Biochemistry: Introduction

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INTRODUCTION

- *Term "Biochemistry" was coined by **Carl Neuberg** in 1903.*
- *Made from two words: **Bio** and **Chemistry**.*
- *It is considered a hybrid science: Biology is the science of living organisms and chemistry is the science of atoms and molecules, so biochemistry is the science of the atoms and molecules in living organisms.*
- *Carl Neuberg studied the transport of soluble chemicals in cells which allowed for day to day cellular processes, such as respiration to be explained.*

Biochemistry is the study of life on a molecular level and is concerned with:

- *the chemical constituents of living cells*
- *the reactions and processes that make the cell alive*

It is the branch of science that deals with the chemical basis of life

- Bio= Bios = Life——
  - Plant———————— Plant Biochemistry
  - Animal————Animal Biochemistry
  - Microbes————Microbial Biochemistry

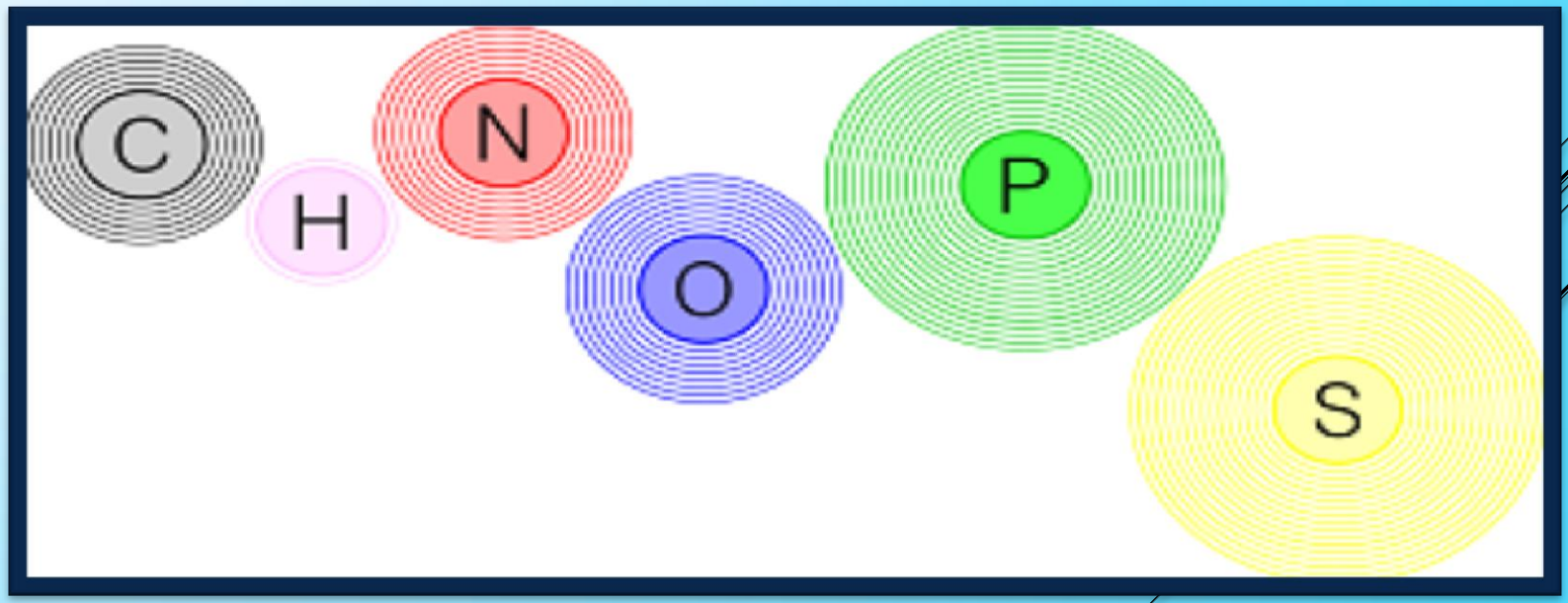
CHEMICAL ELEMENTS OF EARTH ARE 113

IA																	0
1 H 1.008	IIA											IIIA	IVA	VA	VIA	VIIA	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)

BUT HOW MANY OF THEM EXIST IN LIFE?

There are 6 primary elements found in living organisms

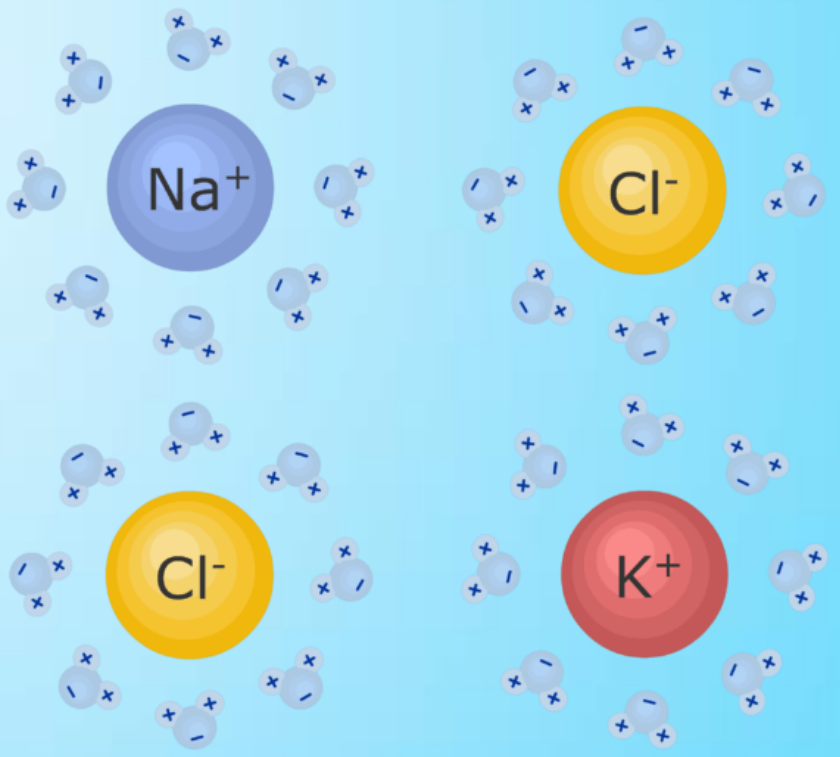
- *Oxygen*
- *Carbon*
- *Hydrogen*
- *Nitrogen*
- *Phosphorus*
- *Sulfur*



