BIOCHEMISTRY

INTRODUCTION

1. Definition ⇝ what is the biochemistry? chemistry of life (study macromolecules)

- Science concerned with chemical basis of life
- Science concerned with the chemical constituents of living cells and with the reactions and processes that they undergo

2. The aim of biochemistry ⇝ two part

- molecules in chemistry (carbohydrate (monosaccharide, disaccharide, polysaccharide) ⇝ hyaluronic acid
- molecules in biological system (reaction of molecules in the body

Describe and explain, in molecular term, all chemical process associated with living cells

bio

Isolate the numerous molecules found in cells

Determine their structures ⇝ enzyme or protein

Analyse how they function
- enzymatic function
- protein function

3. Knowledge of biochemistry is essential to all life sciences

ارتباط الكيمياء الحيوية بالعلوم الأخرى؟

- Physiology: overlap with biochemistry (تداخل)
- Immunology: need biochemical techniques (علم المناعة يهتم دراسة جهاز المناعة)
- Pharmacology: drug metabolism and interaction (علم الأدوية يهتم بدراسة الأدوية ← catabolism and anabolism (الأيض) ← تفاعل)
- pathology: inflammation, cell injury and cancer (علم يدرس الحالة الفيزيولوجية للأعضاء ← التهاب ← إصابة الخلية ← سرطان)
- Toxicology: poisons (علم السموم هو علم يدرس تأثير السموم على الكائنات الحية)
- microbiology: (علم الأحياء الدقيقة وهو علم يدرس الكائنات الحية الدقيقة)

4. Reciprocal relationship between biochemistry & medicine has stimulated mutual advance

العلاقة التبادلة بين الطب والكيمياء الحيوية أدت إلى تحفيز التقدم في كلا المجالين ؟

