College of Science
Biology department

animal physiology -The Urinary System

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Human Excretory System

- **composed of:**
- kidney-functional unit of a kidney- nephron)
- lungs (alveoli)
- skin (sweat glands)
- Liver
- **types of metabolic wastes:**

Waste	**Produced from**
Carbon Dioxide	Aerobic Respiration
Water	Aerobic Respiration
Salts	Metabolic activities
Nitrogenous wastes	Breakdown of excess Amino Acids & Proteins

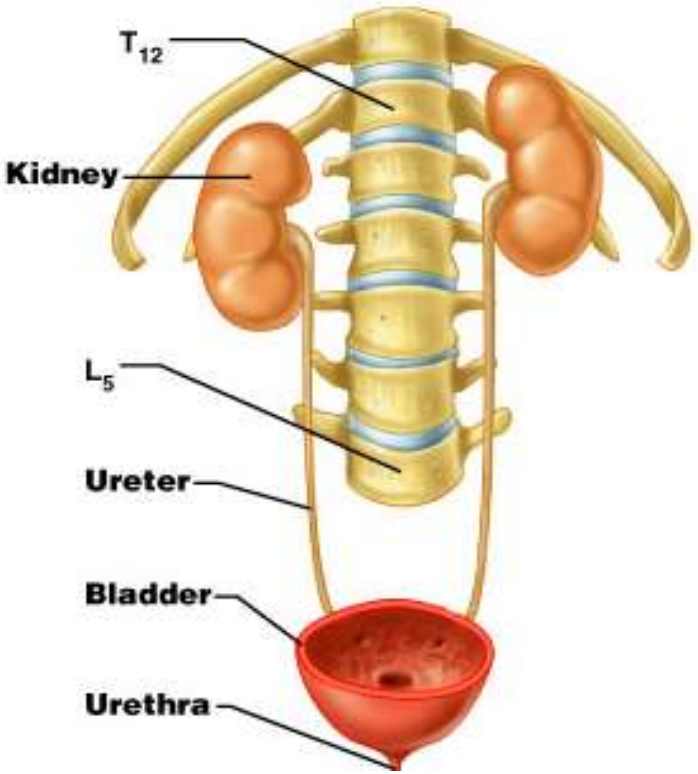
types of nitrogenous wastes	**toxicity**
Ammonia (NH_3)	Highly Toxic
Urea	Moderately Toxic
Uric Acid Crystals	Minimally Toxic

*waste and what its removed by :

1-carbon dioxide- lungs.
2-water - skin, kidney, lungs.
3-salts - skin, kidney.
4-ammonia – liver.
5-urea - kidney .

