UNIVERSITY OF GONDAR

COLLEGE OF NATURALA AND COMPUTATIONAL

Department of Biology

General Biology (Biol. 1012)

By:- Tilahun Yohannes

Come to class!!!



Try not to fall behind!!



Unit 1: INTRODUCTION

Objectives:

- After completing this chapter, you will be expected to:
  - ✓ Define the term biology
  - ✓ Explain scientific methods
  - ✓ Describe the origin and the nature of life

1.1 The meaning and scope of biology

- Biological Science is the study of life and living organisms
- Biology (Greek word) => Bio = life & Logos = study
- The term biology was coined by Lamarck in the late 1700s.
- Previously – considered as science of Botany & Zoology

=> New branches => Biological Sciences

✓ development of new science & technology

❖ “a systematic study of living beings or study of nature”

1.1 The meaning and scope of biology

❖ **Emphasize on**

- ✓ Nature & function of chemical substance of living cell
- ✓ Interaction with living organism & ecosystem
- ✓ Origin, Evolution, Survival & Extinction
- ✓ Geno- and phenotype composition & characteristics
- ✓ Development, Behavioral, structural & functional properties
- ✓ Chemical & molecular

1.2 The origin and nature of life

- Origin => big debating issue and emerging in science
- There are a number of theories about the origin of life

- Sequence of event of the evolution of life on Earth
  i. Living things appeared as the simplest creatures (single-celled)
  ii. Then => more complex and multi-cellular organisms
  iii. Increase in complexity, increase in cell number & cellular specialization (cells carried out specific tasks)
  iv. Living organisms (Eg. Plants, Animals, etc)
    - Millions - Billions of years of changes of organisms
- Accepted by biologists, geologists, paleontologists & theologians

1.2 The origin and nature of life…

- **Creationists:** world was created in six days by Almighty GOD
- **Scientists:** Utilize the scientific method
  - ✓Test Hypotheses & Theories **=>** develop concepts and ideas
- The most sophisticated form of life is man
- Man demonstrates three lives or aspects of life:
  - ✓Life of the body (Physical) - is basic existence
  - ✓Life of the mind - contributes effectiveness and

1.2 The origin and nature of life…

Some Theories of life on Earth

1.Theory of Special Creation: World is created by Almighty God

2. Theory of Spontaneous Generation: living organisms could arise suddenly and spontaneously from any kind of non-living matter

=> Not accepted

=> E.g., maggots could arise from dead flesh

3. Theory of Catastrophism: (Modification of Special Creation)

1.2 The origin and nature of life…

4. Cosmozoic Theory (Theory of Panspermia):

- Life is from other heavenly bodies such as **Meteorites**

=> in the form of highly resistance spores of some organisms

- By Richter in 1865 and rejected (lacks evidence)

5. Theory of Chemical Evolution:

- Also known as Materialistic or Physicochemical Theory
- It states, origin of life on Earth is the result of a

Living tissues and organisms exhibit:

Characteristics of living cell

- **Physiology**: functions of life's physical & chemical phenomena
- **Move:** make change of position or place by organism or part of it
- **Irritability**: the ability to be excited or detect stimuli and respond

Living tissues and organisms exhibit:

Characteristics of living cell

- **Adaptability:** permitting both change and maintenance of balances

  Eg., Homeostasis

- **Metabolism:** the transformation of energy and the use of materials

- **Respire**: chemical/nutrients rxns in cells to produce energy

- **Excretion /Osmoregulation/:** removal of waste products

1.3 Scientific methods

- The process of experimentation that is used to explore
  - ✓Observations and answer questions
  - ✓ It is an empirical method of acquiring knowledge
  - ✓It is also the technique used in the construction and testing of a scientific hypothesis
  - ✓The process of scientific investigation

1.3 Scientific methods

❖The scientific method has five basic steps

✓Make an observation

✓ Ask a question

✓ Form a hypothesis (testable explanation)

✓ Make a prediction based on the hypothesis

✓Test (prove) the prediction

❖**Iterate** (repeat): use results to make new hypotheses / predictions

1.3 Scientific methods…

- **Observation:** Quantitative & qualitative measurements of world
- **Inference /Implication/:** Deriving new knowledge based upon old knowledge
- **Hypotheses:** is a suggested explanation
- **Rejected Hypothesis:** ruled out through experimentation.
- **Accepted Hypothesis:** proven with experiment & not ruled out

1.3 Scientific methods…

- **Theory :** experimentally proven & widely accepted hypothesis

  => procedure – formulate hypothesis /prediction/ then prove

- **Experiment:** Control and experimental group

✓ **Control group**: subject that doesn't undergo the process in question

✓ **Experimental group**: subject exposed to variable of the experiment

Summary of the scientific method

- ✓Step 1: Observe behavior or other phenomena
- ✓Step 2: Form a tentative answer or explanation (a hypothesis or guess a reason)
- ✓Step 3: Use your hypothesis to generate a testable prediction
- ✓Step 4: Make systematic, planned observations (data collection)
- ✓Step 5: Results and Discussion: use the observations to evaluate (support, refute, or refine) the original hypothesis

Unit 2: Biological Molecules

❖**Objectives**: After completing this chapter you will be expected to:

✓Define the term biomolecules

✓Describe list of organic & inorganic molecules and their biological importance

✓ Identify the basic structures of biomolecules

✓ Explain the precursors of each macromolecules with their respective polymerization process

✓State the physical and chemical nature of water and their relevance to the existence of life

Biological Molecules

- **Biomolecule** also called **biological molecule** (Molecules of life)
- Produced by cells /organisms/ or supplied by other cell/ nature
- Categorized as organic and inorganic molecules
- **Organic:** Proteins, Carbohydrates Lipids and Nucleic acids
  - ✓Vital for existence and survival of cell (life)
  - ✓Essential - Structurally and Functionally

