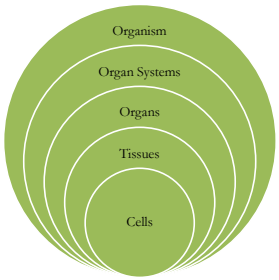
Interactions Among Animal Systems

Learning Objectives

- Identify major organ systems in animals
- Describe the interactions that occur among systems to carry out vital animal functions

Levels of Organization

An organism consists of several levels of organization



Animal Systems

Eleven major organ systems:

System	Function(s)
Skeletal	Structural support
Muscular	Movement
Integumentary (skin)	Barrier from external environment
Circulatory/Cardiovascular	Transport molecules throughout body
Respiratory	Exchange carbon dioxide & oxygen
Digestive	Break down food molecules
Excretory/Urinary	Remove waste products from blood
Immune	Destroy pathogens that enter body
Nervous	Send regulatory messages throughout body
Endocrine	Produce hormones that regulate vital processes
Reproductive	Production of sex cells & offspring

Interactions Among Animal Systems

Organ systems interact to carry out vital functions

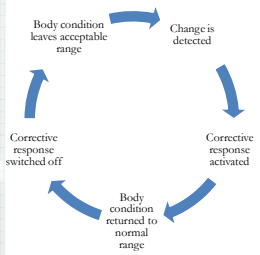
- Examples:
  - Regulation
  - Nutrient absorption
  - Reproduction
  - Defense against injury and illness

Regulation

Regulation – process of maintaining vital body conditions within an acceptable range in order to preserve homeostasis

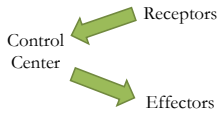
Homeostasis – stable internal conditions required for body systems to function

Negative Feedback



Negative Feedback

- Mechanism consists of three parts:
  - Receptors – sensors that monitor body conditions
  - Control center – brain interprets input from receptors and sends signals to effectors
  - Effectors – organs that respond to brain signals to return body conditions to acceptable range



Regulation

Regulated body conditions include:

- Body temperature
- Heart and respiration rates
- Molecule concentrations in blood

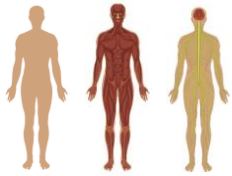
Body Temperature

- Constant internal temperature required to maintain optimal function of cellular processes
- Negative feedback loop:
  - Receptors in skin and brain monitor temperature
  - **High temperature** – brain signals sweat glands to cool body down
  - **Low temperature** – brain signals muscles to contract (shiver) to warm body up

Body Temperature

Organ systems involved:

System	Functions
Integumentary	Skin contains temperature receptors & sweat glands
Muscular	Muscle contractions (shivering)
Nervous	Brain interprets input from temperature receptors and signals effectors to adjust body temperature



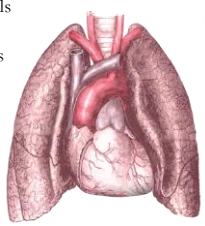
Heart and Respiration Rates

- Heart rate – number of times heart contracts per minute
- Respiration rate – number of breaths per minute
- Body varies these rates based on oxygen needs of body cells
- Example: Exercise
  - Cells utilize oxygen faster
  - Blood pressure rises to meet increased oxygen demand
  - Heart and respiration rates increase

Heart and Respiration Rates

Negative feedback loop:

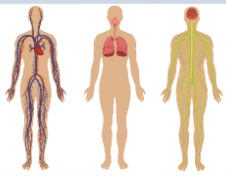
- Receptors in blood vessels and brain monitor blood pressure and oxygen levels in blood
  - **High blood pressure** – brain signals heart to *decrease* heart rate
  - **Low blood pressure** – brain signals heart to *increase* heart rate
  - **High oxygen levels** – brain signals lungs to *decrease* respiration rate
  - **Low oxygen levels** – brain signals lungs to *increase* respiration rate



Heart and Respiration Rates

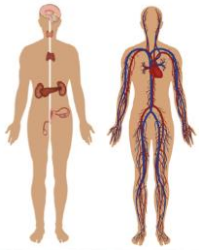
Organ systems involved:

System	Functions
Circulatory	Heart varies heart rate according to signals from brain
Respiratory	Lungs vary respiration rate according to signals from brain
Nervous	Monitors blood pressure and oxygen levels Sends signals to heart and lungs to adjust heart and respiration rates



Molecule Concentrations in Blood

- Body monitors molecule concentrations in blood to ensure appropriate delivery to and from cells
- Regulated concentrations include:
  - Water balance
  - Blood sugar
- Utilizes hormones sent through blood



Molecule Concentrations in Blood

Negative feedback loop:

- Receptors in endocrine glands monitor molecule concentrations in blood
  - **Abnormal concentration** – brain signals endocrine glands to increase or decrease hormone production
  - Change in blood hormone levels signals organs to adjust molecule levels in the blood

Water Balance

- Regulated by hormone ADH
- Negative feedback loop:
  - **Too little water** – ADH level increases, signaling kidneys to remove less water from blood
  - **Too much water** – ADH level decreases, signaling kidneys to remove more water from blood
  - Excess water also excreted through skin (sweating)

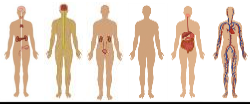
Blood Sugar

- Regulated by hormones glucagon and insulin
  - Glucagon – signals liver to add glucose to the blood
  - Insulin – signals liver, muscles, and fat cells to remove glucose from the blood
- Negative feedback loop:
  - **Low blood sugar** – glucagon production increases and insulin production decreases, blood sugar *rises*
  - **High blood sugar** – insulin level increases and glucagon level decreases, blood sugar *lowers*

Molecule Concentrations in Blood

Organ systems involved:

System	Functions
Endocrine	Hormone levels regulate molecule concentrations in blood
Nervous	Receives input from receptors Signals endocrine glands to alter hormone production
Excretory	Kidneys remove excess water from blood
Integumentary	Skin contributes to water balance (sweating)
Digestive	Liver adjusts glucose level in blood to regulate blood sugar
Circulatory	Blood requires appropriate concentration of molecules Blood transports hormones



Interactions Among Animal Systems

Learning Objectives

- Identify major organ systems in animals
- Describe the interactions that occur among systems to carry out vital animal functions

Interactions Among Animal Systems

Organ systems interact to carry out vital functions

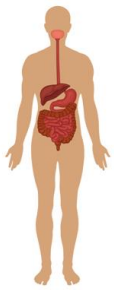
- Examples:
  - Regulation
  - Nutrient absorption
  - Reproduction
  - Defense against injury and illness

Nutrient Absorption

- Nutrient absorption – passage of broken down food molecules through intestinal walls into bloodstream to be delivered to body cells

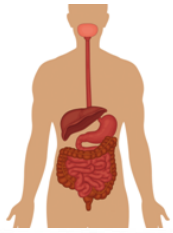
Two processes:

- Digestion
- Absorption



Digestion

- Digestion – break down of large food molecules into small nutrient molecules
- Begins in mouth and continues through stomach and small intestine
- Two types:
  - Mechanical
  - Chemical



Mechanical Digestion

Mechanical digestion – the physical break down of food into smaller particles

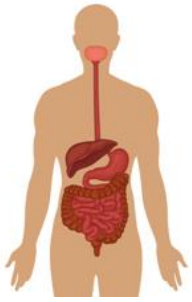
Examples:

- Teeth & tongue chewing
- Stomach muscles churning

Chemical Digestion

Chemical digestion – reaction of digestive acids and enzymes chemically with food molecules to create smaller molecules

- Examples:
  - Saliva in mouth
  - Gastric juices
  - Bile in small intestine



Absorption

Absorption – passage of small nutrient molecules into bloodstream
- Occurs in small intestine

- Microvilli – small, finger-like projections in intestinal wall
  - Lined with blood vessels

- Small nutrient molecules pass through microvilli into blood vessels
- Bloodstream carries nutrient molecules to rest of body to be used by cells

Nutrient Absorption

Organ systems involved:

System	Functions
Digestive	Mouth, stomach, and small intestine digest large food molecules Small intestine is site of absorption
Muscular	Muscle contractions push food through digestive tract Muscle contractions in stomach aid mechanical digestion
Circulatory	Blood vessels absorb nutrients through intestinal walls Blood transports absorbed nutrients to cells throughout body

Reproduction

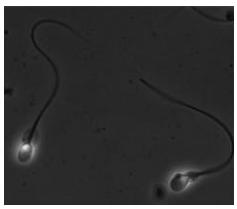
- Combination of male and female gametes to form a zygote that will develop into an offspring

- Gametes – sex cells
  - Male – sperm
  - Female – eggs (ova)
- Zygote – fertilized egg

- Three processes:
  - Gamete production & storage
  - Fertilization
  - Development

Gamete Production & Storage

- Male sperm are produced and stored in the testes

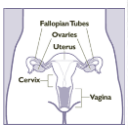


- Female eggs are stored in the ovaries
  - All eggs are present at birth

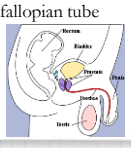
Fertilization

Fertilization – process of a sperm and egg cell (ovum) merging into a single cell (zygote)

- Female egg:
  - Travels from ovary into fallopian tube

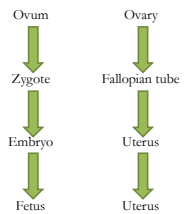


- Male sperm:
  - Travel from testes through vas deferens and out the penis
  - Enter female through vagina, travel through cervix and uterus to fallopian tube

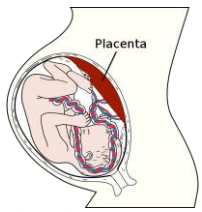


Development

- Zygote travels into and implants in uterus



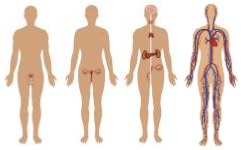
- Fetus develops in uterus and exits through cervix and vagina



Reproduction

Organ systems involved:

System	Functions
Reproductive	Main site of reproductive processes
Endocrine	Hormones (testosterone, estrogen, progesterone, etc.) regulate reproductive processes
Circulatory	Blood delivers hormones to reproductive system Blood delivers nutrients to developing fetus



Defense Against Injury and Illness

- Prevent and minimize damage to body tissues from environmental factors and pathogens

Defense Against Injury

- Skin and skeleton protect internal organs from environment
  - Examples:
    - Skull: brain
    - Rib cage: heart & lungs

- Reflex actions – rapid, involuntary response to external stimulus (heat, pain, etc.)
  - Example:
    - Temperature receptors in skin detect heat & send signals to spinal column
    - Spinal column signals muscles to react to avoid a burn

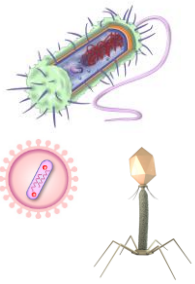
Defense Against Injury

Organ systems involved:

System	Functions
Integumentary	Skin provides physical barrier to foreign objects
Skeletal	Skeleton protect internal organs
Muscular	Muscle reflexes allow quick reactions
Nervous	Sensory receptors detect changes in environment Brain sends signals to muscles

Defense Against Illness

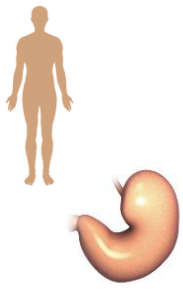
Pathogens – disease-causing agents
  - Examples: bacteria, viruses, parasites



- Three levels of defense:
  - Barriers
  - Innate immune response
  - Adaptive immune response

Barriers

Barriers – physically block pathogens from entering body



- Examples:
  - skin, hair, mucus, coughing, sneezing, stomach acids

Innate Immune Response

Innate response – rapid response to all pathogens in same generalized way

- Response includes:
  - Inflammation
  - Phagocytes
  - Complement system

- Triggered by chemical patterns common to pathogens

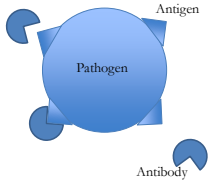
Innate Immune Response

- Inflammation – increased blood flow into affected tissue to deliver defensive molecules
- Phagocytes – white blood cells that engulf and break down pathogens
- Complement system – proteins coat pathogen's surface to speed destruction by phagocytes

Adaptive Immune Response

Adaptive response – slower response dependent on recognition of specific pathogen

- Response includes:
  - Antibodies
  - Lymphocytes



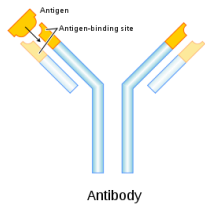
- Triggered by recognition of pathogen-specific antigens

Adaptive Immune Response

Lymphocytes – white blood cells, defend the body

- B cells – make antibodies
- Cytotoxic T cells – kill tagged pathogens
- Helper T cells – direct attacks by others

Antibodies – bind to antigens on pathogens



Immune Memory

Immune memory – phenomenon in which immune system is able to fight a previous infection more quickly

- Lymphocyte cells continue to be produced after pathogen is destroyed
  - Allows for stronger response if same pathogen enters body again

Defense Against Illness

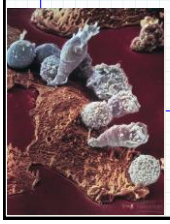
Organ systems involved:

System	Functions
Integumentary	Skin, hair and mucus provide physical barriers to pathogens
Respiratory	Nasal mucus and hairs, coughing and sneezing provide physical barriers to pathogens
Digestive	Stomach acids kill pathogens in food molecules
Circulatory	Blood transports defensive molecules, white blood cells, and antibodies to site of pathogen
Immune	Phagocytes and lymphocytes attack and destroy pathogens Adaptive response leads to immune memory

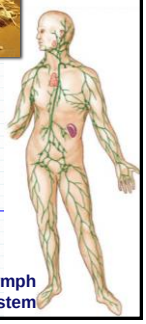
"Fighting the Enemy Within"

phagocytic leukocyte

Immune System



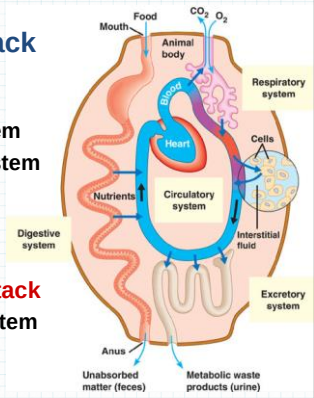
lymphocytes attacking cancer cell



lymph system

Avenues of attack

- **Points of entry**
  - digestive system
  - respiratory system
  - urinary system
  - genitals
  - break in skin
- **Pathways for attack**
  - circulatory system
  - lymph system



Why an immune system?

- Attack from the outside & inside
  - lots of organisms want you for lunch!
  - we are a tasty vitamin-packed meal
    - cells are packages of proteins, carbohydrates & fats
    - no cell wall
  - animals must defend themselves against invaders
    - viruses
      - HIV, flu, cold, measles, chicken pox, SARS
    - bacteria
      - pneumonia, meningitis, tuberculosis
    - fungi
      - yeast
    - protists
      - amoeba, Lyme disease, malaria
  - cancer cells
    - abnormal body cells

How are invaders recognized?

- Antigens
  - chemical name tags on the surface of every cell
    - "self" vs. "invader"

one of your own cells

antigens say: "I belong here"

disease-causing virus

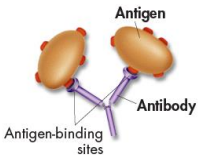
antigens say: "I am an invader"

disease-causing bacteria

antigens say: "I am an invader"

Antigens

- The main role of antibodies is to tag antigens for destruction by immune cells.
- Antibodies may be attached to particular immune cells or may be free-floating in plasma.
- The body makes up to 10 billion different antibodies.
- The shape of each type of antibody allows it to attach to one specific antigen.



Nonspecific Defenses

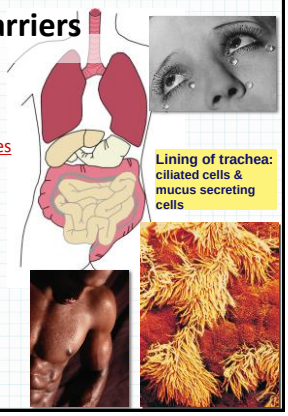
- The body's first defense against pathogens is a combination of physical and chemical barriers. These barriers include the skin, tears and other secretions, the inflammatory response, interferons, and fever.
- These barriers are called nonspecific defenses because they act against a wide range of pathogens.
  - The most widespread nonspecific defense is the skin.
  - Other nonspecific defenses protect parts of the body that are not covered by skin, such as the mouth, nose, and eyes.

Lines of defense

- 1st line: **Barriers**
  - broad, external defense
    - "walls & moats"
  - skin & mucus membranes
- 2nd line: **Non-specific patrol**
  - broad, internal defense
    - "patrolling soldiers"
  - phagocyte (eating) WBCs
- 3rd line: **Immune system**
  - specific, acquired immunity
    - "elite trained units"
  - lymphocyte WBCs & antibodies
    - B & T cells

1st line: Physical Barriers

- non-specific defense
- external barriers
  - skin & mucus membranes
  - excretions
    - sweat
    - stomach acid
    - tears
    - mucus
    - saliva
      - "lick your wounds"

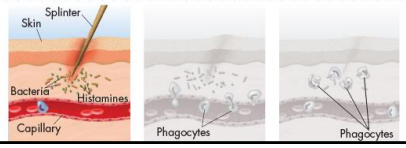


Second Line of Defense

- If pathogens make it into the body, through a cut in the skin, for example, the body's second line of defense swings into action.
- These mechanisms include the inflammatory response, the actions of interferons, and fever.

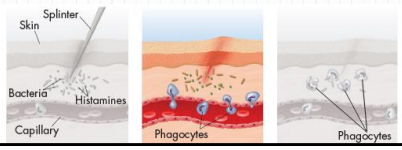
Inflammatory Response

- The inflammatory response causes infected areas to become red and painful, or inflamed.
- The response begins when pathogens stimulate cells called mast cells to release chemicals known as histamines.
- Histamines increase the flow of blood and fluids to the affected area.



Inflammatory Response

- Fluid leaking from expanded blood vessels causes the area to swell.
- White blood cells move from blood vessels into infected tissues.



Inflammatory Response

- Many of these white blood cells are phagocytes, which engulf and destroy bacteria.
- All this activity around a wound may cause a local rise in temperature. That's why a wounded area sometimes feels warm.

Interferons

- When viruses infect body cells, certain host cells produce proteins that inhibit synthesis of viral proteins and help block viral replication.
- Scientists named these proteins interferons because they "interfere" with viral growth.
- Interferons slow down the progress of infection and "buy time" for specific immune defenses to respond.

Fever

- The immune system also releases chemicals that increase body temperature, producing a fever.
- The increased body temperature may slow down or stop the growth of some pathogens.
- Higher body temperature also speeds up several parts of the immune response.