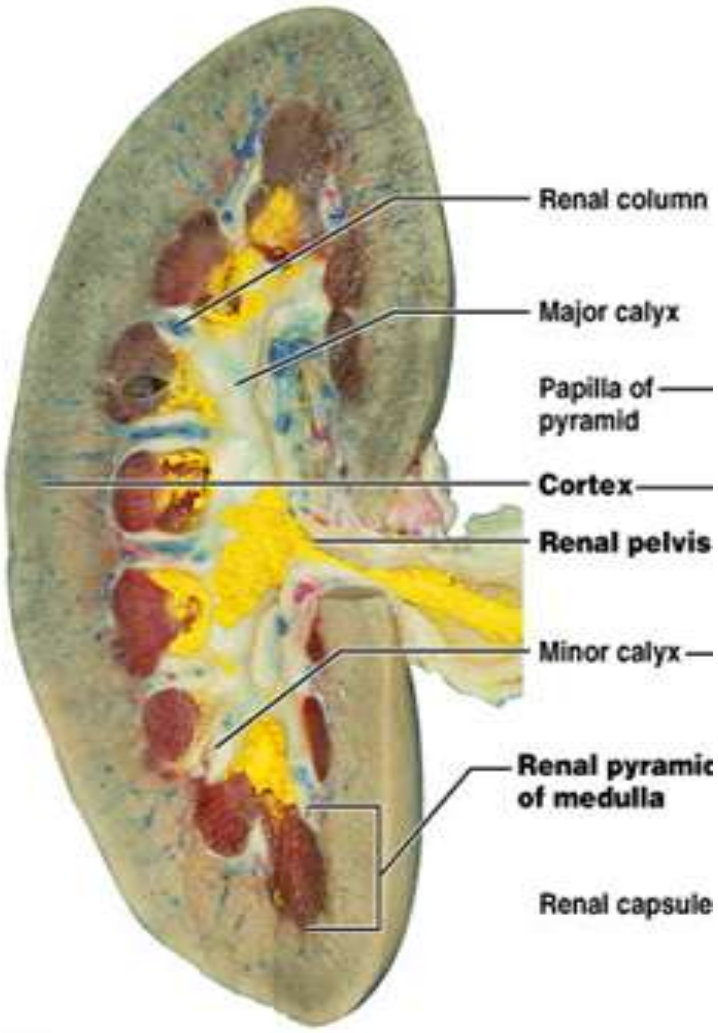
The Urinary System

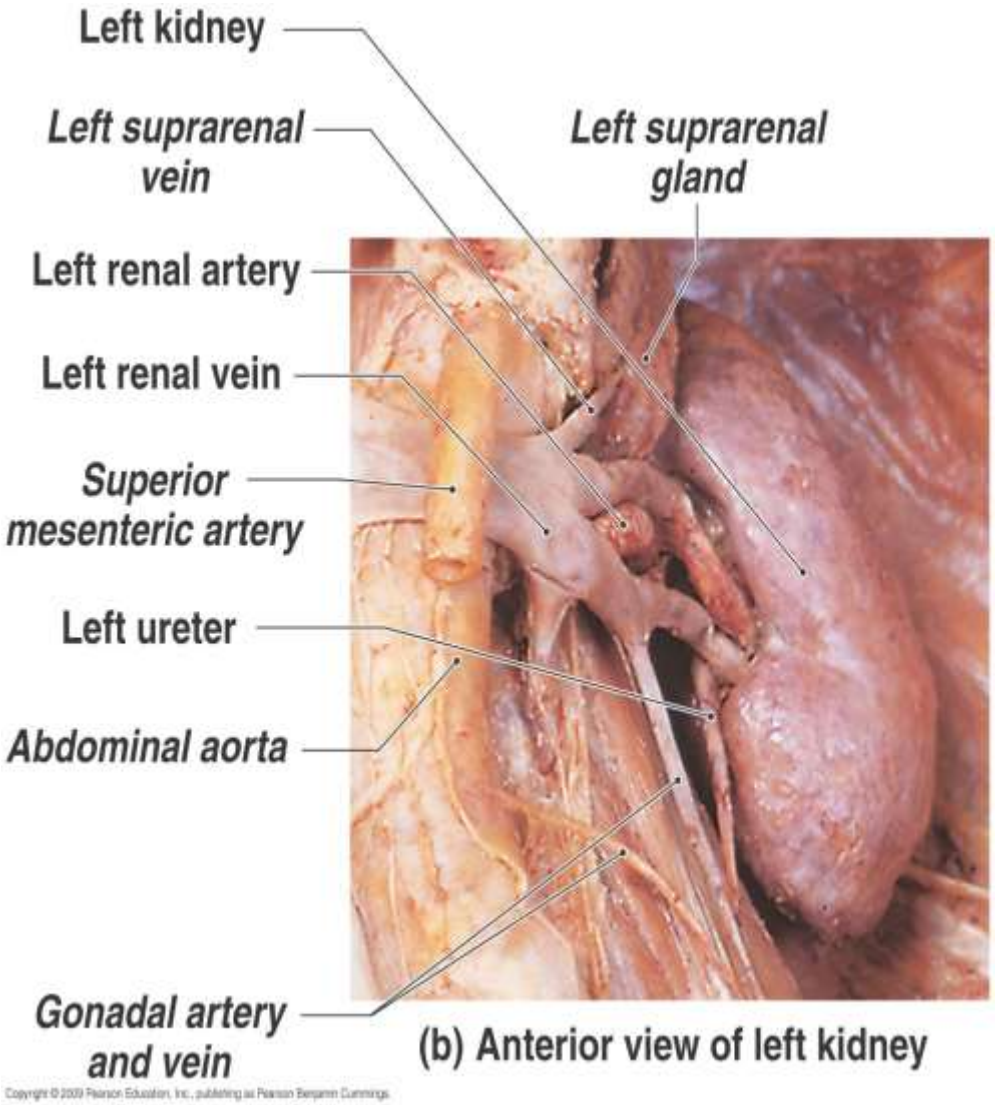
- Paired kidneys
- A ureter for each kidney
- Urinary bladder
- Urethra



Main Functions of Urinary System

- Kidneys filter blood to keep it pure
  - Toxins
  - Metabolic wastes
  - Excess water
  - Excess ions
- Dispose of nitrogenous wastes from blood
  - Urea
  - Uric acid
  - Creatinine
- Regulate the balance of water and electrolytes, acids and bases





(b) Anterior view of left kidney

Kidney has two regions:

Cortex: outer

Columns of cortex divide medulla into “pyramids”

Medulla: inner

Darker, cone-shaped medullary or renal pyramids

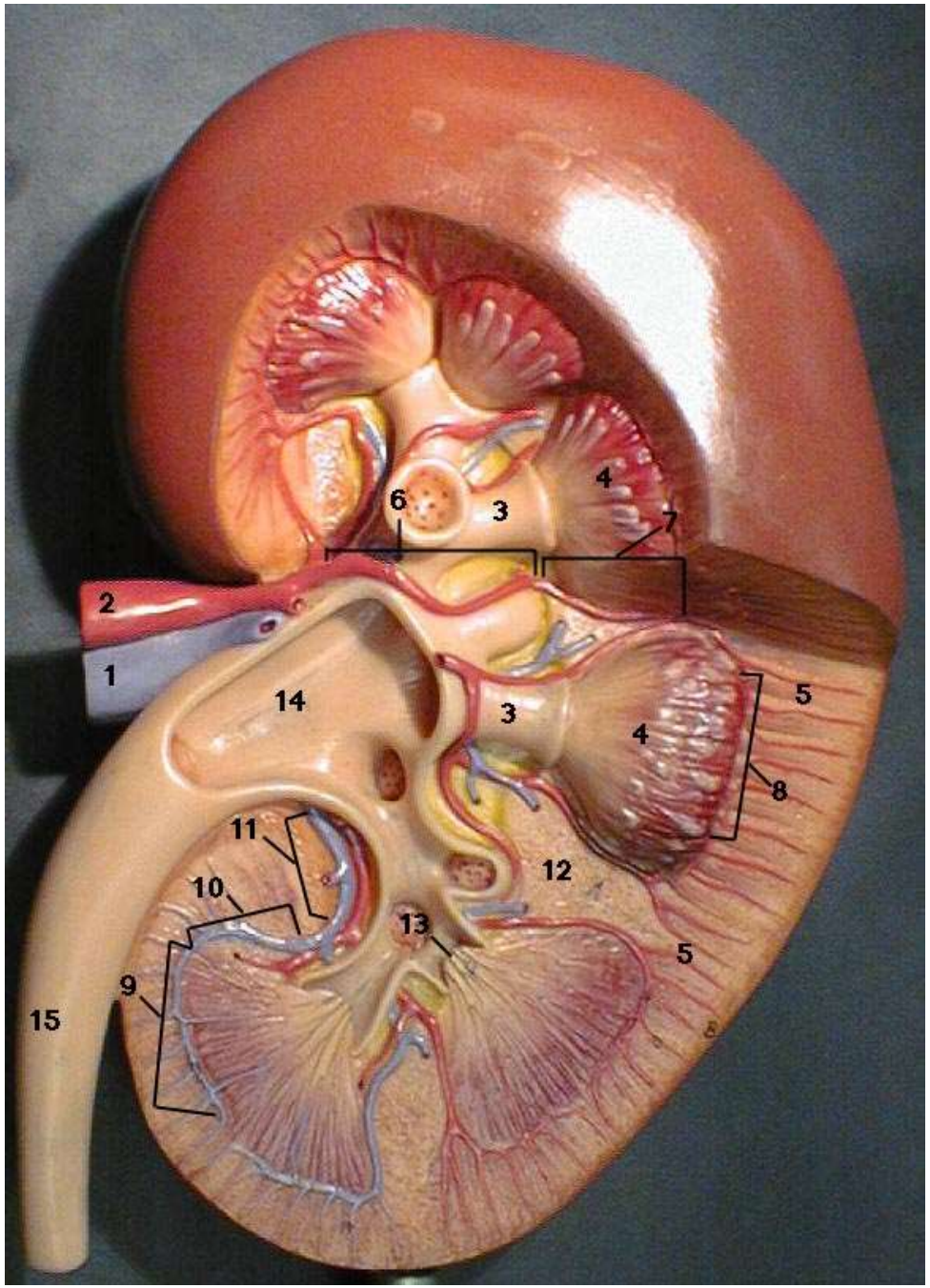
Parallel bundles of urine-collecting tubules

The human kidney has lobes Pyramid and cortical tissue surrounding it 5-11 per kidney . Renal pelvis (=basin) Expanded, funnel shaped, superior part of ureter Branches to form two or three major calices (seen best on right pic below).

