Sheet no. 1

Biochemistry

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Introduction To Biochemistry

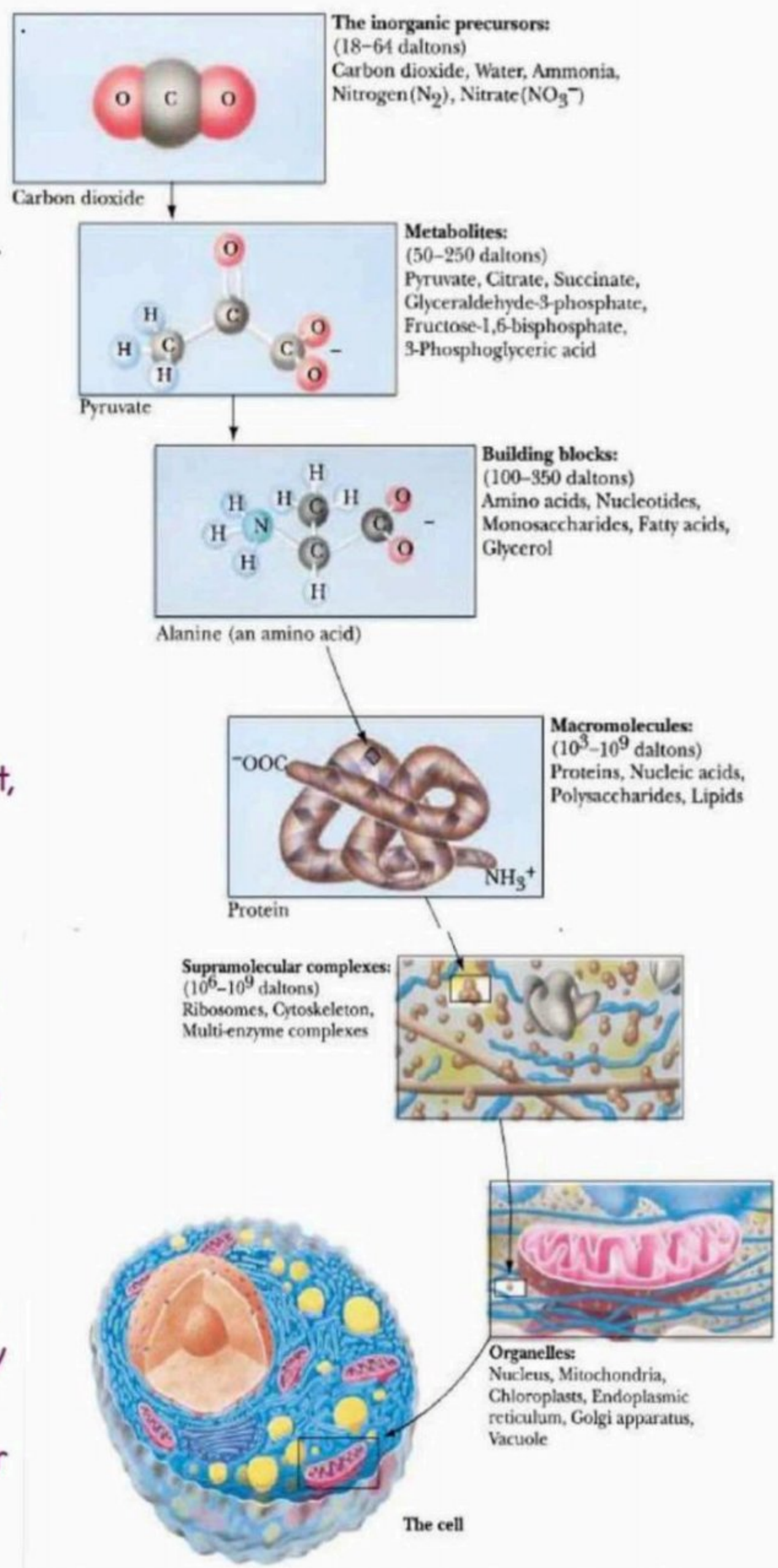
What is Biochemistry?

Biochemistry is the science concerned with studying the various molecules that occur in living cells and organisms and their nature, structure and chemical reactions.

It's about chemistry of living systems.

All living things from the simplest bacterium to the human being use the same types of biomolecules, and they all use energy. As a result, organisms can be studied via the methods of chemistry and physics.

The field of biochemistry draws on many disciplines, and its multidisciplinary nature allows it to use results from many sciences to answer questions about the molecular nature of life processes. Important applications of this kind of knowledge are made in medically related fields; an understanding of health and disease at the molecular level leads to more effective treatment of illnesses of many kinds.



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Why do we study biochemistry?

Biochemistry = understanding life

We study it to:

1.Know the chemical structures of biological molecules.
2. Understand the biological function of these molecules.
3. Understand interaction and organization of different molecules within individual cells and whole biological systems.
4. Understand bioenergetics (the study of energy flow in cells).

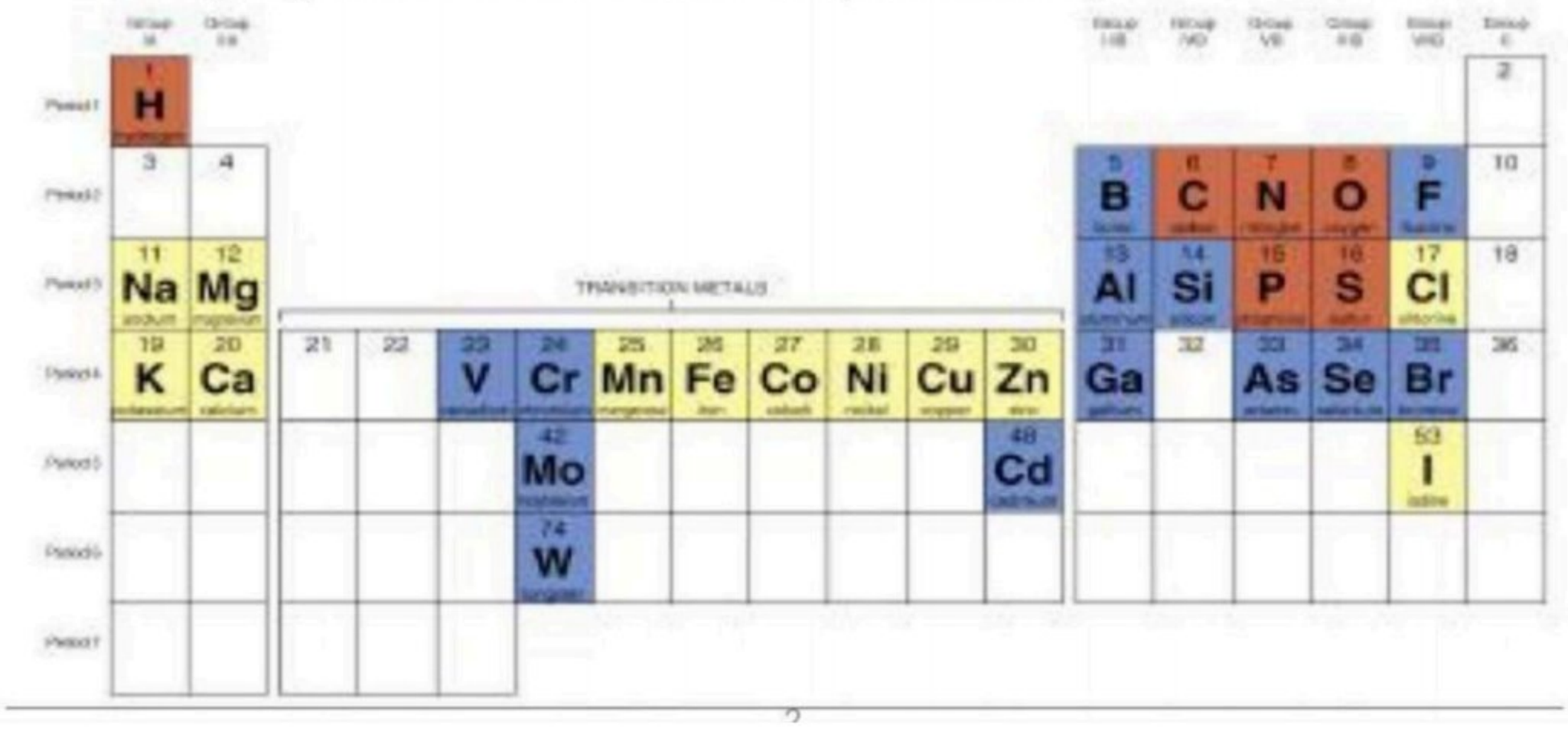
What is the useful of biochemistry in medicine?

