

Chapter 1

INTRODUCTION

Definition

- **Biochemistry** (also called **biological chemistry**) is the study of the composition, properties & interactions of chemicals in living systems.
- Biochemistry has its origin from large areas of Sciences
 - Chemistry, Biology and other Biochemical Sciences such as molecular biology, immunology
 - ✓ and began when people study how living things obtain energy from food, the chemical basis of heredity, what fundamental changes occur in disease, and related issues.
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- The term **Biochemistry** was coined by a German chemist **Carl Neuber** (in 1903)

The Objective & Scope of Biochemistry

- ❖ Main objective of biochemistry is
 - Molecular level understanding of all chemical processes in living systems
 - ✓ to give rise to the processes that occur within/between living cells
 - which in turn relates to understanding of tissues , organs, organism structure and function.
 - And ways to control them

- ❖ Molecular level understanding of life demands such k/ge & skills as :-
 - Isolation of numerous molecules found in cells
 - Determination of the structure of these molecules
 - Analysis of how they function etc...

- ❖ Biochemistry can be divided into three fields
 - Structural biology
 - Enzymology and
 - Metabolism

Cellular foundations of biochemistry

- ❖ Proper understanding physiological processes (growth, development, disease etc.) in living systems
 - requires understanding of life at **cellular** and **molecular** level

Cells

- ❖ Cells are the microscopic units of all living things
- ❖ They are structural, functional and biological units of all living matter
- ❖ Cells generally vary in **size, shape, composition** and **function**
- ❖ Cells are similar to small factories with different laborers and departments that work all the time to make factory well being.
- ❖ Various kinds of cells perform different functions like protein synthesis and energy production.

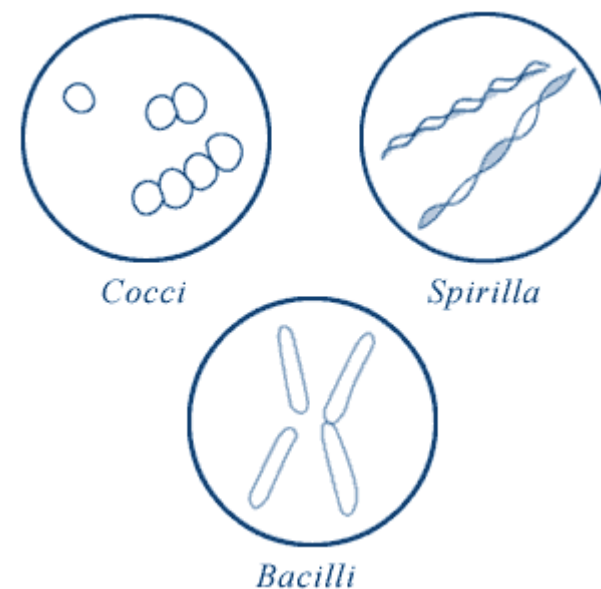
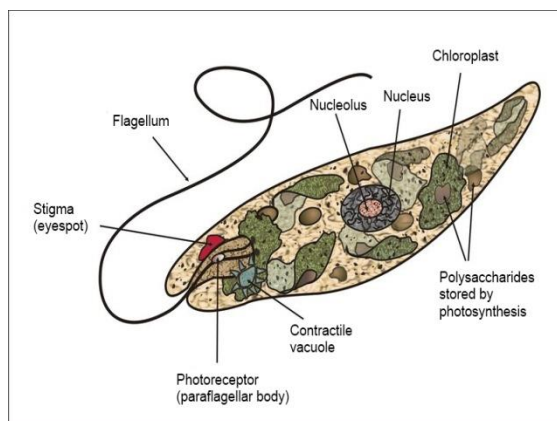
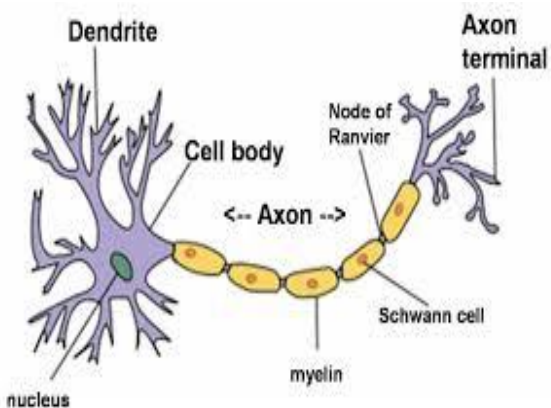
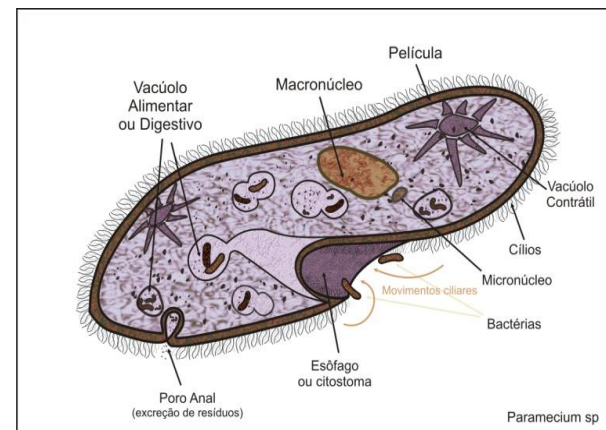
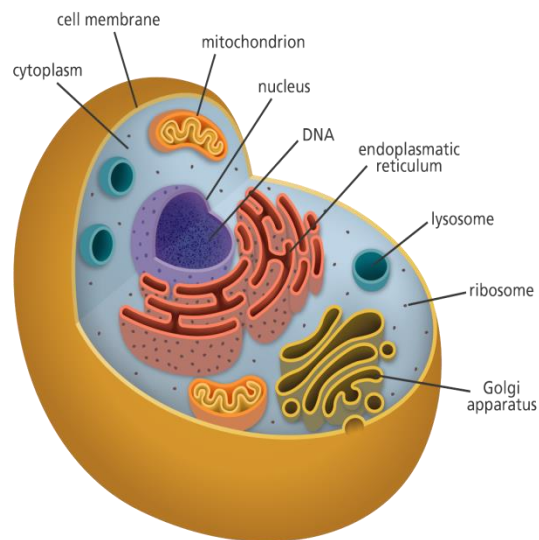
Cellular foundations of biochemistry