(a) Biochemistry studies have illuminated many aspects of health & disease

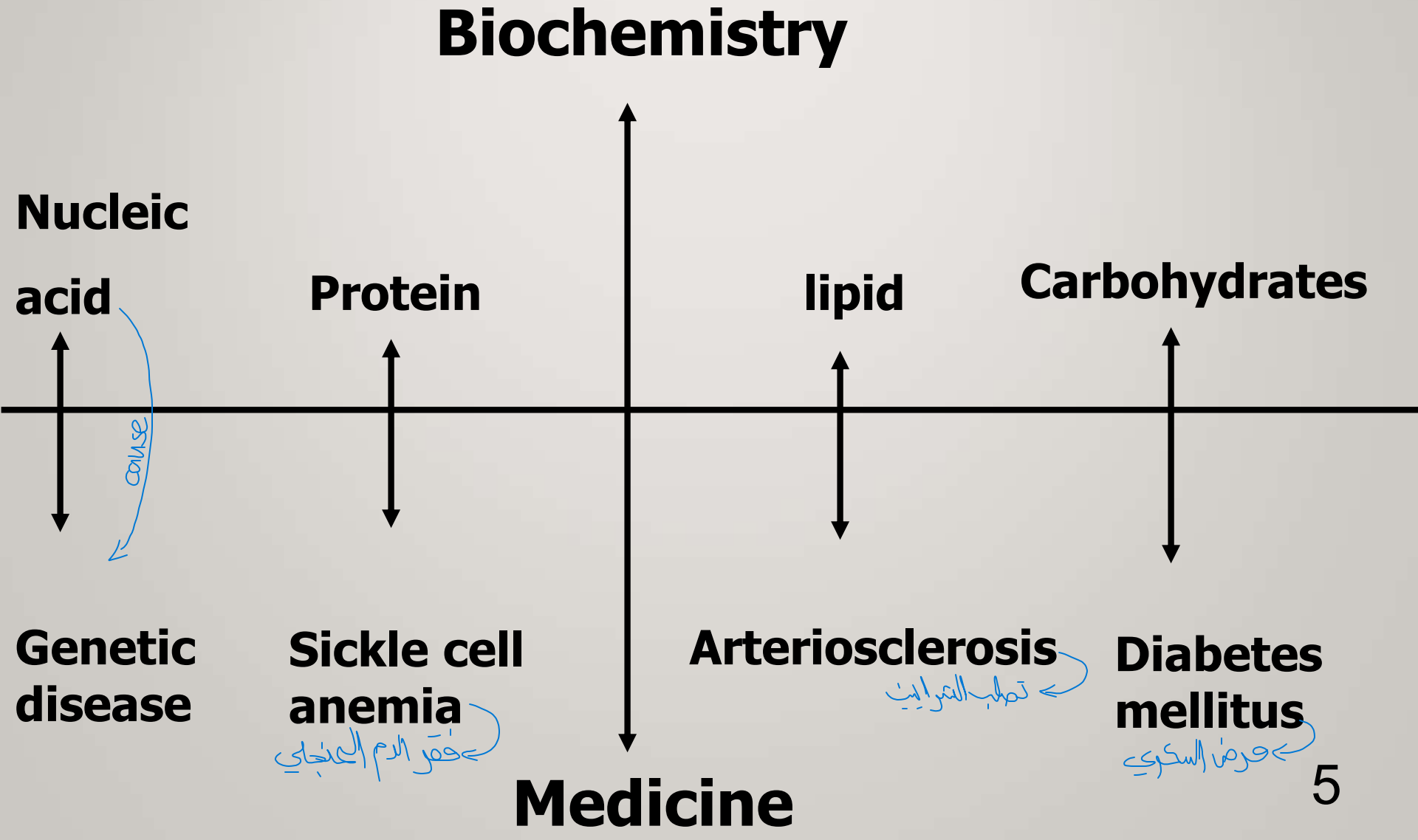
ساهمت بتوضيح

(b) The study of various aspects of health & disease has opened up new areas of biochemistry

For example, knowledge of protein structures and function was necessary to elucidate the difference between normal and sickle cell hemoglobin ⟹ which causes sickle cell anemia

توضيح

مثلاً


Biochemistry
Nucleic acid
Protein
lipid
Carbohydrates
cause
Genetic disease
Sickle cell anemia
فقر الدم المنجلي
Arteriosclerosis
تصلب الشرايين
Diabetes mellitus
مرض السكري
Medicine

5. Normal biochemical processes are the basis of health

Definition of health (WHO)

"Complete physical, mental & social well-being and not merely the absence of disease and infirmity"

A strictly biochemical viewpoint about health: The situation in which all of the many thousands of intra & extra cellular reactions that occur in the body are proceeding at the rates commensurate with its maximal survival in the physiological state

6. Biochemical research has impact on nutrition and preventive medicine

7. All diseases have a biochemical basis

(1) Physical agent:

mechanical trauma, extremes of temperature, sudden changes in atmospheric pressure, radiation, electric shock

(2) Chemical agents:

drugs, certain toxic compounds, therapeutic drugs

(3) Biologic agents:

Viruses, Bacteria, Fungi, Higher forms of parasites

(4) Oxygen lack

loss of blood supply, depletion of the oxygen-carrying capacity of the blood, poisoning of the oxidative enzyme

(4) Genetic disorders: الاضطرابات الجينية

Congenital, molecular

← خلقية

(6) Immunology reaction

Anaphylaxis, Autoimmune disease

← التأق هو رد تحسسي شديد وسريع مما يؤدي إلى استجابة مناعية مفرطة

← أمراض المناعة الذاتية

(7) Nutritional imbalance: (اختلال التوازن الغذائي)

Deficiencies, excesses

(8) Endocrine imbalances

hormonal deficiencies, excesses

8. Biochemical studies contribute to diagnosis, prognosis & treatment

التشخيص — التنبؤ بمسار المرض (الانذار الطبي) — العلاج

Disease	causes
Scurvy ← الإسقربوط	Deficiency of vitamin C
Rickets ← الكساح	Deficiency of vitamin D
Arteriosclerosis ← تصلب الشرايين	Genetic, dietary ← غذائية, environmental factors

Disease	causes
Phenylketonuria ← فينيل كيتونوريا	Mainly mutation in the gene coding (phenylalanine hydroxylase) ← طفرة في هذا الإنزيم ← طفرة
Cystic fibrosis ← (التليف الكيسي)	Mutation in the gene coding the ((CFTR) protein) ← عبارة عن قناة أيونية ← Cystic fibrosis transmembrane conductance
Cholera ← كوليرا	exotoxin of (vibrio cholera) ← بكتيريا الضمة الكوليرية
Diabetes type I ← السكري من النوع الأول	genetic and environment factors resulting in deficiency of insulin ← سبب المرض نقص في الانسولين

9. Many biochemical studies illuminate disease mechanisms & disease inspire biochemical research

Use	Example
(1) to reveal the fundamental causes &mechanisms of diseases	Demonstration of the genetic defects in (CF)
(2) to suggest rational treatment of diseases	use of a diet low in phenylalanine for the treatment of phenylketonuria
(3) to assist in the diagnosis of specific disease	use of the plasma enzyme CK-MB in the diagnosis of (myocardial infarction)

Use	Example
(4) To act as screening tests for the early diagnosis of certain diseases	use of measurement of blood tyrosine or TSH in the neonatal diagnosis of congenital hypothyroidism
(5) To assist in monitoring the progress of certain disease	use of the plasma enzyme ALT in monitoring the progress of infectious hepatitis
(6) To assist in assessing the response of diseases to therapy	use of measurement of blood CEA in certain patients who have been treated for cancer of the colon

THE MOLECULAR COMPOSITION OF CELLS ⇝ (التركيب الجزيئي الخلية)

- Mostly Water: ~80%
- Of remainder weight: (20%)
  - Lipids, fats: 10%
  - Carbohydrates: 15%
  - Proteins: 50%
  - Nucleic Acids: 15%

جزيئات كبيرة ←

- **Proteins** are key macromolecules (play many structural and functional roles in cells)
- Nucleic Acids (**DNA**, RNA; DNA (stores hereditary information in cell)) ← تخزين المعلومات الوراثية
- At some level, chemical forces determine shape of molecules and shape determines function.