1. To explain all disciplines.
2. Diagnose and monitor diseases.
3. Design drugs (new antibiotics, chemotherapy agents).
4. understand the molecular bases of diseases.

-so know that in this course the doctor said we are going to talk about molecules rather than cells and tissues. Also one of the important info you have to know that the human body is made of organic compounds by nature.

Chemical elements in living creatures:

Living organisms on Earth are composed mainly of 31 elements:



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Abundant elements

- There are 31 important elements in the body present in different amounts.

- Four primary elements: carbon, hydrogen, oxygen, and nitrogen.
*side note about the four primary elements: they constiute 96.5% of an organism's weight.

- The second groups include sulfur and phosphorus.

- Most biological compounds are made of only SIX elements: C, H, O, N, P, S.

- Others are minor, but essential, elements. They are mostly metals.

- know that the body is mostly made of the primary four elements with some contribution of the second group mainly sulfur and phosphorus other than that elements that are presented in trace (كميات ضئيلة) amounts (fourth group, they are also called trace elements).

- you must know that the presence of the trace elements in trace amounts dose not mean that they are not important.

Element	Comment
First Tier	
Carbon (C)	Most abundant in *all organisms*
Hydrogen (H)	
Nitrogen (N)	
Oxygen (O)	
Second Tier	
Calcium (Ca)	Much less abundant but found in *all organisms*
Chlorine (Cl)	
Magnesium (Mg)	
Phosphorus (P)	
Potassium (K)	
Sodium (Na)	
Sulfur (S)	
Third Tier	
Cobalt (Co)	Metals present in small amounts in *all organisms* and essential to life
Copper (Cu)	
Iron (Fe)	
Manganese (Mn)	
Zinc (Zn)	
Fourth Tier	
Aluminum (Al)	Found in or required by *some organisms* in trace amounts
Arsenic (As)	
Boron (B)	
Bromine (Br)	
Chromium (Cr)	
Fluorine (F)	
Gallium (Ga)	
Iodine (I)	
Molybdenum (Mo)	
Nickel (Ni)	
Selenium (Se)	
Silicon (Si)	
Tungsten (W)	
Vanadium (V)	

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Covalent Bonds

Important properties of bonds:

1.Bond strength (amount of energy that must be supplied to break a bond).
Triple>double>single
2.Bond length: the distance between two nuclei.
Triple<double<single
3.Bond orientation: bond angles determining the overall geometry of atmos.

The three-dimensional structures of molecules are specified by the bond angles and bond lengths for each covalent linkage.

Polarity of covalent bonds:

Elements forming covalent bonds have different abilities to attract electrons towards them (electronegativity). Atoms having high electronegativity (O & N for example) will attract electrons toward them, which results in a partially negative charge, while atoms having low electronegativity will have partially positive charge.

Covalent bonds in which the electrons are shared unequally in this way are known as polar covalent bonds. The bonds are known as "dipoles".

So, the we have polar bond and polar molecules:
Polar bond-->defference in electronigativty between two atoms.
Polar molecule-->the difference in electronigativity in the whole

Oxygen and nitrogen atoms are electronegative.
Oxygen and hydrogen.
Nitrogen and hydrogen.
Not carbon and hydrogen.

**water is an excellent example of polar molecules, but not CO2

رح نحط الأمثلة يلي بالسلايدات، مع شرح الكتاب للموضوع.

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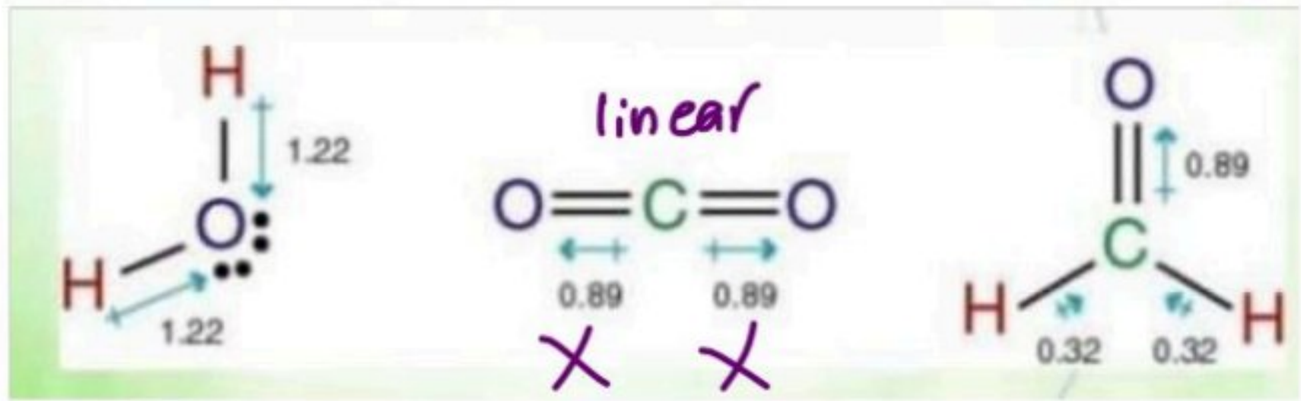

For CO2:

The bonds in a molecule may be polar, but the molecule itself can still be nonpolar because of its geometry. Carbon dioxide is an example. The two C"O bonds are polar, but because the CO2 molecule is linear, the attraction of the oxygen for the electrons in one bond is cancelled out by the equal and opposite attraction for the electrons by the oxygen on the other side of the molecule.

