Biochemistry for Nurses – Introduction

DR. ARNEL BANAGA SALGADO, PhD (PMHN), Ph.D. (Psychology), Ed.D., Sc.D., RN, PGD
H/P No.: 056-88-27-333
URL: *www.ifeet.org; www.arnelsalgado.com*

- *Member:* Sigma Theta Tau International – Honor Society of Nursing *(Constituent No. 1628977)*
- *Member:* American Psychological Association *(APA Roll No. 04438162)*
  - Doctor of Psychology (Psy.D.)
  - Fellow Program in Management (FPM – Psychology)
  - Doctor of Science (D.Sc.)
  - Doctor of Education (Ed.D.)
  - Master of Arts in Nursing (M.A.N)
  - Master of Arts in Teaching – Psychology (M.A.T.)
  - Registered Nurse (PH, MYL, UAE)
  - Licensed Teacher (PH)
  - Certificate in Teaching,
  - Bachelor of Science in Nursing (BSN, PH)

American Psychological Association | Sigma Theta Tau International Honor Society of Nursing®

Introduction

Systems of Life

Classification

Introduction

Life

Modern Views

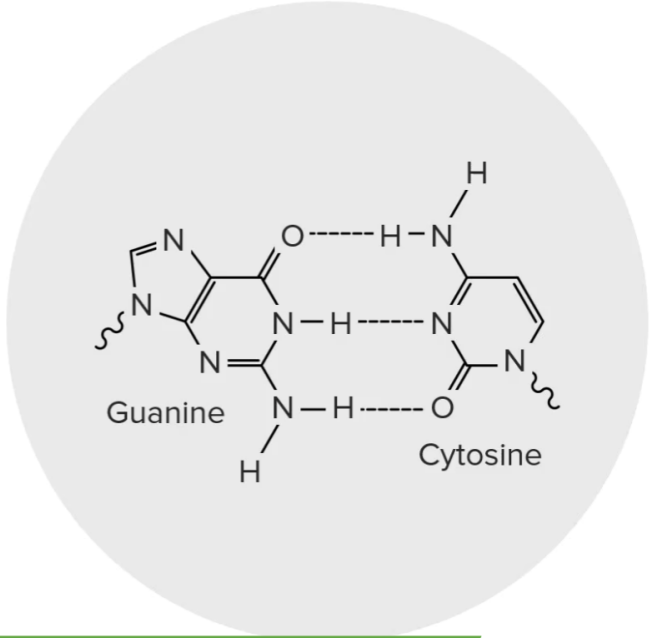
Molecular biology

- Schrödinger

  molecular roots

- Avery, MacLeod and McCarty
- Watson and Crick

  complementarity and inheritance



Introduction

- *Definition of Biochemistry*: Biochemistry is the chemistry of biological systems
- Molecules are lifeless but they compose living things
- These molecules are called Biomolecules

Biomolecules

Building block (Monomer)	**Macromolecule (Polymer)**
Amino Acids	Protein
Sugar residues (e.g glucose, sucrose, fructose)	Carbohydrate
Nucleic Acids	DNA, RNA
Glycerol and fatty acids	Lipids

Characteristics of Living Systems

1. **Living organisms are complicated and highly organized**
   - composed of many cells
   - cells are highly structured into organelles; macromolecules within organelles take part in many chemical reactions

Characteristics of Living Systems

2. Biological structures serve functional purposes

- Structures are specific
- The levels of organization observed by organelles and macromolecules allows them to perform specific functions

Characteristics of Living Systems

3. Energy transfomations occur within living systems

- Solar energy is transformed into ATP (adenosine triphosphate) and NADPH (nicotinamide adenine dinucleotide phosphate) which are special biomolecules which provide energy to the cell
- Activities of the cell which require energy include biosynthesis, movement and osmotic work against a concentration gradient

Characteristics of Living Systems

4. Living systems are highly efficient at self-replication.

- This is due to DNA (deoxyribonucleic acid) molecules which are able to reproduce into duplicate DNA strands from an original DNA strand.

What elements are biomolecules composed of?

