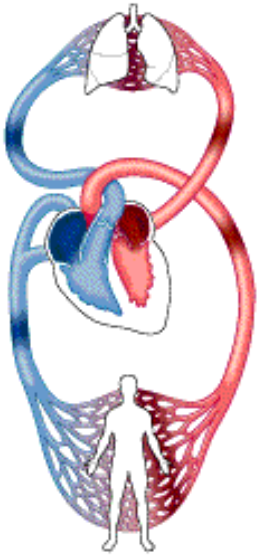
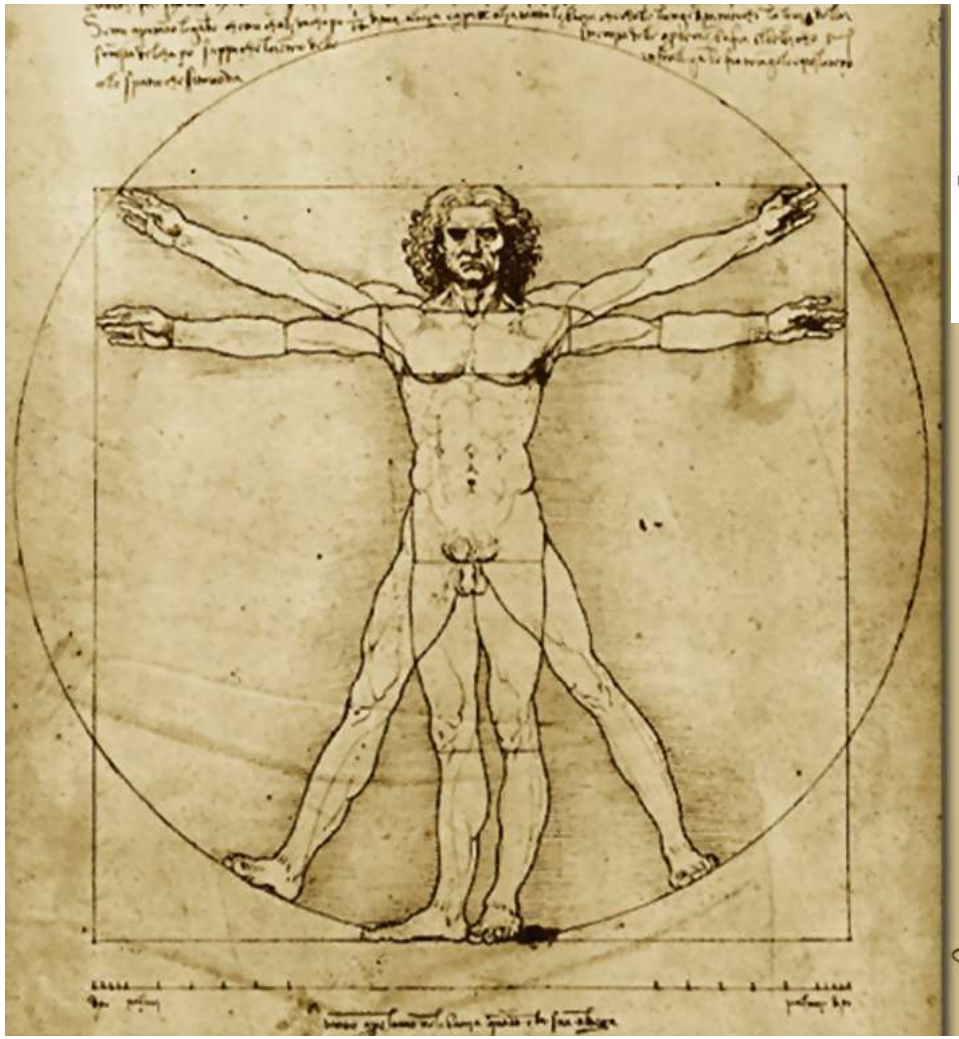
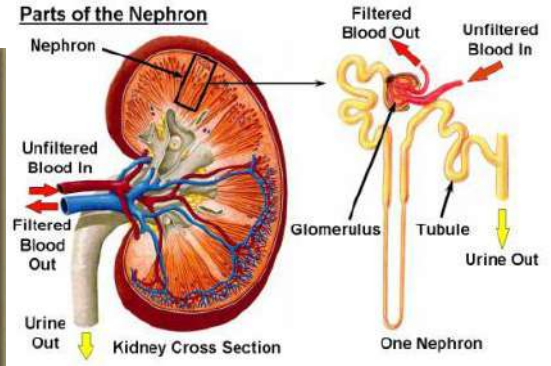
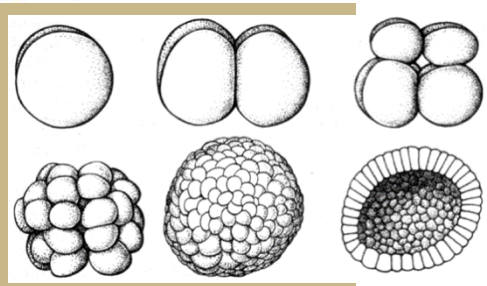
AP Bio Human Anatomy



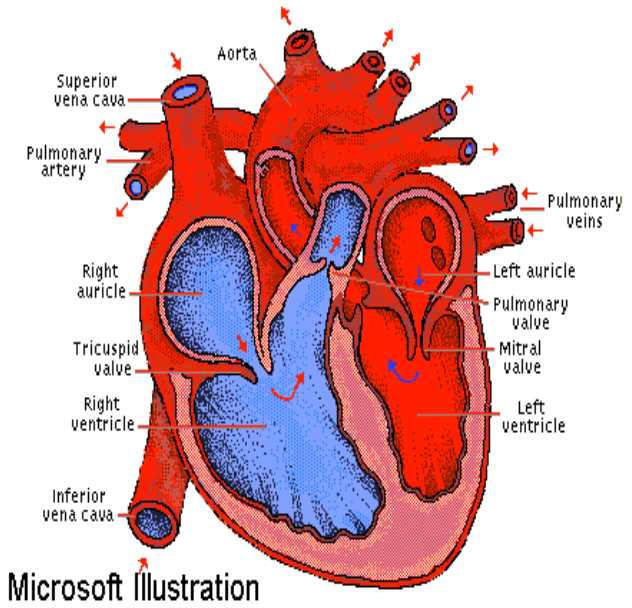




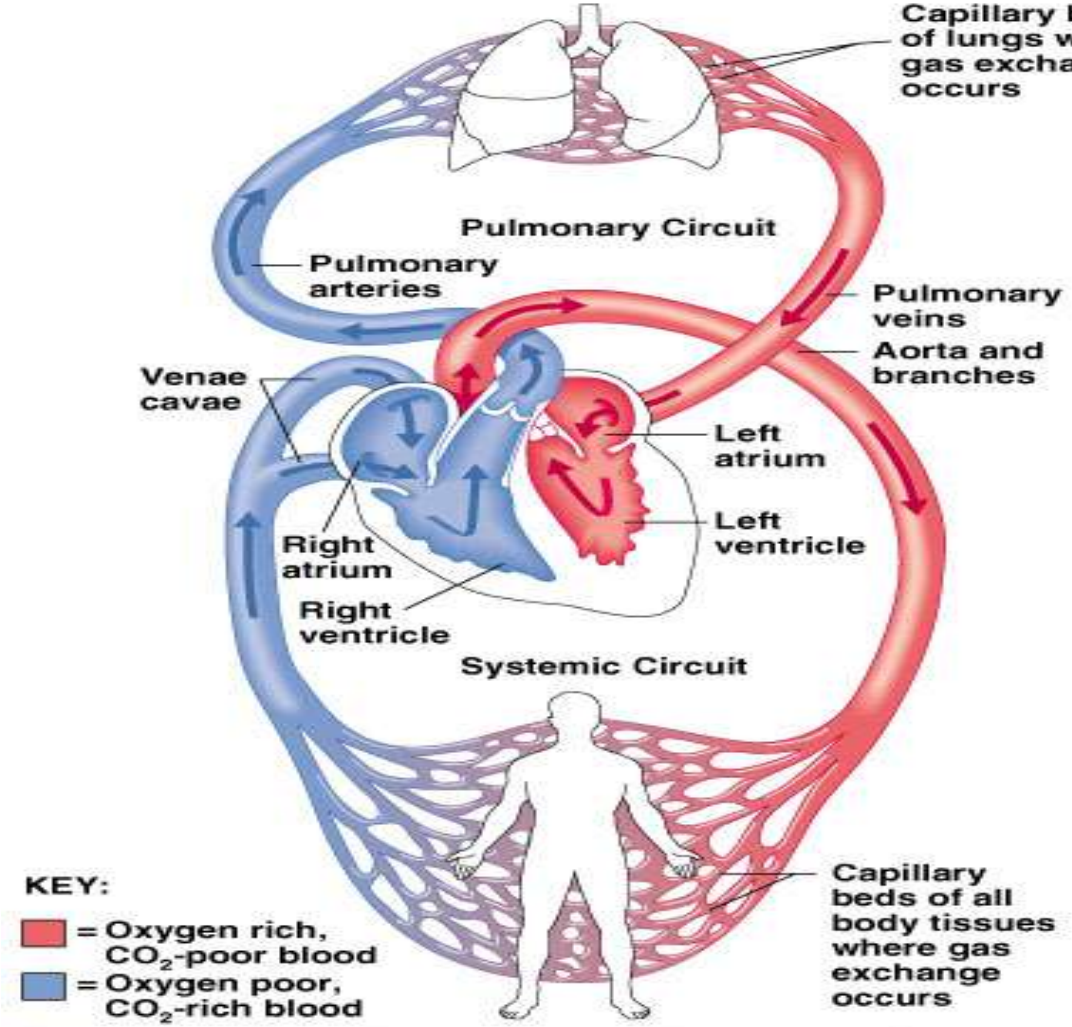


Leonardo Da Vinci

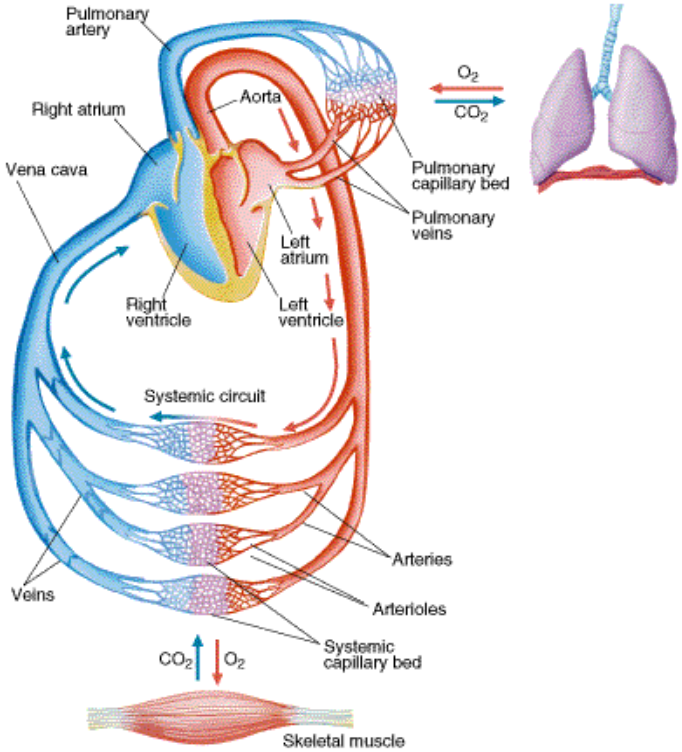
Parts of the Heart



- Location: Thoracic Cavity
- Parts of the heart
  - 4 chambers:
    - 2 atria: thin walled upper chambers which receive blood
    - 2 ventricles: muscled lower chambers which pump the blood out



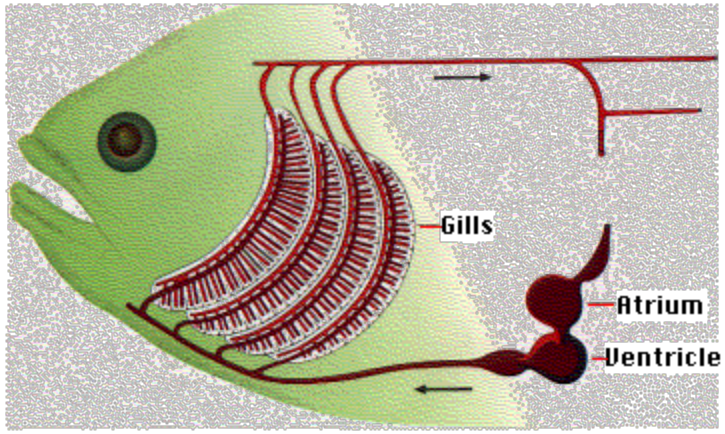
Heart Comparison

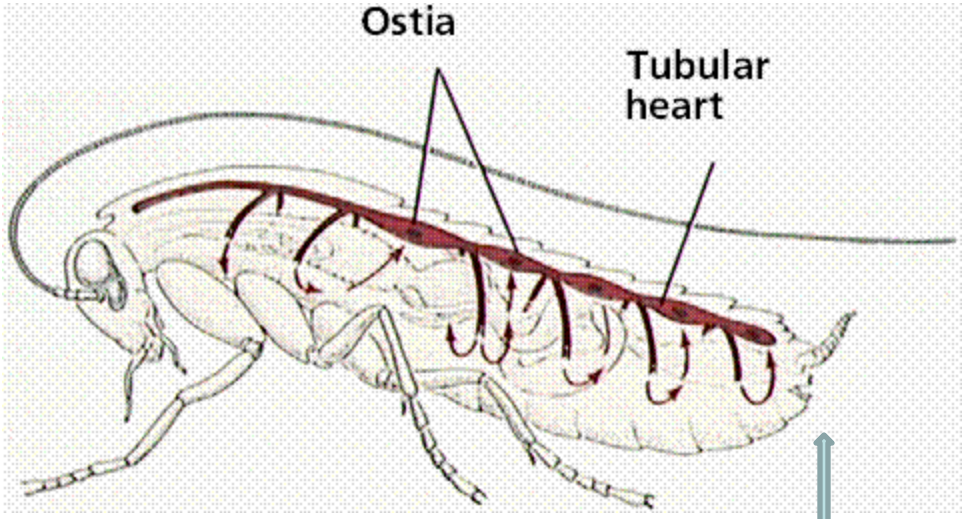


Heart comparison Video

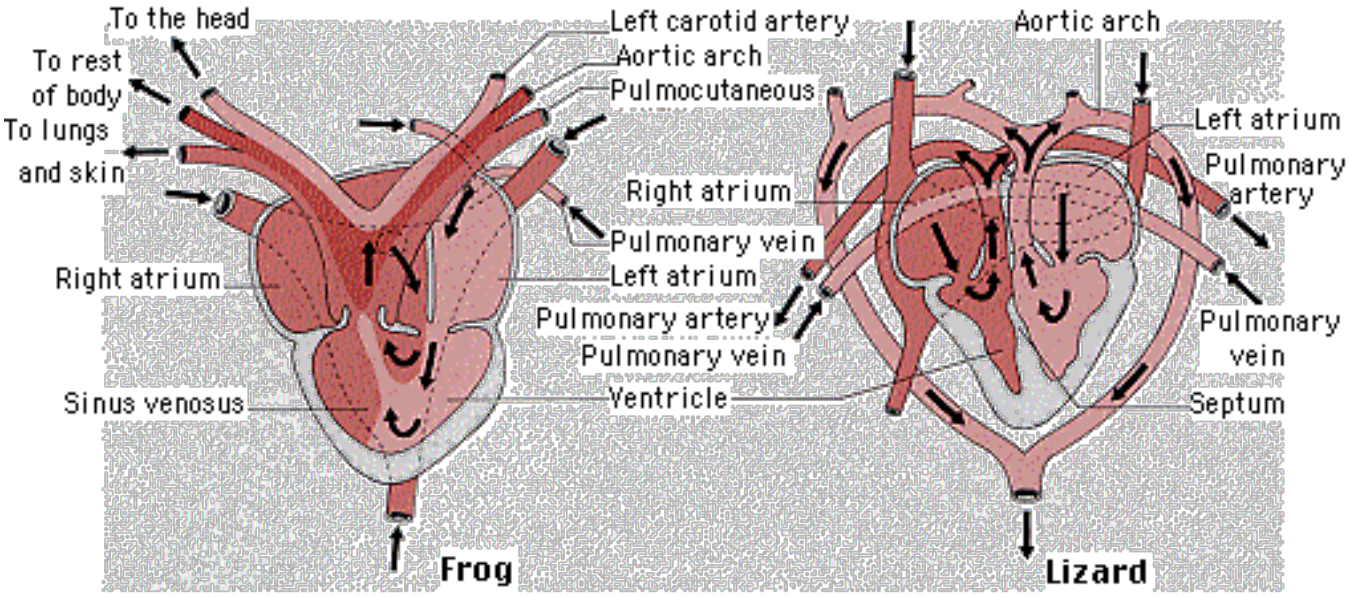
HHMI Myosin Cell Furrowing

Closed Circulatory system





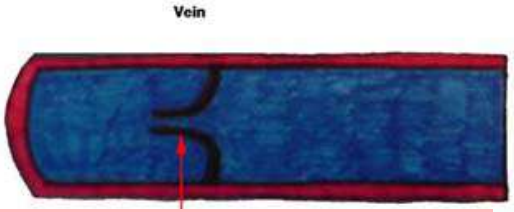
Open Circulatory System



What is the Heart made of?

