

INTRODUCTION TO BIOCHEMISTRY





OBJECTIVES

- ***At the end of lecture, student would be able to:***
 - ☐ Define biochemistry of human body.
 - ☐ Understand the biochemical structure and of the human body.
 - ☐ Describe the three classes of polymeric biomolecules and their monomeric building blocks.

CHEMISTRY

The study of:

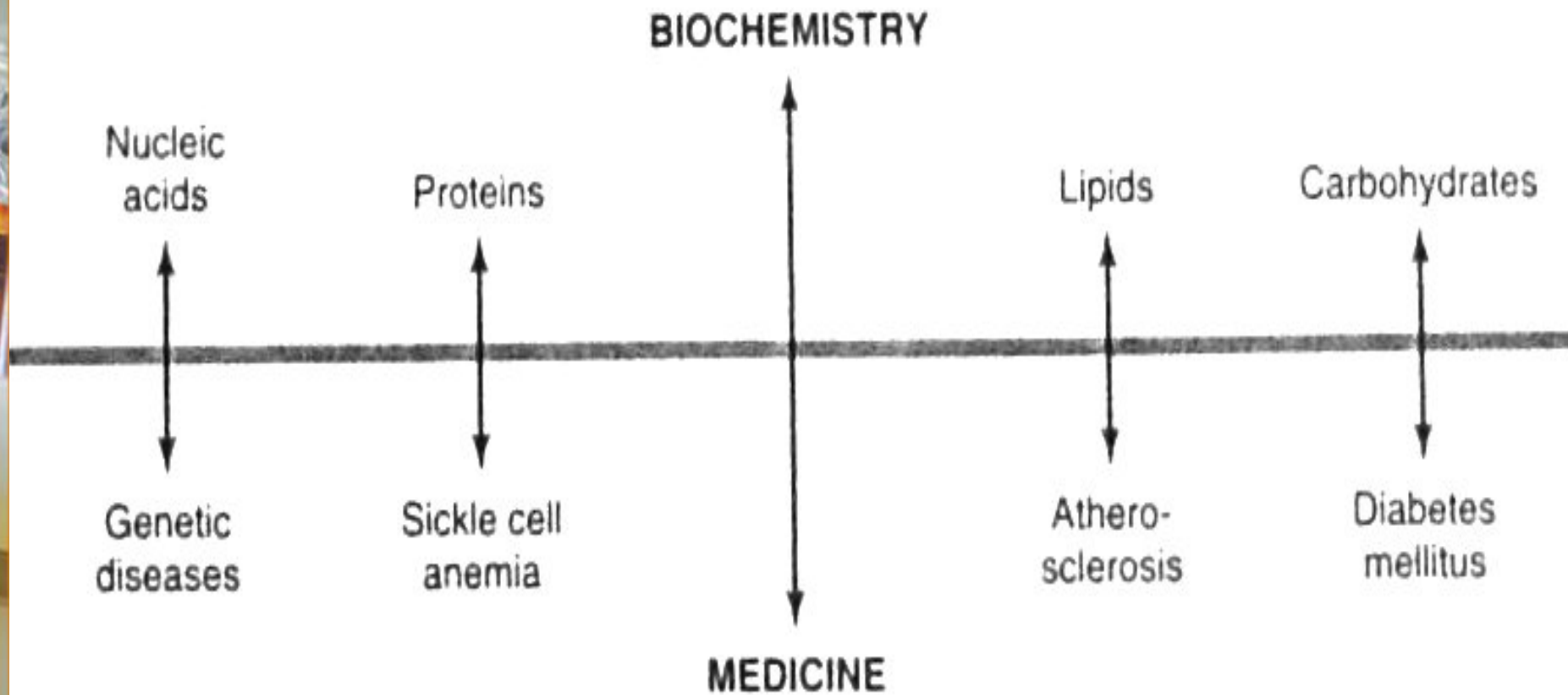
- ☐ the composition (make-up) of matter
- ☐ the changes that matter undergoes

Biochemistry = chemistry of life

Biochemistry has become the foundation for understanding all biological processes.

It has provided explanations for the causes of many diseases in humans, animals and plants

Two-Way Street: Medicine and Biochemistry

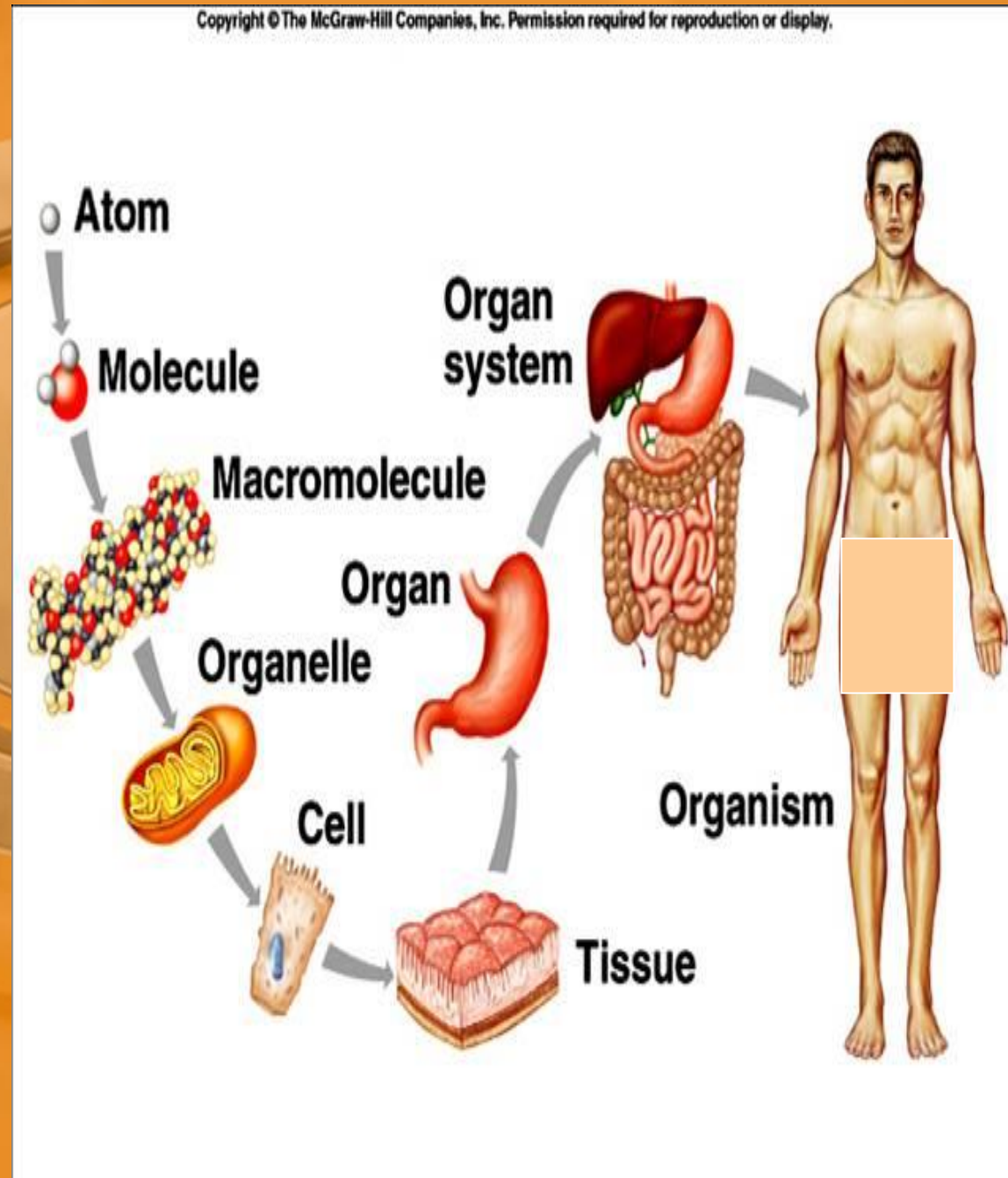


What is Biochemistry ?