Each of these divides again, minor calices: collect urine from papillae of pyramids

1. Renal Vein
2. Renal Artery
3. Renal Calyx
4. Medullary Pyramid
5. Renal Cortex

12. Renal Column
13. Renal Papillae
14. Renal Pelvis
15. Ureter



formation of urine

occurs by a series of three processes that take place in successive parts of the nephron

- **filtration**
- **reabsorption**
- **Secretion**
- ***Uriniferous tubule*** is the main structural and functional unit.

More than a million of these tubules act together to form the urine

Three main mechanisms

a.Glomerular filtration

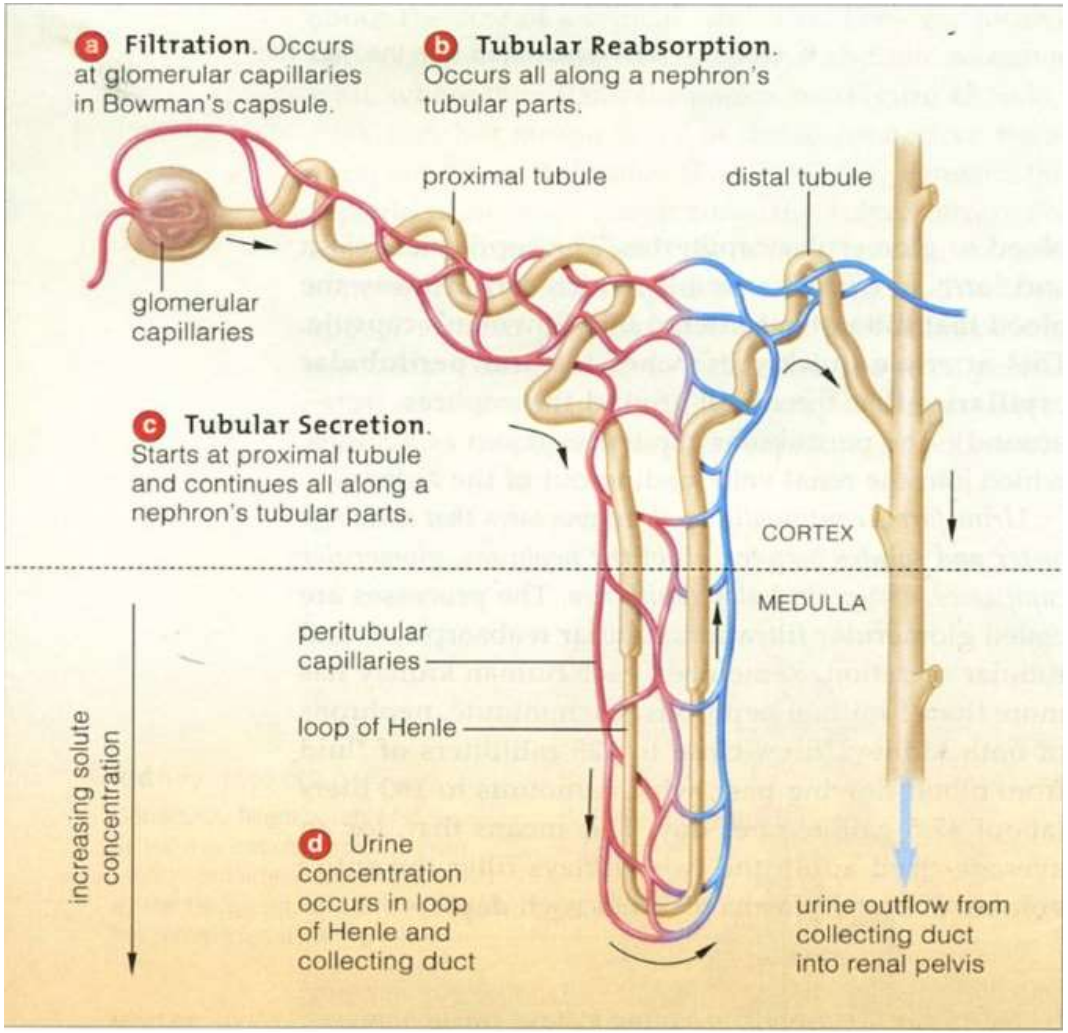
b.Tubular reabsorption

c.Tubular secretion

Two major parts

1.A urine-forming nephron

2.A collecting duct which concentrates urine by removing water from it.