THE FORCES THAT GIVE THESE MOLECULES THEIR PROPERTIES

1. Covalent bond

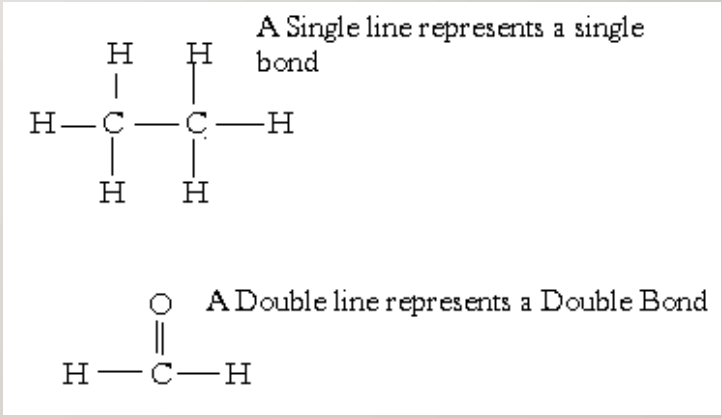
- most important type of bonds
- strongest type of bond – strength ~ 80 kcal/mol

what is the covalent bond ?

- **A covalent bond is the sharing of a pair of electrons**
- There is free rotation about a single covalent bond, but not about a double or triple bond.

→ just in single bond

- Covalent bonds also have a fixed angle. (زاوية محددة)
- Some covalent bonds involve unequal sharing of electrons.



1. COVALENT BOND

- **Some atoms hold onto electrons more tightly than other atoms. The tendency to attract electrons is a measure of electronegativity of an atom**
  - → the ability of atom to attract the electrone
  - → the highest electronegativity F^-.
- Oxygen is a more electronegative atom compared to hydrogen, and thus an O-H bond is considered a polar bond.
- **Carbon and hydrogen have similar electronegatvities, therefore, a C-H bond is considered nonpolar.**

2) HYDROGEN BONDS ⇝ the bond between H and N, O, F

أقوى شكل للرابطة الهيدروجينية عندما يكون طول الرابطة 0.25nm ⇝ إذا أكبر تضعف الرابطة وإذا أصغر بصير في تنافر بين الذرات

- Attraction between a slight positive charge on a hydrogen atom and a slight negative charge (N, O or F) on a nearby atom
- Strength of bond ~ 5 kcal/mol (relatively weak)
- Strongest when the donor, the hydrogen and the acceptor are about 0.25 nm apart
- Hydrogen bonds give order (نظام) and structure to molecules
- A single hydrogen bond is weak, however, most molecules are made up of many

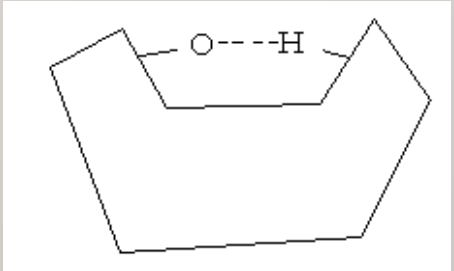
- **Hydrogen bonds; leads to overall strength of molecule**

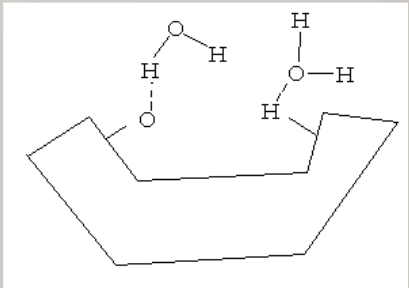
(الكلية)

2) HYDROGEN BONDS

- Properties of water are determined by hydrogen bonding interactions. ?!
  - Water is highly structured even when liquid. Formation of ice is due to the lattice array of hydrogen bonds.
    - ↳ when low tempreture the bonds in water become more stable so that the molecules are arranged to formation lattice array
- Hydrogen bonds form between different regions of a protein
  - In an aqueous environment, these regions will from hydrogen bonds with water molecules. These molecules adopt a more favorable conformation when they interact with water.
    - المستقر ↳ تشكيل

↳ the protien in aqueous environment formation bonds with water to become more stable