- Biochemistry is the application of chemistry to the study of biological processes at the cellular and molecular level.
- It emerged as a distinct discipline around the beginning of the 20th century when scientists combined chemistry, physiology and biology to investigate the chemistry of living systems by:
 - A. Studying the structure and behavior of the complex molecules found in biological material and
 - A. the ways these molecules interact to form cells, tissues and whole organism

Organization of Life

- ☐ Elements
- ☐ Simple organic compounds (monomers)
- ☐ Macromolecules (polymers)
- ☐ Organelles
- ☐ Cells
- ☐ Tissues
- ☐ Organs
- ☐ Organ System
- ☐ Organisms

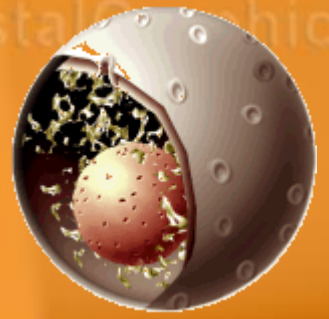


BIOCHEMISTRY

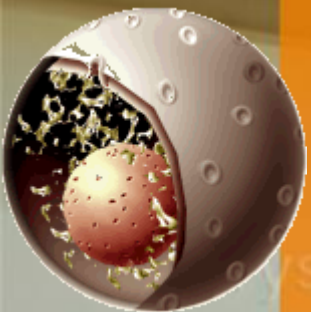
DEFINITION:

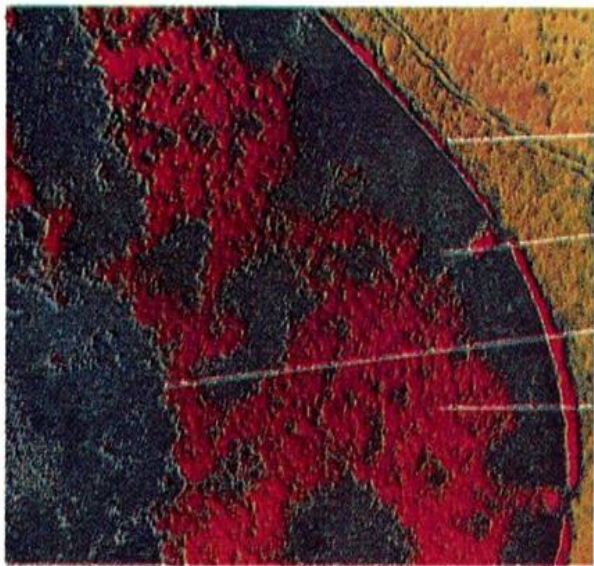
- Chemistry of living organisms.
OR
- The study of biology at the molecular level.
OR
- Study of chemical processes that take place in organisms.
OR
- Study of molecules of living organisms and their habitats





Cells are the structural and
functional units of life
A cell is the basic unit of
life





Nuclear membrane

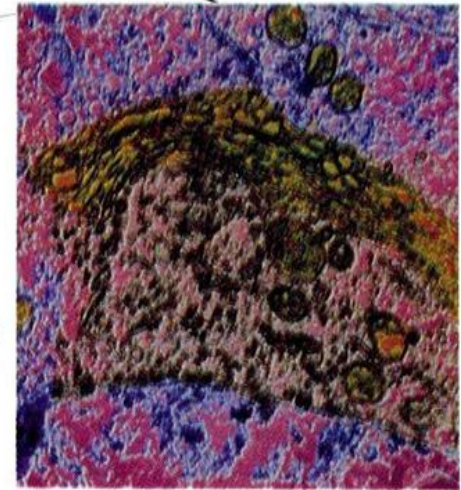
Nucleus

Nucleolus

Chromatin

Centrioles

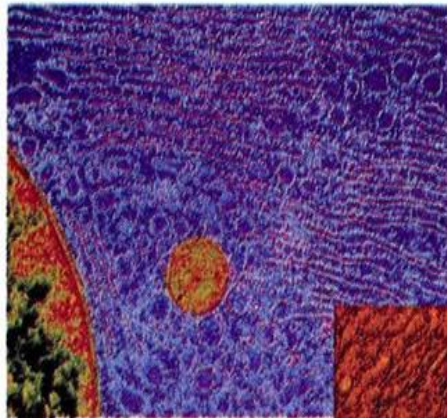
Golgi apparatus



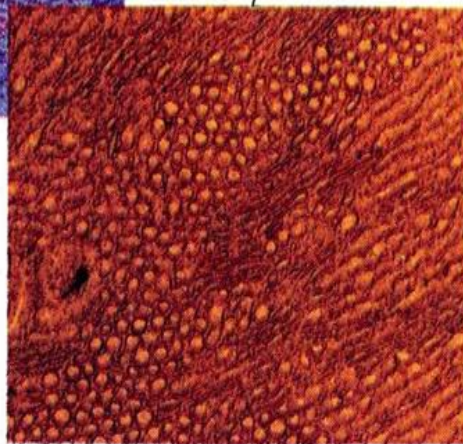
Free ribosomes

Endoplasmic reticulum

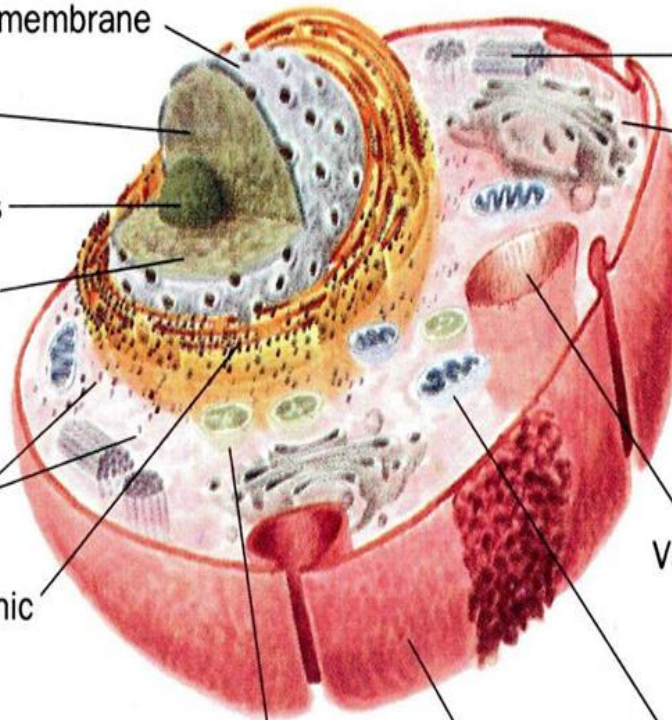
Vacuole



Rough endoplasmic reticulum



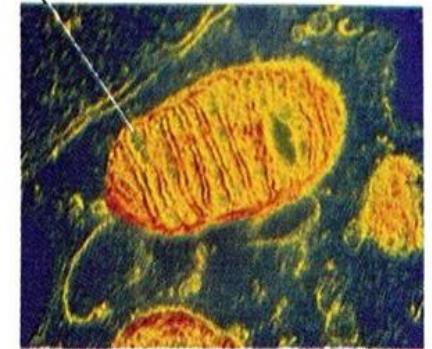
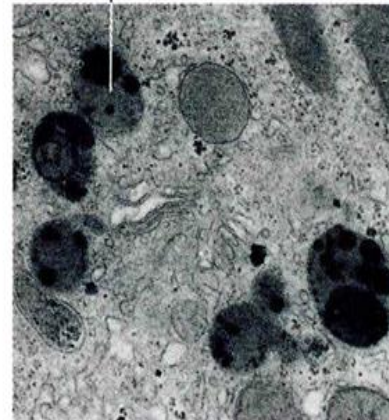
Smooth endoplasmic reticulum