Fever

- When a local response is not enough
  - full body response to infection
  - raises body temperature
  - higher temperature helps in defense
    - slows growth of germs
    - helps macrophages
    - speeds up repair of tissues

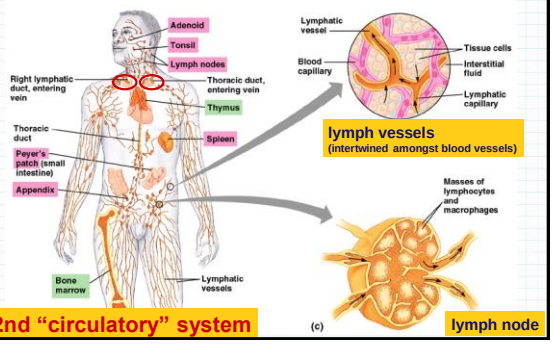
2nd: Generalist, broad range patrols

- Patrolling white blood cells
  - attack invaders that get through the skin
    - recognize invader by reading antigen
      - surface name tag
  - phagocyte cells
    - macrophages
    - "big eaters"

Macrophage "eating" bacteria

Lymph

Production of white blood cells & traps "foreign" invaders



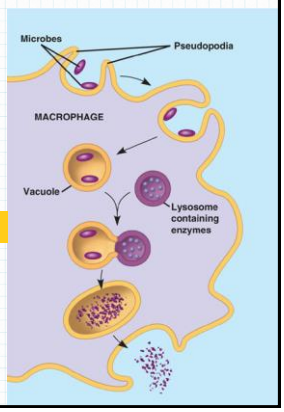
lymph vessels (intertwined amongst blood vessels)

2nd "circulatory" system

lymph node

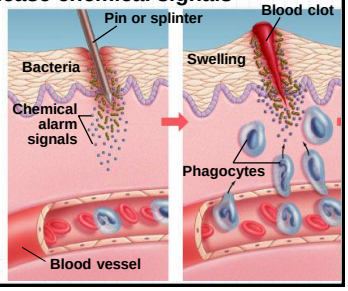
Phagocytes

white blood cells that eat

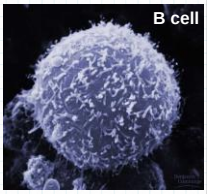


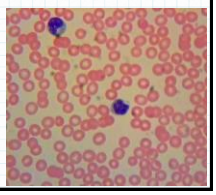
Why do injuries swell?

- **Inflammation**
  - **injured cells release chemical signals**
    - histamines
      - increases blood flow
      - brings more white blood cells to fight bacteria
      - brings more red blood cells & clotting factors to repair



3rd line: Lymphocytes

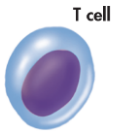




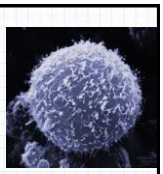
- Specific defense
  - responds to specific invaders
    - recognizes specific foreign antigens
    - white blood cells
      - B cells & antibodies
      - T cells

Lymphocytes

- T cells are produced in the bone marrow but mature in the thymus—an endocrine gland.
- T cells must be presented with an antigen by infected body cells or immune cells that have encountered antigens.
- Each B cell and T cell is capable of recognizing *one* specific antigen. A person's genes determine the particular B and T cells that are produced.
- When mature, both types of cells travel to lymph nodes and the spleen, where they will encounter antigens.



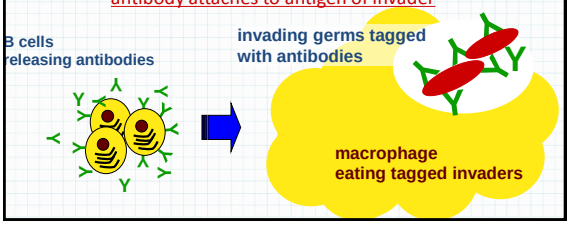
B cells & antibodies



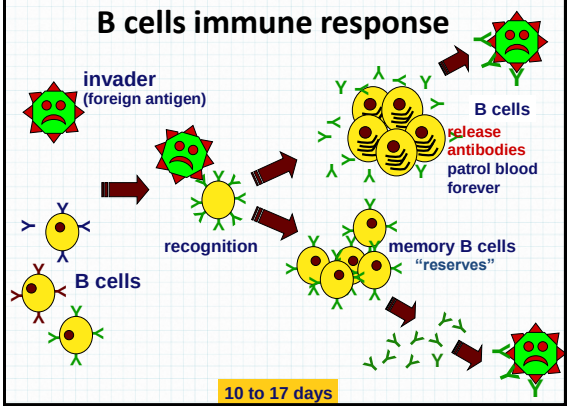
- B cells
  - white blood cells that attack invaders in blood
  - mature in Bone marrow
- Patrolling B cells
  - make antibodies against invader immediately
- Memory B cells
  - remembers invader
  - can make antibodies quickly the next time
    - protects you from getting disease more than once

Antibodies

- Proteins made by B cells that tag invaders in the blood so macrophages can eat them
  - tag says "this is an invader" → gotcha!
    - biological "handcuffs"
  - antibody attaches to antigen of invader

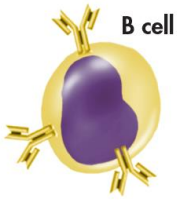


B cells immune response



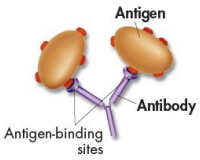
Humoral Immunity

- The immune response that defends against antigens in body fluids, such as blood and lymph, is called humoral immunity.
- B cells play the major role in humoral immunity.
- When a pathogen invades the body, its antigens are recognized by antibodies on the surfaces of a few existing B cells.
- Antibodies are the main weapons of the humoral immune response.



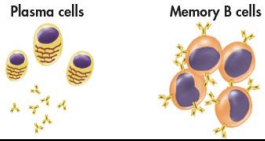
Humoral Immunity

- An antibody is shaped like the letter Y and has two identical antigen-binding sites.
- The shapes of the binding sites enable an antibody to recognize a specific antigen with a complementary shape.



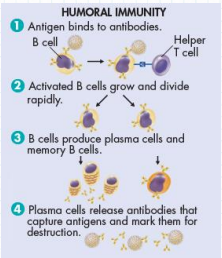
Humoral Immunity

- When an antigen binds to an antibody carried by a B cell, T cells stimulate the B cell to grow and divide rapidly.
- That growth and division produces many B cells of two types: plasma cells and memory B cells.



Plasma Cells

- Plasma cells produce and release antibodies that are carried through the bloodstream.
- These antibodies recognize and bind to free-floating antigens or to antigens on the surfaces of pathogens.
- When antibodies bind to antigens, they signal other parts of the immune system to attack and destroy the invaders.
- Some types of antibodies can disable invaders until they are destroyed.

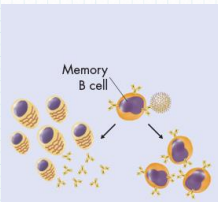


Plasma Cells

- A healthy adult can produce about 10 billion different types of antibodies, each of which can bind to a different type of antigen!
- This antibody diversity enables the immune system to respond to virtually any kind of "other" that enters the body.

Memory B Cells

- Plasma cells die after an infection is gone, but some B cells that recognize a particular antigen remain alive.
- These cells, called memory B cells, react quickly if the same pathogen enters the body again.
- Memory B cells rapidly produce new plasma cells to battle a returning pathogen. This secondary response occurs much faster than the first response to a pathogen.
- Immune memory helps provide long-term immunity to certain diseases and is the reason that vaccinations work.

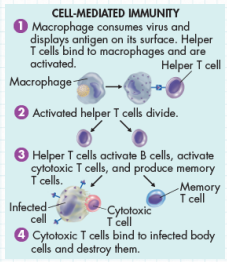


Cell-Mediated Immunity

- Another part of the immune response, which depends on the action of macrophages and several types of T cells, is called cell-mediated immunity.
- This part of the immune system defends the body against viruses, fungi, and single-celled pathogens.
- T cells also protect the body from its own cells when they become cancerous.

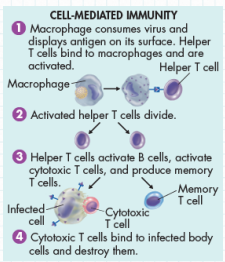
Cell-Mediated Immunity

- When a cell is infected by a pathogen or when a phagocyte consumes a pathogen, the cell displays a portion of the antigen on the outer surface of its membrane.
- This membrane attachment is a signal to circulating T cells called helper T cells.
- Activated helper T cells divide into more helper T cells, which go on to activate B cells, activate cytotoxic T cells, and produce memory T cells.



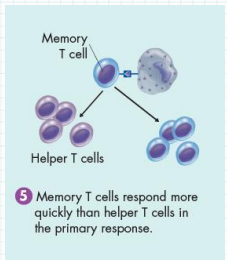
Cell-Mediated Immunity

- Cytotoxic T cells hunt down body cells infected with a particular antigen and kill the cells.
- They kill infected cells by puncturing their membranes or initiating apoptosis (programmed cell death).



Cell-Mediated Immunity

- Memory helper T cells enable the immune system to respond quickly if the same pathogen enters the body again.



Cell-Mediated Immunity

- Another type of T cell, called suppressor T cells, inhibits the immune response once an infection is under control.
- They may also be involved in preventing autoimmune diseases.

Cell-Mediated Immunity

- Although cytotoxic T cells are helpful in the immune system, they make the acceptance of organ transplants difficult.
- When an organ is transplanted from one person to another, the normal response of the recipient's immune system would be to recognize it as nonself. T cells and proteins would damage and destroy the transplanted organ in a process known as rejection.
- To prevent organ rejection, doctors search for a donor whose cell markers are nearly identical to the cell markers of the recipient.
- Organ recipients must take drugs—usually for the rest of their lives—to suppress the cell-mediated immune response.

Vaccinations

- Exposure to harmless version of germ
  - stimulates immune system to produce antibodies to invader
  - rapid response if future exposure
- Most successful against viral diseases
  - A vaccine stimulates the immune system with an antigen.
  - The immune system produces memory B cells and memory T cells that quicken and strengthen the body's response to repeated infection.
  - Antibodies produced against a pathogen by other individuals or animals can be used to produce temporary immunity.

Passive Immunity

- Antibodies produced against a pathogen by other individuals or animals can be used to produce temporary immunity. If externally produced antibodies are introduced into a person's blood, the result is passive immunity.
- Passive immunity lasts only a short time because the immune system eventually destroys the foreign antibodies.
- Passive immunity can occur naturally or by deliberate exposure.
- Natural passive immunity occurs when antibodies are passed from a pregnant woman to her fetus (across the placenta), or to an infant through breast milk.
- For some diseases, antibodies from humans or animals can be injected into an individual.
- For example, people who have been bitten by rabid animals are injected with antibodies for the rabies virus.

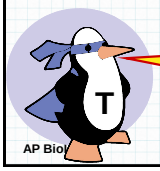
Protecting you from disease

- Vaccinations
  - advantage
    - don't get illness
    - long term immunity
      - produce antibodies for life
    - works against many viruses & bacteria
  - disadvantage
    - not possible against all invaders
- Breastfeeding
  - mother's milk gives baby antibodies & keeps baby healthy`

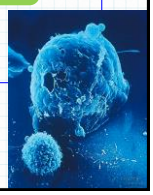
IMPORTANT PROTECTION antibodies pass from mother to baby in breast milk

What if the attacker gets past the B cells in the blood & infects some of your cells?