2.1. Carbohydrates

- Made of atoms of C, H & O and Main source of energy
  - ✓ Provide structural support for cells (Cellulose in plant cell wall)
  - ✓ Help cell-cell recognition (communication)
- Found in the form of single or many sugars linked together called **Saccharides**
- 3 categories (Based on the number of sugar units)
  - ✓ Monosaccharides – single molecule of sugar
  - ✓ Disaccharides – two molecule of sugars
  - ✓ Poly-saccharides (**Oligo-**) – Many (**few < 10**) molecule of sugars

2.1. Carbohydrates…

- Each of the sugar molecules are bonded together through the **Glycosidic linkage/s.**
- Carbohydrate are Polyhydroxy aldehydes or ketones, or

  => substances that yield these compounds on

Aldehydes and Ketones

- An **aldehyde** is an organic molecule containing a carbonyl group that is bonded to at least one hydrogen atom



- A **ketone** is an organic compound that contains a carbonyl group bonded to two carbon atoms



2.1. Carbohydrates…

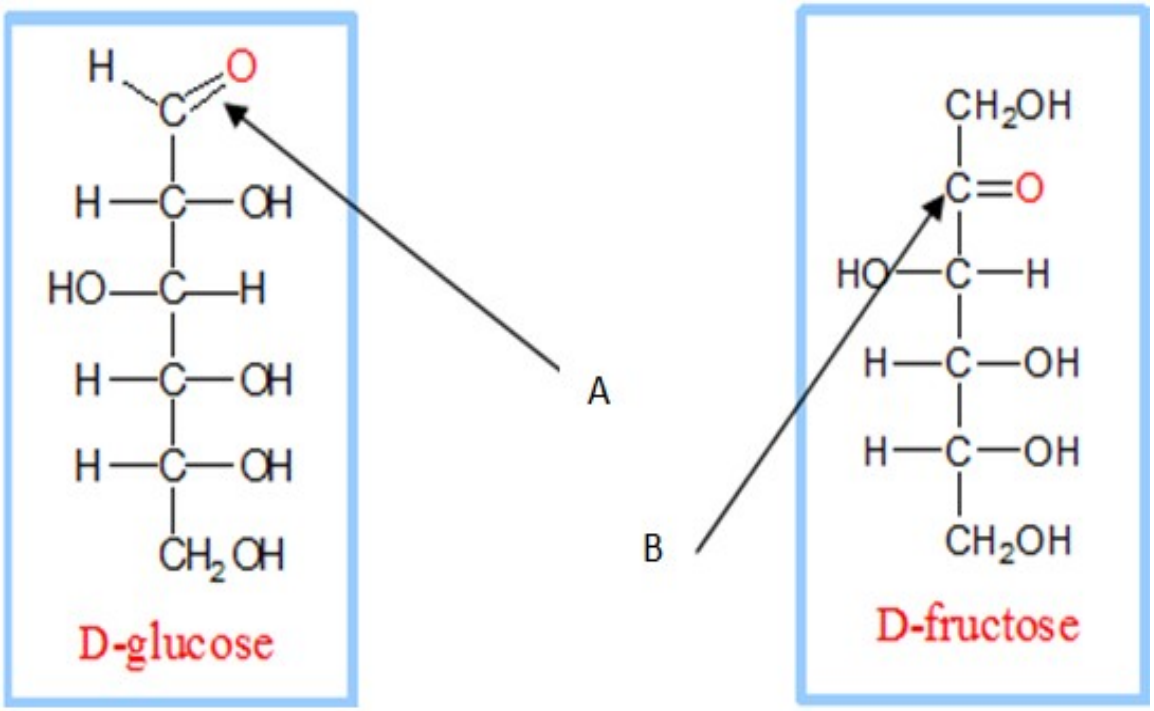


Fig: 2.1. Structures of monosaccharides (α-glucose and β-fructose)

- **Glycosidic linkage/s**: covalent bond that joins a carbohydrate (sugar) molecule to another group, which may or may not be another carbohydrate. Their linkage is formed by O after losing H_2O

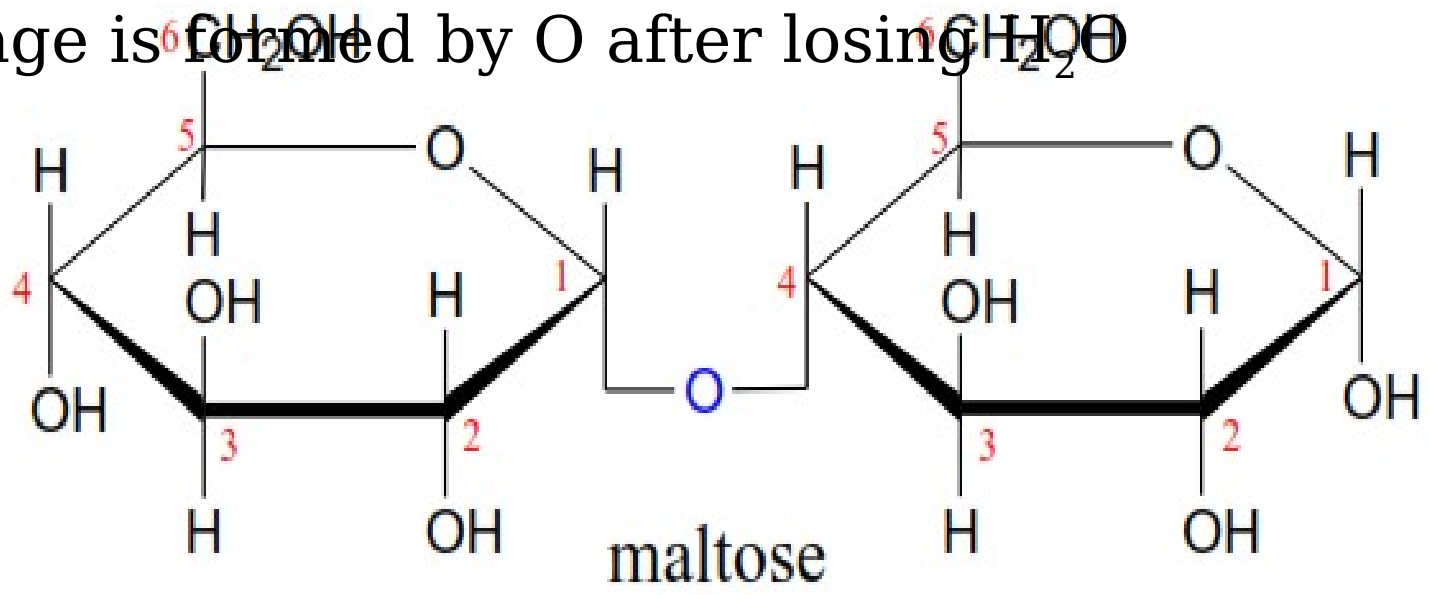


Fig: 2.2. A structure of maltose (disaccharide)