- **Cardiac muscle**
- **Cells are elongated and cylindrical, striated, & only have one nucleus.**
- **They have rapid, involuntary, rhythmic contractions**
- **Cardiac muscle cells form an intercalated discs containing gap junctions, which bridge cells.**

The Heart Valves

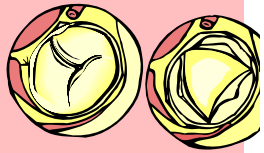


- **What causes the sound your heart makes?**
- **The 1st heart sound** (lub) is caused by the closure of the Tricuspid and Mitral Valves.
- **The 2nd sound** (dub) is caused by the closure of the Pulmonary and Aortic Valves.

Job: blood flow in one direction.

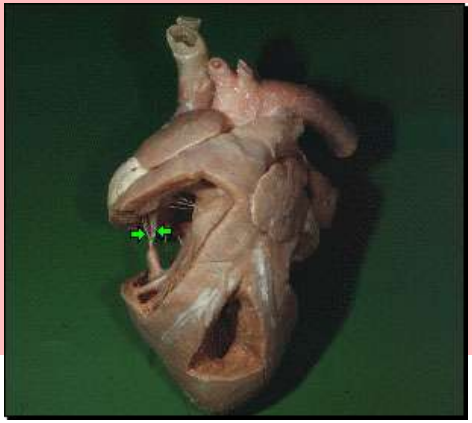
Semilunar valves: between the arteries and ventricles

- Pulmonary semilunar valve
- Aortic semilunar valve



Pulmonary valve

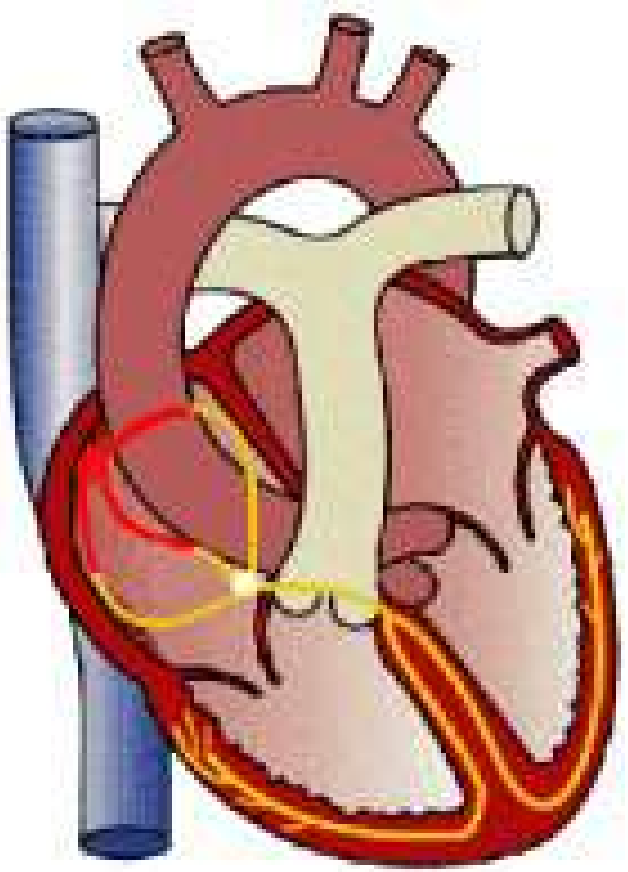
- **Atrioventricular valves**: between the atria and ventricles
  - Tricuspid valve (right)
  - Bicuspid (mitral) valve (left)



What causes the Heart beat?

- **SA Node** begins the signal (pacemaker)
- **AV Node** (bundle of His) works as a resistor and slows the signal down.
- Finally goes to the **Purkinji fibers**

How It Works

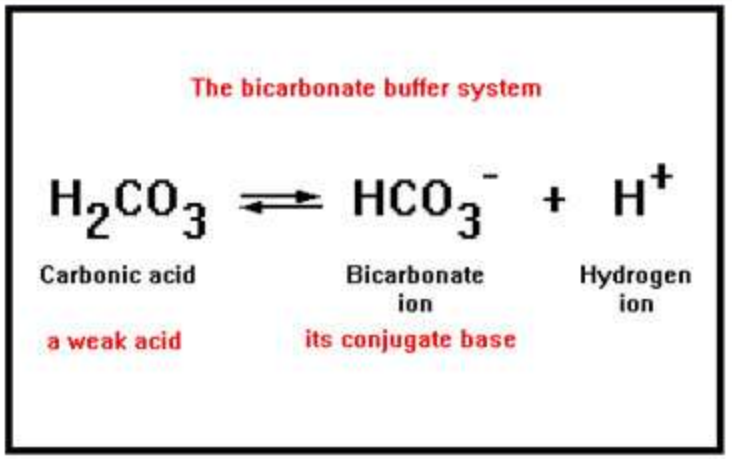


Watch Adam and then go to next page to learn about the electrical System

EKG Examples

What regulates O2 in Blood?

- Carbon dioxide in blood plasma
- Buffering system: carbonic acid-bicarbonate ion system: pH 7.4
- CO_2 + H_20= Carbonic acid => bicarbonate ion and a proton H+ (lowering blood pH)
- Brain monitors CO_2 levels.



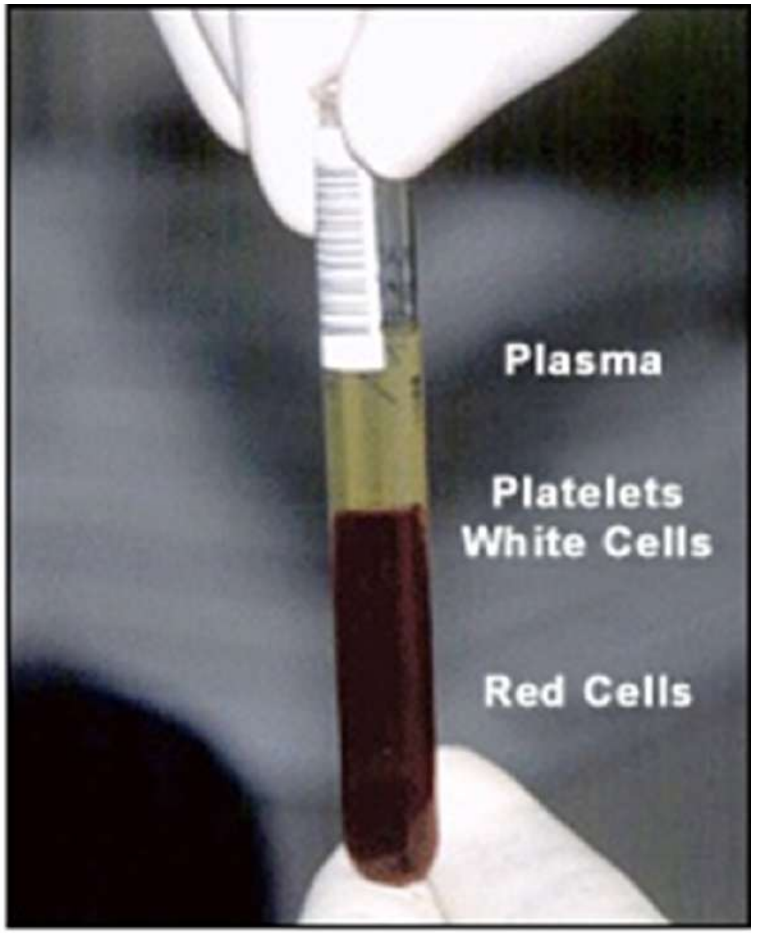
Variations in Blood Pressure

- Human normal range is variable
  - Normal
    - 140–110 mm Hg systolic
    - 80–75 mm Hg diastolic
  - Hypotension
    - Low systolic (below 110 mm HG)
    - Often associated with illness
  - Hypertension
    - High systolic (above 140 mm HG)
    - Can be dangerous if it is chronic

BP Animation

Components

- Plasma---55%
- Formed elements---45%
  - platelets
  - erythrocytes
  - leukocytes



What is the Endocrine System?

- Series of cells, tissues, and organs that secrete hormones into body fluids (blood).
- Hormone= a chemical secreted by endocrine glands which has a specific effect on another cell or organ (target). ***Hormones are a type of Ligand.*** ***Ligands communicate between cells.***
  - **Tropic hormones**: far-

  Reaching, stimulate other glands (TSH) & Pheromones

  Vs. hormones that affect neighboring cells: NO (nitric oxide (dilate blood vessels, etc.), prostaglandins

What are the two types of hormones?

- Steroid Hormones
  - Soluble in fat. Penetrate cell membran
  - Reach nucleus. Act as transcription factors. Turn on different genes: muscles= muscle mass. Hair= karatin production.
- Nonsteroid Hormones
  - Not soluble in fat. Bind to cell membra
  - Cascade of chemical reactions.
  - Use a secondary messenger inside the cell: c-AMP;
  - 1 epinephrine=20cAMP=10,000 glucose

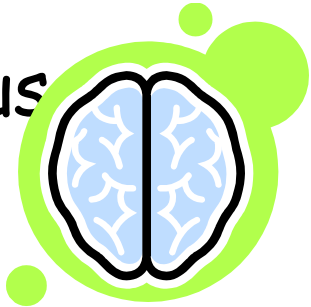
Steroid Hormone

Adrenalin
The non Steroid Hormone

Nonsteroid Hormones

How are Hormone Secretions Controlled?

Negative Feedback System Gland A secretes causing Gland B to secrete. Gland B's secretions inhibit A. Like a thermostat. **Maintains homeostasis.** TSH and of the thyroid (releases thyroxin which regulates metabolism) and the hypothalamus



Positive feedback enhance an already existing response. Allergic Reactions, Blood clotting, & Childbirth- more child's head pushes on the cervix, more the smooth muscles contract.

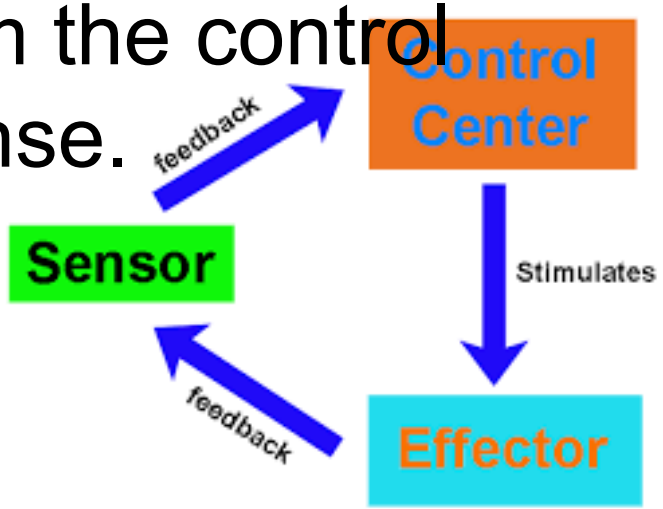
Nerve Control Controlled by the brain. Complicated.

Neg. Sys.

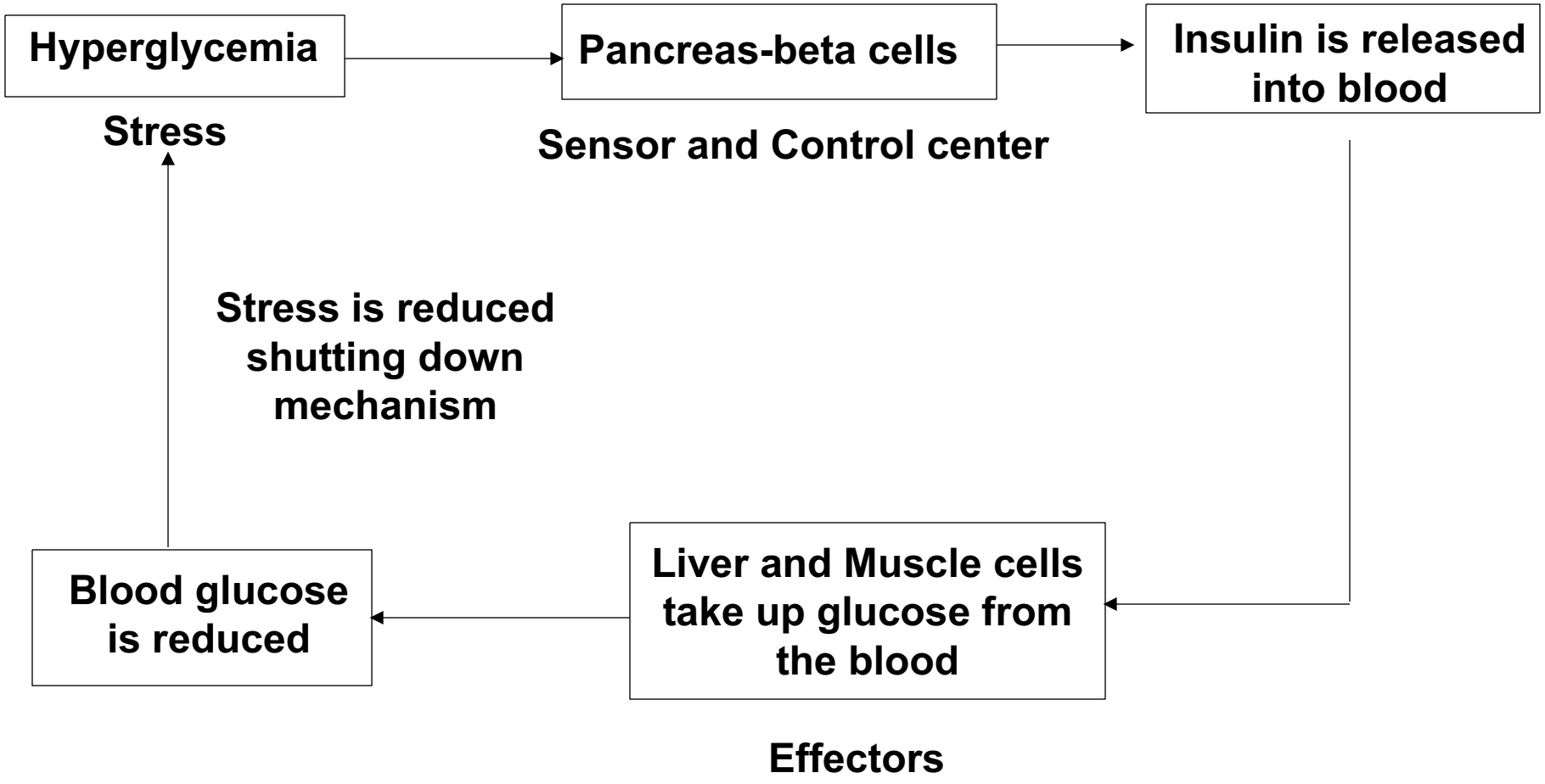
3 parts of a Feedback System

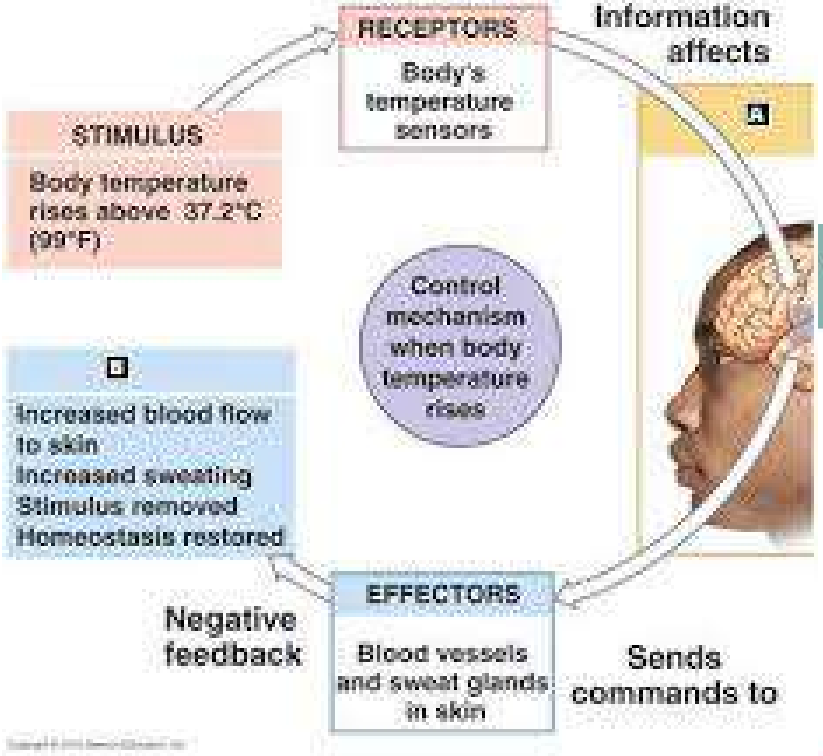
- **Receptor:** a body structure that monitors changes, sends info to the control center.
  Sweat Glands
- **Control Center/ Integrator:** Evaluates input and generates output in the form on *nerve signals* or *hormones*. ***Hypothalamus***
- **Effector:** receives output from the control center and produces a response.

