

NURSING

Science Lectures



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LEARNING OBJECTIVES

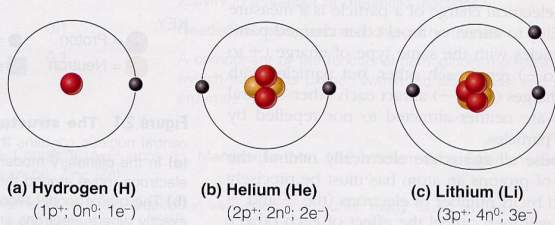
Lecture 2: Overview of Metabolism (Biochemistry)

- revise atomic composition of all matter
- understand metabolic sources of chemical energy
- identify macromolecules of life (sugars, fats, proteins, nucleic acids)

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MATTER – composed of atoms

- nucleus protons (+) **red**
 neutrons (o) **yellow**
- electron shell electrons (-) **black**



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PERIODIC TABLE

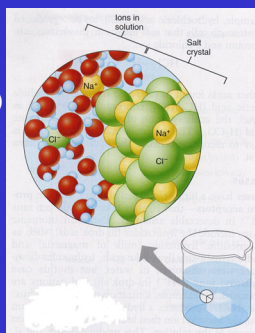
elements vary in atomic composition

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MOLECULES

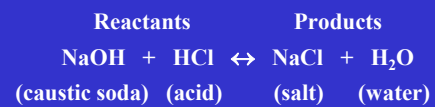
mixtures of atoms
(water = H₂O, salt = NaCl)

- solutions (solvent/solutes)
(homogeneous mix)
- suspensions
(heterogenous mix)
(will settle out)
- colloids/emulsions
(heterogenous mix)
(will not settle out)



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CHEMICAL EQUATIONS



- exchange/displacement (atoms/groups/..)
- reversible (two way reactions)
- balanced equation (stoichiometry)
- redox reactions
 - oxidation (reaction with oxygen)(lose e⁻)
 - reduction (removal of oxygen)(gain e⁻)

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BONDS

atoms bonded together by:

- ionic bonds (donate electrons: cations [+], anions [-])
- covalent bonds (share electrons: single/double/triple)
- hydrogen bonds (polar molecules)

Sodium atom (Na) Chlorine atom (Cl) Sodium ion (Na⁺) Chloride ion (Cl⁻)
 (11p⁺; 12n⁰; 11e⁻) (17p⁺; 18n⁰; 17e⁻) Sodium chloride (NaCl)

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CHEMICAL ENERGY IN BONDS

ATP (adenosine triphosphate)

- a high energy compound used by all cells
- add water
- cleave phosphate group
- releases energy

Adenosine triphosphate (ATP) Adenosine diphosphate (ADP) Inorganic phosphate (Pi) Energy

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What is ENERGY?

concepts: $E = mc^2$
 (Einsteins law of conservation of energy)

matter - has mass (occupies space)
 - solid, liquid, gas

energy - no mass (does not occupy space)
 - kinetic (active), potential (stored)
 - chemical (e.g. ATP)
 - electrical (e.g. charged particles)
 - mechanical (e.g. movement)
 - radiant (e.g. electromagnetic)

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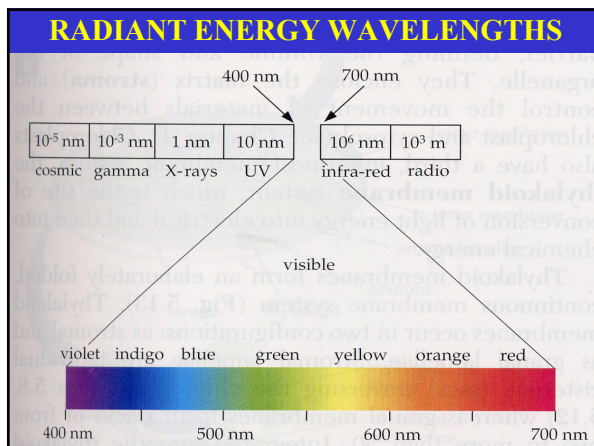
RADIANT ENERGY

isotopes (altered composition), heavier isotopes unstable, spontaneously decay, emitting radioactivity:

- alpha (α) particles (2p+2n packets)
- beta (β) particles (electron-like)
- gamma (γ) particles (electromagnetic energy)

Hydrogen (¹H) Deuterium (²H) Tritium (³H)
 (1p⁺; 0n⁰; 1e⁻) (1p⁺; 1n⁰; 1e⁻) (1p⁺; 2n⁰; 1e⁻)

