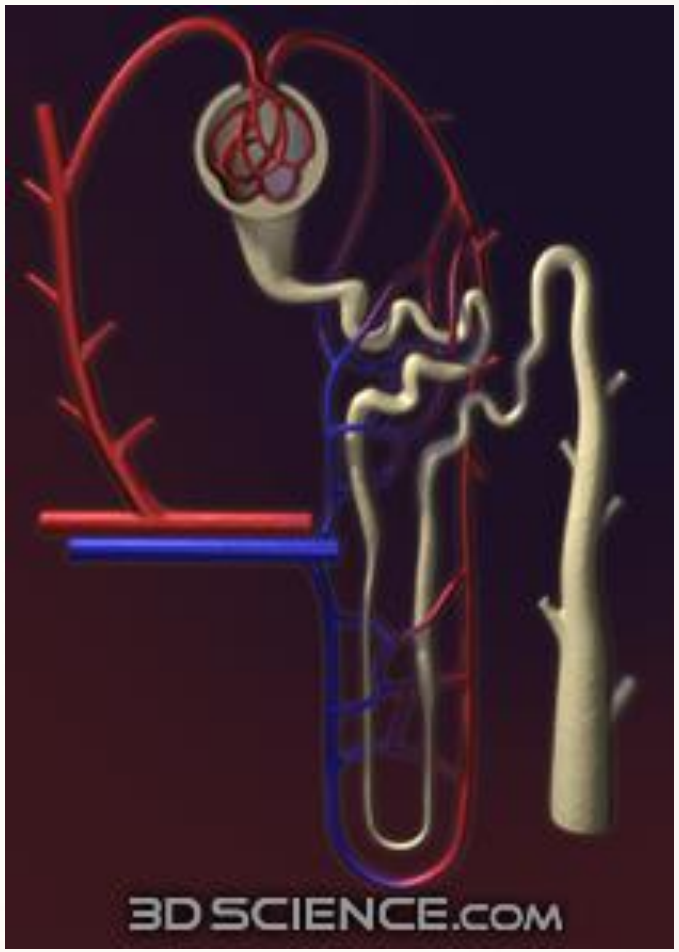
The second step is reabsorption of materials.

- In the loop of Henle, water can be reabsorbed one final time to reduce the volume of urine. In fact, There is an increase in sodium concentration in the cells of the loop of Henle as we move from the area of the cortex to the inner pelvis of the kidney. This causes water to be drawn from the filtrate.

- The ascending loop actively transports chloride ions (sodium ions follow passively) into the surrounding area, recycling salt and creating a hyperosmotic state in the kidney medulla. The hypertonic state is further increased by urea, which diffuses out of the collecting ducts.

- The distal tubule: The active secretion of sodium ions occurs with chloride ions and water passively following. Potassium ions enter the tubule.

- Collecting ducts. Water leaves the collecting ducts in response to antidiuretic hormone (ADH), which is secreted by the posterior pituitary in response to high osmotic pressure in the blood (actually detected by the hypothalamus).