- Biomolecules are composed mainly of six nonmetallic elements: **carbon, oxygen**, **hydrogen**, **nitrogen, phosphorous**, and **sulfur**
- These atoms make up >97% of the weight of most organisms
- These elements can form stable covalent bonds

Points to note:

- Water is a major component of cells
- Carbon is more abundant in living organisms than it is in the rest of the universe

Periodic Table showing the elements present in biomolecules

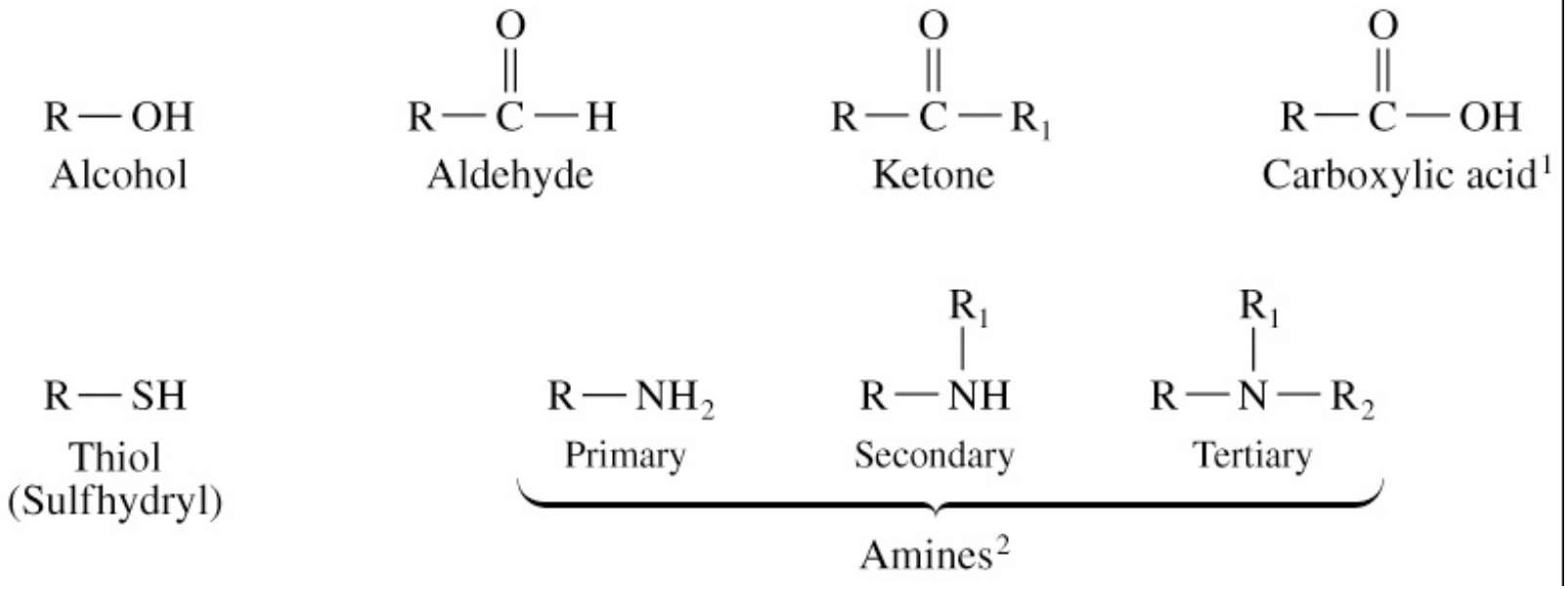
- Important elements found in living cells are shown in color
- The six abundant elements are in **red** (**CHNOPS**)
- Five essential ions are in **purple**
- Trace elements are in **dark blue** (more common) and **light blue** (less common)

IA												IIIA	IVA	VA	VIA	VIIA	0
1 **H** 1.008	IIA																2 **He** 4.003
3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31	IIIB	IVB	VB	VIB	VIIB	VIIIB			IB	IIB	13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.87	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.39	31 **Ga** 69.72	32 **Ge** 72.61	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
55 **Cs** 132.9	56 **Ba** 137.3	57 * **La** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.8	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89** **Ac** (227)	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (264)	108 **Hs** (265)	109 **Mt** (268)	110 (269)	111 (272)	112 (277)	113	114 (285)	115	116 (289)	117	118 (293)

58* **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.3	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
90** **Th** 232.0	91 **Pa** 231	92 **U** 238.0	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)