Filtration

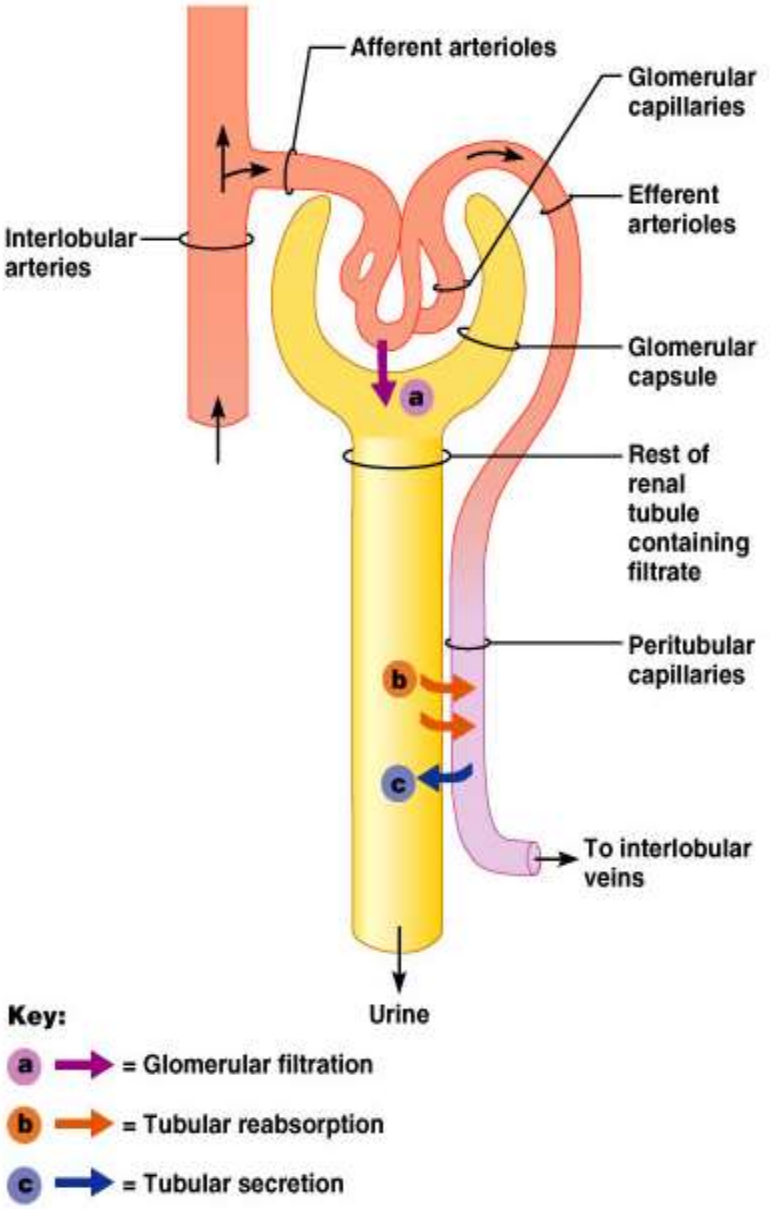
a. Fluid is squeezed out of the glomerular capillary bed

Resorption

b. Most nutrients, water ad essential ions are returned to the blood of the peritubular capillaries

Secretion

c. Moves additional undesirable molecules into tubule from blood of peritubular capillaries



the nephron

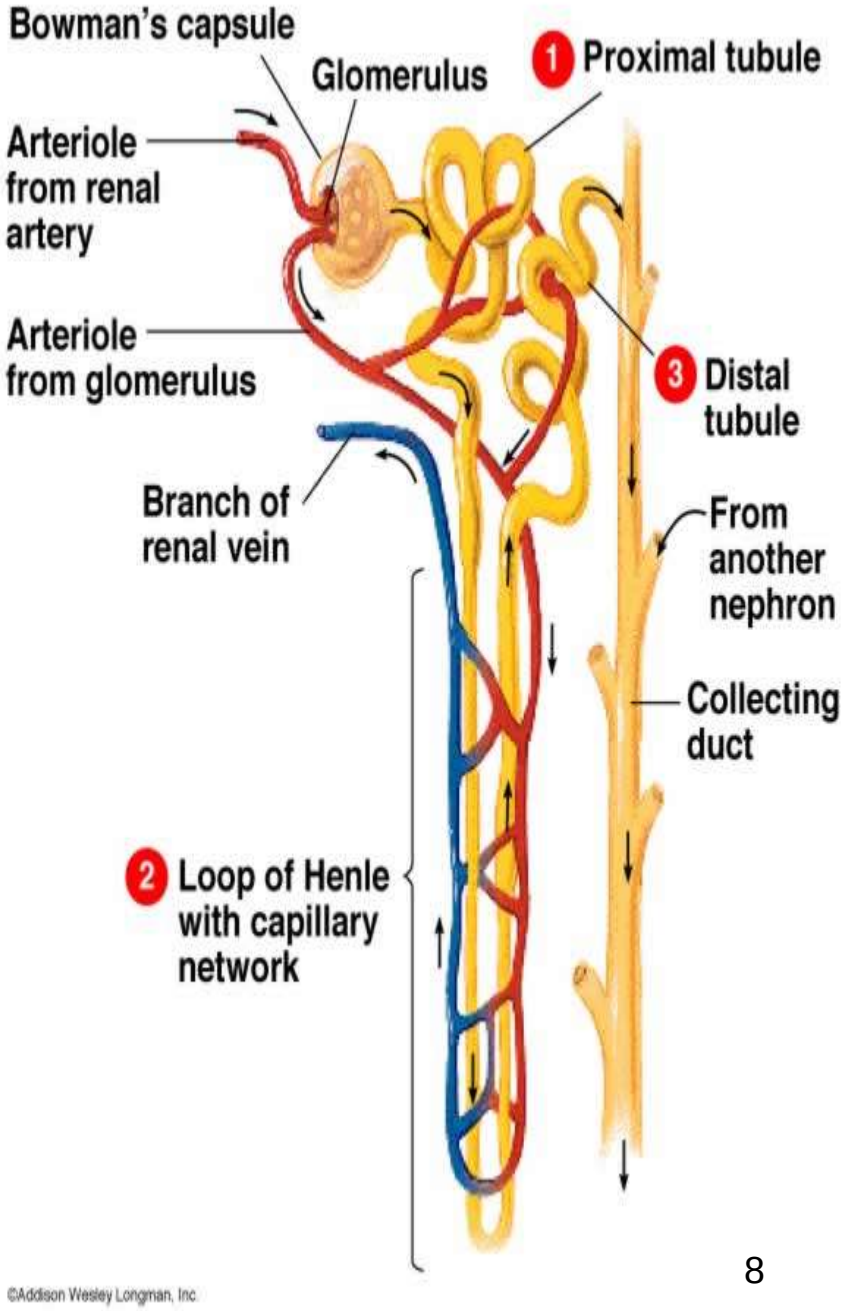
The nephron begins with Bowman's capsules, which surrounds the glomerulus, a ball of capillaries arising from an afferent arteriole of the renal artery. Leaving the glomerulus is an efferent arteriole, which forms the peritubular capillaries, where reabsorption takes place. These spread over the nephron to later form a venule that joins others to make up the renal vein.

Bowman's capsule leads to the proximal convoluted tubule, the loop of Henle, and the distal convoluted tubule, which joins a collecting duct. The afferent arteriole also connects with the distal convoluted tubule, forming the juxtaglomerular complex.