For H2O:

Water is bent molecule with a bond angle of 104.3,and the uneven sharing of electrons in the two bonds is not cancelled out as it is in CO2. The result is that bonding electrons are more likely to be found at the oxygen end of the molecule than at hydrogen end. Bonds with positive and nigative ends are called dipoles.

Non covalent interaction

They are reversible and relatively weak.

The new that we have to now:
These interactions can also occur between partially charges.

الدكتورة ديالا وضّحت: بالعادة ويلي بنعرفهم، إنه ايون موجب يتجاذب مع أيون سالب، بس برضه ممكن يكون التفاعل بين شحنات جزيئية.

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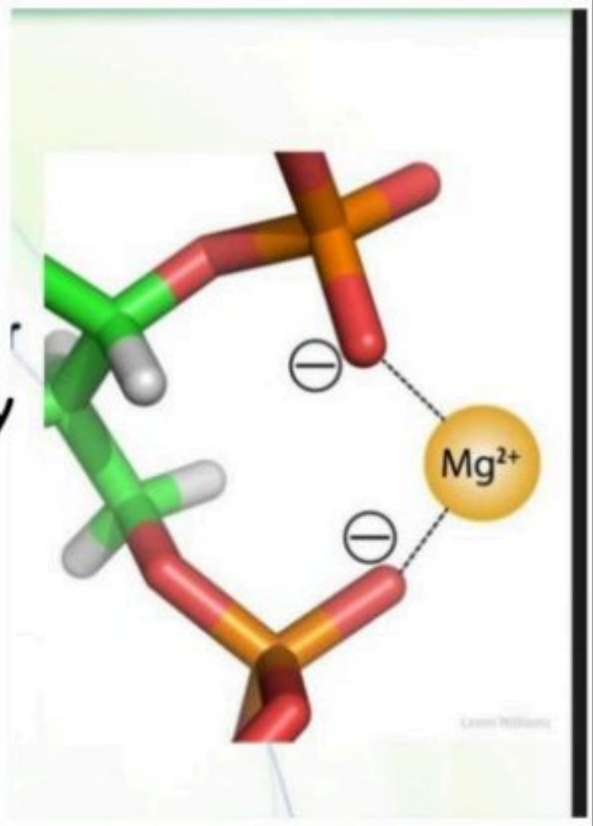
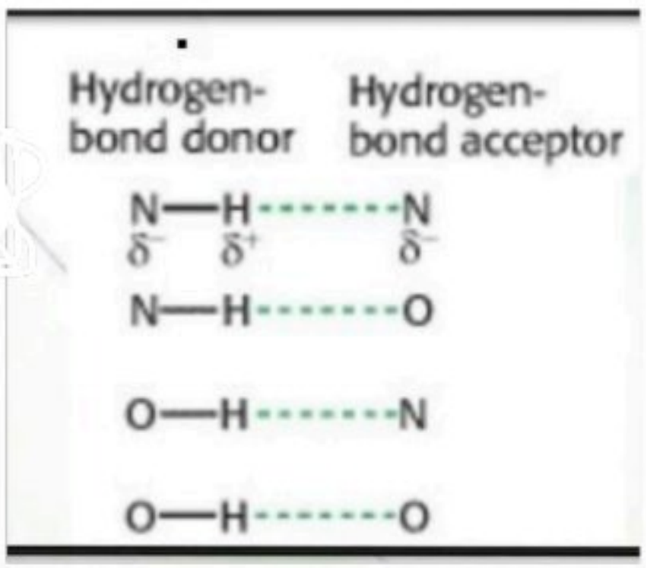
There are different types of non-covalent interactions:



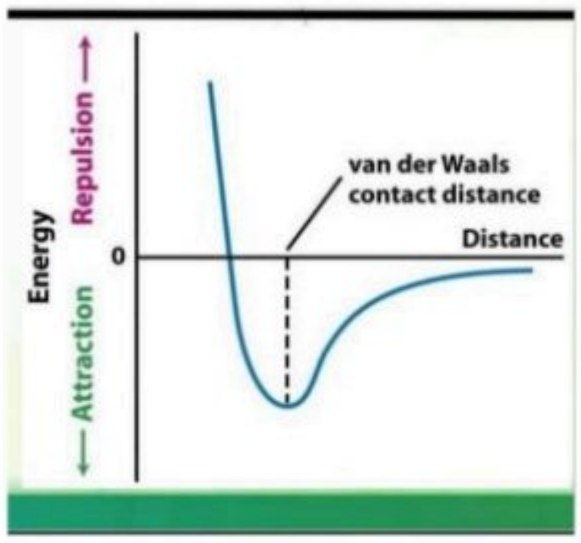
1. Electrostatic interactions (charge-charge interactions).
*called Ionic interactions.
1.They are interactions between charged particles whether they have full or partial charge, different charges attract while similar charges repel.
2.These forces are quite strong in the absence of water.

2.Hydrogen bonds
A hydrogen atom is partly shared between two relatively electronegative atoms (a donor and an acceptor).



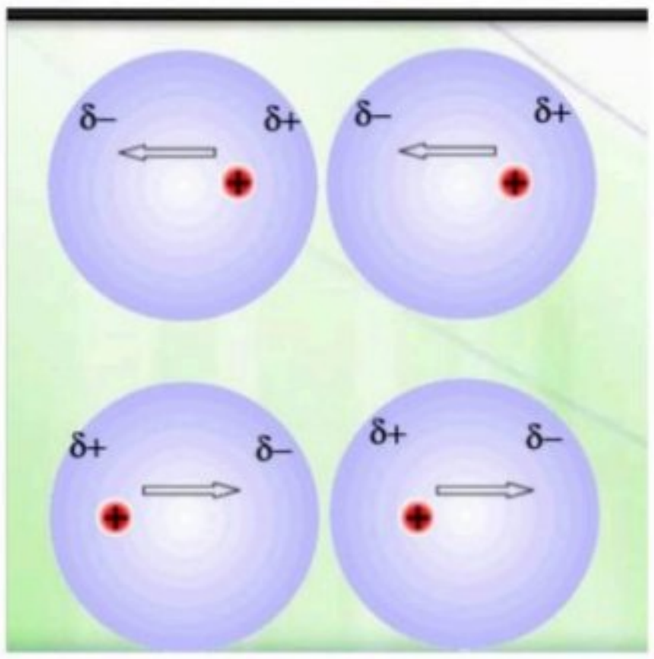
It has to have an hydrogen atom with a partially positive Charge.
It is a *hydrogen* bond, of course it has to have an H with another atoms(N,O,F).

3.van der Waals interactions
*Unequal distribution of electronic charge around an atom changes with time.
*The strength of the attraction is affected with distance.



When we increase the atomic number the van der waals strength increase.

Electrons move around nucleus an unequal movement, according to its movement it makes partially nigative charge, leaving other sites with partially positive charge.
Partially nigative charge with partially povsitive charge from another molecule make van der waal interaction



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That is how van der waal

Interactions between nonpolar molecules themselves are very weak and depend on the attraction between short-lived temporary dipoles and the dipoles they induce. A large sample of nonpolar molecules will always include some molecules with these temporary dipoles, which are caused by a momentary clumping of bonding electrons at one end of the molecule. A temporary dipole can induce another dipole in a neighboring molecule in the same way that a permanent dipole does. The interaction energy is low because the association is so short-lived. It is called a van der Waals interaction (also referred to as a van der Waals bond). The arrangement of molecules in cells strongly depends on the molecules' polarity, as we saw with micelles.