You need trained assassins to kill off these infected cells!



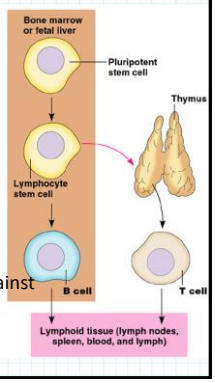
Attack of the Killer T cells!



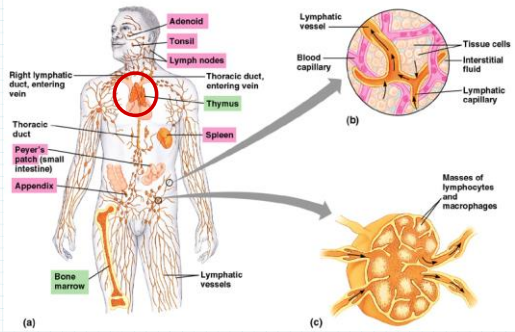
AP Bio

T cells

- T cells mature in Thymus
- Helper T cells
  - sound the alarm for rest of immune system
- Killer T cells
  - destroy infected body cells
- Memory T cells
  - remembers invader & reacts against it again quickly

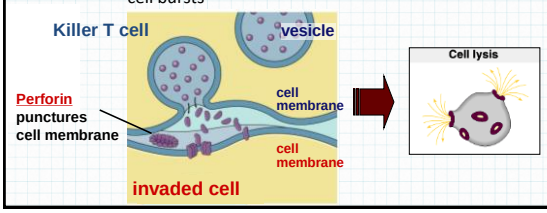


Thymus

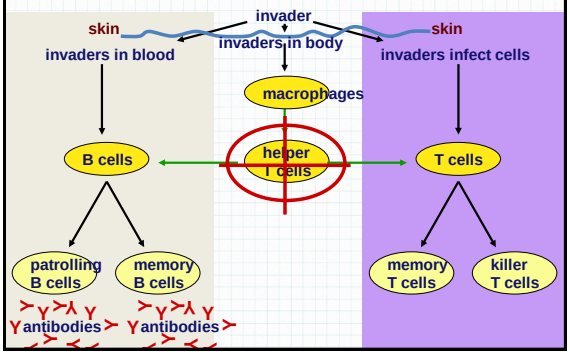


Attack of the Killer T cells

- Killer T cells destroy infected body cells
  - T cell binds to invaded cell
  - secretes perforating protein
    - punctures cell membrane of infected cell
    - cell bursts

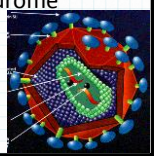


Immune response



Diseases of the immune system

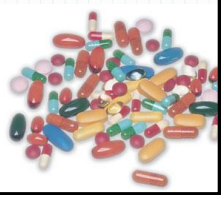
- HIV: Human Immunodeficiency Virus
  - infects helper T cells
  - helper T cells can't activate rest of immune system
    - body doesn't hear the alarm
- AIDS:
  Acquired ImmunoDeficiency Syndrome
  - immune system is weakened
  - infections by other diseases
  - death from other invading diseases or cancer



How to protect yourself…

Curing you of disease

- Antibiotics = medicine
  - advantage
    - kill bacteria that have successfully invaded you
      - make you well after being sick
  - disadvantage
    - use only after sick
    - only good against bacteria
    - possible development of resistance by bacteria (if don't use correctly)
    - can get sick again

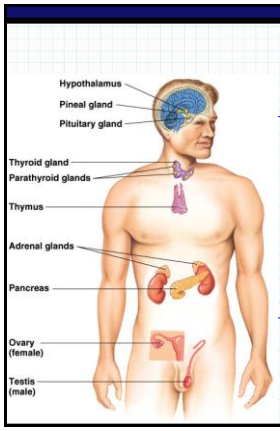


Immune system malfunctions

- Auto-immune diseases
  - immune system attacks own cells
    - lupus
      - antibodies attack many different body cells
    - rheumatoid arthritis
      - antibodies causing damage to cartilage & bone
    - diabetes
      - insulin-making cells of pancreas attacked & destroyed
    - multiple sclerosis
      - T cells attack myelin sheath of brain & spinal cord nerves
      - fatal

Immune system malfunctions

- Allergies
  - over-reaction to harmless compounds
    - allergens
      - proteins on pollen
      - proteins from dust mites
      - proteins in animal saliva
    - body mistakenly thinks they are attackers



Endocrine System Hormones & Homeostasis

2009-2010

Homeostasis

- Homeostasis
  - maintaining internal balance in the body
    - organism must keep internal conditions stable even if environment changes
    - also called "dynamic equilibrium"
  - example: body temperature
    - humans:
      - too cold = shiver
      - too warm = sweat
    - lizard:
      - too cold = bask in sun
      - too warm = hide in shade

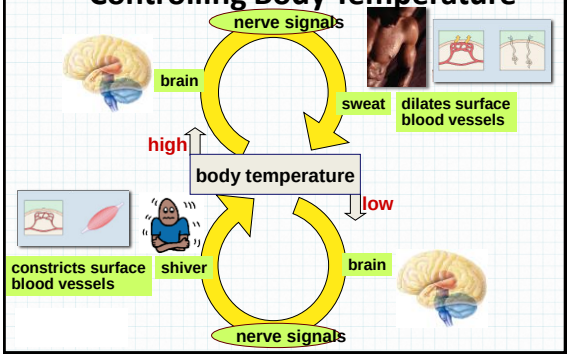
Regulation

- How we maintain homeostasis
  - nervous system
    - nerve signals control body functions
  - endocrine system
    - hormones
    - chemical signals control body functions

Nervous System Control

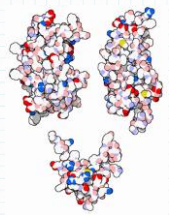
Feedback

Controlling Body Temperature



Hormones

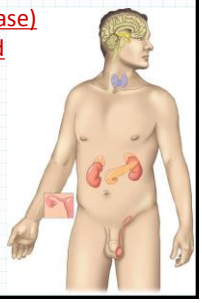
- Why are hormones needed?
  - chemical messages from one body part to cells in other parts of body
  - communication needed to coordinate whole body
  - maintaining homeostasis



growth hormones

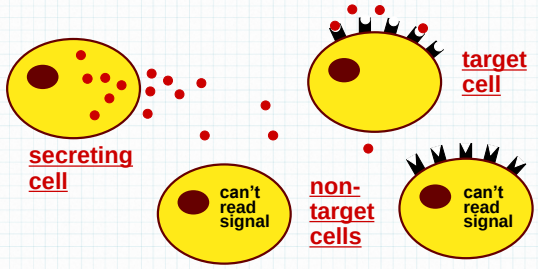
Endocrine System

- Endocrine system releases hormones
  - glands which secrete (release) chemical signals into blood
    - chemicals cause changes in other parts of body
      - growth hormones
      - sex hormones
      - response hormones
      - metabolism hormones
      - and more….



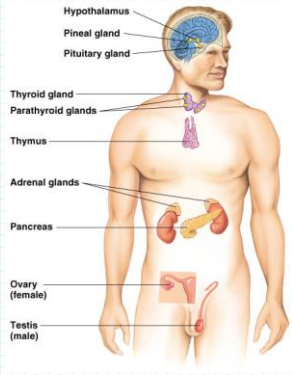
Responding to hormones

- Lock and key system
  - hormone fits receptor on "target" cell



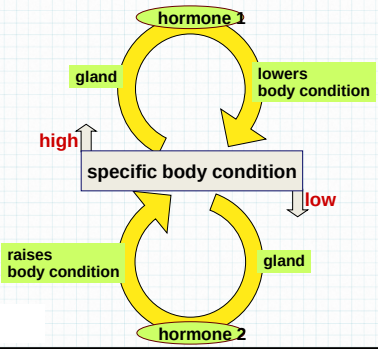
Glands

- Pineal
  - melatonin
- Pituitary
  - many hormones: master gland
- Thyroid
  - thyroxine
- Adrenal
  - adrenaline
- Pancreas
  - insulin, glucagon
- Ovary
  - estrogen
- Testes
  - testosterone



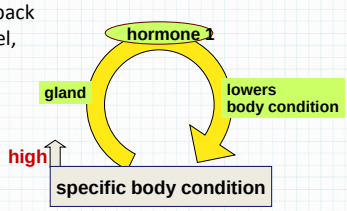
Maintaining homeostasis

Feedback



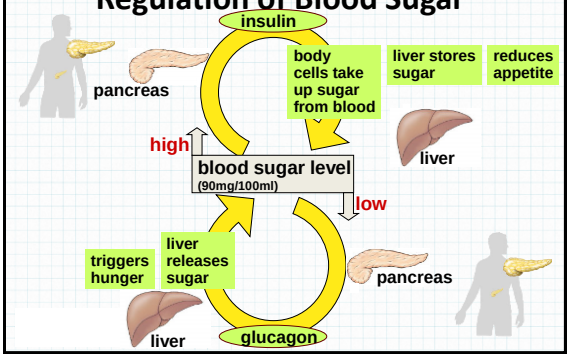
Negative Feedback

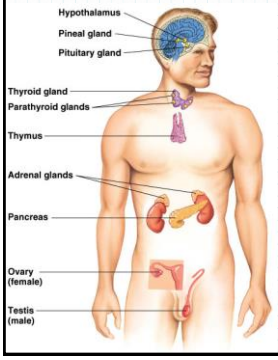
- Response to changed body condition
  - if body is high or low from normal level
    - signal tells body to make changes that will bring body back to normal level
  - once body is back to normal level, signal is turned off