Biomolecules are essentially organic compounds

(a) *Organic compounds*

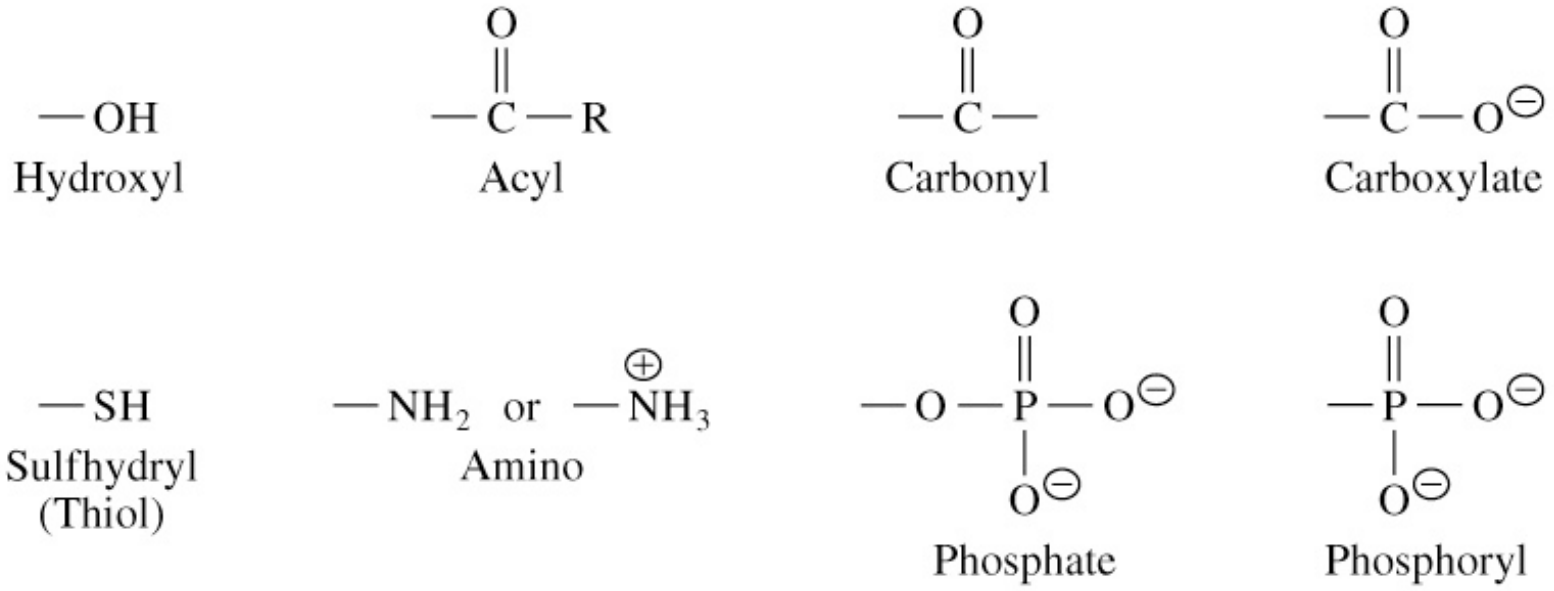


[1] Under most biological conditions, carboxylic acids exist as carboxylate anions: $R-\overset{\overset{O}{\|}}{C}-O^{\ominus}$.

[2] Under most biological conditions, amines exist as ammonium ions: $R-\overset{\oplus}{N}H_3$, $R-\overset{R_1}{\overset{|}{\overset{\oplus}{N}}}H_2$, and $R-\overset{R_1}{\overset{|}{\overset{\oplus}{N}}}H-R_2$.

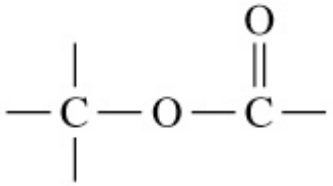
Common functional groups present in biomolecules