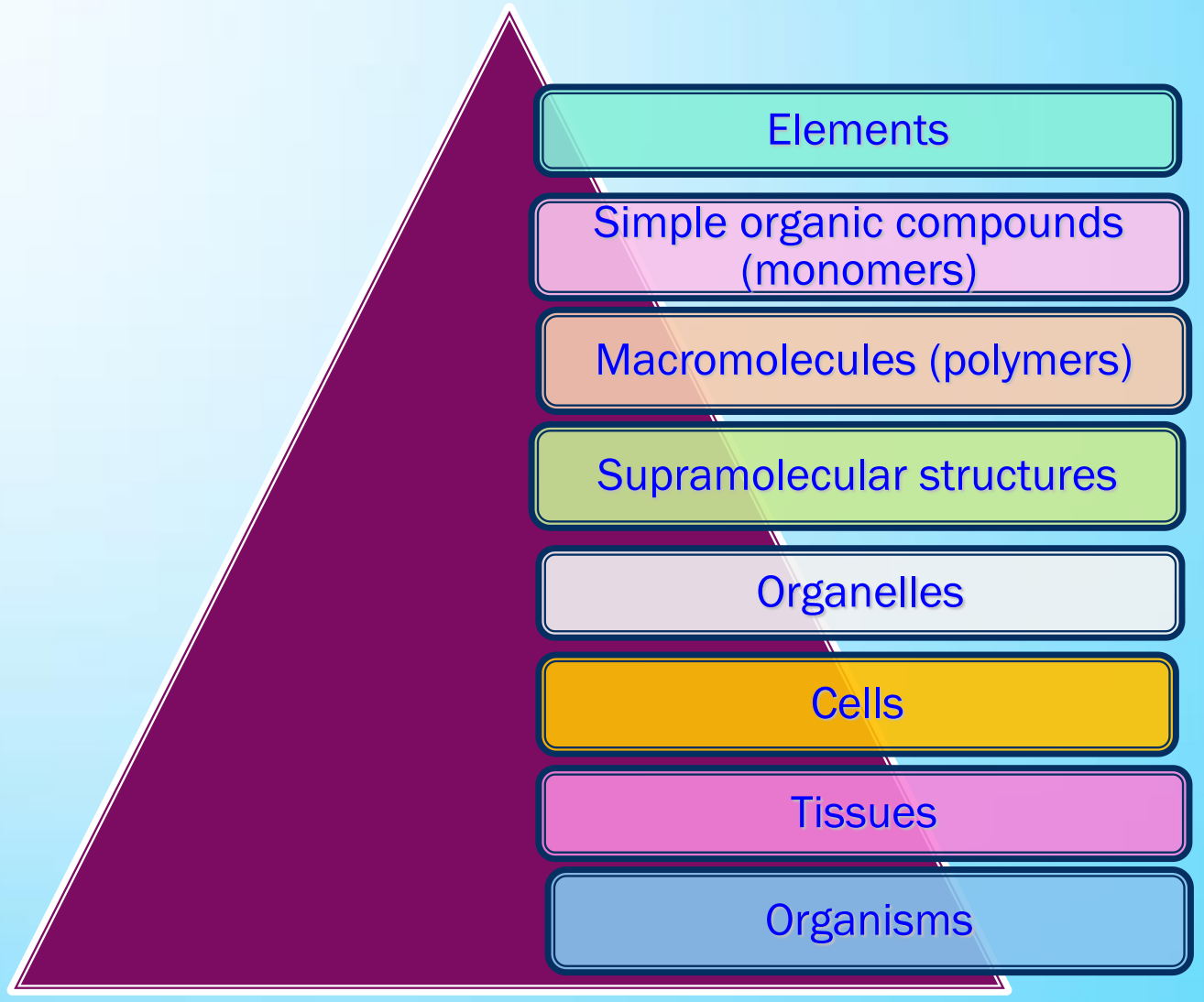
IONS

5 common ions found in all organisms:

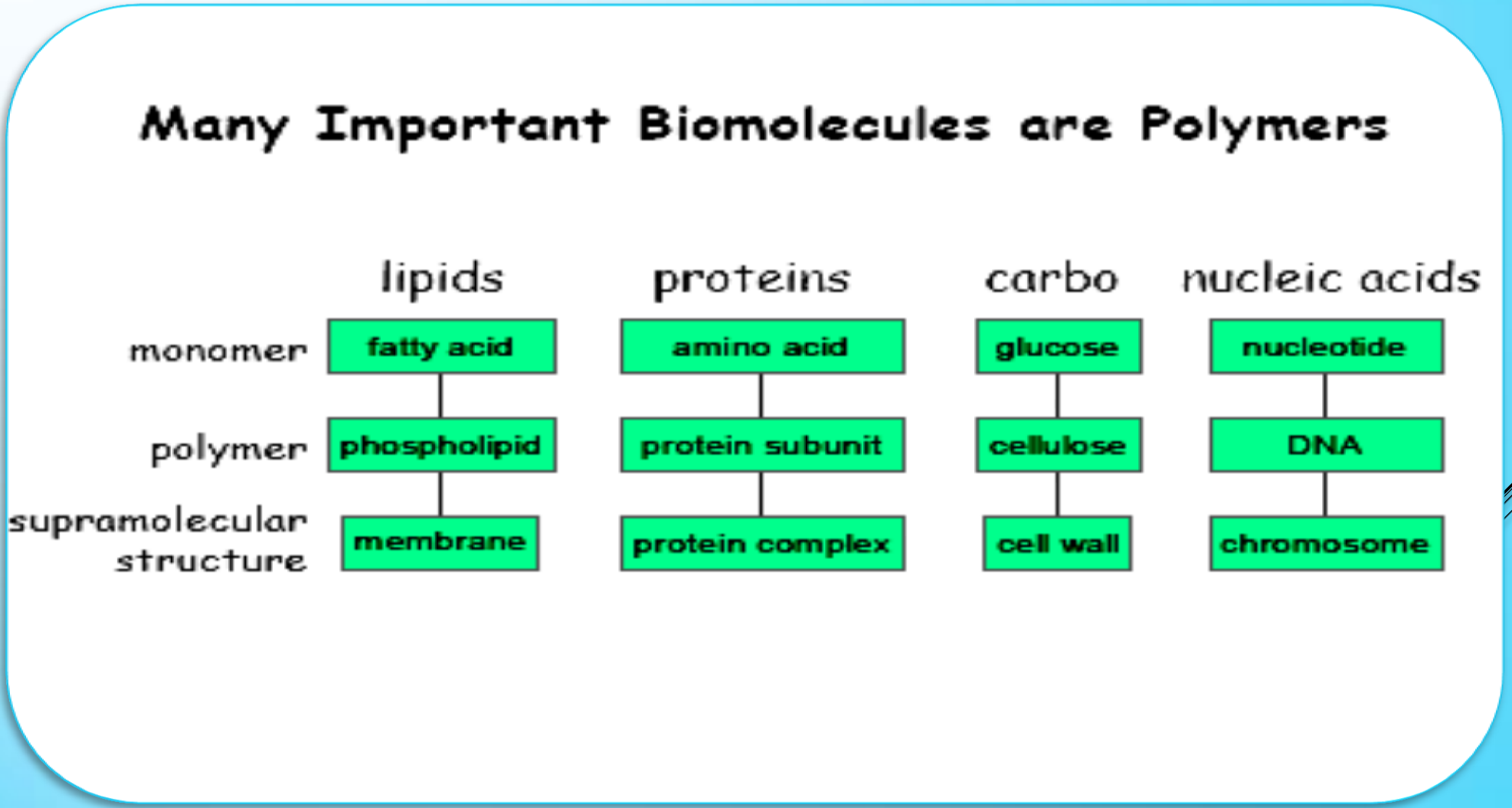
- Calcium (Ca^{2+})
- Potassium (K^{+})
- Sodium (Na^{+})
- Magnesium(Mg^{2+})
- Chloride (Cl^{-})