Endocrine System Control
Regulation of Blood Sugar

Feedback



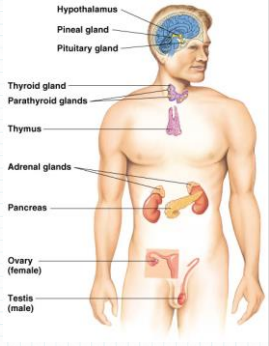


Endocrine System Hormones & Reproduction

2009-2010

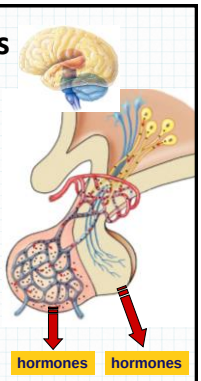
Sex & Growth Hormones

- Large scale body changes
  - how do they work
    - turn genes on
    - start new processes in the body by turning genes on that were lying "dormant"



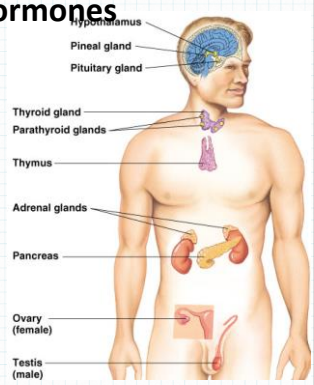
Pituitary gland hormones

- Sex & reproductive hormones
  - FSH
    - follicle stimulating hormone
    - stimulates egg & sperm production
  - LH
    - luteinizing hormone
    - stimulates ovaries & testes
    - prepares uterus for fertilized egg
  - oxytocin
    - stimulates childbirth contractions
    - releases milk in nursing mothers
  - prolactin
    - milk production in nursing mothers

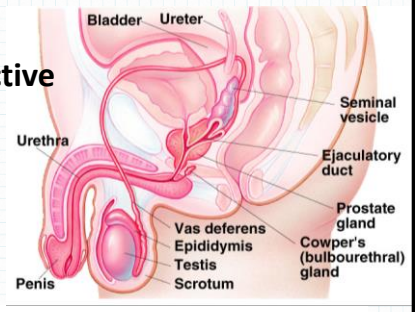


Reproductive hormones

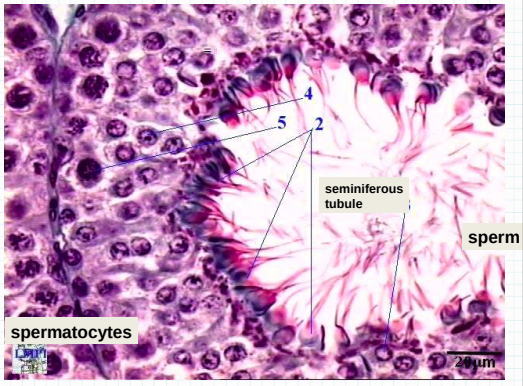
- Testosterone
  - from testes
  - sperm production & secondary sexual characteristics
- Estrogen
  - from ovaries
  - egg production, preparing uterus for fertilized egg & secondary sexual characteristics



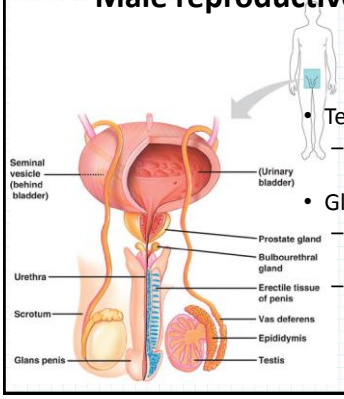
Male reproductive system



- Sperm production
  - over 100 million produced per day!
  - ~2.5 million released per drop!



Male reproductive system

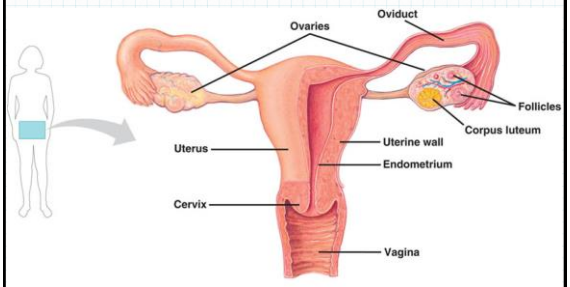


- Testes & epididymis
  - sperm production & maturation
- Glands
  - seminal vesicles, prostate, bulbourethal
  - produce seminal fluid
    - nutrient-rich

Male reproductive system

- Testicles
  - produces sperm & hormones
- Scrotum
  - sac that holds testicles outside of body
- Epididymis
  - where sperm mature
- Vas deferens
  - tubes for sperm to travel from testes to penis
- Prostate, seminal vesicles, Cowper's (bulbourethal) glands
  - nutrient rich fluid to feed & protect sperm

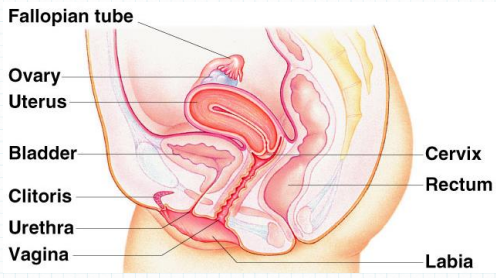
Female reproductive system



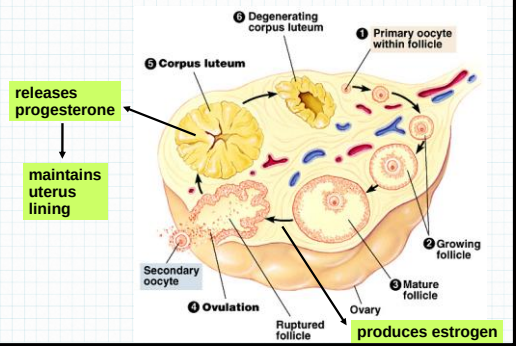
Female reproductive system

- Ovaries
  - produces eggs & hormones
- Uterus
  - nurtures fetus; lining builds up each month
- Fallopian tubes
  - tubes for eggs to travel from ovaries to uterus
- Cervix
  - opening to uterus, dilates 10 cm for birthing baby
- Vagina
  - birth canal for birthing baby

Female reproductive system

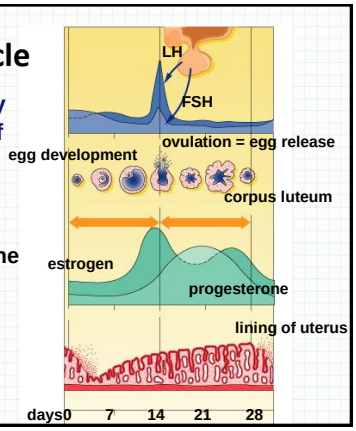


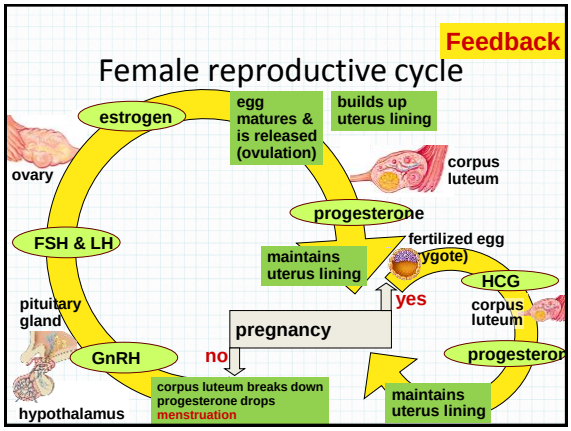
Egg maturation in ovary



Menstrual cycle

- Controlled by interaction of 4 hormones
  - FSH & LH
  - estrogen
  - progesterone

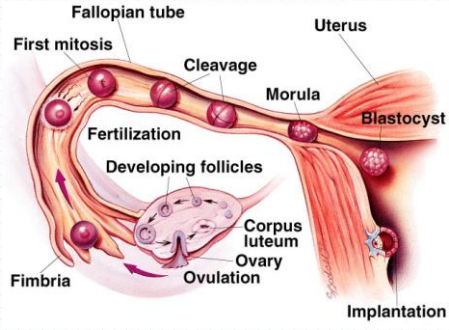




Female hormones

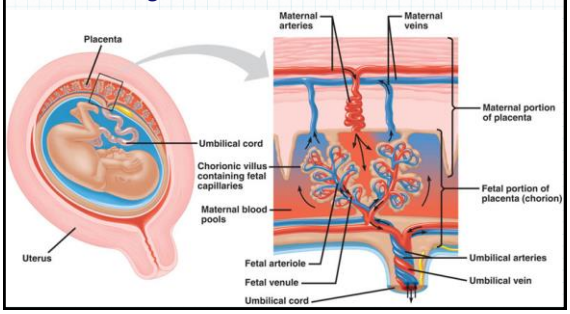
- FSH & LH
  - released from pituitary
  - stimulates egg development & hormone release
  - peak release = release of egg (ovulation)
- Estrogen
  - released from ovary cells around developing egg
  - stimulates growth of lining of uterus
  - decreasing levels causes menstruation
- Progesterone
  - released from "corpus luteum" in ovaries
    - cells that used to take care of developing egg
  - stimulates blood supply to lining of uterus
  - decreasing levels causes menstruation

Fertilization



Placenta

- Food & gases diffuse across blood vessels



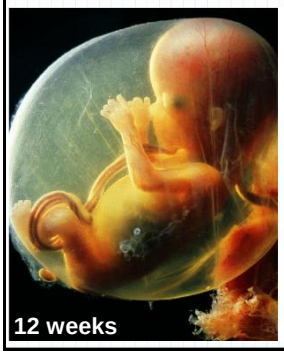
Human fetal development

4 weeks

7 weeks

Human fetal development

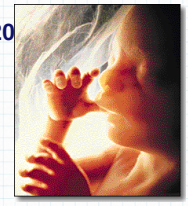
Human fetal development



Human fetal development

- The fetus just spends much of the 2nd & 3rd trimesters just growing
  - …and doing various flip-turns & kicks inside amniotic fluid