Cell size

- **Plant cells** (10 to 100 μm in diameter)
- **Animal cells** (5 to 30 μm in diameter)
- **Bacteria** (1 - 2 μm in diam. But mycoplasmas = 300 nm)

Cellular foundations of biochemistry

Cell shape



Cellular foundations of biochemistry

Cellular organization

- ❖ A typical animal cell contains a cytoplasm
 - Which is enclosed by a membrane and
 - That contains
 - ✓ Subcellular components (organelles) and
 - ✓ Several biomolecules like proteins, nucleic acids, etc...

Cellular foundations of biochemistry

Cellular organization

❖ Cell Membrane (plasma membrane)

- Is a **bilayer** of **phospholipid** embedded or attached with proteins, carbohydrates or other lipids

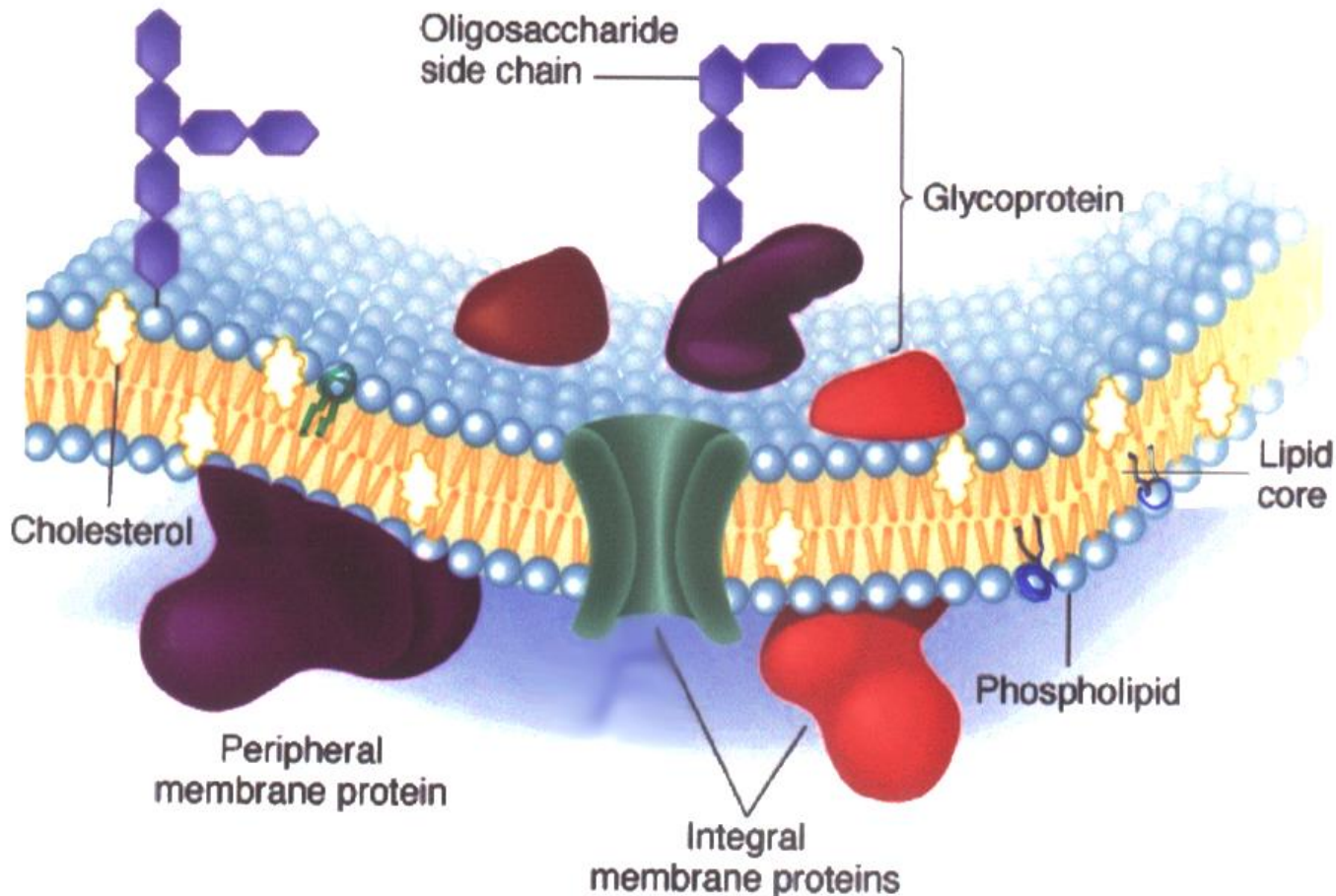
Role

- Keeps the cytoplasmic fluid not **leak out**
- Physical boundary of the cell to **control movement** of materials into and out of the cell (i.e selectively permeable membrane)
- **Protein/carbohydrate components** have role in transport, recognition, adhesion & e-transfer processes

Cellular foundations of biochemistry

Cellular organization

❖ Cell Membrane (plasma membrane)



Cellular foundations of biochemistry

Cellular organization

❖ Cytoplasm

- Gel-like material within the cell membrane
- Consists of water (80% -90%), salts, enzymes, proteins, other organic/inorganic molecules (as nutrients) and organelles

Role

- Mechanical: maintain the shape and consistency of the cell
- Serves as a "molecular soup"
 - to suspend organelles
 - as reservoir for chemical substances required for life/metabolic reactions