Items filtered out of the blood into the Bowman's capsule :

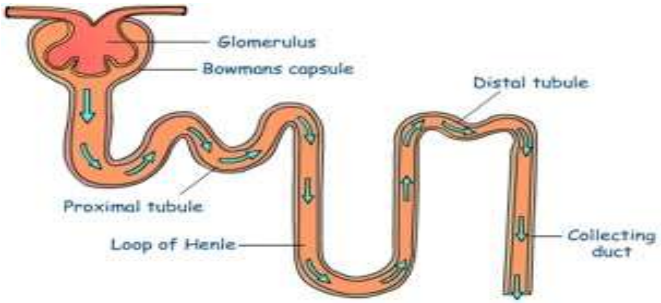
Glucose (but must be returned to the blood by active transport at the loop of Henle) urea, salts and water.

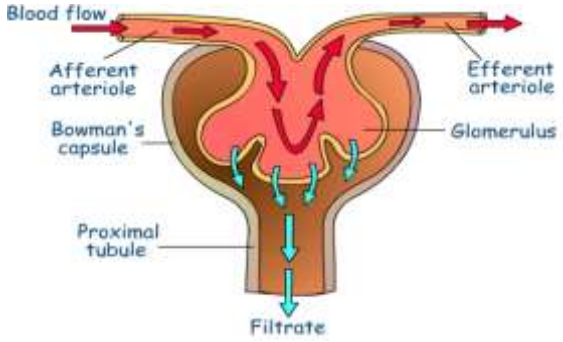
Items that remain in the blood are :RBCs , WBCs , platelets ,large chemicals like hormones .

