THE CHEMISTRY OF LIFE

A Primer

R. Collé

Organic chemistry is the basis.

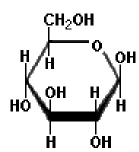
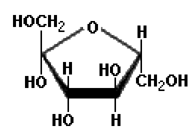
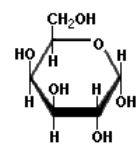
All living things made up of organic molecules and use organic molecules to function.

Chief feature of chemistry of C is ability of carbon atoms to form 4 bonds with other elements and with other C atoms itself.

FOUR BASIC GROUPS OF ORGANIC COMPOUNDS IN BODY

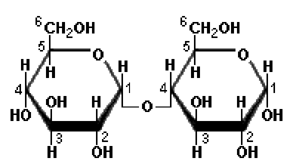
Organic Compound	Elements	Building Blocks
Carbohydrates	C H O	Simple sugars (**monosaccharides**)
Lipids (fats)	C H O	**Glycerol** and **Fatty Acids**
Proteins	C H O N P S	**Amino Acids**
Nucleic Acids (DNA and RNA)	C H O N P	**Nucleotides**

CARBOHYDRATES -- **monosaccharides** – **glucose**, **fructose** and **galactose** (H/O ratio same as water)

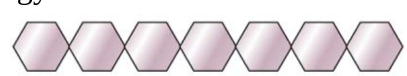
CARBOHYDRATES – **disaccharides – sucrose, maltose, lactose [G + F; G +G; G + Ga]**

maltose di-sugar



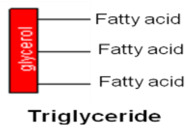
CARBOHYDRATES – **polysaccharides** (many (hundreds) of monosaccraride units

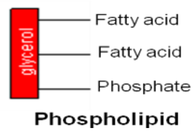
Glycogen – food stored in body for energy
Cellulose – plant cell walls – wood
Chitin – shells of crustaceans



LIPIDS (fats**)** **- trigylcerides**
- phospholipids
- chloestorol

(important structural component of all cells –especially cell membranses)
on mass basis, provides twice as much energy as carbohydrates



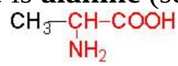


PROTEINS **--** very large, complex molecules composed of elements C, H, & O + other elements in very small amounts – made from **amino acids** as building blocks. As protein molecule grows larger, shape become more & more complex.

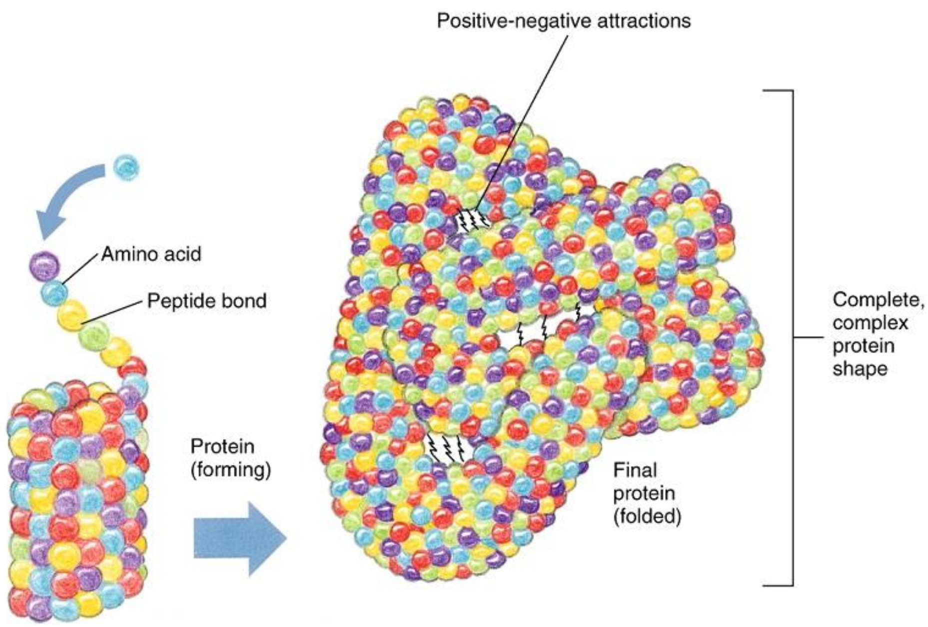
example of very complex protein is **hemoglobin** found in red blod cells

AMINO ACIDS – 20 different kinds, joined together in proteins with covalent **peptide bonds**.