(b) *Functional groups*

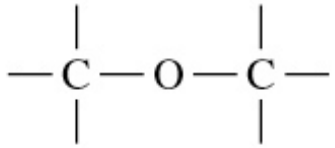


Common linkages present in biomolecules

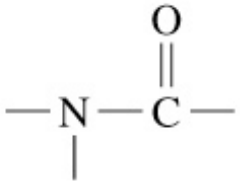
(c) *Linkages in biochemical compounds*



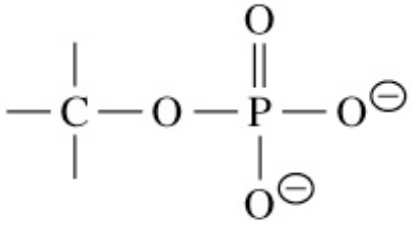
Ester



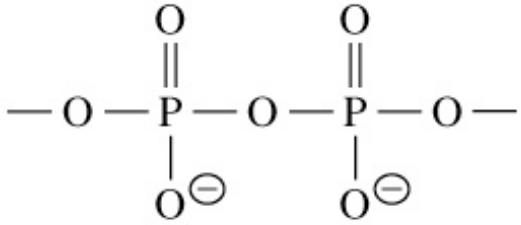
Ether



Amide



Phosphate ester

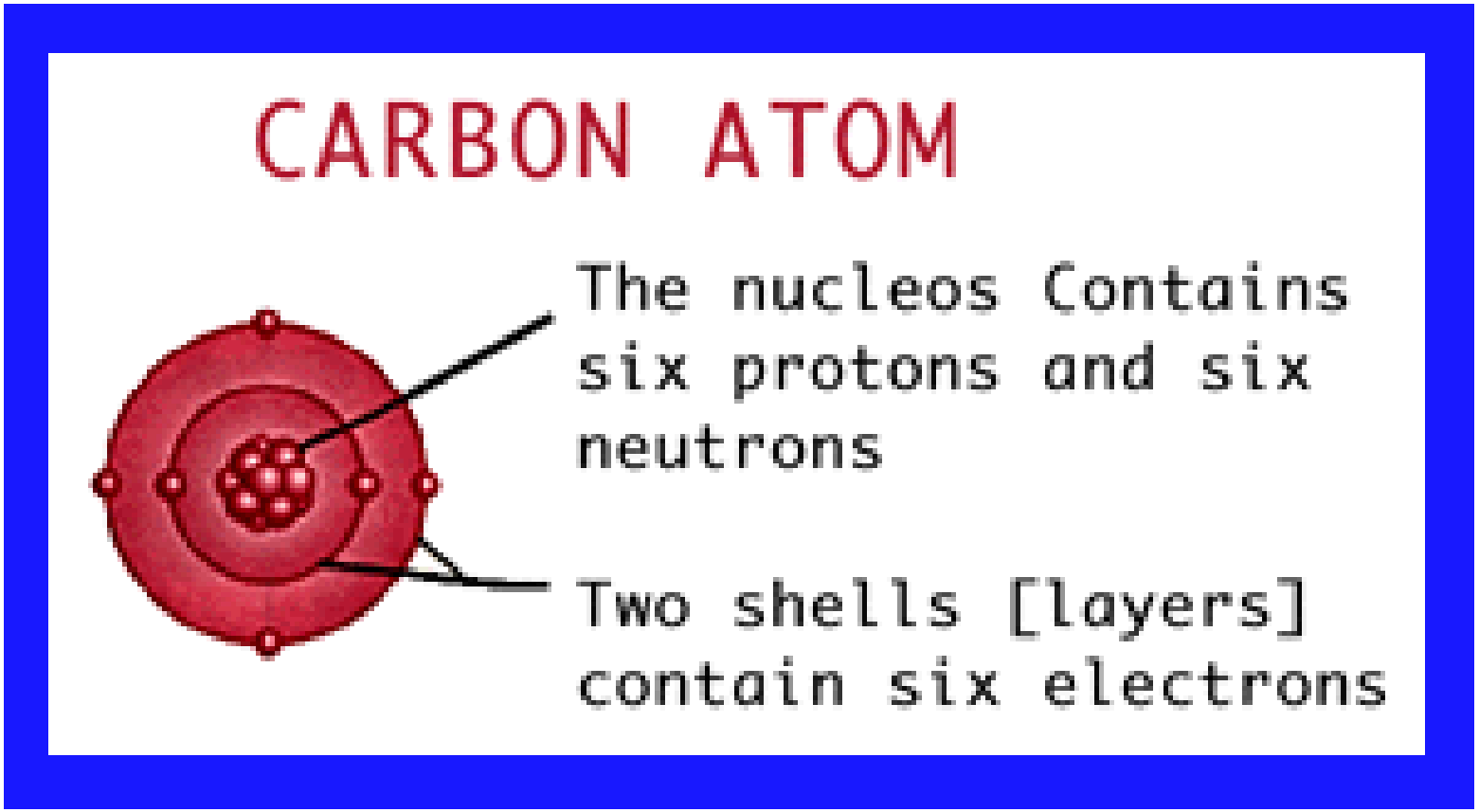


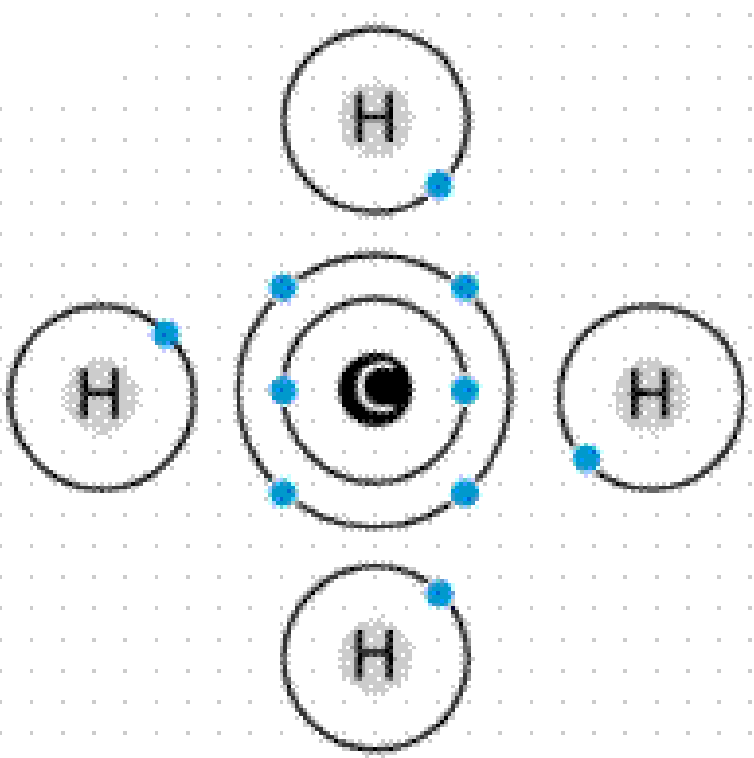
Phosphoanhydride

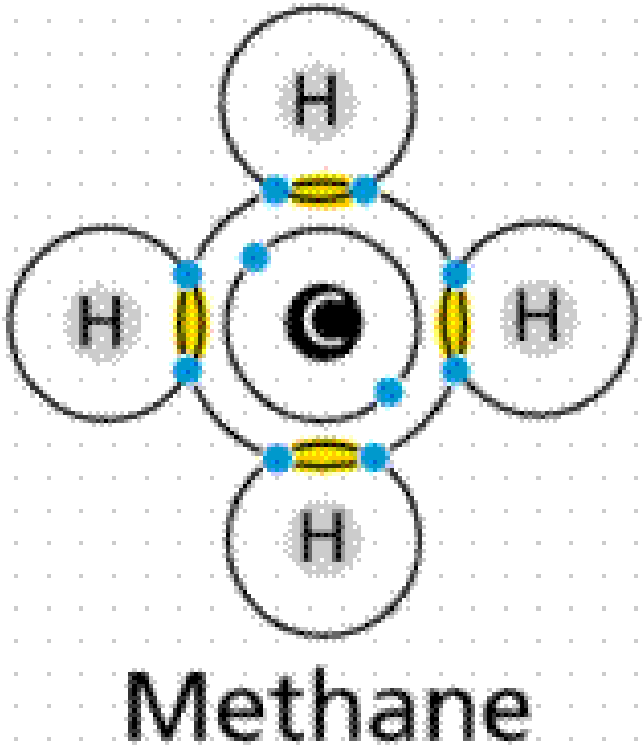