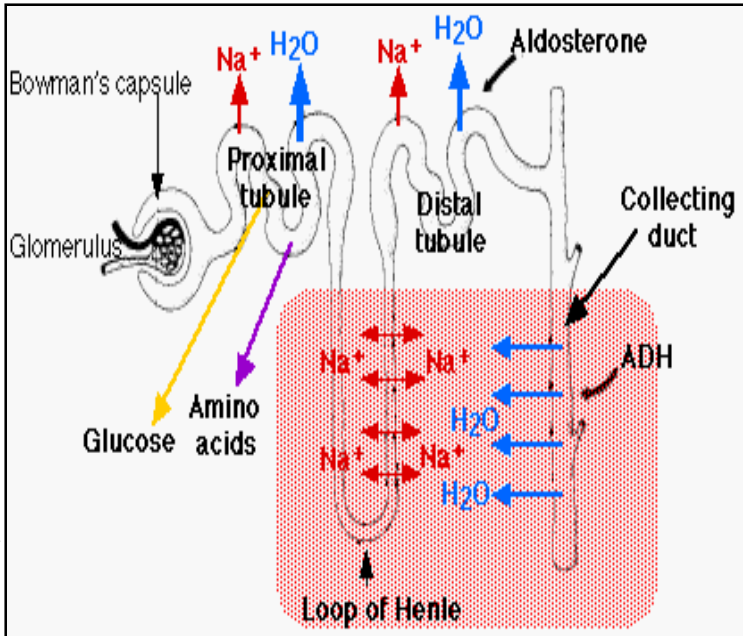


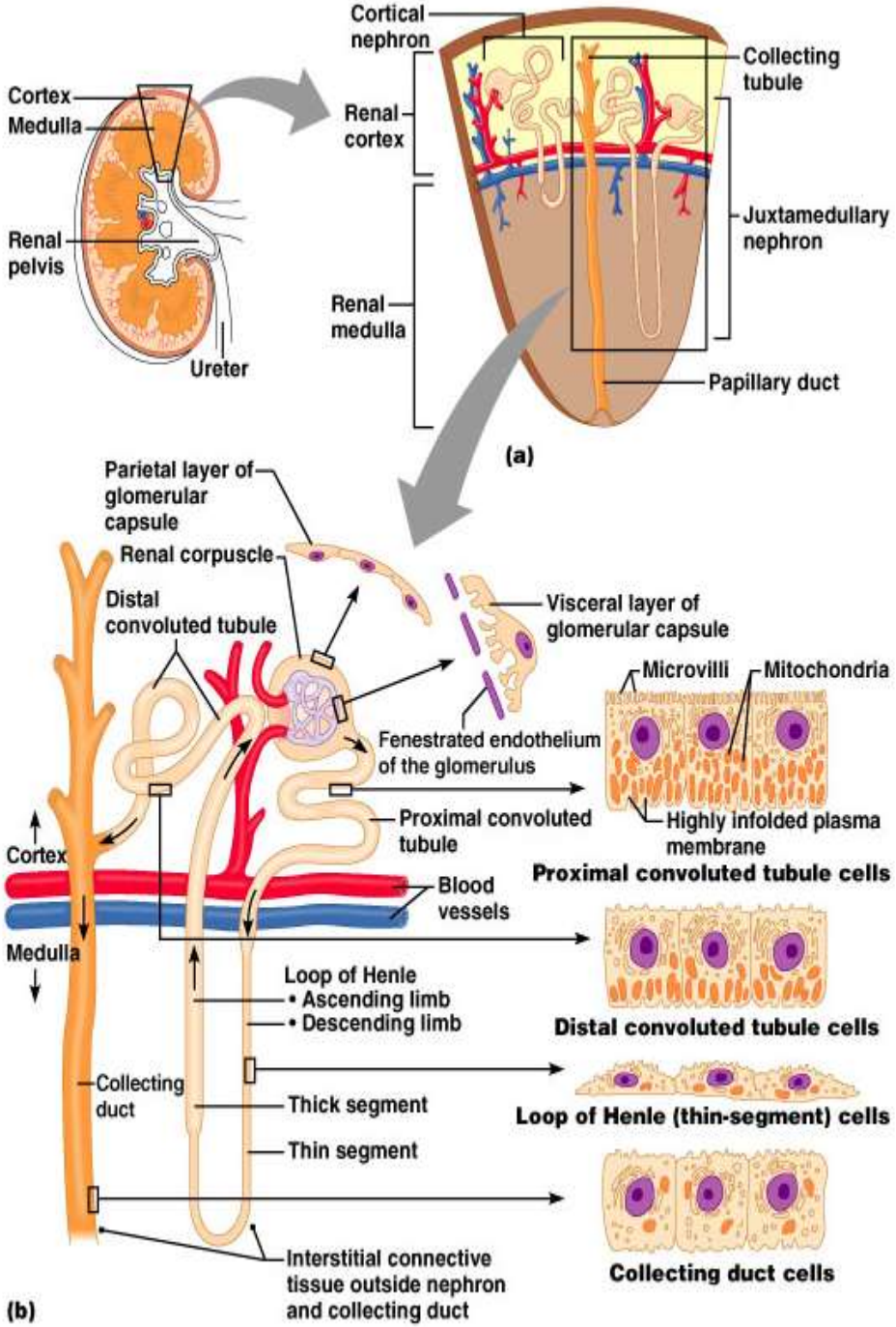
parts of the nephron & functions

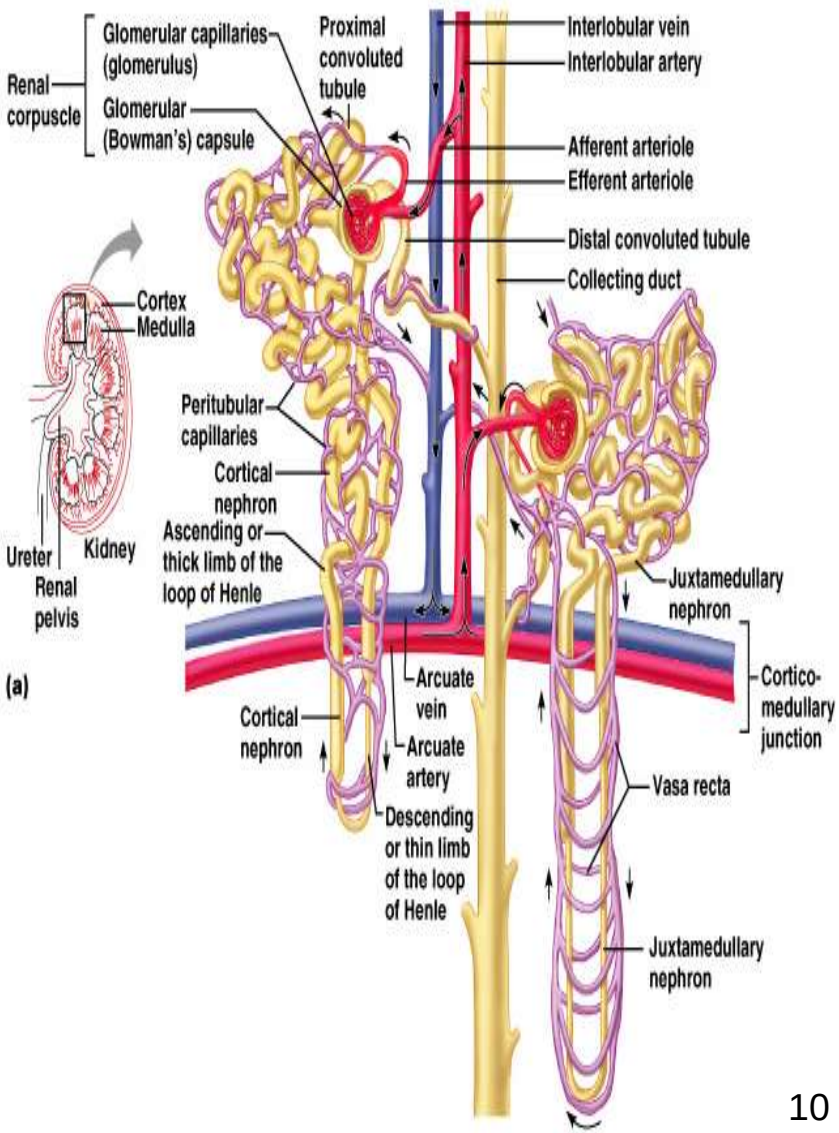
- *Bowman's capsule*. Force *filtration* in Bowman's capsule causes much of the water and ions and smaller molecules to leave the blood and enter the proximal convoluted tubule.
- *The proximal tubule*. the peritubular capillaries contain blood in a hyperosmotic state, so much of the water filtrate reenters (*reabsorption*) the blood by osmosis. Active transport also returns sodium (chloride following passively), glucose, and amino acids to the blood.
- The loop of Henle. 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 osmotic conditions in the blood (actually detected by the hypothalamus).









