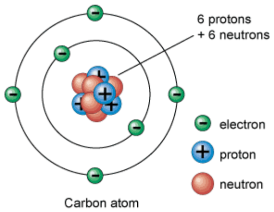
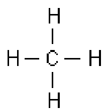
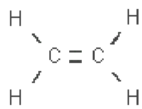
CHAPTER 4- CARBON – The Backbone of Biological Molecules

Cells are 70-95% water; rest is mostly carbon-based compounds



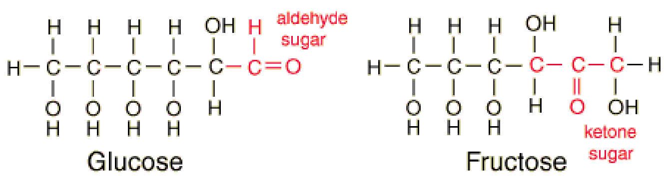
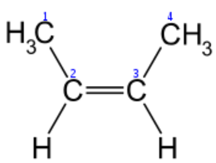
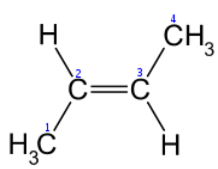
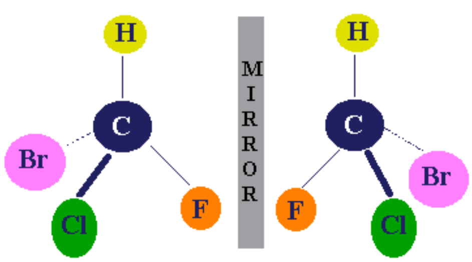
PROPERTIES OF CARBON

- Has 4 valence electrons
- Tetravalence of carbon makes large, complex molecules possible by bonding COVALENTLY to FOUR other atoms
- Living matter-mainly of carbon (C), oxygen (O), hydrogen (H), and nitrogen (N) with smaller amounts of sulfur (S) and phosphorus (P).

SINGLE BOND shares pair of electrons	DOUBLE BOND Shares 2 pairs of electrons	TRIPLE BOND Shares 3 pairs of electrons
		

- CO_2 is the source of carbon for all organic molecules found in organisms
- It is usually fixed into organic molecules by the process of photosynthesis
- Carbon chains can be straight, branched, or arranged in closed ring
- Carbon skeletons vary in length, number and location of double bonds, and presence of other elements

Isomers = compounds that have the same molecular formula, but different structures and chemical properties

 aldehyde sugar Glucose Fructose ketone sugar	STRUCTURAL ISOMERS = same molecular formula but different arrangement of atoms EX: Glucose and Fructose both $C_6H_{12}O_6$ • Isomerase enzyme can switch forms
 Cis = groups on same side sides  Trans = groups on opposite	GEOMETRIC ISOMERS = same covalent partnerships but different spatial arrangement of atoms around a carbon–carbon double bond • double bond don't let atoms rotate freely Ex: The biochemistry of vision involves a light-induced change in the structure of rhodopsin in the retina from one geometric isomer to another.
 MIRROR	ENANTIOMERS = four different atoms or groups of atoms are bonded to the same carbon (=*asymmetric carbon*) • Can't be superimposed (like LEFT and RIGHT hands) • Designated L (levo) and D (dextro) • Usually only one form is biologically active Examples: • Most amino acids used to make proteins are the L form; • Most sugars are the D form • L-dopa drug treats Parkinson's disease; D-dopa is inactive • Thalidomide- one enantiomer of used to treat morning sickness; other form caused birth defects Rate of racemization (changing from L-forms to a mixture of L-forms and D-forms) used to date forensic samples and fossils.

