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HOMEOSTASIS -- Maintaining an Internal Balance

A. Homeostasis and Control Systems

- some optimal human body conditions are:
    - internal body temperature of 37°C
    - 0.1% blood sugar level
    - blood pH of 7.35
- the external environment does not always provide these ideal conditions for life – for example, atmospheric temperatures in Canada can range from -40°C to +40°C, most foods don't contain 0.1% glucose, and possess a pH of 7.35
- the internal environment does not always provide these ideal conditions for life – for example, when you take part in strenuous activity, or when you are under a lot of stress, or when an event takes place that shocks the system
- in order to maintain a stable, favorable, tolerable, and functional internal environment, body systems collaboratively work together
- the term **homeostasis** refers to the body's attempt to adjust to a fluctuating external environment
- the word means "similar" or "like" state
- the misconception is that no change takes place and the internal conditions are stable -- in fact, human body systems are constantly active, constantly monitoring and responding to changing conditions
- homeostasis is a dynamic process that ensures a **dynamic equilibrium**
- Figure 1, p. 334 illustrates how interactions of several regulatory systems result in making adjustments necessary to maintain tolerable internal conditions
- all homeostatic control systems have three functional components:
    - a monitor
    - a coordinating centre
    - a regulator
- as soon as any organ is operating outside normal, tolerable conditions, special sensors (monitors) located throughout the body, signal a coordinating centre, which in turn, relays the information to the appropriate regulator that then restores the normal balance
- for example, high CO_2 levels in the blood because of increased respiratory rates, triggers chemical receptors in the brain

- this stimulus causes nerve cells from the brain to carry impulses to muscles that increase the depth and rate of breathing, which helps to expel excess CO_2 from the lungs
- the arteries of the neck possess chemical receptors that detect low levels of oxygen in the blood – a nerve is then excited and sends a message to the brain, which relays the information by way of another nerve to the muscles that control breathing movements
- both these regulatory systems are constantly monitoring the blood to ensure that oxygen levels are maintained within a tolerable range
- Figure 2, p. 335 illustrates that even though there are fluctuations in blood glucose, body temperature, blood pressure, and blood pH, the homeostatic mechanism ensures that all body systems function within an acceptable range to sustain life

HOMEOSTASIS AND NEGATIVE FEEDBACK – the thermostat analogy

- mechanisms that make adjustments to bring the body back within an acceptable range are referred to as **negative feedback** systems
- Figure 3**,** p. 336, illustrates how the home thermostat is an excellent analogy for this kind of system
- the coordinating centre, called a thermostat, also contains the monitor (a thermometer)
- when the room temperature falls below a set point, i.e room temperature, the thermostat switches on the regulator (the furnace)
- when the thermometer detects a temperature above the set point , the thermostat switches the furnace off
- this is called a negative feedback system because a change in the variable being monitored triggers the control mechanism to counteract any further change in the same direction
- negative feedback systems prevent small changes from getting worse or too large

HOMEOSTASIS AND POSITIVE FEEDBACK

- **positive feedback** systems are less common in types of homeostasis
- positive feedback systems reinforce any changes – they move the controlled variable even further away from a steady state, causing a discrete physiological event to be accomplished rapidly
- once the event is accomplished, the feedback system stops
- an excellent example of such a system is in the birth process – a decrease in progesterone levels, near the end of pregnancy, stimulates the uterus to contract
- the contractions bring about the release of another hormone, oxytocin, which causes much stronger contractions of the uterus
- as contractions build, the baby is forced toward the cervix, which in turn, causes even more oxytocin to be released and even greater contractions until the baby is expelled from the uterus
- once the baby is expelled, the contractions stop, which in turn stops the release of oxytocin