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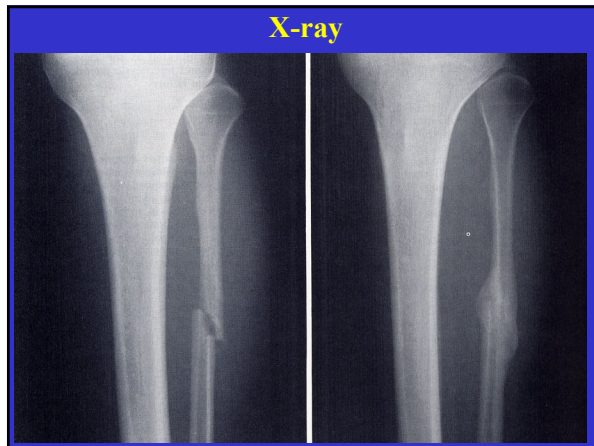
APPLICATIONS

Medical imaging

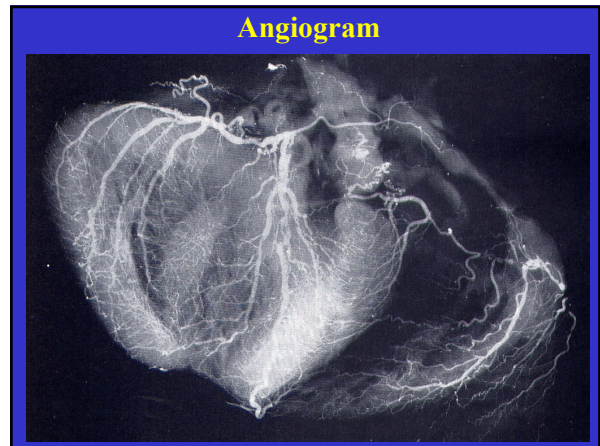
- X-ray (radiograph)
- Ultrasound (sonography)
- CT/CAT (computerized axial tomography)
- MRI (magnetic resonance imaging)

Brain right lung heart left lung spinal cord
 nose tongue trachea liver stomach spleen aorta spinal cord spleen
 spinal cord liver stomach liver buccal mucosa stomach content

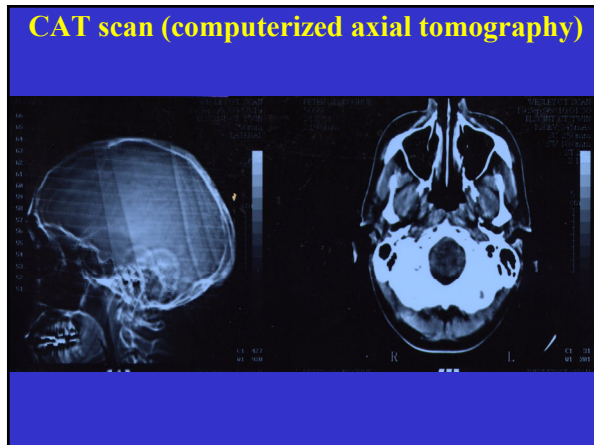
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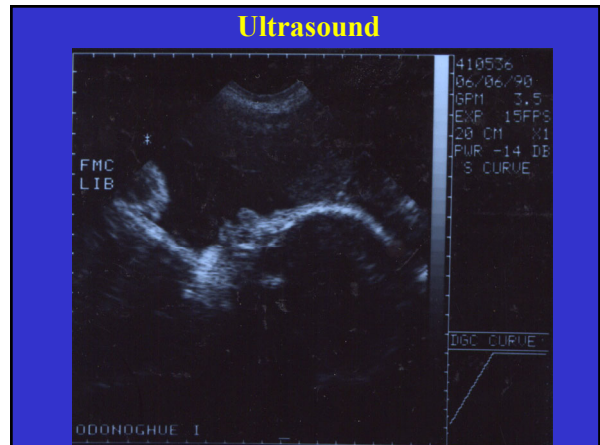
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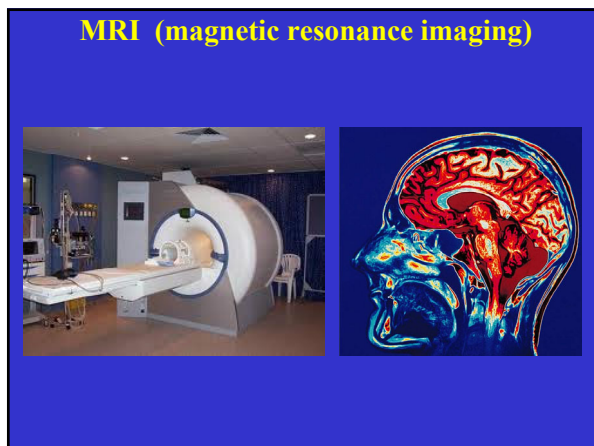
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**Back to
CHEMICALS OF LIFE**