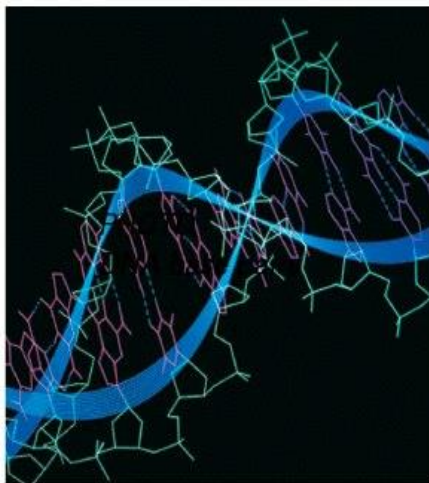
Lysosomes

Cell membrane

Mitochondrion

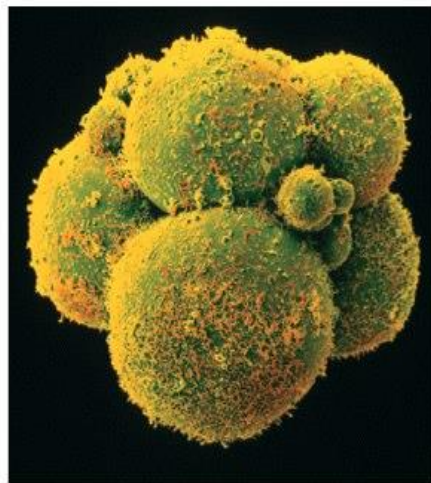


(a)



Nanometers

(b)



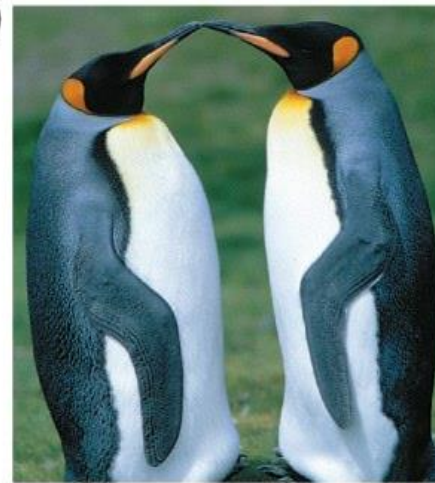
Micrometers

(c)

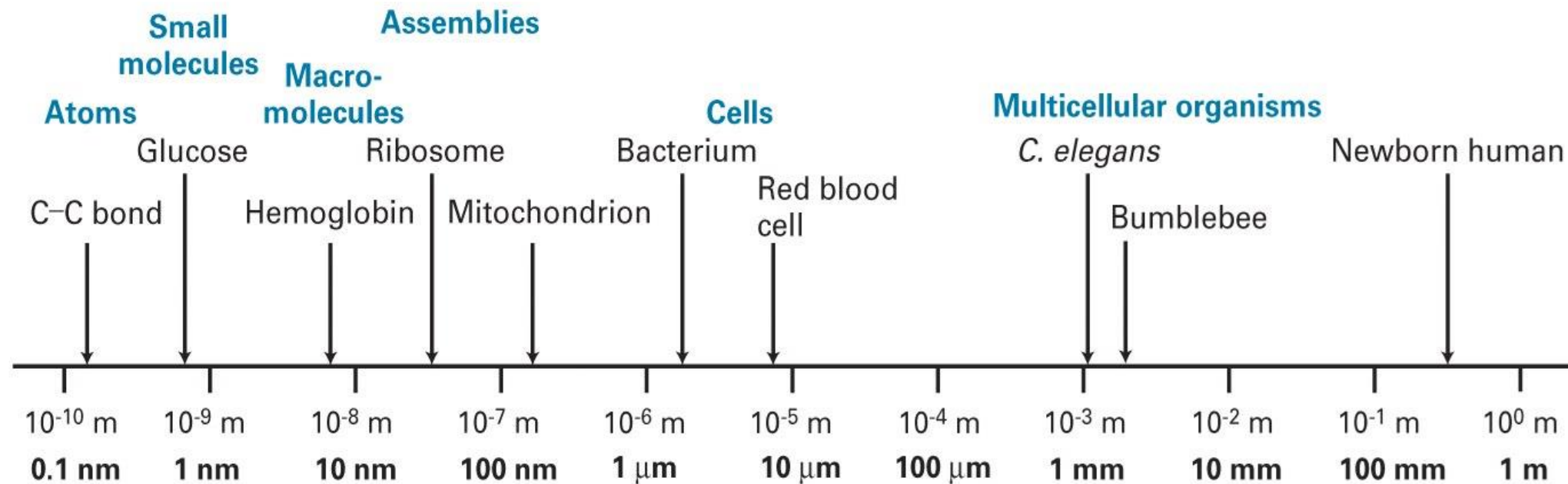


Millimeters

(d)

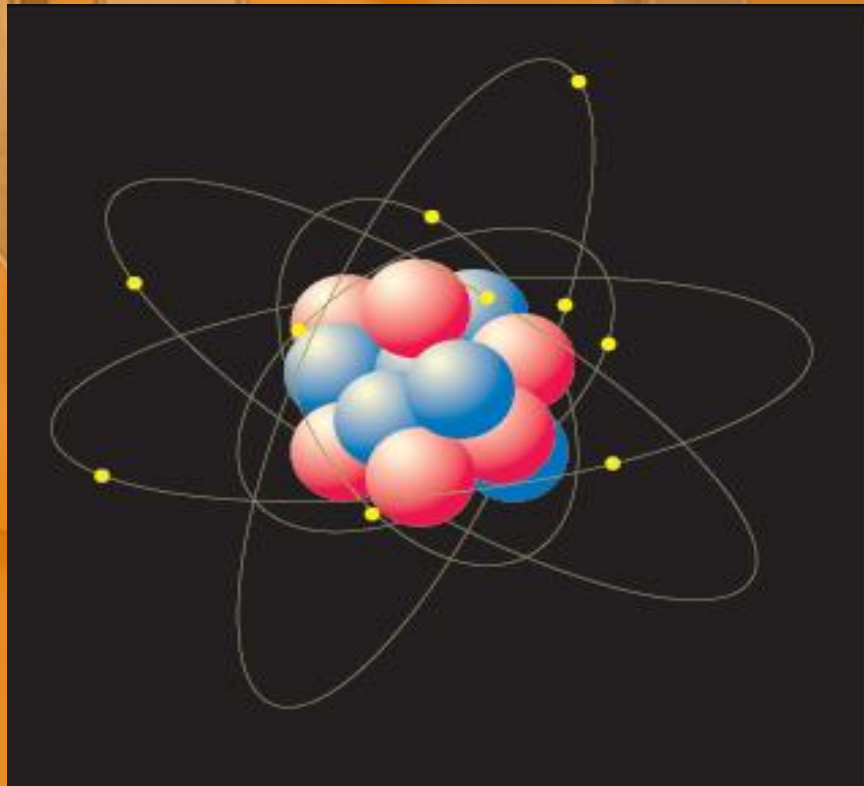


Meters



Atoms

- ❑ Subunits of elements.
- ❑ Smallest complete units of matter.
- ❑ Cannot be broken down or changed by ordinary chemical and physical means.