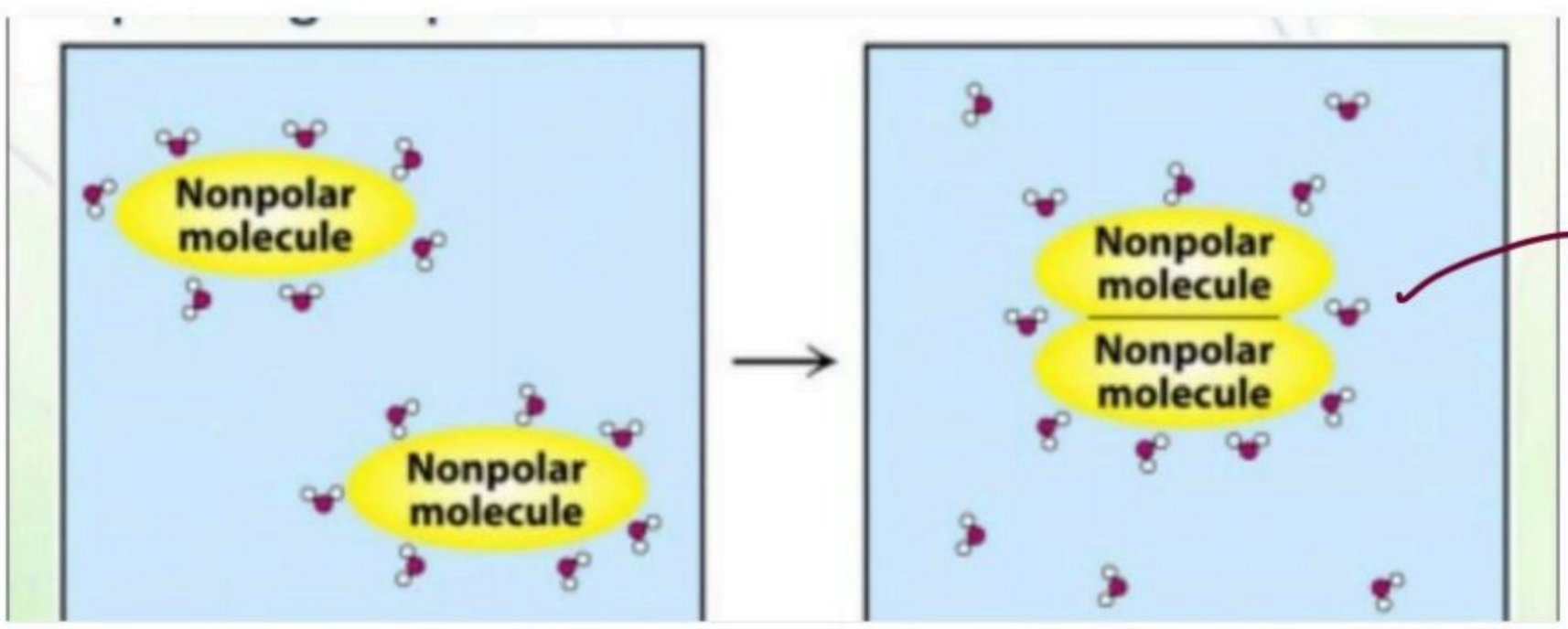
Hydrophobic interactions

*Not true interactions.

There is a bond energy so the bond is physical not chemical.

*Self-association of nonpolar compounds in an aqueous environment

*Minimize unfavorable interactions between nonpolar groups and water.



less water molecule here.

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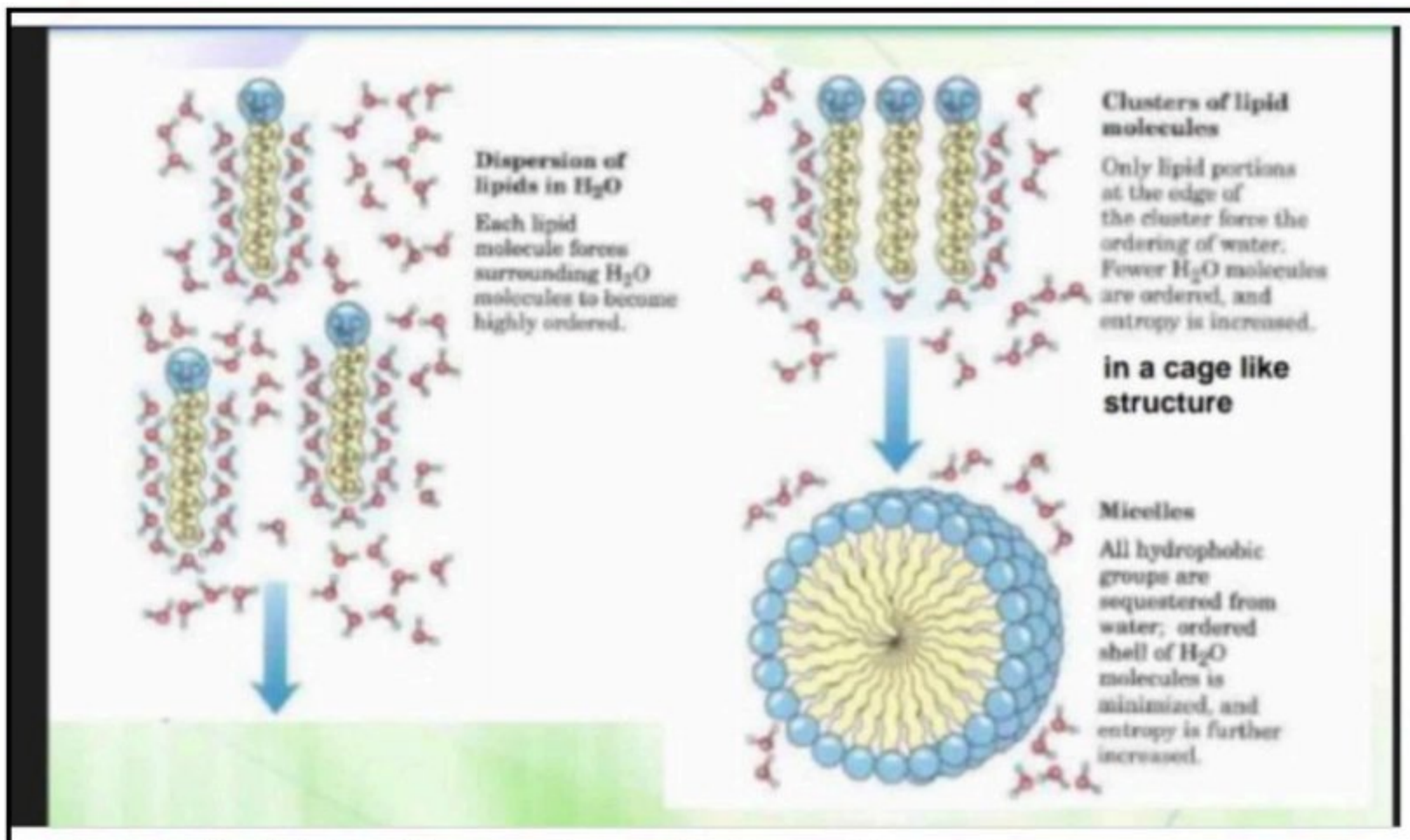

Hydrophobic interactions and micelle formation:

*Recall: amphipathic molecules are molecules containing both polar and non-polar parts in its structure.