Capillaries

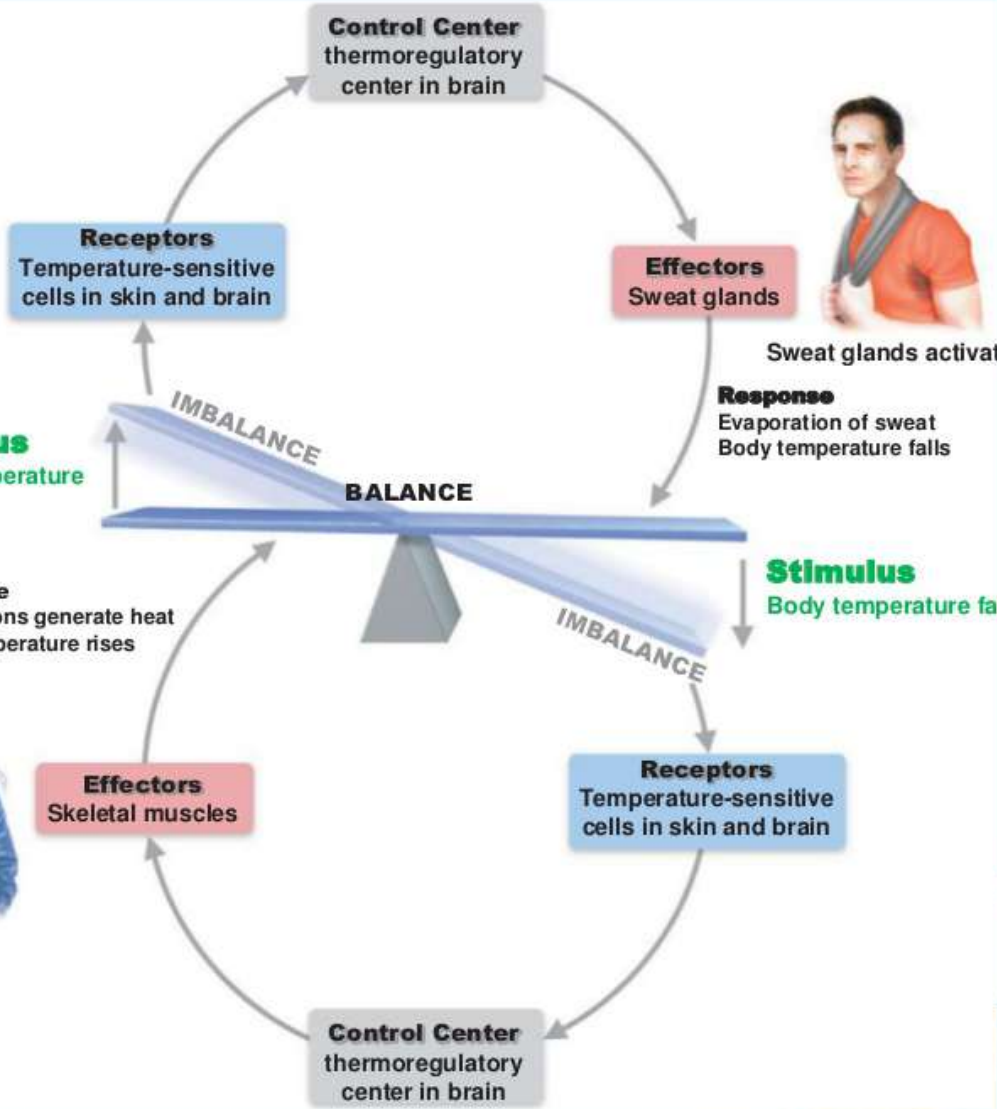


Homeostatic Regulation of Blood Sugar through Negative Feedback

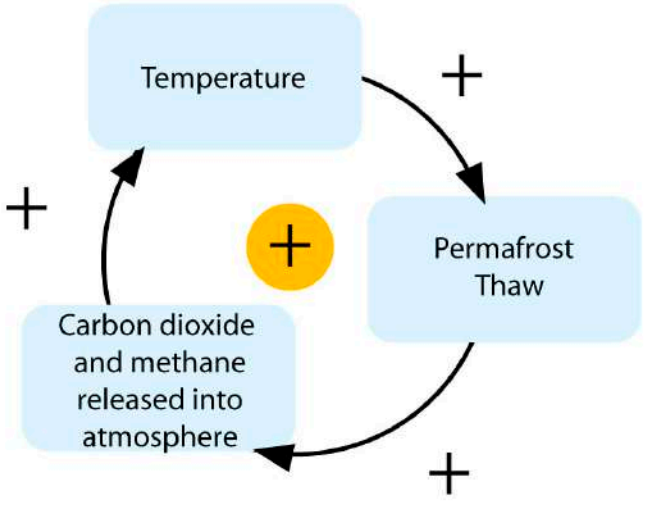




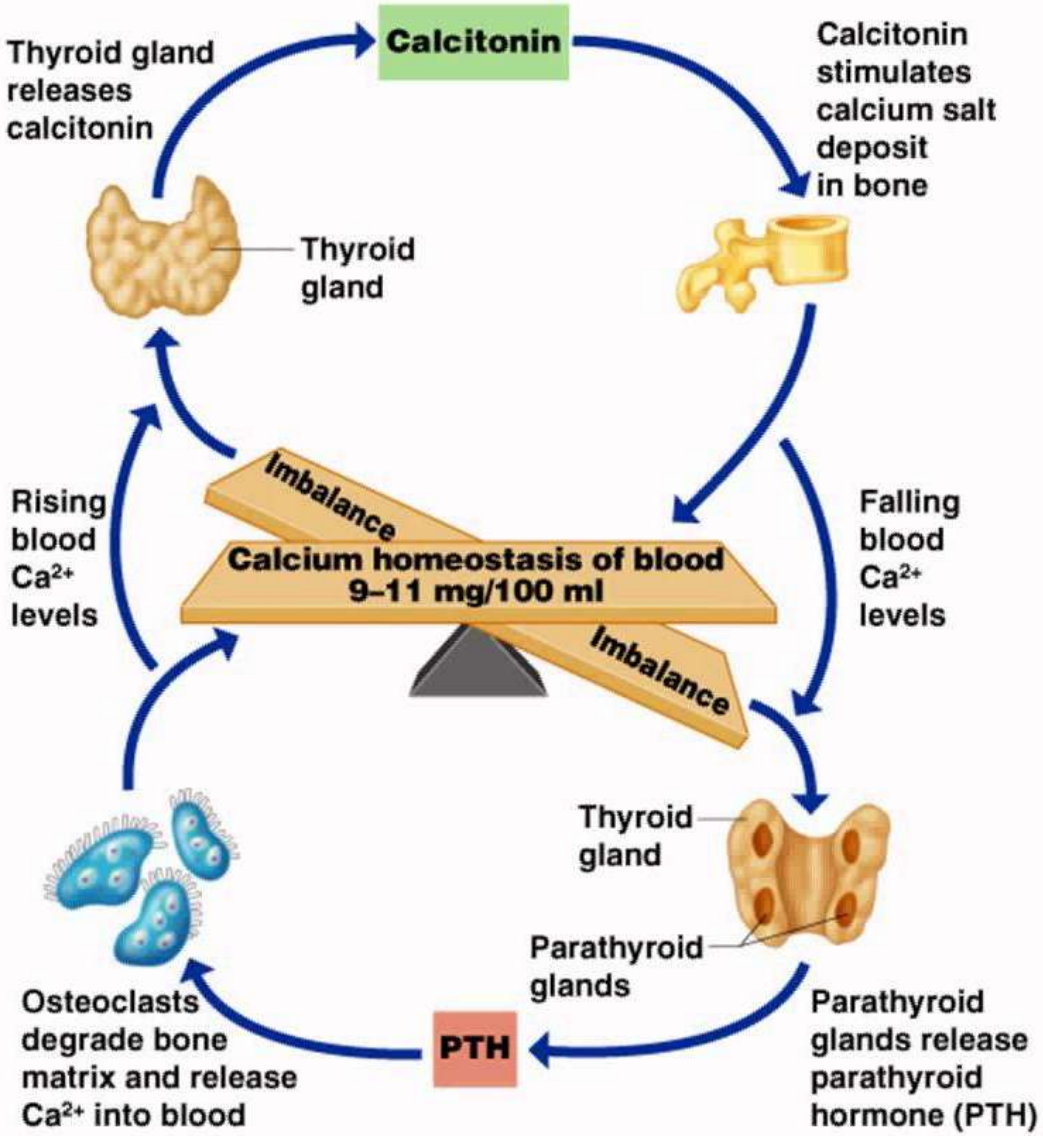
temperature by a negative feedback mechanism.

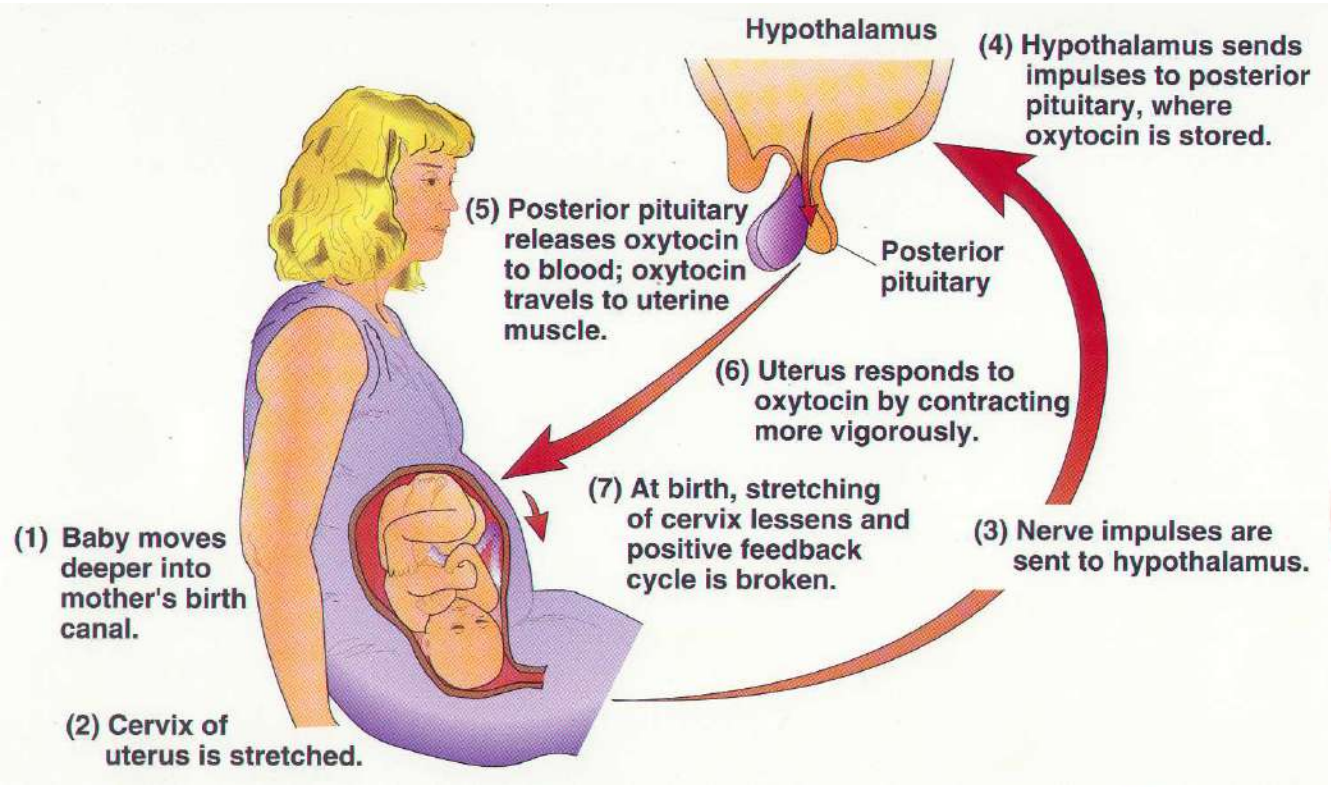


Positive Feedback

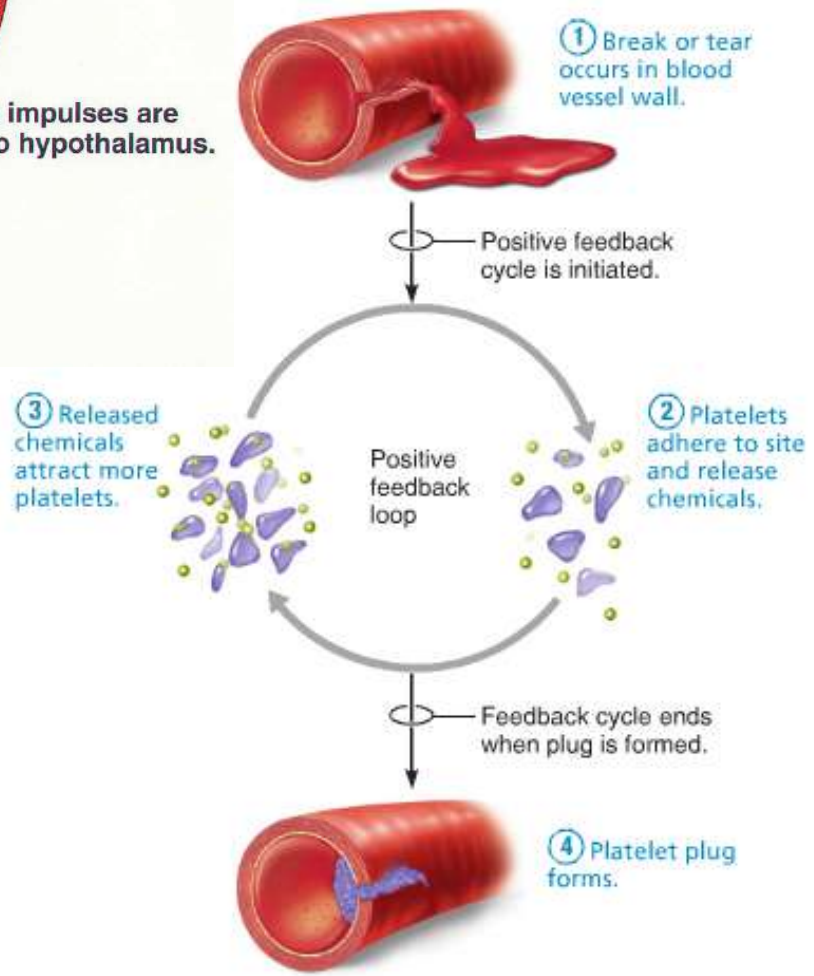


THYROID & PARATHYROID GLAND HORMONES REGULATE BLOOD CALCIUM LEVELS




Hypothalamus
(4) Hypothalamus sends impulses to posterior pituitary, where oxytocin is stored.
(5) Posterior pituitary releases oxytocin to blood; oxytocin travels to uterine muscle.
Posterior pituitary
(6) Uterus responds to oxytocin by contracting more vigorously.
(7) At birth, stretching of cervix lessens and positive feedback cycle is broken.
(1) Baby moves deeper into mother's birth canal.
(3) Nerve impulses are sent to hypothalamus.
(2) Cervix of uterus is stretched.


© Alamy


1 Break or tear occurs in blood vessel wall.
Positive feedback cycle is initiated.
3 Released chemicals attract more platelets.
Positive feedback loop
2 Platelets adhere to site and release chemicals.
Feedback cycle ends when plug is formed.
4 Platelet plug forms.

