Lipids

Classification of Lipids
Fatty Acids
Glycerides
Nonglycerol Lipids
Complex Lipids
Structure of Biological Membranes

Types of lipids

Fatty Acids
- Saturated
- Unsaturated

Glycerides
- Neutral
- Phosphoglycerides

Complex Lipids
- Lipoproteins
- Glycolipids

Nonglycerides
- Sphingolipids
- Steroids
- Waxes

Lipid functions

Cell membrane structure
- Creates a barrier for the cell.
- Controls flow of materials.

Energy storage
- Fats stored in adipose tissue.

Hormones and Vitamins
- Hormones – communication between cells.
- Vitamins – assist in the regulation of biological processes.

Fatty acid structure

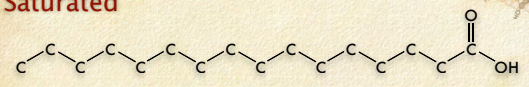
Long chain monocarboxylic acids

$CH_3(CH_2)_nCOOH$

- Size Range: C_{12} – C_{24}
- Always an even number of carbon.
- **Saturated** – no double bonds.
- **Unsaturated** – one or more double bonds.

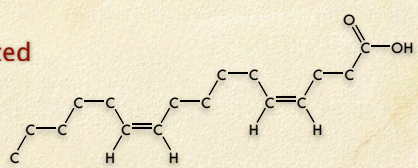
Fatty acid structure

Saturated

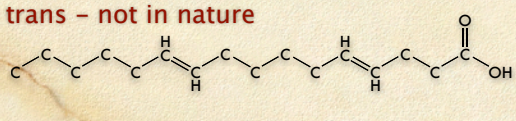


Unsaturated

cis



trans – not in nature

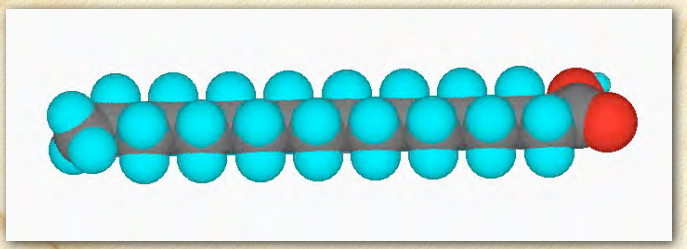


Some common fatty acids

Common name	IUPAC name	MP ^oC	Formula
Lauric	n-dodecanoic	44	$C_{11}H_{23}COOH$
Palmitic	n-hexadecanoic	63	$C_{15}H_{31}COOH$
Stearic	n-octadecanoic	70	$C_{17}H_{35}COOH$
Palmitoleic	cis-9-hexadecenoic	0	$C_{15}H_{29}COOH$
Oleic	cis-9-octadecenoic	16	$C_{17}H_{33}COOH$
Linoleic	cis,cis,9,12-octadecadienoic	5	$C_{17}H_{31}COOH$

Presence of double bonds reduces melting point. In nature, all double bonds are 'cis.'

Steric acid



Oleic acid

Reactions of fatty acids

React like any other carboxylic acid.

Esterification

$$RCOOH + ROH \rightarrow R\text{-}\overset{O}{\overset{\|}{C}}\text{-}OR + H_2O$$

Hydrolysis

$$RC\text{-}\overset{O}{\overset{\|}{C}}\text{-}OR + H_2O \rightarrow R\text{-}\overset{O}{\overset{\|}{C}}\text{-}OH + ROH$$

Acid-base

$$RCOOH + NaOH \rightarrow RCOO^- Na^+ + H_2O$$

Reactions of unsaturated fatty acids

- They can undergo the same reactions.
- Will also undergo addition.
- Most common addition is hydrogenation.

$$R\text{-}\overset{H}{\underset{|}{C}}=\overset{H}{\underset{|}{C}}\text{-}CH_2CH_2COOH \xrightarrow[Ni]{H_2} R\text{-}CH_2CH_2CH_2CH_2COOH$$

- Used to convert vegetable oils to margarine. It is during hydrogenation that trans fatty acids can be produced.