Elements

- ❑ Substance that cannot be broken down to other substances by chemical reaction.
- ❑ Make up all matter.
- ❑ 92 occur in nature.
- ❑ Identified by names or chemical symbols (abbreviations of modern or Latin names).
- ❑ Described and organized in periodic table.

Periodic Table
of the Elements

| | | | | | | | | | | | | |
|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 0 | He | 2 | Ne | 10 | Ar | 18 | Kr | 36 | Xe | 54 | Rn | 86 |
| 1 | H | 3 | Li | 11 | Na | 19 | K | 37 | Rb | 55 | Cs | 87 |
| 2 | He | 4 | Be | 12 | Mg | 20 | Ca | 38 | Sr | 56 | Ba | 88 |
| 3 | | 5 | B | 13 | Al | 21 | Sc | 39 | Y | 57 | *La | 89 |
| 4 | | 6 | C | 14 | Si | 22 | Ti | 40 | Zr | 58 | Ce | 90 |
| 5 | | 7 | N | 15 | P | 23 | V | 41 | Nb | 59 | Pr | 91 |
| 6 | | 8 | O | 16 | S | 24 | Cr | 42 | Mo | 60 | Nd | 92 |
| 7 | | 9 | F | 17 | Cl | 25 | Mn | 43 | Tc | 61 | Pm | 93 |
| 8 | | 10 | Ne | 18 | Ar | 26 | Fe | 44 | Ru | 62 | Sm | 94 |
| 9 | | 11 | Na | 19 | K | 27 | Co | 45 | Rh | 63 | Eu | 95 |
| 10 | | 12 | Mg | 20 | Ca | 28 | Ni | 46 | Pd | 64 | Gd | 96 |
| 11 | | 13 | Al | 21 | Sc | 29 | Cu | 47 | Ag | 65 | Tb | 97 |
| 12 | | 14 | Si | 22 | Ti | 30 | Zn | 48 | Cd | 66 | Dy | 98 |
| 13 | | 15 | P | 23 | V | 31 | Ga | 49 | In | 67 | Ho | 99 |
| 14 | | 16 | S | 24 | Cr | 32 | Ge | 50 | Sn | 68 | Er | 100 |
| 15 | | 17 | Cl | 25 | Mn | 33 | As | 51 | Sb | 69 | Tm | 101 |
| 16 | | 18 | Ar | 26 | Fe | 34 | Se | 52 | Te | 70 | Yb | 102 |
| 17 | | 19 | K | 27 | Co | 35 | Br | 53 | I | 71 | Lu | 103 |
| 18 | | 20 | Ca | 28 | Ni | 36 | Kr | 54 | Xe | 72 | Hf | 104 |
| 19 | | 21 | Sc | 29 | Cu | 37 | Rb | 55 | Cs | 73 | Ta | 105 |
| 20 | | 22 | Ti | 40 | Zr | 38 | Sr | 56 | Ba | 74 | W | 106 |
| 21 | | 23 | V | 41 | Nb | 39 | Y | 57 | *La | 75 | Re | 107 |
| 22 | | 24 | Cr | 42 | Mo | 40 | Zr | 58 | Ce | 76 | Os | 108 |
| 23 | | 25 | Mn | 43 | Tc | 41 | Nb | 59 | Pr | 77 | Ir | 109 |
| 24 | | 26 | Fe | 44 | Ru | 42 | Mo | 60 | Nd | 78 | Pt | 110 |
| 25 | | 27 | Co | 45 | Rh | 43 | Tc | 61 | Pm | 79 | Au | 111 |
| 26 | | 28 | Ni | 46 | Pd | 44 | Ru | 62 | Sm | 80 | Hg | 112 |
| 27 | | 29 | Cu | 47 | Ag | 45 | Rh | 63 | Eu | 81 | Tl | 113 |
| 28 | | 30 | Zn | 48 | Cd | 46 | Pd | 64 | Gd | 82 | Pb | 114 |
| 29 | | 31 | Ga | 49 | In | 47 | Ag | 65 | Tb | 83 | Bi | 115 |
| 30 | | 32 | Ge | 50 | Sn | 48 | Cd | 66 | Dy | 84 | Po | 116 |
| 31 | | 33 | As | 51 | Sb | 49 | In | 67 | Ho | 85 | At | 117 |
| 32 | | 34 | Se | 52 | Te | 50 | Sn | 68 | Er | 86 | Rn | 118 |
| 33 | | 35 | Br | 53 | I | 51 | Sb | 69 | Tm | 87 | | |
| 34 | | 36 | Kr | 54 | Xe | 52 | Te | 70 | Yb | 88 | | |
| 35 | | 37 | Rb | 55 | Cs | 53 | I | 71 | Lu | 89 | | |
| 36 | | 38 | Sr | 56 | Ba | 54 | Xe | 72 | Hf | 90 | | |
| 37 | | 39 | Y | 57 | *La | 55 | Cs | 73 | Ta | 91 | | |
| 38 | | 40 | Zr | 58 | Ce | 56 | Ba | 74 | W | 92 | | |
| 39 | | 41 | Nb | 59 | Pr | 57 | *La | 75 | Re | 93 | | |
| 40 | | 42 | Mo | 60 | Nd | 58 | Ce | 76 | Os | 94 | | |
| 41 | | 43 | Tc | 61 | Pm | 59 | Pr | 77 | Ir | 95 | | |
| 42 | | 44 | Ru | 62 | Sm | 60 | Nd | 78 | Pt | 96 | | |
| 43 | | 45 | Rh | 63 | Eu | 61 | Pm | 79 | Au | 97 | | |
| 44 | | 46 | Pd | 64 | Gd | 62 | Sm | 80 | Hg | 98 | | |
| 45 | | 47 | Ag | 65 | Tb | 63 | Eu | 81 | Tl | 99 | | |
| 46 | | 48 | Cd | 66 | Dy | 64 | Gd | 82 | Pb | 100 | | |
| 47 | | 49 | In | 67 | Ho | 65 | Tb | 83 | Bi | 101 | | |
| 48 | | 50 | Sn | 68 | Er | 66 | Dy | 84 | Po | 102 | | |
| 49 | | 51 | Sb | 69 | Tm | 67 | Ho | 85 | At | 103 | | |
| 50 | | 52 | Te | 70 | Yb | 68 | Er | 86 | Rn | 104 | | |
| 51 | | 53 | I | 71 | Lu | 69 | Tm | 87 | | 105 | | |
| 52 | | 54 | Xe | 72 | Hf | 70 | Yb | 88 | | 106 | | |
| 53 | | 55 | Cs | 73 | Ta | 71 | Lu | 89 | | 107 | | |
| 54 | | 56 | Ba | 74 | W | 72 | Hf | 90 | | 108 | | |
| 55 | | 57 | *La | 75 | Re | 73 | Ta | 91 | | 109 | | |
| 56 | | 58 | Ce | 76 | Os | 74 | W | 92 | | 110 | | |
| 57 | | 59 | Pr | 77 | Ir | 75 | Re | 93 | | 111 | | |
| 58 | | 60 | Nd | 78 | Pt | 76 | Os | 94 | | 112 | | |
| 59 | | 61 | Pm | 79 | Au | 77 | Ir | 95 | | 113 | | |
| 60 | | 62 | Sm | 80 | Hg | 78 | Pt | 96 | | | | |
| 61 | | 63 | Eu | 81 | Tl | 79 | Au | 97 | | | | |
| 62 | | 64 | Gd | 82 | Pb | 80 | Hg | 98 | | | | |
| 63 | | 65 | Tb | 83 | Bi | 81 | Tl | 99 | | | | |
| 64 | | 66 | Dy | 84 | Po | 82 | Pb | 100 | | | | |
| 65 | | 67 | Ho | 85 | At | 83 | Bi | 101 | | | | |
| 66 | | 68 | Er | 86 | Rn | 84 | Po | 102 | | | | |
| 67 | | 69 | Tm | 87 | | 85 | At | 103 | | | | |
| 68 | | 70 | Yb | 88 | | 86 | Rn | 104 | | | | |
| 69 | | 71 | Lu | 89 | | 87 | | 105 | | | | |
| 70 | | 72 | Hf | 90 | | 88 | | 106 | | | | |
| 71 | | 73 | Ta | 91 | | 89 | | 107 | | | | |
| 72 | | 74 | W | 92 | | 90 | | 108 | | | | |
| 73 | | 75 | Re | 93 | | 91 | | 109 | | | | |
| 74 | | 76 | Os | 94 | | 92 | | 110 | | | | |
| 75 | | 77 | Ir | 95 | | 93 | | 111 | | | | |
| 76 | | 78 | Pt | 96 | | 94 | | 112 | | | | |
| 77 | | 79 | Au | 97 | | 95 | | 113 | | | | |
| 78 | | 80 | Hg | 98 | | 96 | | | | | | |
| 79 | | 81 | Tl | 99 | | 97 | | | | | | |
| 80 | | 82 | Pb | 100 | | 98 | | | | | | |
| 81 | | 83 | Bi | 101 | | 99 | | | | | | |
| 82 | | 84 | Po | 102 | | 100 | | | | | | |
| 83 | | 85 | At | 103 | | 101 | | | | | | |
| 84 | | 86 | Rn | 104 | | 102 | | | | | | |
| 85 | | 87 | | 105 | | 103 | | | | | | |
| 86 | | 88 | | 106 | | 104 | | | | | | |
| 87 | | 89 | | 107 | | 105 | | | | | | |
| 88 | | 90 | | 108 | | 106 | | | | | | |
| 89 | | 91 | | 109 | | 107 | | | | | | |
| 90 | | 92 | | 110 | | 108 | | | | | | |
| 91 | | 93 | | 111 | | 109 | | | | | | |
| 92 | | 94 | | 112 | | 110 | | | | | | |
| 93 | | 95 | | 113 | | 111 | | | | | | |
| 94 | | 96 | | | | 112 | | | | | | |
| 95 | | 97 | | | | 113 | | | | | | |
| 96 | | 98 | | | | | | | | | | |
| 97 | | 99 | | | | | | | | | | |
| 98 | | 100 | | | | | | | | | | |
| 99 | | 101 | | | | | | | | | | |
| 100 | | 102 | | | | | | | | | | |
| 101 | | 103 | | | | | | | | | | |
| 102 | | 104 | | | | | | | | | | |
| 103 | | 105 | | | | | | | | | | |
| 104 | | 106 | | | | | | | | | | |
| 105 | | 107 | | | | | | | | | | |
| 106 | | 108 | | | | | | | | | | |
| 107 | | 109 | | | | | | | | | | |
| 108 | | 110 | | | | | | | | | | |
| 109 | | 111 | | | | | | | | | | |
| 110 | | 112 | | | | | | | | | | |
| 111 | | 113 | | | | | | | | | | |
| 112 | | | | | | | | | | | | |
| 113 | | | | | | | | | | | | |

