# CHM 103

## ORGANIC CHEMSTRY I

Department of Chemical Sciences
Faculty of Science and Technology
Bingham University, Karu

**Course Lecturer: Joseph C. Oguegbulu**

**Joseph.oguegbulu@binghamuni.edu.ng**

# COURSE CONTENT

**PART A – Mr. Joseph**

- Introduction. History, classifications 0.5 week
- Carbon: Bonding in organic compounds, structure 0.5 week
- Functional groups 0.5 week
- IUPAC nomenclature 1 week
- Isomerism – Structural & Stereo-isomerism 2 weeks
- Hybridisation – Resonance effects & others 2 weeks

**PART B – Assoc. Prof. Okoli**

- Alkanes, Alkenes, Alkynes
- Alkyl halides, Alkanols
- Carbonyl compounds: Alkanals and Alkanones.

# LECTURE I

- INTRODUCTION/GENERAL INFORMATION
- BACKGROUND
- COURSE CONTENT
- HISTORICAL PERSPECTIVE
- FLASHBACK: SOME BASIC CONCEPTS

# ORG. CHEM.: A HISTORICAL PERSPECTIVE

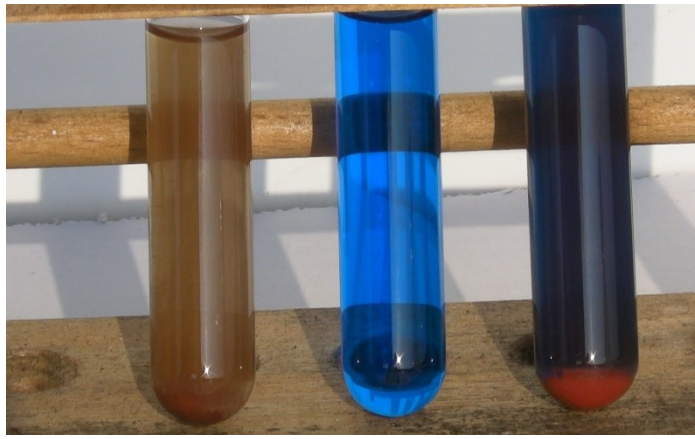
If CHM 101A is **PHYSICAL** CHEMISTRY, why do we do CHM 103???

Why is Organic Chemistry studied?

# A HISTORICAL PERSPECTIVE: Vitality

- Historically, substances that exist in biological systems such as **blood, sweat, urine, cholorophyl, rubber, semen,** etc were thought to be different from 'test tube compounds'

- They were regarded as possessing a **"Vital Force"**
- This was regarded as the *"Theory of VITALITY"*
  - They could not be synthesised from inorganic components
- But this was not true!!!

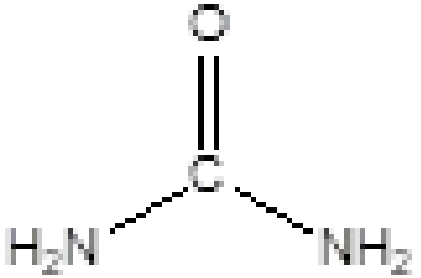


# THEORY OF VITALITY DEBUNKED

- This idea was held until the 19th century (i.e. 1800s)

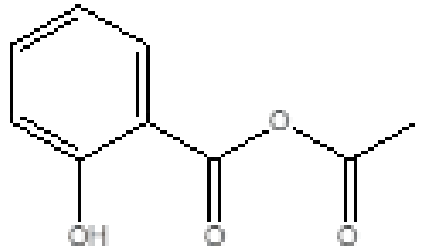
**UNTIL THE FOLLOWING HAPPENED**

- Synthesis of carbamide (urea) (*Friedrich Wholer1828)*
  - $NH4^+$ + $^-OCN$ ---------> **$H_2N$-CO-$NH_2$ (Urea)**
- Making of **soaps** from fats&oils (*Michel Chevereul* 1816)



urea
(Carbamide)

- Synthesis of Perkin's mauve (*Willian Perkins* 1856).
- Manufacture of **aspirin** (acetyl salicylate) (1899)



acetyl salicylate
(Aspirin)