Unsaturated fatty acids eicosanoids

Eicosanoids

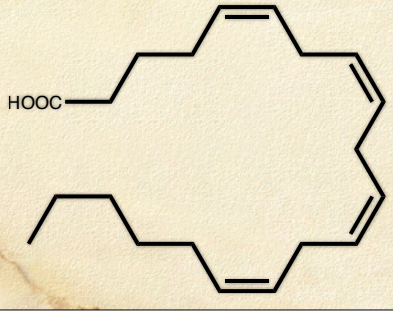
- All are unsaturated.
- All have twenty carbons.
- Two are Essential Fatty Acids.
  Can't be produced by the body.
  examples: linolenic and linoleic acids

Three groups
Prostaglandins, leukotrienes, thromboxanes

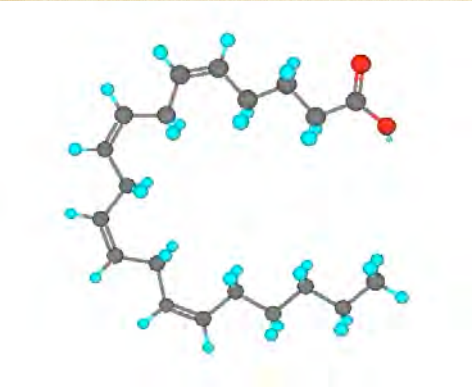
Prostaglandins

Originally isolated from seminal fluid.

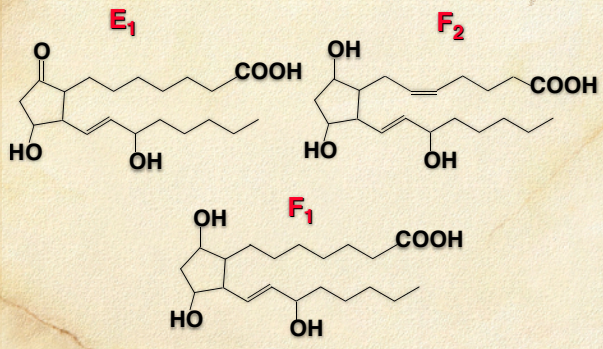
All are derived from arachidonic acid.



Arachadonic acid



Prostaglandins



Prostaglandins

Biological effects

- Stimulation of smooth muscles
- Regulation of steroid production
- Inhibition of gastric secretion
- Inhibition of hormone-sensitive lipases
- Inhibition / stimulation of plate aggregation
- Regulation of nerve transmission
- Sensitization to pain
- Mediation of inflammatory response

Blood clotting

Thromboxane A_2

Produced by platelets in blood.
Stimulates constriction of blood vessels.
Aggregation of platelets.

Prostacyclin

Produced by cells that line blood vessels.
Reverses effects of Thromboxane A_2.

Aspirin therapy

(1/day) following strokes or MI. Acts as anticoagulent – antiplatelet aggregation.

Inflammatory response

Protective mechanism when tissue is damaged.
Results in swelling, redness, fever, and pain.
Prostaglandins promote this response.

Drugs like aspirin and Ibuprofen

- Anti-inflammatory.
- Block prostaglandin synthesis.
- Cause reduction in this response.

Tylenol – analgesic, not an anti-inflammatory

Smooth muscle contractions

Prostaglandins stimulate contractions in the reproduction system – uterine contractions

Dysmenorrhea

- Painful menstruation.
- Evidence shows that this may result from an excess of prostaglandins.
- Physicians often order Motrin (Ibuprofen) for this.

Gastrointestinal tract

Prostaglandins will:

Inhibit the secretion of hydrochloric acid in the stomach.

Increase secretion of mucus layer. Protects mucosa from acid invasion.

Aspirin inhibits prostaglandin production
Extended use can result in ulceration of the stomach lining. Why?