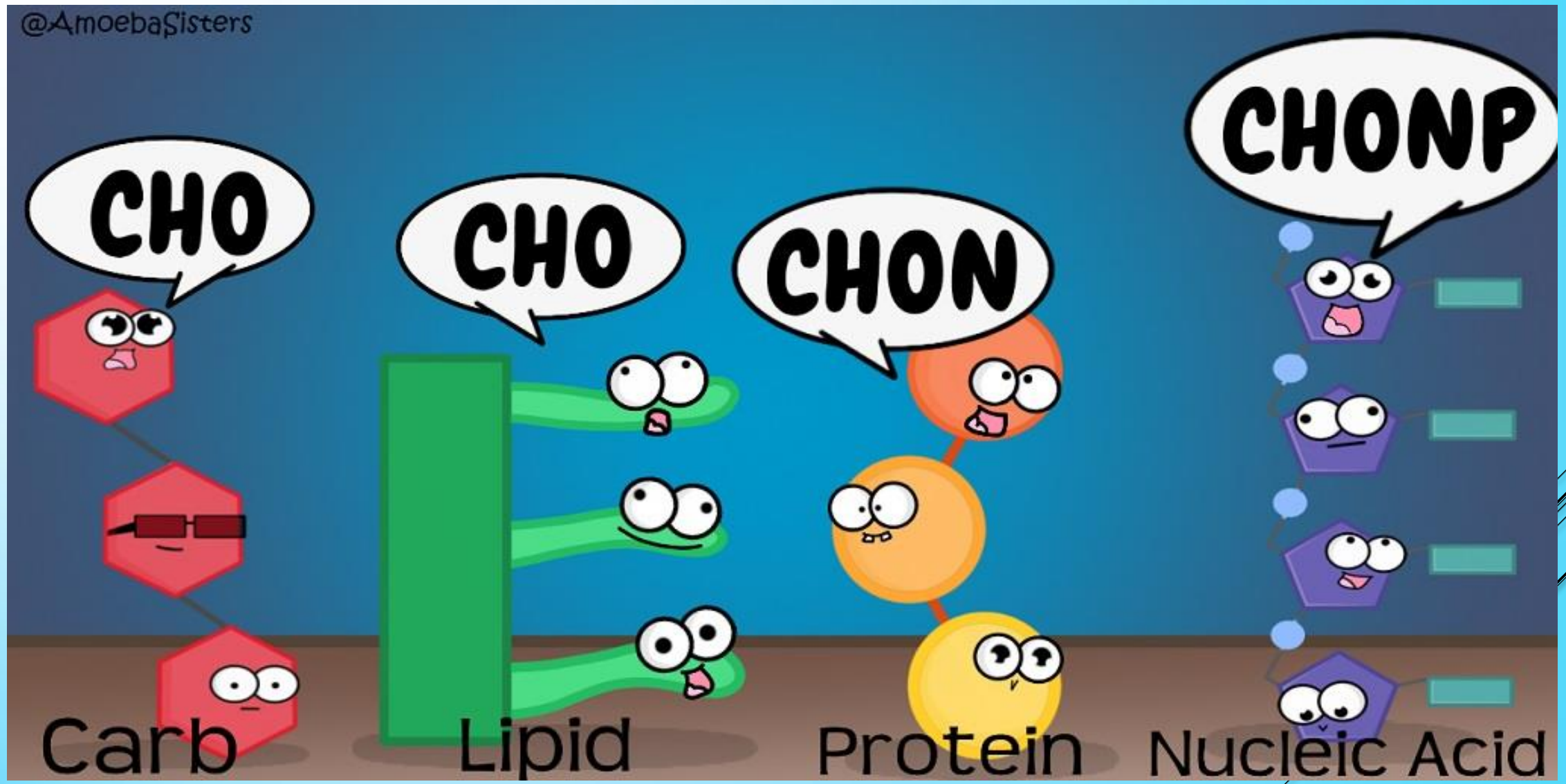


Organization of Life



BIOMOLECULES IN LIVING ORGANISMS



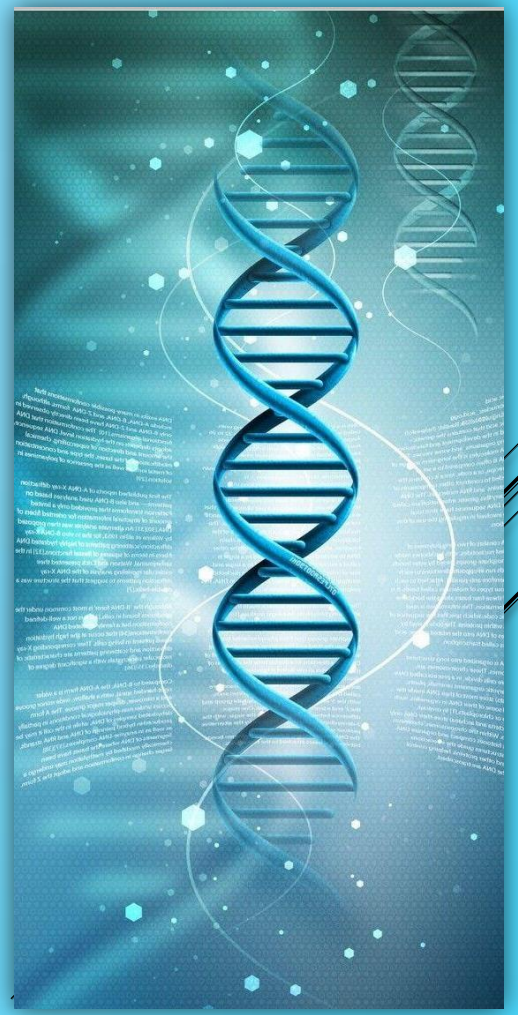

@AmoebaSisters
CHO
CHO
CHON
CHONP
Carb
Lipid
Protein
Nucleic Acid

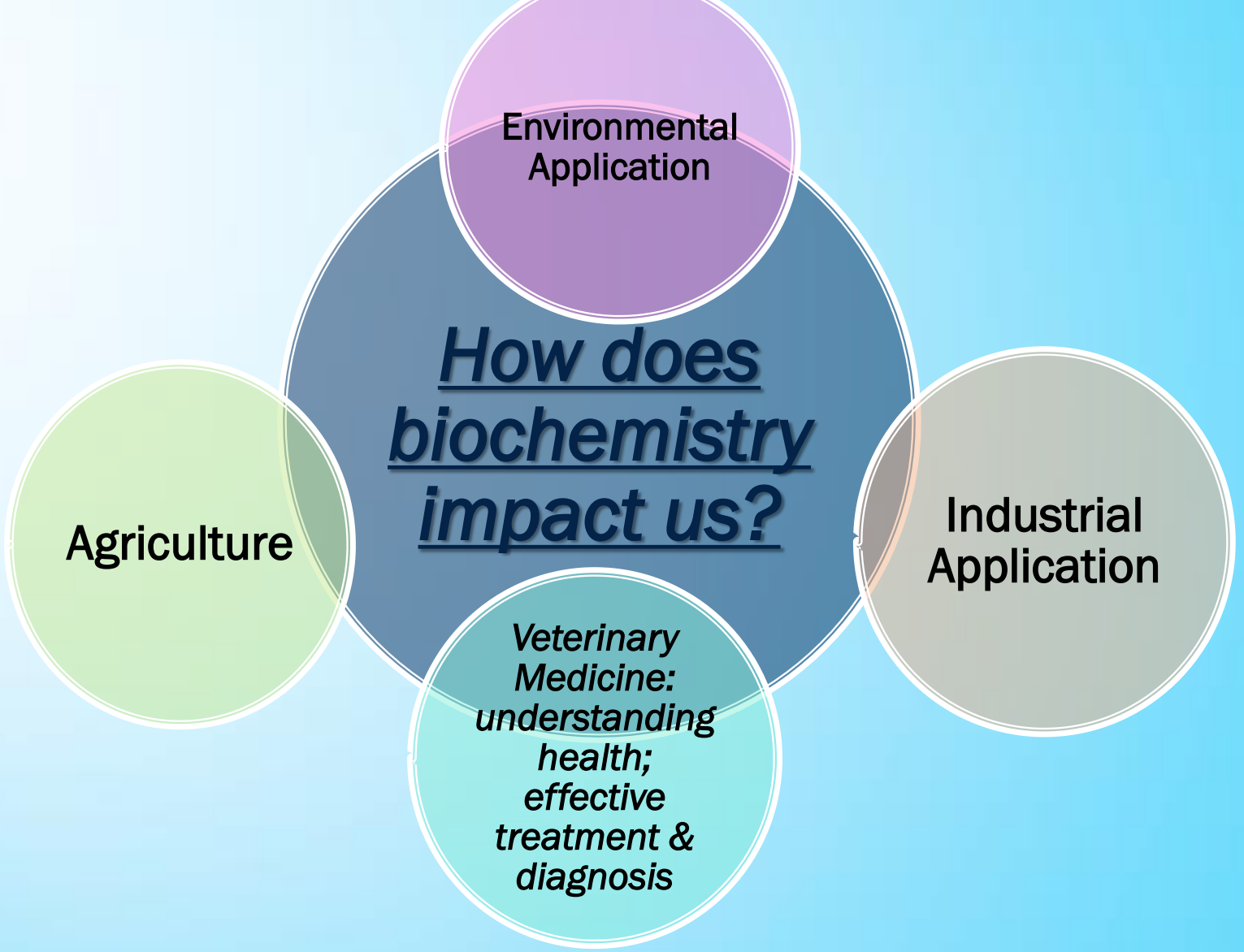
MAJOR COMPLEX BIOMOLECULES OF CELLS

Biomolecule	building block	major functions
• Protein	• amino acids	• structure & function
• Carbohydrate	• Monosacharide	• storage energy (short term
• Lipids	• fatty acids & glycerol	• storage energy (long term
• DNA	• Deoxyribonucleotides	• hereditary information
• RNA	• ribonuclotides	• protein biosynthesis

Knowledge of Biochemistry is essential to all life sciences

- *We take a drug to lower our fever. That drug was developed by a pharmaceutical company's biochemists to inhibit a key enzyme involved in prostaglandin biosynthesis.*
- *We shave with a cream containing compounds that soften beard. These active agents were developed after studies of the physical properties of keratin, the protein in hair.*
- *We take a breakfast cereal fortified with vitamins identified through nutritional biochemistry.*
- *We wear a shirt made from pest-resistant cotton. The cotton plants were bioengineered by biochemists through the transfer of genes from a bacterium into plants.*
- *We wash our cloths with a detergent that contain enzymes that will remove stains. That enzyme was developed by biochemists to hydrolyze the proteins causing the stains.*
- *We take milk before bedtime. Our sleep is helped by the amino acids in the milk, which are converted by brain into molecular signals that lead to a resting state in other parts of brain.*




Environmental Application
How does biochemistry impact us?
Agriculture
Industrial Application
Veterinary Medicine: understanding health; effective treatment & diagnosis

PRINCIPLE AREAS OF BIOCHEMISTRY

Structure and function of biological macromolecules- UNIT-1

