Teacher Copy

A1&2. CELL ORGANELLES - Structure and Function

Nucleus
-large, centrally located
-surrounded by a double layer membrane with pores
-contains DNA
-**control centre** of the cell
-transcription and replication occur in here

Nucleolus (Nucleoli)
-dark staining areas in the nucleus (usually spherical)
-contains specialized parts of chromosomes
-involved in **rRNA production**
Ribosomes
-small dese staining granules
-involved in **protein synthesis** (ensure correct amino acids and make peptid bond)
-found on surface of E.R. (for producing proteins to be exported out of cell)
-also found free floating in cytoplasm in small groups called **polysomes**
-polysomes produce proteins to be used inside the cell.
polysome on mRNA

Rough E.R. (Endoplasmic Reticulum)
-series of tubular canals connected in places with nuclear membrane
-covered with ribosomes
-produces proteins to be **exported out of cell.**
-proteins move inside the E.R. to the Golgi apparatus

Smooth E.R.
-similar in structure to rough E.R. except no ribosomes on surface
-associated with **lipid and steroid production**
-detoxification in liver cells

Vesicle
-a **small vacuole**
-often used to move certain compounds that need to be separated from the cytoplasm
-often formed from the Golgi apparatus or from infoldings of the cell membrane

Chromosomes
-only found in the nucleus, except when the nuclear membrane dissapears during cell division.
-**contains DNA** and proteins (histones) densly coiled together
-only visible near the time of cell division
-contains all the genetic material for the cell / organism

Mitochondria
-site of **cellular respiration** (glucose + O2 -> CO2 + H2O + ATP energy
-located in cell cytoplasm
-the more active a cell is, the more mitoch. it will have (eg muscle, retinal cells)
-converts food energy to a form of energy which can be used by the cell (this energy is in the form of ATP (adenosine tri-phosphate)
-a double membraned structure where the inner membrane is highly infolded into ***cristae*** to increase inner surface area.
-have their own DNA

-found in cilia, flagella and centrioles.

Cillia and Flagella
-hairlike projections of the cell (cillia - short and many, flagella - long and few)
-cell locomotion
-inside a "9 + 2" arrangement of microtubules (in X-section)
-both have a basal body at their base in the cytoplasm to act as an anchor. This has a "9 + 0" microtubule pattern

"9 + 2"
Centrioles
-found in **animal cells only**
-create **spindle apparatus** during cell division
-also produce the basal bodies for flagella and cilia
-usually 2 centrioles lie on either side of the nucleus (during times of nuclear division)
-have a "9 + 0" microtubule arrangement

Differences Between Plant and Animal Cells:

1. **plant** cells have a **cell wall** , animal cells don't
2. **plant** cells have **plastids** , animal cells don't
3. **plant** cells usually have a **large central vacuole** , animal cells don't
4. **animal** cells have **centrioles** , plant cells don't

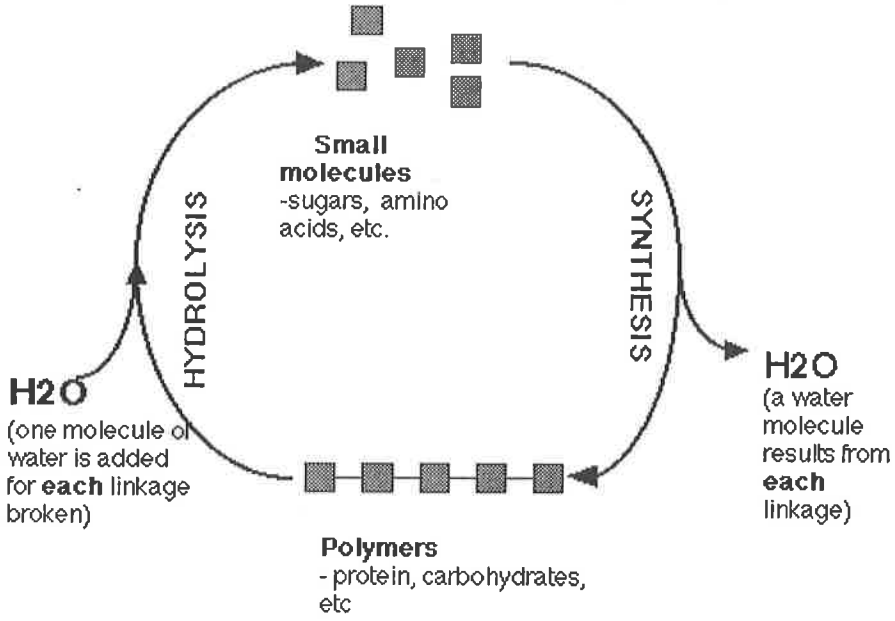
C. BIOLOGICAL MOLECULES

C1. Synthesis and Hydrolysis of Polymers

- most important biological compounds are polymers
- *Poly* means "many"

Polymers

- a many piece chain of subunits
- Subunits are; sugars, amino-acids, nucleotides, or fatty acids.
- these are made (synthesized) or broken down (Hydrolysis) over and over in living cells



C2. Types of Polymers

Proteins : Polymers of amino acids

Nucleic acids (DNA, RNA): Polymers of nucleotides

Carbohydrates : Polymers of sugars

Lipids : Polymers of fatty acids and glycerol

Three Important Polysaccarides:

I) **Starch** : - The main storage form of sugar in plants
- few side chains
- many glucose molecules linked together

II) **Glycogen** - Main sugar storage in animals
- Many side chains
- linked as for starch

III) **Cellulose** - structural (cell walls)
- long chains
- linkage between C atoms of adjacent chains sugars is different than I and II above
- no mammal can break this bond

- lard, butter, animal fats

H H H H H H
C-C-C-C-C-C-H
H H H H H H

Unsaturated:
- *Not* all Carbon atoms have 2 Hydrogen atoms attached
- makes them a liquid at room temperature
- olive oil, corn oil, palm oil etc.

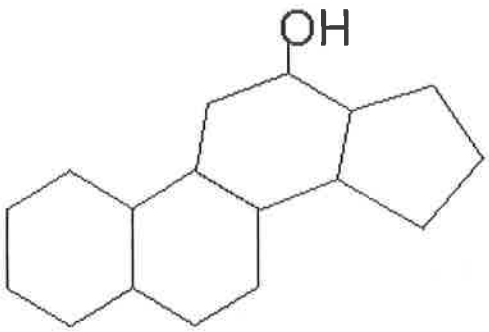
H H H H H
C-C=C-C-C=C=C-C-H
H H H H H

Monounsaturated:

-1 Carbon atom not saturated

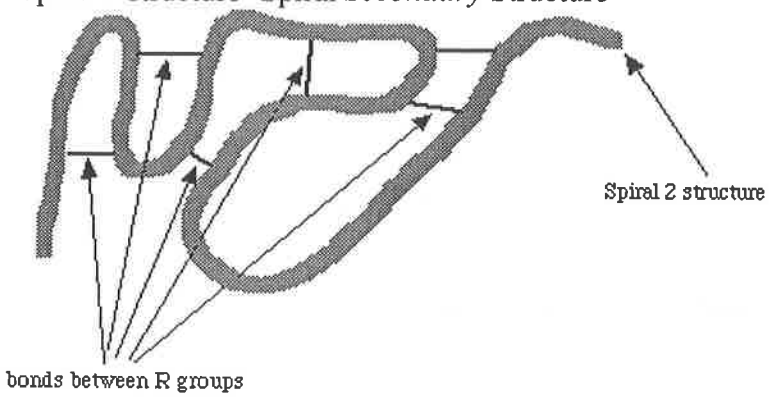
Polyunsaturated:
- Many double bonds
- fewer hydrogens

Steroids: 4 Carbon rings (5 or 6 carbons) in each ring fused together
- related to cholesterol
- used as sex hormones
- constructed from cell membranes



Tertiary Structure:

- The spiral strand folds into a specific shape, due to various kinds of bonds between 'R' Groups.
- Gives the protein its specific function
-Spiral 2 structure=Spiral *Secondary* Structure



Quaternary structure

- some proteins (fairly often) are actually 2 or more molecules (tert. structure) joined to form a functional protein

eg) Insulin - 2 subunits (poly peptides)
Hemoglobin - 3 subunits
Collagen - 3 helical subunits coiled together

Denaturing:
- loss of protein's tertiary structure by breaking R group bonds
- protein loses function, becoming useless
- heat, chemicals, pH
- egg white cooked
- heavy metals (mercury, lead etc.) bind preferentially with the S in Cystine, breaking the tertiary structure.