Cellular foundations of biochemistry

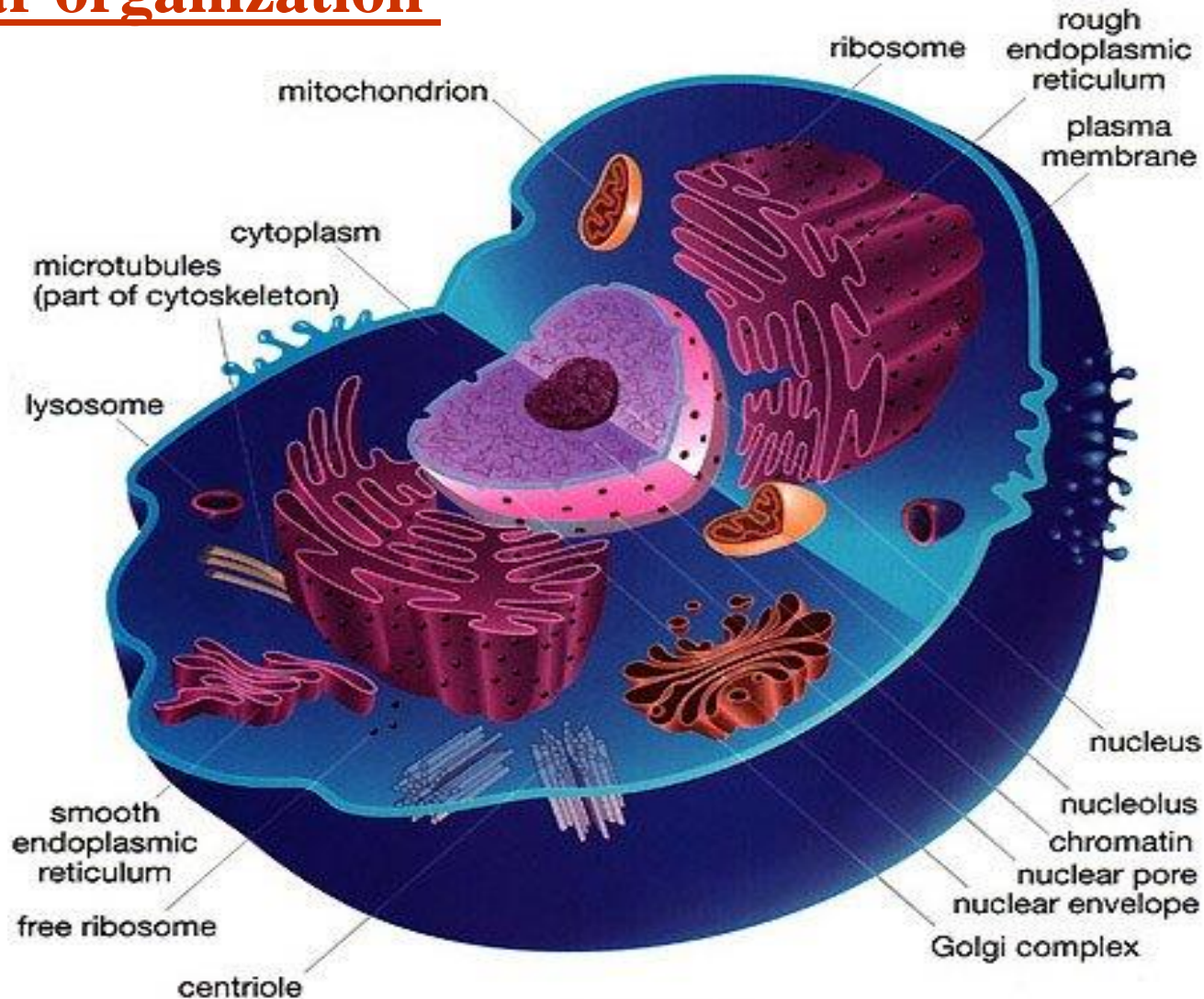
Cellular organization

❖ Organelles

- Are bodies embedded within the cytoplasm
- Each have different **composition, size** and **specific functions** vital to keep our cells alive
- Serve to **physically separate the various metabolic activities** that occur within cells