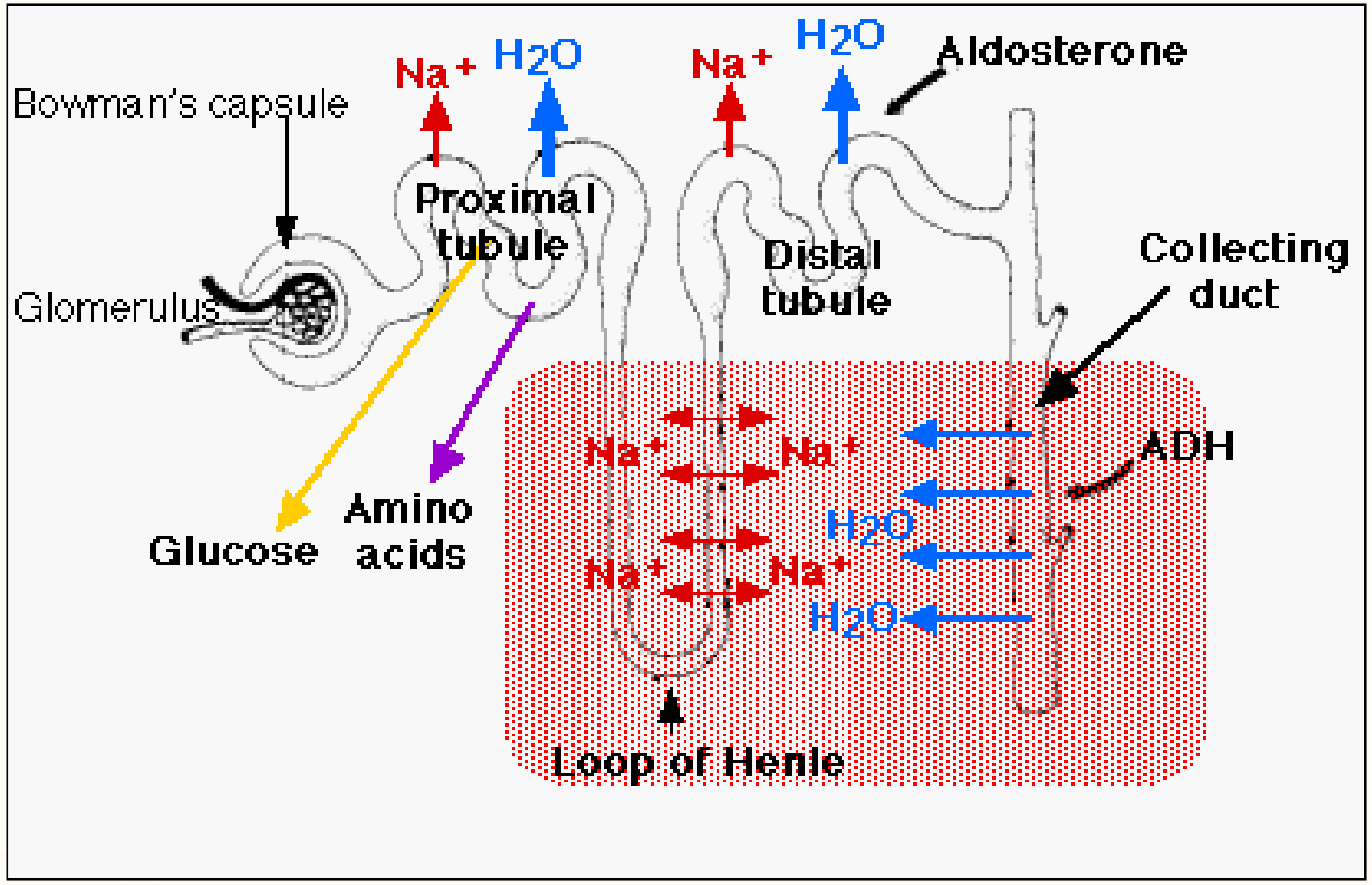
Urine formation processes

The second step is reabsorption of materials.

Substances that are NOT reabsorbed fully

- Things that lack carriers
- Things that are not lipid soluble
- Things that are too large: Examples: urea, creatinine, uric acid

Urine formation processes

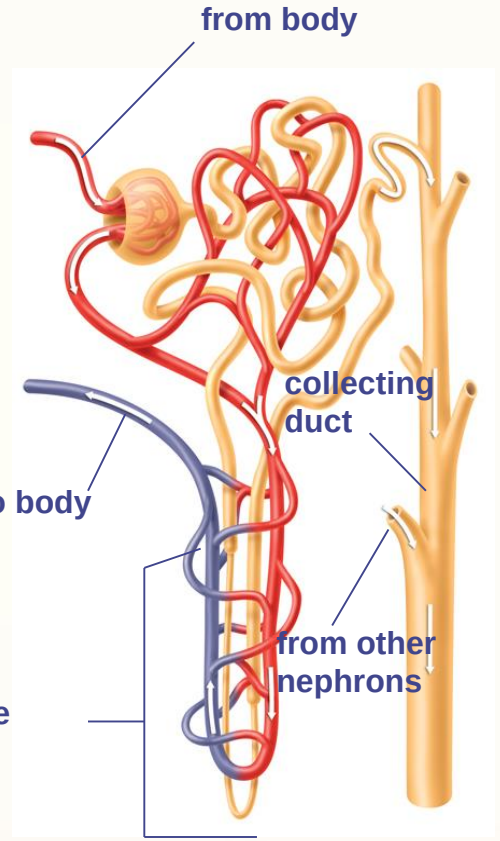


Urine formation processes

The third step is secretion of materials.