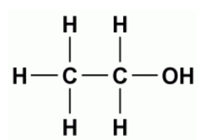
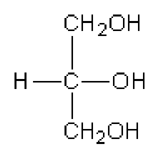
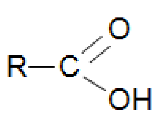
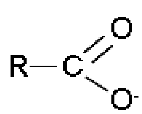
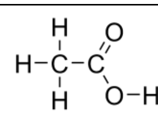
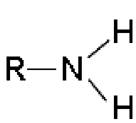
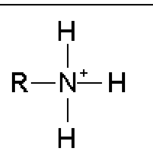
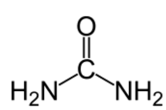
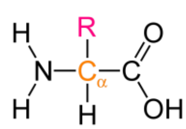
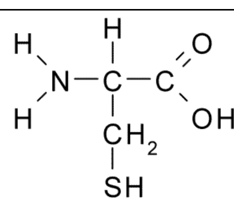
ORGANIC CHEMISTRY = branch of chemistry that specializes in the study of carbon
Organic molecules = Molecules that contain carbon

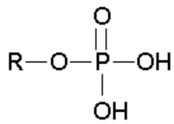
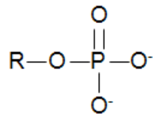
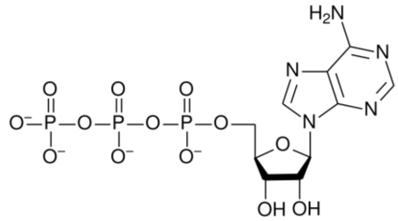
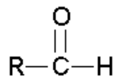
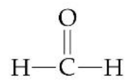
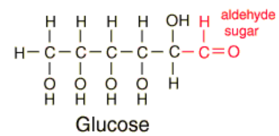
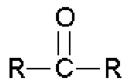
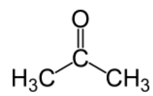
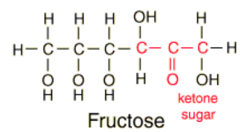
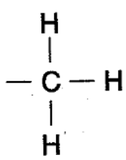
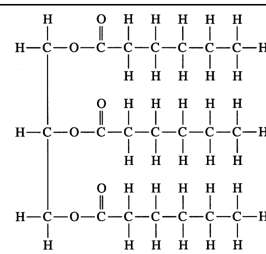
Early 19th century ~ VITALISM = belief in a life force outside the jurisdiction of chemical/physical laws
• believed that only living organisms could produce organic compounds because chemists could not artificially synthesize organic compounds

Later mainstream biological thought shifted as scientists began to synthesize organic compounds from inorganic molecules
MECHANISM = belief that all natural phenomena are governed by physical/chemical laws
EX: Friedrich Wohler (1828) synthesized urea; Hermann Kolbe synthesized acetic acid;
Stanley Miller (1953) demonstrated the possibility that organic compounds could have been produced under the chemical conditions of primordial Earth

HYDROCARBONS = Molecules containing only carbon and hydrogen
• Hydrocarbon chains are hydrophobic/nonpolar
• major components of fossil fuels produced from the organic remains of organisms living millions of years ago
• some biologically important molecules may have regions consisting of hydrocarbon chains
EX: FATS-long carbon tails attached to a non-hydrocarbon component

FUNCTIONAL GROUPS

	STRUCTURE Non-ionized	Ionized	EXAMPLE	CLASS NAME
HYDROXYL • Polar • Hydrophilic • Found in SUGARS	R—OH	X	ETHANOL  GLYCEROL 	ALCOHOLS
CARBOXYL • Polar • weak acid • hydrophilic			 ACETIC ACID AMINO ACIDS SUGARS FATTY ACIDS	CARBOXYLIC ACIDS
AMINO • Polar • Weak base • hydrophilic			UREA  AMINO ACIDS 	AMINES
SULFHYDRYL • Form disulfide bridges • Help stabilize tertiary structure of proteins	R—SH	X	 Cysteine	THIOLS

PHOSPHATE • Polar • Acid • hydrophilic • Important in energy transfer			 Adenosine triphosphate (ATP) PHOSPHOLIPIDS DNA	ORGANIC PHOSPHATES
CARBONYL • Polar • Hydrophilic	 at end of C chain	X	FORMALDEHYDE  SUGARS 	ALDEHYDE
	 in middle of Cchain	X	ACETONE  SUGARS 	KETONE
METHYL • Non-polar • Hydrophobic		X	 FATTY ACIDS OILS WAXES	

- Each functional group behaves consistently from one organic molecule to another.
- Number and arrangement of functional groups help give molecules their unique properties

EX: TESTOSTERONE (a male sex hormone) and ESTRADIOL (a female sex hormone) are both steroids with same fused four ring structure but different functional groups attached to the rings result in different functions

http://local.brookings.k12.sd.us/krscience/open/chemistryoflife.htm