# ORGANIC CHEMISTRY: Introduction

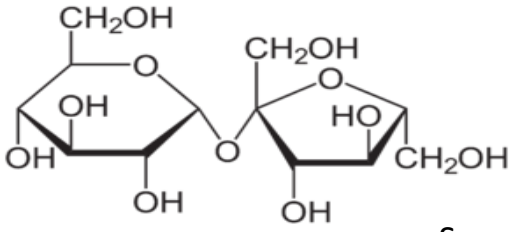
- Today Organic chemistry is better understood
- Org. Chem. is “The chemistry/study of carbon (C) and its compounds”
  - Also called “Chemistry of Life”
  - **Reason:** Lots of compounds found in biological systems are studied
- Every organic compound contains carbon
- However, not all compounds containing carbon are ‘Organic’ e.g. $CO_2$, $HCO_3$ etc.

# ORGANIC CHEMISTRY: Introduction

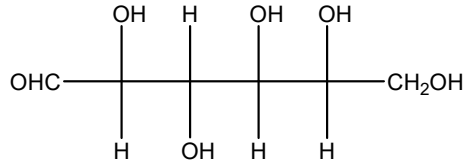
- Organic Chemistry Studies…
  - Hydrocarbons
  - Biomolecules
  - Organometallics
  - Petrochemicals
  - Natural products, etc

# BIOMOLECULES

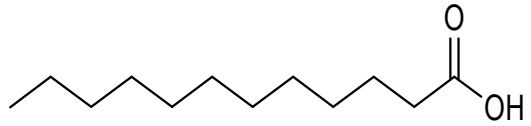
- There are FOUR (4) classes of biomolecules
  - **Carbohydrates** (Glucose, sucrose, starch, chitin)
  - **Proteins**(Enzymes, receptors, antibodies, skin, hair)
  - **Lipids** (Fats, oils, phospholipids, steroids)
  - **Nucleic acids** (RNA, DNA)



Sucrose



2,3,4,5,6-pentahydroxyhexanal
(D-Glucose)



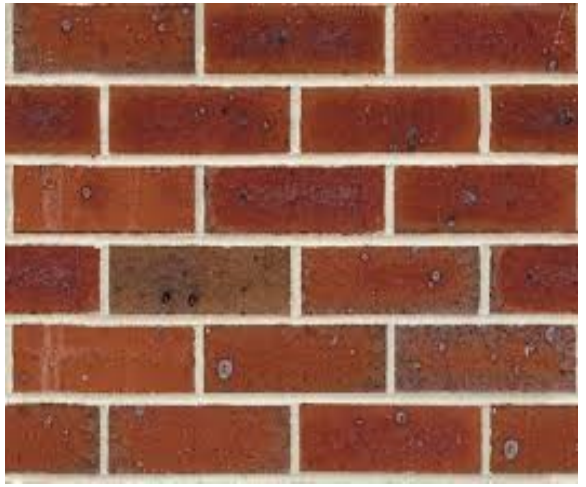
A Lipid

# BIOMOLECULES

- They are macromolecules (very large molecules) found in nature and biological systems

Monomer

- Sometimes called Biopolymers when made up of monomer units
  - Proteins <== amino acids
  - Cabohydrates (sugars) <== monosacharides
  - Nucleic acids <== single DNA, RNA units
  - Lipids <== NOT POLYMERS

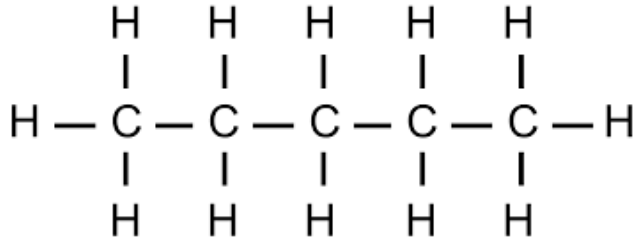


Polymer

# WHY IS CARBON SO SPECIAL

- **Catenation:** Ability to form long carbon to carbon chains. C-C-C-C-C-C-C. Have you ever seen N-N-N-N-N- or O-O-O-O-O? **NO**
- **Strength of the Carbon to Carbon bond**
  - C-C = 350 KJ/mol, N-N =160 KJ/mol, O-O = 150 KJ/mol
- **Ability to fully utilise its valence electrons**
  - Valence electrons are outermost electrons
  - E.g. O has 6, but uses 2, N has 5, uses 3, C has 4, uses 4
- **Different Degrees of Unsaturation**; C-C (Saturated);