Other uses

In the kidneys

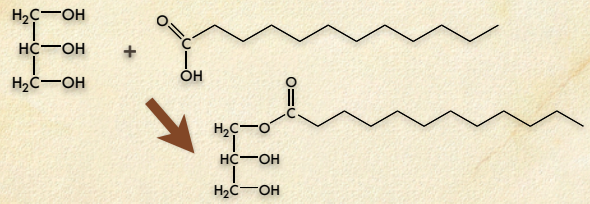
- Cause renal blood vessels to dilate.
- Aid in excretion of water and electrolytes.

In the respiratory tract

- Produced by in lungs – leukotrienes.
- Cause constriction of bronchi – asthma
- Other prostaglandins act as bronchodilators.

Neutral glycerides

Ester of glycerol and a fatty acid.
Principal function is energy storage – fat or oil.

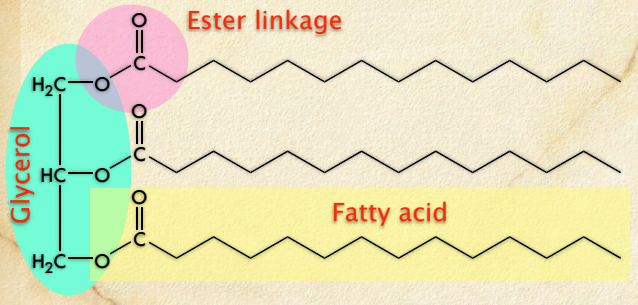


May have 1 – 3 fatty acids which need not be the same.

1 – monoglyceride 2 – diglyceride 3 – triglyceride

Neutral glycerides

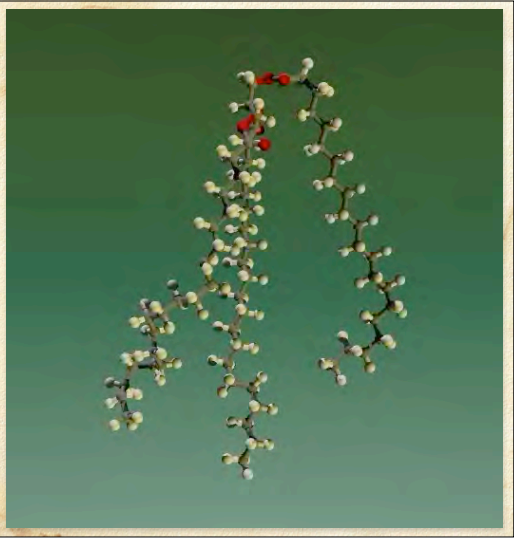
An example of a triglyceride.

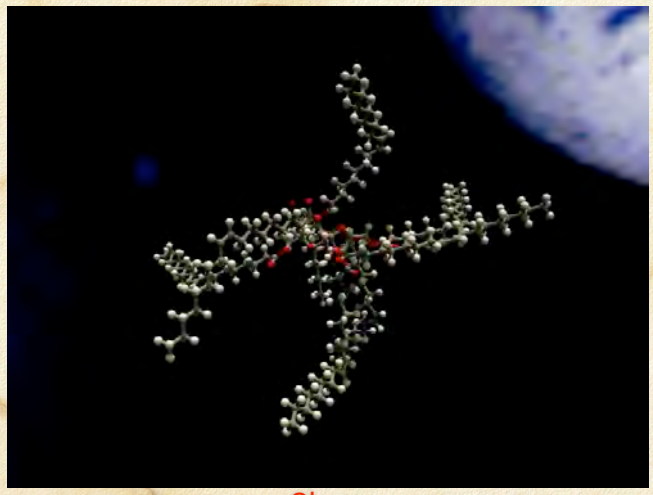


Fats and oils

- Both are triglycerides.
- Fats
  - Typically obtained from animals
  - Solids at room temperature.
  - Made from saturated fatty acids.
- Oils
  - Typically obtained from plants.
  - Liquids at room temperature.
  - Made from unsaturated fatty acids.