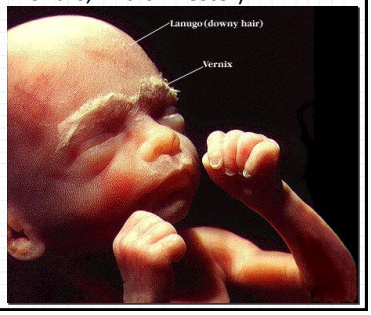
Week 20



Human fetal development

- 24 weeks (6 months; 2nd trimester)

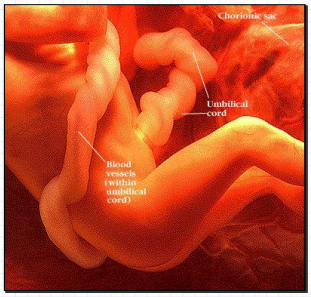
fetus is covered with fine, downy hair called lanugo. Its skin is protected by a waxy material called vernix



Human fetal development

- 30 weeks (7.5 months)

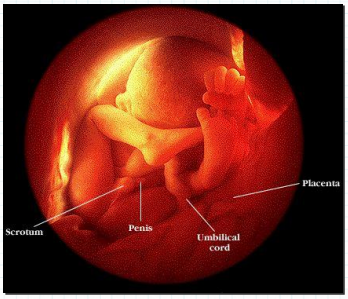
umbilical cord

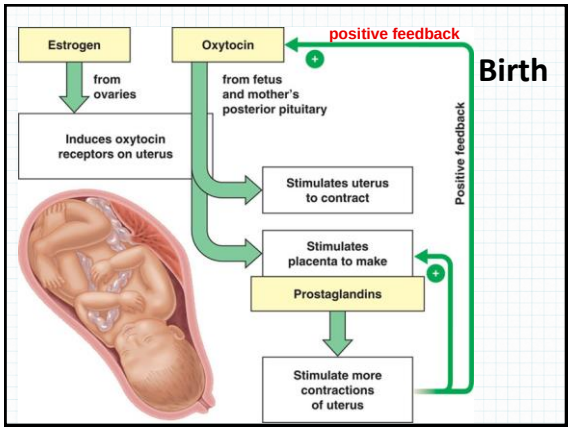


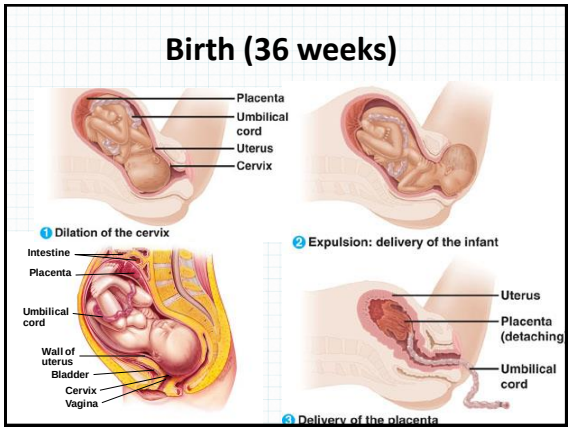
Getting crowded in there!!

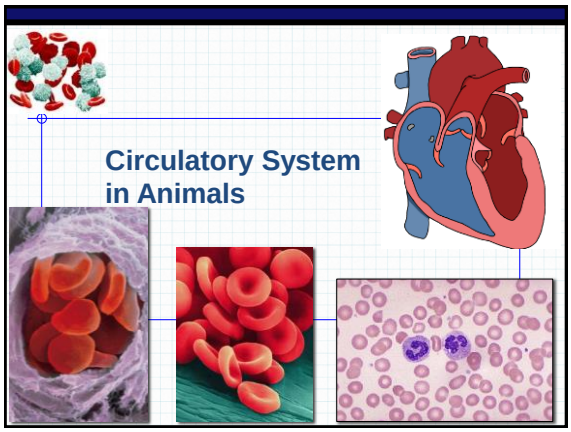
- 32 weeks (8 months)

The fetus sleeps 90-95% of the day & sometimes experiences REM sleep, an indication of dreaming



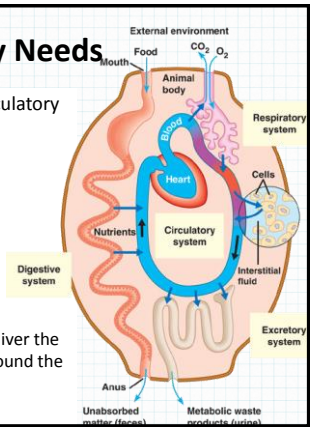






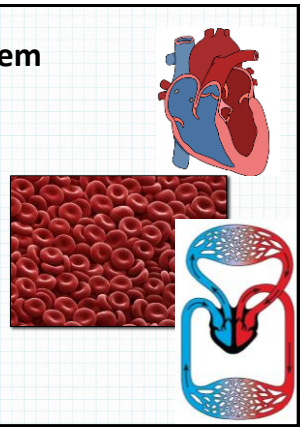
Feeding Energy Needs

- Why do we need a circulatory system?
  - supplies in
    - fuel (sugars)
      - digestive system
    - oxygen
      - respiratory system
  - waste out
    - CO_2
      - respiratory system
  - need to pick up & deliver the supplies & wastes around the body
    - circulatory system



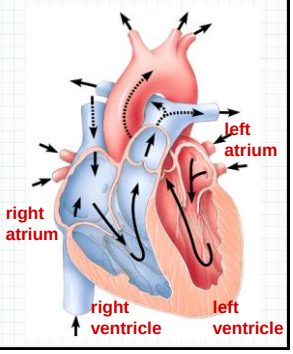
Circulatory System

- Organ
  - heart
- Tissues & cells
  - blood vessels
    - arteries
    - veins
    - capillaries
  - blood
    - red blood cells
    - plasma (liquid)



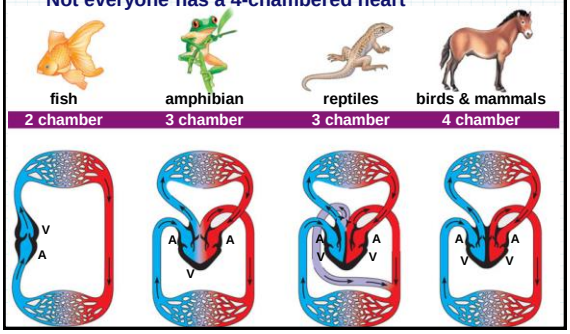
Vertebrate Heart

- 4-Chambered heart
  - atria (atrium)
    - thin wall
    - collection chamber
    - receive blood
  - ventricles
    - thick wall pump
    - pump blood out



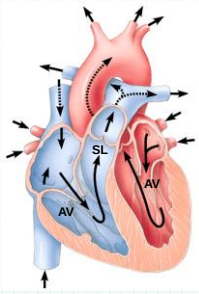
Evolution of circulatory system

Not everyone has a 4-chambered heart

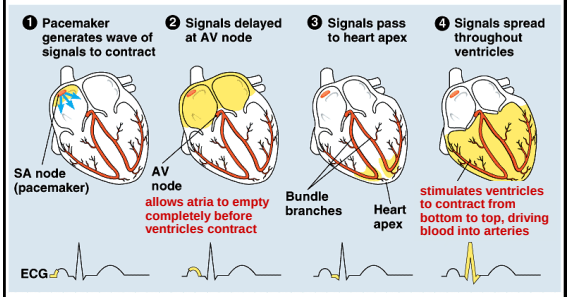


Lub-dub, lub-dub

- 4 valves in the heart
  - flaps of tissue
  - prevent backflow of blood
- Heart sounds
  - closing of valves
  - "Lub"
    - force blood against closed AV valves
  - "Dub"
    - force of blood against semilunar valves
- Heart murmur
  - leaking valve causes hissing sound
  - blood squirts backward through valve



Electrical signals



- heart pumping controlled by electrical impulses
- signal also transmitted to skin = EKG

Cardiac Cycle

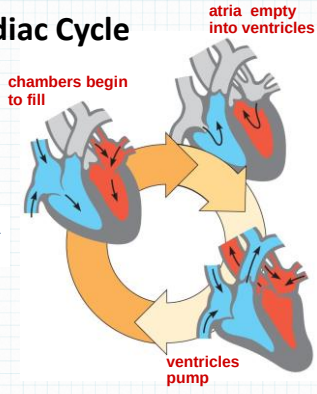
How is this reflected in blood pressure measurements?

pump (peak pressure)

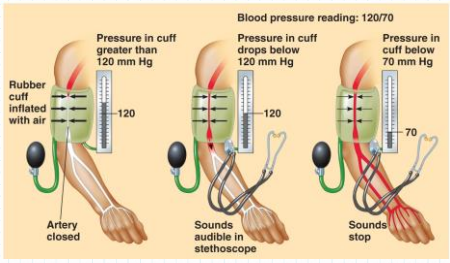
fill (minimum pressure)

110

80



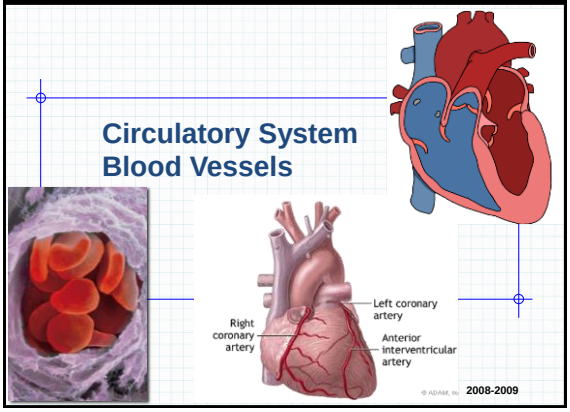
Measurement of blood pressure



hypertension = (high blood pressure)

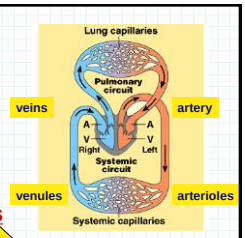
if top number > 150 or if bottom number > 90