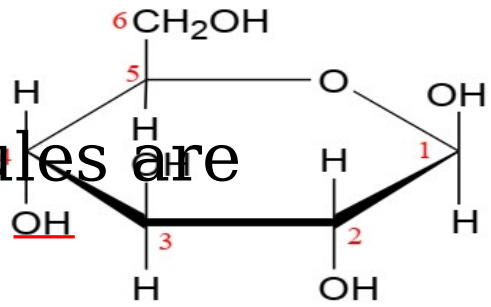
A. Monosaccharides

- Monosaccharides - simple sugars with multiple OH groups.
- Based on number of carbons (3, 4, 5, 6) a monosaccharide is named as triose, tetrose, pentose or hexose.

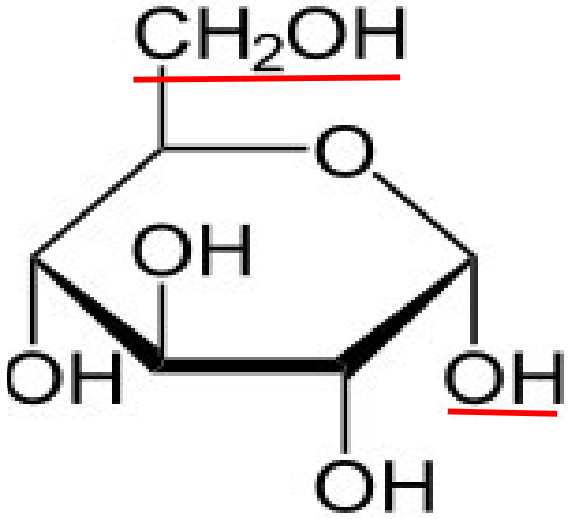
  => Pentose & Hexose exist in cyclic form (form larger saccharides)
- Monosaccharide with the aldehyde group are **aldoses** & with a ketone group are **ketoses**.

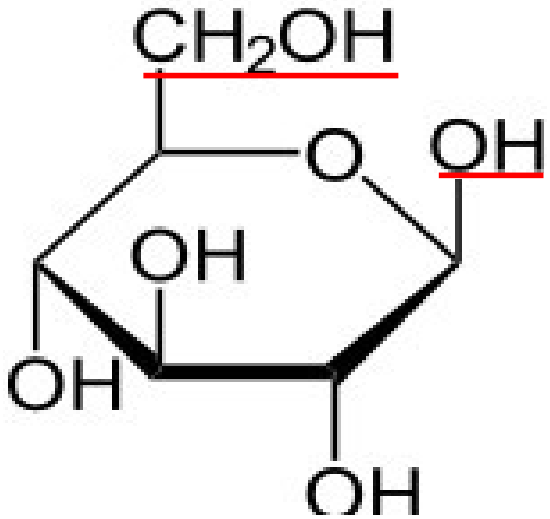
A.1. Glucose ($C_6H_{12}O_6$)

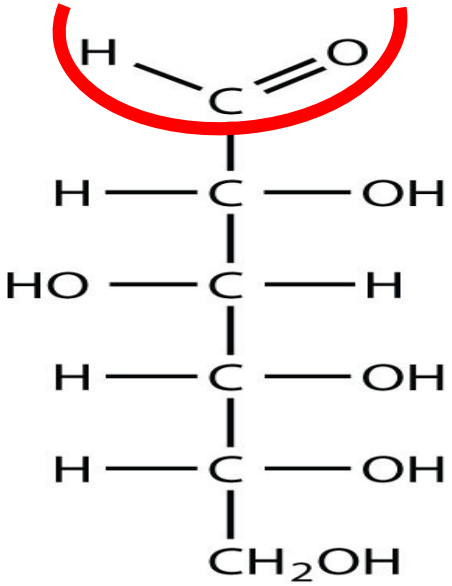
- Glucose is the most important fuel in human cells
- The small size and solubility in water => pass the cell membrane
- Energy is released when the molecules are metabolized.
- It is Aldose and reducing sugar



- **α-Glucose (opposite) β – Glucose (same) Reducing sugar**



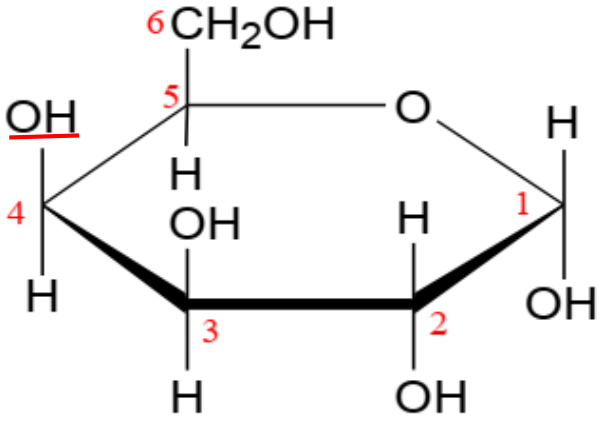




- Hydroxyl group attached to C-1 & the -CH2OH group at C-5 lies
  - ✓ **Opposite** side = **α-** and on the **same** side = **β-**glucose
- **Reducing sugar**: Having free CHO group (O = C - H) or (O = C - R)

A.2. Galactose

- Very similar to glucose molecules but differ in function
- Galactose + Glucose make **Lacto**