Why is carbon so predominant in living systems?

- This is because of the ability of carbon atoms to bond together to form long chains and rings.

Carbon

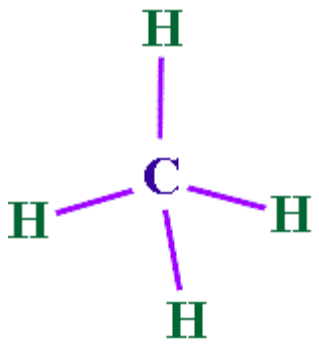

CARBON ATOM
The nucleos Contains six protons and six neutrons
Two shells [layers] contain six electrons





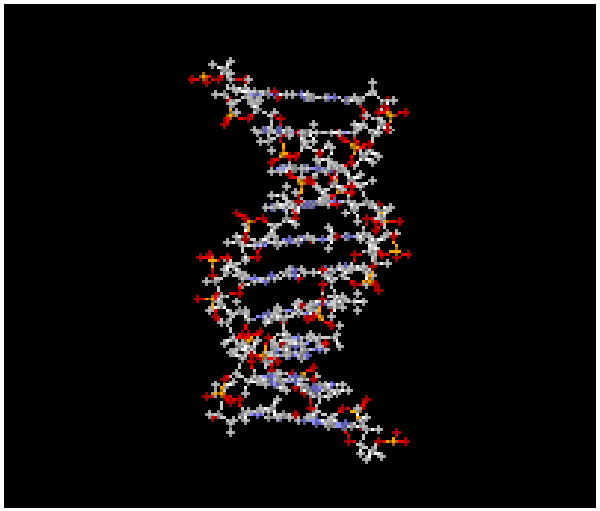
Carbon can covalently bond with up to four other atoms.

Carbon can form immensely diverse compounds, from simple to complex.