-When mixing amphipathic and water molecules, water molecules will try to form interactions around each of these amphipathic molecules but this reaction is unstable due to the presence of the hydrophobic tails.

-The hydrophobic interactions would aggregate/accumulate these molecules and get them in line next to each other as you can see in the picture

*Blue part from the outside(polar region) and yellow part from the inside(nonpolar region)

-The interactions between hydrophobic part and water become less but are still present the sides and the bottom, thus cluster remains unstable.

-So, for a complete isolation of the hydrophobic part of these molecules from the aqueous environment, molecules will form a bowl or a cage like structure called micelle

-This structure is stable, as Water molecules can now surround the polar part of the micelle structure and form hydrogen bonds whereas hydrophobic tails are hidden in the core of micelle, away from water molecules.

Properties of non covalent Interactions:

*Reversible

*Relatively weak. 1-30 kj/mole vs. 350 kj/mole in C—C bond

*Molecules interact and bind specifically.

- Noncovalent forces significantly contribute to the structure, stability, and functional competence of macromolecules in living cells.

*Can be either attractive or repulsive

*Involve interactions both within the biomolecule and between it and the water of the surrounding enviroment.

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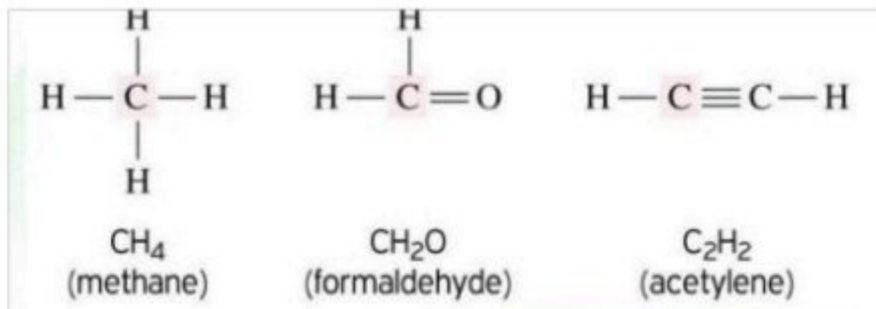
Carbon

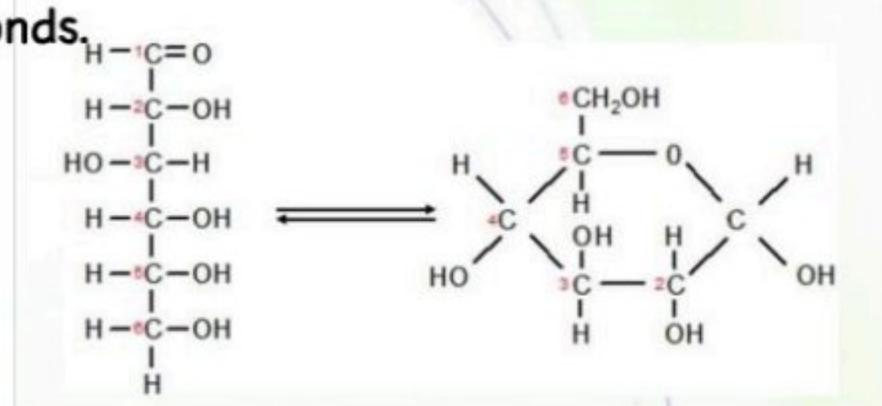
The road to diversity and stability.😈

Properties of carbon:



*It can form four bonds, which can be single, double, or triple bonds.

Dr. Nafez said: it can do quadrant bonds.

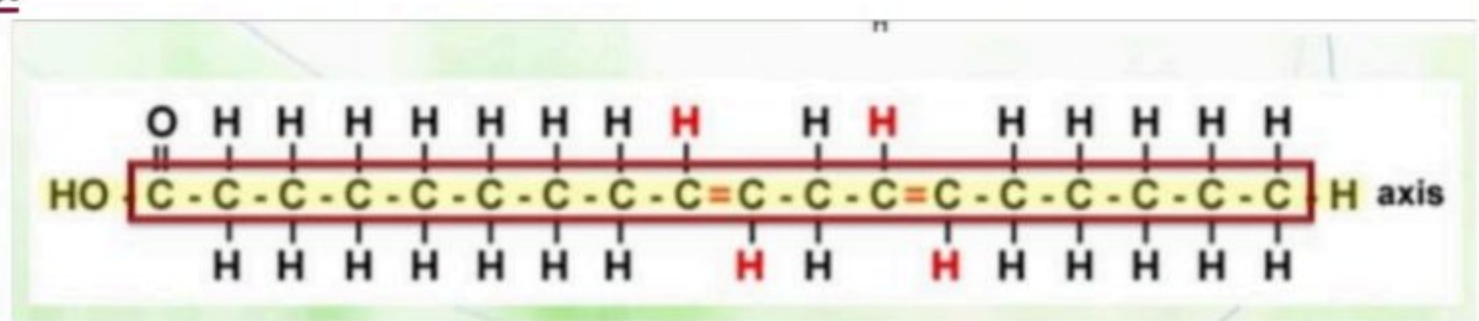


*Each bond is very stable.

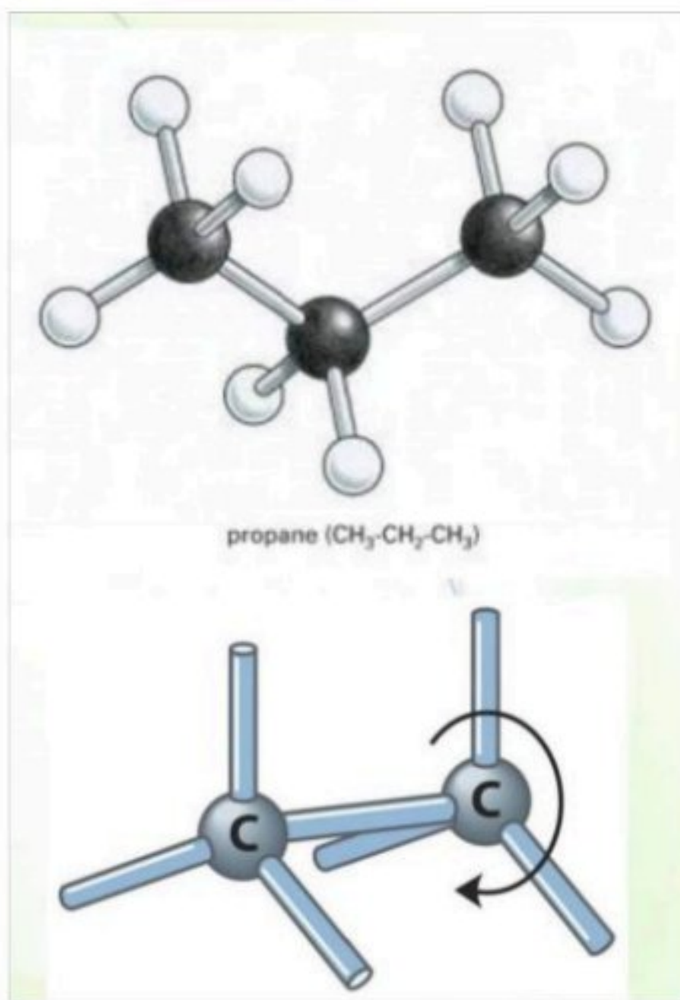
-strength of bonds: triple > double > Single)

*They link C atoms together in chains and rings.