Circulatory System Blood Vessels



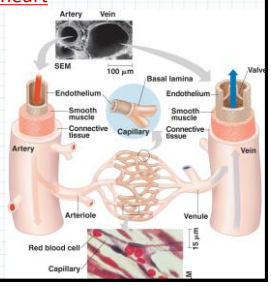
Blood vessels

arteries → arterioles → capillaries → venules → veins



Arteries: Built for their job

- Arteries
  - blood flows away from heart
  - thicker walls
    - provide strength for high pressure pumping of blood
  - elastic & stretchable



Major arteries

aorta

carotid = to head

to brain & left arm

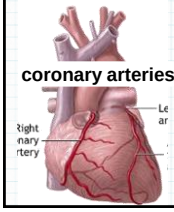
to right arm

to body

pulmonary artery

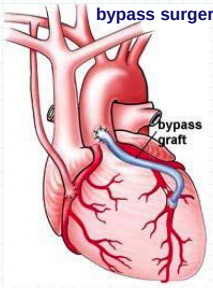
pulmonary artery = to lungs

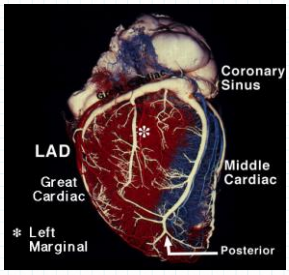
coronary arteries



Coronary artery bypass

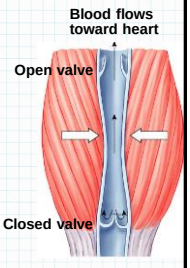
bypass surgery





Veins: Built for their job

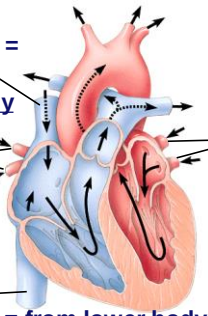
- Veins
  - blood returns back to heart
  - thinner-walled
    - blood travels back to heart at low speed & pressure
    - why low pressure?
      - far from heart
    - blood flows because muscles contract when we move
      - squeeze blood through veins
  - valves in large veins
    - in larger veins one-way valves allow blood to flow only toward heart



Major Veins

superior vena cava = from upper body

pulmonary vein = from lung

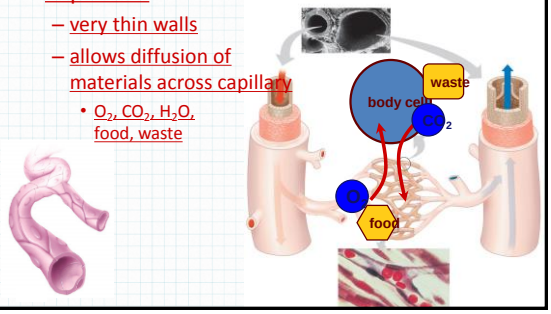


pulmonary vein = from lung

inferior vena cava = from lower body

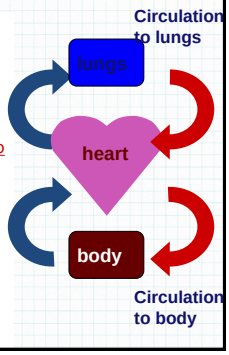
Structure-function relationship

- Capillaries
  - very thin walls
  - allows diffusion of materials across capillary
    - O_2, CO_2, H_2O, food, waste



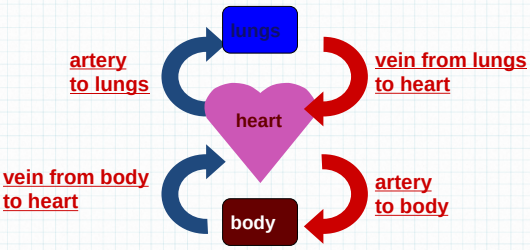
Circulation of Blood

- 2 part system
  - Circulation to lungs
    - blood gets O_2 from lungs
    - drops off CO_2 to lungs
    - brings O_2-rich blood from lungs to heart
  - Circulation to body
    - pumps O_2-rich blood to body
    - picks up nutrients from digestive system
    - collects CO_2 & cell wastes



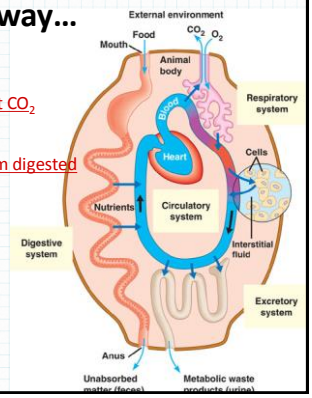
Vertebrate circulatory system

- 2 part system



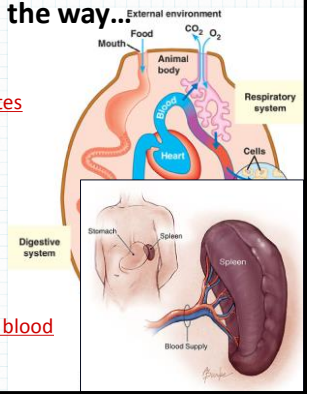
Stops along the way…

- Lungs
  - pick up O_2 / clean out CO_2
- Small Intestines
  - pick up nutrients from digested food
- Large Intestines
  - pick up water from digested food
- Liver
  - clean out worn out blood cells



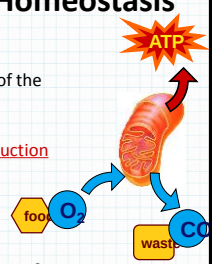
More stops along the way…

- Kidneys
  - filters out cell wastes (urea)
  - extra salts, sugars & water
- Bone
  - pick up new red blood cells
- Spleen
  - pick up new white blood cells

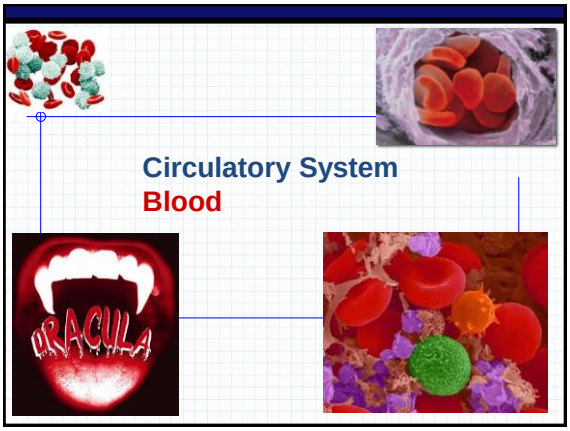


Circulatory System & Homeostasis

- Homeostasis
  - keeping the internal environment of the body balanced
  - need to balance food & O_2 in
  - need to balance energy (ATP) production
  - need to balance CO_2 & waste out
- Exercise
  - heart beat faster
    - need more ATP
    - bring in more O_2 & food; remove more CO_2 & waste out

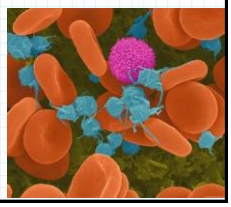


Disease
- poor lung or heart function = heart beat faster
  - need to work harder to bring in O_2 & food & remove wastes



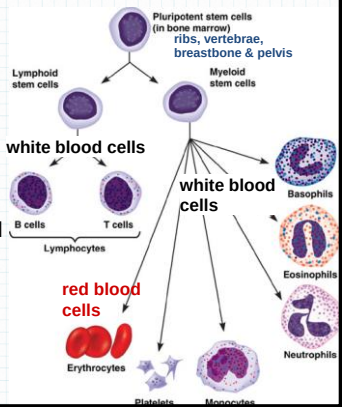
Blood & blood cells

- Blood is a tissue of fluid & cells
  - plasma
    - liquid part of blood
    - dissolved salts, sugars, proteins, and more
  - cells
    - red blood cells (RBC)
      - transport O_2 in hemoglobin
    - white blood cells (WBC)
      - defense & immunity
    - platelets
      - blood clotting

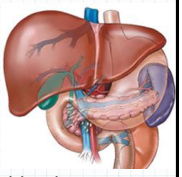


Blood Cell production

- Stem cells
  - "parent" cells in bone marrow
  - develop into all the different types of blood cells
    - red blood cells
    - white blood cells



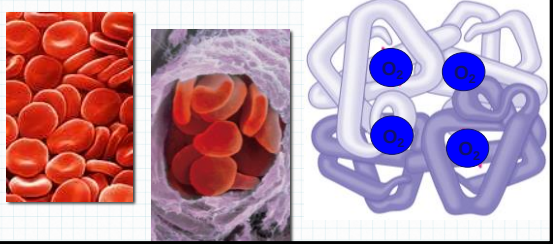
Red blood cells



- Small round cells
  - produced in bone marrow
  - 5 liters of blood in body
  - 5-6 million RBC in drop of human blood
  - last 3-4 months (120 days)
    - filtered out by liver
    - ~3 million RBC destroyed each second

Hemoglobin

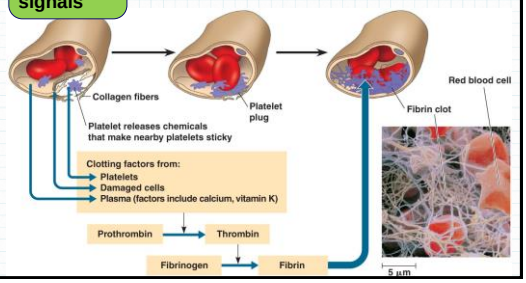
- Protein which carries O_2
  - 250,000 hemoglobin proteins in one red blood cell



emergency repair of circulatory system

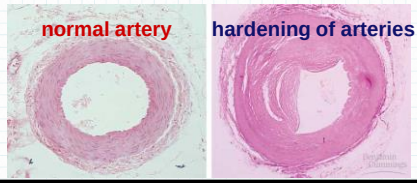
Blood clotting

chemical emergency signals | platelets seal the hole | protein fibers build the clot



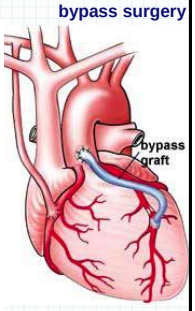
Cardiovascular disease

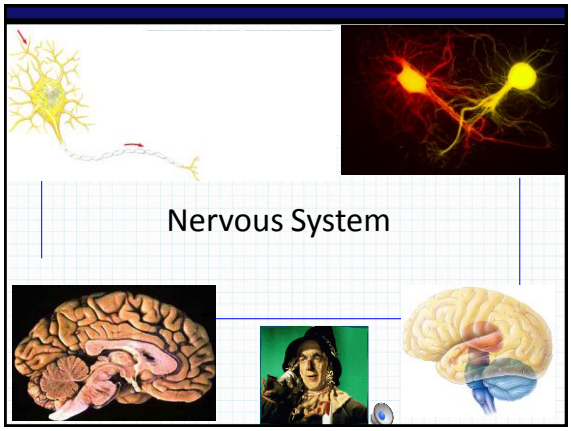
- Atherosclerosis & Arteriosclerosis
  - deposits inside arteries (plaques)
    - develop in inner wall of the arteries, narrowing their channel
  - increase blood pressure
  - increase risk of heart attack, stroke, kidney damage



Cardiovascular health

- Risk Factors
  - genetics
  - diet
    - high animal fat
  - exercise & lifestyle
    - smoking
    - lack of exercise



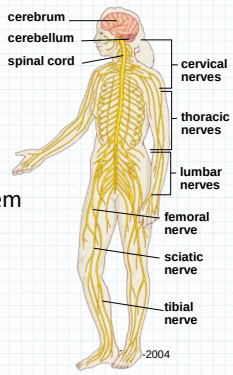


Why do animals need a nervous system?