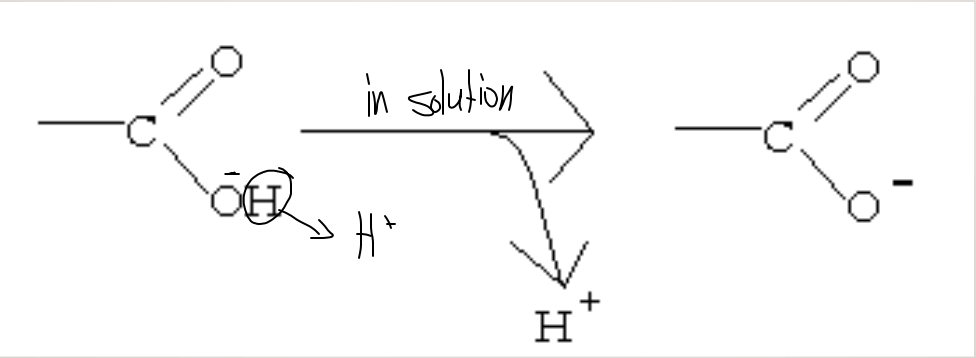
3) IONIC BONDS

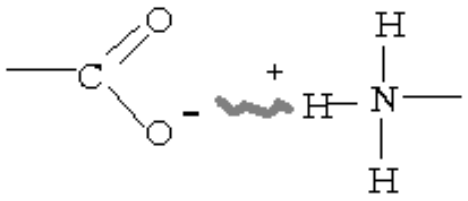
تفاعل كهروستاتيكي

- electrostatic interaction between two oppositely charged groups in a molecule
- Limiting cause of unequal sharing of electrons; one atom keeps the electron ⇝ not sharing the electron

$$NaCl \rightarrow Na^+ + Cl^-$$

- unequal sharing of electrons, Cl^- keeps both electrons.
- **Strength of ionic bond is about 3-7 kcal/mol; strongest when the two atoms are about 0.28 nm apart** ⇝ إذا أقصر بمسير تنافر وإذا أطول بمسير ضعف
- **In solution this group becomes ionized, loses a proton (H^+) and becomes negatively charged** ⇝ حمضية (يعني تفقد أو تكسب بروتون)





ionic bond

Charged atoms are held by a force called Coulomb/s law:
F = q1 q2/ (R) (R)

Force of attraction is proportional to the charges (q) of the two groups and the distance (R) between them

4) VAN DER WAAL INTERACTION

↳ three type ?

① London forces :- between any two atoms and molecules

② Induced dipole interaction

③ dipole - dipole interaction :- between two polar molecules

- Nonspecific attractive force that occurs when ?! any two atoms come in close range

لـ تقرب

- Most favorable when atoms are 0.2-0.3 nm apart

↳ استقطاب مؤقت

- Transient polarity induced between atoms a nonpolar bond leads to attraction with nearby atoms

- Very weak interaction
  - strength is ~1 kcal/mol. However the sum of many Van Der Waal interactions leads to increased strength and stability

4) VAN DER WAAL INTERACTION

جزيء يرتبط على سطح الخلية أو داخلها مثل الأدوية، الهرمونات والنواقل العصبية

- Example: A ligand interacting with its receptor is accomplished by many noncovalent interactions such as Van Der Waal interactions

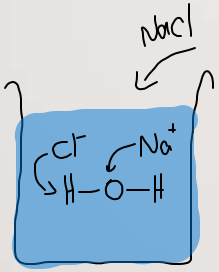
5) HYDROPHOBIC INTERACTIONS/ ENTROPY

تقليل الطاقة وترتبط فيه وهو مقياس العشوائية في النظام

- Overall, a molecule is held together by many interactions. A molecule forms a particular shape because it likes to adopt the lowest energy state (minimize entropy)
- In adopting this shape, the alternative conformations are selected, and the groups that cannot form hydrogen bonds with water (the hydrophobic ones) tend to cluster on the inside of the molecule (away from water). لتجمع
  - **Hydrophobic:** ("water hating") uncharged, nonpolar molecules, don't interact with water
  - **Hydrophilic: ("water loving"): charged or polar molecules; from hydrogen bonds with water**

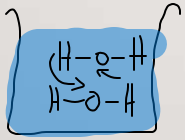
OTHER INTERACTIONS

- Ionic-dipole



between ion and polar molecules

- Dipole-dipole



between two polar molecules

- The shape that biological macromolecules adopt is dependent on a large number of molecular interactions.
  - ↳ more than one interaction

MACROMOLECULES

- Most biologically important macromolecules are polymers, called biopolymers.

- Biopolymers fall into three classes:
  - proteins,
  - polysaccharides (carbohydrates), and
  - nucleic acids.

SUGARS, CARBOHYDRATES

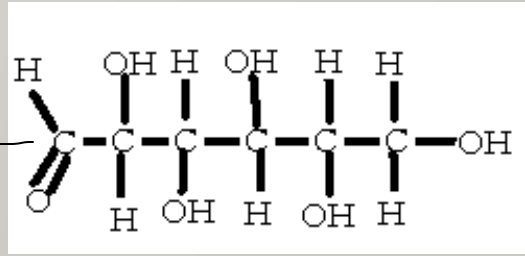
- The most abundant biological compounds
- Structurally related but have a different chemical properties
  لـ متشابهة — متشابهة في التركيب مختلفة الخصائص الكيميائية
- Involved in the storage and transport of energy (Starch, Glycogen)
- As structural component (Cellulose in plants and Chitin in animals)
- Divided into: Monosaccharides , disaccharides and Polysaccharides