Cellular foundations of biochemistry

Cellular organization

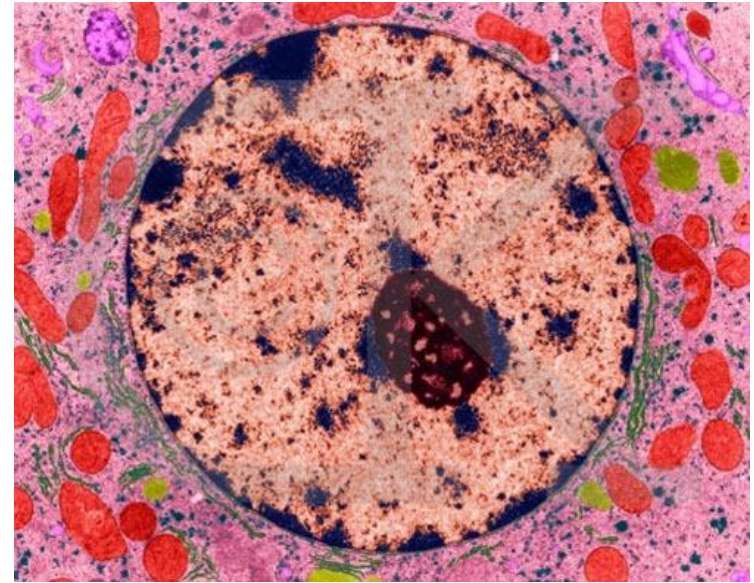


Structure of Animal Cell

Cellular foundations of biochemistry

Cellular organization

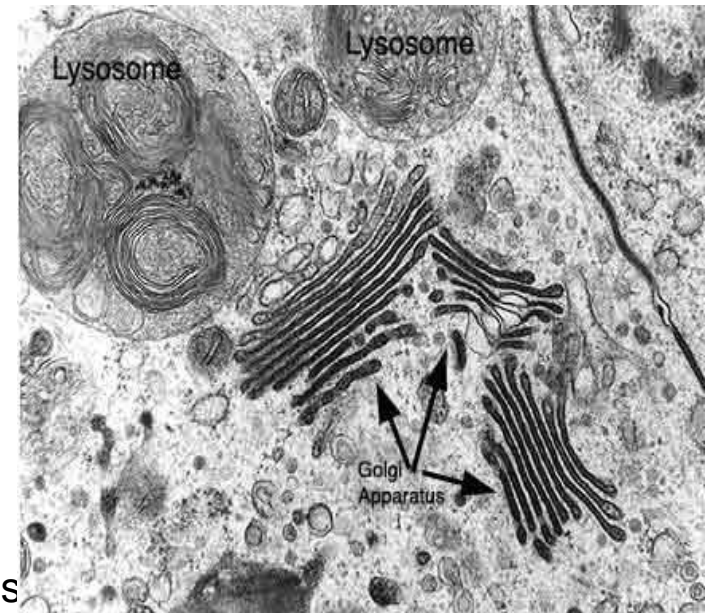
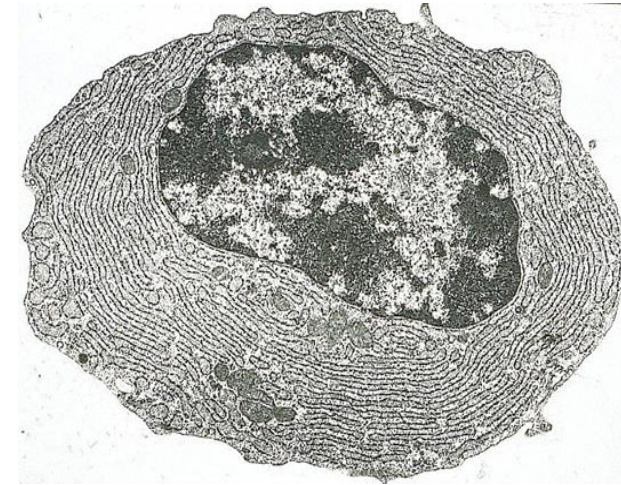
- Organelles (Nucleus)
 - Location of main genome
 - Site of **DNA /RNA synthesis**
 - Composed of
 - A nuclear envelope
 - Chromatin and DNA
 - Nucleolus
- Organelles (Mitochondria)
 - Double membrane organelle
 - Possess mitochondrial (maternal) DNA
 - “**Power House**” of the cell
 - Food converted into energy
 - Adenosine triphosphate (ATP)
 - Consumes Oxygen, produces CO₂



