Molecules – General

Inorganic Molecules

~2/3rd 's of body consists of inorganic molecules

general characteristics:

small molecules: only a few atoms & bonds

little or no carbon atoms

usually dissolve easily in water

Major kinds of inorganic molecules inside cells:

1. Water

perhaps most important and most abundant molecule in the body

The human body is made up mostly of water; ~60 - 65% (40 L)

can live for several weeks or a month without food but not more than a few days without water

its unique properties relate to its structure, strong polar nature and hydrogen bonds it can form

a. Universal solvent

can only have chemical reactions (metabolism) if the chemicals are dissolved in some liquid (=**solvent**)

more things dissolve in water than in any other solvent

b. chemical reactant

water molecules are directly used in some important chemical reactions

eg. synthesis and decomposition of most organic polymers

c. ability to stabilize temperature

water absorbs and releases heat slowly

contributes to temperature homeostasis

eg. sweating → cooling

d. acts as lubricant

prevents friction and damage to moving parts

eg. heart, lungs, joints, stomach, intestine, etc

e. cushioning

water protects organs from physical damage if jostled

water baths brain and spinal cord

fluid surrounds each cell

f. transport medium

blood, lymph

moves things from place to place

2. Electrolytes (ions)

molecules that tend to disperse in solution into charged atoms

[some organic molecules are also electrolytes]

ions; eg Ca^{++}, Na^{+}, Cl^{-}, K^{+}, et
salts; NaCl, carbonates, phosphates
acids and bases; HCl, NaOH

organisms are extremely sensitive to changes in electrolyte composition

general functions of electrolytes:

a. help maintain salt/water balance
b. acid/ base balance
c. bone and teeth formation

d. functioning of nerve and muscle cells
e. enzyme activation

a. Calcium

99% of Ca^{++} is in bones as reservoir (eg.Calcium phosphate)
1% circulates in body fluids
? muscle cells
functions:
- blood clotting
- synapses
- hormone secretion
- nerve impulses
- muscle contractions

b. Sodium

main cation (+) in extracellular fluid (ECF)
main regulator of its volume
also helps in acid/base balance
nerve transmission
muscle contractions

c. Potassium

main cation in intracellular fluid
nerve impulse transmission
muscle contraction
steady heartbeat

d. Iron

most of body's iron is in form of hemoglobin and myoglobin
→oxygen transport and storage
also used as cofactor in enzymes
→ ETS energy pathways
→enzymes for AA, hormone and neurotransmitter synthesis

e. Iodine

I_2 (=iodine gas) is a poison, but I is essential for life
integral part of 2 hormones of thyroid

→regulate body temperature
metabolic rate
reproduction
blood cell formation
nerve and muscle function

acids and **bases**

acids → release H^+ (proton donors)
bases → releases OH^- (proton acceptors)

pH = -log $[H^+]$
pure water: $\#H^+ = \#OH^-$ → neutral, pH=7

pH = 7 = .0000001 gm H^+/liter

pH 6 is 10x's more acidic than pH of 7

body is protected from drastic pH changes by the presence of buffers

3. Gasses

O_2 gas

comprises about 20% of atmosphere
essential for aerobic respiration
not same thing as oxygen atoms

CO_2 gas

comprises 0.03% of earth's atmosphere
source of carbon in organic molecules
waste product of respiration

NO gas (nitric oxide)

acts as neurotransmitter and hormone
eg. relaxes smooth muscles (Viagra)

CO

poison

Organic Molecules

~1/3rd of body consists of organic molecules

large – made of 100's, 1000's 10,000's atoms

contain lots of carbon = **carbon backbone**
carbon can form 4 covalent bonds
easily forms chains, rings, branching structures

also usually contain lots of
H, O, N and P atoms

may or may not dissolve easily in water

all major organic molecules except vitamins can be used for energy production

major kinds of organic molecules:

1. **carbohydrates**
2. **lipids**
3. **proteins**
4. **nucleic acids (include ATP)**
5. **vitamins**

most larger organic molecules are **polymers** of smaller units:

carbohydrates → monosaccharides (simple sugars)
proteins → amino acids
fats → fatty acids & glycerol
nucleic acids → nucleotides

Carbohydrates

sugars and starches, fiber

comprise 1-2% of total body mass

larger ones contain long chains of carbon atoms
→ many chemical bonds
→ huge store of chemical energy

Kinds

Simple Carbohydrates = **sugars**
Complex Carbohydrates = **starches** and **fiber**

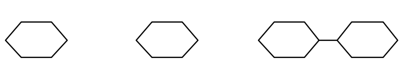
simple sugars (monosaccharides)

simplest kinds of carbohydrates
5 or 6 carbon atoms

eg. glucose, fructose, ribose, deoxyribose

disaccharides

hook two monosaccharides together
eg.



glucose + glucose = maltose

in process of forming disaccharide, a molecule of water is removed = **dehydration synthesis**

addition of water to break bond = **hydrolysis**

eg. sucrose, lactose

sucrose
fructose-glucose
fruits, veggies, grains
table sugar: refined from sugar cane, sugar beets

lactose
galactose-glucose
main carbohydrate in milk (30 – 50% of milks energy)

starches (complex carbohydrates)

complex carbohydrates

simple sugars polymerize to form starches

consist of many glucose units and sometimes a few other kinds of sugars

= polysaccharides
eg. "starch", glycogen, "fiber"

<u>**General Functions of Carbohydrates:**</u>

1. decomposition to provide most energy for cell in form of ATP

most cells in body get most energy from carbohydrates (esp brain and RBC's)