C11. FUNCTIONS OF PROTEINS

- polymers of amino acids
- have 2 major functions

I) Structural
- large proteins are important
- muscle, tendon, cartillage, hair etc.

Keratin -- hair, nails
Collagen -- cartilage, tendons
Actin, Myosin -- muscle tissue

II) Enzymes
- **very** important
- are Catalysts:

-speed up reactions, and allow to happen at a lower temperature
- therefore control all cell activity

D. DNA, RNA

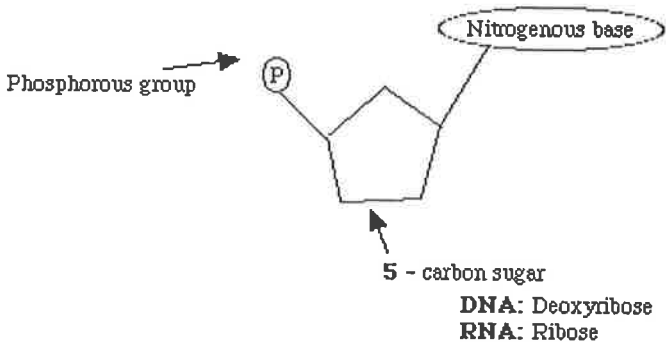
D1. Structure: DNA & RNA are **polymers** of nucleotides.

synthesis

NUCLEOTIDES ⇌ NUCLEIC ACID (DNA / RNA)

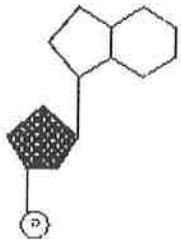
hydrolysis

Nucleotide - nucleotides are composed of 3 parts:



BASE: DNA: Adenine RNA: Adenine
Thymine Uracil
Guanine Guanine
Cytosine Cytosine

The bases are single or double ring structures that contain some nitrogen - "Nitrogenous bases"



ADENINE THYMINE
GUANINE CYTOSINE

Purines and pyrimidines

Adenine, Guanine: ***Purine*** (Double ring bond) -larger

- any mistakes in copying is a *MUTATION* .
- each cell receives 1/2 mother (old) DNA and 1/2 new DNA (*semi- conservative*)
- the entire process invoves many enzymes

D3. Recombinant DNA

Recombinant DNA is the use of various techniques and enzymes to recombine DNA from different organisms. Genes from one species can be cut out and inserted into the DNA of an entirely different species. The new gene can then be expressed by the recipient species.

Recombinant DNA involves the use of special enzymes (called restriction enzymes) that cleave DNA at specific sites, and other enzymes such as DNA polymerase, Ligase, Reverse transcriptase.

D4. Uses for recombinant DNA

There are many possibilities for uses of recombinant DNA.

1. *Protein production.*
   It is possible to isolate a gene from one organism (say Human insulin), and using recombinant DNA techniques, insert that gene into a different organism (say E. coli bacteria). The new organism can then produce that protein. By culturing large quantities of the bacteria it is possible to collect large amounts of Human insulin inexpensively. Many other useful human proteins are being produced in this manner (interferon, Growth Hormone, interluekins etc.)

2. *Gene therapy*
   It is possible to correct genes in individuals that have non-functional (mutated) genes. For example, the corrected gene for the protein that causes Cystic fibrosis has been inserted into a virus that infects human lung cells. The virulent part of the virus genes has been deactivated. The virus then injects the corrected cystic fibrosis gene into the cells of the cystic fibrosis patient, and their symptoms are greatly reduced!

3. *Transgenic organisms* (have a foreign gene inserted into them)
   Selected genes can be inserted into a plant to give it features that were not possible through breeding. For example, a bacterial insect toxin gene can be inserted into a plant (eg. potatoe) so the plant is now toxic to insects, and fewer insecticides are needed in order to grow it!

D5. Compare and Contrast DNA and RNA

DNA: - Deoxyribose (5 C sugar with one less oxygen)
- Bases: Adenine, Guanine, ***Thymine***, Cytosine
- Strands: Double Stranded, with base pairing
- Double helix shaped
- Only found in Nucleus
- Longer than RNA
- 1 Kind

RNA: - Ribose (5 C. sugar with one more oxygen)
- Adenine, Guanine, ***Uracil***, Cytosine
- Single Stranded
- Not double helix shaped

E1. PROTEIN SYNTHESIS

i) Transcription - DNA ---> mRNA

1. DNA unzips (as in replication) but only at a specified spot (a gene).
   -(only a portion of the DNA unzips)

2. RNA is transcribed (copied from the DNA in the nucleus)
   -Uracil (U) replaces Thymine (T)
   -RNA nucleotides match up with their complementary DNA bases.
   - only 1 side of DNA is used
   - called Messenger RNA (**mRNA**)

(Note: There are 3 kinds of RNA transcribed in the nucleus; Messenger, Transfer and Ribosomal. Transfer and Ribosomal are stable, and reused so it is mostly mRNA that is being continuously transcribed)

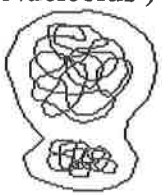
1. The mRNA then moves out through the nuclear pores into the cytoplasm where it is ***translated*** into an amino acid sequence.

DNA ⟶ mRNA ⟶ PROTEIN

TRANSCRIPTION TRANSLATION

ii) Translation (mRNA to Protein)

- occurs with *ribosomes*
-small organelles composed of protein and rRNA (ribosomal RNA is transcribed in the nucleus in the **Nucleolus**)



- ribosomes are usually found on the surface of the endoplasmic reticulum (ER) or in groups (polysomes) free floating in the cytoplasm.

- they are the site of protein synthesis (Translation)

The Code - codons

- the ***codon*** is a three base unit of the **mRNA**
- each codon calls for a specific amino acid

eg)

Translocation: pieces of separate chromosomes are exchanged (example above)
Deletion: Pieces become missing
Duplication: Extra pieces are copied and added
Inversion: Pieces are flipped into reverse order

Gene
- A gene is the segment of DNA on a chromosome that codes for **one** protein.
- The human genome (all the DNA in all 46 chromosomes in one human cell) is aprox. 3 billion base pairs. Only 10 - 15 % of this DNA is actual genes.
- *Haemophilus influenzae* , the first organism (a bacteria) that has had its entire genome worked out (each base!) is 1.8 million bases long.

Gene Mutation:
- a change in the nucletide sequence
- only one gene is affected
Deletion: One base is left out
- serious
- change all of the codons following it

Addition: One base is added
- serious
- change all the codons following it

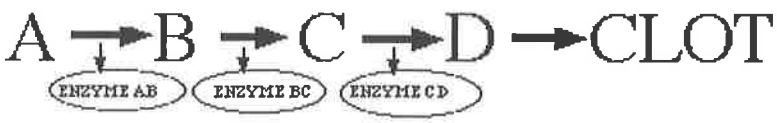
Substitution: Pieces are replaced with each other.
- less serious
- only one codon is affected.