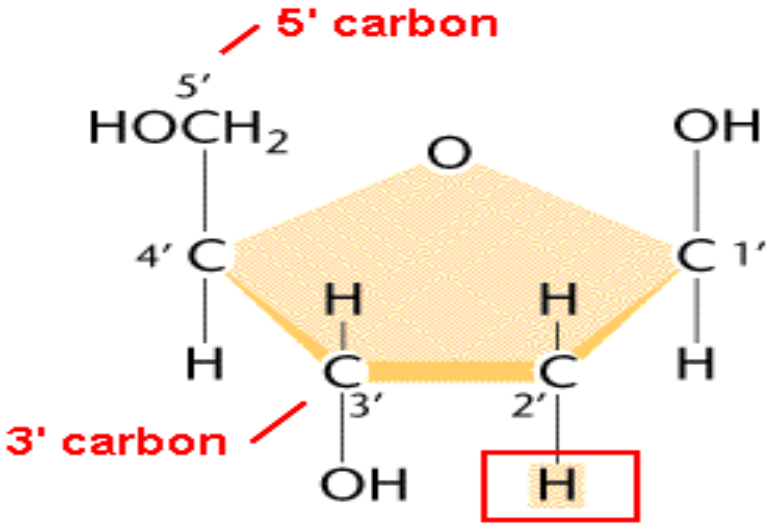
- It is Aldose and reducing sugar

A.3. Fructose

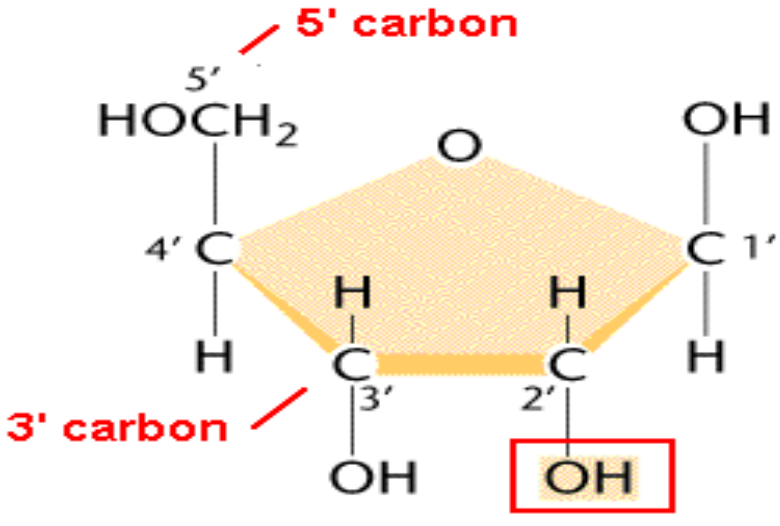
- fructose is a ketose (a non-reducing sugar).
- Fructose + Glucose make **Sucrose** (disaccharide**)**

A.4. Ribose and Deoxyribose

- Ribose and deoxyribose are pentoses.
- Ribose unit forms part of a **nucleotide of RNA.**
- Deoxyribose unit forms part of the nucleotide of



2-Deoxyribose



Ribose

B. Disaccharides

- Most sugars found in nature are in disaccharides form
- Formed when two monosaccharides react.
- Soluble in water but too big to pass through cell membrane
- Digested in the small intestine and form 2 **monosaccharides**

  => can pass through cell membranes (as energy source)

- Hydrolysis rxn is di- → mono-saccharides & release energy
- Condensation rxn is mono- → di- /poly-saccharides (stored)

  => Glycosidic bond is formed & water is released

- Lactose & Maltose are Reducing sugar
- Sucrose is non-Reducing sugar

C. Polysaccharides

❖Formed with series of condensation rxns of Monosaccharides

= called **Condensation Polymerization**

❖Its building blocks are called **Monomers**

❖ Its properties are depend on:

- ✓Its length (number of monomers)
- ✓The extent of any branching (side chain)
- ✓ Any folding which results in a more compact molecule
- ✓Whether the chain is 'straight' or 'coiled'

C.1. Starch

❖Polymer of α-glucose & stored energy in plant

❖ It exists in 2 forms: **amylose** and **amylopectin.**

✓**Amylose** is an unbranched polymer of glucose

- Helical structure & form colloidal suspension (in hot water)

✓**Amylopectin** is a branched polymer of glucose

- Completely insoluble in water

C.2. Glycogen

❖ Polymer of α-glucose & Energy stored in Animal

❖ Amylopectin but highly branched & more compact

=> Very short distances b/n the branching side-chains => Easily degraded by enzyme

C.3. Cellulose

- Polymer of ß-glucose & Straight (no branching)
- It makes up the cell walls in plant cells
  - ✓ Form **Tough** structure & support the cell
    - Due to Glucose arrangement (straight chain) and
    - Stabilized Hydrogen bond
- Not easily hydrolyzed & not digested by human (can't be energy source)
  - ✓ Herbivores digest it by enzyme = **Cellulase**

- **Chitin**: hard exoskeleton of Arthropods (insect)
  - ✓ Made of Homo-poly-saccharide of ß-glucose

Summary of carbohydrates

- ✓The most abundant organic molecules in nature
- ✓Important source of & storage form of energy
- ✓Can be structural components of many organisms
- ✓Mediating cell communication (as cell-membrane components)
- ✓Can be cell-surface antigens
- ✓Can be part of the body's extracellular ground substance
- ✓Can be associated with proteins and lipids
- ✓Part of RNA, DNA & several coenzymes (NAD+, NADP+,

2.2. Lipids

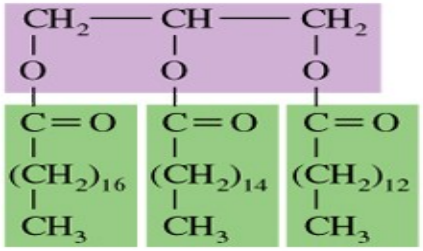
- Highly variable group of molecules & water-insoluble
  - ✓Includes fats, oils, waxes and some steroids.
- **Esters** of fatty acids and alcohol (**glycerol** or chains of alcohols)
  - ✓Glycerol – produce mono-, Di- or **Tri-glycerides** (Dietary fats)
- Triglyceride lipid **=** **Fat** (solid) & **Oil** (liquid) at room temperature
- Fatty acids are made from chains of C & H with different atoms
- The primary function of lipids is to store energy
- Triglycerides are stored in the fat cells **=** **Adipocytes (Lipocytes)**