Metabolism – anabolic and catabolic processes of life- UNIT-2

Molecular Biology – How life is replicated and regulated?

Clinical Biochemistry– How biochemistry can be used in diagnosis & clinical conditions? - UNIT-3

HISTORY OF BIOCHEMISTRY

- *Biochemistry is a fairly new field of science, developed largely in the 20th century.*
- *It originated as a way to treat diseases. The oldest available evidence is of **Theophrastus**; who first acquired the knowledge of chemistry and then entered the field of medicine to apply his knowledge of chemistry. He proclaimed that "All life processes are essentially of chemical nature and diseases can be cured by medicines".*
- *The strong basis of biochemistry was, laid down by chemists like **Karl Wilhelm Scheele** and **Antoine Lavoisier Scheele** discovered the chemical composition of various drugs, plants and animal materials.*
- ***Lavoisier**, a French chemist, studied the composition of air and laid the theory of conservation of matter. He developed the concept of oxidation and also explained the nature of animal respiration. Lavoisier is thus often spoken of as "Father of Modern Biochemistry".*
- *Later. It was **Wohler** who synthesized urea in lab and demonstrated that the building blocks of life were the same as those of non-living things; thus disapproving vitalism theory.*
- *The work of Wohler is considered as a great milestone in the field of Biochemistry and a starting point also.*

HISTORY OF BIOCHEMISTRY

- *The DNA Breakthrough: Avery et al. showed that DNA is the genetic material that determines the traits (phenotype) of organisms*
- *In1953, Watson and Crick made the discovery of the double helical structure of DNA*
- *The sequence of base pairs in a double helical structure provided an explanation for how information could be stored and reproduced*
- *Crick's Central Dogma: DNA >RNA>Protein>body*