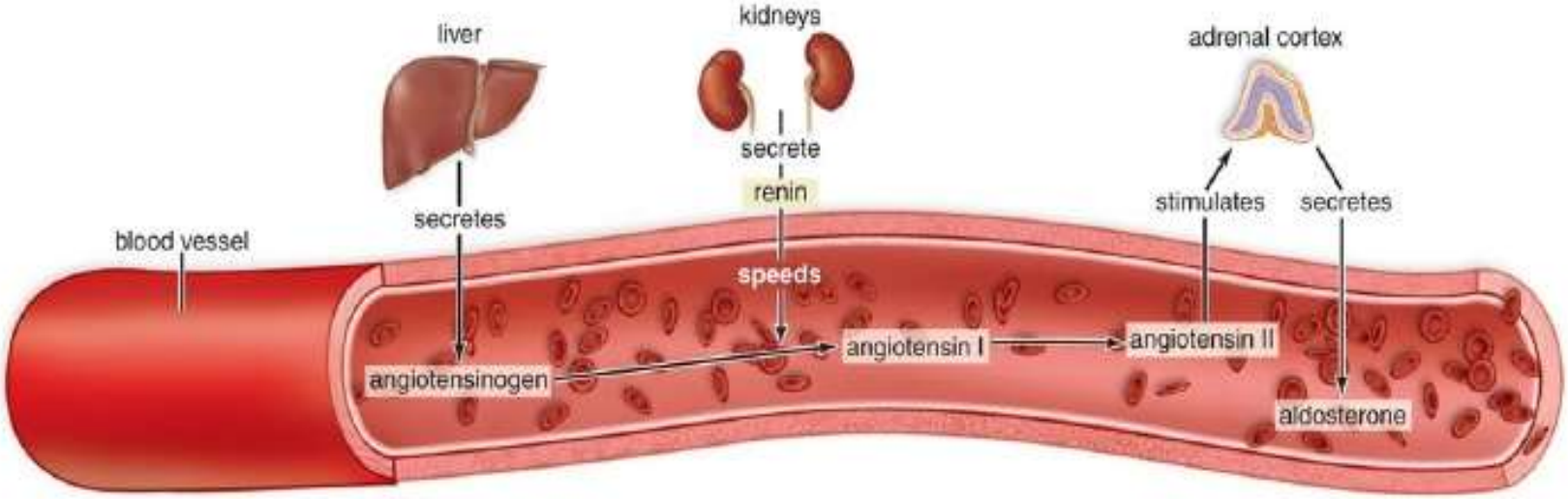


- **The collecting ducts :**
- The most important role is to conserve body fluids
- When the body must conserve water, the posterior pituitary gland secretes ADH (antidiuretic hormone)
- ADH increases the permeability of the collecting tubules and distal tubules to water so more is reabsorbed
- This decreases the total volume of urine
- Alcohol inhibits the release of ADH, so less water is reabsorbed producing copious amounts of dilute urine (can cause dehydration).
- wastes – urine: 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 .
- **Control of nephron:**
- Nephron control is hormonal, with water reabsorption controlled by ADH from the posterior pituitary and sodium chloride reabsorption controlled by aldosterone from the adrenal medulla. Sodium chloride transport is monitored by the juxtaglomerular complex. The arteriolar cells secrete renin, which stimulates the adrenal cortex to secret aldosterone.
- Aldosterone increases the absorption of sodium chloride and the excretion of potassium.

Hormones Control the Reabsorption of Salt

- Blood volume and pressure is, in part, regulated by salt reabsorption
  - When blood volume and blood pressure is not sufficient to promote glomerular filtration the kidneys secrete **renin,** an enzyme that changes angiotensinogen into angiotensin I
  - Later, angiotensin I is converted into angiotensin II, a vasoconstrictor that causes blood pressure to increase
- **Aldosterone** promotes the excretion of potassium ions (K^+) and the reabsorption of sodium ions (Na^+)
  - Reabsorption of sodium ions is followed by the reabsorption of water, and blood volume and pressure increase
- **Atrial natriuretic hormone (ANH) -** hormone secreted by the atria of the heart when cardiac cells are stretched due to increased blood volume
  - Promotes excretion of Na^+ followed by excretion of water, and therefore blood volume and blood pressure decrease

Figure 33.9B The renin-angiotensin-aldosterone system



33.10 Lungs and kidneys maintain acid-base balance

- *Bicarbonate (HCO_3^-) buffer system* works together with the breathing process to maintain the pH of the blood

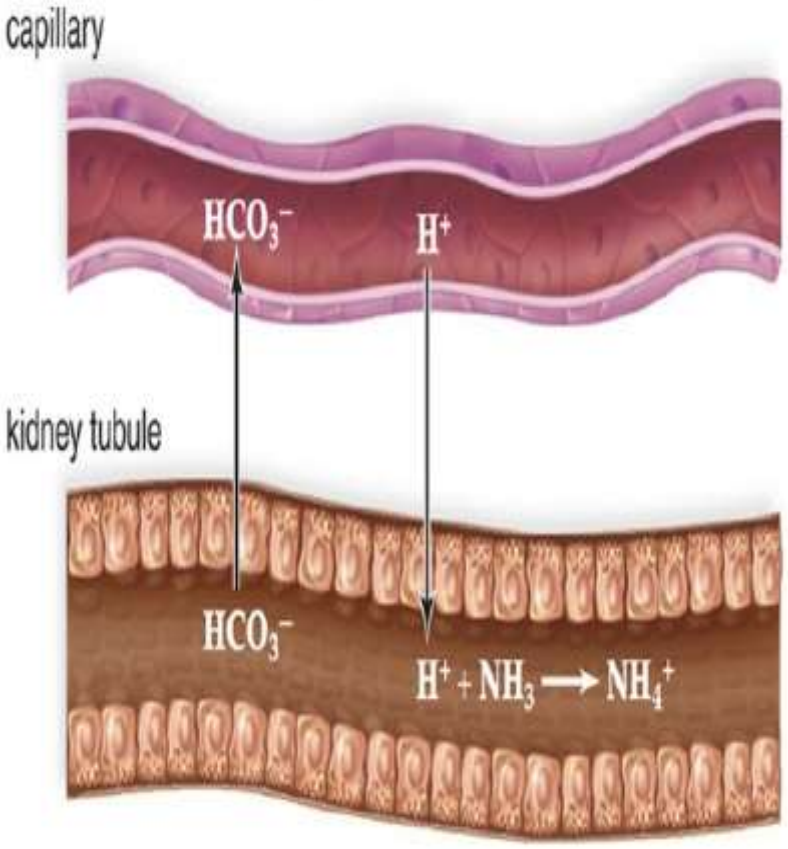
$$H^+ + HCO_3^- \rightleftharpoons H_2CO_3 \rightleftharpoons H_2O + CO_2$$

- *Excretion of carbon dioxide (CO_2) by the lungs* helps keep the pH within normal limits
  - When CO_2 is exhaled, hydrogen ions (H^+) are tied up in water
- Only the kidneys can rid the body of a wide range of acidic and basic substances
  - Ammonia (NH_3) produced in tubule cells provides a means of buffering these hydrogen ions in urine

$$NH_3 + H^+ \longrightarrow NH_4^+$$

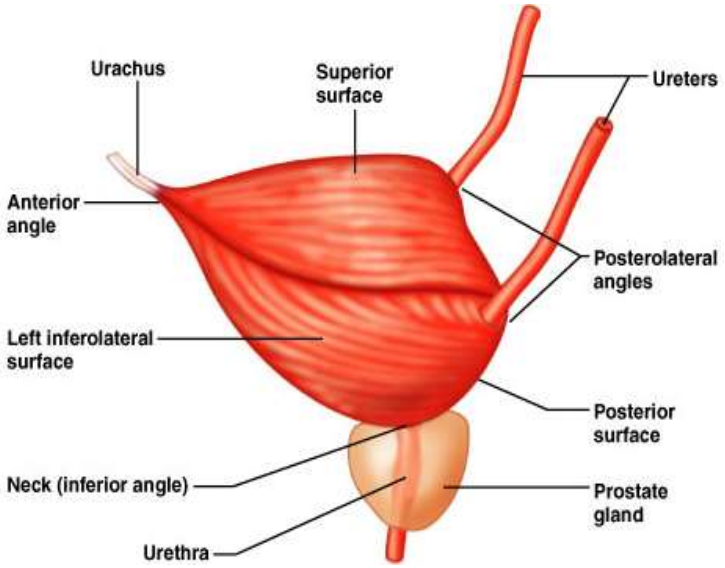
- **Acidosis and Alkalosis**
  - Normal pH of arterial blood is around 7.4
  - A person is said to have acidosis when the pH is below 7.34 and alkalosis when the pH is higher than 7.45