* Lanthanide Series
+ Actinide Series

Elements cont...

- Among 92 nature elements, only 25 elements are essential to life.
- Only 4 elements: C, H, O, N make up 96% of living matter.

Table 2.1 Naturally Occurring Elements in the Human Body

| Symbol | Element | Atomic Number (See p. 29) | Percentage of Human Body Weight |
|--------|------------|------------------------------|---------------------------------------|
| O | Oxygen | 8 | 65.0 |
| C | Carbon | 6 | 18.5 |
| H | Hydrogen | 1 | 9.5 |
| N | Nitrogen | 7 | 3.3 |
| Ca | Calcium | 20 | 1.5 |
| P | Phosphorus | 15 | 1.0 |
| K | Potassium | 19 | 0.4 |
| S | Sulfur | 16 | 0.3 |
| Na | Sodium | 11 | 0.2 |
| Cl | Chlorine | 17 | 0.2 |
| Mg | Magnesium | 12 | 0.1 |

Trace elements (less than 0.01%): boron (B), chromium (Cr), cobalt (Co), copper (Cu), fluorine (F), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se), silicon (Si), tin (Sn), vanadium (V), and zinc (Zn).

The background of the slide is a composite image. On the left, there is a vertical strip showing laboratory glassware, including a beaker with orange liquid and a graduated cylinder. The rest of the background is a warm orange color with a faint, large, metallic-looking gear or circular structure in the center. The text is overlaid on this background.

□ Trace elements = elements that are required by an organism in only minute quantities.

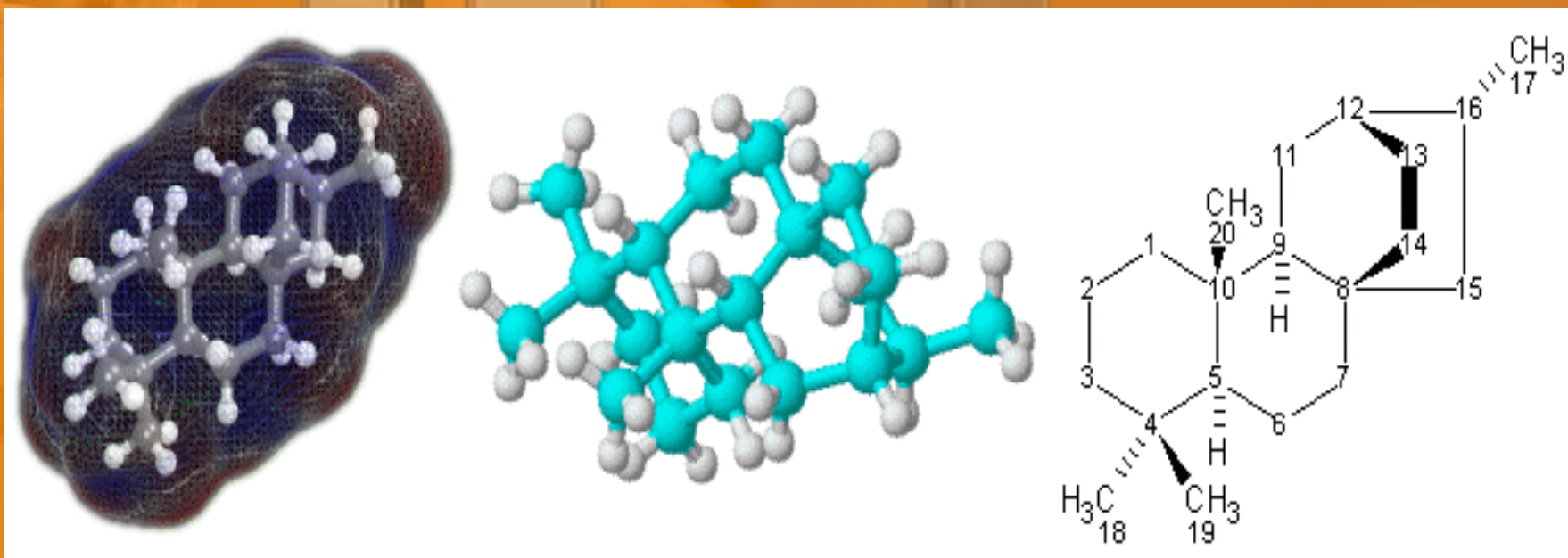
**I = an ingredient of thyroid hormone
(need 0.15mg/day)**