2. excess food converted to glycogen
mostly stored in liver and muscles

3. synthesis of glycoproteins and glycolipids
cell markers, transport

4. ribose and deoxyribose to synthesize DNA and RNA

Lipids

fats and oils, waxes
- oils → liquid at room temperature
- fats → solid at room temperature

most abundant organic molecules in body
(14 - 20% in lean adult)

many different kinds:
- triglycerides
- phospholipids
- steroids

most fats are polymers of
- glycerol,
- fatty acids, and
- sometimes phosphates

Structure of Different Kinds of Lipids

1. Triglycerides:

90% of dietary fats and oils are triglycerides

also are predominant lipid found in body

responsible for much of the flavor, tenderness, aroma and palatability of foods

polymers of **glycerol** (3C's) and 3 **Fatty Acids**

2. Phospholipids:

replace one fatty acid with phosphate group

3. Sterols

lipid compound with multiple rings
characteristic 4-ring structure

eg. cholesterol
- sex hormones
- bile salts
- vitamin D
- cortisol

General Functions of Lipids:

1. store excess food energy:

2x's energy/gm than carbohydrates contain

2. carry with them fat soluble vitamins: ADEK

3. protective insulation from heat and cold

4. insulation around neurons = **myelin**

5. phospholipids are one of main components of all cell membranes

6. sterols are used to manufacture bile & some hormones

Proteins

second most abundant organic molecules in body
(15-18%).

much more complex structure than either carbohydrates or lipids

often polymers of 100'x or 1000's amino acids
(MW of 6000 to 40M)

all amino acids have the same basic structure:
- amino group: $-NH_2$
- acid group: -COOH
- R group → unique for each AA

20 different kinds of amino acids (22 in bacteria)
→ ~ half are **essential nutrients**

the body can synthesize ~ half of the 20 AA's

8 AA's are essential to adults and must be gotten in

diet (10 in children)

complete vs incomplete proteins

→ small chains = **polypeptides**
→ long chains = **proteins**

the **sequence of amino acids** in each protein
determines its **shape**
and therefore its **function**

their different 3-D shapes determine their function

sequence of amino acids
→ conformation
→ function

proteins are very sensitive to environmental changes

→ changes in temp, pH, salts, etc can cause them to "denature" and become nonfunctional

they uncoil or loose their shape and function

eg. cooked cheese, eg mozzarella and Swiss, becomes stringy → proteins unwind and get hooked together end on end by calcium camps

eg. albumin in cooked egg turns solid

Functions of Proteins

the AA's of dietary protein are used to synthesize:

1. **structural elements or fibers**
   eg. collagen in bones and teeth, tendons and ligaments, arterial walls
   eg. actin and myosin in muscle cells

2. **hormones**
   messenger molecules
   eg. insulin

3. **transport proteins**
   oxygen → hemoglobin
   lipids (Hold's, LDL's)
   hormones
   iron

4. **membrane carriers**
   facilitated diffusion
   active transport

5. **antibodies**
   = globulins = immunoglobins
   attaches to antigen in inactivate or kill it

6. **buffers**
   can absorb and release H^+

7. **regulate salt/water balance**
   osmotically active → attract water
   as proteins build up draws water in (edema)

8. **clotting**
   fibrinogen

9. **photoreceptors**
   eg. rhodopsin is light sensitive changes shape with light hits it to generate a nerve impulse

10. **enzymes**
    up to 50,000 different kinds of reactions in each cell
    → each requires specific enzyme

many genetic diseases are the result of an error in a gene that substitutes the wrong amino acid into a critical part of a protein causing it to have the wrong shape and therefore doesn't function properly or at all

eg. hemophilia
eg. sickle cell anemia

Nucleic Acids

comprise <1% by wt of body but vitally important:
1. stores genetic code (genes on chromosomes)
2. controls cell division (mitosis and meiosis)
3. regulates metabolism
   → by controlling enzyme synthesis

very complex molecules that represent the basis for all life

two major kinds of nucleic acids
DNA
RNA

both are polymers of **nucleotides**

each **nucleotide** consists of three major parts:
sugar
phosphate

Nitrogen base

<u>ATP</u>

ATP is a special energy transfer molecule

ATP is the immediate source of energy for cells

food breakdown
→ releases energy from food and stores it as ATP until needed

The energy released by the catabolism of glucose is used for various processes in cells:

Vitamins - General

vitamins are:
1. small organic molecules
   other than proteins, carbohydrates, lipids and nucleic acids
2. used in very small amounts
3. don't form polymers
4. most cannot be made by body
5. cannot be broken down for energy
   [but may play an important role in energy pathways as coenzymes and cofactors]

categorized as:
water soluble and **fat soluble** vitamins

→ affects: a. what foods they are found in
b. if and where they are stored in body
c. toxicity

d. how they are eliminated

Water Soluble (B's, C)

dissolve easily in water, not fat

sensitive to heat and light
→generally don't store well
→lost in cooking

absorbed directly into blood and travel freely throughout the body

generally not stored well in body

→eliminated daily by kidneys
→fewer toxicities
→ needed in frequent, small doses

Fat Soluble vitamins (A, D, E, K)

dissolve easily in fat, not water

generally more heat and light stable
→not destroyed by cooking or storage

first enter lymphatic system

generally require protein transport molecules to travel in blood

blood concentrations are maintained because body retrieves them from storage as needed

stored in liver and fat cells and accumulate; not readily excreted

→don't need every day
→easier to have toxicity:
can reach toxic levels if consumed in excess
→ needed in less frequent doses

play major roles in growth and maintenance

their presence affects health and functions of
- eyes
- skin
- GI tract
- lungs
- bones and teeth
- nervous system
- blood

tend to appear in different foods than water soluble vitamins