-These serve as a backbones.



*Carbon bonds have angles giving molecules three- dimensional structure.



*In a carbon backbone, some carbon atoms rotate around a single covalent bond producing molecules of different shapes.

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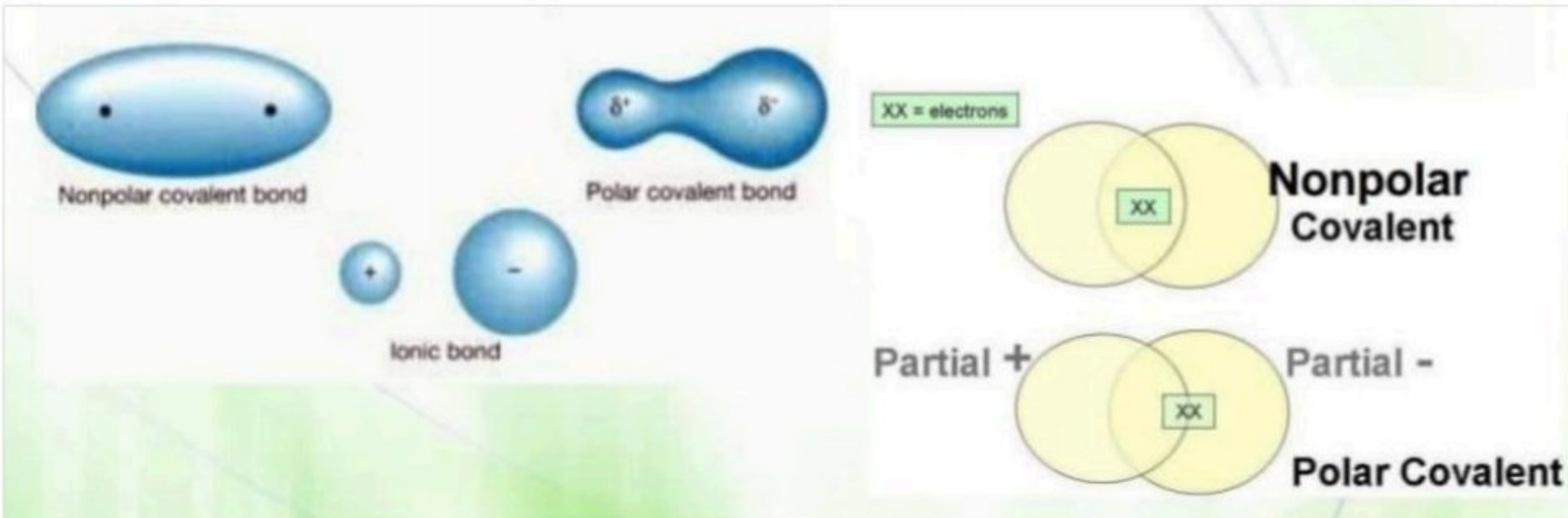
*The electronegativity of carbon is between other atoms.
It can form polar and non-polar molecules.

*Pure carbon is not water soluble, but when carbon forms covalent bonds with other elements like O or N, the molecule that makes carbon compounds to be soluble.



الجداول هاي الدكاترة التنين حكوا إنه نحنا مطالبين فيهم، مش رح يسألوا عنهم بطريقة مباشرة، بس كتير مهم نكون عارفينهم.

Functional groups (Groups of atoms attached to a carbon skeleton)

Class of Compound	General Structure[a]	Functional Group Structure	Functional Group Name	Example
Alkane	RCH_2-CH_3	$-\overset{\vert}{C}-\overset{\vert}{C}-$ (H H)	Carbon–carbon and carbon–hydrogen single bonds	H_3C-CH_3
Alkene	$RCH{=}CH_2$	$>C{=}C<$	Carbon–carbon double bond	$H_2C{=}CH_2$
Alcohol	ROH	$-OH$	Hydroxyl group	CH_3OH
Thiol	RSH	$-SH$	Thiol or sulfhydryl group	CH_3SH
Ether	$R-O-R$	$-O-$	Ether group	CH_3-O-CH_3
Amine[b]	RNH_2, R_2NH, R_3N	$-N<$	Amino group	H_3C-NH_2
Imine[b]	$R{=}NH$	$>C{=}N-H$	Imino group	$(H_3C)_2C{=}NH$
Aldehyde	$R-\overset{O}{\overset{\Vert}{C}}-H$	$-\overset{O}{\overset{\Vert}{C}}-H$	Carbonyl group	$CH_3\overset{O}{\overset{\Vert}{C}}H$
Ketone	$R-\overset{O}{\overset{\Vert}{C}}-R$	$-\overset{O}{\overset{\Vert}{C}}-$	Carbonyl group	$CH_3\overset{O}{\overset{\Vert}{C}}CH_3$
Carboxylic acid[b]	$R-COOH$	$-\overset{O}{\overset{\Vert}{C}}-OH$	Carboxyl group	$CH_3\overset{O}{\overset{\Vert}{C}}OH$

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Ester	$R-C(=O)-OR$	$-C(=O)-OR$	Ester group	$CH_3C(=O)-OCH_3$
Amide	$R-C(=O)-NH_2$	$-C(=O)-N(H)H$	Amide group	$CH_3C(=O)-NH_2$
Phosphoric acid[b]	$HO-P(=O)(OH)-OH$	$HO-P(=O)(OH)-OH$	Phosphoric acid group	$HO-P(=O)(OH)-OH$
Phosphoric acid ester[b]	$R-O-P(=O)(OH)-OH$	$-O-P(=O)(OH)-OH$	Phosphoester group or phosphoryl group	$CH_3OP(=O)(OH)-OH$
Phosphoric acid anhydride[b]	$R-O-P(=O)(OH)-O-P(=O)(OH)-OH$	$-O-P(=O)(OH)-O-P(=O)(OH)-OH$	Phosphoric anhydride group	$CH_3O-P(=O)(OH)-O-P(=O)(OH)-OH$
Carboxylic acid–phosphoric acid mixed anhydride[b]	$R-C(=O)-O-P(=O)(OH)-OH$	$-C(=O)-O-P(=O)(OH)-OH$	Acyl-phosphoryl anhydride	$CH_3C(=O)-O-P(=O)(OH)-OH$

[a] R refers to any carbon-containing group.
[b] These molecules are acids or bases and are able to donate or accept protons under physiological conditions. They may be

Water

*Why water is important to our bodies?