Homework: **1-7, p. 337**

B. Thermoregulation

- the maintenance of body temperature within a range that enables cells to function efficiently is called **thermoregulation**
- each animal species possesses its own unique temperature range
- invertebrates, as well as most fish, amphibians, and reptiles, are referred to as **ectotherms** – their metabolic rates are regulated by the air temperature in their external environment, which makes their metabolic rates vulnerable to the elements
- various behavioral and physiological adaptations take place to overcome this limitation:
    - some reptiles have developed behavioral adaptations, such as remaining motionless in the sun, or retreating to shaded areas
    - very active fish, such as tuna, have highly adapted circulatory systems designed to conserve heat which makes some of their internal organs much warmer than the surrounding water
- mammals and birds are referred to as endotherms – they are able to maintain a constant internal body temperature regardless of their surroundings
- various physiological adaptations take place to overcome any external change in temperature:
    - adjustments are made to decreases in environmental temperatures by increasing the rate of cellular respiration to generate heat
- the "thermostat" for thermoregulation is the **hypothalamus**
- for humans, the hypothalamus is set at 37°C, give or take a degree
- the temperature setting actually varies throughout the day, falling slightly at night
- body core temperatures are higher than peripheral body temperatures – for example, chest and abdominal cavity temperature is usually set at slightly higher than 37°C, and the peripheral temperatures can be as much as 4°C lower on very cold days

HEAT STRESS RESPONSE

- Figure 2, p. 339 illustrates how the body responds to heat stress
- thermoreceptors in the skin send messages to the brain that the body is getting too hot
- in the brain, the hypothalamus coordinates a response by sending a signal to sweat glands to initiate sweating
- the evaporation of the water from the surface of the skin draws heat from the body, thus cooling it down
- at the same time, a nerve message is sent to the blood vessels in the skin, causing them to dilate
- this increases blood flow to the surface of the skin

- the warm blood heats up the sweat droplets on the surface of the skin, and loses heat to evaporate them, returning to the core of the body much cooler
- unfortunately, sweat carries valuable salts with it, so when the body sweats, it loses these dissolved substances
- the kidneys compensate for this by regulating this loss of electrolytes

COLD STRESS RESPONSE

- Figure 2, p. 339 illustrates how the body responds to cold stress
- thermoreceptors in the skin send messages to the brain that the body is getting too cold
- in the brain, the hypothalamus coordinates a response by sending a signal to the organs and tissues to increase body temperature
- nerves going to the arterioles of the skin cause smooth muscles to contract and the arterioles to constrict, limiting blood flow
- the blood is shunted away from the extremities and goes to the core of the body, bathing internal organs – this is why our fingers, toes, nose, and ears feel numb when we're out in the cold for very long
- nerve messages are also carried to the smooth muscle that surrounds the hair follicles in your skin, causing the hair to stand up, causing a "goosebump"
- when the hair is erect, it traps warm, still air next to the surface of the skin and helps reduce heat loss
- the hypothalamus also sends messages that initiate shivering – a rhythmic contraction of skeletal muscle that generates ATP production, while at the same time releasing heat
- prolonged exposure to cold can create a hormonal response that also elevates metabolic rates
- this kind of heat production is often associated with special fatty tissue called **brown fat** – a type of fat that can be readily converted from chemical energy into heat
- this kind of heat production is especially important in newborns because they lack the ability to shiver
- babies contain small amounts of brown fat in their neck and armpits and near the kidneys that insulates and generates heat
- an extreme response to cold stress is the ability to slow down the heart rate and divert blood to the brain and other vital organs – this is how some people have survived sustained exposure to cold temperatures
- some animals have extreme physiological adaptations to cold stress – they possess biological antifreeze mechanisms that prevent their blood from freezing in the winter
- for example, the wood frog has 100 times the glucose as the average human does in its blood – apparently, this can act as an antifreeze agent
- the frog loses over 60% of its water, during freezing, reducing the dangers posed by ice crystals