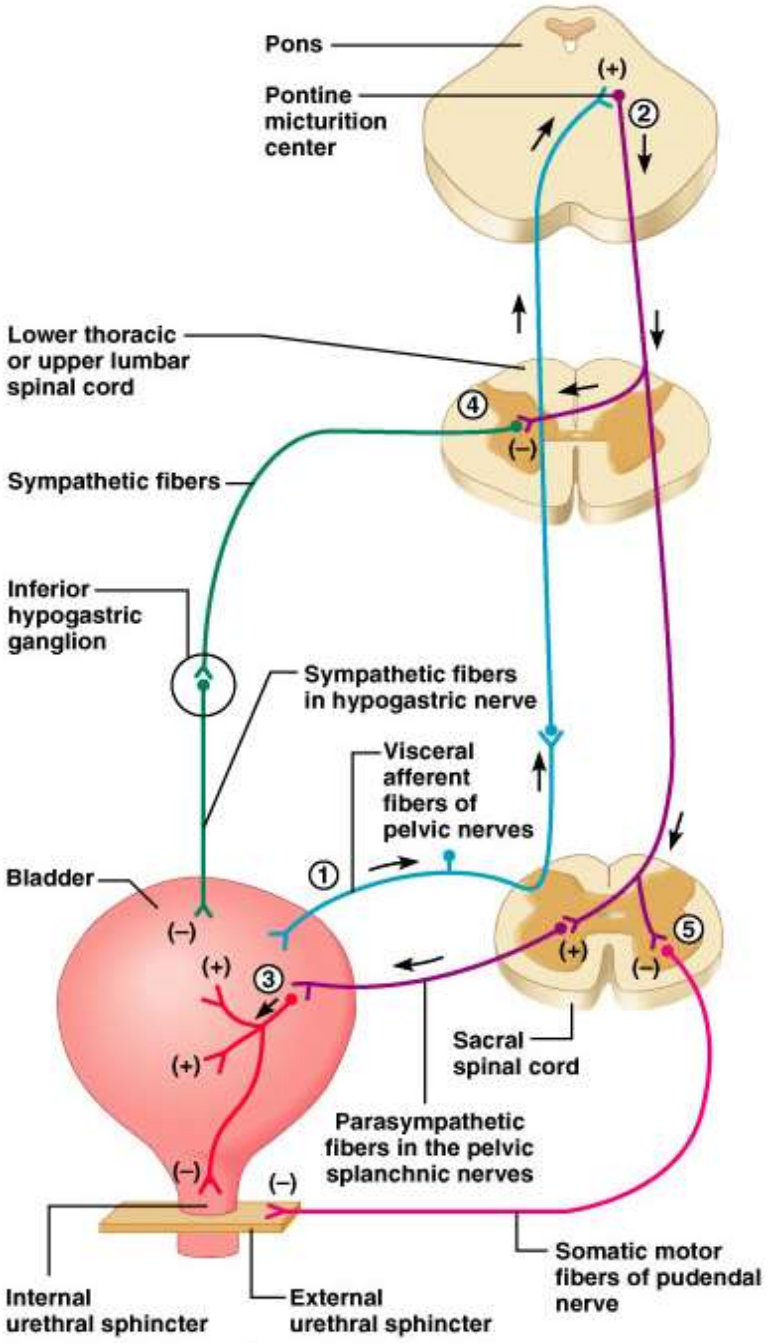
Figure 33.10 Excretion of these ions regulates pH



33-30

- If full: bladder is spherical and extends into abdominal cavity (holds about 500 ml or 1 pt)
- If empty: bladder lies entirely within pelvis with shape like upside-down pyramid
- Urine exits via the ***urethra by Micturition.***





urinalysis

physical, chemical, microscopic examination of urine

color

- pale yellow (straw)
- light yellow
- yellow
- green-yellow (olive)
- red-yellow
- red
- red-brown
- brown-black
- black
- milky

turbidity (cloudiness)

Normally, freshly voided urine is clear and transparent. It may be cloudy due to crystals and cells will centrifuge out; bacteria will not.

a few disorders of the excretory system

Obstructive disorders : kidney stones , kidney cancer.

Renal failure - (kidney failure)

UTIs - urinary tract infections, often caused by gram-negative bacteria cystitis-bladder infections urethritis-inflammation of the urethra pyelonephritis-inflammation of the kidneys.

1-Kidney stone:

Cause - metabolic disorder involving calcium, proteins and uric acid the build up of these substances into a large deposit (stone)

Symptoms - irritation of the urinary tract, bleeding in the urinary tract, in cases with large stones there can be extreme pain as the stone(s) try to pass through the tract . The most common crystals are from calcium oxalate, while others could be from uric acid and cystine. Factors such as recurrent urinary bladder infections, insufficient water intake and consumption, low levels of physical activity, and too much Vitamin C and D intake can lead to kidney stones. One of the best ways to decrease the occurrence of stones is to drink lots of water and to change your dietary habits. Treatments - removal by surgical means, breakdown of stones by either physical (ultrasound) or chemical means, dietary changes to reduce chances of stones.

2-renal (kidney) failure:

Causes - infections, trauma, diabetes, tumors

Symptoms - build up of toxins in the blood stream (urea), jaundice, fatigue

Treatments - dialysis, drug therapy, transplants.

3-bladder infections :

Causes - infection of the urinary tract

Symptoms - burning sensation in the flanks that can move down from the middle of the back towards the front of the groin, burning sensation while urinating

treatments - antibiotics .

APPLYING THE CONCEPTS—HOW SCIENCE PROGRESSES

33.11 The artificial kidney machine makes up for faulty kidneys

- After a person suffers kidney damage waste substances accumulate in the blood, a condition called **uremia**
- Patients in renal failure most often seek a kidney transplant
  - In the meantime they undergo **hemodialysis** utilizing an artificial kidney
  - Substances more concentrated in blood diffuse into the dialysis solution, and substances more concentrated in the dialysate diffuse into the blood
  - Artificial kidney either extracts substances from blood, including waste products or toxic chemicals and drugs, or adds a substance to the blood

Figure 33.11 An artificial kidney machine