Fat

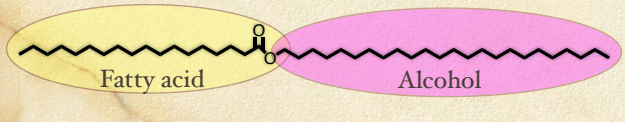




Olestra

Waxes

- Water insoluble and hard to hydrolyze
- Often used to provide a protective coating (leaves, skin, fur, hair...)
- Beeswax and Sebum are examples.
- Ester of a fatty acid and a long chain alcohol.



Phosphoglycerides

Lipids that contain a phosphate group.

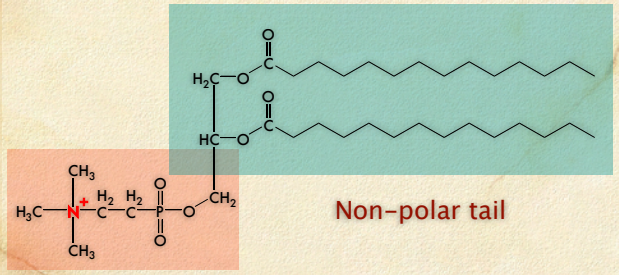
Modified fat where a phosphate replaces one of the fatty acid chain.

Uses

- Production of cell membranes.
- Emulsifying agents.

Phosphoglycerides

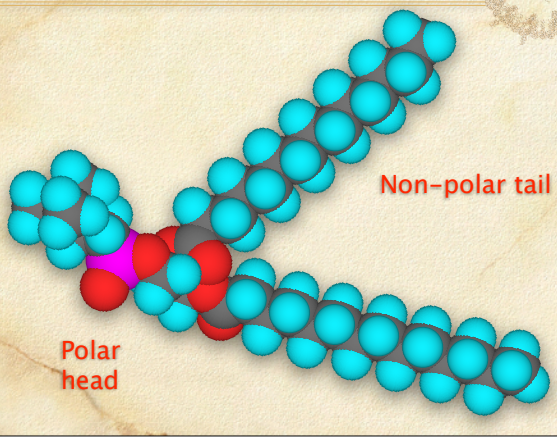
Lecithin – phosphatidylcholine



Non-polar tail

Polar head

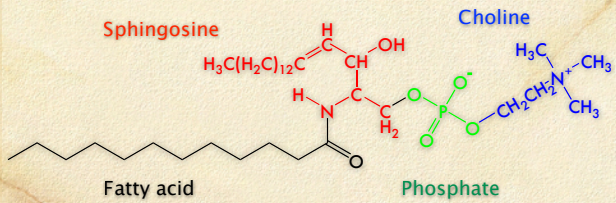
Lecithin



Nonglycerol lipids

Sphingolipids

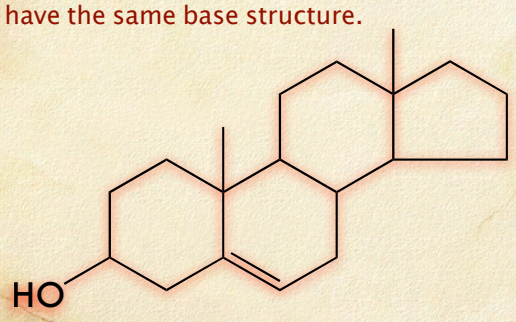
- A type of phospholipid NOT derived from fat.
- Used primarily in nerve tissue - myelin sheath.
- In people, 25% of all lipids are sphingolipids.



Sphingomyelin

Steroids

Broad class of compounds that all have the same base structure.

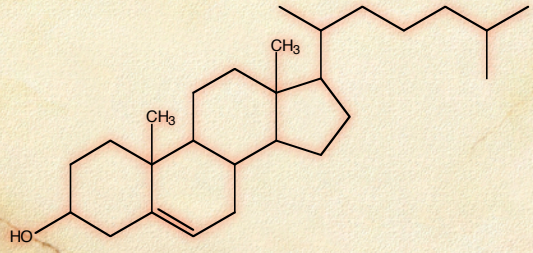


Steroid nucleus

Steroids

Cholesterol

Principal membrane lipid for fluidity.