E3. Causes of Mutations:

Germinal
- can be passed on to offspring (occurs in egg/sperm cell)
- haemophilia
Stomatic Mutation
- body cell
- not inheritable
- responsible for many cancers
X-rays, Radiation, Chemicals etc. can all be mutagens

E. 4 Mutations and Genetic Disorders

- normally, chemical reactions occur in "pathways"



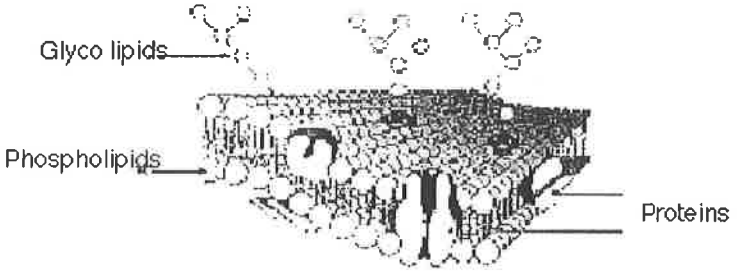
- If Enzyme BC were mutated and nonfunctional, then compounds C and D could no be made. Clot would not form - *Hemophelia*
- this is an abnormal body function, or ***disease.***

SELF QUIZ

G1. CELL MEMBRANE:

3. Cell Membrane:

Fluid Mosaic Model:
- double layer of phospholipids
- protien molecules imbedded in and throughout the double layer

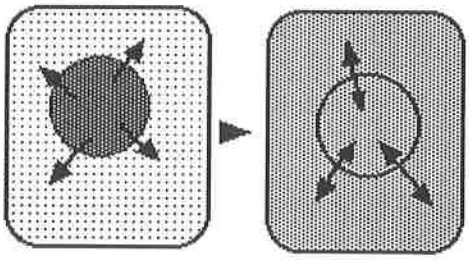


Proteins - help to move stuff through the membrane
- receptor sites that influences cell metabolism.
- Some compounds (proteins, carbohydrate, lipids) are attached to outer surface of the membrane, sometimes glycolipids, glycoprotiens etc.
- These act as cell "fingerprints" or "identity factors"

G2. - G5 MOVEMENT ACROSS A CELL MEMBRANE

Selectively Permeable
- some things can pass through it, other cannot
- depends upon size etc.
- *selects in 6 ways* :

1) *Diffusion* : - particles moving from an area of greater concentration towareds an area of lesser concentration until it is equally distributed.
Increase rate by:
- increasing temperature
- increase surface area
- changes in shape of molecules
- changes in concentrations
-decrease size of molecules

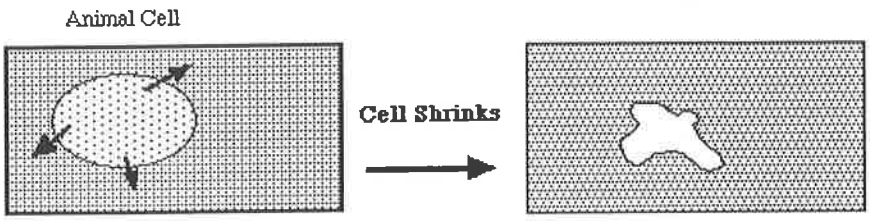


Examples:
- alcohols (can disolve in phospholipids)
- gases (O2, CO2)
- water **This is called ***osmosis***

2) *Osmosis:*
defined as:
- The net movement of water molecules from the area of greater concentration of water to the area of lesser concentration of water until it is evenly distributed
- must be across a ***selectively permeable membrane***

- no net diffusion or osmosis occurs.

b) *Hypertonic:*
- The solution **outside** the cell is more concentrated than inside

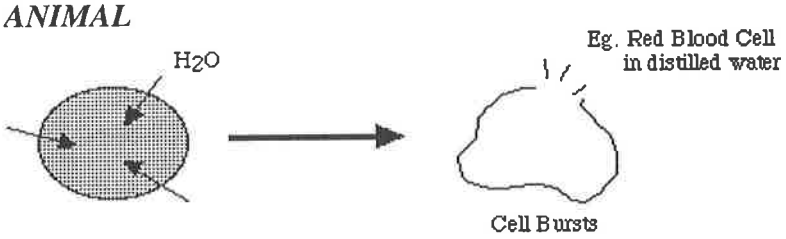


- therefore, the water will move ***out*** of the cell (osmosis) because the water is more concentrated inside the cell than outside.

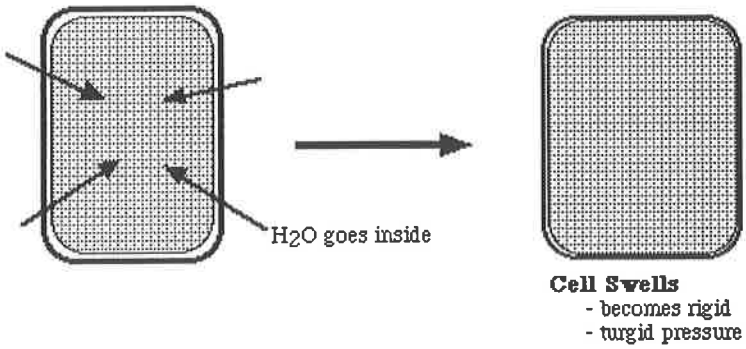
In a plant cell this process pulls the cell membrane away from the cell wall, the cell looses its rigidity - ***Plasmolysis***

c) *Hypo tonic:*
-Concentration **inside** the cell is more concentrated than outside.
- Water will move ***into*** the cell

ANIMAL



PLANT:



This is known as ***Turgor Pressure*** and gives plant cells their rigidity.

G8. SURFACE AREA WITH RESPECT TO CELL SIZE

- Use Suface Area to Volume ratio

- This is why cells are small
- If the volume of the cell increases, the amount of surface area does not increase in the same proportion.
- larger cells have much more volume for not as much increase in the amount of surface area.
- Cells overcome this by changing their shape

H1. ENZYME TERMINOLOGY

A. Enzymes:

- A **Protein** that speeds up a chemical reaction
- No cell reaction will occur without its specific enzyme

Metabolism:

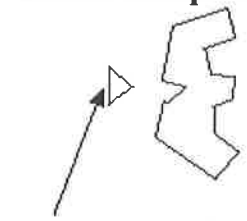
- the total rate of all chemical reactions in a cell body.

Substrate:

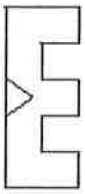
- the starting chemicals that the enzyme works on.
- "Starting Compounds"
- reactants

B. Coenzyme:

- smaller **non-protein part of an enzyme** required in order to make an enzyme active ***usually vitamins** *

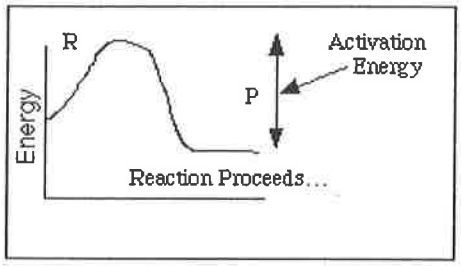


Coenzyme- Enzyme Cannot Catalyze

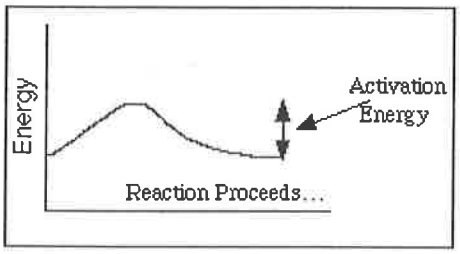


Enzyme with Coenzyme (now active)

C. Activation Energy:



NO ENZYME



WITH ENZYME

- An enzyme lowers the amount of energy (EA or Activation Energy) needed for the reaction to occur.

ex: Reactions that occur at 100C can occur at 37C with the use of an enzyme

H2. THYROXIN

Thyroxin is a hormone produced in the Thyroid gland (neck) that controls the metabolic rate (rate of the chem. reactions in the cell) in **all** the cells in your body. The more thyroxin present the greater the metabolic rate. This will increase sugar and oxygen consumption and also creates more body heat.

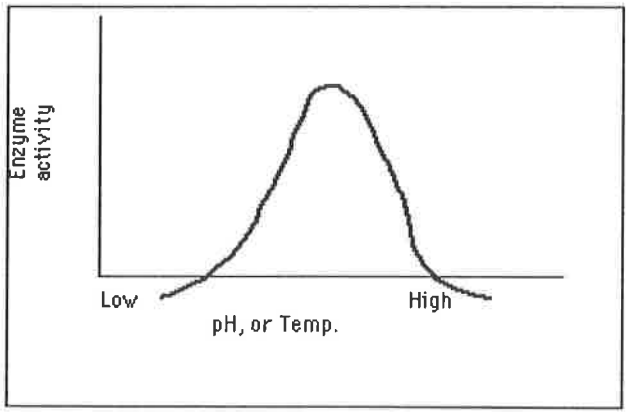
- The enzyme loses its activity.

Factors:
pH : certain enzymes work best only at specific pH levels. Any change from that level denatures the enzyme.