- What characteristics do animals need in a nervous system?
  - fast
  - accurate
  - reset quickly

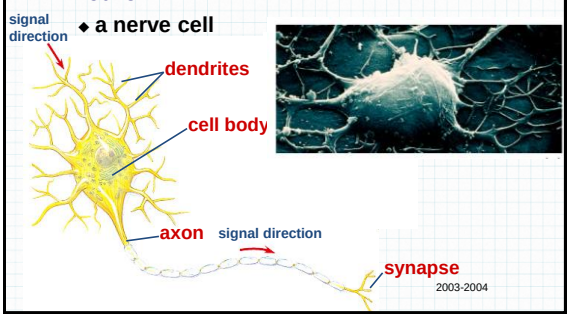
Nervous System

- Central nervous system
  - brain & spinal chord
- Peripheral nervous system
  - nerves from senses
  - nerves to muscles



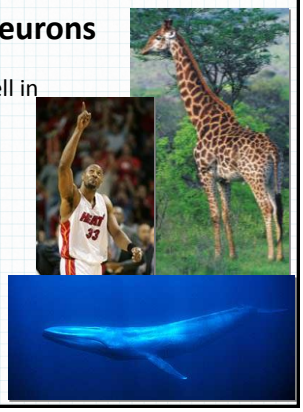
Nervous system cells

- Neuron
  - a nerve cell



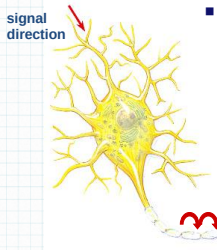
Fun facts about neurons

- Most specialized cell in animals
- Longest cell
  - blue whale neuron
    - 10-30 meters
  - giraffe axon
    - 5 meters
  - human neuron
    - 1-2 meters



Nervous system allows for 1 millisecond response time

Myelin sheath

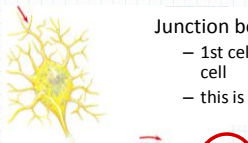


- **Axon coated with insulation made of myelin cells**
  - **speeds signal**
    - **signal hops from node to node**
  - **330 mph vs. 11 mph**

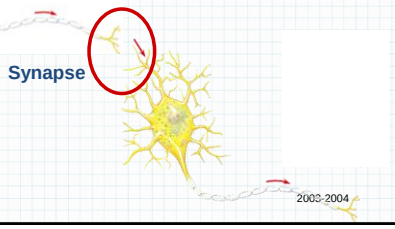
Multiple Sclerosis
- **immune system (T cells) attacks myelin sheath**
- **loss of signal**

2003-2004

Synapse

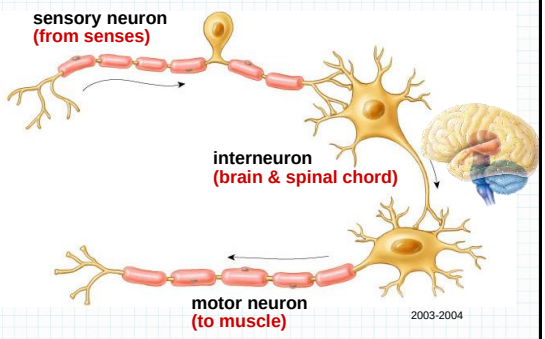


Junction between nerve cells
- 1st cell releases chemical to trigger next cell
- this is where drugs affect nervous system



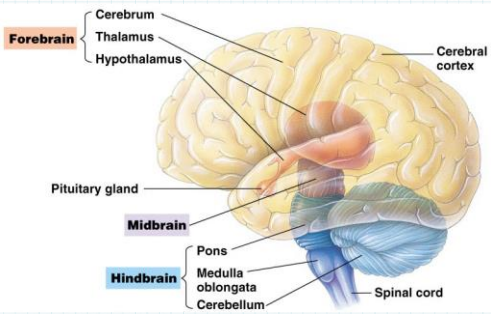
2003-2004

Types of neurons



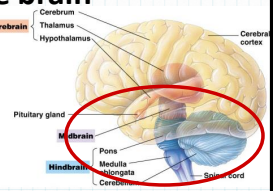
2003-2004

Human brain



Primitive brain

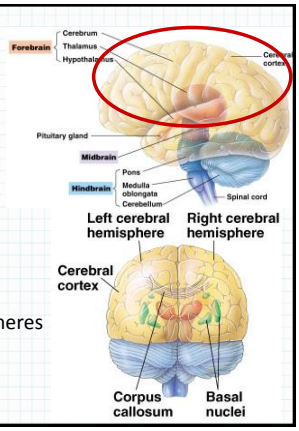
- The "lower brain"
  - medulla oblongata
  - pons
  - cerebellum
- Functions
  - basic body functions
    - breathing, heart, digestion, swallowing, vomiting
  - homeostasis
  - coordination of movement



2003-2004

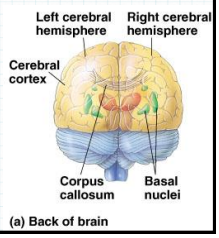
Higher brain

- Cerebrum
  - hemispheres
  - left = right side of body
  - right = left side of body
- Corpus callosum
  - major connection between 2 hemispheres



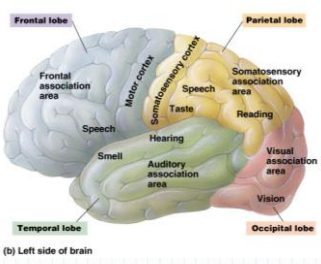
Division of Brain Function

- Left hemisphere
  - "logic side"
  - language, math, logic operations, vision & hearing details
  - fine motor control
- Right hemisphere
  - "creative side"
  - pattern recognition, spatial relationships, non-verbal ideas, emotional processing, parallel processing of information



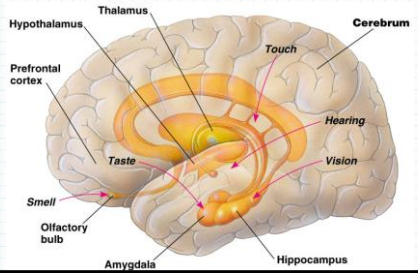
Cerebrum specialization

- Regions of the cerebrum are specialized for different functions
- Lobes
  - frontal
  - temporal
  - occipital
  - parietal



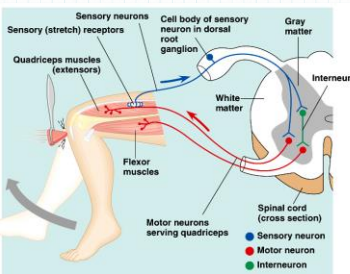
Limbic system

Controls basic emotions (fear, anger), involved in emotional bonding, establishes emotional memory



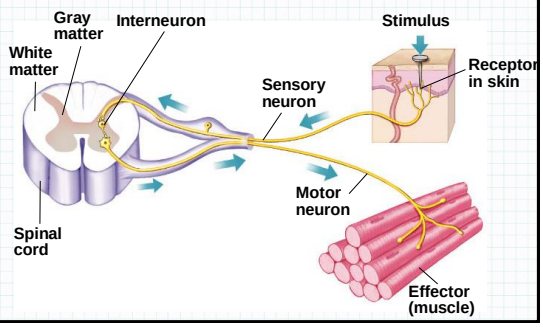
Simplest Nerve Circuit

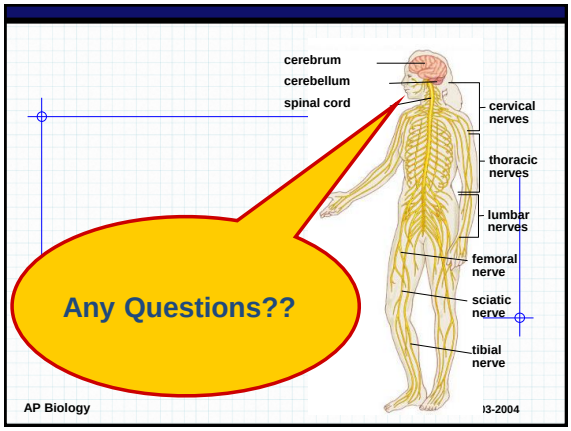
- **Reflex, or automatic response**



- rapid response
  - automated
- signal only goes to spinal cord
  - no higher level processing
- advantage
  - essential actions
  - don't need to think or make decisions about
    - blinking
    - balance
    - pupil dilation
    - startle

Eye Blink or Pain Withdrawal Reflex




cerebrum
cerebellum
spinal cord
cervical nerves
thoracic nerves
lumbar nerves
femoral nerve
sciatic nerve
tibial nerve
Any Questions??
AP Biology
)3-2004