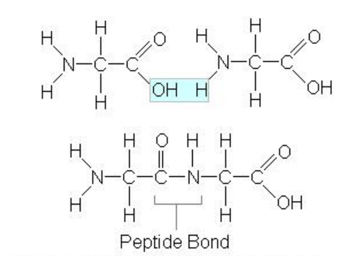
example of a simple one is **alanine** (see page 3)



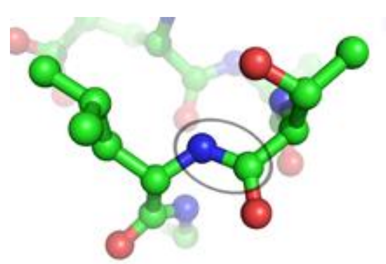
Protein structure



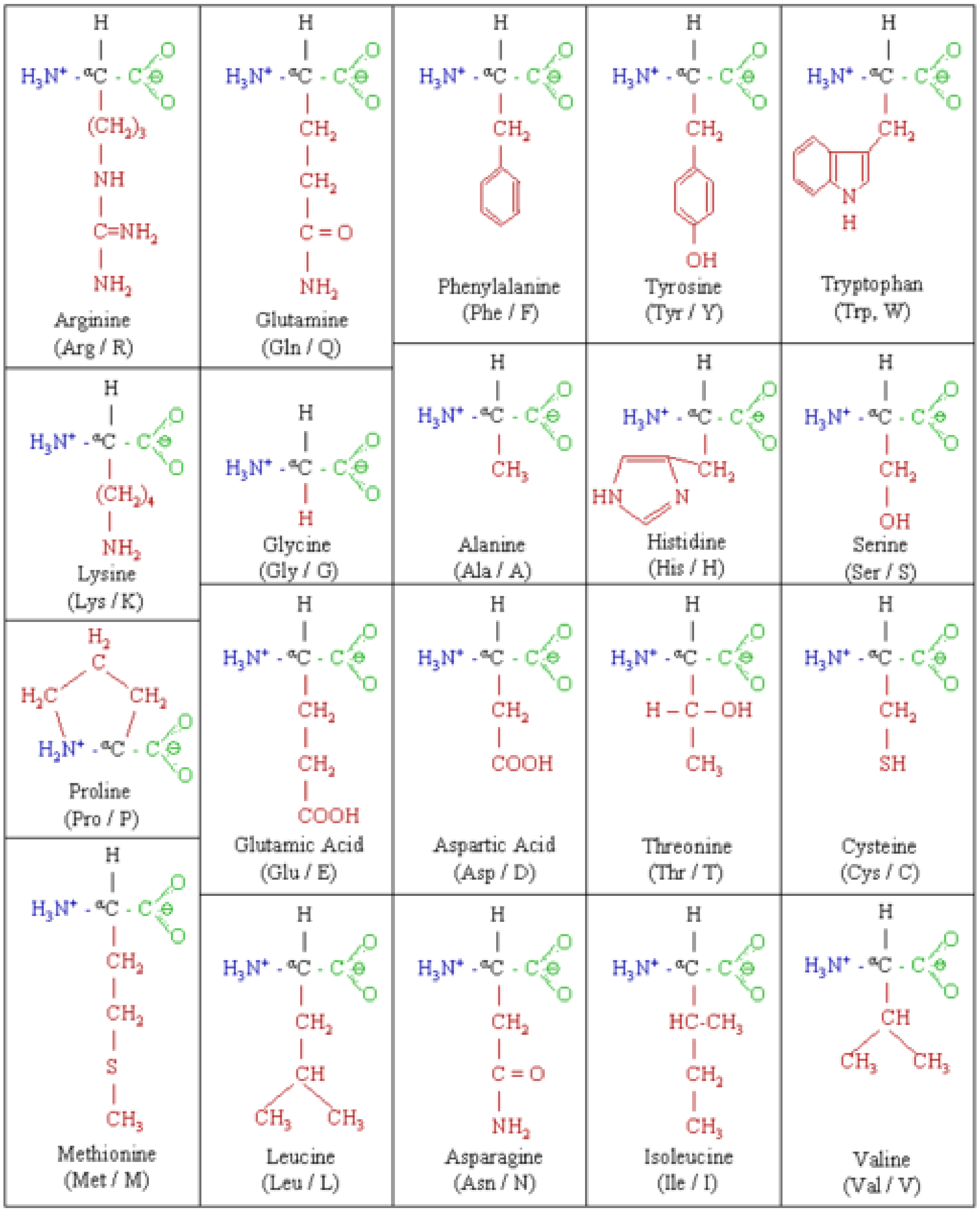
PEPTIDE BOND (amide bond) -- a covalent bond formed between two molecules when the carboxyl group of one reacts with the amino group of the other, causing the release of water (example below)



A molecule of water is removed from two glycine amino acids to form a peptide bond.