Temp .:37C is optimum for human enzymes
>40C: some enzymes begin to denature, reaction slows or stops.
At low temperature, there are fewer number of collisions between the substrate and the enzyme, which will decrease the reaction rate.

Heavy metals : Mercury, lead break bonds between R groups and denature the enzymes

Substrate concentration : As a rule, if you increase substrate concentration (the amount of **starting** compound), as long as enough enzyme is present, the rate of reaction will increase. This will occur until the point that the enzyme is overwhelmed (too much substrate) at which time the rate of reaction will level off. In order to increase the rate of reaction at this point, more enzyme must be added.



Enzymes usually have very specific ranges (temp. pH etc.) under which they work efficiently.

H. 7 EXPERIMENT A Biological experiment tests a **hypothesis** (an educated guess, or tentative solution to a question. It almost always has a **control** (a baseline or comparison point).

I2. DIGESTIVE ENZYMES

- These enzymes break down food into small molecules which are then absorbed.

Salivary Amylase:
Source: Salivary glands
pH: Neutral
Food digested: Starch
Product: Maltose (a disaccharide)

Pepsin:
Source: Stomach
pH: Acidic (pH 3.5)
Food Digested: Protein
Product: Peptides (short amino acid chains)
Note: Secreted as *Pepsinogen* , an inactive form. A low pH converts pepsinogen into the active pepsin
Pancreatic Amylase:
Source: Pancreas
pH: Basic (pH 7.5)
Food Digested: Starch
Product: Maltose

Trypsin:
Source: Pancreas
pH: Basic (pH 7.5)
Food Digested: Protein
Product: Peptides (short amino acid chains)

Lipase:
Source: Pancreas
pH: Basic (pH 7.5)
Food Digested: Fat
Product: Glycerol, Fatty Acids

Peptidases: (many different ones)
Source: Small intestine
pH: Basic (pH 7.5)
Food Digested: Peptides
Product: Amino Acids

Maltase:
Source: Small intestine
pH: Basic (pH 7.5)
Food Digested: Maltose
Product: Glucose

Nuclease:
Source: Small intestine ***and*** Pancreas
pH: Basic (ph 7.5)
Food Digested: Nucleic Acid (DNA & RNA)
Product: Nucleotides (A,C,G,T & U)

muscles to convert glucose to glycogen, as well as promoting the formation of fats and proteins.

A second hormone produced by the same cells called **Glucagon** does just the opposite of glucose, so will increase blood glucose levels.

I6. BILE

The liver is connected to the intestines (villi) by the Hepatic **portal** vein which carries blood rich in foods to the liver. The liver acts as the gatekeeper to the blood by keeping levels of various foods in the blood (Hepatic vein) constant.

An important digestive function of the Liver
- secretes ***bile*** , which is stored in the gall bladder- green fluid
- breakdown fluid of hemoglobin
- ***emulsifies*** fats
- breaks fat drops into tiny droplets which are *homogeneous* .
- stay in suspension.
- increases surface are of the fat droplets for Lipase to work on.

I7. THE 6 FUNCTIONS OF THE LIVER:

1. It removes poisonous substances (detoxifies blood)

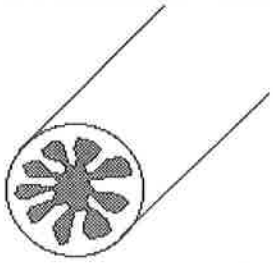
2. Stores glucose in the form of *Glycogen* . Converts glycogen to glucose when blood sugar levels drop.
3. Destroys old red blood cells
   - (converts hemoglobin to bile)
   - stores bile in gall bladder to be used for fat emulsification.

4. Produces urea from breakdown product of amino acids
   - urea: nitrogenous waste

5. Makes blood proteins

6. Converts amino acids to glucose if necessary
   - "Gluconeogenesis"

I9. SMALL INTESTINE



- 6 meters in length
- First 15cm is called *Duodenum*
- Produces digestive enzymes
- **lactase, peptidases, maltase, nucleases**
- Most important function: Absorption
- Structure:
- walls highly convoluted
- to increase surface area
- covered with villi

CIRCULATORY SYSTEM

J1. FIVE TYPES OF BLOOD VESSELS

i) arteries - large, carry blood ***away*** from the heart
- thick elastic walls (can stretch)
- surrounded by smooth muscle (can control size)

ii) arterioles - smaller
- mostly smooth musle (much control)

iii) capillaries - microscopic
-nutrient, gas, waste exchange here
- 1 cell thick
- present all over body (networks, or beds)
- blood flow is controlled highly
- often have sphincters (muscle rings) between arterioles and capilary beds to control flow of blood into entire cap. beds.

iv) venules - drain blood from capillary beds
- begin flow ***towards*** the heart

v) veins - larger
- have ***valves*** - allow blood to flow only in one direction, **towards** the heart.
- act as a blood resevoir. (more than 50% of blood is in veins).
- thinner walls than arteries.

J4 PULMONARY AND SYSTEMIC CIRCULATION

Pulmonary circulation is to the lungs. It involves the right side of the heart (right ventricle) which pumps deoxygenated bllod into the pulmonary artery to the lungs. There, the blood is oxygenated in the capillaries of the alveoli. It returns to the heart via the pulmonary vein into the left atrium.
Systemic circulation is to the body. Blood is pumped out of the left ventricle into the aorta where it heads off via a number of blood vessels to the rest of the body. It collects to return to the heart in two major veins, the superior (anterior) Vena cava which drains the head and upper body, and the inferior (posterior) Vena cava which drains the lower body. Both enter the right atrium.
Pulmonary - Lung

- pulmonary arteries - from R. Ventricle to lungs. ***Unoxygenated***
- pulmonary veins - from lungs to L. atrium. ***Oxygenated***
- lungs - capillary system for O2 / CO2 exchange

Systemic - Body

- all vessels leaving the heart - *Oxygenated*
- all vessels returning to the heart - *Unoxygenated* .

*** Note*** ***This is opposite to the Pulmonary System***

J2 - BODY BLOOD VESSEL

O. renal veins - returns blood from the kidneys to posterior vena cava
P. hepatic portal vein - carries blood from the intestines to the liver
Q. hepatic vein - returns blood from the liver to posterior vena cava

J5. ADULT / FETAL CIRCULATION

The main differnnce is the fact that the fetus receives its O2 blood from the *placenta* , and does *not* use its lungs. To do this, there are **four features** in the fetus not present in the adult.

a) *Oval opening or foramen ovale*

- an opening between the L. and R. atria
- covered by a flap that acts as a valve
- reroutes blood away from lungs to the aorta

b) *Arterial duct or ductus arteriosus*

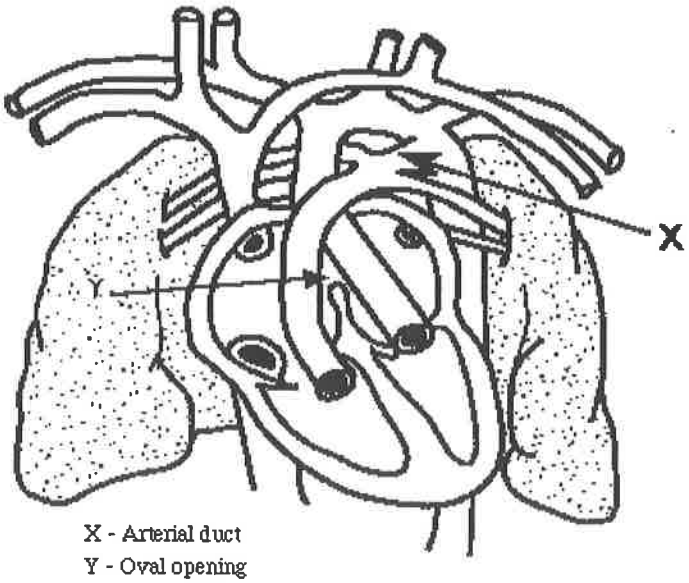
- connection between the pulmonary artery and the aorta
- reroutes blood away from lungs to the aorta

c) *Umbilical arteries and veins*

- Artery travels toward placenta with waste, Vein travels to fetus with blood rich in O2 and nutrients

d) *Venous duct or ductos venosus*

- connection between the umbilical vein and the vena cava
- umbilical vein carries O2 blood which mixes with unO2 blood in the vena cava.