C=C and C≡C (unsaturated)

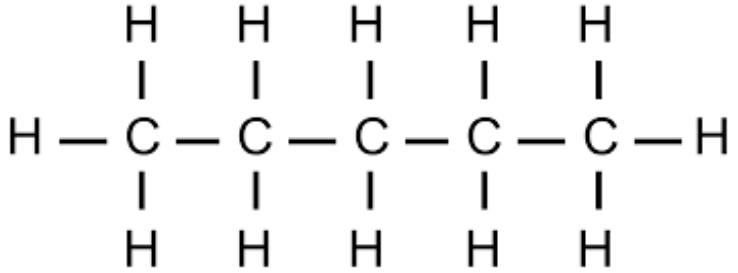


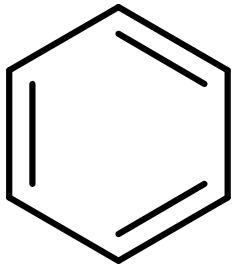
# QUESTIONS???

# CLASSIFICATION OF ORGANIC COMPOUNDS

Organic compounds can be generally classified as…

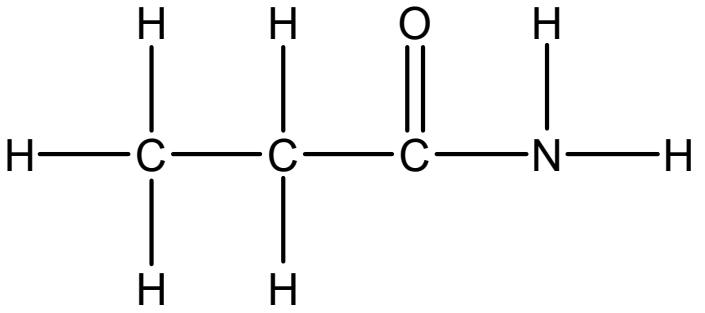
- **HYDROCARBONS &**
- **NON- HDROCARBONS**





Hydrocarbons: Containing only C and H

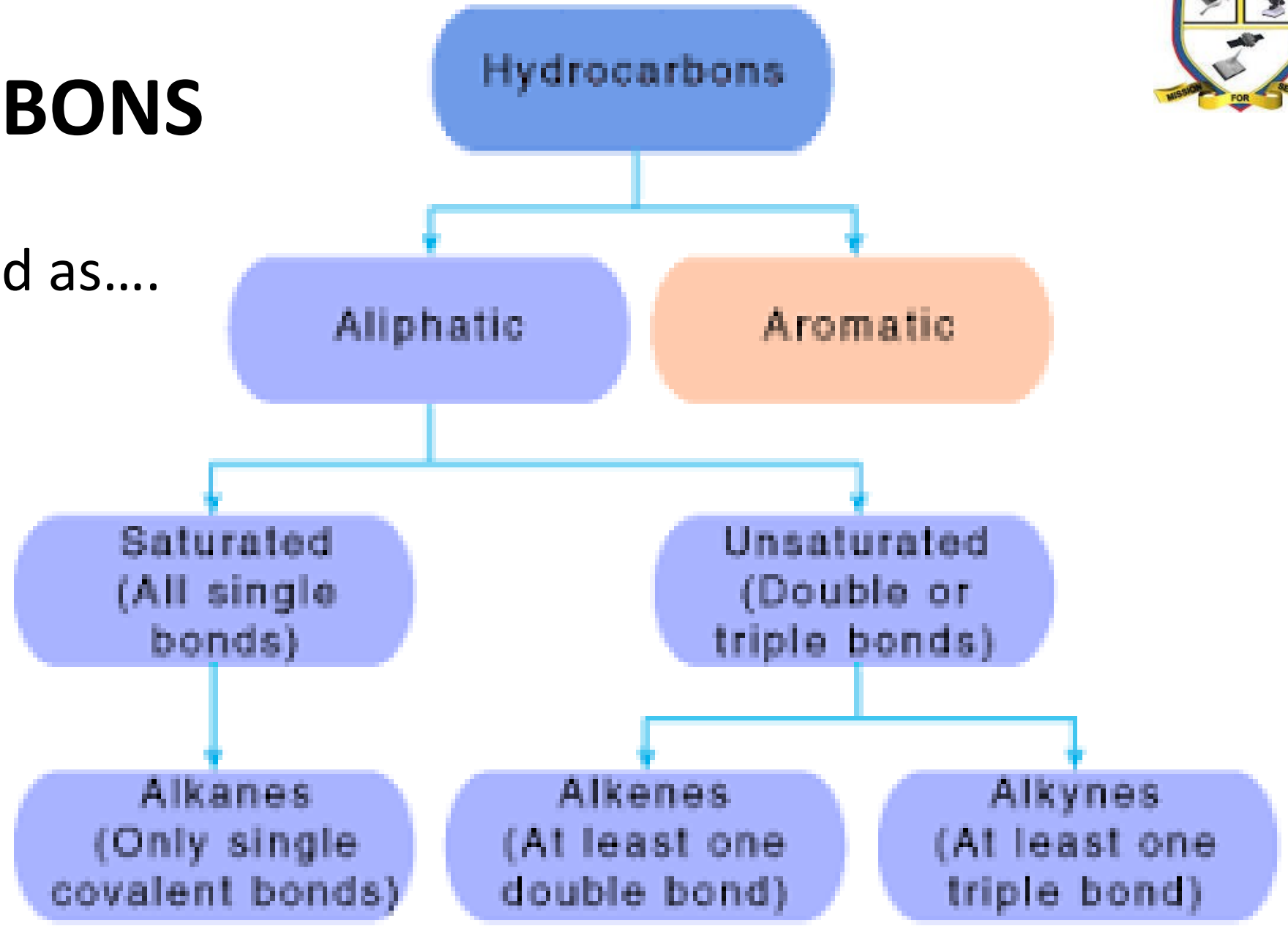
Non-Hydrocarbons: Any organic compounds containing N, O, S, Cl, Br, F, *(heteroatoms)*