Cellular foundations of biochemistry

Cellular organization

- **Organelles (Endoplasmic Reticulum, EPR)**
 - Continuous membrane through out the cell
 - Site where cell membrane and exported material is made
 - Two sites
 - Rough ER:-make **protiens**
 - Smooth ER:- make **lipids**
- **Organelles (Golgi Apparatus)**
 - Series of flattened sacs
 - Involved in
 - Receives and **modifies proteins**
 - Directs new materials
- **Organelles (Lysosomes)**
 - Membrane bound sacs containing hydrolytic enzymes
 - Role
 - Intracellular **digestion** and breakdown of wastes
 - Help releases **nutrients**



Cellular foundations of biochemistry

Cellular organization

- Organelles (**Peroxisomes**)
 - Sacs where H_2O_2 is generated and degraded

- Organelles (**Vesicles**)
 - Membrane bound sacs
 - Can be of different type (Membrane, ER, Golgi derived, etc.)
 - Have role in material transport

- Organelles (**Cytoskeleton**)
 - Filamentous matter (actin and microtubules)
 - Role
 - **Movement** of organelles and cell
 - **Structure/strengthen** cell

Chemical foundations of biochemistry

Chemical elements in Living Organisms

- About 30 elements constitute the living matter.
 - » **Six elements: S, P, O, N, C & H**
 - Account for $\geq 97\%$ of weight of most organisms
 - Are involved in forming strong covalent bonds & serve as backbone of biomolecules
 - » **Ca, K, Fe, Cl, I, Na, Mg, Cu, Mn & others**
 - Constitute only $\leq 3\%$ of the body weight
 - Play essential role in life
 - As electrolyte to keep hemostasis
 - As enzyme cofactors etc...

Chemical foundations of biochemistry

Periodic Table of the Elements

IA																		0
1 H 1.008																		2 He 4.003
	IIA											IIIA	IVA	VA	VIA	VIIA		
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											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95	
		IIIB	IVB	VB	VIB	VIIB	VIII B			IB	IIB							
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)			

Pink= Major elements; **purple**= essential elements; **dark blue**= more common (Trace) and **light blue**= less common (ultra trace) elements

Chemical foundations of biochemistry

- ❖ Many organic molecules (e.g. Macromolecules, vitamins) are associated with living cells