Goiter due to iodine deficiency



Molecules

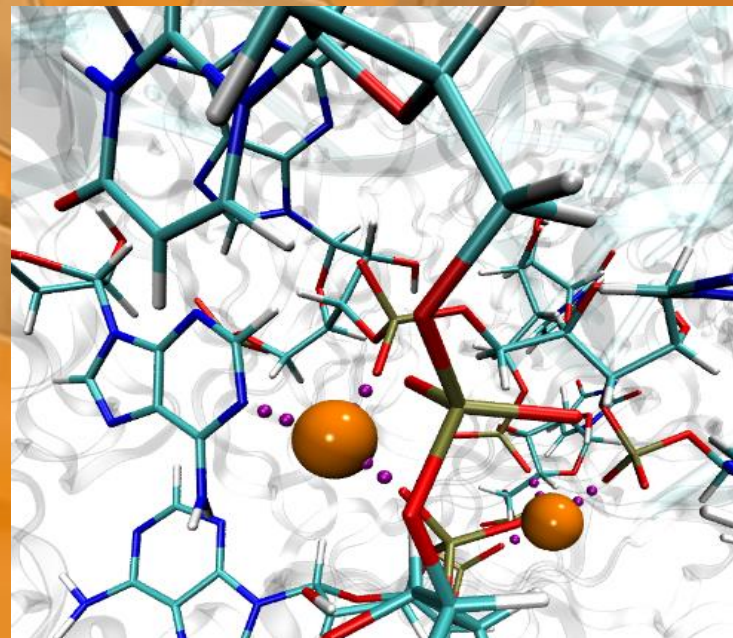
- ❑ Formed when two or more atoms unite on the basis of their electron structures
- ❑ Can be made of like atoms or atoms of different elements



Biomolecules

- A biomolecule is any organic molecule that is produced by a living organism.
- As organic molecules, biomolecules consist primarily of **carbon and hydrogen, nitrogen and oxygen**, and, to a smaller extent, phosphorus and sulfur. Other elements sometimes are incorporated but are much less common. A diverse range of biomolecules exist, including:

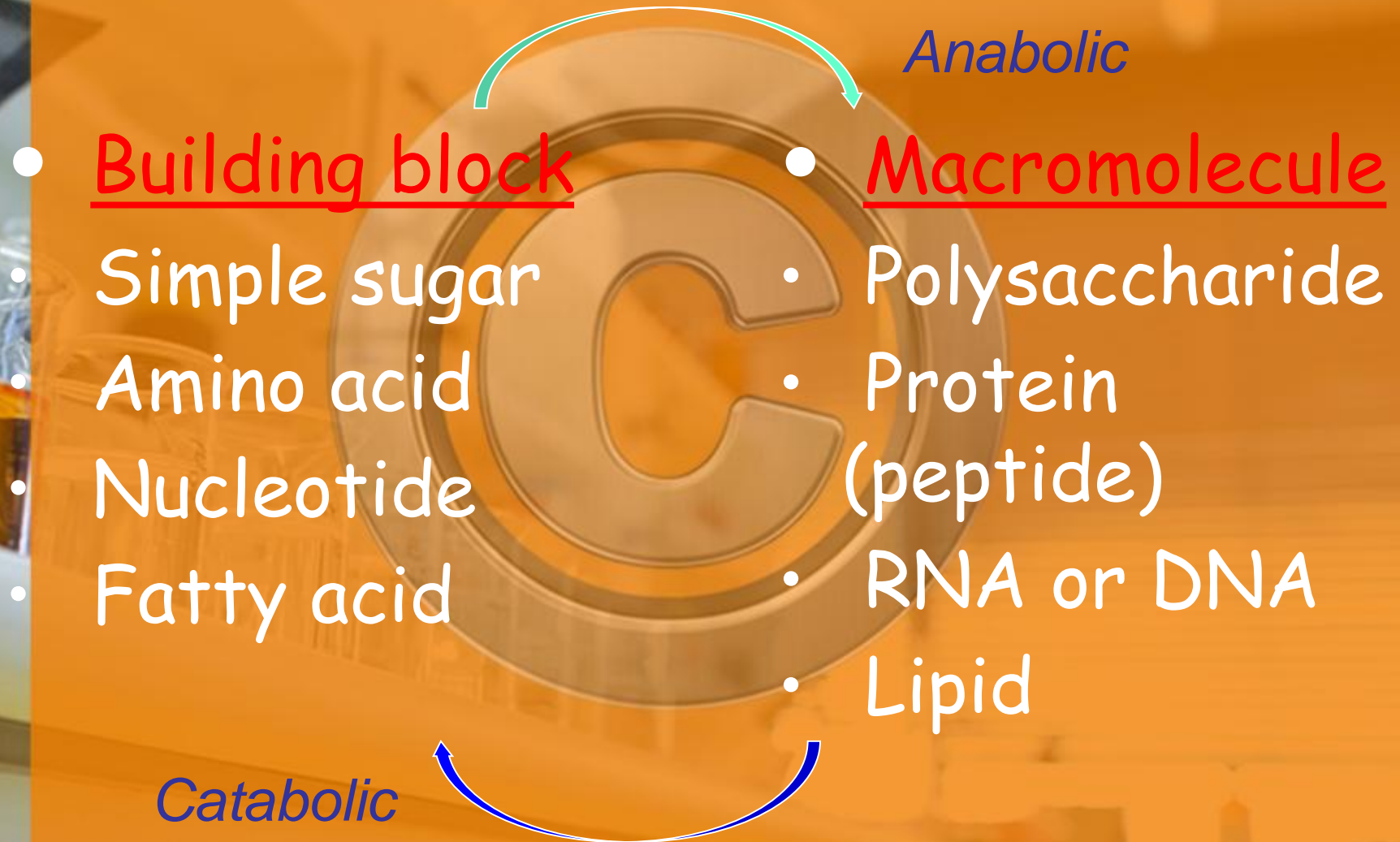
- ☐ Carbohydrates
- ☐ Lipids
- ☐ Proteins
- ☐ Nucleic acid



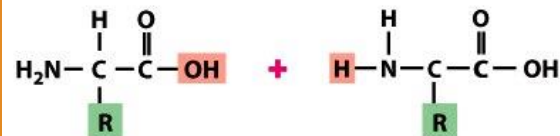
Biomolecules cont..