2.2. Lipids …

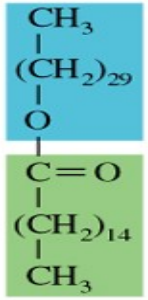
- ❖Store fats and lipids (energy store in animal's body)
- ❖2 types (ways of storing lipids) - white & brown fat cells
- ❖White fat cells store one large lipid drop
- ❖Brown fat cells store smaller & multiple droplets of lipids
  - ✓ Spreading in the whole body of the cell
- ❖Types of lipids (human): triacylglycerol, cholesterol & **polar** lipids

  => phospholipids, glycolipids & sphingolipids.
- ❖Plant leaves coated with lipids called **Waxes** (prevent water loss)
- ❖Honeycomb in a beehive is made of **beeswax**

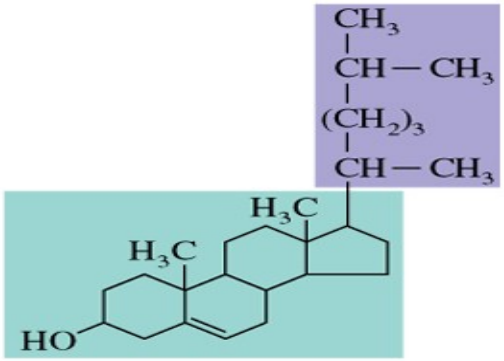
2.2. Lipids ...



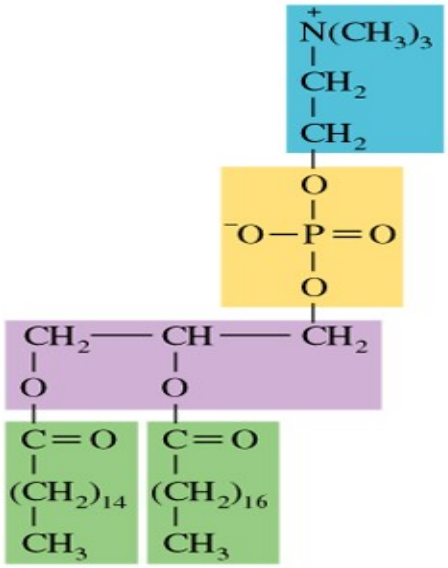
A fat



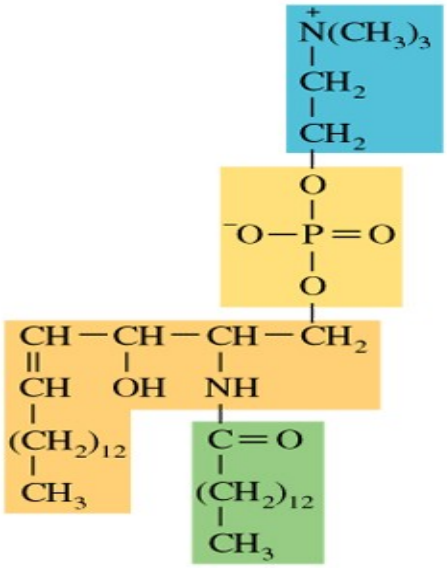
A biological wax



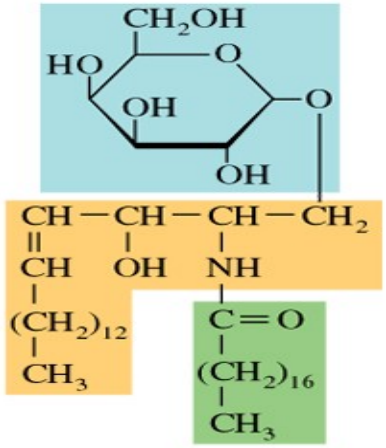
A steroid



A glycerophospholipid



A sphingophospholipid



A sphingoglycolipid

2.2. Lipids …

- The basic structure of a lipid includes fatty acid tails
- Each tail is a chain of C atoms bonded to H & other C atoms

  => by single or double bond
- Based on bond b/n C, & more H: Saturated & Unsaturated fat
- **Saturated fat**: have tail chains with only single bonds b/n the C atoms & no more H can bond to the tail
- **Unsaturated fat**: have at least one double bond b/n C atoms & can accommodate one more H
- **Polyunsaturated fats**: Fats with more than one double bond in the tail

Properties of lipids

- ❖ Insoluble in water (soluble in Non-polar/organic/ solvents)
- ❖ Longer chains => More hydrophobic & less soluble
- ❖ Double bonds increase solubility
- ❖ Melting points:
  - ✓ Depend on chain length and saturation
  - ✓ Double bonds lead chain disorder & low melting temperatures
  - ✓ Unsaturated fatty acids are solid at room

❖Importance of lipids

- ✓ As the main component of cell membranes (phospholipids)
- ✓ Insulation of heat and water,
- ✓ Storing energy (efficient energy sources)
- ✓ Structural components, Protection & cellular communication
- ✓ Role in structure & functioning in Vitamins & Hormones

  => dissolve & assist digestion of Vitamins

2.3. Proteins

- Made (polymer) of small compounds = **Amino acids**

  => made of C, N, O, H, and sometimes Sulfur.

- Amino acids have a central C atom bonded with H, amino group (–NH2), carboxyl group (–COOH), and a variable group (–R).