Homework: **1-8, p. 341**

C. The Importance of Excreting Waste

- simpler compounds made from complex organic compounds may in fact cause a cell harm
- simple byproducts that cause cells harm are considered cellular waste, and must be eliminated in order to prevent toxic levels from impeding biochemical processes
- for example, the lungs eliminate CO_2 from cellular respiration, the large intestine removes toxic wastes from the digestive system, the liver transforms ingested toxins, such as alcohol and heavy metals, into soluble compounds that can be eliminated by the kidneys, and it also transforms the hazardous products of protein metabolism into metabolites, which are then eliminated by the kidneys
- the kidneys play a crucial role in removing waste, balancing blood pH, and maintaining water balance in the blood
- when proteins are digested, the amino group is removed – **deamination** – in the liver
- the byproduct of deamination is ammonia, a water-soluble, toxic gas
- in the liver, two molecules of ammonia combine with carbon dioxide to form **urea** – a substance which is 100 000 times less toxic than ammonia
- 33 mg of urea dissolves in 100mL of blood
- another waste product, **uric acid**, is formed by the breakdown of nucleic acids
- Table 1, p. 342 summarizes the roles of the excretory organs in the removal of wastes
- water reserves are depleted much faster than food reserves – humans cannot survive more than five days without water
- the average adult passes 180 L of blood through their kidneys in one day, 1 L to 2 L of water is removed from the blood every day through urine, perspiration, and exhaled air – even greater volumes are lost when physical activity increases
- in order to maintain a healthy water balance, humans must consume 2 L of fluids daily
- a drop in fluid intake by as little as 5% will bring about extreme pain and collapse, while a decrease of 10% will cause death

EXCRETION FROM SIMPLE TO MORE COMPLEX ANIMALS

- unicellular organism and simple organisms expel their waste into their external environment via diffusion
- water currents then carry the wastes away
- since these organisms are hypertonic to their freshwater surroundings, fluid regulation is very important for them
- without a system of fluid regulation, these cells would draw in water by osmosis, expand, and eventually burst
- a **contractile vacuole** expels excess water, preventing the cell from bursting
- Figure 3, p. 343 shows contractile vacuoles of the *Paramecium* expanding as water enters the cell
- Figure 4 and Figure 5, p. 344 illustrates how earthworms and insects remove waste from their blood and body cavities
- complex multicellular organisms are faced with two major problems as they regulate water balance

- not every cell is in direct contact with external environment, so wastes must be collected and temporarily stored
- not every cell is designed to remove waste since specialization exists

- wastes must be transported to cells that are capable of excretion – these cells work together in the excretory system to remove wastes from the body or store the wastes until signaled to remove them
- earthworms possess a series of tubules to remove wastes from the blood and body cavity – the waste collects in the tubules and is expelled through special pores called nephridiopores
- insects possess Malpighian tubules that run throughout the body cavity and absorb wastes by diffusion and release them into the gut where they are eliminated with solid wastes from the anus

Homework: **1-6, p. 345**

D. The Urinary System

- the kidneys are supplied “junk” blood by the renal arteries
- the renal veins return “clean” blood to the heart so it can be circulated back around the body
- at any given time, up to 25% of the body’s blood is held by the kidneys
- the waste that filters out of the blood collects in the ducts of the kidneys and is moved into the bladder via the **ureters**
- at the base of the bladder is a sphincter muscle that acts as a valve, permitting the storage of urine
- as the bladder fills – first to 200 mL, then to 400 mL – it activates stretch receptors and sends a message to the brain to urinate
- if this is ignored, and the bladder fills up to 600 mL, the sphincter loses control, and the urine enters the **urethra**, and it is voided
- Figure 1, p. 346 illustrates a cross-section of the kidney
- the outer layer, the **cortex**, encircles the kidney
- the inner layer, the **medulla**, is found beneath the cortex
- a hollow chamber, the **renal pelvis**, joins the kidney with the ureter

NEPHRONS

- about 1.25 million slender tubules, called **nephrons**, are the functional units of the kidney
- Figure 2, p. 347 illustrates the nephron
- each nephron is supplied with blood by the **afferent arterioles**
- the afferent arterioles branch into a capillary bed, called the **glomerulus** – a cluster of arterioles enclosed in a capsule, called **Bowman’s capsule**