1) GENERAL FORMULA FOR A SUGAR

الصيغة العامة للسكر

- (CH2O)n e.g. Glucose C6H12O6
- In all sugars, n-1 of the carbons has a hydroxyl (OH) group and the C-1 carbon has a carbonyl (C=O) group. The location of the carbonyl group and the orientation of the hydroxyl groups determine the type of sugar. what is ?!!
- If the carbonyl group is at the end (an aldehyde group) then it is an aldose (e.g. glucose)
- If the carbonyl is in the middle (a ketone group) then it is a ketose (e.g. fructose)
- Six carbon sugars are called hexoses (e.g. glucose)
- Five carbon sugars are called pentoses (e.g. ribose)
- Three carbon sugars are called trioses (e.g. glyceraldehyde)

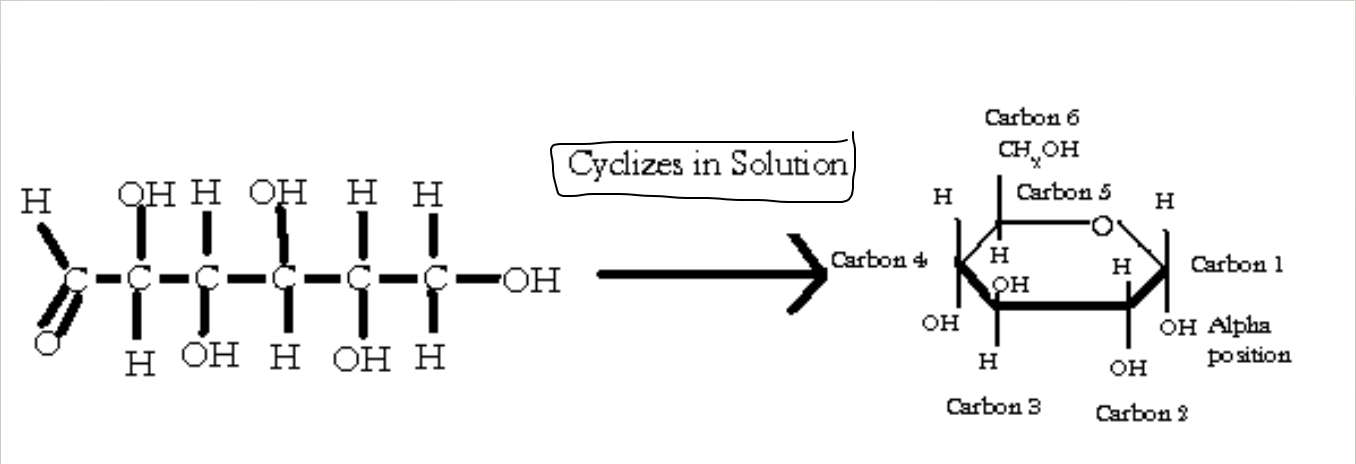
(glucose structure) ←



2)CONFORMATION OF SUGARS (تكوين السكر)

a)Monosaccharides

- Glucose is more often found in a ring form in solution.
- The Orientation (اتجاه) of the OH group on the C-1 carbon can be either in the alpha (below the plane of the ring) or beta (above the plane of the ring) position

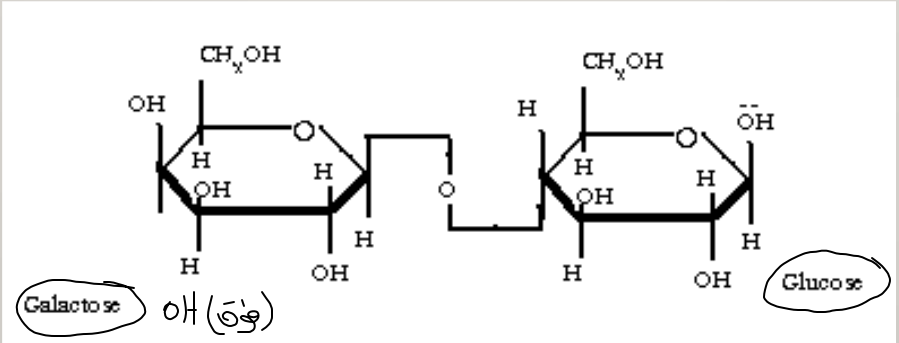


SUGARS, CARBOHYDRATES

b)Disaccharides ⇒ composed from ?

- Disaccharides consist of two Monosaccharides linked by a covalent bond:
- **Lactose (form)** component from ?
- (Galactose (1-> 4) Glucose)
- The enzyme lactase breaks down lactose to glucose and galactose. Many adult individuals stop synthesizing lactase enzyme. As a result a large percent of certain populations becomes lactose-intolerant.

لعدم تحلل اللاكتوز (حموضة هضم اللاكتوز)



Lactose (galactose (1-> 4) glucose

SUGARS, CARBOHYDRATES

c) Polysaccharides ⟹ composed from ?