ALL 20 AMINO ACIDS



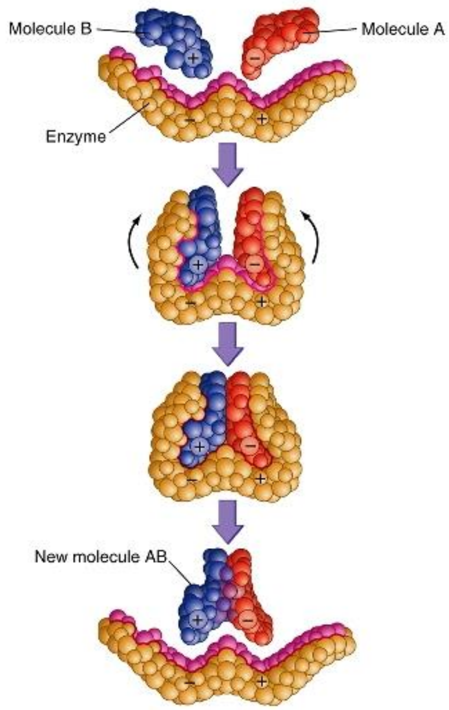
PROTEIN FUNCTIONS

Proteins carry out a wide range of functions in the body:

1. **Collagen** and **keratin** are structural proteins. Collagen holds the **tissues** together throughout the body and strengthens **ligaments** and **tendons.**
2. Keratin is a protein that toughens and waterproofs the skin.
3. Many hormones that regulate body functions are proteins.
4. The proteins **actin** and **myosin** permit our **muscles** to contract.
5. Hemoglobin is a blood protein that transports oxygen and carbon dioxide throughout the body.
6. **Antibodies** are proteins in the blood and body fluids that help to fight infections.
7. **Enzymes** are a special class of proteins that assist other chemicals to react with each other. <u>These reactions are the basis of all life chemistry.</u>

ENZYMES -- * are catalysts (assists chemical reactions without being chemically changed itself)
* most important characteristic of an enzyme molecule is its shape.
*shape of the enzyme molecule must fit the shape of the specific molecules the enzyme works on -- like a key fits into a lock.

In example given here, molecules A & B are joined together to form a new substance AB.



<u>Enzymes are needed to permit every chemical reaction in the body to occur.</u>

ENZYME CHARACTERISTICS

1. Enzymes are used to regulate the rate (speed) of chemical reactions.
2. All enzymes are proteins, but not all proteins are enzymes.
3. Each chemical reaction in an organism requires its own specific enzyme.
4. Each chemical that is worked on by an enzyme is called a **substrate.**
5. Each enzyme can also be called an organic **catalyst.**
6. Enzymes are never changed by their reactions! They are reusable ...

BASIS OF ENZYME ACTION (**Lock & Key Model**)

Each enzyme has a specific area for linking up with its own specific substrate. This is called an **active site** (the place where substrate and enzyme are attached)

- An enzyme and substrate that are compatible link up at the active site. The shapes of the enzyme and substrate fit together like a lock and key
- This forms the **enzyme-substrate complex** where the enzyme goes to work (can put together or take apart a substrate.)
- The enzyme and products separate: the enzyme is ready to work on another substrate.
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METABOLISM (as an aside to understanding)

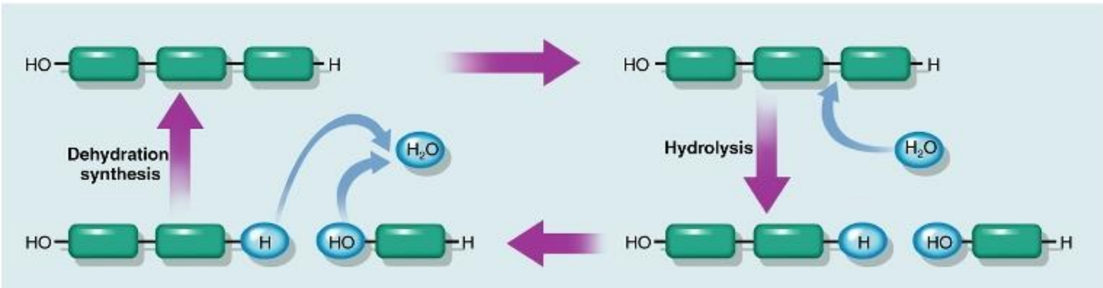
Metabolism is the set of chemical reactions that happen in living organisms to sustain life.