Cholesterol

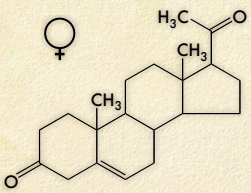
Associated with hardening of the arteries. Appears to coat the arteries – plaque formation.

Results in increased blood pressure from:

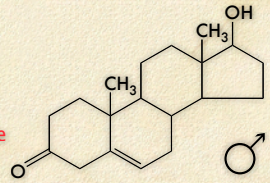
- Narrowing of arteries
- Reduced ability to stretch
- Clot formation leading to:
- Myocardial Infarction
- Stroke

Steroids

Some reproductive hormones.



progesterone

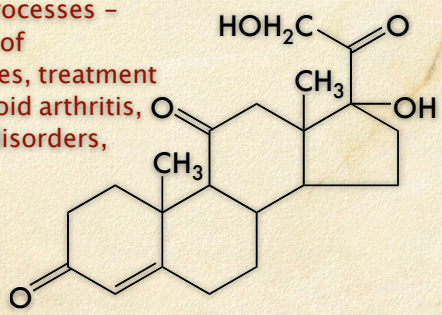


testosterone

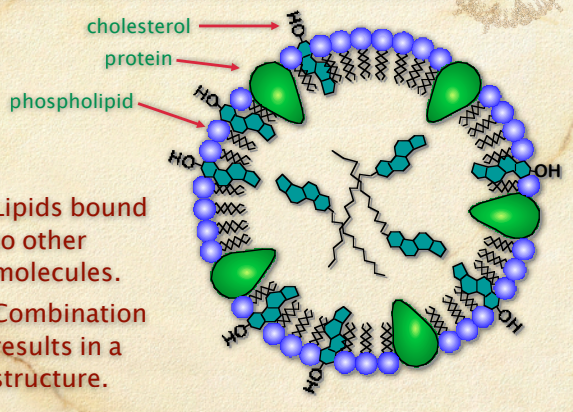
Steroids

Cortisone

Associated with a many biological processes – metabolism of carbohydrates, treatment for rheumatoid arthritis, asthma, GI disorders, rashes ...



Complex lipids



Lipids bound to other molecules.

Combination results in a structure.

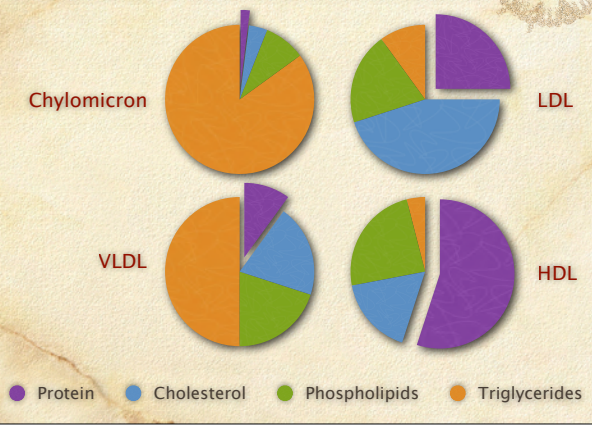
Complex lipids

Four major classes of plasma lipoproteins.

- Chylomicrons
- Very low-density lypoproteins (VLDL)
- Low-density lypoproteins (LDL)
- High-density lypoproteins (HDL)

Each is composed of several types of lipids.

Composition of complex lipoproteins



Composition of complex lipoproteins

Lipoprotein	Density, g/cm^3	Diameter, nm
Chylomicron	< 0.95	80-500
Very low density	0.95 - 1.006	30-800
Low density	1.006 - 1.063	18-28
High density	1.063 - 1.2	5-12

Function of lipoproteins

Chylomicrons

Transport triglycerides from intestines to other tissue - except kidneys. (Transport exogenic products.)

