Chemical compounds that contain both carbon and hydrogen.

Hydrocarbons consist almost entirely of carbon and hydrogen.

Four types: carbohydrates, lipids, proteins, and nucleic acids.

Monomers (single units) linked together to form polymers.

Linked using dehydration — take water out.

Broken apart by hydrolysis — add water in.
And Biochemistry . . .

- Carbohydrates: simple sugars and complex carbo’s — provide energy and structure.

- Lipids: all hydrophobic — provide energy, regulation, and structure.

- Proteins — enzymes, regulation, structure . . . lots and lots of things!

- Nucleic Acids — the ‘informational’ molecules, but also enzymatic structures.
Carbohydrates are . . .

* Organic molecules that consist of carbon, hydrogen and oxygen (often in a 1:2:1 ratio). They include . . .

* Simple sugars — a ready source of energy. Which include . . .

* **Monosaccharides** — 5 or 6 carbon atoms:
  * The same number of carbon atoms can be put together differently to give very different molecules. And . . .

* **Disaccharides:**
  * Two monosaccharides joined by dehydration synthesis.
  * For example, sucrose = fructose + glucose.

* And . . . **Oligosaccharides** — 3-100 monomers:
  * Many of these attach to [glyco]proteins on the cell membrane.
The other carbohydrates are the complex carbohydrates. These are . . .

- Polysaccharides, which consist of . . .
  - Hundreds of monosaccharides. And include . . .
- Cellulose — used in plant cell walls. And . . .
- Chitin — used in insect exoskeletons, and fungi cell walls. And . . .
- Starch — used for plant energy storage. And . . .
- Glycogen — used by animals and fungi for energy storage.
For example:

a. **Monosaccharides**: simple sugars composed of carbon, hydrogen, and oxygen in the proportions 1:2:1.

- Glyceraldehyde: \( \text{C}_3\text{H}_6\text{O}_3 \)
- Ribose: \( \text{C}_5\text{H}_{10}\text{O}_5 \)
- Glucose: \( \text{C}_6\text{H}_{12}\text{O}_6 \)
- Fructose: \( \text{C}_6\text{H}_{12}\text{O}_6 \)
- Galactose: \( \text{C}_6\text{H}_{12}\text{O}_6 \)

b. **Disaccharides**: molecules composed of two monosaccharides joined by dehydration synthesis. Hydrolysis converts disaccharides into their component monosaccharides. (The structures of the molecules are simplified to emphasize the joining process.)

\[
\text{Glucose} \quad \text{C}_6\text{H}_{12}\text{O}_6 \quad + \quad \text{Fructose} \quad \text{C}_6\text{H}_{12}\text{O}_6 \quad \xrightarrow{\text{Dehydration}} \quad \text{Sucrose} \quad \text{C}_{12}\text{H}_{22}\text{O}_{11} \quad \xrightarrow{\text{Hydrolysis}} \quad \text{Glucose} \quad \text{C}_6\text{H}_{12}\text{O}_6 \quad + \quad \text{Fructose} \quad \text{C}_6\text{H}_{12}\text{O}_6
\]

c. **Polysaccharides**: complex carbohydrates composed of long chains of simple sugars, usually glucose. Their chemical characteristics are determined by the orientation and location of the bonds between the monomers.
Lipids (a.k.a. fats)!

* All cannot dissolve in water. That means they are . . .
* Hydrophobic. They contain . . .
* Large areas with nonpolar bonds.
* They are not polymers; made of monomers.
* This is unlike the other three major macromolecules.
* There are several groups of them:
* triglycerides, sterols, waxes, and phospholipids.
Triglycerides (normal fats):

- Three fatty acids bonded to a glycerol.
- Use dehydration synthesis and hydrolysis.
- Saturated fatty acids have all single bonds between carbons.
- Animal fats, solid.
- Unsaturated fatty acids have at least one double bond between carbons.
Sterols: vital in regulatory and structural roles.

- All have four interconnected carbon rings.
- Examples include Vitamin D, cortisone, testosterone, and . . .
- Cholesterol, used in cell membranes, and to make other lipids.

What makes men men!
Waxes:

- Fatty acids combined with either alcohols or other hydrocarbons.

- Usually forms water-repellent covering, e.g. on leaves, fruits, fur, and feathers.
Proteins: the workers!