# HYDROCARBONS

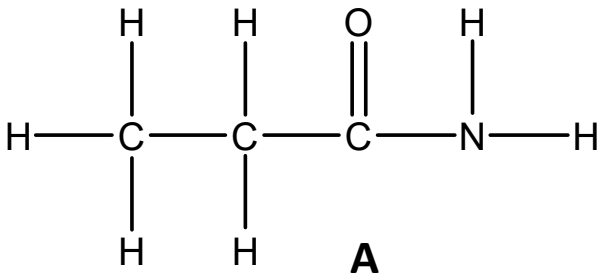
Broadly classified as….

- **ALIPHATIC**
- **AROMATIC**

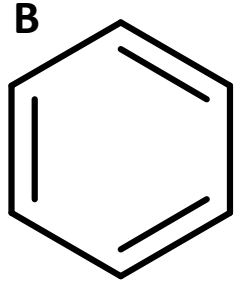


# TUTORIAL II: Classification of Org Cmpds

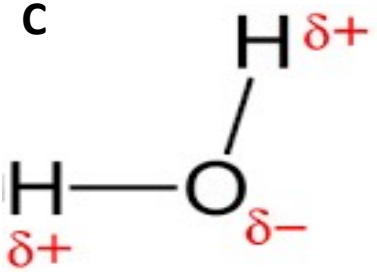
- **Q4:** How would you classify the following compounds?