1. ~60% of our body is water, 70-85% of the weight of a typical cell
2. A solvent of many substances our bodies need such as *glucose, *ions, etc.
3. Acts as a medium in which acids and bases release their chemical groups to maintain a constant cellular environment or homeostasis.
4. Essential buffer that maintain pH
5. Temperature regulation- high specific heat capacity.
The heat that is required to change its heat is high.
6. A participant in many biochemical reactions.

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Water distribution in body compartments:

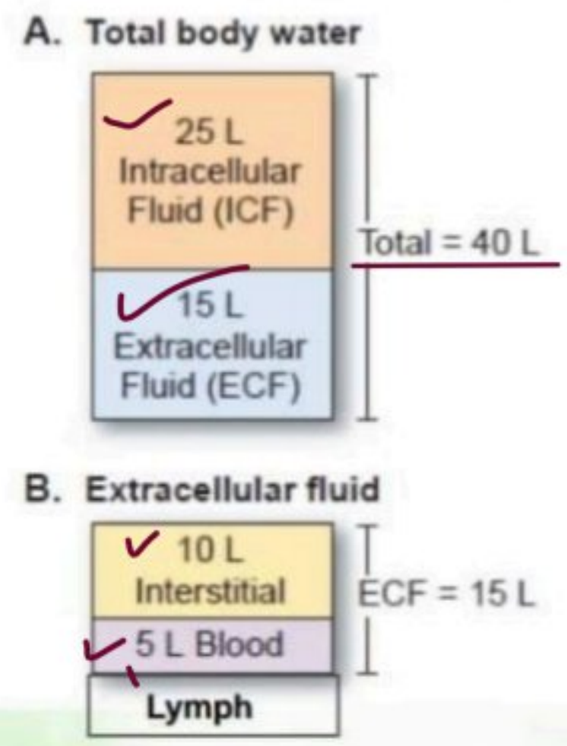
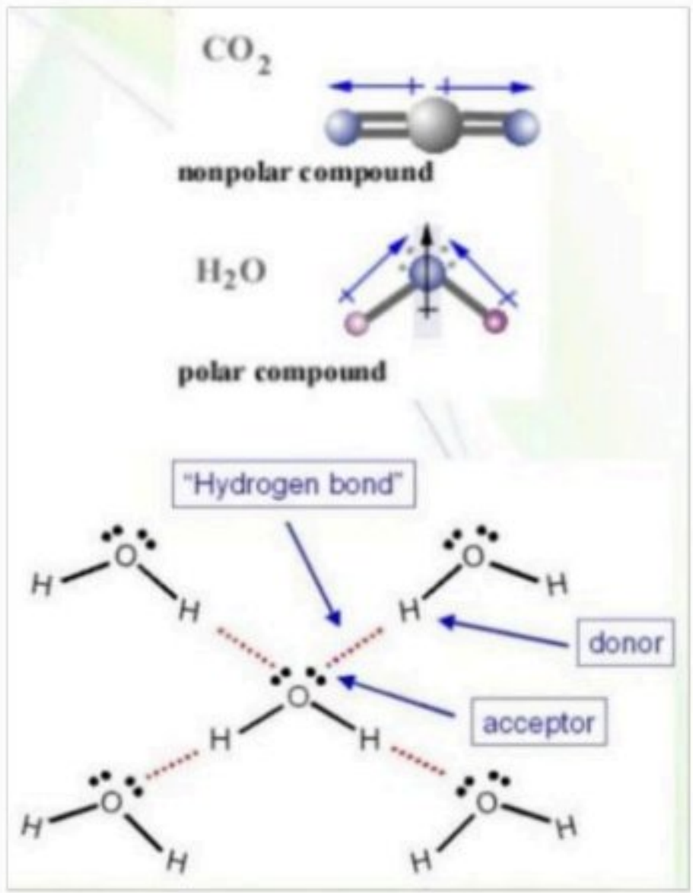


FIG. 4.2. Fluid compartments in the body based on an average 70-kg man.

Properties of water:

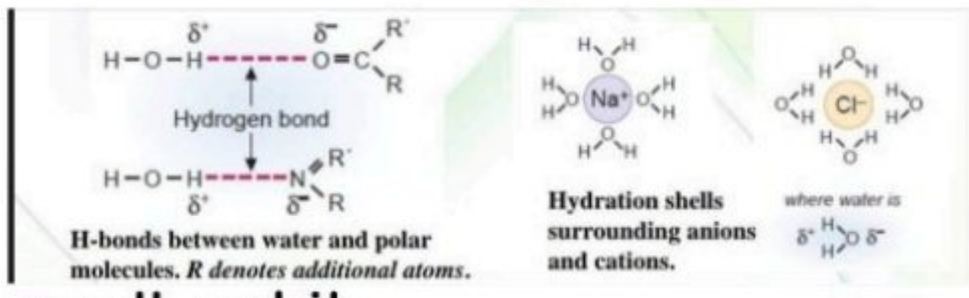
*Water is a polar molecule as a whole because of:

-the different electronegativitiy between Hydrogen and oxygen,
-It is angular.

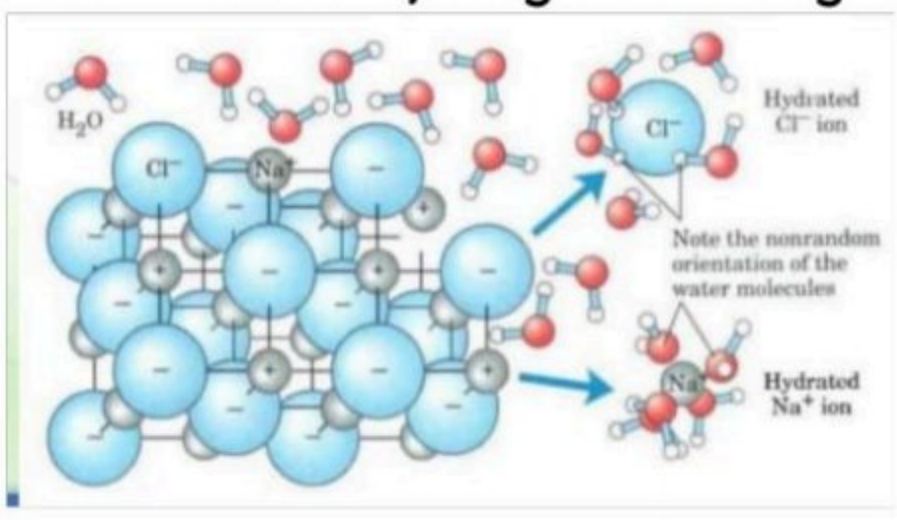


*Water is highly cohesive.

*Water molecules produce a network.



*Water is an excellent solvent because It is small and it weakens electrostatic forces and hydrogen bonding between polar molecules.