- blood leaves the glomerulus by way of other arterioles, the **efferent arterioles**
- the efferent arterioles eventually become the **peritubular capillaries** – tubules that wrap around the kidney tubules
- the Bowman's capsule, the afferent arteriole, and the efferent arteriole are located in the cortex of the kidney
- fluids that will eventually become urine enter the Bowman's capsule from the blood
- the capsule tapers to a thin tubule, called the **proximal tubule**
- urine is carried from the proximal tubule to the **loop of Henle**, which descends into the medulla of the kidney
- urine then moves through the **distal tubule**, the last segment of the nephron, and into the **collecting ducts** – structures that collect urine from many nephrons that, in turn, merge in the pelvis of the kidney
- Table 1, p. 348 lists and describes the structures of the urinary system

Homework: **1-4, p. 348**

E. Formation of Urine

- there are three processes that result in urine formation:
  - FILTRATION
  - REABSORPTION
  - SECRETION

FILTRATION

- the movement of fluids from the blood into the Bowman's capsule is called **filtration**
- each nephron of the kidney has an independent blood supply, and blood moves through the afferent arteriole into the glomerulus, a high pressure filter
- the pressure in the Bowman's capsule is about 4 times as much as it is in normal blood capillary beds
- dissolved solutes leave the afferent arteriole and enter the capsule
- Table 1, p. 349 compares sample solutes extracted from the glomerulus and Bowman's capsule
- plasma protein, blood cells, and platelets are too large to move through the walls of the glomerulus
- smaller molecules pass through the walls and enter the nephron

REABSORPTION

- the transfer of essential solutes and water from the nephron back into the peritubular capillaries (blood) is called **reabsorption**.
- every minute, about 600 mL of fluid flows through the kidneys – 20% of that is filtered into the nephrons

- if none of the filtrate were reabsorbed, you would form 120 mL of urine each minute, and would be requiring 1 L of fluids every 10 minutes to maintain water balance
- actually, only 1 mL of urine is formed for every 120 mL of fluids filtered into the nephron, which means that the remaining 119 mL of fluids is reabsorbed
- both active and passive transport help reabsorb the fluids:
    - ***active transport***
        - carrier molecules move Na^+ ions across the cell membranes of the cells that line the nephron
        - negative ions such as Cl^- and HCO_3^-, follow the positive Na^+ ions by charge attraction (see Figure 1, p. 350)
        - the energy necessary for the movement of these ions is supplied by ATP, which is limited
        - reabsorption occurs until the **threshold level** of a substance is reached
        - excess NaCl remains in the nephron and is excreted with the urine
        - other molecules are actively transported from the proximal tubule, such as glucose and amino acids, as they "hitch a ride" with specific carrier molecules that "shuttle" them out of the proximal tubule and back into the blood
        - again, the amount solute that can be reabsorbed is limited – all excess glucose that cannot be reabsorbed remains in the nephron and is expelled with urine
        - a person who eats a high glucose diet, will excrete some of the excess glucose in the urine
    - ***passive transport***
        - the proteins that remain in the blood draw water out of the nephron **interstitial fluid** and into the peritubular capillaries passively
        - as water is reabsorbed, the urine becomes more and more concentrated
        - some urea and uric acid also diffuses passively back into the blood as well, but not as much as was originally filtered
- the following table summarizes urine formation:

Site	Description of Process	Substances Transported
1. glomerulus and Bowman's capsule	• filtration of water and dissolved solutes occurs as blood is forced through walls of glomerulus into Bowman's capsule by fluid pressure in capillaries	• sodium ions (Na^+), chloride ions (Cl^-), water (H_2O), hydrogen ions (H^+), glucose, amino acids, vitamins, minerals, urea, uric acid
2. proximal tubule	• selective reabsorption of nutrients from filtrate back into blood by active and passive transport • within proximal tubule, pH is controlled by secretion of hydrogen (H^+) and reabsorption of bicarbonate ions	• bicarbonate ions (HCO_3^-), salt (NaCl), water (H_2O), potassium ions (K^+), hydrogen ions (H^+), ammonia (NH_3), glucose, amino acids, vitamins, urea