- Just like cells are building blocks of tissues likewise bio-molecules are building blocks of cells.
- Animal and plant cells contain approximately 10, 000 kinds of molecules (bio-molecules)
- Water constitutes 50-95% of cells content by weight.
- Almost all other kinds of bio-molecules are organic (C, H, N, O, P, S)
- Infinite variety of molecules contain C.
- Most bio-molecules considered to be derived from hydrocarbons.

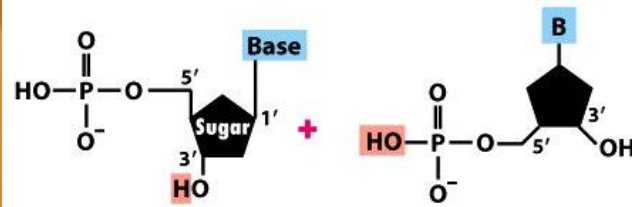
Biomolecules - Structure



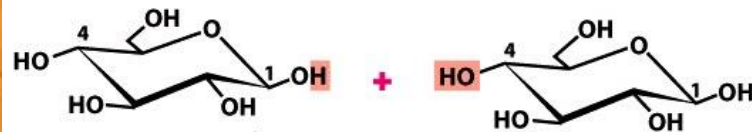
MONOMERS



Amino acid

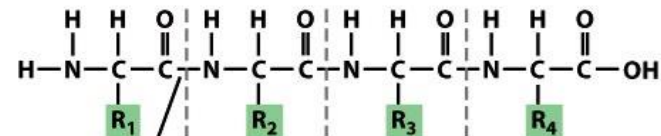


Nucleotide



Monosaccharide

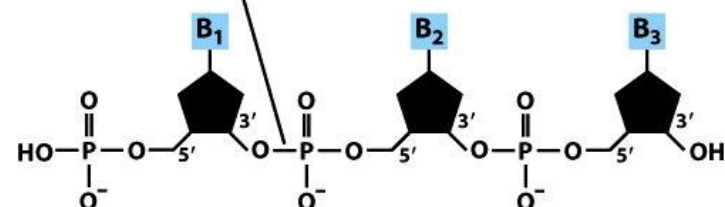
POLYMERS



peptide bond

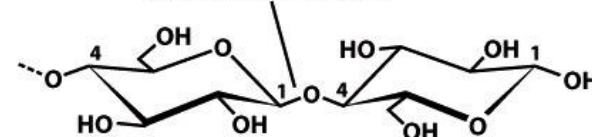
Polypeptide

phosphodiester bond



Nucleic acid

glycosidic bond



Polysaccharide

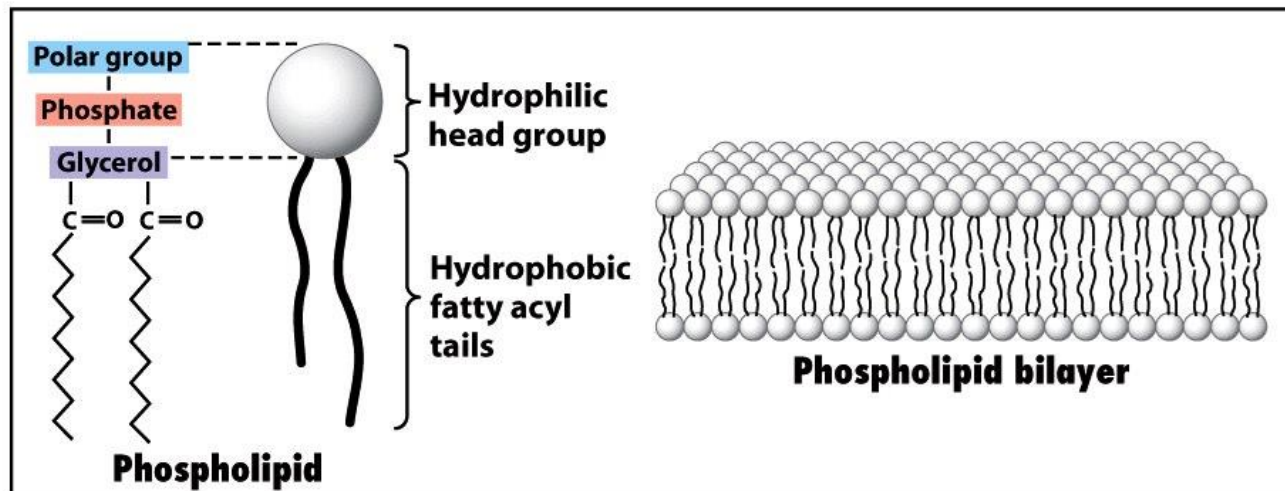
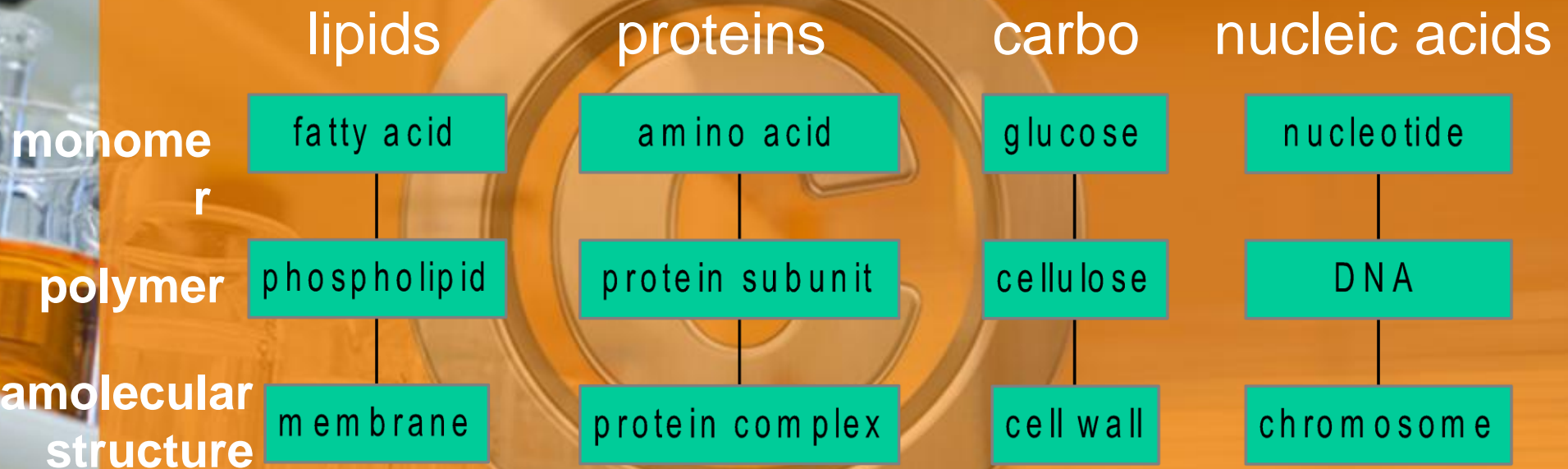


Figure 2-13

Molecular Cell Biology, Sixth Edition

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Many Important Biomolecules are Polymers