- Polysaccharides consist of many monosaccharide units (usually glucose monomers) linked together to form long chains.
- e.g. starch, glycogen, cellulose
- Polysaccharides are used as a form of storage of energy and also for structural roles.
- Starch is an unranked polymer of Glucose (1-> 4) linkage
  ← غير متفرع
  ↳ number of bond (1-4)
- Cellulose – plays an important structural role in plants; one of the most abundant molecules on earth. it is an unbranched polymer of glucose in (1->4) linkage.

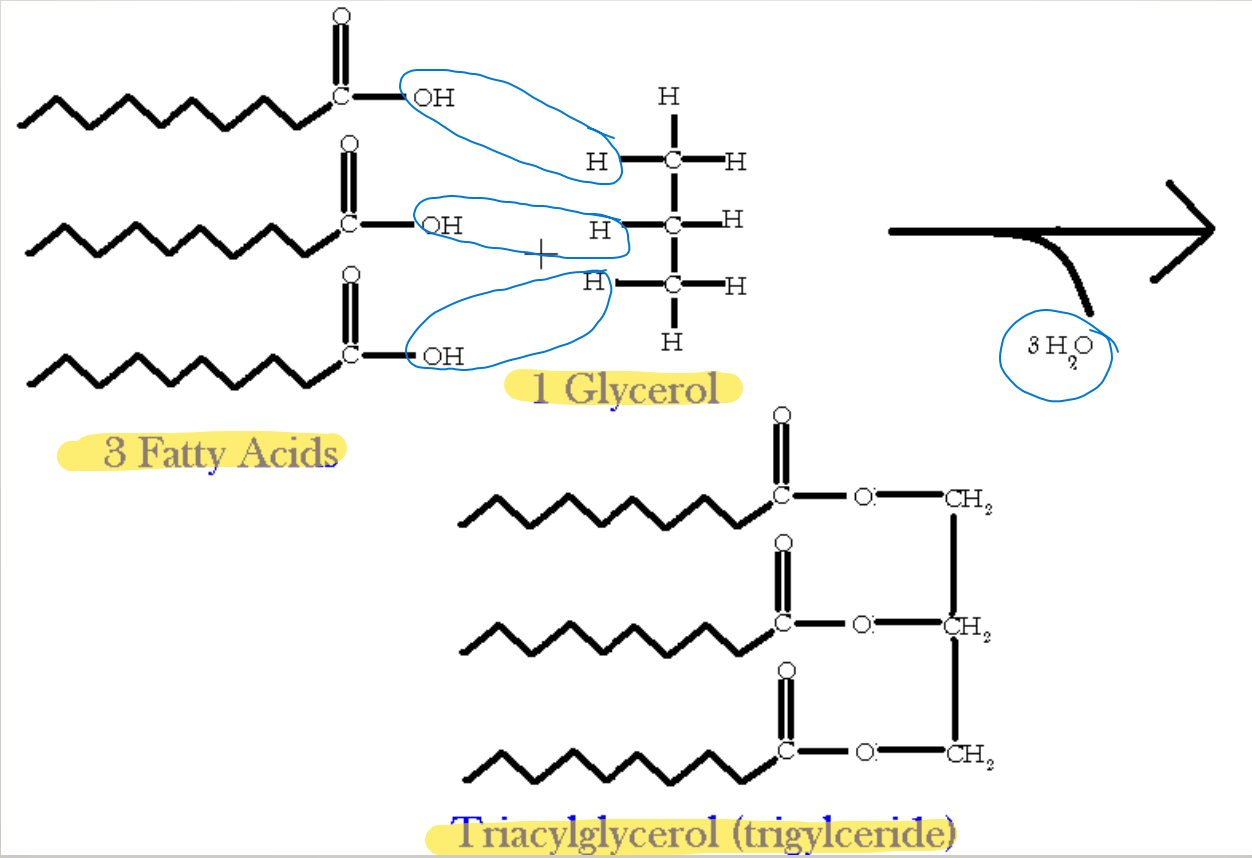
LIPIDS

- fatty acid by adding a carboxyl group (COOH) group to a hydrocarbon

- A fatty acid is an amphipathic molecule: contains both hydrophobic and hydrophilic portions