	(HCO_3^-)	
3. descending limb of loop of Henle	• descending limb of loop of Henle is permeable to water, resulting in loss of water from filtrate by osmosis • salt (NaCl) becomes concentrated in filtrate as descending limb penetrates inner medulla of kidney	• water (H_2O)
4. ascending limb of loop of Henle	• thin segment of ascending limb of loop of Henle is permeable to salt, resulting in diffusion of salt out of ascending limb • salt continues to pass from filtrate to interstitial fluid in thick segment of ascending limb	• salt (NaCl)
5. distal tubule	• selective reabsorption of nutrients from blood into nephron by active transport. Distal tubule helps regulate potassium (K^+) and salt (NaCl) concentration of body fluids • as in proximal tubule, pH is controlled by tubular secretion of hydrogen ions (H^+) and reabsorption of bicarbonate ions	• salt (NaCl), potassium ions (K^+), water (H_2O), hydrogen ions (H^+), bicarbonate (HCO_3), uric acid, and ammonia (NH_3)
6. collecting duct	• urine formation	• water (H_2O), salt (NaCl), urea, uric acid, minerals

SECRETION

- the movement of materials from the blood back into the nephron is called **secretion**
- nitrogen-containing waste, excess H^+ ions, and other minerals are balanced with secretion
- drugs, such as penicillin, can be secreted
- cells loaded with mitochondria line the distal tubule
- like reabsorption, tubular secretion occurs by active transport – unlike reabsorption, molecules are shuttled from the blood into the nephron

Homework: **1-7, p. 352**

F. Water Balance

- basically, the body adjusts for increased water intake by increasing urine output, and it adjusts for low water levels in the blood by reducing urine output
- in order for these adjustments to take place, two body systems must interact: the nervous system and the endocrine system

1. REGULATING ADH

- the body produces a hormone called antidiuretic hormone (ADH) – it helps regulate the osmotic pressure of body fluids by causing the kidneys to increase water reabsorption
- when ADH is released, a more concentrated urine is produced, thereby conserving body water
- ADH is produced by specialized nerve cells in the hypothalamus, moves along specialized fibres from the hypothalamus to the pituitary gland, which stores and releases ADH into the blood
- changes in osmotic pressure in the blood are picked up by specialized nerve receptors in the hypothalamus called **osmoreceptors**
- if your blood water level drops because of sweating, blood solutes become more concentrated, which in turn, increases the blood's osmotic pressure – water moves out of cells and into the bloodstream
- when the cells of the hypothalamus shrink, a nerve message is sent to the pituitary, signaling the release of ADH
- the ADH is carried by the blood to the kidneys, making the tubules more permeable to water, which in turn, allows for more water to be reabsorbed into the blood
- as a result, a more concentrated urine is produced
- a greater amount of water in the blood causes its osmotic pressure to stop increasing, and prevents body cells from losing water to the blood and becoming dehydrated
- the shrinking of hypothalamus cells also initiates a behavioral response – the sensation of thirst
- thirst promotes drinking, which in turn, increases water levels in the blood, reducing solute concentration and preventing dehydration
- as soon as the amount of water in the blood increases, it begins to re-enter the hypothalamus cells
- as the hypothalamus cells swell, the nerve messages to the pituitary stop, ADH is not released, and less water is reabsorbed from the nephrons
- this process repeats continuously to regulate water levels in blood

2. *ADH AND THE NEPHRON*

- about 85% of the water that is reabsorbed from the nephron is done so at the proximal tubule since it is this part of the nephron that is very permeable to water
- as seen in Figure 1, p. 350, the descending loop of Henle is permeable to water and ions, but the ascending tubule is only permeable to NaCl
- active transport of Na^+ ions from the ascending section of the loop concentrates solutes within the medulla of the kidney
- without ADH, the rest of the tubule remains impermeable to water, but continues to actively transport Na^+ ions from the tubules – this means that the remaining 15% of the water filtered into the nephron would be lost if no ADH were present
- ADH makes the upper part of the distal tubule and collecting duct permeable to water
- the water leaves the upper part of the distal tubule and enters the blood, making the urine more concentrated
- only 15% of the reabsorption that takes place in the nephron is controlled or regulated – the other 85% takes place in the proximal tubule and is passive
- because of the release of ADH by the pituitary, and its effect on the distal tubule's permeability to water, the kidney is able to regulate the osmotic concentration of body fluids