MAJOR ACHIEVEMENTS IN BIOCHEMISTRY

1) DETERMINATION OF STRUCTURES OF BIOMOLECULES
2) ELUCIDATION OF FUNCTION OF MANY BIOMOLECULES
3) RECOMBINANAT DNA TECHNOLOGY
4) ISOLATION AND ESTABLISHMENT OF FUNCTIONS OF MAJOR INTRACELLULAR ORGANELLES
5) ANALYSIS OF STRUCTURE AND FUNCTION OF ENZYMES AND RIBOZYMES
6) DELINEATION OF METABOLIC PATHWAYS AND THEIR FUNCTIONS
7) DETERMINATION OF MAJOR PRINCIPLES OF METABOLIC REGULATION
8) MEMBRANE STRUCTURE AND FUNCTION
9) MECHANISM OF HORMONE ACTION
10) INSIGHTS INTO MOLECULAR BASIS OF MANY DISEASES

STUDY OF BIOCHEMICAL PROCESSES

Studies at whole animal level

Tissue slice

Homogenate

Isolated sell organelles

Subfractionation of organelles

Isolation and characterization of metabolic e

Cloning of genes and proteins

WHAT DO WE STUDY IN BIOCHEMISTRY?

Chemical constituents of life

Physiological Biochemistry

Metabolism

Clinical Biochemistry

Molecular Biology

CHEMICAL CONSTITUENTS OF LIFE

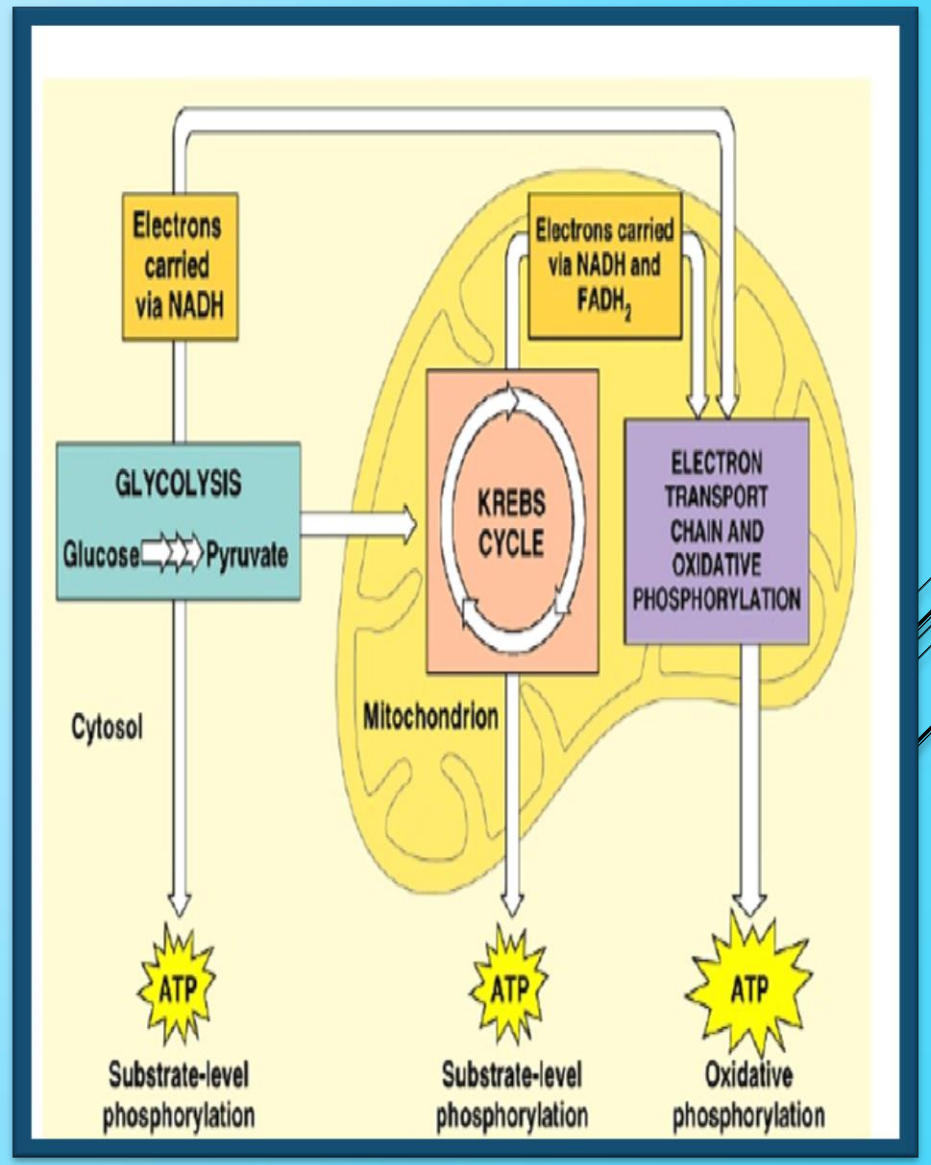
- *Carbohydrates*
- *Proteins & Plasma proteins*
- *Amino acids*
- *Lipids*
- *Nucleic acids*
- *Enzymes*
- *Vitamins*
- *Minerals*

PHYSIOLOGICAL BIOCHEMISTRY

- *Digestion & Absorption*
- *Plasma proteins*
- *Hemoglobin & porphyrins*
- *Biological oxidation*
  - *Energy rich compounds*
  - *Biological oxidation*
  - *Respiratory chain*
  - *Oxidative phosphorylation*

