The Nature of Biology

A Little Biochemistry (very little.)

- Twenty-five elements are essential to life.
  - Four of these (O, C, H, N) make up about 96% of the weight of the human body.
  - Trace elements occur in smaller amounts.
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A Little Biochemistry *(very little.)*

- Water, water everywhere.
  - Life on Earth began in water & evolved there for over 3 billion years.
  - Modern life still remains tied to water.
  - Cells are composed of 70%–95% water.
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A Little Biochemistry (*very little.*)

- Water’s life-supporting properties:
  - Cohesive nature
  - Ability to moderate temperature
  - Floating ice
  - Versatility of water as a solvent
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Water, water everywhere ...

• Water’s cohesive nature.
  – Water molecules “stick” together as a result of hydrogen bonding.
    • This is called cohesion.
    • Cohesion is vital for water transport in plants.
  – Hydrogen bonds give water an unusually high surface tension.
    • Surface tension is the measure of how difficult it is to stretch or break the surface of a liquid.
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Water, water everywhere ... 

- Water can moderate temperatures
  - Earth’s giant water supply causes temperatures to stay within limits that permit life.
  - Evaporative cooling removes heat from the Earth & from organisms.
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Water, water everywhere ...

- Floating Ice
  - Since ice floats, ponds, lakes, and even the oceans do not freeze solid.
  - Marine life could not survive if bodies of water froze solid.
The Universal Solvent

A solution is a liquid consisting of two or more substances evenly mixed.

- The dissolving agent is called the solvent.
- The dissolved substance is called the solute.
- When water is the solvent, the result is called an aqueous solution.
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Organic Chemistry

• Although a cell is mostly water, the rest of the cell consists mostly of carbon-based molecules.

• Organic chemistry is the study of carbon compounds.
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We are organic life-forms.

- The versatile carbon (C) atom.
- Carbon can bond to itself in an almost limitless combination of straight or branched chains.
- Form an infinite number of compounds.
- No other element can do so.
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The simplest organic compounds are **hydrocarbons**.

- These are organic molecules containing only carbon and hydrogen atoms.

- Example of simple hydrocarbons: *methane* ($CH_4$).

- Complex: *gasoline*.

- The hydrocarbons of fat molecules provide energy for our bodies.
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3-D shape defines organic molecule function.

- Each type of organic molecule has a unique 3-D shape that defines its function in an organism.
- The molecules of your body recognize one another based on their shapes.
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3-D shape defines organic molecule function.

- The unique properties of an organic compound depend not only on its carbon skeleton but also on atoms attached to the skeleton called **functional groups**.

![Functional groups](image)

- **Hydroxyl group**
  - Found in alcohols and sugars

- **Carbonyl group**
  - Found in sugars

- **Amino group**
  - Found in amino acids and urea in urine

- **Carboxyl group**
  - Found in fatty acids
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Giant Molecules.

• On a molecular scale, many of life’s molecules are gigantic.
  – Biologists call them macromolecules.
  – Examples: proteins, DNA

• Most macromolecules are polymers.
  – Polymers are made by stringing together many smaller molecules called monomers.
There are four categories of large molecules in cells.

- Carbohydrates
- Lipids
- Proteins
- Nucleic acids
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Watch those carbs.

• Carbohydrate function:
  – Structural components of cells
  – Source of energy
  – Protective covering (example: chitin)
  – Essential constituents of important molecules (example: pentose in nucleic acids)
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Watch those carbs.

- Carbohydrates include:
  - Monosaccharides - simple (single) sugars like:
    - Glucose (sports drinks)
    - Fructose (fruit)
  - Disaccharide - double sugars like:
    - Sucrose (table sugar) - glucose + fructose
    - Lactose (milk sugar) - glucose + galactose
  - Polysaccharides - large (complex) carbohydrates
    - Starches like pasta & potatoes
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Watch those carbs.

• Example of polysaccharides:
  – Starch
    • Plant cells store starch for energy.
  – Glycogen
    • Animals store excess sugar in this form.
  – Cellulose (most abundant organic compound)
    • Forms cable-like fibrils in the tough walls that enclose plants.
    • Major component of wood.
    • Also known as dietary fiber.
Lipids.

• Lipid function:
  – Food / energy reserve
  – Cell boundaries
  – Waterproofing, cushion, insulators (example: waxes)
  – Chemical messengers (example: steroids)

• Lipid characteristics:
  – Hydrophobic (do not mix with water)
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Lipids.

• Fat Molecules
  – Dietary fat consists largely of the molecule triglyceride.
  • A combination of glycerol & three fatty acids.
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Lipids.

• **Cholesterol**
  - Needed to maintain fluidity of cell membrane
  - Associated with cardiovascular disease (‘clogged arteries’)
  - Synthesized internally

• **Saturated fats** (single bonds) decrease the fluidity of cell membranes by packing too tightly together
  - lard, butter and cream contain saturated fats

• **Unsaturated fats** (double bonds) keep membranes more flexible & are less easily converted into cholesterol
  - polyunsaturated fats are believed to lower cholesterol
  - omega-6 fatty acids (safflower, sunflower, and soybean oils)
  - omega-3 fatty acids (fish and flax oils)
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Lipids.

- *Trans fats*
  - Type of unsaturated fat
  - Most trans fats chemically created by partially hydrogenating plant oils
  - solid at room temperature, but melts upon baking (or eating).
  - extends shelf-life
Lipids.

• Lipids are insoluble in water
  – Transport through blood requires transport molecules (lipoproteins)
  – Low-density lipoproteins (LDLs) or ‘bad cholesterol’
    • carry cholesterol from liver to body cells
  – High-density lipoproteins (HDLs) or ‘good cholesterol’
    • collects cholesterol from the body’s tissues & brings it back to liver
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Proteins

• Protein functions:
  – Enzymes
  – Hormones
  – Antibodies
  – Structural elements in membranes and muscle
  – Storage materials (*egg yolk*)
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Proteins

• Protein characteristics:
  – A protein is a polymer constructed from a common set of 20 amino acid monomers.
  – Proteins perform most of the tasks the body needs to function.
  – They are the most elaborate of life’s molecules.
Cells link amino acids together to form proteins.

The arrangement of amino acids makes each protein different & unique in structure and function.

A slight change in the primary structure of a protein affects its ability to function.
Nucleic Acids

- Nucleic acids are information storage molecules.
- They provide the directions for building proteins.
- There are two types of nucleic acids:
  - DNA, deoxyribonucleic acid
  - RNA, ribonucleic acid
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Nucleic acids are polymers of nucleotides

- **Nucleotide** = Phosphate + 5-Carbon sugar + Base
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Nucleic acids are polymers of nucleotides

• Each DNA nucleotide has one of the following bases:
  – Adenine (A)
  – Guanine (G)
  – Thymine (T)
  – Cytosine (C)
Nucleotide monomers are linked into long chains

- These chains are called polynucleotides, or DNA strands.
- A sugar-phosphate backbone joins them together.
- Two strands of DNA join together to form a double helix.
RNA, ribonucleic acid, is different from DNA

- It has the base uracil (U) instead of thymine (T)
  - Adenine (A)
  - Guanine (G)
  - Uracil (U)
  - Cytosine (C)