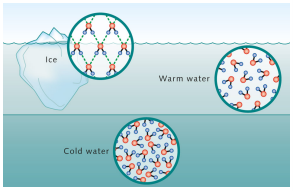
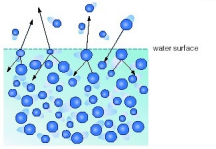
## Properties of Water

- Solid/Liquid Density
  - Water is densest at 4ºC
  - Ice floats
    - Allows life under the ice

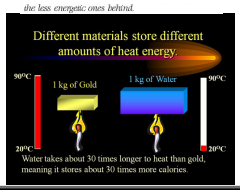


## Benefits of Water

- Temperature Moderator
  - Evaporative cooling
  - High specific heat capacity
    - Water has a great capacity to absorb and retain heat
    - Because of this, the oceans act as heat buffers for the Earth, thus stabilizing Earth's temperature

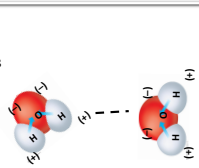


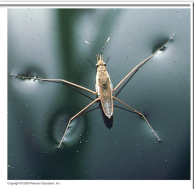

*During evaporation, the more energetic particles escape from the surface leaving the less energetic ones behind.*

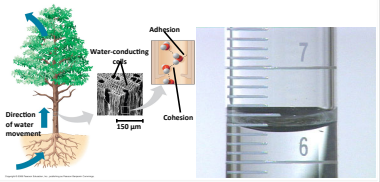



## More properties of water

- Cohesion
  - Water molecules attracted to each other
- Adhesion
  - Water molecules attracted to other substances





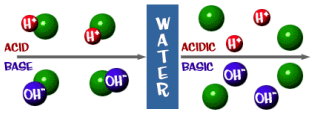


## More properties of water

- Water repels non-polar substances
  - **Hydrophobic** – water fearing
    - Any nonpolar substance
  - **Hydrophilic** – water loving
    - Any polar or ionic substance

## pH

- **Acids** release hydrogen ions ($H^+$) in water (↓ pH)
  - E.g. of a *strong* acid:
    - $HCl \rightarrow H^+ + Cl^-$
  - E.g. of a *weak* acid:
    - $H_2CO_3 \leftrightarrow H^+ + HCO_3^-$
- **Bases** remove $H^+$ in water (↑ pH)
  - Often by releasing hydroxide ions ($OH^-$)
  - $NaOH \longrightarrow Na^+ + OH^-$



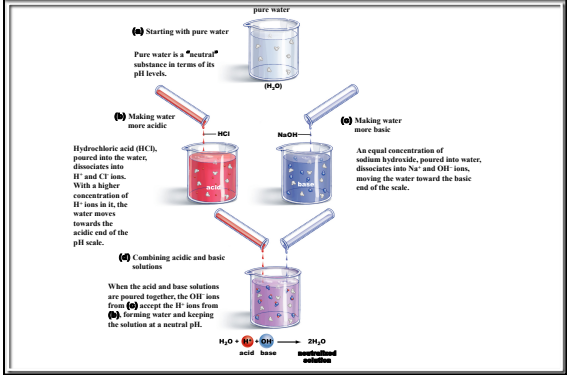

## Buffers

- **Buffer** = resists pH changes
  - Consists of weak acid and a weak base
  - Removes or replaces hydrogen ions ($H^+$) in water
- **Buffer systems** = maintain pH homeostasis in body fluids
  - E.g. carbonic acid-bicarbonate buffer system

$$CO_2 + H_2O \Leftrightarrow H_2CO_3 \Leftrightarrow HCO_3^- + H^+$$

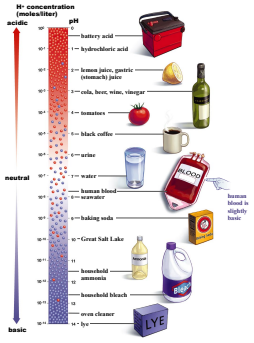
  - Carbonic acid functions as a weak acid
    - » Gives up $H^+$
  - Bicarbonate functions as a weak base
    - » Takes up $H^+$

## Acids and Bases



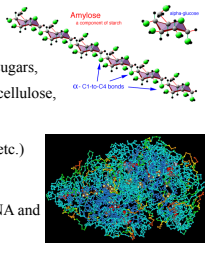

## pH

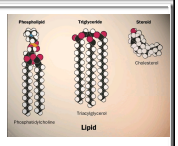
- pH scale
  - measure of H+ concentration
  - smaller number, higher concentration of H+
  - pH scale is logarithmic
    - 3 to 2 is a 10x increase in H+
    - 3 to 1 is a 100x increase in H+
  - This scale runs from 0 to 14, with 0 most acidic,14 the most basic, and 7 neutral