X - Arterial duct
Y - Oval opening

J6. PATH OF A BLOOD CELL

- List all of the blood vessels and heart chambers starting from the aorta (and returning to there) if the blood

ii) *Vessels and Organs*

a) *Vessels*
- lymph capillaries take up cell fluids
- lymph veins (have valves)

The fluid (lymph) travels through the system and reenters the circulatory system through the right and left subclavian veins.

b) *Lacteals*
- blind ends found in the villi of intestines which absorb fats

c) *Nodes*
- small ovoid / round structures
- produce lymphocytes (type of white blood cell). These fight infection by producing antibodies which combine with, and deactivate foreign proteins
- filter and trap bacteria etc. (inc. spreading cancer cells)

d) *Parts of other organs*
- tonsils
- appendix
- spleen
- thymus gland
- *All* help fight infection

J.9 BLOOD CELL COMPONENTS

a) ***Red Blood Cells*** - erythrocytes
- small, biconcave disks, no nuclei
- continuously made in red bone marrow
- pass through several developmental stages during which they loose a nucleus and gain hemoglobin
-# in blood is related to O2 tension in air
- live 120 days
- iron is reused
- heme part (protein) is turned into bile pigments in the liver
- transport O2 and CO2

b) ***White Blood Cells*** - leucocytes
- larger, have a nucleus
- fewer in number
- some are ameboid in shape
- several kinds

1. Neutrophils - 55 to 70%
   - granules in cytoplasm
   - *polymorphonuclear* (many lobed nucleus)
   - produced in bone marrow
   - phagocytic (engulf foreign stuff)

2. Lymphocytes - 20 to 30%
   - no granules in cytoplasm
   - mononuclear
   - matured in lymph tissue, thymus gland, spleen, tonsils

TRANSFUSIONS

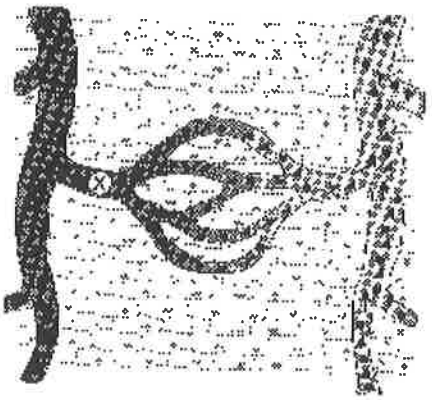
- The donor's cells must match the recipient's plasma

Donor's Cells	A	B	AB	Universal donor O
Recipient's Plasma				
A (anti-B)	YES	NO	NO	YES
B (anti-A)	NO	YES	NO	YES
[universal recipient] AB (none)	YES	YES	YES	YES
O (anti A/B)	NO	NO	NO	YES

J. 12 CAPILLARY - TISSUE FLUID EXCHANGE

At the arterial end of a capillary bed, blood pressure (40 mm Hg.) is higher than the osmotic pressure (25 mm Hg.). Thus water (plasma) will be forced out through the walls of the capillaries into the surrounding tissues. Plasma proteins and blood cells are too big and remain in the capillaries.

Oxygen, sugars and amino acids in the fresh blood diffuses into the tissue cells where they are used up. CO2 and waste molecules produced in the tissue cells diffuse out of the tissues back into the blood. At the veinule end of the capillary beds, blood pressure is now reduced (10 mm Hg.), whereas osmotic pressure is the same (25mm Hg.). H2O now is pulled by osmotic pressure back into the blood vessels. Since osmosis is a slower process, not all of the H2O originally leaving the blood will return. The remaining fluid is picked up and carried back to the circulatory system by the Lymph system.



ERYTHROBLASTOSIS AND THE Rh SYSTEM (This may be optional)

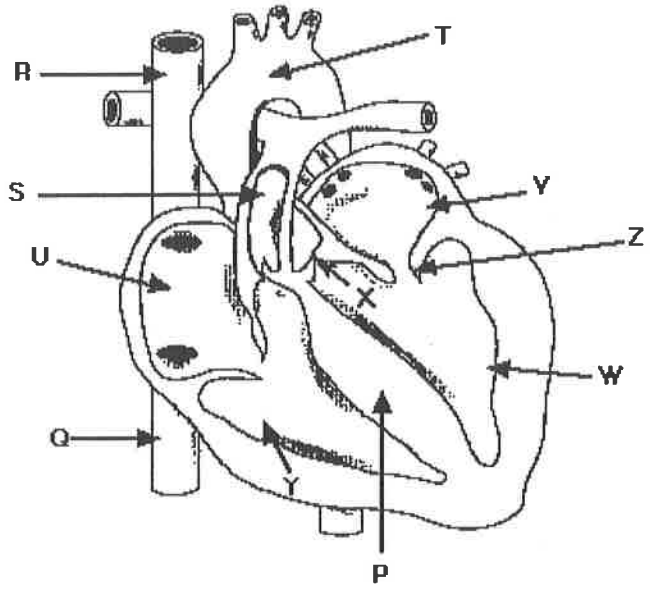
Rh factor - another antigen

Rh+ has antigen (85% of Caucasians)
Rh - doesn't have the antigen

If Rh antigens are mixed with Rh antibodies, clumping occurs.

* Rh - people do **not** normally have Rh antibodies, but **can** *if exposed to Rh antigens.*
This becomes important in pregnacies because a Rh- mother can have and Rh+ baby. Normally, the mother / fetal blood does not mix or cross the placenta. At birth, there is usually some mixing, so the mother begins to produce Rh antibodies in response to the Rh antigens on the baby's RBC's introduced during birth. There is no danger for either the mother or the first baby.

K1. HEART STRUCTURE AND FUNCTION



Key to Heart Diagram

P. septum - separates left and right ventricles
Q. posterior vena cava - drains blood from lower body into left ventricle
R. anterior vena cava - drains blood from upper body into left ventricle
S. pulmonary trunk - unoxygenated blood from r. ventricle to lungs, branches into l. and r. pulmonary arteries
T. aorta - oxygenated blood from l. ventricle to body
U. right atrium - pumps blood into right ventricle
V. left atrium - pumps blood into left ventricle
W. left ventricle - pumps blood into aorta to systemic system
X. a semi lunar valve, one at the exit of ech ventricle, prevents backflow of blood into ventricle
Y. right ventricle - pumps unoxygenated blood into pulmonary artery to lungs
Z. an atrioventricular valve - one between each atrium and ventricle, prevents backflow of blood from ventricles into atria.

Not shown on diagram

chordae tendineae - fibres running from the atrioventricular valves to the bottom of the ventricles, prevent the atrioventricular valves from collapsing backwards
coronory arteries and veins - on the outside of the heart. Arteries branch off the aorta and supply the heart muscle with oxygenated blood. Veins return to vena cava .

K.2 NODES

The left and right side beat in **syncronization** (together).
- both atrium contract, then both ventricles.

- the heartbeat is independent, it can beat without nervous stimulation.

There are two **nodes** (comb. of muscle and nervous tissue)

- a number of factors contribute
- sympathetic nerves increase blood pressure
- inc. Na+ by kidneys or diet increase blood pressure
- arterioles constricting increase blood pressure
- atherosclerosis increases blood pressure

Atherosclerosis - accumulation of soft masses of fatty material, esp. cholesterol, beneath inner linings of arteries. These protrude and interfere with blood flow and increase blood pressure. The presence of hard plaque on artery walls can cause blood to form clots. If the clots stay in place they will block blood flow in the artery (thrombus). An embolus occurs if the clot moves. An embolus causes an embolism when it stops and blocks off a smaller blood vessel. This causes a heart attack if the artery is a coronary artery or a stroke if it is an artery in the brain.

L2. CILLIA AND MUCUS

Cillia line the tubes of the respiratory tract. The tubes also produce mucus, which traps bacteria and dust particles. The cillia sweep the mucus upward, cleaning the resp. tubes.

L3. ALVEOLI

- 700,000 alveoli in human lung, 100x surface of skin
- thin walled sacs covered with a capillary network
- CO2 and O2 can diffuse directly through the walls
- site of O2 / CO2 exchange

L4. & L5. INHALATION AND EXHALATION

BREATHING
- The taking in of air into the lungs.
in - inspiration
out - expiration
The lungs lie in a sealed off cavity - chest or thoracic cavity
- the ribs make up the top and sides, the diaphram makes up the bottom, the pleural membranes seal it.