- The variable group makes each amino acid different

- 20 d/t Amino acid groups & combine to form d/t Proteins

  => by **Peptide bonds (**covalent) – b/n amino- & Carboxyl group

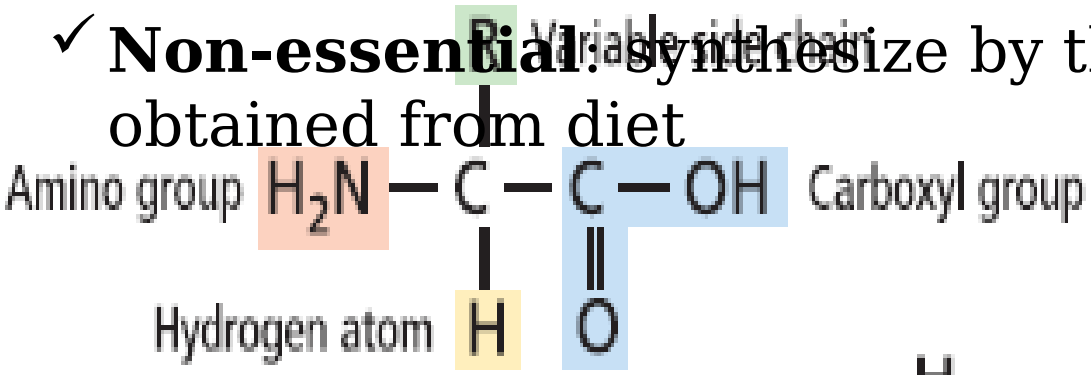
- Based on the variable groups in the amino acids – 4 levels of structure: Primary, Secondary, Tertiary & Quaternary

2.3. Proteins…

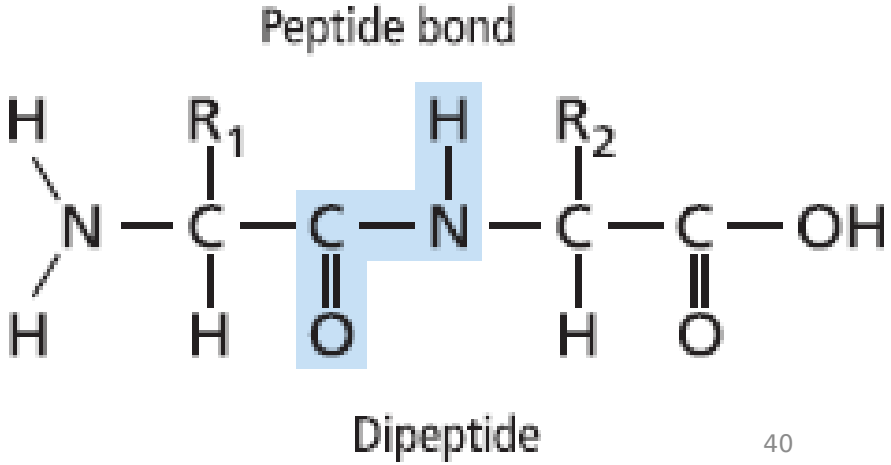
- Amino acids: very essential normal growth & functioning of cell
- Divided in 2: essential & non-essential

✓ **Essential:** Not synthesize by the organism & obtained through the diet

✓ **Non-essential**: synthesize by the organism & not obtained from diet



Basic structure of amino acid



Level of Protein structure

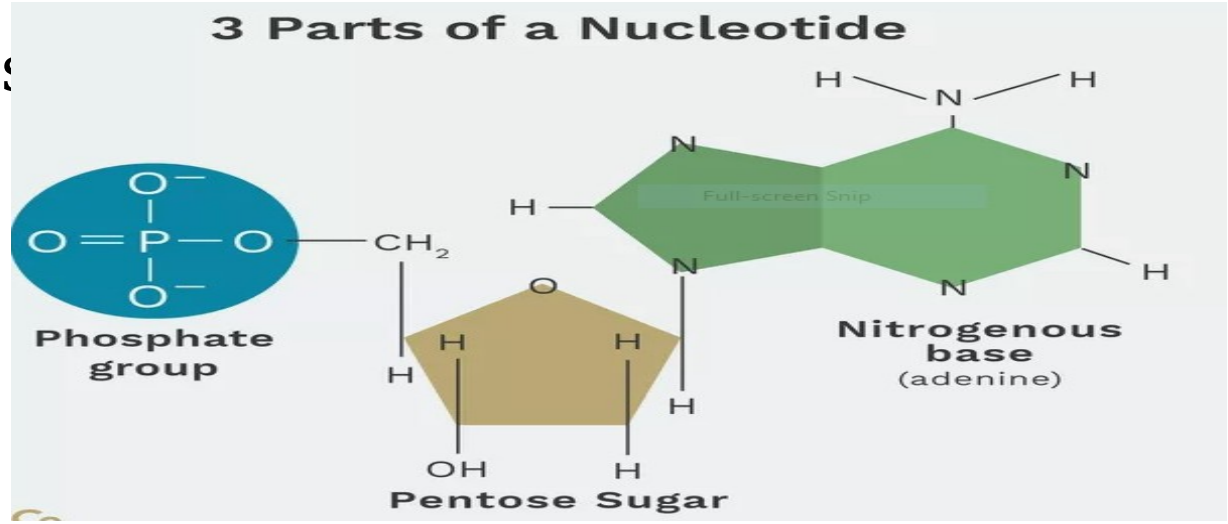
- **Primary structure**: number of amino acids in a chain
- **Secondary structure**: an amino acid chain folds into a unique three-dimensional shape by hydrogen bond
- **Tertiary structure**: a protein might contain many helices, pleats, and folds by **non-covalent interactions**
- **Quaternary structure** the fourth level of structure formed by combining with other proteins
  - ✓ Complex or an assembly of two or more separate peptide chains

Importance of protein

- Make up 15% of total body mass
- Involved in the function of body part
- Made part of the body (muscles, skin, hair, etc)
- Structural support of cells
- Transport substances inside the cell & between cells
- Communicate signals within the cell and between cells
- Speed up chemical reactions and control cell growth