Completion of getting rid of other waste materials that not filtered through glomeruli but rather secreted from capillaries surrounding tubules such as K and H ions.

The remaining wastes, now called urine are transported out through the collecting tubule to an area known as the renal pelvis (a collecting area) where the urine then passes into the ureter.



Hormonal control

The different parts of the nephron are subject to hormonal control.

Antidiuretic hormone (ADH)

- The anti-diuretic hormone (ADH) is secreted by the posterior pituitary and controls water reabsorption.
- It causes the distal and collecting tubules to become more permeable to water. This allows hypertonic urine to be formed.
- Fluid intake low = ADH secreted

- Stimulates reabsorption of water in nephron.
- Urine output decreases and is more concentrated

- Fluid intake high: ADH not secreted

- Less reabsorption of water in nephron
-Urine output increases and is relatively dilute

Hormonal control

Aldosterone

- Secreted from adrenal cortex in response to a decrease of Na^+ or an increase of K^+ in blood.
- It increases Na^+ absorption and K^+ secretion in the DCT and cortical portion of the collecting duct.
- It helps to maintain blood volume and pressure.

Hormonal control

Atrial Natriuretic Factor

- Secreted by the atrial myocardium in response to high blood pressure.
- It inhibits sodium and water reabsorption, increases the output of both in the urine, and thus reduces blood volume and pressure.

Hormonal control

Renin

- The arteriolar cells secrete renin (an enzyme), which stimulates the adrenal cortex to secrete aldosterone which increases the absorption of sodium chloride and the excretion of potassium.

Urine

Urinalysis: Physical and chemical examination of urine

Color

- Normal and fresh urine is clear and transparent, containing no blood cells and little proteins. If cloudy, it could indicate the presence of bacteria, semen, blood, or menstrual fluid.
- It could be: Pale yellow, light yellow, yellow, green yellow (olive), red-yellow, red, red-brown, brown-black, black, milky.

Odor

Strong odors of urine needs to be identified because many can give clues to the origin of diseases. For example:

- Ammoniacal may be related to some bacterial infections.
- Effects of drugs and diet-Many ingested substances will give the urine a distinct odor as ingested asparagus giving urine its characteristic odor.
- Decomposition of urine containing cystine or pus will have the odor of rotten eggs (H_2S).

Urine

Urinalysis: Physical and chemical examination of urine

pH

4.6-8.0 pH (fresh is acidic)

Urine Volume

- An average adult produces ***1-2 L*** of urine per day.
- Excessive urine output is called ***polyuria***.
- Scanty urine output is ***oliguria***. An output of less than ***400 mL/day*** is insufficient to excrete toxic wastes.