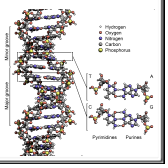

## Organic compounds

- Primarily composed of C and H, and usually O too
- Four classes
  1. **Carbohydrates** (sugars, starch, glycogen, cellulose, chitin)
  2. **Lipids** (fats, oils, etc.)
  3. **Proteins**
  4. **Nucleic acids** (DNA and RNA)
     - Also high-energy compounds (e.g. **ATP**)



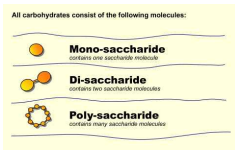





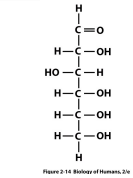



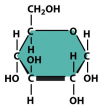
## Carbohydrates

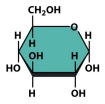
- General formula = $(CH_2O)_n$
  - I.e. carbon and water (carbo- + hydro-)
- Water-soluble
- General functions (in humans):
  - *Energy source and energy reserve*
    - E.g. glucose, starch and glycogen
  - *Structural molecules*
    - E.g. deoxyribose in DNA backbone
- Classifications of carbohydrates:
  - **Monosaccharides** (e.g. glucose, fructose)
  - **Disaccharides** (e.g. sucrose, maltose)
  - **Polysaccharides** (e.g. starch, glycogen)




## Examples of mono- and disaccharides

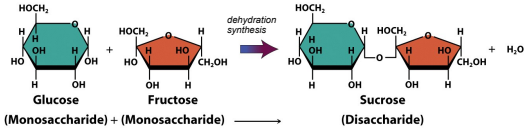






Glucose (represented 3 different ways)

Figure 2-14 Biology of Humans, 2/e




**Glucose** + **Fructose** → **Sucrose**

**(Monosaccharide) + (Monosaccharide) → (Disaccharide)**

Figure 2-15 Biology of Humans, 2/e
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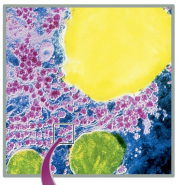
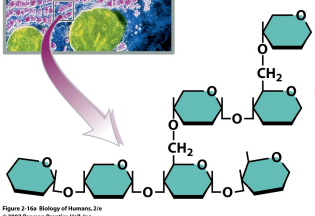
## Example of a polysaccharide





Glycogen (a short segment of it)

Figure 2-16a Biology of Humans, 2/e
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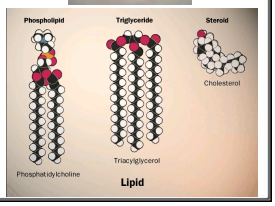
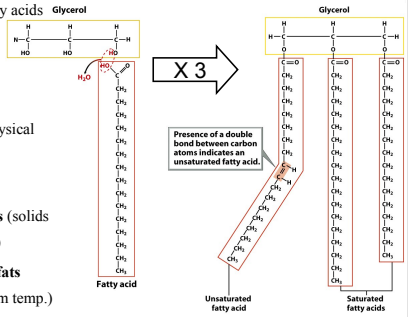
## Lipids

- C, H, and O (but way less O compared to carbohydrates)
- Not water-soluble
- General functions:
  - Concentrated energy storage (over 2X as energy-dense as carbos)
  - Cell membrane components
  - Hormones (most)
- 3 main types:
  - 1. Triglycerides (fats and oils)
  - 2. Phospholipids
  - 3. Steroids



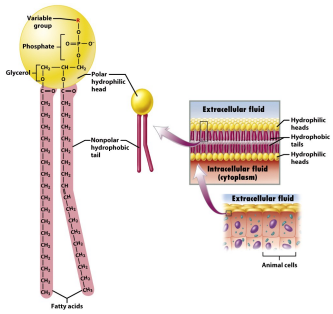

## Triglycerides

- = glycerol + 3 fatty acids
- Functions:
  - Stored energy
  - Insulation
  - Protection (physical cushioning)
- Types:
  - **Saturated fats** (solids at room temp.)
  - **Unsaturated fats** (liquids at room temp.)



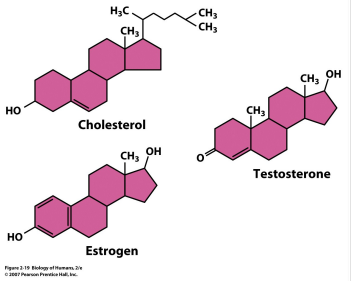

## Phospholipids

- Two fatty acid "tails" (nonpolar/ hydrophobic)
  - + phosphate-containing "head" (polar/ hydrophilic)
- Function: important component of cell membranes



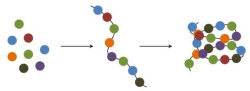
## Steroids

- = cholesterol and its derivatives
- General functions:
  - Hormones
  - A component of cell membranes