1. *Inspiration*
   - diaphram contracts (lowers)
   - rib muscles contract (pull up and out)
   This expands the thoracic cavity which causes a low pressure, air is "sucked" in.

2. *Expiration*
   - diaphram relaxes (raises)
   - ribs relax
   Thoracic cavity relaxes (gets smaller) and air is forced out.

The pleural membranes seal the thorasic cavity so the negative pressure formed during inhalation forces air to be sucked in through the trachea.

L6. ROLE OF CO_2, H+, AND MEDULLA OBLONGATA

- the urge to breathe is brought about primarily by CO2 / H+ ions
- monitored in the blood by the *medula oblongata* - resp. centre in brain
- low O2 is monitored by chemo receptors in the carotid artery (neck). Low O2 will cause the rate and depth of breathing to increase.
- High CO2 stimulates breathing centre which stimulates diaphram and rib muscles to contract. You breathe in.
- when lungs are filled, stretch receptos on the alveoli send messages to the breathing centre, which shut down signals to the diaphram and rib muscles. They relax and you breathe out.

L7. 7 L8. GAS EXCHANGE AND TRANSPORT

External (at Alveoli)
- the CO2, O2 exchange in the alveoli
- relies on *diffusion*

High CO2 ⟶ Low CO2

Gas Exchange

Gasses (CO_2, O_2) easily exchange due to the process of *diffusion*

Internal

i) body tissue - O_2 is low (always used up)
- CO_2 is high (being produced)

ii) blood - O_2 is high (HbO_2)
- CO_2 is low

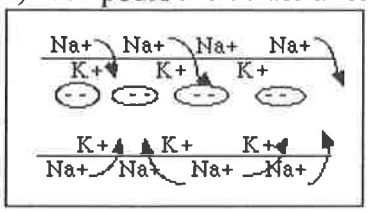
External

i) alveoli - O_2 is high (20% of air)
- CO_2 is low (.5% of air)

blood - O_2 is low (diffused out in body tissue)
- CO_2 is high (produced in body tissue, carried as HCO_3^-

Two phases

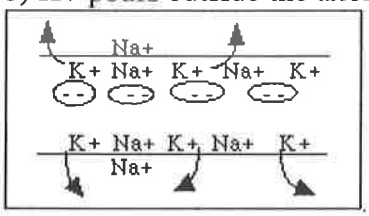
a) Na+ pours inside the axon due to sodium gates in the fibre membrane opening



Action potential = +40 mV

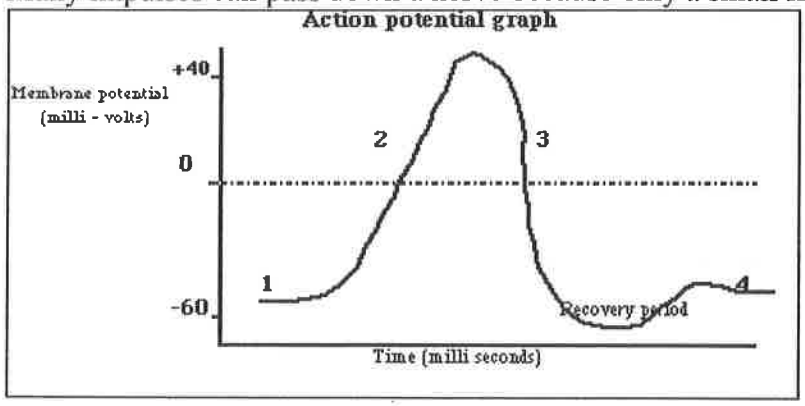
- The inside is now + with respect to the outside

b) K+ pours outside the axon due to pottasium gates opening



Action potential = -60mV
- the inside is again - with respect to the outside
- after a very brief recovery period, the fibre is now ready to transmit another impulse
- **repolarization**

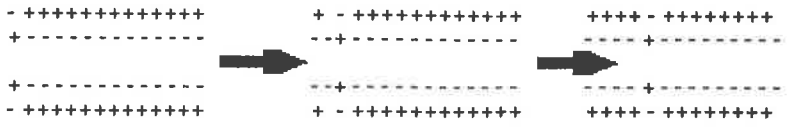
Many impulses can pass down a nerve because only a small fraction of the Na+ and K+ actually move.



1 - Resting potential (sod.-pot. pump)
2 - Action potential, Na+ gates opening, Na+ pouring in
3 - Action potential, K+ gates opening, K+ pouring out
4 - Resting potential, fibre is ready to conduct again (after rec. period)

After a time however, a nerve can lose its ability to make an action potential because too much Na+ and K+ have traded places. The nerve needs a resting period, and the Na+ and K+ are **actively pumped** back across the membrane.

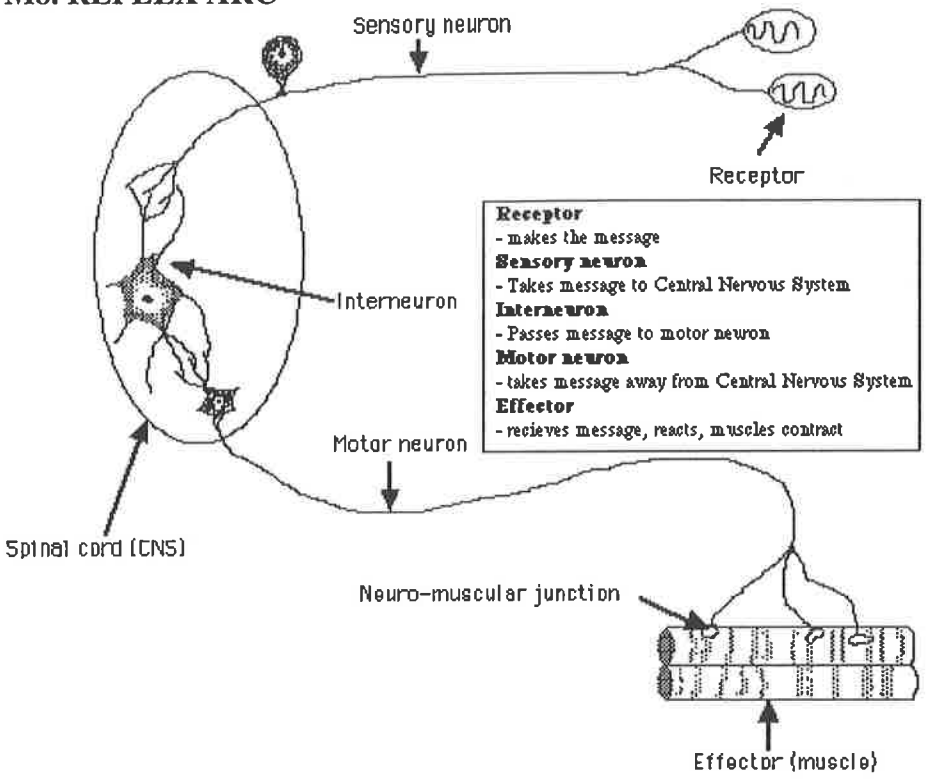
The impulse moves down the fibre, because reversal at one point of the fibre (an action pot.) stimulates the sodium gates to open at the very next point. The gates that have just opened and closed cannot be restimulated for a very brief period of time, (**Recovery period**) so the impulse moves *in one direction only.*



- an action potential can only be initiated at the dendrite end of a nerve fibre (receptor or synapse) Thus the impulse can only travel away from the receptor towards the axon. It never goes in the opposite direction (although it can be made to do so artificially)

new impulse can be rapidly transmitted. It also allows reuse of the neurotransmitters as the parts diffuse back into the axon to be rebuilt into new neurotransmitter substance.
Example: Acytlcholinesterase (destroys Acytlcholine into choline and acetic acid)