- These processes allow organisms to grow, reproduce, maintain their structures, and respond to their environments.
- Divided into 2 categories: **catabolism** (breaks down organic matter – example is cellular respiration) & **anabolism** (uses energy to construct components of cells – like proteins & nucleic acids)
- Chemical reactions of metabolism have specific pathways (steps) – chemicals transformed by enzyme catalysts.
- Enzymes regulate responses to cell's environment or signals from other cells; determines which substances will be nutritious and which poisonous
- Metabolic rate (speed of metabolism) influences how much food is required & affects how it will get food

TWO SIMPLE EXAMPLES OF ENZYME ACTIVITIES

(**Dehydration Synthesis and Hydrolysis)**

- They are two very common chemical reactions assisted by enzymes.
- When the subunits of carbohydrates, lipids and proteins are being put together to form larger molecules, water is removed by the action of an enzyme. This process is called dehydration synthesis (anabolism example).
- When large organic compounds are being broken down into their subunits, an enzyme controlled reaction adds water between the subunits. This is called hydrolysis (catabolism example)

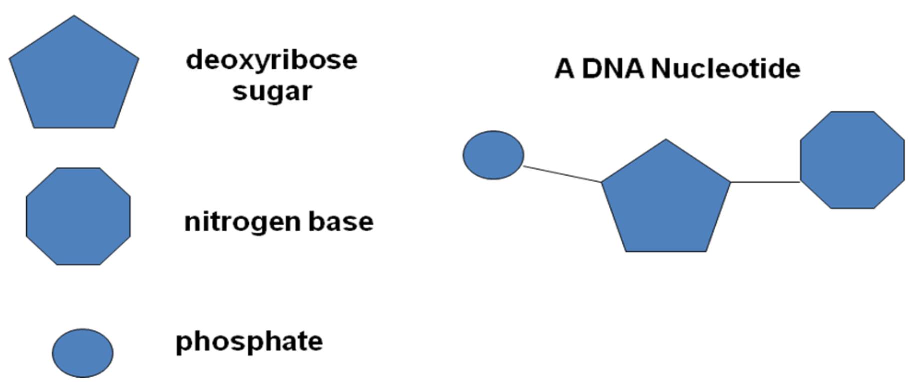


NUCLEIC ACIDS (DNA & RNA)

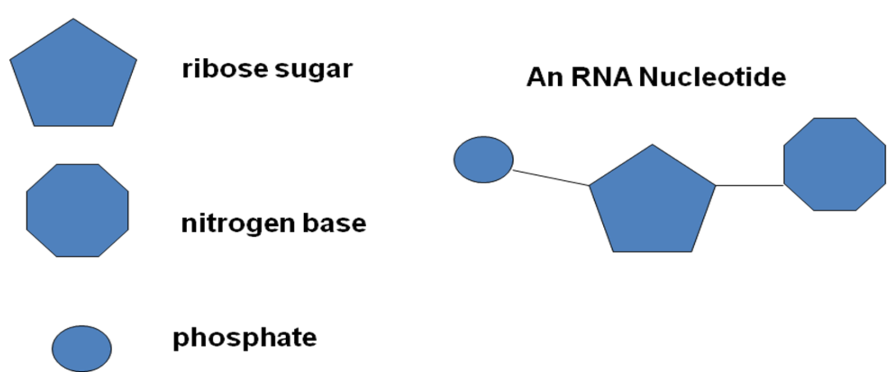
- **Deoxyribonucleic acid (DNA)** -- a very complex double stranded molecule which stores all of the information needed by the cell and the entire organism to carry out life activities. DNA is found primarily in the **nucleus** of the **cell**.
- **Ribonucleic acid (RNA)** a single stranded molecule which is found in several locations within the cell. RNA carries a copy of the coded information in DNA to the place in the cell where that information will be used to manufacture enzymes needed to allow all of the chemical processes of life to occur in the cell.

DNA **(a macromolecule)** is built up from building blocks called **nucleotides,** which are made up of three kinds of particles: a **deoxyribose sugar molecule**; a **nitrogen base;** and a **phosphate.**

Stores hereditary information that controls the activities of every cell of the body.