Methane

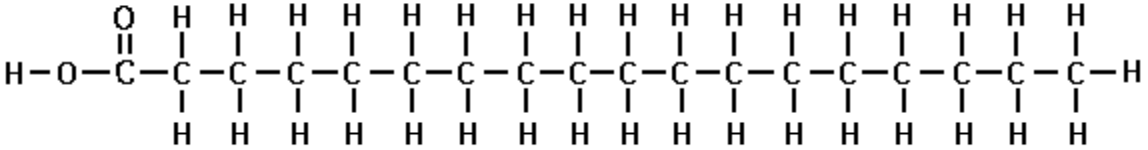
Methane with 1 Carbon atom



DNA with tens of Billions of Carbon atoms

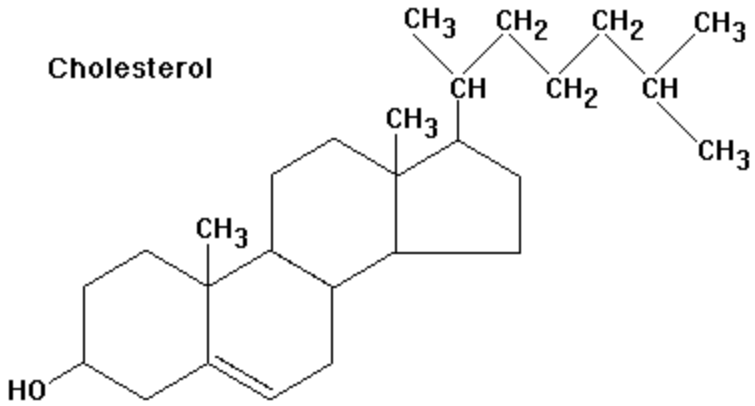
Examples of Carbon Biomolecules

LINEAR ALIPHATIC

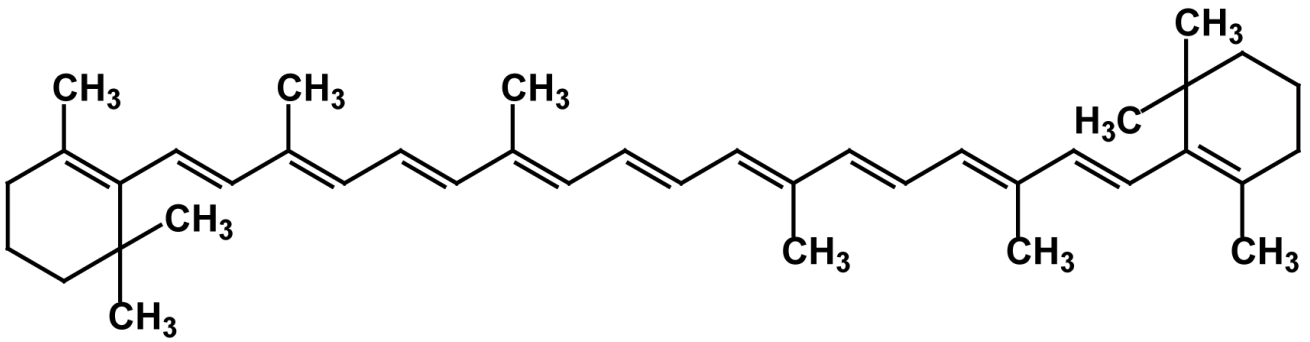


Stearic Acid

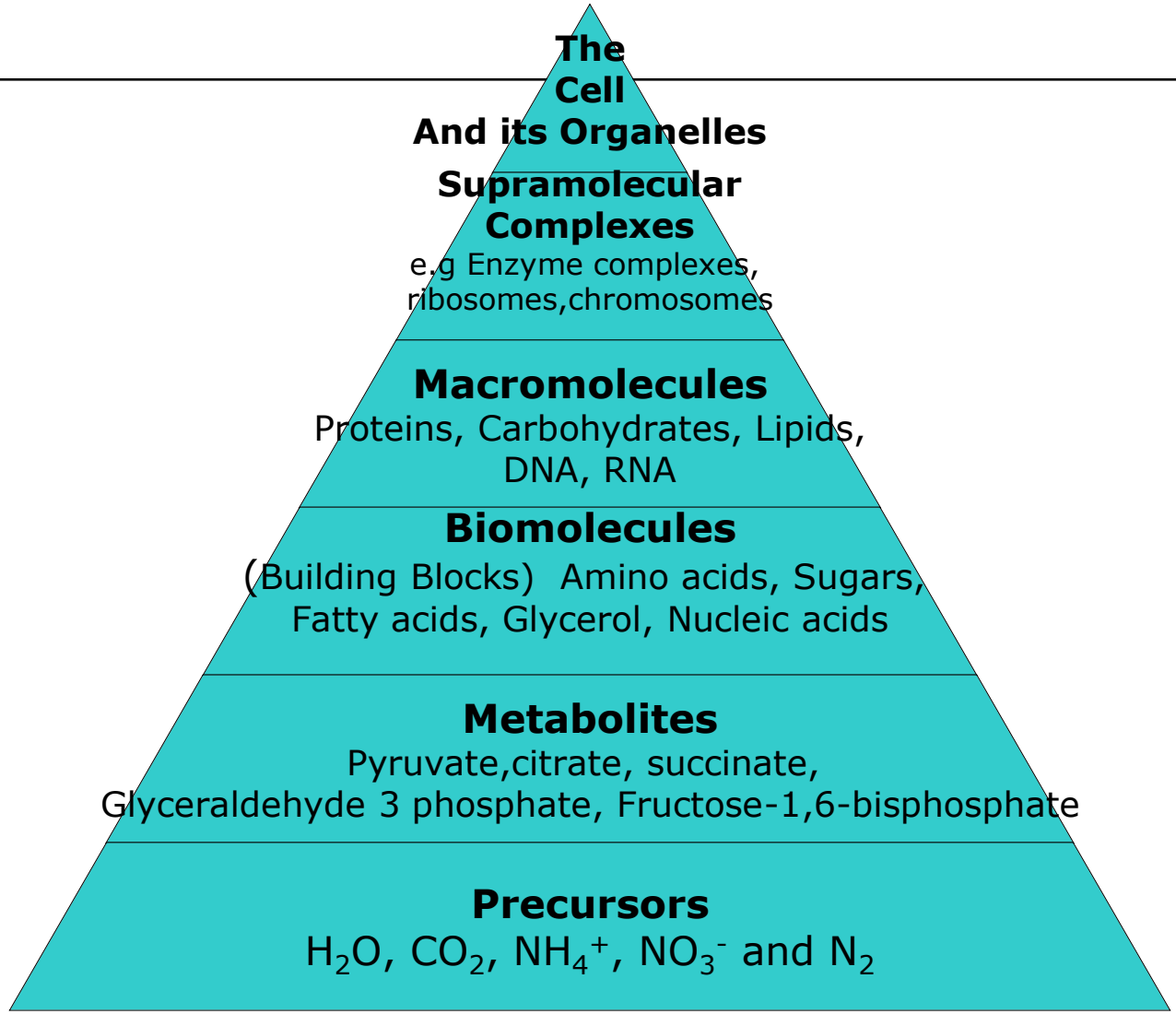
CYCLIC



BRANCHED



Hierarchy of Molecular Components in a Cell

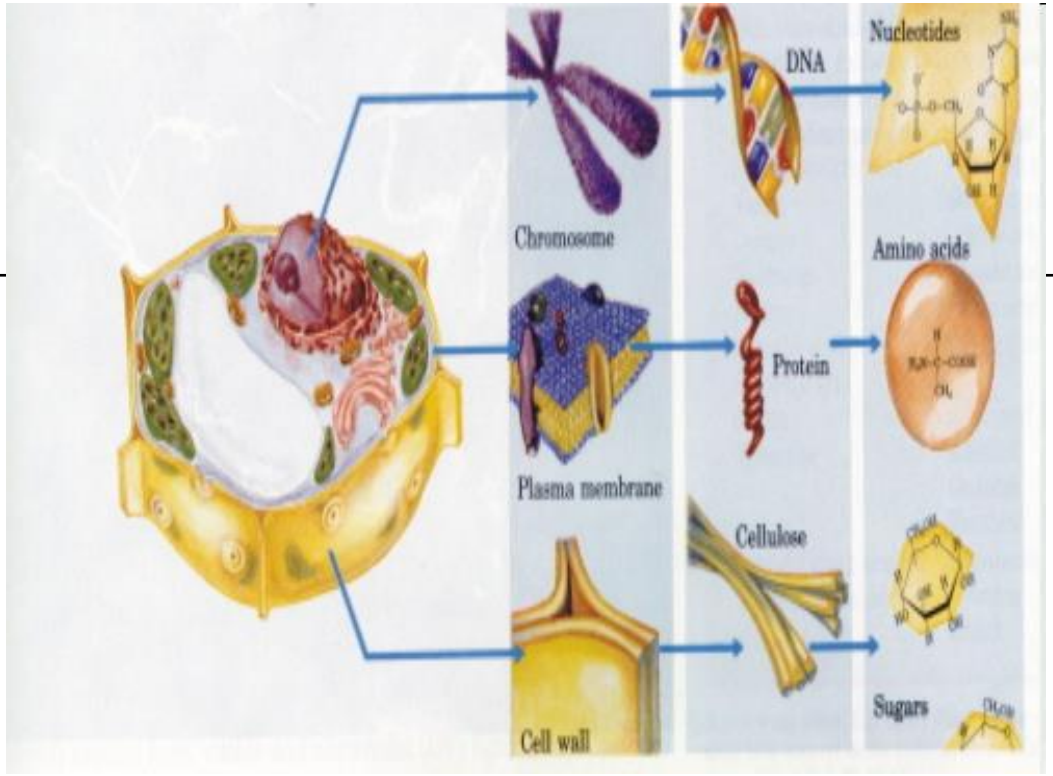


- **Precursors or metabolites** (H_2O, CO_2, NO_3^-, NH_4^+ and N_2) react chemically to produce **biomolecules** such as amino acids, sugars (monosaccharides), nucleic acids, fatty acids, glycerol.
- These biomolecules are building blocks or monomers for the formation of the polymers which are **macromolecules**

  Each type of macromolecule is made up of a different type of building block.
- Macromolecules are assembled into **supramolecular complexes** (e.g chromosomes, ribosomes, enzyme complexes) which are responsible for specialized functions
- Supramolecular complexes are localized into **organelles** within each cell. Organelles also have specific functions

Properties of Biomolecules Which Reflect their Suitability for Living Systems

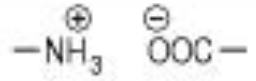
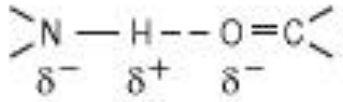
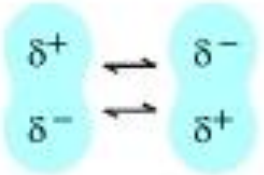
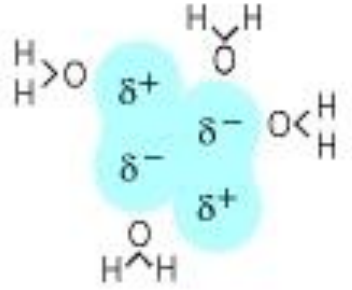