M8. REFLEX ARC



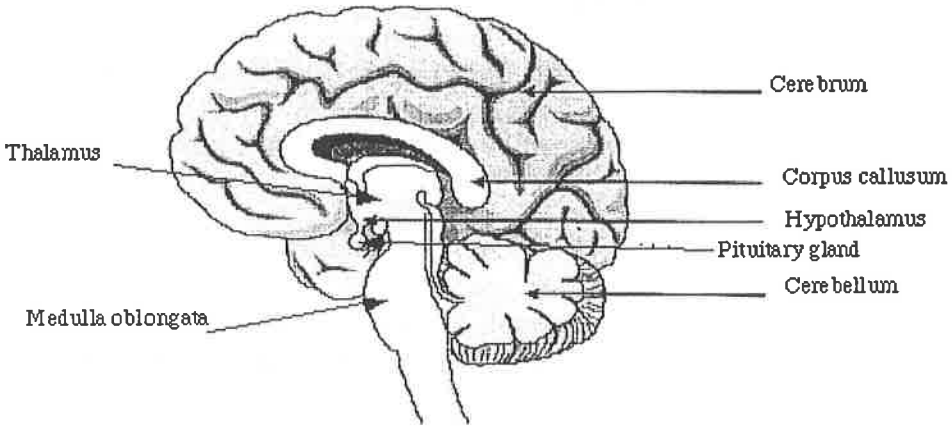
- A reflex action (eye blink, hand jerking away from a hot object) in which a stimulus causes a response, without the brain being invloved in making a decision.
- The inter neuron ***bypasses*** the brain
- Another neuron also goes to the brain, but by the time the impulse reaches the brain, the motor neuron has already contracted the muscle.

N3. ADRENAL GLAND

Adrenallin is a hormone produced by the medulla (inner layer) of the adrenal glands (one on top of each kidney). It is responsible for maintaining the "fight or flight" response. It is secreted in times of emergency or stress. Some affects of adrenalin are
- dilated pupils
- increased heart rate
- decreased blood flow and peristalsis in digestive tract
- increased blood flow to the CNS and skeletal muscles

It continues the affect of sympathetic nerve impulses, and is used as a neurotransmitter substance in this system as well.

N4. BRAIN PARTS AND FUNCTIONS

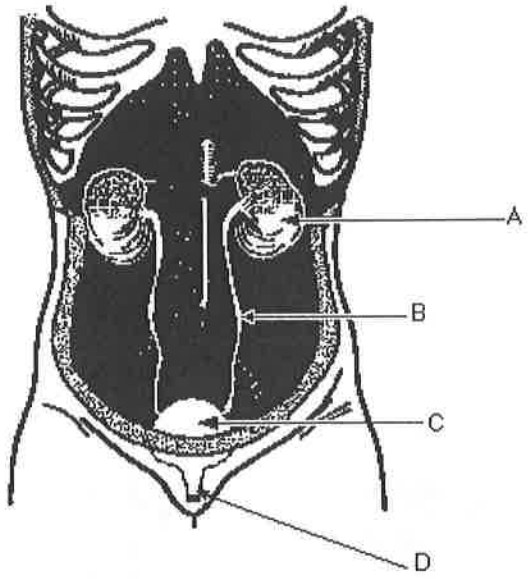


Medulla Oblongata:
- Unconscious part
- Closest to the spinal cord
- centers for heartbeat, breathing
- vomiting, coughing, sneezing, hiccoughing, swallowing
- Control of internal organs

Cerebrum
- Responsible for consciousness
- largest portion of the brain (human)
- Outer layer: Cortex

Thalamus:
- "Gatekeeper" to cerebrum
- Last stop before the cerebrum
- Central relay station for sensory impulses (sorts out messages to cerebrum)
- Channels impulses to appropriate regions of the brain

Cerebellum:
- Resembles a butterfly
- 2nd largest portion of brain
- lets body have smooth and graceful motions (muscle coordination)



O1. KIDNEY FORM AND FUNCTION

A. Kidneys:
- Produce urine

B. Ureters:
- Transport urine from kidneys to bladder

C. Bladder:
- Storage of urine

D. Urethra:
- Elimination of urine from bladder

Renal Cortex (outer layer of kidney)
- Contains glomerulus, proximal and distal tubules
- Pressure filtration, selective reabsorption and tubular excretion
- Responsible for most of the work of the kidney

Renal Medulla (inner layer of kidney)
- Contains loop of Henle, and most of the collecting duct.
- Responsible for H2O reabsorption and salt balance

O2. NEPHRON STRUCTURE AND FUNCTION

- a few materials are **actively** excreted from blood into tubules. (penicillin, histamines, H+, etc.)

C - Collecting duct - Common duct which collects filtrate from many distal tubules (Nephron)
- Very important in regulating the overall water content of urine
- Can control from very dilute urine (lots of water) to very concentrated urine, (very little water, most reabsorbed)

O3. BLOOD IN RENAL ARTERY AND VEIN

Substance Renal Artery Renal Vein

- Glucose - 100 mg/l - 98 mg/l
- Urea - 30 mg/l - 25 mg/l

Glucose is 100% reabsorbed from the filtrate into the blood. The 2 mg/l drop above is a result of sugar used to make ATP to fuel all the active transport that is happening in the tubules.
Urea is lower in the renal vein because it is excreted in the filtrate. Some is reabsorbed by the tubules. The kidneys do not remove all the wastes from the blood, they remove enough to keep the blood at a constant level. One kidney can actually be sufficient, a human can easily survive with only one. Sometimes people will donate a kidney to a close relative.

O4. ADH AND ALDOSTERONE

i) **ADH** - Anti Diuretic Hormone

- controls H2O balance
- ADH is secreted by the **posterior pituitary** gland
- increases the permeability of the distal tubule and collecting duct so that more water can be reabsorbed back into the blood.
- if ADH is secreted:
blood volume increases
blood becomes more dilute
urine becomes more concentrated
- ADH secretion is controlled by the water content of the blood. As blood conc. increases, more ADH is secreted, so more water is reabsorbed, and blood conc. then decreases.

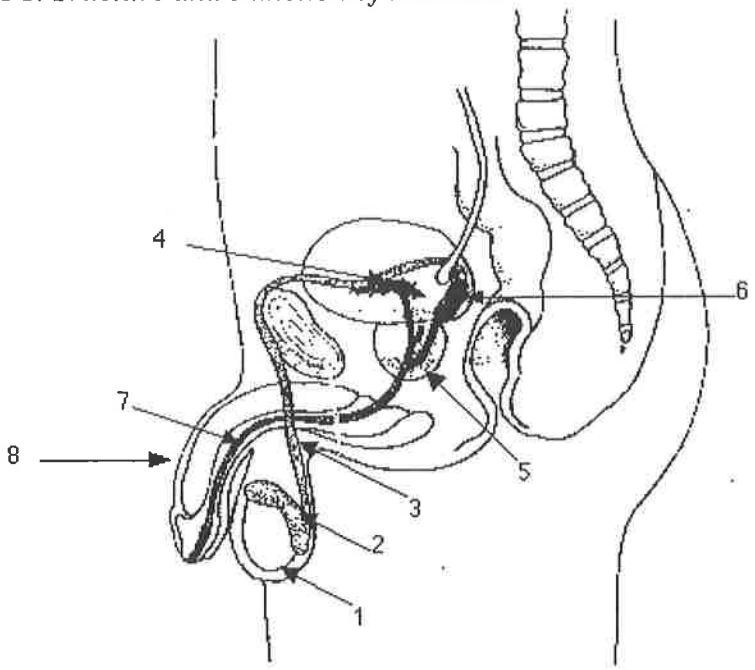
ii) **Aldosterone**

- hormone secreted by **adrenal cortex** gland (outer layer of the adrenal gland on top of each of the kidneys).
- controls the excretion of Na+ and K+
- increases reabsorption of Na+ (inc. Na+ in blood)
- increases excretion of K+ (decr. K+ in blood)
- If blood Na+ level is too low, Aldosterone is secreted, reabsorption of Na+ by the kidneys occurs, so blood Na+ begins to increase.
- also controls blood volume (& pressure). Increase in Na+ in blood causes H20 to be reabsorbed, increasing blood volume & pressure

Role of Hypothalamus - area of the brain directly above the pituitary gland

The hypothalamus actually secretes the ADH which is released by the Posterior pituitary gland. The hormone is transferred and stored in a series of nerve cells which run from the hypothalamus to the post. pit. gland. The actual conc. (water) of the blood is monitored by the hypothalamus. If the blood is too