WATER (H₂O)

physical states

- liquid (water)
- gas (vapour)
- solid (ice)

essential to life

- high heat capacity
- reactant (hydrolysis)
- universal solvent

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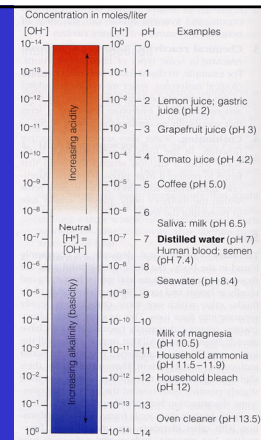
SOLUTES

- salts (electrolytes) dissolved in water
- important for osmotic balance, pH buffering, regulation of membrane permeability
- **cations**
 - sodium Na^+ , potassium K^+
 - calcium Ca^{++} , magnesium Mg^{++}
- **anions**
 - chloride Cl^-
 - bicarbonate HCO_3^-

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ACID-BASE BALANCE

- measured on pH scale
- negative logarithm of hydrogen ion concentration $-\log[\text{H}^+]$
- physiological saline pH 7.4



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MACROMOLECULES (organic molecules > 1,000 MW)

Living organisms consist of 4 main chemicals:

- **carbohydrates (sugars)**
(composed of mono-, di-, poly-saccharides)
- **proteins**
(composed of amino acids)
- **lipids (fats/oils)**
(composed of fatty acids)
- **nucleic acids**
(composed of nucleotides)

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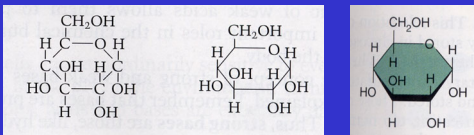
CARBOHYDRATES

Blood glucose

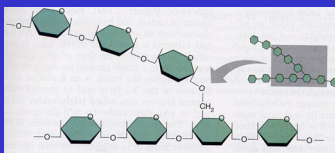
- ingested foods digested by enzymes
- taken up by small intestine
- stored in liver as glycogen
- metabolism under hormonal control (insulin)
- major disorder
 - diabetes (hyper/hypo-glycaemia)

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Glucose



stored as glycogen



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PROTEINS

Polymers composed of up to 20 amino acids

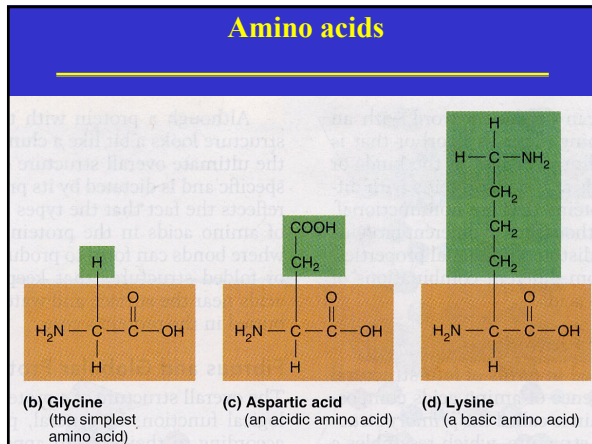
Classified according to structure:

- primary (amino acids)
- secondary (α -helix)
- tertiary (folding) - monomers
- quaternary (combination) - dimers, etc

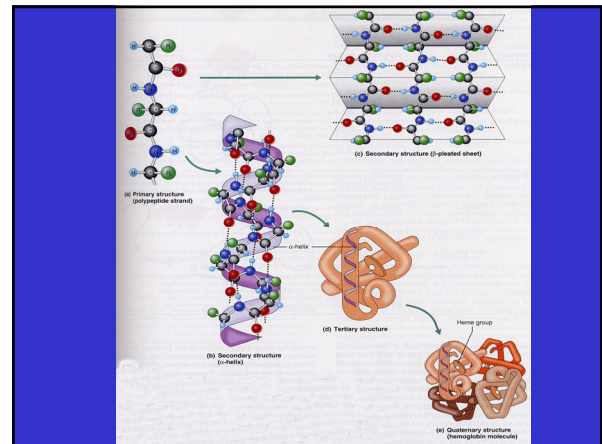
or classified according to chemical class

- simple (amino acids)
- conjugated (metalloproteins, nucleoproteins, lipoproteins, phosphoproteins, glycoproteins)

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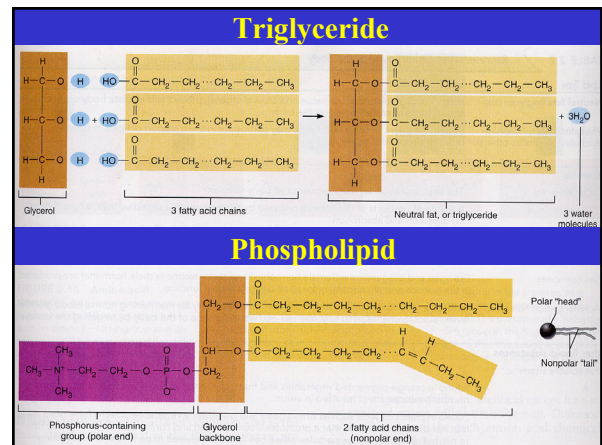
LIPIDS