VLDL

Bind triglycerides in liver and released to the blood.

LDL

Carry fat and cholesterol to peripheral tissues. Produced from VLDL in blood. Conversion also releases some cholesterol into blood vessels.

HDL

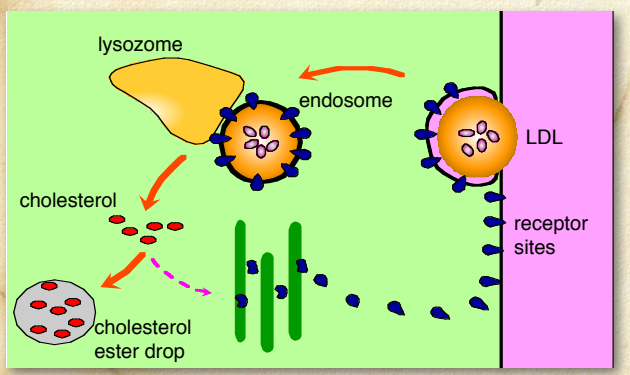
Bound to plasma cholesterol. Transport cholesterol and fat to liver. Can pick up chlosterol that has been 'dumped' in the blood stream.

Entry of LDL into cells

Receptor-mediated endocytosis

- Receptors on cell membrane sense LDL.
- Pocket forms in membrane - invagination.
- Takes LDL into cell, forming endosome.
- Endosome fuses with lysosome. - digestive organelle
- Enzymes digest LDL, releasing cholesterol.

Receptor-mediated endocytosis

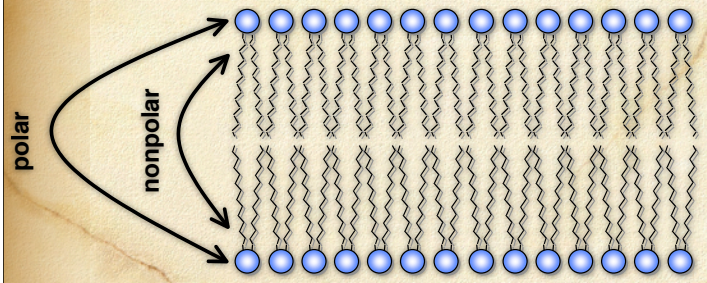


Regulation of LDL

- Presence of cholesterol in cell
  - Reduces synthesis of more cholesterol.
  - Inhibits production of LDL receptors.
- Large number of receptors in liver allow rapid removal of LDL
- LDL defect in gene coding
  - Allows too much cholesterol to accumulate in the plasma.
  - Excess cholesterol is then deposited artery walls – atherosclerosis.

Biological membranes

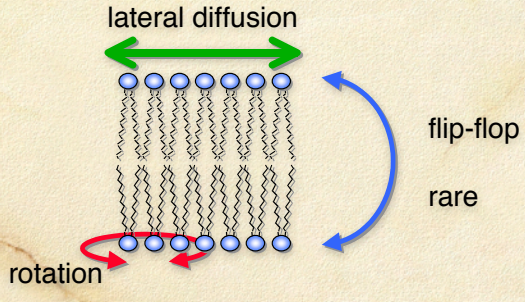
Cell and organelle membranes are composed of two layers – lipid bilayers.



Fluid structure of membranes

Membranes are not static.

Layers move over each other based on percent of unsaturated fatty acids.



Mosaic structure of membranes

Components

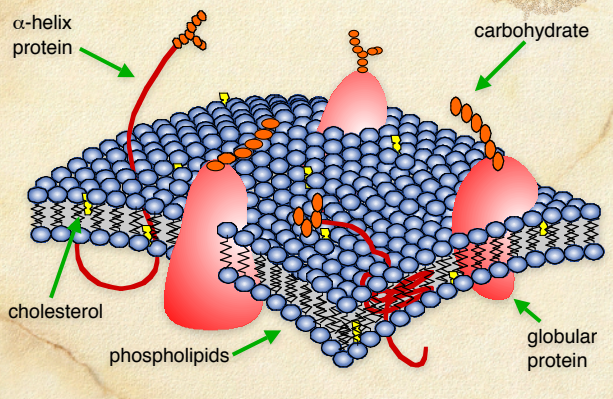
Peripheral membrane proteins
bound only to one side of membrane.