REPRODUCTION
P1. Sructure and Function of the Male



1) *Testes*
- outside abdominal cavity in scrotum
- sperm production needs < body temp
- sperm is produced inside tubes called *seminiferous tubules*
- *interstilial cells* also in testes produce male sex hormones -*testosterone,* and *androgens*
- maturing sperm are moved to the epididymis

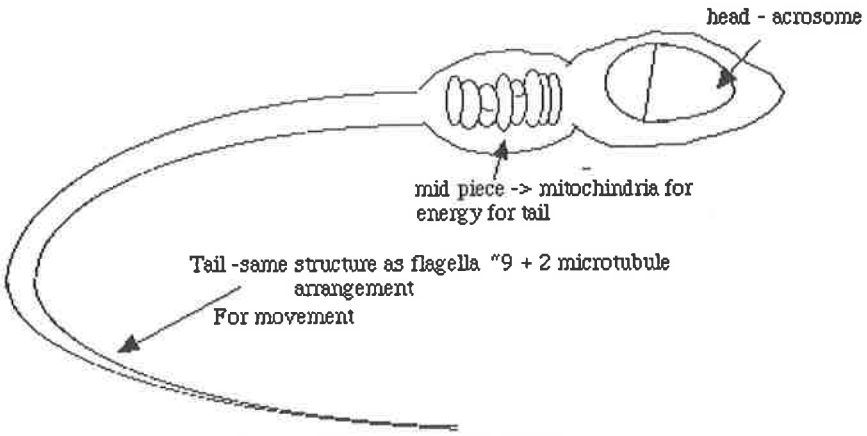
2) *Epididymis*
- area where sperm mature (coiled tubes)
- then moved to the ductus (vas) deferens

3) *Ductus (vas) deferens*
- sperm stored here
- leads to urethra
- long tube from epid. to urethra

4) *Seminal vesicles*
- 2 small glands
- joins vas deferens at the base of the bladder
- makes part of seminal fluid
- creates a slightly basic (pH 7.5) fluid, high in fructose

5) *Prostate Gland*
- found around urethra
-*prostaglandins* (a hormone that causes contractions of the vagina to help move sperm), and buffers

6) *Cowper's glands*
- adds to seminal fluid
- 2 small glands
- secretes alkaline fluid to neutralise urine in urethra
* seminal fluid + sperm = semen

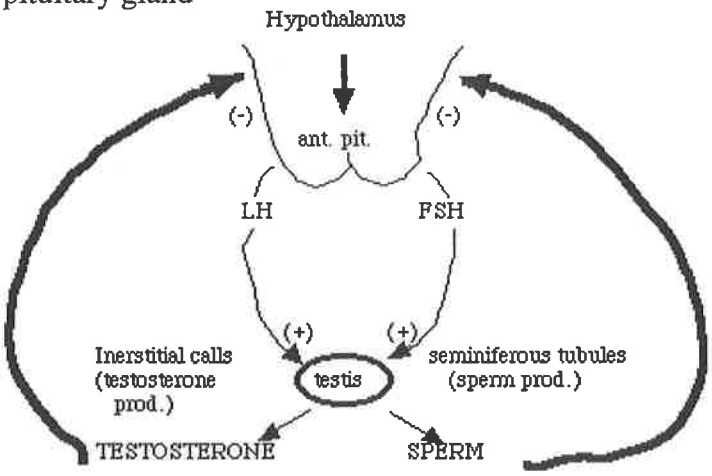


P5. FUNCTIONS OF TESTOSTERONE

- *testosterone*
- is the major hormone of the male
- develop and functioning of sex organs
- maturation of sperm
- second hair (facial hair, pubic etc.)
- voice deepens
- including muscle mass

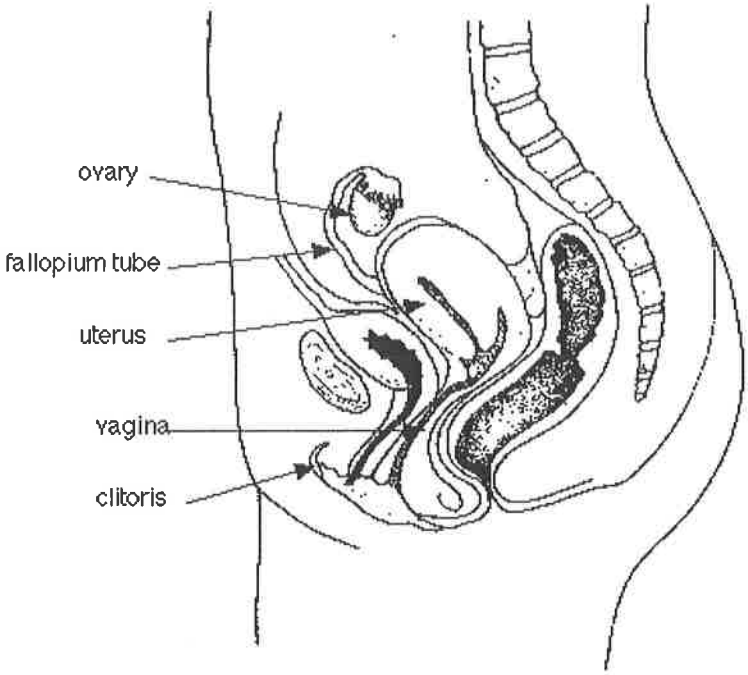
P6. CONTROL OF TESTOSTERONE

- control of testosterone levels is done by hypothalamus and gonadotrophic hormones from the ant. pituitary gland



P7. STRUCTURE AND FUNCTION OF THE FEMALE

(1) *The Ovaries* - 2 Functions
(a) Produce eggs from follicles
(b) Produces sex hormones: **estrogen** (from follicles) & **progesterone** (from corpus lutem).



P8. The Female Hormones

1. Anterior Pituitary - makes 2 hormones that act on the ovaries

a) **FSH** - Follicle Stimulating Hormone - stimulates the follicle to mature and causes it to produce estrogen

b) **LH** - Leutinizing Hormone - maintains the corpus luteum and causes it to produce estrogen
- these are the *Gondadotrophic Hormones* (FSH & LH)

- they regulate the ovary's production of *female sex hormones*

2. Ovary - makes 2 hormones that act on the endometrium (uterus lining)

a) **Estrogen** (made by the follicle)

b) **Progesterone** (made by the corpus luteum)

Functions of Estrogen
stimulates:
- growth of uterus and vagina
- secondary sex characteristics (body hair, fat distribution, increased pelvic girdle, breasts)
- egg maturation
- endometrium thickening

- increased levels of progesterone causes endometrium to thicken further (2x) and thick mucoid secretion
- endometrium is ready to receive fertilized egg (zygote)

NORMALLY ->
- egg is not fertilized therefore copus luteum begins to degenerate therefore progesterone falls
- low progesterone and estrogen cause endometrium to be shed. Menstration begins

P12. Implantation

- fertilized egg attaches to endometrium (uterus lining) several days after fertilization
- hormones are produced by the zygote to prevent menstruation
- **HCG** - Human Chorionic Gonadotrophin is the hormone, and it *maintains the corpus luteum* which continues to produce estrogen which prevents the endometrium from shedding. Pregnancy test uses monoclonal antibodies to test for this hormone.
- corpus luteum persists for 3 - 6 months
- endometrium and fetus develop the *plaecenta* (organ of exchange between maternal and fetal blood systems)
- the placenta continues production of HCG, and also produces *prog* . and *estrogen* . Higher levels of these 2 hormones shut of release of FSH from ant. pit. preventing ovulation and maintaining the endometrium. (Birth control pill does this too)

P11. Oxytocin

Oxytocin is a hormone produced by the **Posterior pituitary gland** . It is controlled by a positive feedback system. In a positive feedback system, the level of the hormone in the blood feeds back to the post. pit. and *increases* release of Oxytocin. Oxytocin is responsible for causing the uterus to contract during birth. Thus, one birth contraction stimulates the release of more oxytocin, which leads to a stronger, closer contraction, which stimulates the release of *more* oxytocin and so on. Thus, birth contractions get stronger and closer until the birth of the baby. A positive feedback system is unstable and does not lead to homeostasis. They are rare in the human body.