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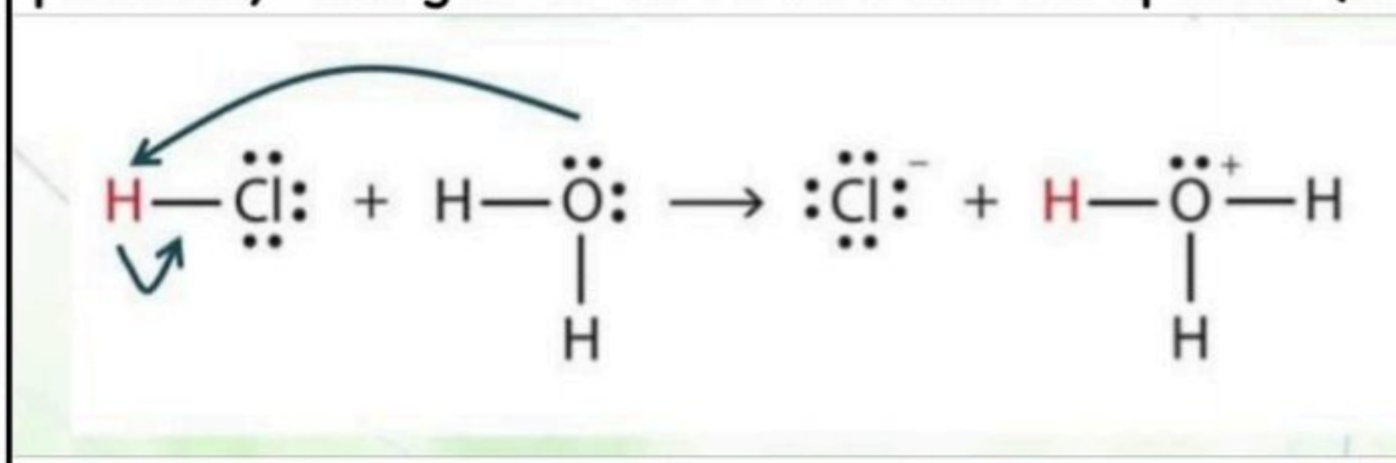
*It is reactive because it is a nucleophile.
A nucleophile is an electron-rich molecule that is attracted to positively-charged or electron-deficient species (electrophiles).



*Water molecules are ionized to become a positively- charged hydronium ion (or proton), and a hydroxide ion:
At the end that reaction will raech an eqalibrium, that is because is a stability.

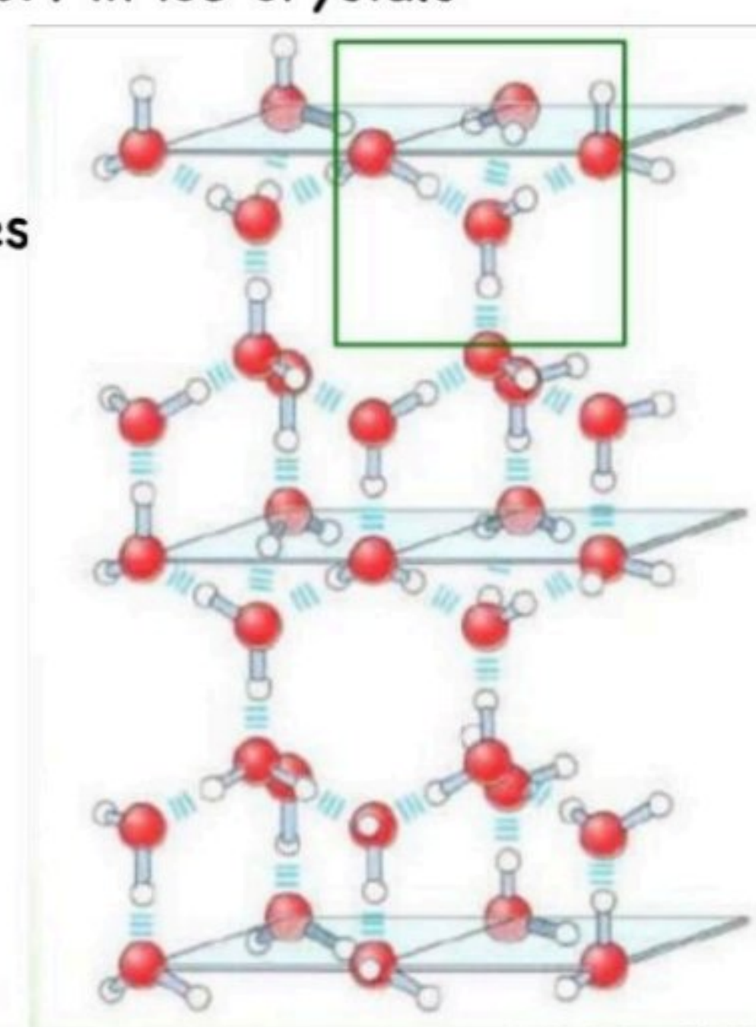
$$H_2O + H_2O \rightleftharpoons H_3O^{\oplus} + OH^{\ominus}$$

Net energy= Zero

Hydrogen Bonds (H-bonds) between Water Molecules
H-bond is stronger if
X—H.....A
A is O, N or F
X is O, N or F

-Average number of H-bond in liquid water at 10oC is 3.4 in ice crystals is 4

-Number of H-bonds decrease with higher temperatures



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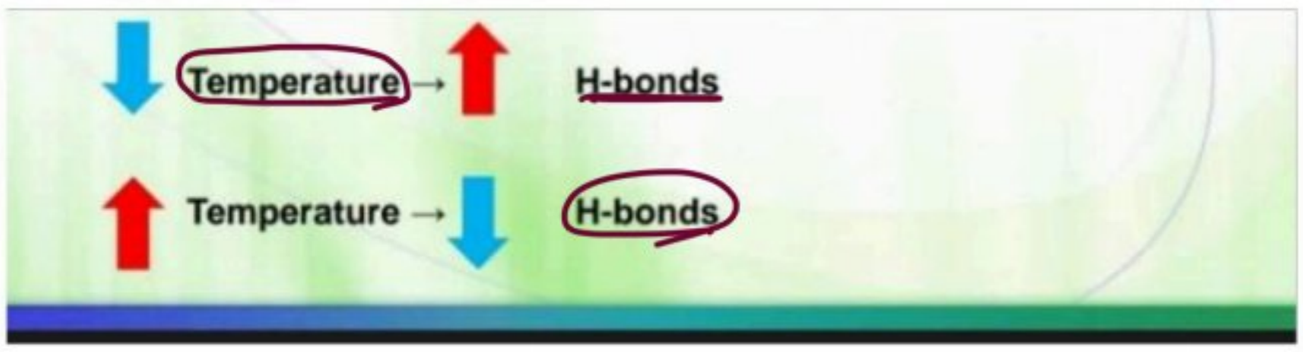
Water and Thermal Regulation

Water structure resists sudden and large temperature changes because:

High thermal conductivity thus, facilitates heat dissipation from high energy consumption areas into the body water pool.

High heat of fusion, so a large drop in temperature is needed to convert liquid water to ice.

High heat capacity and heat of vaporization; when liquid water sweating is converted to a gas and evaporates from the skin, we feel a cooling effect.



صيفي موّفق جدًا❤️

Good luck.

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