1. Macromolecules are made up of building blocks which make them non-symmetrical. They have **structural polarity**
2. Because of this structural polarity, they are **able to store information**. The sequence of building blocks which make up the macromolecules allows different bits of information to be stored e.g proteins (made up of amino acids) and DNA (made up of nucleic acids)
3. They have unique 3D shapes because of their sequences which give them **different chemical and physical properties** and allow them to perform different functions
4. Weak chemical forces (non-covalent) link macromolecules together which allow constant formation and breaking of interactions between macromolecules. These forces include hydrogen bonds, van der Waals forces, ionic and hydrophobic interactions.
5. There is **structural complementarity** between certain macromolecules which allow them to recognize each other. Weak chemical forces hold these macromolecules together when necessary so that their functions can be carried out, after which the attractions are broken e.g an enzyme and its specific substrate



LEVEL 1: THE CELL AND ITS ORGANELLES
LEVEL 2: SUPRAMOLECULAR COMPLEXES
LEVEL 3: MACROMOLECULES
LEVEL 4: BIOMOLECULES

IN SUPRAMOLECULAR COMPLEXES, THE DIFFERENT MACROMOLECULES ARE HELD TOGETHER BY (e.g.)
HYDROGEN BONDS (between polar groups),
IONIC INTERACTIONS (betw. charged groups),
HYDROPHOBIC INTERACTIONS (betw. nonpolar groups), AND