2.4. Nucleic acids

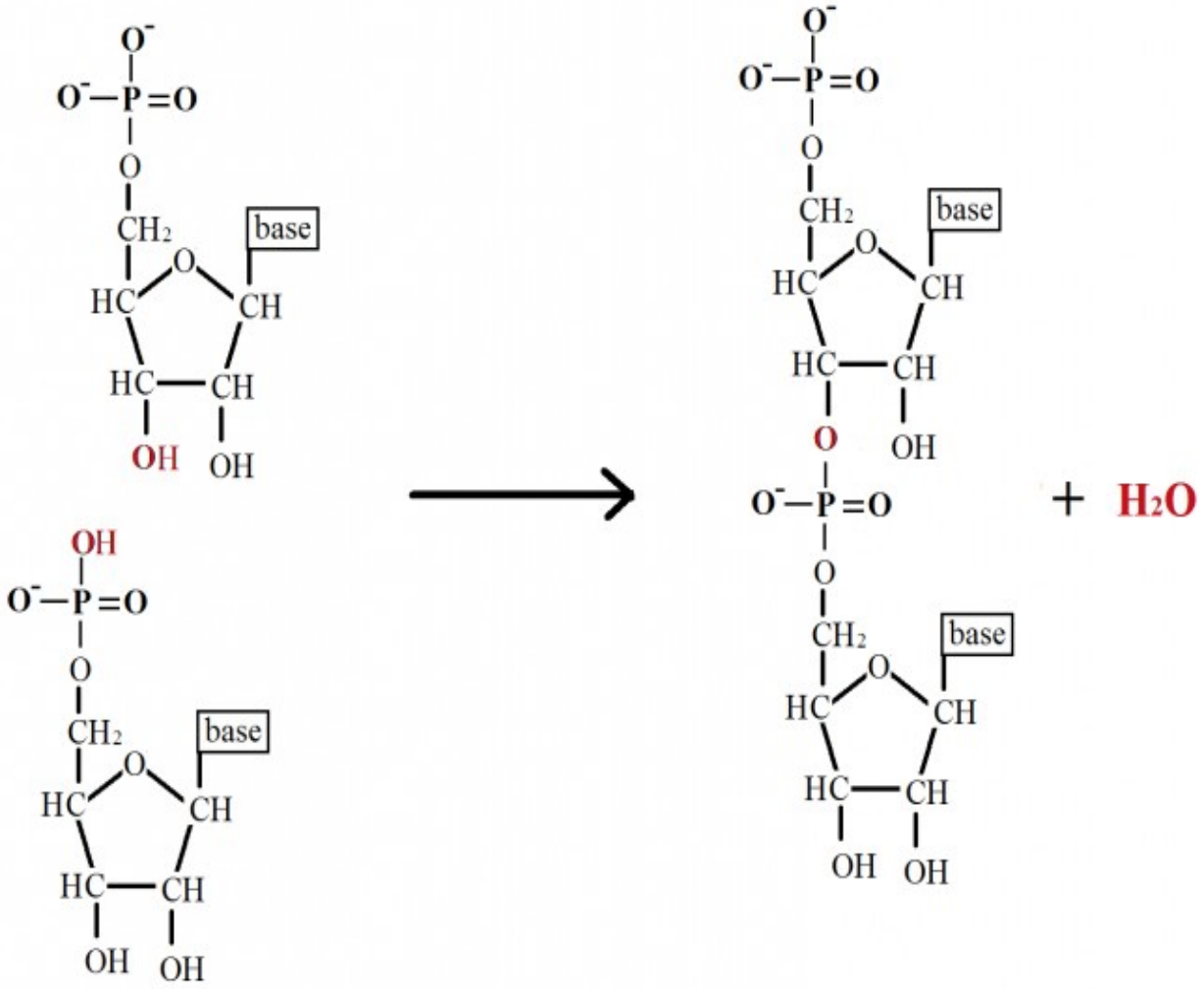
- Store and transmit genetic information
- made of smaller repeating subunits = **nucleotides**
- Composed of C, N, O, phosphorus, and H atoms.
- 6 major nucleotides & have phosphate, nitrogenous base, & ribos



Basic structure of nucleotide

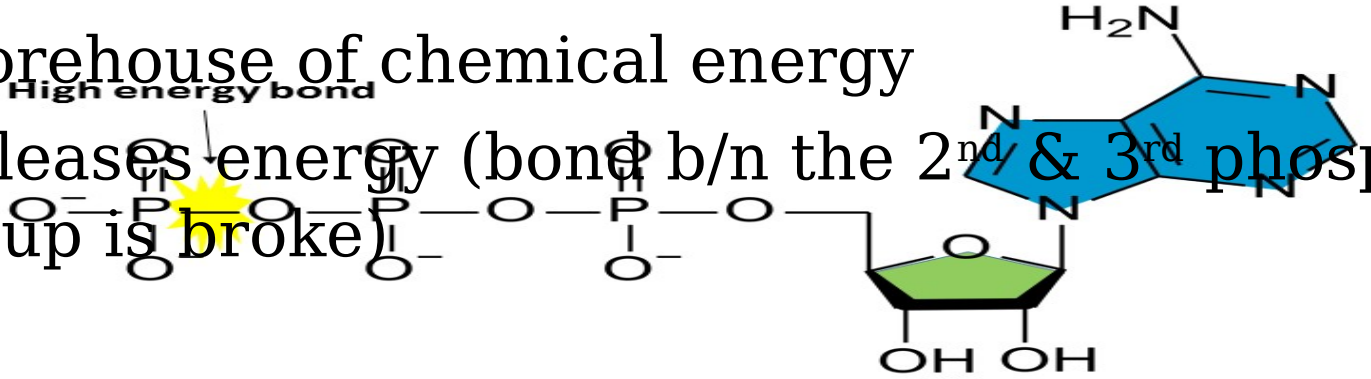
- 2 types of **Nucleic Acids** in living organisms
  = Deoxyribonucleic Acid (DNA) & Ribonucleic Acid (RNA).
  - ✓ The sugar of one nucleotide bonds to the phosphate of the other
- 5 d/t Nitrogenous bases found in nucleotide subunits
  - ✓ namely Adenine, Cytosine, Guanine, Thymine & Uracil
  - ✓ Make up DNA and RNA.
- DNA formed by Adenine = **Thymine** & Guanine ≡ Cytosine
- RNA formed by Adenine = **Uracil** & Guanine ≡ Cytosine
  - ✓ Linkage b/n nucleotides is called a **Phosphodiester** bond