Comprise:

- long-chain fatty acids (stored as triglycerides - lipoproteins)
- phospholipids (constituents of membranes)
- cholesterol (precursor of steroid hormones, bile acids)

- insoluble, rely on proteins for transport
- synthesized in most tissues (esp. liver)
- problems - hyperlipidaemia (viscous plasma)

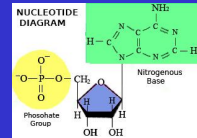
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NUCLEIC ACIDS

- DNA/RNA composed of Adenine/Thymine, Guanine/Cytosine
- Structural unit (nucleotide) composed of
 - N-containing base,
 - pentose sugar (ribose/deoxyribose in RNA/DNA),
 - and phosphate group



NUCLEOTIDE DIAGRAM

Phosphate Group | Sugar | Nitrogenous Base

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METABOLISM

- break down organic substances to derive chemical energy
- assemble low MW precursors into polymeric components
- form and degrade biomolecules for specialized functions

anabolism = synthesis (requires E)

catabolism = breakdown (produces E)

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Cellular energy pathways

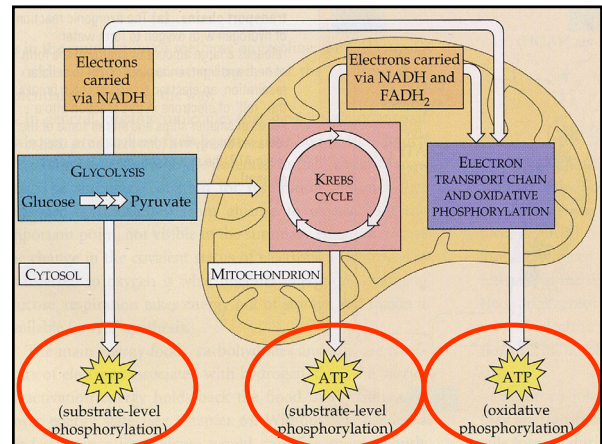
***GLYCOLYSIS: burn sugar to produce energy**

Glucose + 6 Oxygen gas → 6 Carbon dioxide + 6 Water + Energy (ATP)

Additional pathways:

- Krebs cycle (citric acid cycle)
- respiratory chain

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Metabolism

burn:

- sugar
- fat
- protein

(a) Carbohydrates: polysaccharides, disaccharides, composed of simple sugars (monosaccharides)

Polysaccharide → GI digestion to simple sugars → Monosaccharides → To capillary → Cellular uses → ATP

Excess stored as glycogen or fat → Broken down to glucose and released to blood → Cellular uses → ATP

(b) Fats: composed of 1 glycerol molecule and 3 fatty acids: triglycerides

Fatty acids + Glycerol → Lipid (fat) → GI digestion to fatty acids and glycerol → Metabolized by liver to acetyl CoA → Cellular uses → ATP

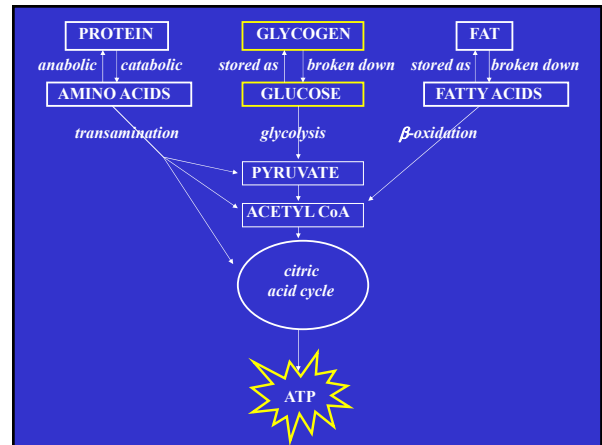
Insulation and fat cushions to protect body organs → Fats build myelin sheaths and cell membranes → Cellular uses → ATP

(c) Proteins: polymers of amino acids

Protein → GI digestion to amino acids → Amino acids → Normally infrequent → Cellular uses → ATP

ATP formation if inadequate glucose and fats or if essential amino acids are lacking → Functional proteins (enzymes, antibodies, hemoglobin, etc.) → Structural proteins (connective tissue fibers, muscle proteins, etc.) → Cellular uses → ATP

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SUMMARY

Structure:
humans are composed of tissues and organs
(learn names and relationships)

Function:
humans are complex chemical reactions
(learn basic metabolism)
(do not rely on media views of diets)

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