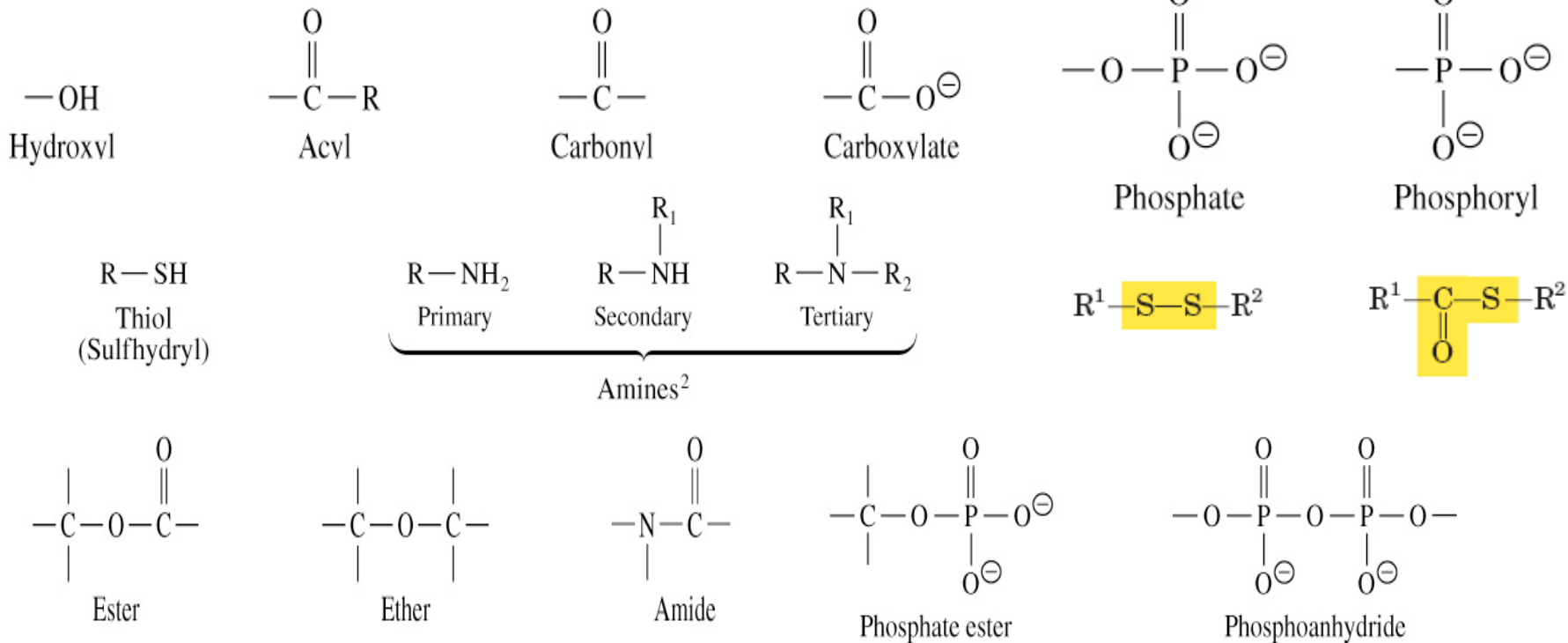
Macromolecule

- Are large molecules created by joining many smaller organic molecules called monomers (residues)
 - by condensation reactions
- Have a M. masses of the order of a million or larger
- Constitute all matter in all living organisms
- Can be grouped in to four groups:
 - Proteins
 - Lipids
 - Nucleic acids
 - Carbohydrates

Chemical foundations of biochemistry

Functional groups

- Specific parts of molecules (atoms or groups of atoms) attached to the carbon backbone
- They are mostly involved in biochemical reactions and contribute much to their chemical properties and diversity



Common organic functional groups and linkages

Chemical foundations of biochemistry

Chemical and Biochemical Reactions

- Chemical reactions that occur inside the cell are some how similar to reactions occurring outside cells
- Some basic aspects of the chemical and biochemical reactions are summarized as follows.

<u>Chemical Reactions</u>	<u>Biochemical Reactions</u>
<ul style="list-style-type: none">-Takes place in test tubes, beakers & flasks in larger volumes-Generally occur at variable temperature-The rate of the reaction can be controlled by changing the pH-Are facilitated by chemical agents called catalysts (e.g metals)	<ul style="list-style-type: none">-Takes place in a living cell in a restricted area (cytosol/organelles)-Takes place at the constant- pH is constant, generally about 7.3- Are catalyzed by enzymes

Application areas of Biochemistry

- **Pharmaceutical sciences** :- in design/formulation of drugs, metabolic study of drugs, investigate the mechanism of a drug action
- **Medicine dentistry, and veterinary medicine** –to understanding diseases and their effective management modalities
 - ✓ Investigation of tissue/organ structure and function
 - ✓ use chemical concepts, procedures & and techniques to diagnosis of disease and the assessment of health.
- **Food science/Nutrition:-** to determine the chemical composition of foods, research ways to develop abundant and inexpensive sources of nutritious foods, develop methods to extract nutrients from waste products, and/or invent ways to prolong the shelf life of food products. understanding and maintenance of
- **Environmental Sciences & Toxicology:-** See effect of pollutants, harmful chemicals and poisons on living organisms
- **Agriculture:-**Proper use of herbicides, pesticides, transgenic crops
- **Chemical industries-**production of marketable products and waste control

Activity 1

Compare and contrast

- Prokaryotic and eukaryotic cells
- Plant and animal cells