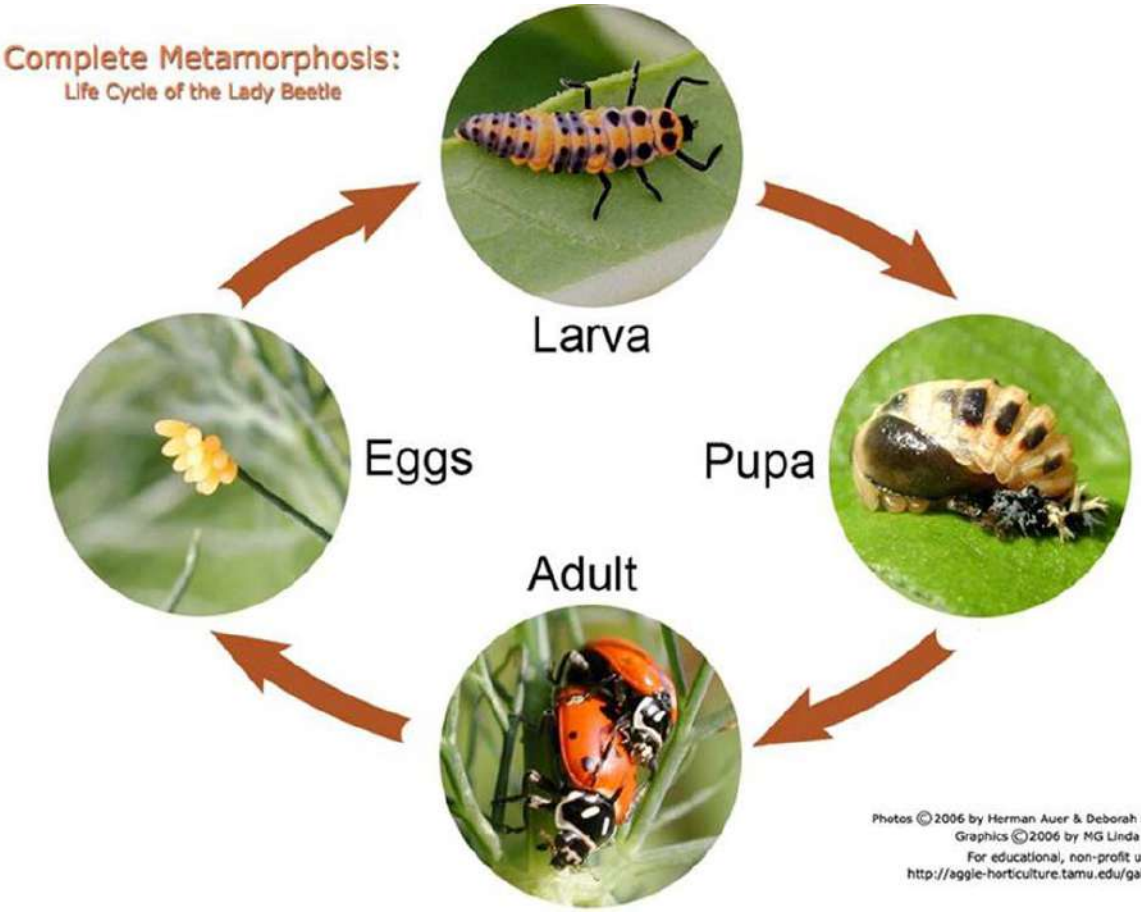
How does Blood Clot?

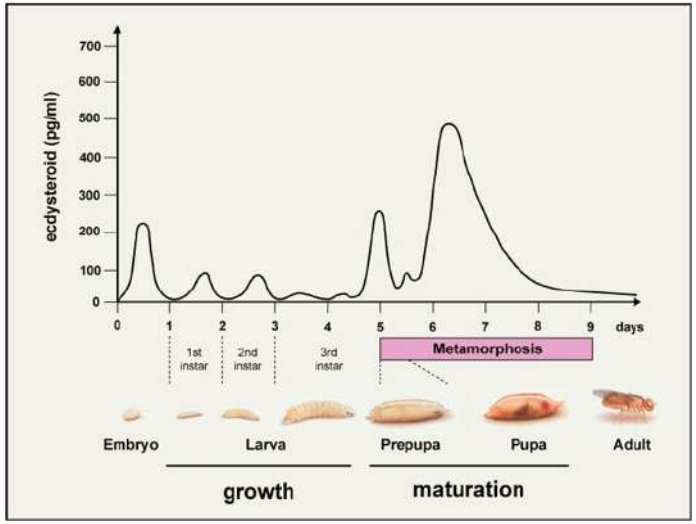
- **Release Clotting factors** when collagen is exposed.
- **Platelets** break.
- **Fibrin** holds it in place.
- Clotting action intensifies.
- When collagen is not exposed the process stops. = **thrombus** or clot is made.
- What type of feedback system is this?

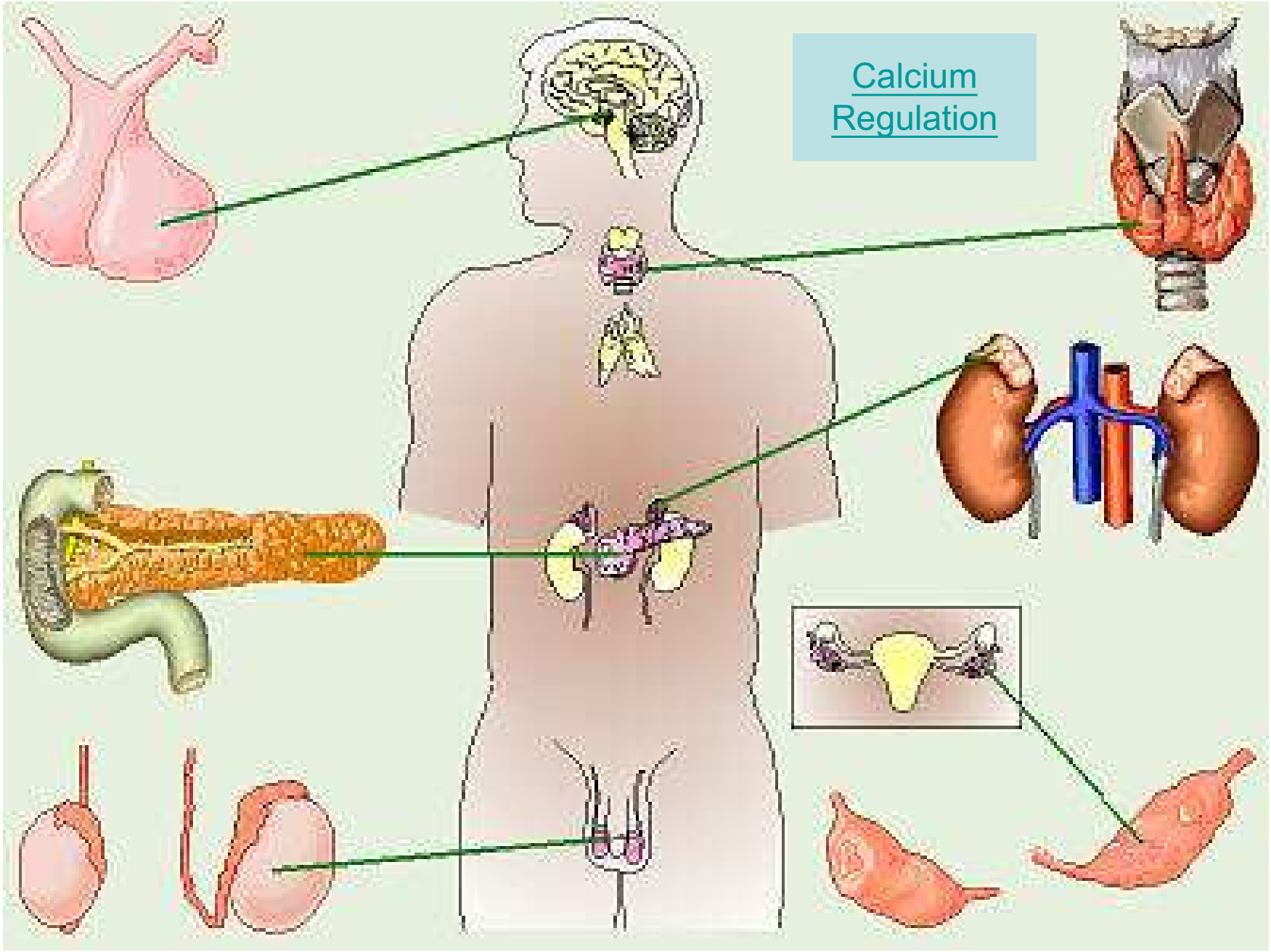
Hormones in other areas of science….

Metamorphosis

- Ecdysone: controls metamorphosis

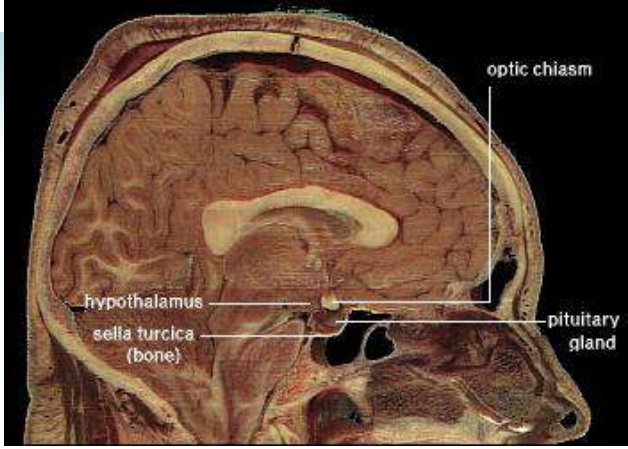




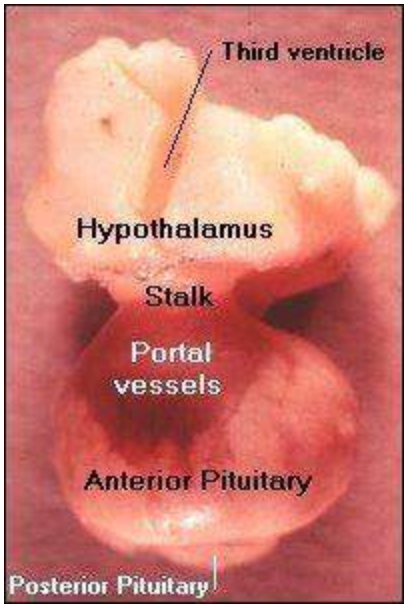


BPA mimics estrogen …problem?

The Pituitary Gland



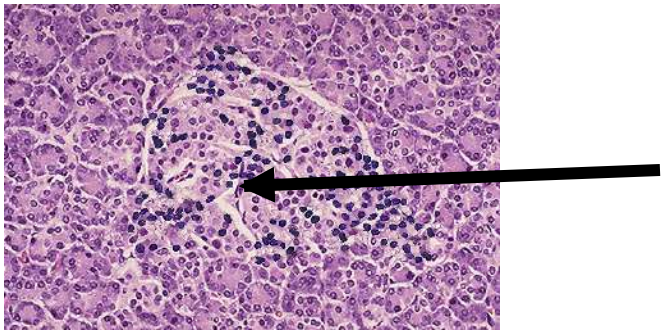
- Location: Between the eyes and ears.
  - Hangs by the hypothalamus stalk.
  - **Hypothalamus** bridge between nervous and endocrine system
    - Nerve: signals the release of adrenaline and gonadotropic-releasing hormones, regulates thrermostat, hunger, and thirst
    - Gland: produces oxytocin and ADH (stores in posterior pituitary)
- Has two functional lobes
  - Anterior pituitary – glandular tissue (lots of H.)
  - Posterior pituitary – nervous tissue (ADH)



Pancreatic Islets

The pancreas, Insulin, Glucose, & Diabetes

- The **Islets of Langerhans** produce hormones
  - **Insulin** – allows glucose to cross plasma membranes into cells from beta cells. (Storage and use into liver, muscle cells, fat cells)
  - ***Glucagon*** – allows glucose to enter the blood from alpha cells.
  - These hormones are antagonists that maintain blood sugar homeostasis.



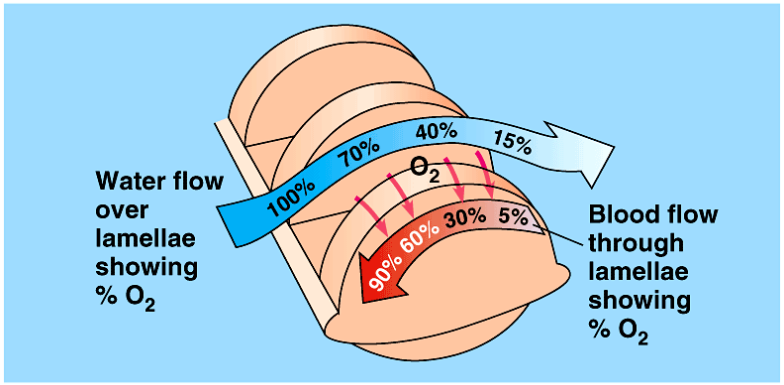
Temperature Regulation

- Optimum temp for life: **0-50 deg Celsius**
- **Ectotherms**: (cold-blooded) heated from the outside. **Poikilotherms** (non-mammal sea life) seek areas of water at optimal temperature and stay there. Use behavioral changes to help control.

- **Homeotherms/ Endotherms**: only birds and mammals. More challenging for small animals that large. Not true if hybrinating..
  - 60% of nutritional intake goes to body heat
  - 10X more energy needed than a reptile of comparable size. (eat more and digest/ absorb more efficiently)
  - Flying birds eat 30% of their body weight a day.

Problems of living on land

- **Maintaining homeostasis**
- (heat)
  - Ear size in rabbits
  - Panting
  - Shivering
  - Sunning



- **North-south cline** (anatomical differences across geographic ranges)
- ***Solution:* Countercurrent exchange** warms extremities. Arteries and veins of a polar bear lie side by side.

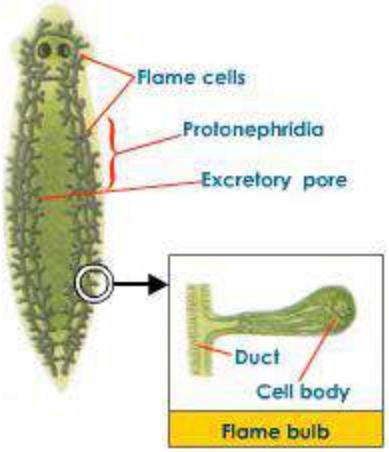
Countercurrent Flow

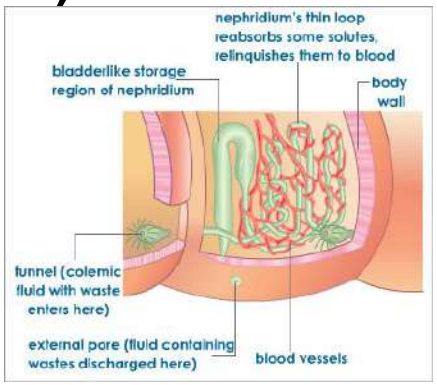
Osmoregulation
(regulating water and solute concentration)

- Marine vertebrates: Hypertonic environment leads to dehydration
  - Produce very little urine
  - Drink large amounts of water and actively transport salt out.
- Freshwater vertebrates: Hypotonic environment leads to taking in too much water and loosing too much salt.
  - Uptake salt by active transport and excrete water through highly diluted urine.
- Terrestrial: Must rid themselves of metabolic wastes and retain water and salt

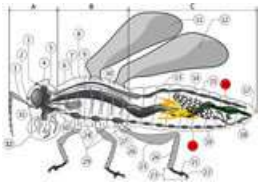
How to osmoregulate:

- Protista: contractile vacuole
- Platyhilminthes (planaria): flame cell

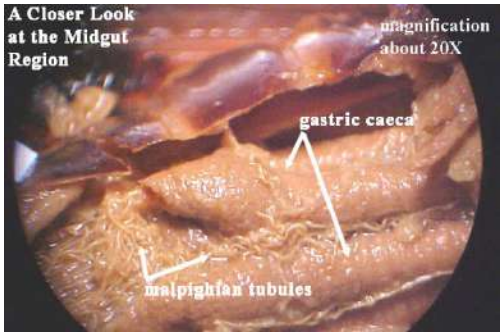




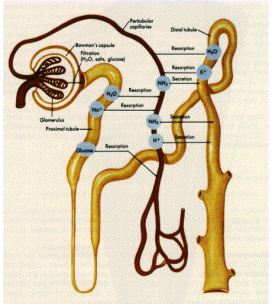
- Earth worm: Nephridia



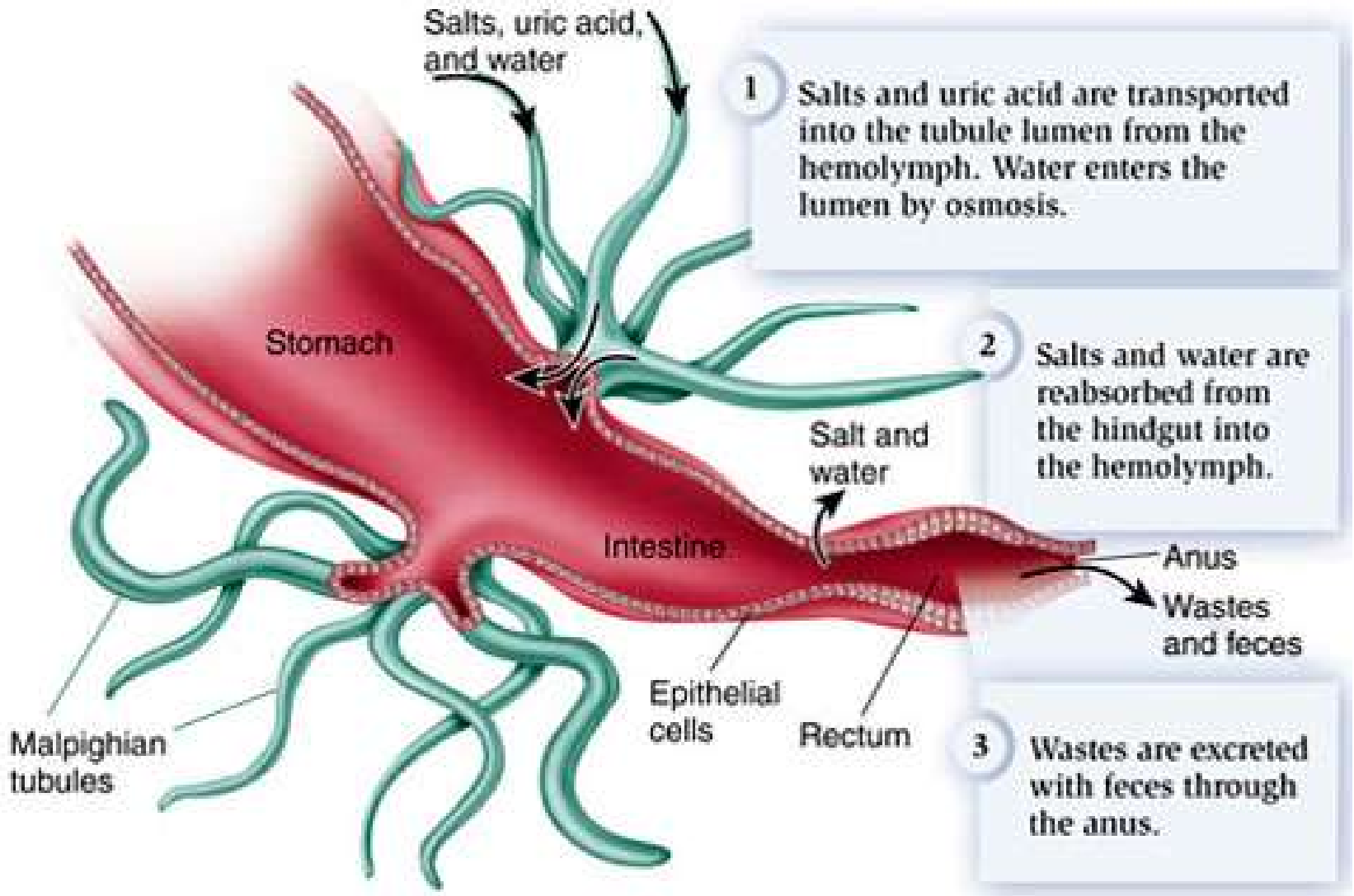
- Insects: Malphigian tublules



- Humans: Nephrons



Flame Cell

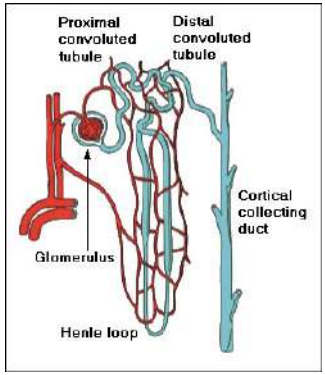

Salts, uric acid, and water
1 Salts and uric acid are transported into the tubule lumen from the hemolymph. Water enters the lumen by osmosis.
Stomach
2 Salts and water are reabsorbed from the hindgut into the hemolymph.
Salt and water
Intestine
Anus
Wastes and feces
Malpighian tubules
Epithelial cells
Rectum
3 Wastes are excreted with feces through the anus.

Excretion: the products

- **Types of excretion:** *Metabolic* from cell respiration: CO2 & water, *Nitrogenous* waste from protein metabolism.
- **Organs that remove waste**: skin, lungs, kidney, and liver (produces urea)

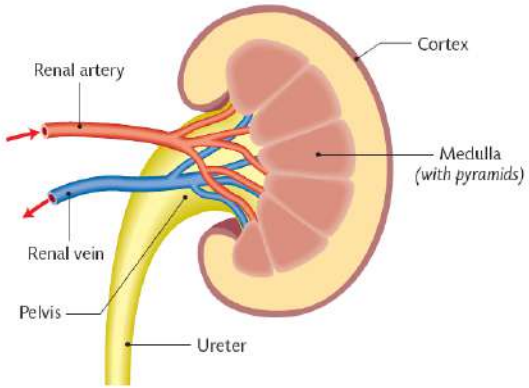
- Types of nitrogenous waste:
  - **Ammonia:** highly toxic and soluble in H2O. Fish & hydra
  - **Urea**: formed in the liver from ammonia in mammals. Earthworms and humans.
  - **Uric Acid:** Paste-like. Not soluble in water. The least toxic. Insects, reptiles, birds. Conserves water.

The Human Kidney: Renal

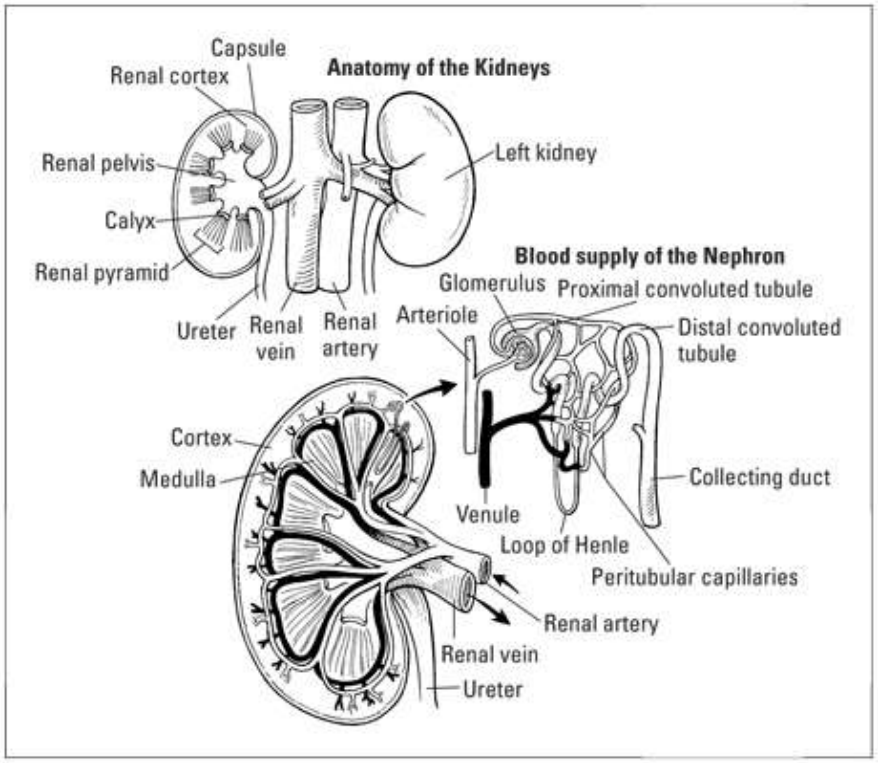


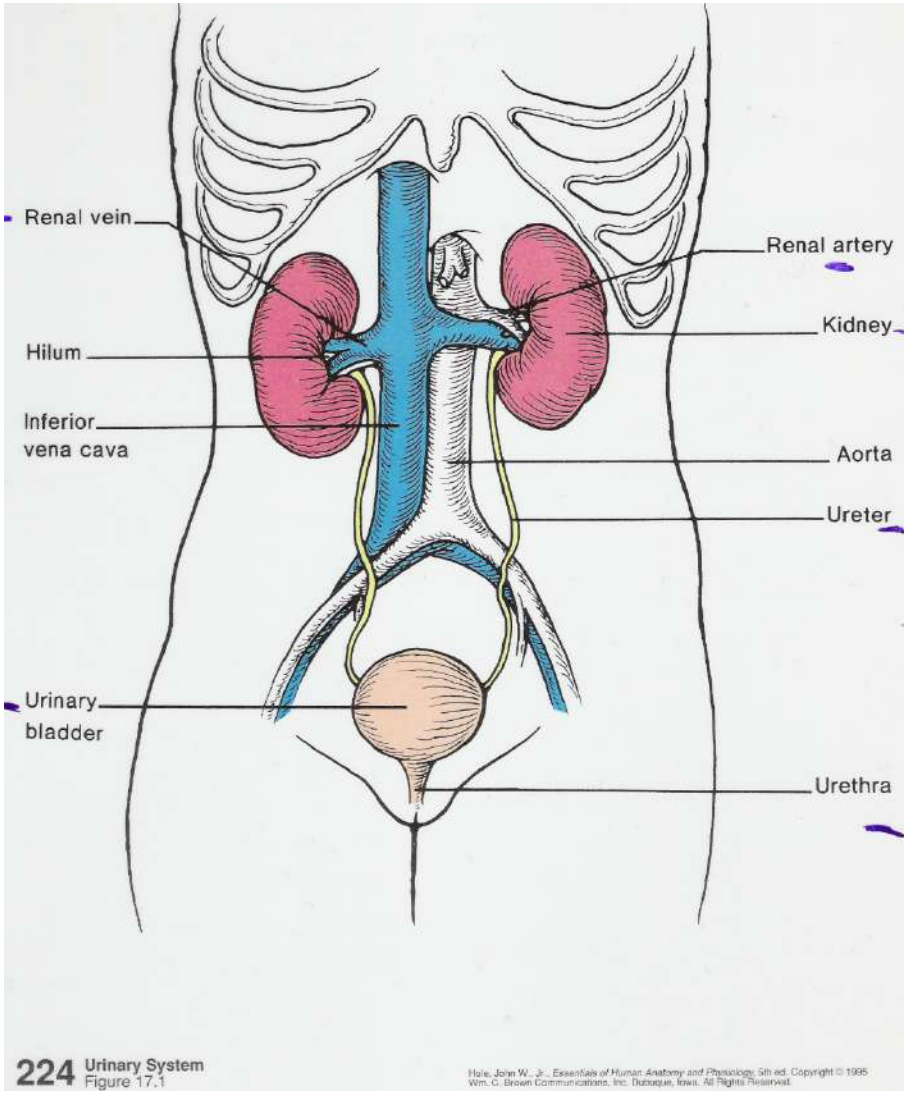
- **Jobs:** Osmoregulation and excretion.
- **Filter** 1,000-2,000L of blood per day making **1.5L of urine**.
  - Urine can be more **dilute** or **concentrated** depending on the water/salt balance.
  - Functional unit of the kidney: The Nephron. 1 million per kidney.

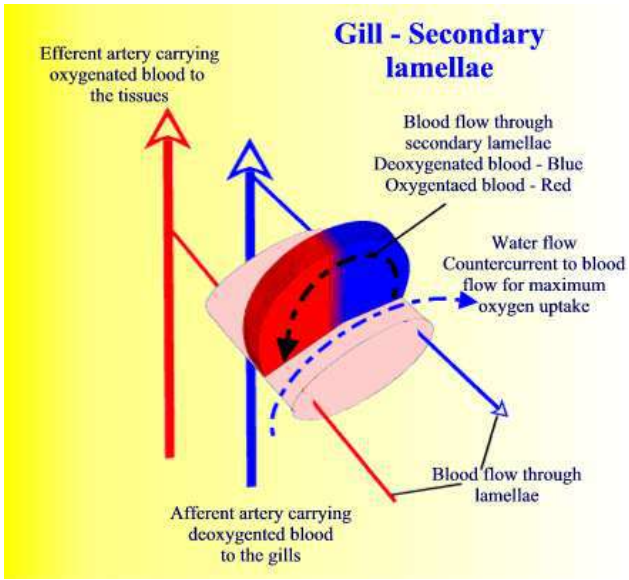
Kidney and Nephron Function



Kidney With Quiz

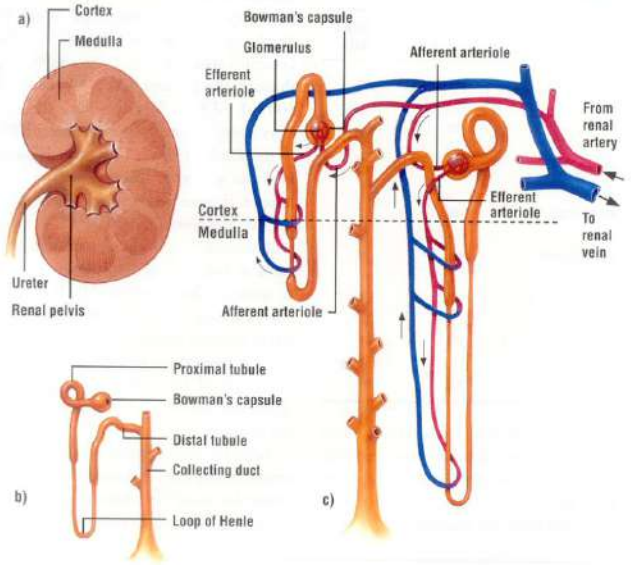

Anatomy of the Kidneys
Capsule
Renal cortex
Renal pelvis
Calyx
Renal pyramid
Ureter
Renal vein
Renal artery
Left kidney
Blood supply of the Nephron
Glomerulus
Proximal convoluted tubule
Arteriole
Distal convoluted tubule
Cortex
Medulla
Collecting duct
Venule
Loop of Henle
Peritubular capillaries
Renal artery
Renal vein
Ureter


Renal vein
Renal artery
Hilum
Kidney
Inferior vena cava
Aorta
Ureter
Urinary bladder
Urethra
224 Urinary System
Figure 17.1


Gill - Secondary lamellae
Efferent artery carrying oxygenated blood to the tissues
Blood flow through secondary lamellae
Deoxygenated blood - Blue
Oxygentaed blood - Red
Water flow
Countercurrent to blood flow for maximum oxygen uptake
Blood flow through lamellae
Afferent artery carrying deoxygented blood to the gills

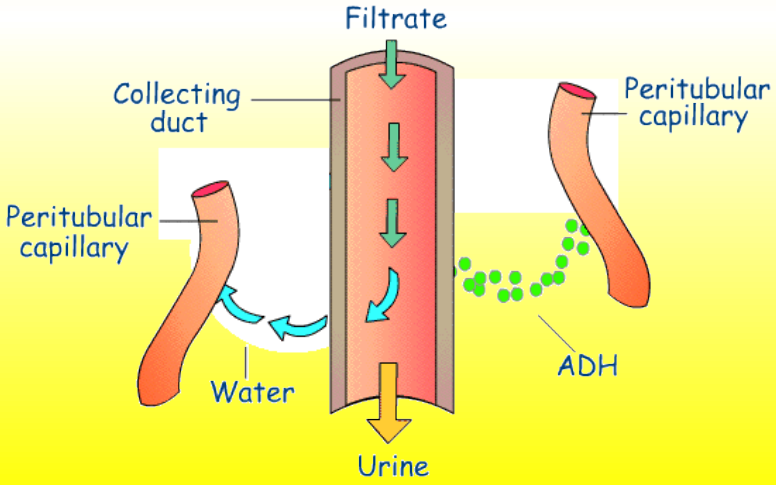
How the Nephron works:

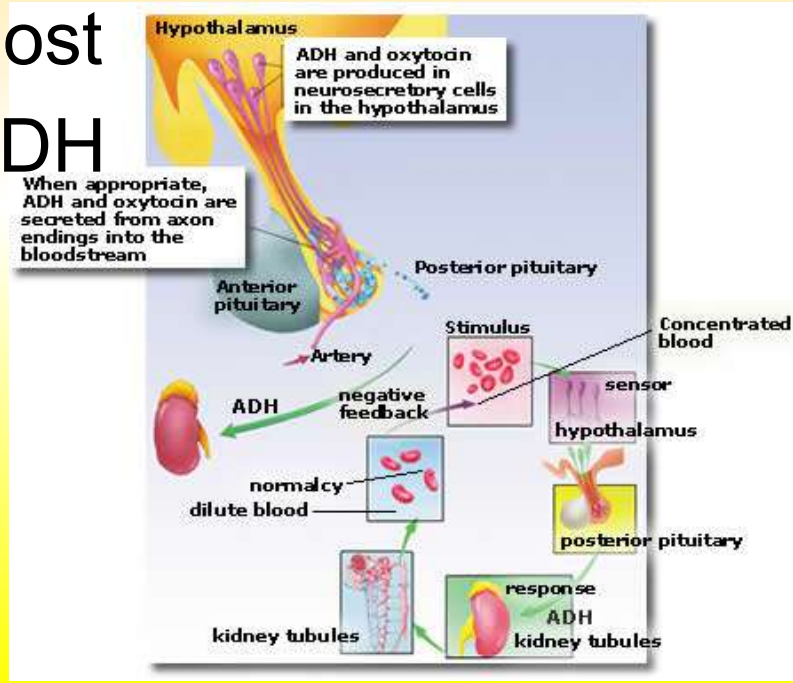
- Blood enters the **nephron** through the **glomerous** which is surrounded by **Bowman's capsule**.
- Uses Counter current flow.
- Jobs: Filtration, secretion, reabsorption, and excretion.



How is BP regulated?