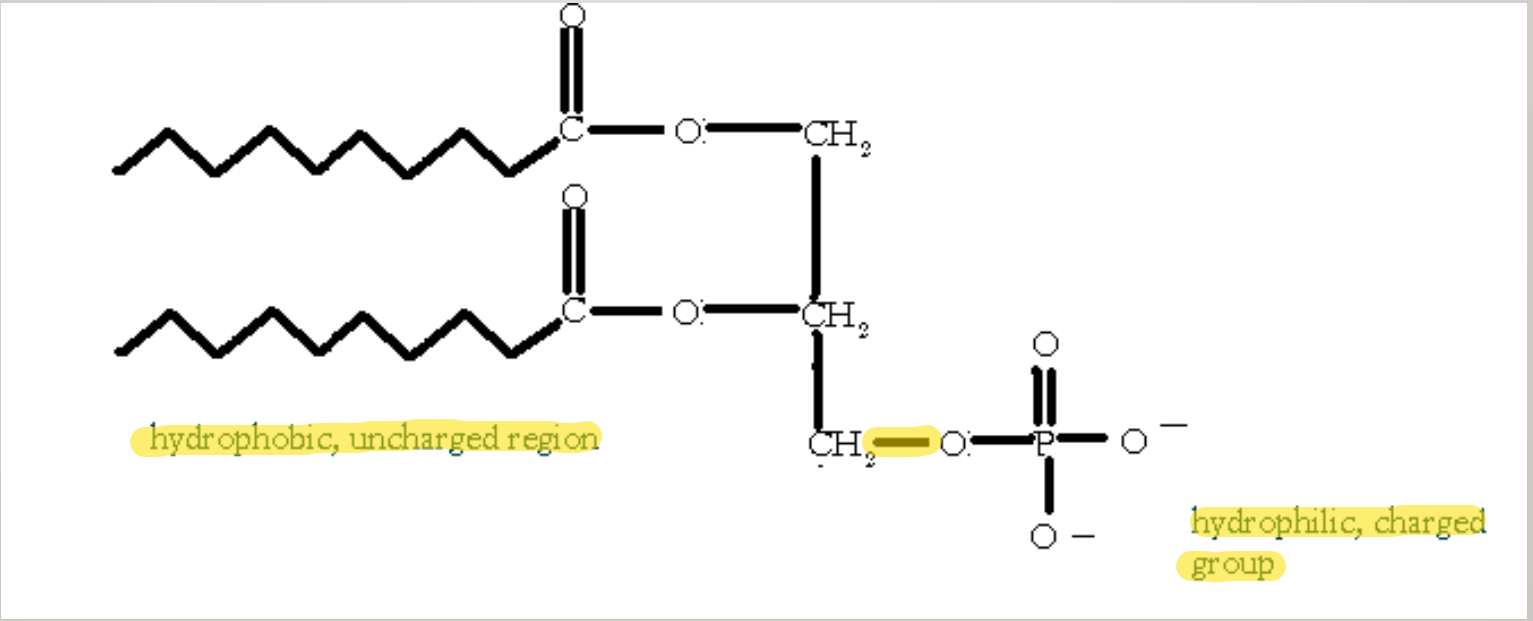
- Three fatty acids and one glycerol molecule can be combined in a dehydration synthesis to from a lipid (a triglyceride).

- Triglycerides are major storage forms of fatty acids inside cells



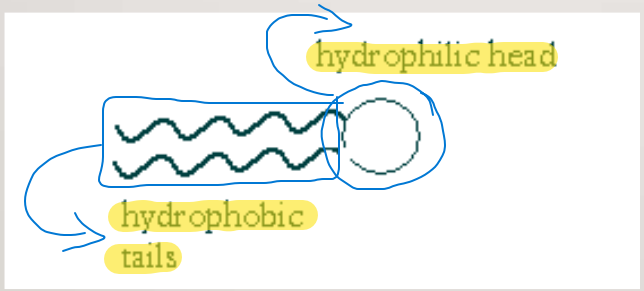
PHOSPHOLIPIDS

- A subgroup of lipids that play a key role in cell structure.
  Phospholipids are formed by combining two fatty acids and a phosphate group

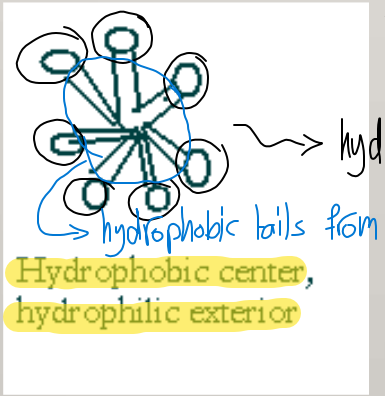


PHOSPHOLIPIDS

- The phospholipid can also be represented as:



- In solution, phospholipids will assemble to form micelles.