* Consist of amino acid monomers.
* Which have a central carbon atom bonded to a hydrogen, a carboxyl group, an amino group, and an R group.
* The R group distinguishes amino acids.
* Dehydration synthesis links amino acids together (peptide bond), hydrolysis break them apart.
* Come as various peptides, dipeptides, tripeptides, polypeptides, and proteins.
### Table 2.5  Protein Diversity in the Human Body

<table>
<thead>
<tr>
<th>Proteins</th>
<th>Function</th>
<th>Proteins</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actin, myosin, dystrophin</td>
<td>Muscle contraction</td>
<td>Fibrin, thrombin</td>
<td>Blood clotting</td>
</tr>
<tr>
<td>Antibodies, cytokines</td>
<td>Immunity</td>
<td>Growth factors</td>
<td>Promote cell division</td>
</tr>
<tr>
<td>Carbohydrases, lipases, proteases, nuclease</td>
<td>Digestive enzymes*</td>
<td>Hemoglobin, myoglobin</td>
<td>Transport and storage of oxygen</td>
</tr>
<tr>
<td>Casein</td>
<td>Milk protein</td>
<td>Insulin, glucagon</td>
<td>Control of blood glucose level</td>
</tr>
<tr>
<td>Collagen, elastin</td>
<td>Connective tissue</td>
<td>Keratin</td>
<td>Structure of hair, fingernails</td>
</tr>
<tr>
<td>Colony-stimulating factors</td>
<td>Blood cell formation</td>
<td>Transferrin</td>
<td>Iron transport in blood</td>
</tr>
<tr>
<td>DNA and RNA polymerase</td>
<td>Enzymes* required for DNA replication, gene expression</td>
<td>Tubulin, actin</td>
<td>Cell movements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tumor suppressors</td>
<td>Block cell division</td>
</tr>
</tbody>
</table>

*Enzymes, discussed further in chapter 4, are proteins that speed chemical reactions. Without enzymes, most of the cell’s reactions would proceed much too slowly to sustain life.*
What these molecules really are.
What about these amino acids?
The physiochemical properties of amino acids determine everything about the protein they make.

http://www.bio.davidson.edu/courses/genomics/jmol/aatable.html

The Venn diagram categorizes the twenty naturally occurring amino acids according to their physiochemical properties.

http://prowl.rockefeller.edu/aainfo/pchem.htm

Monday, January 16, 2012
OK, then what sort of structures do they create?

* Protein folding creates unique 3D structures.
* **Primary** (1°) structure — this is the amino acid sequence determined by an organism’s genetic code (DNA).
* **Secondary** (2°) structure — these are the interactions between amino acids to form helices, sheets, and loops.
* **Tertiary** (3°) structure — the overall shape arising from interactions between R groups, 2° structure, and water.
* **Quaternary** (4°) structure — are the interactions between multiple polypeptide subunits (e.g. hemoglobin has 4 subunits, two alpha and two beta in adults).
* Denaturation — a loss of structure due to physical means (e.g. heat, salt, pH); causes the loss of function.
Once more. What do these look like?

**a. Primary structure**—the sequence of amino acids

**b. Secondary structure**—hydrogen bonds between nonadjacent carboxyl and amino groups

**c. Tertiary structure**—disulfide and ionic bonds between R groups, interactions between R groups and water

**d. Quaternary structure**—hydrogen and ionic bonds between separate polypeptides
Nucleic Acids! Information molecules

Two types:
* Deoxy-ribonucleic acid (DNA),
* Ribonucleic acid (RNA).

Nucleotide monomers:
Each has a five carbon sugar, a phosphate group, and a nitrogenous base.

Nucleotides:
consist of a sugar (ribose or deoxyribose), a phosphate, and one of five nitrogenous bases.

- **Cytosine (C)**
- **Thymine (T)**
- **Adenine (A)**
- **Uracil (U)**

Nitrogenous base
Guanine (G)

Sugar (Deoxyribose)

Phosphate group
Nucleotide polymers = nucleic acids

- DNA
- Deoxyribose sugar;
- A, C, G and T (not U);
- Double helix.
- Hydrogen bonds hold halves together.
- Always A with T, and C with G.
- Strands are complementary.
- Genetic code — each group of three DNA bases specifies one amino acid.
RNA

* Ribose sugar;
* A, C, G and U (not T);
* Often single stranded.
* Different kinds: messenger, transfer, ribosomal, small nuclear . . . .
* Most enable DNA to be expressed.
* Some function as an enzyme.
* An RNA nucleotide, adenosine triphosphate (ATP), carries energy.
Once more. What do they look like?

Nucleic acids: nucleotides joined together in long chains to form DNA or RNA. DNA is composed of the nucleotides A, C, T and G. RNA contains the sugar ribose and the nucleotide U instead of T.
Next time — we begin to look into the Cell.

- The Cell — “the basic structural and functional unit of all known living organisms.”
- And all of its constitutive parts.