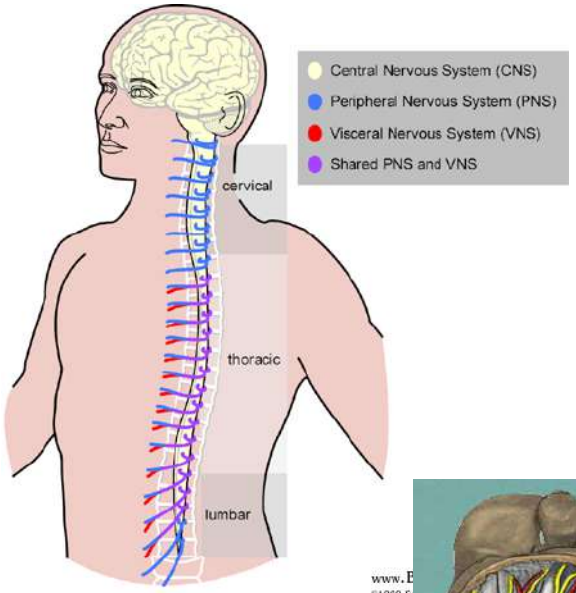
- **ADH**- antidiuretic hormone secreted from the hypothalamus & stored in the posterior pituitary: prevents excess water loss.
  - If not functioning: Loose a lot of water: i.e. Diabetes Insipidus. 25L/day lost
  - **Alcohol blocks** release of ADH

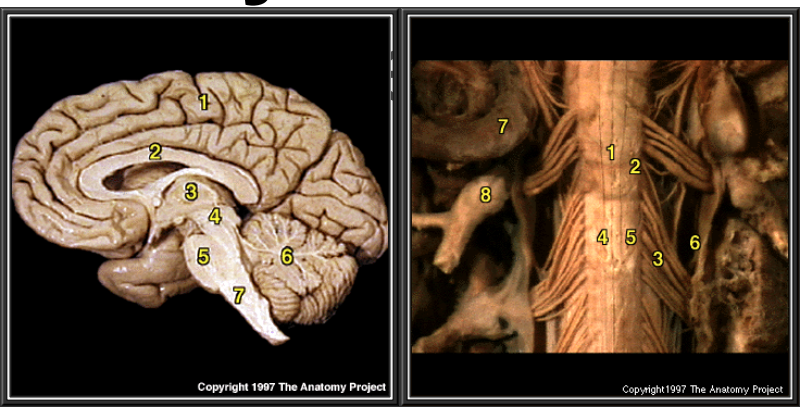




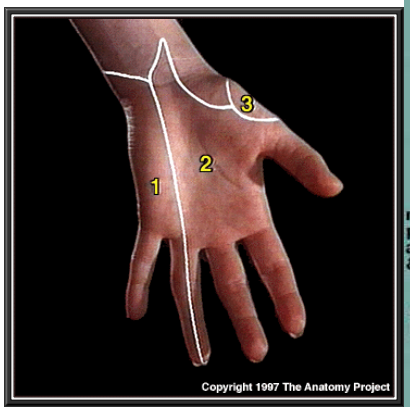
What are the two major parts of the nervous system and what are they composed of?

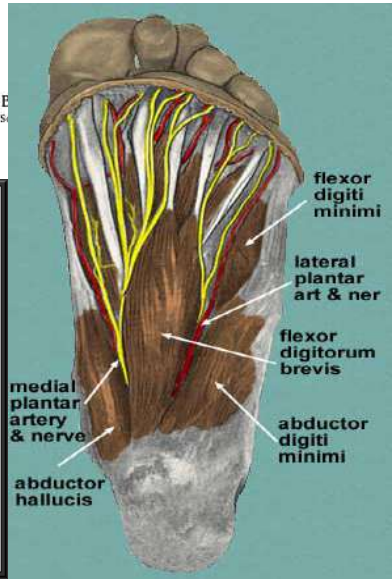
- **Central nervous system**: Brain and Spinal chord
- **Peripheral nervous system**: All other





Vs.



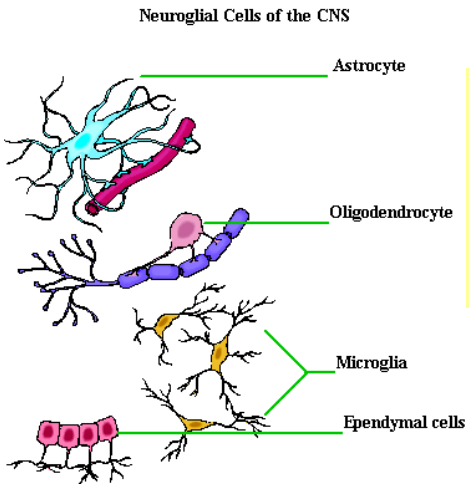


Parts of the Peripheral Nervous System (PNS)

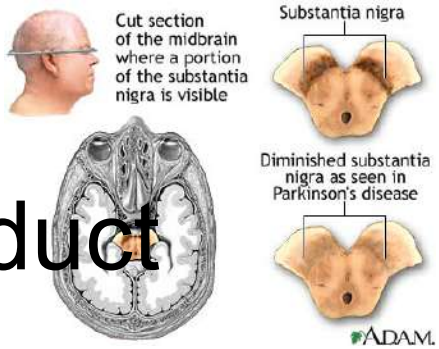
- **Somatic** Nervous System
  - Called *Voluntary* Nervous System
- **Autonomic** Nervous System
  - *Involuntary* Nervous System**2 Major Branches**
    - Sympathetic
      - Fight or flight
      - Liver: glycogen to glucose, Bronchi dilate, Adrenaline increases, Heart rate and breathing increase
    - Parasympathetic
      - Calms body down. Decreases Heart and breathing, increases digestion.

The NS In Action

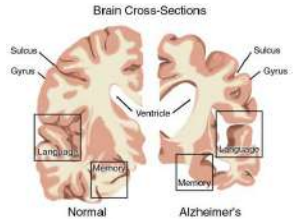
Parasympathetic vs. Sympathetic Nervous System



What is nervous tissue?

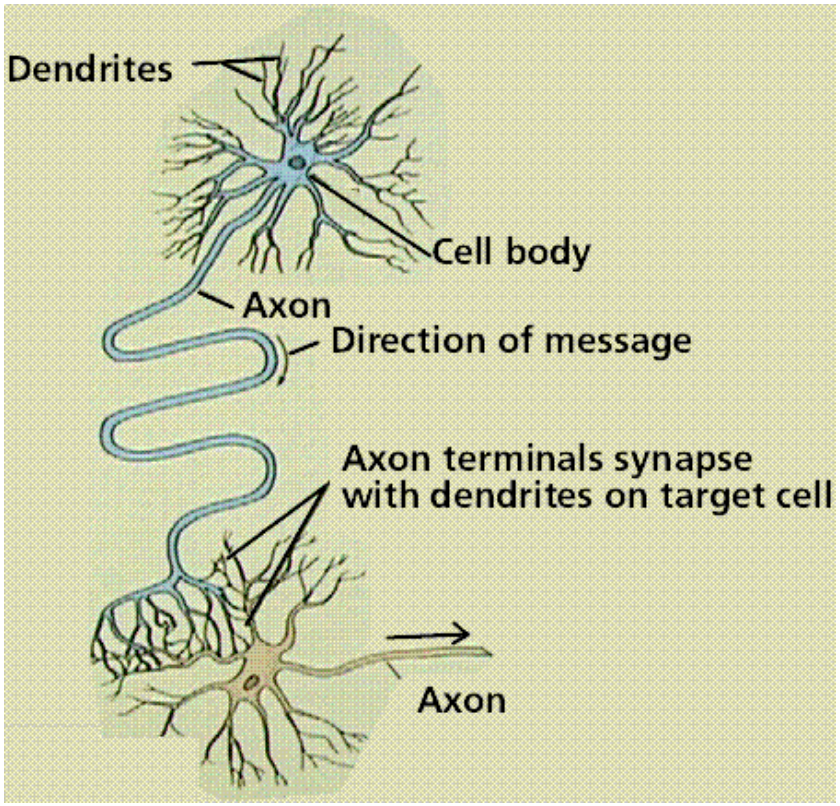


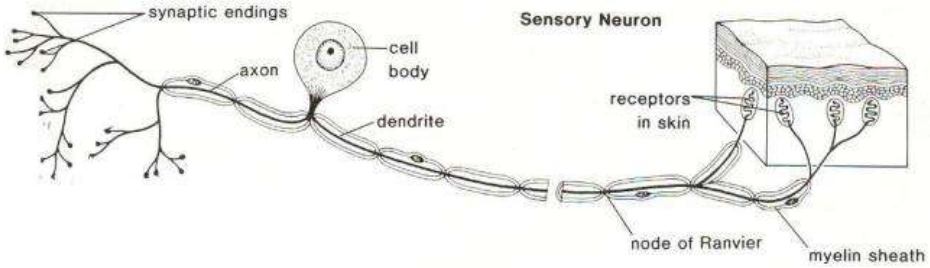
- **Neurons:** or nerve cells. Conduct the impulses.
- **Neuroglial/ Glial cells:** nurse cells to neurons. Protect, feed, speed up the signal. May be the cause of Alzheimer's and Parkinson's.
  - Schwann Cells: form myelin sheath



What are the parts of a nerve?

- **Axon** (carry nerve signals Away) **slow**: 0.5m/s
- **Dendrite** (pick up the nerve signal)
- **Cell Body** (organelles)
- Nucleus: (can not divide)
- **Myelin** (speeds up nerve signal) **super-fast**: 120m/s
- **Node of Ranvier** (space between myelin)





What are the 3 types of neurons?

- **Sensory function**: Detect changes in and out of the body.
- **Motor function:** Effect Muscles & glands.
- **Integrative function**: To connect the Sensory and Motor function in brain and spinal chord. Produces thought.

How does a reflex work?

- Reflex: Inborn, automatic, and protective
- Reflex Arc
  - Stimulus →Receptor end of a Sensory neuron → Interneuron (reflex center, often the spinal cord) → Motor neuron → Effector (Muscle being moved)→Response (Hand)
  - Knee Jerk reflex: Sensory neuron to motor neuron
- Can you control a reflex?
  - No. Reflexes are automatic & unconscious.
  - Anesthesiologists will often use this information to test if the medicine is working.

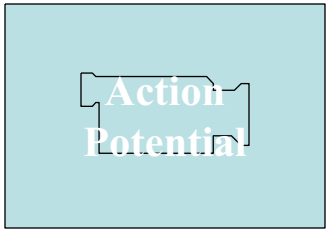
Reflex Arc

How do nerves communicate?

- Through Neurotransmitters: chemical signals sent from the Axon terminals of the nerve.
- Nerves communicate through electrical signals.
- These electrical signals are created through action and resting potentials.

How is an action potential reached?

- Change in nerve membrane permeability. Na+ rushes in the nerve is **depolarized** (loses its charge).
- K+ then rushes out which **repolarizes** the nerve cell.
- 1/1000 of a second. Both steps together are the **action potential**.
- Active transport soon reestablishes the resting potential.



With quiz

So… How does a nerve signal reach **resting potential**?

- Nerve has a slightly negative charge inside and a slightly positive charge outside at rest. = **Polarized** See fig 7.9
- K+ ions are inside, Na+ ions outside. Negative charge can't diffuse through the membrane.
- **Active transport** is used to **push Na+ out** and **K+ in.** More + leave than enter= neg. charge inside.

What do muscles and nerves have in common?

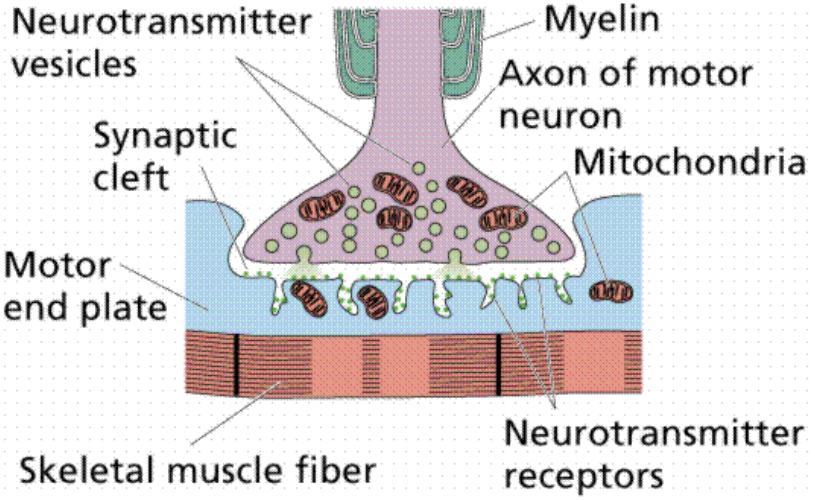
- **All or none response**. The nerve impulse is either conducted or not. The intensity of the signal does not change.

How are Neurotransmitters released?

- Action potential causes **Ca+ ions** to enter the terminal end of the axon.
- **Synaptic vesicles** then fuse with the membrane.
- Contents are **released** into the synaptic cleft.
- Neurotransmitters are **decomposed and** the vesicles retreat to be **refilled**.

What is a Synapse?

- The junction between two communicating nerves.
- Presynaptic neuron to the synaptic cleft to the Postsynaptic neuron



What kind of neurotransmitters cross the synaptic cleft?

- **Acetylcholine**: Muscles (stimulates release of nitric oxide (NO)
- **Epinephrine**/ Adrenaline: Fight or Flight
- **Norepinephrine**: almost the same as epinephrine but has no effect on the heart.
- **Dopamine**: brain functions: not working= schizophrenia and Parkinson's
- **Seratonin**: suppresses pain impulses

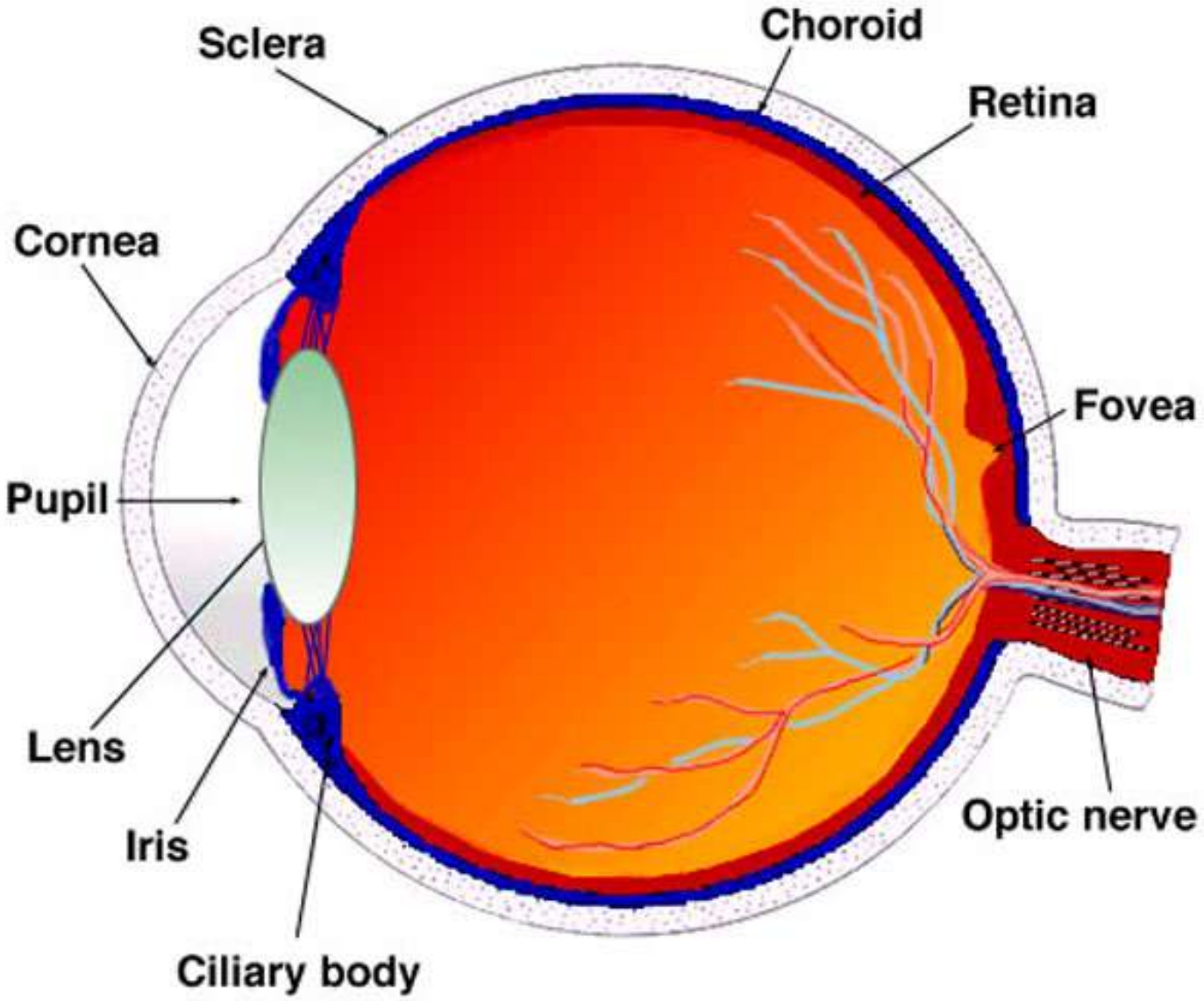


Fig. 6. Vertical sagittal section of the adult human eye.