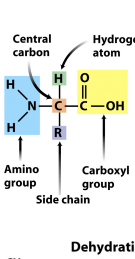

## Proteins

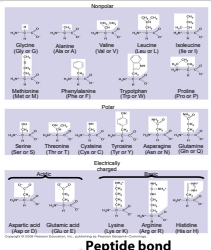
- = large, complex 3-D molecules made up of long chains of **amino acids** joined by *peptide (covalent) bonds*
- Some general functions:
  - Structural support (e.g. bone, hair)
  - Contraction/movement (e.g. muscle)
  - Enzymes = biological catalysts that speed up chemical reactions
  - Oxygen carriers (e.g. hemoglobin)
  - Hormones (e.g. insulin, growth hormone)

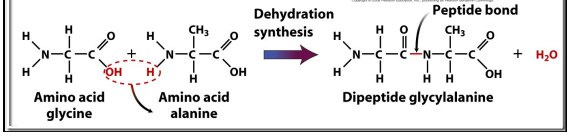



## General structure of amino acids and short peptides

- The R group (side chain)
  - variable and gives each amino acid its specific properties

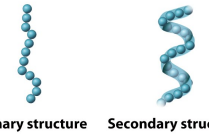


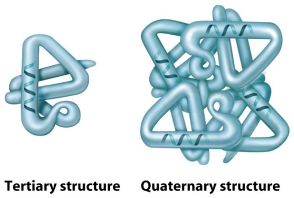
## 4 levels of protein structure

1. Primary structure: linear sequence of amino acids in polypeptide




2. Secondary structure: folding of parts of polypeptide into a helix or pleated sheet

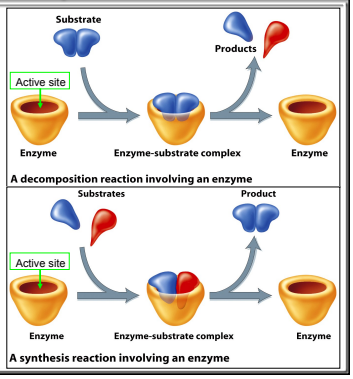
3. Tertiary structure: overall 3-D shape of polypeptide




4. Quaternary structure: interactions between two or more polypeptides to form a larger protein complex

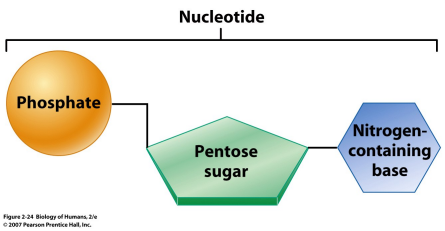
## Enzymes

- Bring specific substrates together and speed up chemical reactions without being consumed in the process




## Nucleic acids

- General function: encode genetic information (instructions for synthesizing specific proteins)
- = long chains of nucleotide subunits
- 2 main types:
  - DNA
  - RNA

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## RNA

- = ribonucleic acid
- Single-stranded
- Sugar: ribose
- Function: aid in protein synthesis
- Nitrogenous bases:
  - Cytosine (C), which can pair with…
    - Guanine (G)
  - Adenine (A), which can pair with…
    - Uracil (U)

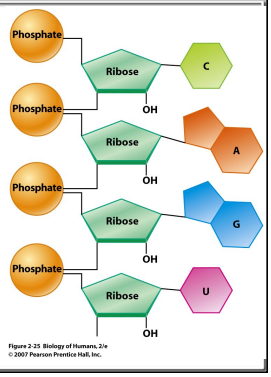


Figure 2-25 Biology of Humans, 2/e
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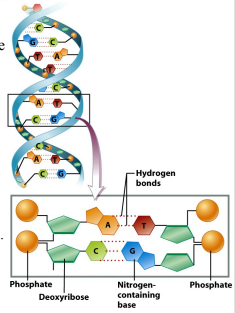
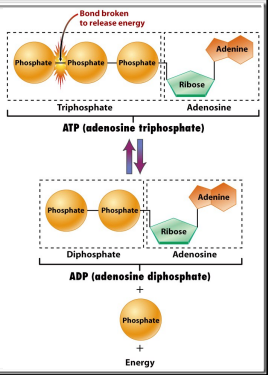
## DNA

- = deoxyribonucleic acid
- Double-stranded and twisted into a helix shape
- Sugar: deoxyribose
- Function: genetic code for protein synthesis; inherited genetic material
  - Makes up genes, which are located on chromosomes
- Nitrogenous bases:
  - Cytosine (C), which again can pair with…
  - Guanine (G)
  - Adenine (A), which can pair with…
  - Thymine (T)
    - I.e., T is to DNA what U is to RNA




## ATP

- = adenosine triphosphate
- ATP is a nucleotide with 2 additional phosphates
  - that are connected by "high-energy bonds"
- Function: "energy currency";
  - temporary storage and quick release of chemical energy to meet immediate energy demands of cells
  - Energy acquired from breakdown of molecules like glucose
    - must first be converted to ATP before being used