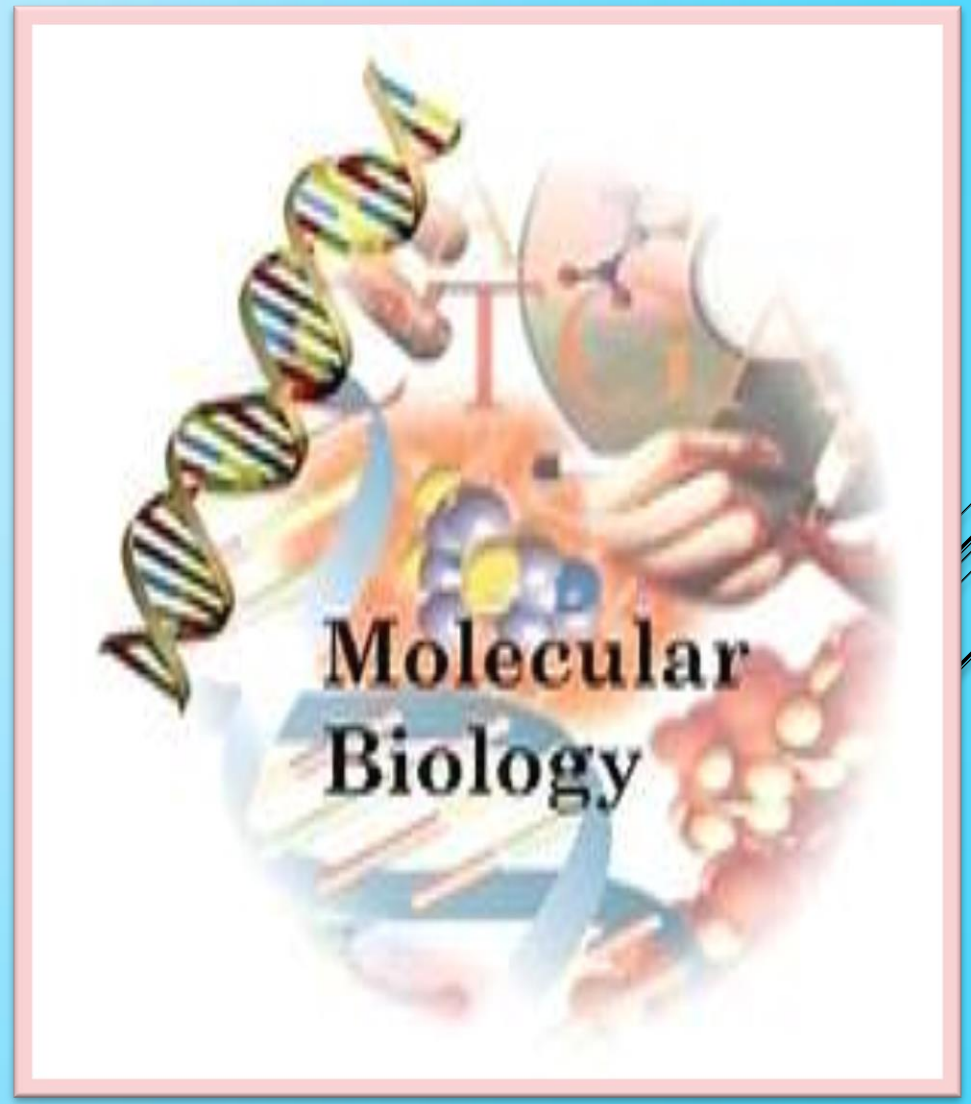
METABOLISM

- *Metabolism of carbohydrates*
- *Metabolism of proteins & amino acids*
- *Metabolism of lipids*
- *Metabolism of minerals*
- *Metabolism of Hormones*
- *Metabolism of nucleic acids & nucleotides*
- *Metabolism of Hemoglobin*
- *Metabolism of Prostaglandins*
- *Metabolism of Xenobiotics*
- *Integration of metabolism*



MOLECULAR BIOLOGY:

- *Nucleotides*
- *Replication*
- *Transcription*
- *Translation*
- *Recombinant DNA technology*
- *Human genome project*
- *Gene therapy*



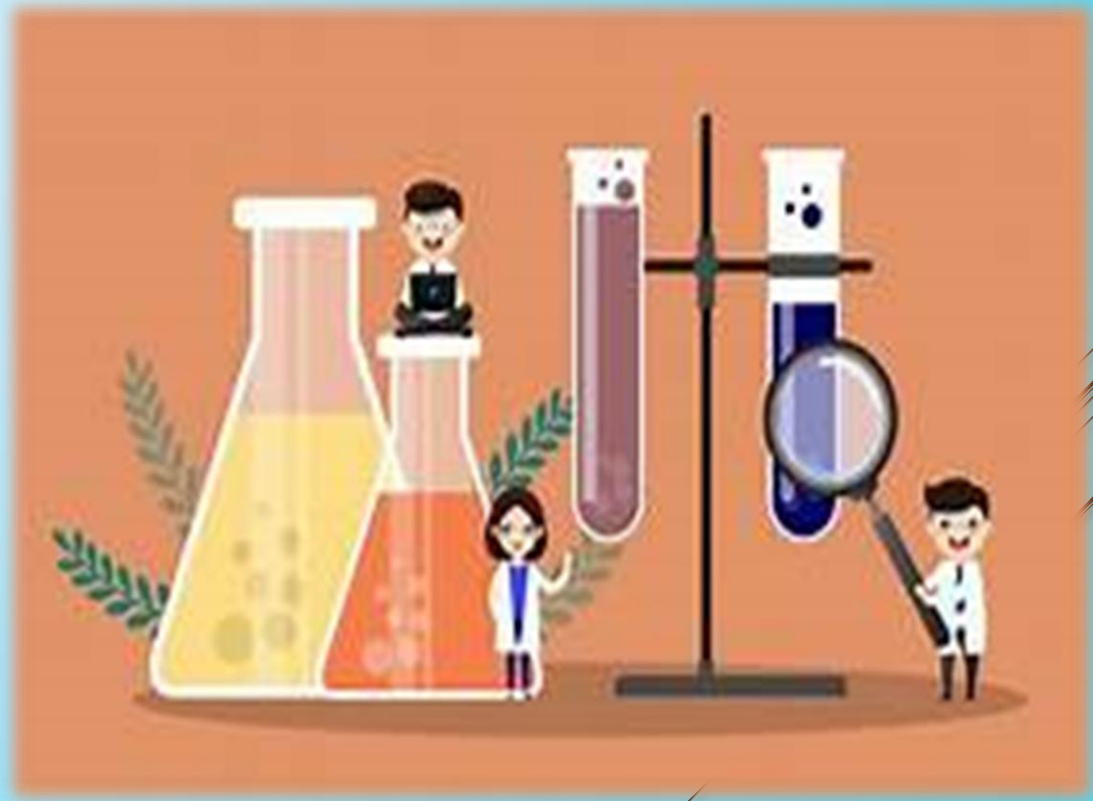
CLINICAL CHEMISTRY:

- *Insulin & Diabetes mellitus*
- *Liver function test*
- *Kidney function test*
- *Clinical Enzymology*
- *Free radicals & Antioxidants*
- *Water, Electrolyte & Acid-Base balance*

CAREERS IN BIOCHEMISTRY

A biochemist can work in any of the fields listed below.

- Analytical chemist
- Biomedical scientist
- Biotechnologist
- Healthcare scientist, clinical biochemistry
- Clinical research associate
- Forensic scientist
- Medicinal chemist
- Nanotechnologist
- Pharmacologist
- Physician associate
- Research scientist (life sciences)
- Scientific laboratory technician
- Toxicologist



INDUSTRIES WHERE A BIOCHEMIST CAN WORK

- *Research Institutes*
- *Universities*
- *Government Agencies and Parastatals*
- *The National Health Service*
- *Forensic Science Services*
- *Environment Agency*
- *Food Industry*
- *Pharmaceutical Industry*
- *Biotechnology Industry*

BIOCHEMISTRY & NOBEL

The Nobel in this field is given under Chemistry. The Biochemistry is such important field that most of the nobel prizes under the category "Chemistry" is conferred for the discovery in the field of Biochemistry. Some of the discoveries is listed below

Year	Scientist & Discovery
2020	Emmanuelle Charpentier and Jennifer A. Doudna "for the development of a method for genome editing"
2018	Frances H. Arnold "for the directed evolution of enzymes", George P. Smith and Sir Gregory P. Winter "for the phage display of peptides and antibodies"
2017	Jacques Dubochet, Joachim Frank and Richard Henderson "for developing cryo-electron microscopy for the high-resolution structure determination of biomolecules in solution"
2016	Jean-Pierre Sauvage, Sir J. Fraser Stoddart and Bernard L. Feringa "for the design and synthesis of molecular machines"
2015	Tomas Lindahl, Paul Modrich and Aziz Sancar "for mechanistic studies of DNA repair"
2012	Robert J. Lefkowitz and Brian K. Kobilka "for studies of G-protein-coupled receptors"

2009	Venkatraman Ramakrishnan, Thomas A. Steitz and Ada E. Yonath “for studies of the structure and function of the ribosome”
2008	Osamu Shimomura, Martin Chalfie and Roger Y. Tsien “for the discovery and development of the green fluorescent protein, GFP”
2006	Roger D. Kornberg ”for his studies of the molecular basis of eukaryotic transcription”
2004	Aaron Ciechanover, Avram Hershko and Irwin Rose ”for the discovery of ubiquitin-mediated protein degradation”
2003	“for discoveries concerning channels in cell membranes” Peter Agre ”for the discovery of water channels”, and Roderick MacKinnon ”for structural and mechanistic studies of ion channels”
2002	“for the development of methods for identification and structure analyses of biological macromolecules” John B. Fenn and Koichi Tanaka ”for their development of soft desorption ionisation methods for mass spectrometric analyses of biological macromolecules”. Kurt Wüthrich ”for his development of nuclear magnetic resonance spectroscopy for determining the three-dimensional structure of biological macromolecules in solution”

Year	Discovery
1997	Paul D. Boyer and John E. Walker ”for their elucidation of the enzymatic mechanism underlying the synthesis of adenosine triphosphate (ATP)” Jens C. Skou ”for the first discovery of an ion-transporting enzyme, Na+, K+ - ATPase”
1993	“for contributions to the developments of methods within DNA-based chemistry” Kary B. Mullis ”for his invention of the polymerase chain reaction (PCR) method” Michael Smith ”for his fundamental contributions to the establishment of oligonucleotide-based, site-directed mutagenesis and its development for protein studies”
1989	Sidney Altman and Thomas R. Cech ”for their discovery of catalytic properties of RNA”
1988	Johann Deisenhofer, Robert Huber and Hartmut Michel ”for the determination of the three-dimensional structure of a photosynthetic reaction centre”
1987	Donald J. Cram, Jean-Marie Lehn and Charles J. Pedersen ”for their development and use of molecules with structure-specific interactions of high selectivity”
1980	Paul Berg ”for his fundamental studies of the biochemistry of nucleic acids, with particular regard to recombinant-DNA” Walter Gilbert and Frederick Sanger “for their contributions concerning the determination of base sequences in nucleic acids”

Wherever there is a new discovery in Biology, Biochemistry must be there