The Human Immune System: *Nonspecific Defense*

- First Line of Defense
  - Skin
  - Mucous membranes (lysozyme/antimicrobial)
  - Cillia (trachea, etc.)
  - Stomach Acid
- Second Line of Defense
  - Histamine: Inflammation, cold like symptoms.
  - Prostaglandins
  - Chemokines: attract phagocytes
  - Pyrogens: fever
  - Phagocytes: neutrophils & macrophages
  - Interferons: stops cell-to-cell viral infections
  - Natural Killer cells

Adaptive Immunity: Third line of Defense

- Recognition: B cells and T lymphocytes
- Activation Phase: antigen receptor activates B and T cells. Creates effector and memory cells.
- Effector Phase: Humoral response produce antibodies and engages T cells.

Humoral Immunity
B-Cells

- **Long Term Memory**
- B-Cells make antibodies which trigger a T-Cell reaction to kill the invader
- **Vaccines, Chicken Pox, Viral Infections**

Humoral Immunity (Go animation)

Incidence of Blood Types in the United States

Blood Type (percentage)

Population Group	O	A	B	AB	Rh+
White	45	40	11	4	85
Black	49	27	20	4	95
Korean	32	28	30	10	100
Japanese	31	38	21	10	100
Chinese	42	27	25	6	100
Native American	79	16	4	1	100

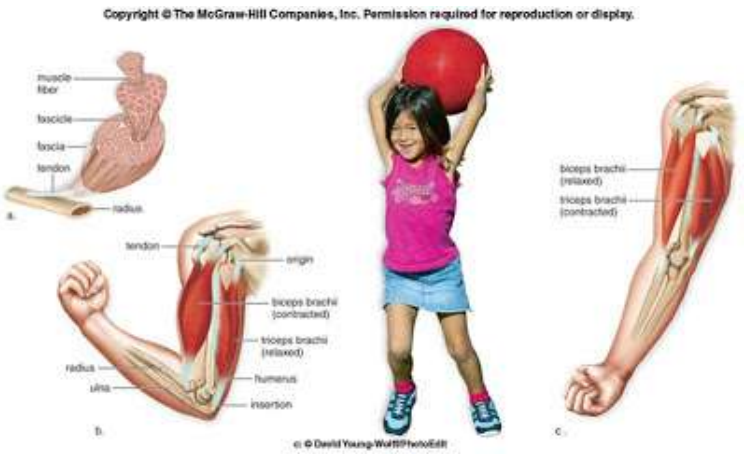
Blood Typing Game

BLEEDING

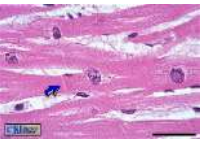
Details of Blood Clotting

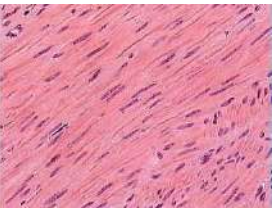
- The mismatch of an Rh^- mother carrying an Rh^+ baby can cause problems for the unborn child
  - The first pregnancy usually proceeds without problems
  - In a second pregnancy, the mother's immune system produces antibodies to attack the Rh^+ blood (hemolytic disease of the newborn)

The 3 Muscle Types



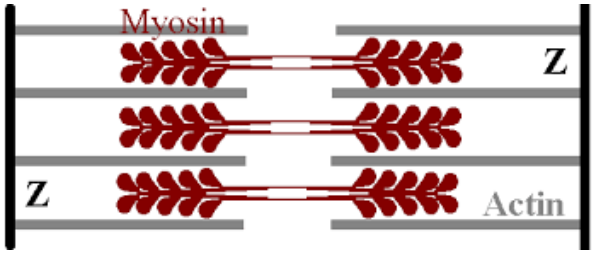
- The job of all muscles is to contract
- They are all fibrous because cells are elongated
- The 3 Muscle Types Are:
  - **Skeletal Muscle**: voluntary, striated, multinucleated. Work in pairs
  - **Cardiac Muscle**: involuntary, heart only
  - **Smooth Muscle:** involuntary





So how do these bands work?

- The myofibrils are surrounded by the **sarcoplasmic reticulum,** a specialized form of smooth endoplasmic reticulum that releases calcium.
- They are made of bands of

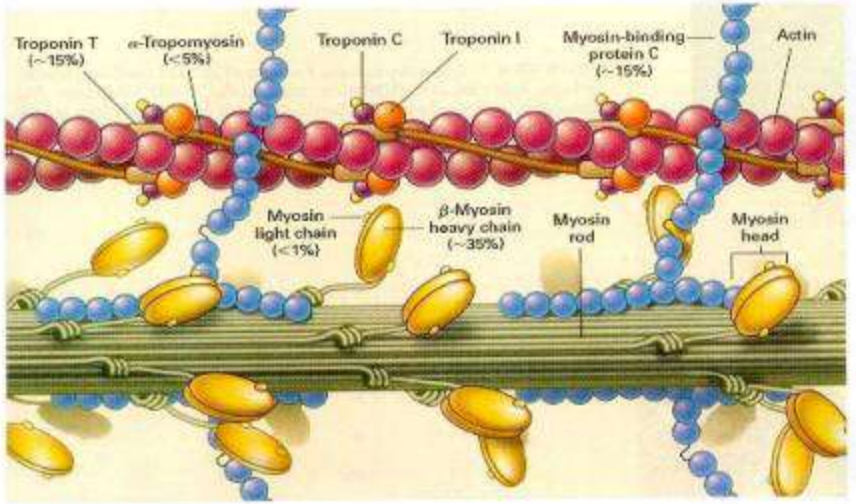


  - **Actin** (the thin filaments) that make up the I-bands
  - **Myosin** (the thick filaments) that make up the A-bands

Description of
Muscle movement

So what is the Molecular Basis of Muscle Contraction? (pg. 176)

- 1) Nerve sends out **Acetylcholine** or Ach
- 2) **Motor Unit**= All muscles triggered by nerve. (1 nerve→Triggers 100's of cells)
- 3) The Sarcolema becomes permeable to Na+
- 4) Na+ causes an ***action potential*** because it disturbs the electrical conditions of the sarcolema



How does ACh stimulate the muscle?

- ACh causes the sarcolema to release Calcium (Ca+)
- Ca+ binds to the actin causing it to change shape.
- Myosine finds actin's new shape attractive and grabs hold.

What happens after the Myosin grabs hold?

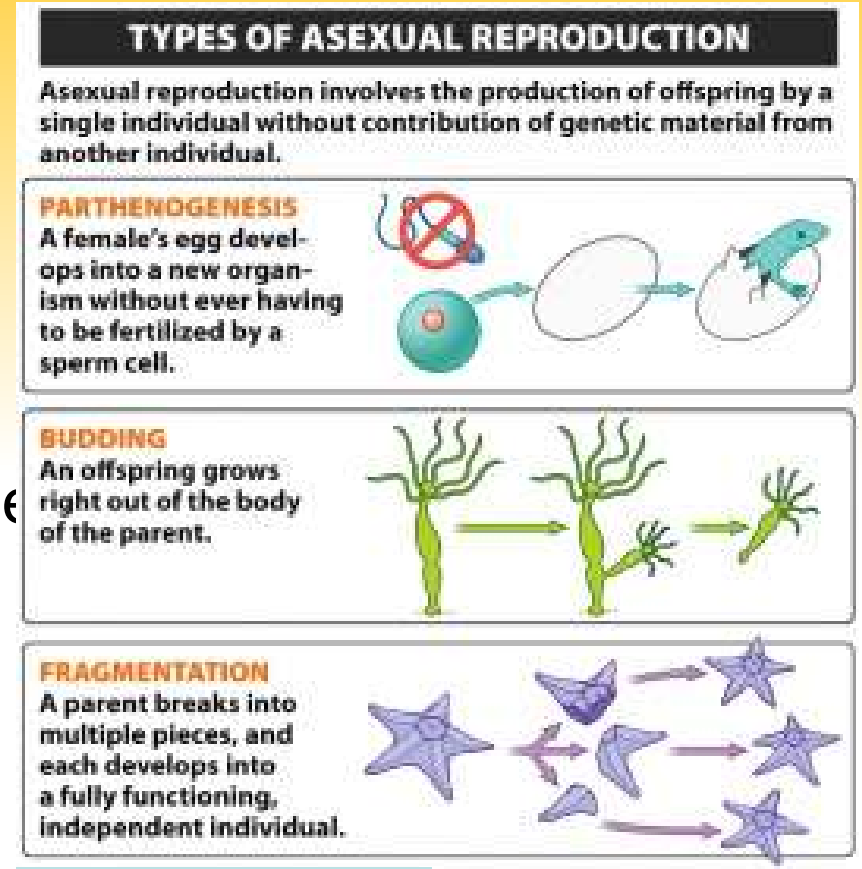
- Myosin's head snap towards the H-band of the sarcomere.
- ATP releases and re-cocks the myosin
- Only some myosin heads move at one time.

How does the muscle relax?

- When the action potential ends:
  - Sarcomere absorb Ca+
  - ATP releases myosin heads
  - Actin takes on its former and less attractive shape.
  - Muscle Cells can relax

Asexual Reproduction: Clones

- Advantages:
  - No mate necessary
  - Lots of offspring fast
  - No energy needed for sex
  - Great in a stable environme
- Fission
- Budding
- Fragmentation
- Parthenogenesis
- Vegetative Propagation

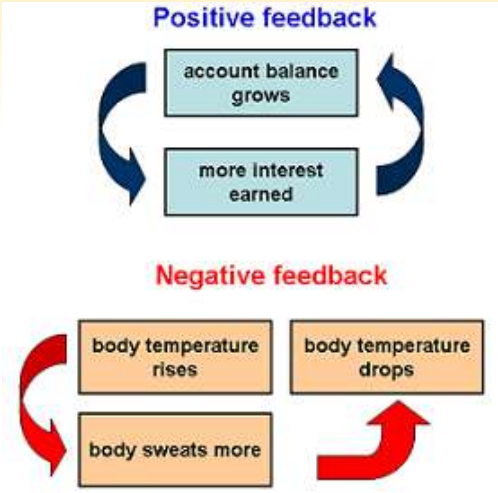


Reproduction

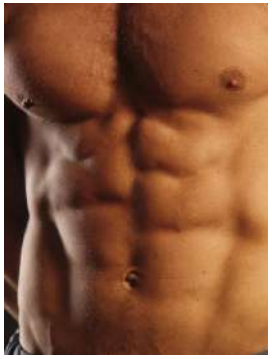
Starfish/ Sea Stars

Sexual Reproduction: Variation

- **Advantages:** Offspring may have a survival advantage, Genetically unique!
- **Disadvantage:** Lots of energy in hormones and attraction of mates.



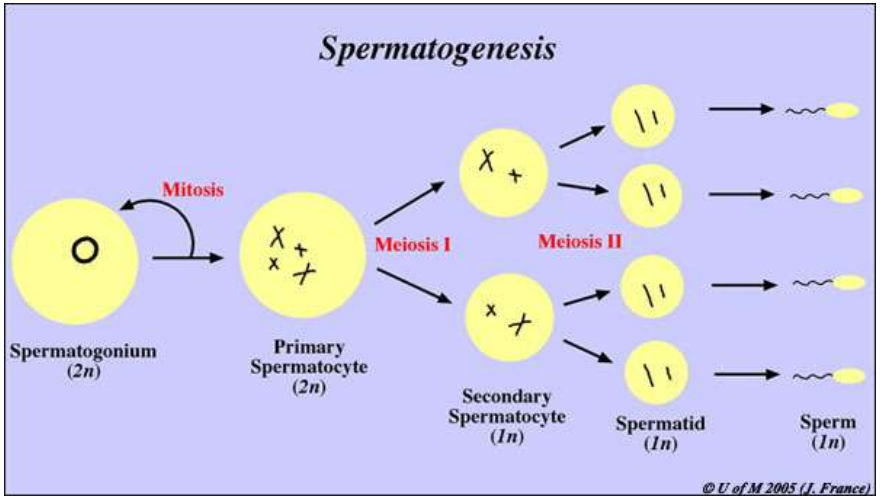
Reproduction

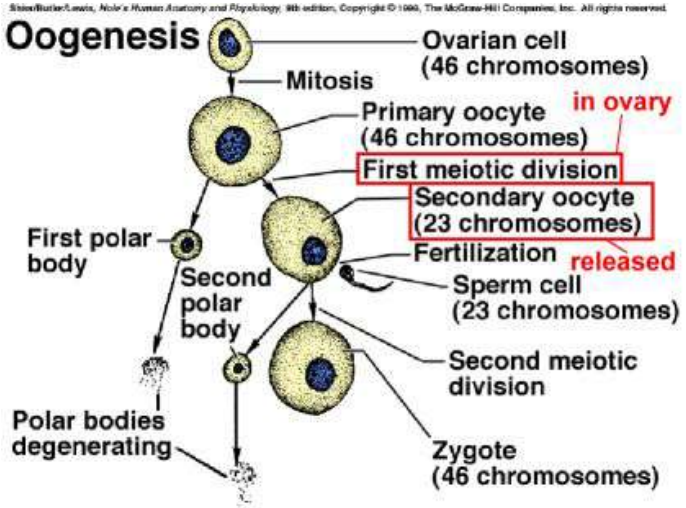


- Male Repro System
- Female Repro System
  - Endocrine system: Menstrual cycle and ovulation. **Positive feedback** LH: **Negative** Estrogen and Progesterone

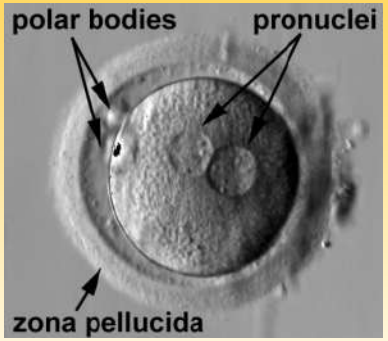
The making of gametes: Know your haploids and diploids!

- Sperm: Spermatogenesis. Primary spermatocyte (2n), Secondary spermatocyte (n), Spermatids (non-mobile sperm), Spermatozoa (the swimmers)
- Eggs: Oogenesis, production of ova (eggs)
  - Begins prior to birth
- Oogonium (2n), Primary Oocyte (2n), Secondary Oocyte (n), Egg cell/ ovum (n) and 3 polar bodies (n)

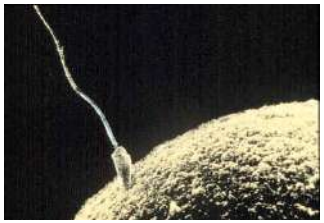




Fertilization: fusion of sperm and ovum

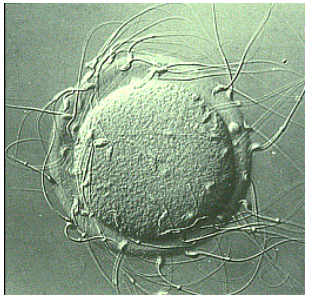


- **Acrosome**, head of the sperm releases hydrolytic enzymes that penetrate egg.
- **Membrane** of egg **depolarizes**
- Female egg becomes 1n, joins sperm 1n and becomes **2n or Zygote.**



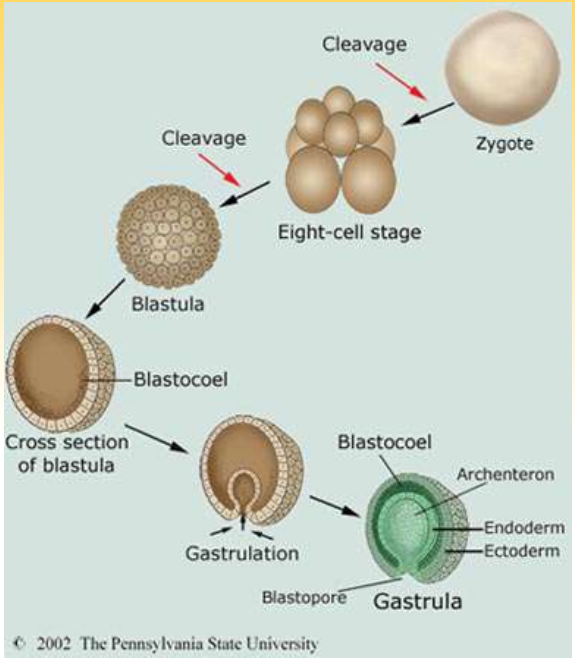
Vs.

- *Parthenogenesis:* Drone honeybees develop from unfertilized eggs and are haploid *males*. Activated by *electrical stimulation* or *influx of Ca++*



Embryonic Development: general animal egg development is below.

- Cleavage:
- Blastula.
- Gastrulation:
- Organ ogenesis



- Where is this typical? Sea Urchin, yolkless
  - Frogs have yolk cleavage is unequal with little division in yolk
  - Birds lots of yolk, cleavage is in nonyolky disc at the top of the egg.