3. KIDNEYS AND BLOOD PRESSURE

- the total blood volume is adjusted by the kidneys
- a hormone called **aldosterone** acts on the nephrons to increase Na^+ reabsorption (see Figure 2, p. 354)
- aldosterone is produced in the cortex of the adrenal glands which lies above the kidneys
- as the reabsorption of NaCl increases, the osmotic gradient increases and more water moves out of the nephron and into the blood
- when increase fluid loss takes place, the over all pressure of the blood drops – this could reduce blood flow, which ultimately reduces the delivery of oxygen and nutrients to tissues
- blood pressure receptors, located in a structure called **juxtaglomerular apparatus** – found near the glomerulus, detect low blood pressure at the glomerulus
- specialized cells within the apparatus release renin
- the renin converts a plasma protein called angiotensinogen into angiotensin
- the angiotensin does two things:
    - constricts blood vessels – thus increasing blood pressure
    - stimulates the release of aldosterone from the adrenal gland
- the aldosterone travels in the blood to the kidneys, where it acts on the cells of the distal tubule and collecting duct to increase Na^+ transport
- when Na^+ is reabsorbed, water follows, increasing the blood volume, thus increasing blood pressure

4. pH BALANCE

- if you were to eat a vinaigrette salad, your pH would decrease below the preferred level
- during cellular respiration, cells produce excess acids which dissociate into H^+ ions, lowering the pH of your blood
- bicarbonate ions in the blood act as buffers that neutralize the effects of decreasing or increasing pH levels beyond tolerable ranges
- the reaction is as follows:

$$H^+ (aq) \quad + \quad HCO_3^- (aq) \quad « \quad H_2CO_3 (aq) \quad « \quad H_2O (l) \quad + \quad CO_2 (g)$$

- the bicarbonate ion pulls the excess H^+ ions out of the blood, forming carbonic acid
- the carbonic acid breaks down into carbon dioxide and water
- the CO_2 is transported to the lungs were much of it is exhaled
- some of the CO_2 is actively transported from the peritubular capillaries into the cells that line the nephron
- the CO_2 combines with water to initiate the reverse reaction, regenerating HCO_3^- and H^+ ions
- the bicarbonate ions diffuse back into the blood, thereby restoring the buffer
- the H^+ ions recombine with either phosphate ions or ammonia and are excreted with the filtrate from the nephron

Homework: **1-9, p. 356**

G. Kidney Disease

- kidney function can be affected when other systems break down
- as well, when the kidneys break down, other systems are affected
- Figure 1, p. 357 is a requisition form for a urinalysis – the test that can detect kidney disorders as well as effects on the kidney from other nonfunctioning systems
- here is how the kidneys are affected by various common diseases:

1. DIABETES MELLITUS

- when a deficiency of insulin occurs, because of a defect in the pancreas, blood sugar levels tend to rise
- the cells of the proximal tubule are supplied with enough ATP to reabsorb 0.1% blood sugar
- when higher blood sugar concentrations exist, such as in a person with diabetes, the excess sugar remains in the nephron
- the excess sugar in the nephron draws water into the nephron, increasing the volume of urine
- individuals with diabetes mellitus void large volumes of urine, which explains why they are often thirsty and have to replace the lost water

2. DIABETES INSIPIDUS

- diabetes insipidus occurs when the ADH-producing cells of the hypothalamus, or the nerve tracts leading from the hypothalamus to the pituitary gland, are destroyed