VAN DER WAALS INTERACTIONS (these bonds have energies of only a few kJ; covalent bonds have bond energies of 200 to 900 kJ/mol)

Comparison of non-covalent forces of attraction between molecules

Noncovalent forces	Origin	
Electrostatic forces	Attraction between opposite charges	
Hydrogen bonds	Hydrogen shared between electronegative atoms (N,O)	
Van der Waals forces	Fluctuations in electron clouds around molecules oppositely polarize neighboring atoms	
Hydrophobic forces	Hydrophobic groups interact unfavorably with water and tend to pack together to exclude water molecules. The attraction also involves van der Waals forces	

Metabolism

- Definition: **Metabolism is the set of chemical reactions that happen in living organisms to maintain life.** These processes allow organisms to grow and reproduce, maintain their structures, and respond to their environments. en.wikipedia.org/wiki/Metabolism

Cells – 2 categories

Prokaryotes - do not have a membrane-bound nucleus or other organelles

2 classes or lineages – eubacteria and archaea (thermoacidophiles, halophiles and methanogens)

- **Eukaryotes** - possess nucleus and other organelles

References

- Biochemistry (3rd Edition) by Garrett and Grisham
- *acad.erskine.edu/facultyweb/smith/…/**Powerpoint**s/HortonCH1.**ppt***
- *www.passovoy.com/biology/**Biochemistry**-Biomolecules.**ppt***