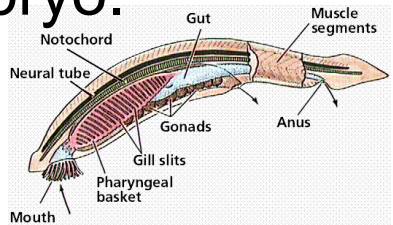
Cleavage animation

The parts…

Fertilization, Cleavage

- Cleavage:
- Both create a blastula
- Gastrulation:
  - Protostomes: mollusks, annelids, arthropods
    - Cleavage is spiral and determinant by the 4 cell stage.
  - Deuterostomes: echinoderms, chordates
    - Cleavage is radial and indeterminant. Each cell can be complete and become a normal embryo.

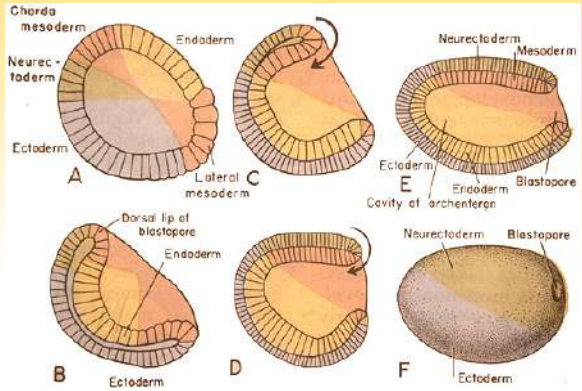
Protostomes
Deuterostomes

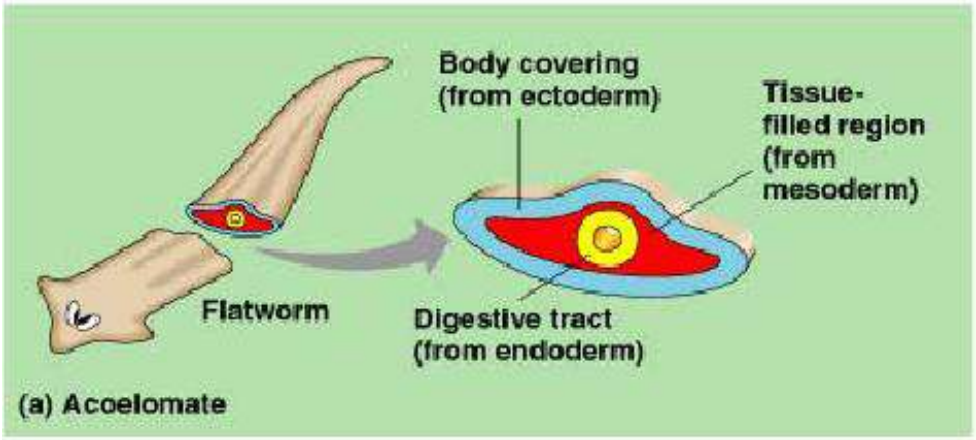


Embryonic Development continued….

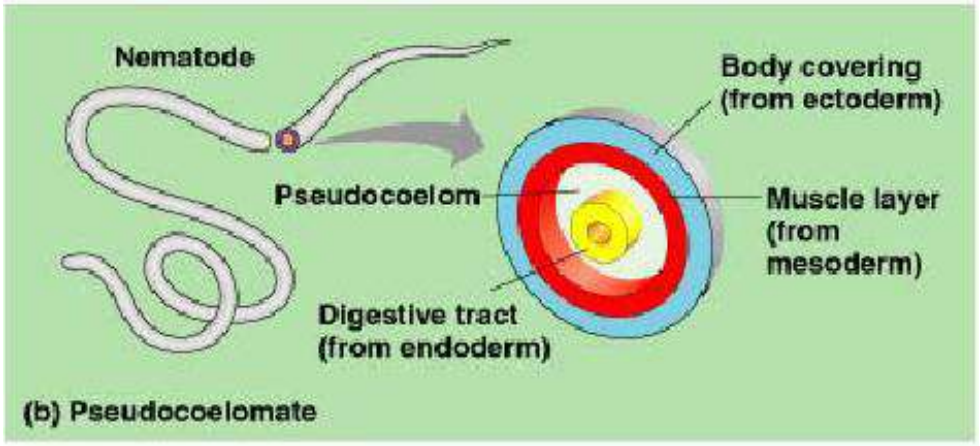
Gastrulation

- Gastrulation: Blastula indents, opening is called the blastopore.
  - 3 embryonic germ layers
    - Ectoderm: skin and nerves
    - Mesoderm: muscle, blood, bones
    - Endoderm: lungs, liver, and digestive organs (viscera)
    - F.Y.I: sponges and cnidarians only have a mesoglea
  - Organogenesis: organ building, cells differentiate thereafter embryo increases in size.



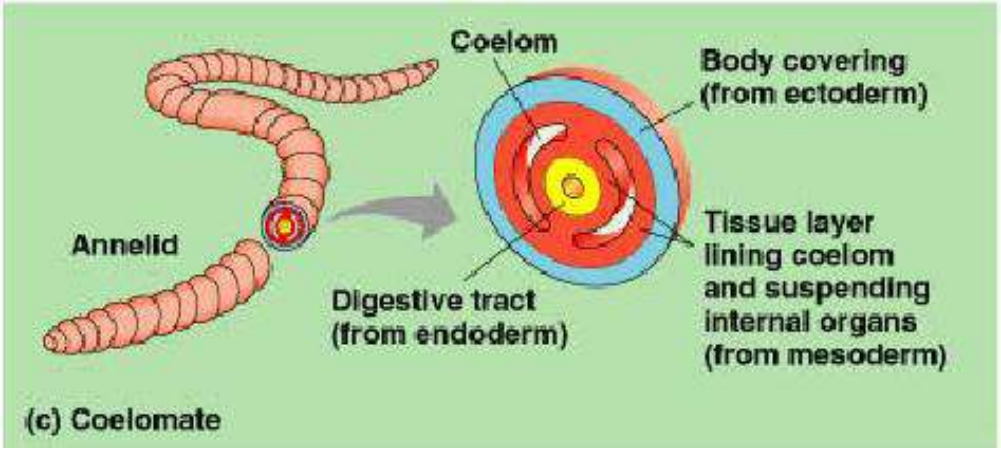


Acoelomates :
Solid body, no cavity between gut (endoderm) and outer body. Lack a blood vascular system.



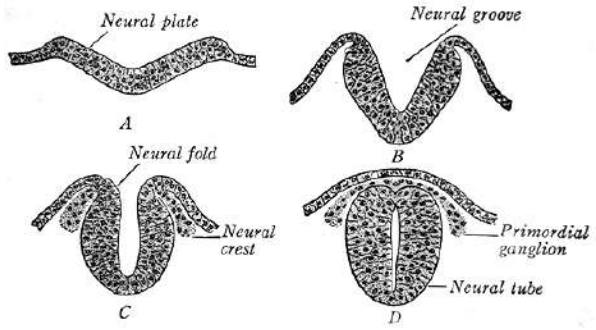
Pseudocoelomates :
Body cavity is not completely lined with mesoderm.

Coelomates / Eucoelomates :
Body cavity is completely lined with mesoderm-derived tissue; it is a true coelom.



Cytoplasmic Determinants

Hans Spemann and the gray crescent showed cytoplasmic determinants.
Embryonic induction: one group of embryonic cells influences another group.



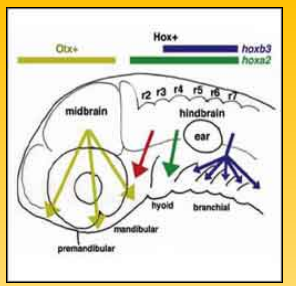
Hans Spemann Experiment

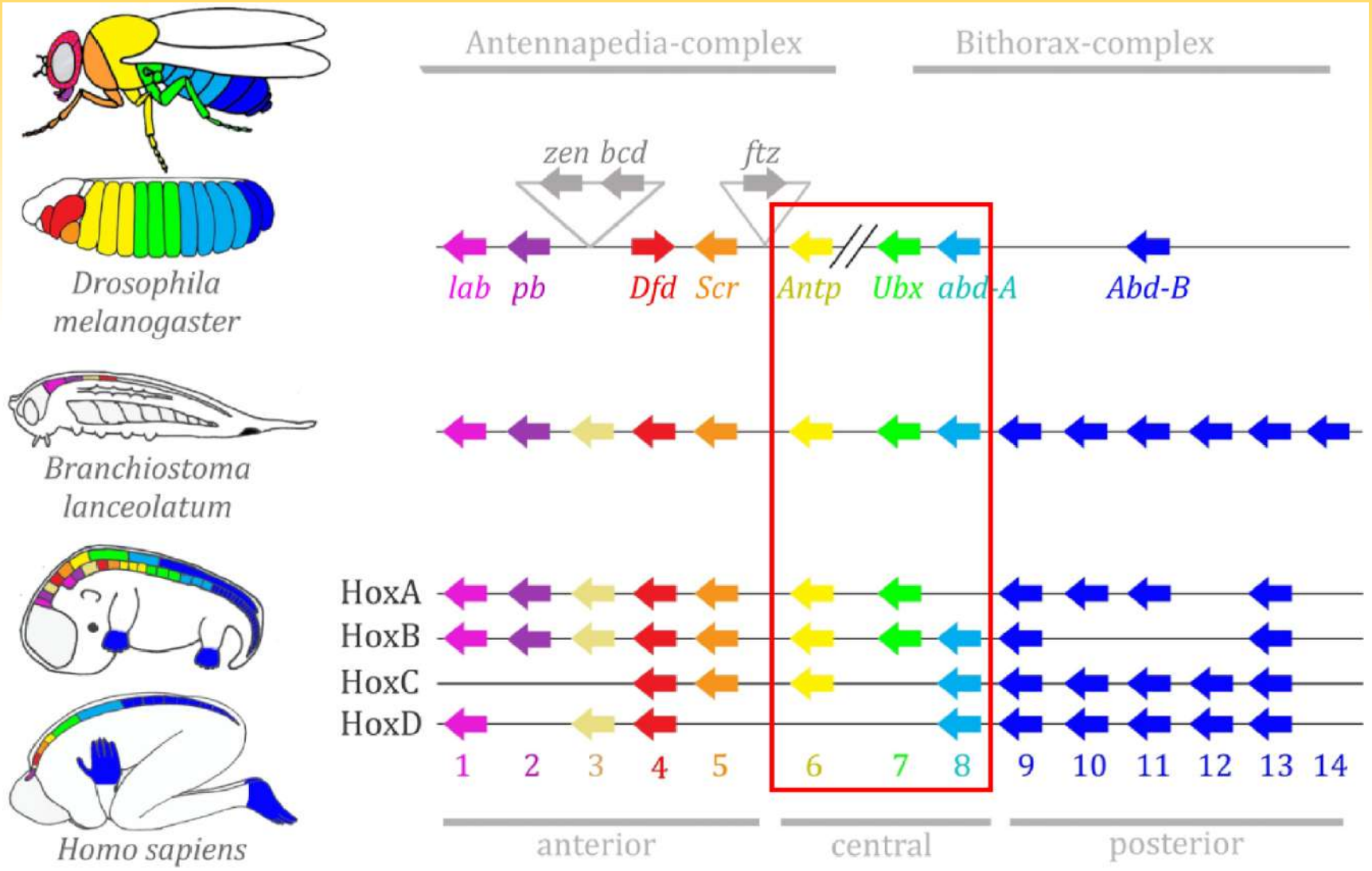
How could understanding this link to understanding cancer?

TED talk: *Mina Bissell*

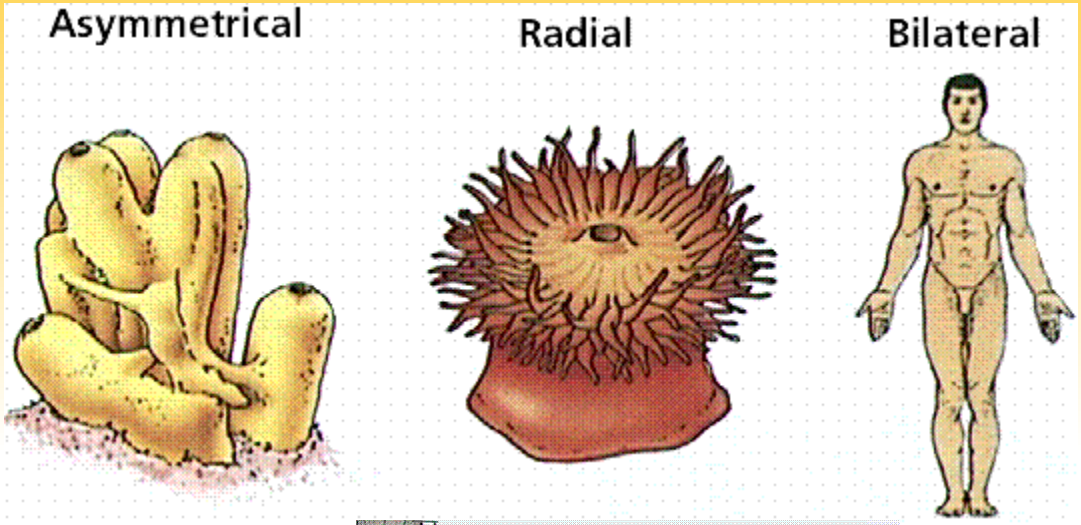
Homeotic, Homeobox, or Hox Genes

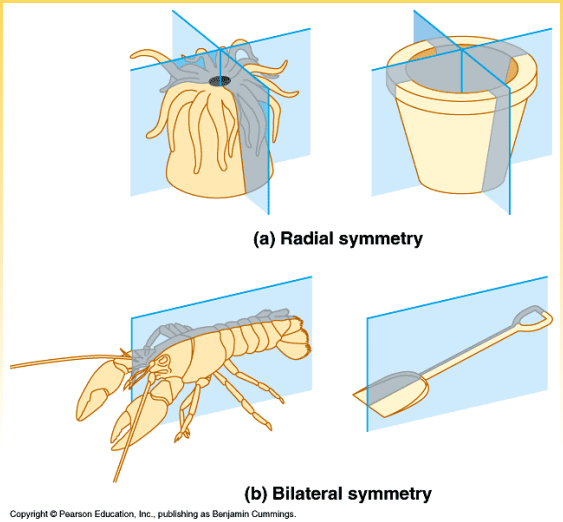
Hox Gene

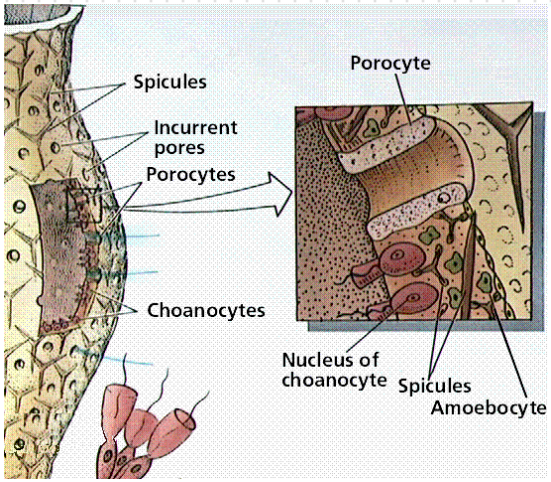


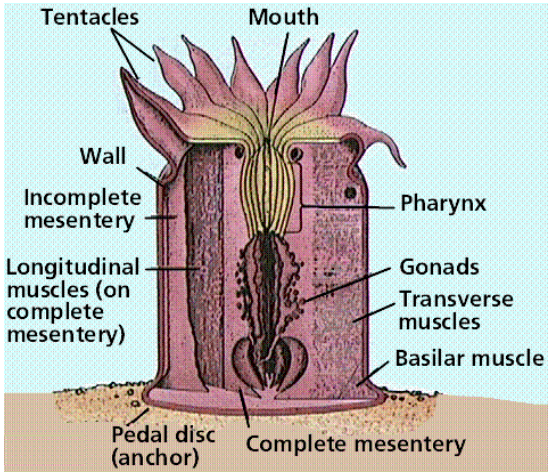


Body Symmetry





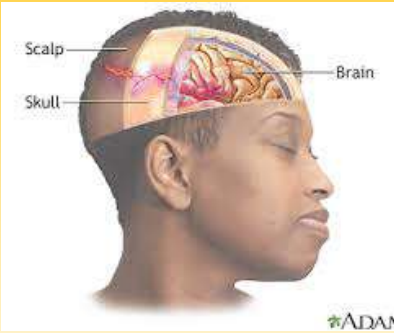




http://www.emc.maricopa.edu/faculty/farabee/biobk/biobookdiversity_9.html

Advantage of Cephalization?

- *Cephalization is an evolutionary trend in which the neurons in an organism become concentrated at one end of its body -- particularly the head region -- allowing the brain to be located in one place. It is advantageous because a complex brain can be formed which, along with a bilateral body plan, allows the organism to make quick, complex movements.*



- ***Evolution of Cephalization***
- Flatworms
- arthropods (crustaceans, insects, and spiders)
- annelids (earthworms)
- chordates (including humans)
- all undergone cephalization.