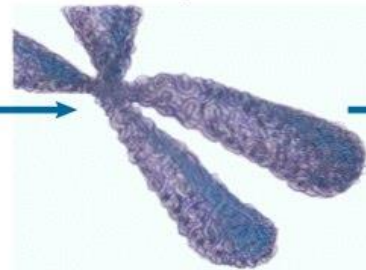
Molecular Organization of a cell

Level 4:
The cell
and its organelles

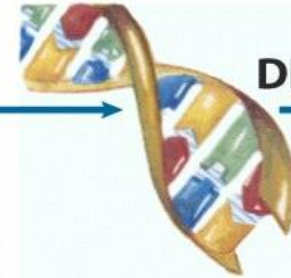
Level 3:
Supramolecular
complexes

Level 2:
Macromolecules

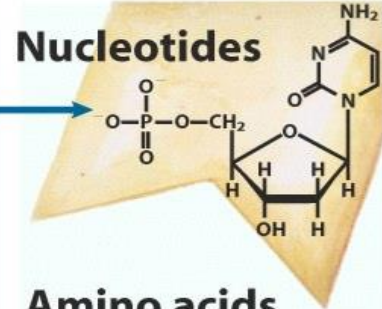
Level 1:
Monomeric units



Chromosome



DNA



Nucleotides

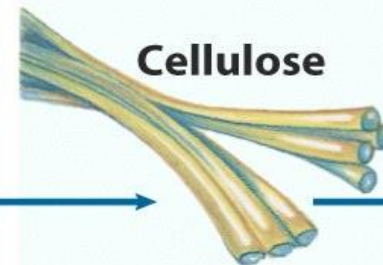
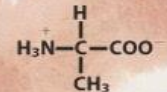


Plasma membrane

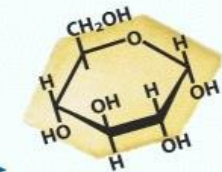


Protein

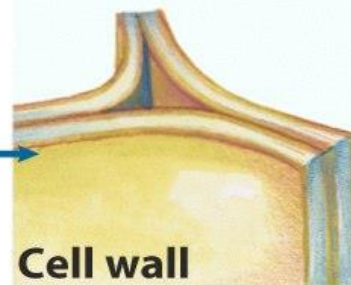
Amino acids



Cellulose



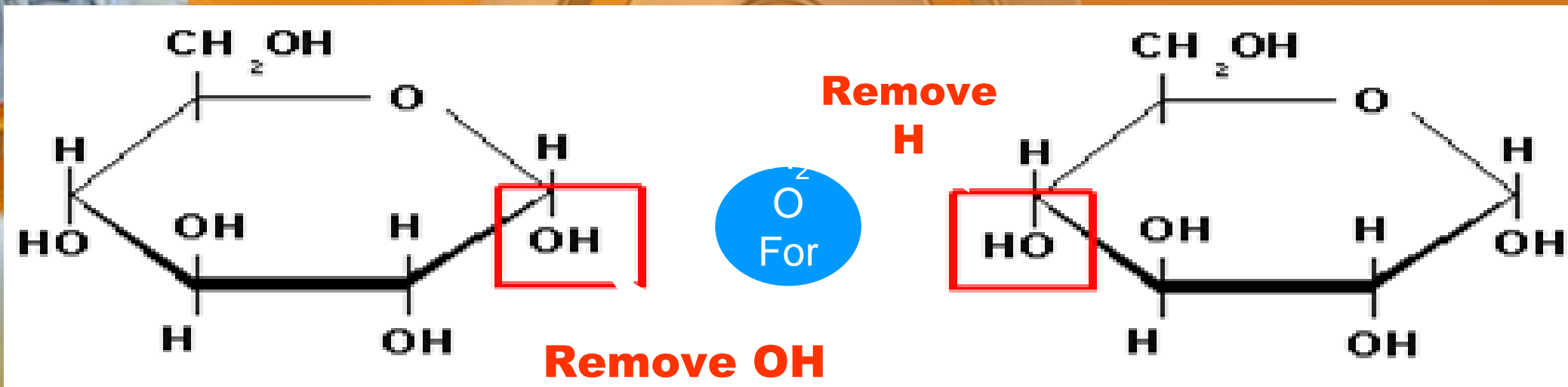
Sugars



Cell wall

Linking Monomers

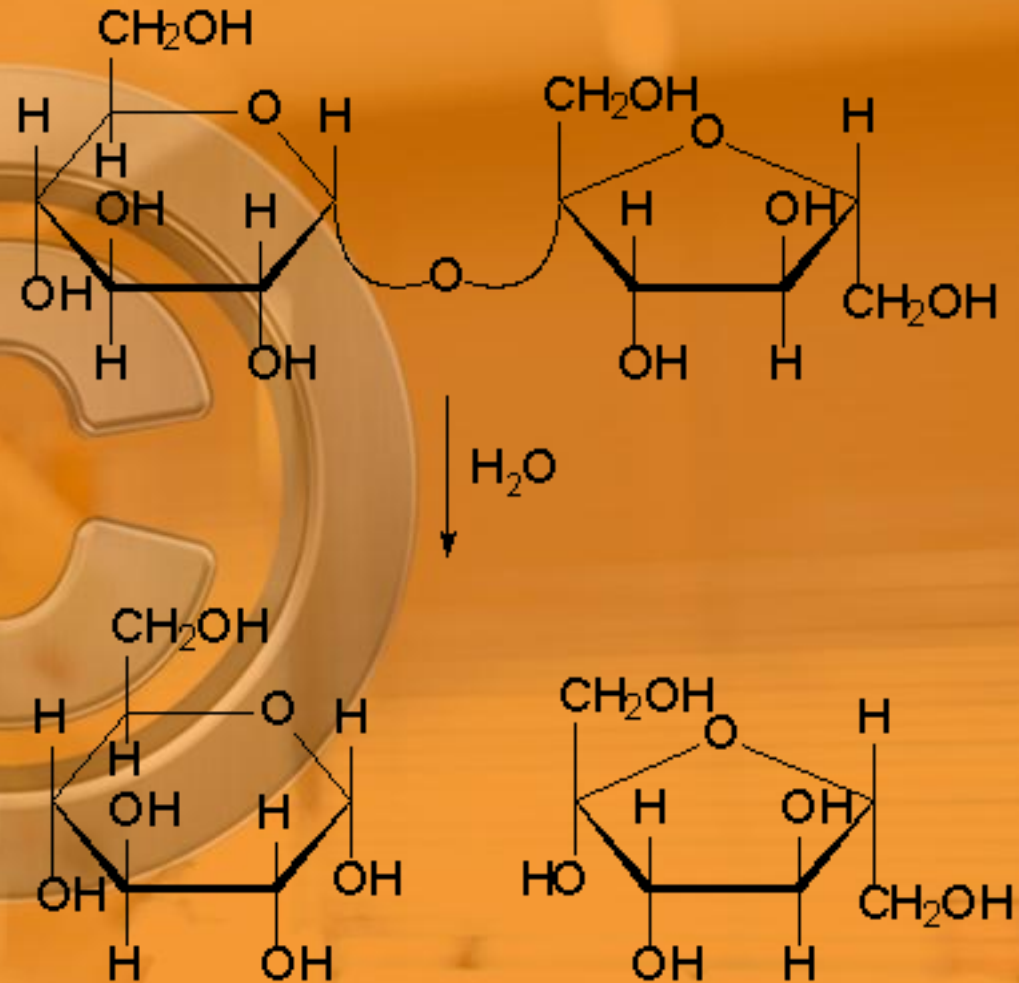
Cells link monomers by a process called dehydration synthesis (removing a molecule of water)



This process joins two sugar monomers to make a double sugar

Breaking Down Polymers

- Cells break down macromolecules by a process called hydrolysis (adding a molecule of water)



Water added to split a double sugar