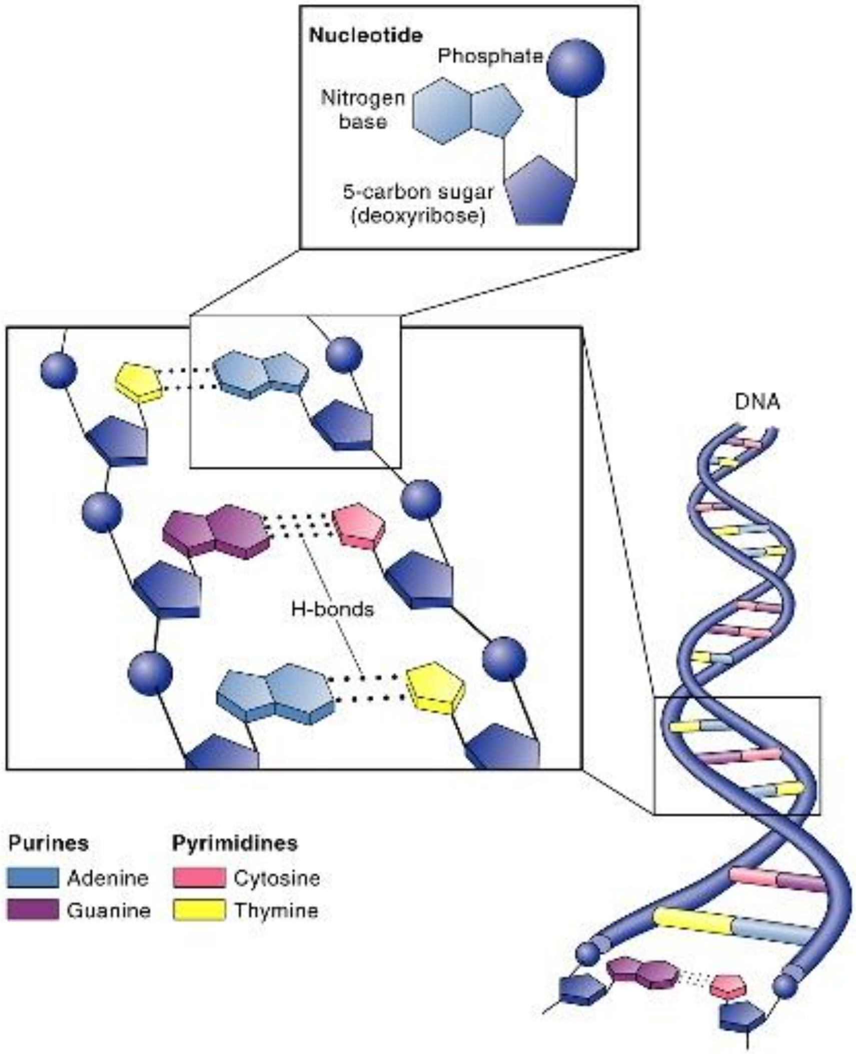


RNA --can be thought of as one half of a DNA molecule, which carries coded hereditary information from the nucleus of the cell to the **cytoplasm**. RNA is also built up from nucleotides containing 3 parts: a **ribose sugar** molecule; a nitrogen base; and a phosphate.



STRUCTURE OF DNA

- There are four kinds of nitrogen bases in DNA: **adenine, guanine, cytosine and thymine**.
- The nucleotides containing these bases are put together to form a structure called a **double helix**.
- A double helix has the shape of a ladder that has been twisted lengthwise so that the sides of the ladder coil around each other.
- The sides of the ladder are formed by sugar and phosphate groups. The rungs of the ladder consist of nitrogen bases.



TAKE BIOLOGY if you now want to know how these pieces of chemistry fit into the structure of cells, which builds tissues, organs, and all living things

ALL LIVING THINGS, IN ORDER TO SURVIVE AND GROW, NEED A NUMBER OF DIFFERENT SUBSTANCES

- NUTRIENTS – carbohydrates; proteins; and lipids (fats)
    - taken in by animals & made by animals & plants
- ACCESSORY FOODS – water and minerals – need by both palnts & animals
- VITAMINS – needed by animals only (to help the enzymes catalyze): A,C, D, E, K, and B complex (group with at least 10 vitamins)
- ROUGHAGE (or FIBER) – needed by many animals to move food through the gut

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