- without ADH to regulate water reabsorption, urine output increases considerably – none of the 15%, other than the 85% that is reabsorbed at the proximal tubule, is recovered
- as much as 20 L of dilute urine may result, creating a strong thirst response, and a severe need to replace lost water

3. BRIGHT'S DISEASE

- this disease is also known as nephritis – the inflammation of the nephrons
- one type of nephritis affects the tiny blood vessels of the glomerulus
- toxins produced by invading microbes destroy the tiny blood vessels, altering the permeability of the nephron
- this means that proteins and other large molecules are able to pass into the nephron
- since no mechanism occurs in the nephron membrane to reabsorb protein, it remains in the nephron and draws water from the neighbouring peritubular capillaries, which in turn, increases the output of urine
- eliminating essential amino acids and proteins can lead to severe health problems

4. KIDNEY STONES

- when mineral solutes from the blood precipitate out, they can accumulate and lodge themselves in the renal pelvis or move into the narrow ureter
- the stones can either be alkaline or acidic – calcium oxalate or calcium phosphate
- as they move into the bladder, stones can tear delicate tissues and cause severe pain and discomfort
- they can also work their way further down the excretory passage and lodge in the urethra, causing a burning sensation, along with excruciating pain
- a common technique used to shatter kidney stones that are less than 2 cm in size, to a size that does not cause severe discomfort is called extracorporeal shock-wave lithotripsy (ESWL)
- high energy shock waves travel through soft tissue and reach the stones, breaking them into small fragments so that they can reach the bladder without pain
- once there, they are further broken down to tiny granules, and are passed
- ESWL is not always the preferred treatment – the size of the stone, its location in the urinary tract, and the stone composition all determine the effectiveness of the treatment

Dialysis Technology

- the term "dialysis" refers to the exchange of substances across a semi permeable membrane
- a dialysis machine is used for people whose kidneys cannot effectively process bodily wastes
- the principles of diffusion and blood pressure both influence the operation of a dialysis machine
- this means that a dialysis machine cannot perform active transport like a kidney can

- two types of dialysis exist: (see Figure 3, p. 359)
  - hemodialysis
    - a dialysis machine connected to a patient's circulatory system by a vein
    - blood is pumped through a series of dialysis tubes that are submerged in a bath of various solutes
    - glucose and a mixture of salts establish desired concentration gradients – for example, HCO_3^- ions will move from the bath into the blood if it is too acidic
    - since the dialysis fluids have no urea, this solute always moves from the blood into the dialysis fluid until equal concentration are established
    - the dialysis fluid is continuously replenished, resulting in a constant removal of urea and other wastes from the blood
    - along with this process, hormones are also administered through intravenous, since the kidney cannot produce them on their own
  - peritoneal dialysis
    - also known as continuous ambulatory peritoneal dialysis (CAPD)
    - 2 L of dialysis fluid, called dialysate, are pumped into the abdominal cavity
    - the membranes of the cavity selectively filter wastes from the blood
    - urea and other waste diffuse from the plasma into the peritoneum and into the dialysis fluid
    - waste accumulates in the dialysate, which can be drained off and replaced several times a day
    - this system allows for greater independence because patients can perform the procedure on their own at home

- dialysis cannot accomplish other tasks of the kidneys, such as hormone production
- a recent technique involves the transplant of kidney cells from a pig into a dialysis machine
- the pig kidney cells produce renal hormones and help regulate electrolytic concentrations

Kidney Transplants

- today, kidney transplants are 85% successful
- the immune response to the transplanted kidney is the only obstacle in a transplant
- a kidney transplant involves placing a new kidney and ureter in the lower abdomen near the groin, where they are surgically attached to the blood vessels and bladder (see Figure 6, p. 361)
- unless the old kidney is severely damaged or chronically infected, it isn't removed
- a catheter is inserted into the bladder for several days to drain the urine produced by the new kidney
- is some cases, dialysis is required after the transplant until the new kidney can fully function

- to help prevent rejection, immunosuppressive drugs are given to the patient immediately after the surgery

Homework: **1-7, p. 362**