لـ هياكل كروية تتكون عند وضع phospholipid في الماء

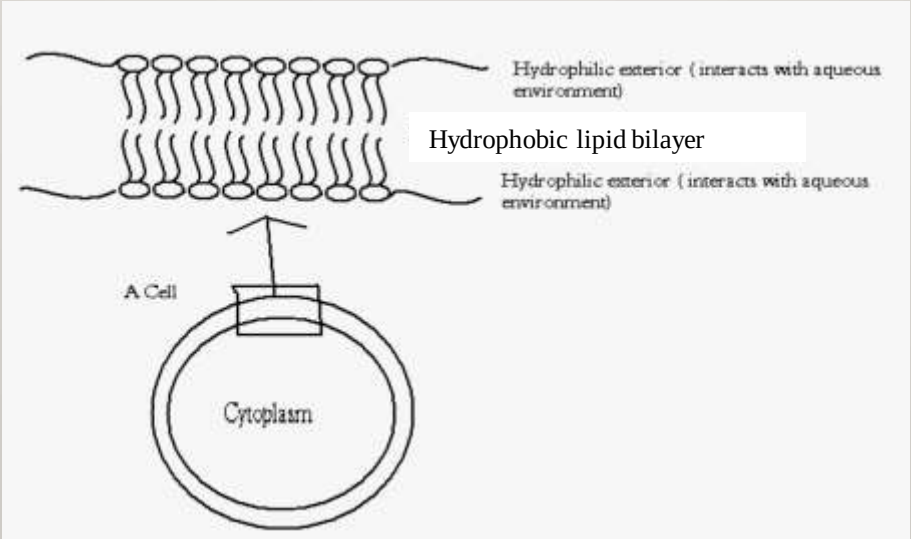
hydrophilic head from outside

hydrophobic tails from inside

PHOSPHOLIPIDS

- Phospholipids form a lipid bilayer in an aqueous solution. A typical cell is enclosed by a plasma membrane, which is made up of a phospholipid bilayer
- The hydrophobic interior of the plasma membrane is impermeable to charged or polar molecule

لمحبر منفذ



PROTEINS

- have many functions in the cell
- structural and functional roles
- 105 different kinds of proteins made in eukaryotic cells

لـ خلايا حقيقة النواة

- Proteins are polymers of building blocks known as amino acids
- 20 different amino acids and so can make 20n combinations of proteins length n ⟹ n=length

example:- If n=2 calculate the possible combination ?

$20^{(2)} = 20 * 20 = 400$ combination

AMINO ACIDS & PEPTIDE BONDS

the only different between amino acid.

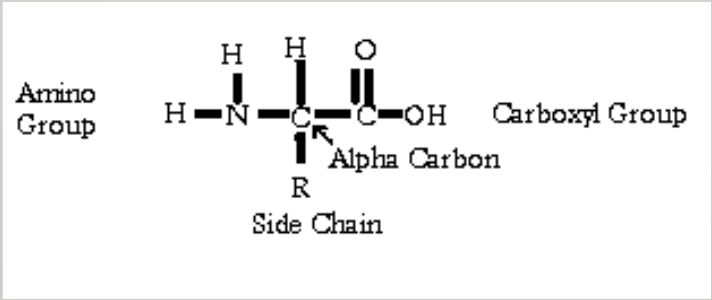
- R group (side chain) varies among the 20 different amino acids. 20 different amino acids make up all proteins

(10–20) monomers

- Peptides are oligomers of amino acids formed via a dehydration reaction when the carboxyl group of one peptide is linked to the amino group of a second amino acid

what is mean the protein ?

- A long polypeptide made up of many amino acids is called a protein. Each protein has a specific order of amino acids and adopts a particular shape – which is determined by the sequence of amino acids



LEVELS OF PROTEIN STRUCTURE

primary, secondary and tertiary structure → one chain

but Quaternary structure → more than one chain

(1) Primary Structure → ترتبط مع بعضها البعض برواط ببتيدية

The linear sequence of amino acids (e.g. NH3+..met-cys-leu-lys-glu...COO-)

← نهاية ← التسلسل الخطي للأحماض الأمينية ← البداية

(2) Secondary Structure

ترتيب محلي

The local arrangement of amino acids that are close together in the linear chain to form structures that include α-helices, β-pleated sheets and random coils and loops.

← لفات وحلقات عشوائية

(3) Tertiary Structure

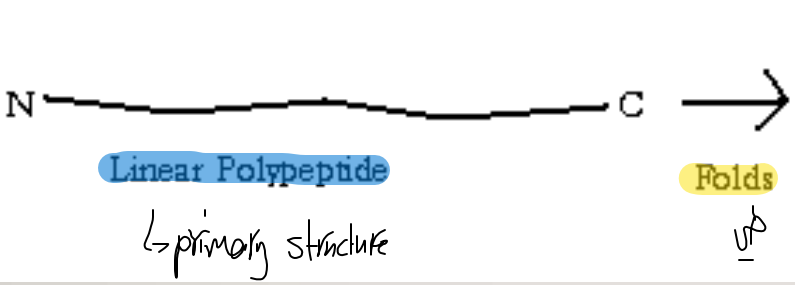
ترتيب فراغي

Spatial arrangement of amino acids that are far apart in the linear polypeptide chain to form the full 3-dimensional (folded) structure of the protein. Also includes disulfide bonds

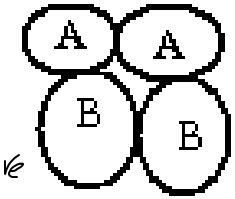
← مطوية

(4) Quaternary structure

Interaction of more than one polypeptide chain; association between different proteins to form complexes such as dimers, trimers, tetramers



e.g.
Hemoglobin (oligomeric protein)
↳ Quaternary structure



Consits of 4 polypeptide chains:
2 A chains
2 B chains