In DNA and RNA, the **phosphodiester bond** is the **linkage between** the 3' carbon atom of one sugar molecule and the 5' carbon atom of another

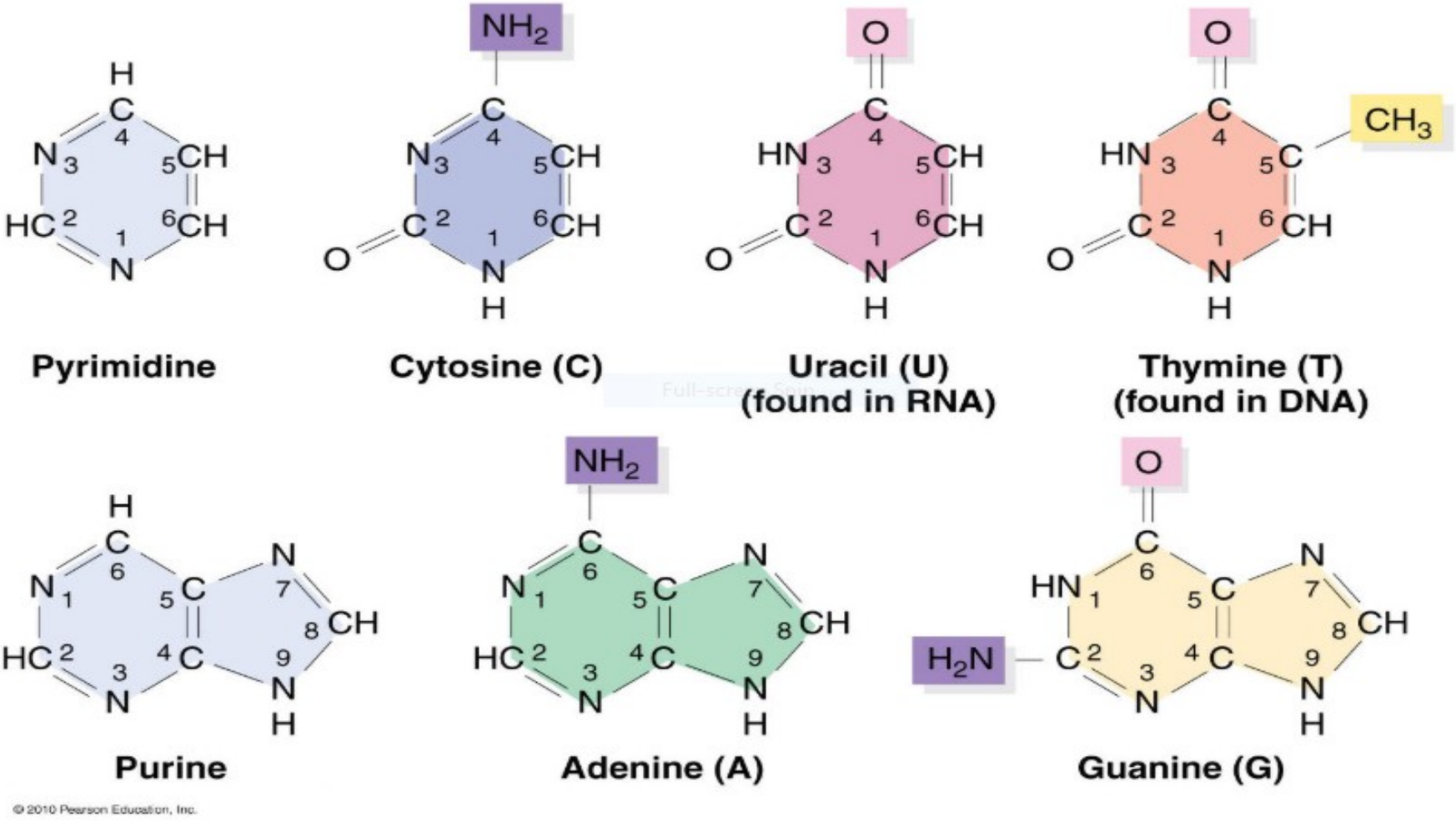


- **Purines:** Adenine & Guanine and two C-N ring bases
- **Pyrimidines**: Cytosine, Thymine & Uracil and one C-N ring bases

- Nucleotide (3 phosphate groups) is **Adenosine Triphosphate** (ATP)
  - ✓ Its Nitrogenous base is **Adenine,** which is purines
  - ✓ Storehouse of chemical energy
  - ✓ Releases energy (bond b/n the 2nd & 3rd phosphate group is broke)



2.4. Nucleic acids...



Double-ringed Purine / Single-ringed Pyrimidine bases

2.5. Vitamins

- Organic compounds
- Needed in small amounts for metabolic activities.
- Most vitamins cannot be made by the body
- Vitamin D is made by cells in skin (exposure to Sun)
- Some B vitamins & vitamin K are produced by bacteria *(E. coli)*
- Well-balanced diet can provide the vitamins.
- Many vitamins help enzymes function well
- Some are fat-soluble & stored in liver & fatty tissues (small amount)

2.6. Water

- Molecules formed by covalent bonds b/n 2 H with 1 O atom
- The most plentiful & essential of compounds
- It is tasteless and odorless
- Existing in gaseous, liquid, and solid states
- Dissolve (solvent is essential to living organisms)
- Media for transportation of substances
- It is **polar molecules**: has unequal distribution of charges with oppositely charged regions.

2.7. Minerals

- Inorganic compounds & used as body building material
- Involved with metabolic functions
- Iron is needed for functioning of hemoglobin (RBCs) to deliver O
- Calcium (with other minerals) are important components of bones
- Calcium involved in the function of Bone, muscle & nerve
- Calcium serve as cofactors for enzymes
- Magnesium is an important component of the green pigment
- Chlorophyll, involved in photosynthesis.