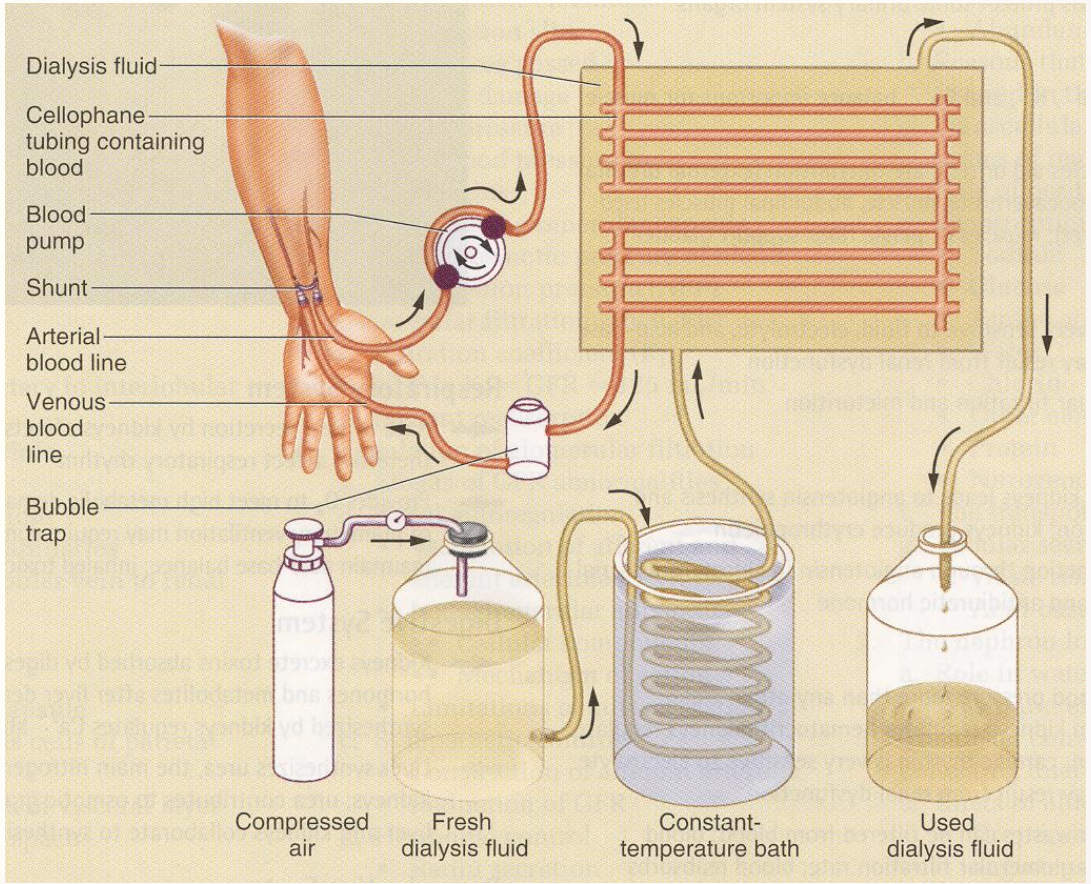
Disorders of the Excretory System

Uremia

- Urine and other wastes are not filtered out of blood, poisoning cells.

When the kidneys fail, excess fluids and wastes accumulate in blood.

Hemodialysis: Artificially clearing wastes from the blood.



Disorders of the Excretory System

Doctors analyze urine for disease:

- Normal urine contains water, urea and trace minerals.
- Sugar in urine indicates Diabetes
- Protein in urine indicates the kidneys are not working and the person, or animal, is very sick.

UTI (Urinary Tract Infection)

- Is a very common disorder. If the bladder has become infected, it is known as cystitis. If the urethra is infected., it is called urethritis.
- Symptoms include painful urination, frequent urination and bloody or brown urine.

This can lead to chills, fever, nausea, vomiting and upper abdomen tenderness.

If left untreated, all UTI's can lead to permanent kidney damage and possible kidney failure.

A person should drink lots of water.