Integral membrane proteins
embedded within the membrane.

Both types of proteins can move around on surface of cell.

Proteins don't flip in and out or act like revolving door.

Mosaic structure of membranes



Membrane transport

- Cell membrane controls passage of materials in and out of cell.
- Most transport is controlled by integral membrane transport proteins.
- Small molecules, like water, pass through membrane on their own – passive transport.
- Larger molecules and ions may require energy to pass through membrane – active transport.

Passive transport

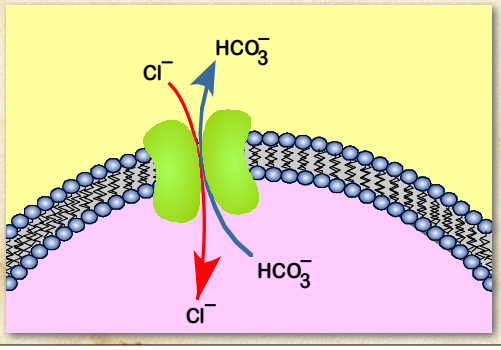
Diffusion

- Small molecules (CO_2, O_2, H_2O) will simply pass through cell membrane.
- Entropy is driving force – wants equal concentrations of both sides of membrane.
- Membrane is considered selectively permeable to these molecules.
- This concept was discussed last semester.

Facilitated diffusion

Permeases

Specific protein transports materials across a membrane.



Osmosis
Review of Chapter 7

The diffusion of a solvent from a dilute solution through a semipermeable membrane to a more concentrated one.

Semipermeable membranes

- ☑ Only allow small molecules to go through.
- ☑ Cell walls are semipermeable membranes.

Osmotic pressure

Three conditions can exist for cells

Concentration is the same on both side

isotonic

Concentration is greater on the inside

hypertonic

Concentration is greater on the outside

hypotonic

Isotonic

A red blood cell and plasma have the same osmotic pressure

Cells in 'high salt' solutions

If the level of salt in the plasma is too high, the cell collapses.

Hypotonic cell, hypertonic solution.

Crenation – water is drawn out of the cell.

Cells in 'low salt' solutions

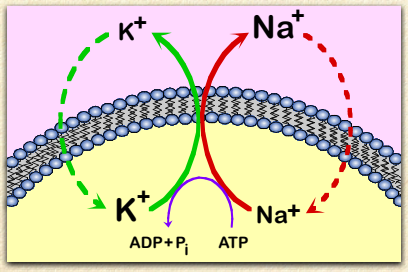
If the level of salt in the plasma is too low, the cell swells and ruptures.

Hypertonic cell, hypotonic solution.

Hemolysis – water is drawn into the cell.

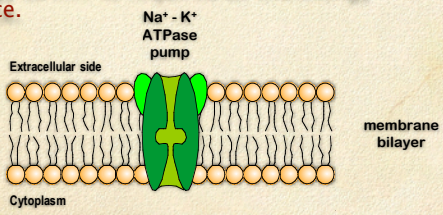
Active transport

When a cell must expend energy to move needed materials across the cell membrane.

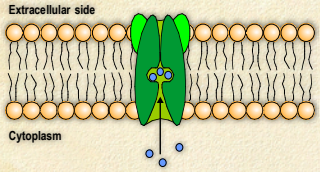


Na^+ – K^+ ATPase pump

- This system is used to pump sodium out of the cell and potassium into it.
- Two protein subunits span the cell membrane.
- Energy as ATP is required as the energy source.



Passing Na^+ out of cell.



3 Na^+ move into the unit where they bind.

Energy is used to shift the position of the proteins, releasing the sodium