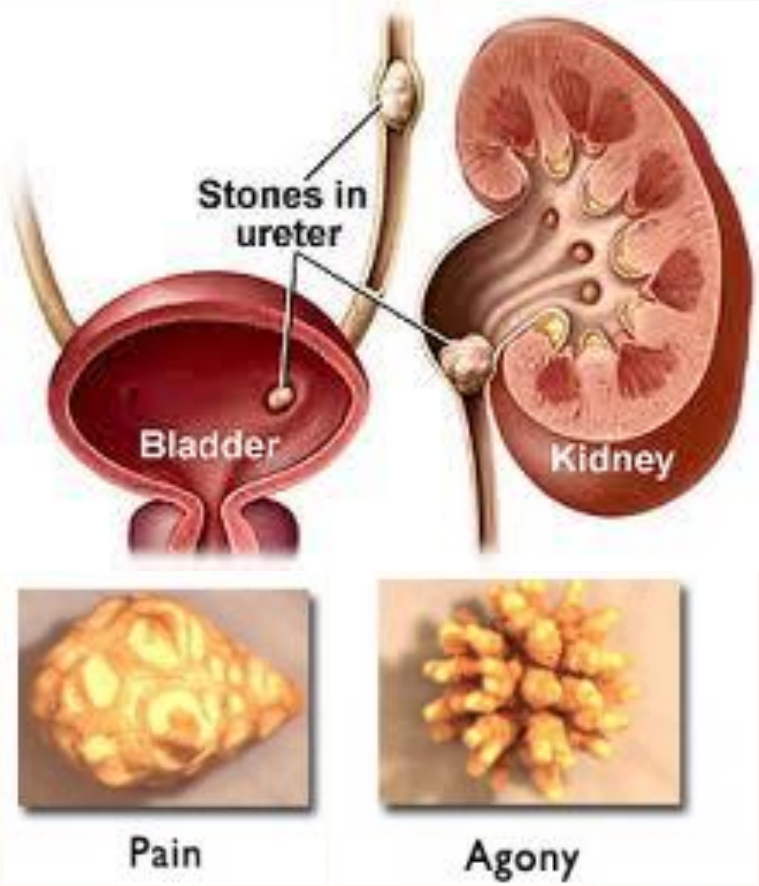
Disorders of the Excretory System

Kidney Infections

- Result when an infection reaches the kidneys and becomes known as pyelonephritis.
- Common causes can be infection from elsewhere in the body or obstruction of the prostate gland (usually in older men).

Kidney Stones

- Crystals formed from minerals in urine. They can be found in the kidney, ureter or bladder. 80% of those stricken are males. The most common crystals are: Calcium Oxalates and Uric acid
- Symptoms include severe back or abdomen pain, blood in the urine, nausea and vomiting.



Disorders of the Excretory System

Kidney Stones

- Crystals formed from minerals in urine. They can be found in the kidney, ureter or bladder. 80% of those stricken are males.
- The most common crystals are: Calcium Oxalates and Uric acid
- Symptoms include severe back or abdomen pain, blood in the urine, nausea and vomiting.
- Real large stones require surgery for removal.

How to avoid kidney stones:

- Increase liquid intake (more than 2l / day)
- Limit sodium intake
- Limit animal protein (link shown in men)
- Limit foods high in oxalate (spinach, strawberries, nuts, dark chocolate, brewed tea)

Disorders of the Excretory System

Gout

Similar to arthritis where excess production of uric acid leads to deposits of crystals in joints (esp. toes)

Summary

- The excretory system is responsible for cleaning the blood by removing metabolic wastes, excess solutes, and excess water and excreting them as urine.
- Main functions of kidneys include: Regulation of blood volume and composition, regulation of blood pH and blood pressure as well as contribution to metabolism (gluconeogenesis, erythropoietin).
- If there is too much water in the blood, then it is removed and put in urine.
- If there is not enough water in the blood, the kidneys will not remove it.
- If there is too much urea or other solutes in the blood, the kidneys will remove these excess solutes.
- By regulating solute numbers and water volume, the kidneys normally maintain homeostasis in blood solute concentration.

Summary

The key functions of the excretory system are :

- **Filtration**
  - Fluid is filtered through selectively permeable epithelium.
  - Hydrostatic pressure or blood pressure is used to force solutes and water across membrane into the excretory system, creating filtrate.
- **Selective Re-absorption**

Essential small molecules are recovered from filtrate and returned to body fluids by active transport.

- **Secretion**

Processed filtrate leaves the system and the body as urine.

Summary

- Antidiuretic hormone (ADH) – prevents excess water loss from kidneys
- Alcohol – inhibits secretion of ADH = more urine volume.
- Aldosterone – prevents excess loss of sodium and water from kidneys
- Caffeine – increases rate of salt and water loss from kidneys
- Increased blood pressure – increase rate of water loss from kidneys
- system (RAGlomerular filtration rate (GFR) is the amount of filtrate formed in all renal corpuscles of both kidneys each minute. It is regulated by renin-angiotensin- S).