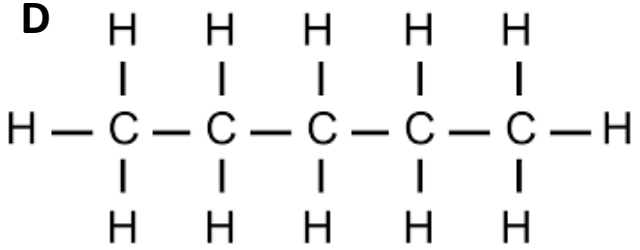

A



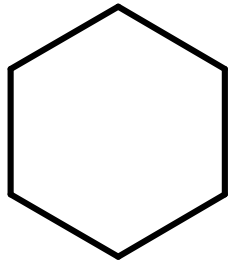
B



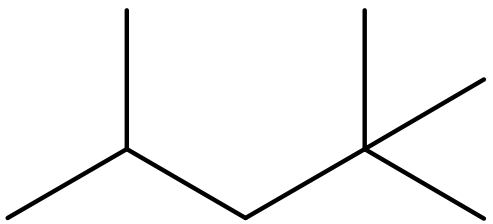

C



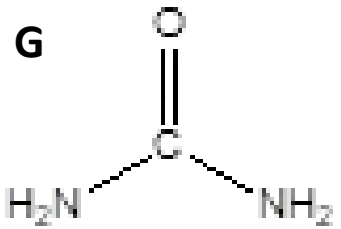

D



E

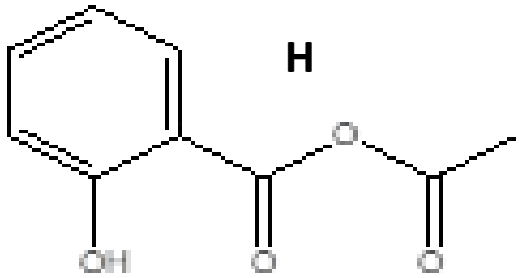


F



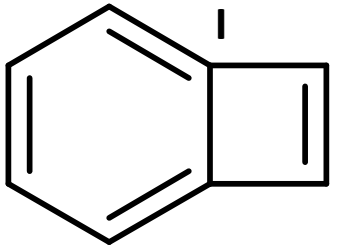

G

urea
(Carbamide)




H

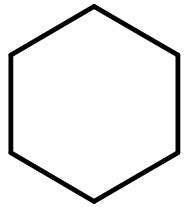
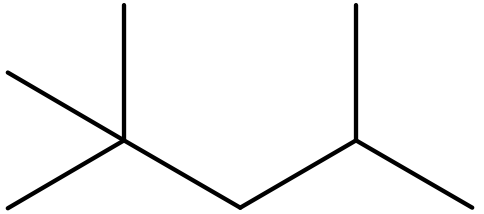
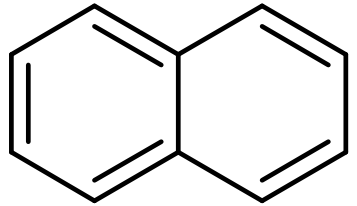
acetyl salicylate
(Aspirin)



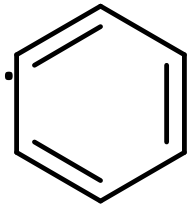
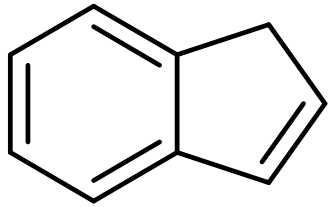
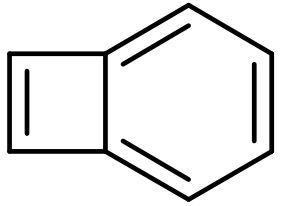
I

# WHAT MAKES A COMPOUND AROMATIC?

- Compound must be ***cyclic***

- Compound must have a ***system of conjugated double bonds***
  - Double-single-double-single-double-single…

- Compound must obey ***Huckel's rule***
  - i.e. The number of pi-electrons in the molecule must = **4n + 2**
  - Where 'n' is any integer, 1,2,3,4,5,6……
  - Simply put; **aromatic cmpds have 6 or 10 or 14 or 18…etc. pi - $e^-$**

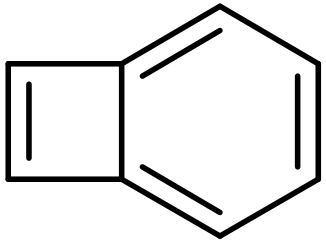
- *The atoms must be co-planar: i.e. must be on one plane*

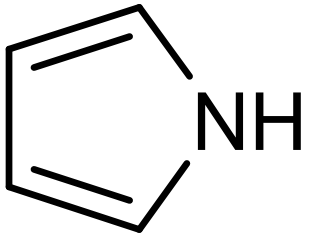
# QUESTIONS???

# CONDITIONS FOR AROMATICITY

**Q5**

- **Which of these compounds would NOT be aromatic?**
- **Give reasons**





# FLASHBACK

Refresh your memory…

- Element, atom, molecule, ion
- Neutrons, protons, electrons
- Atomic number, mass number
- Bonding
- Functional groups
- etc


Questio

# CHM 103

## ORGANIC CHEMSTRY I

Department of Chemical Sciences
Faculty of Science and Technology
Bingham University, Karu

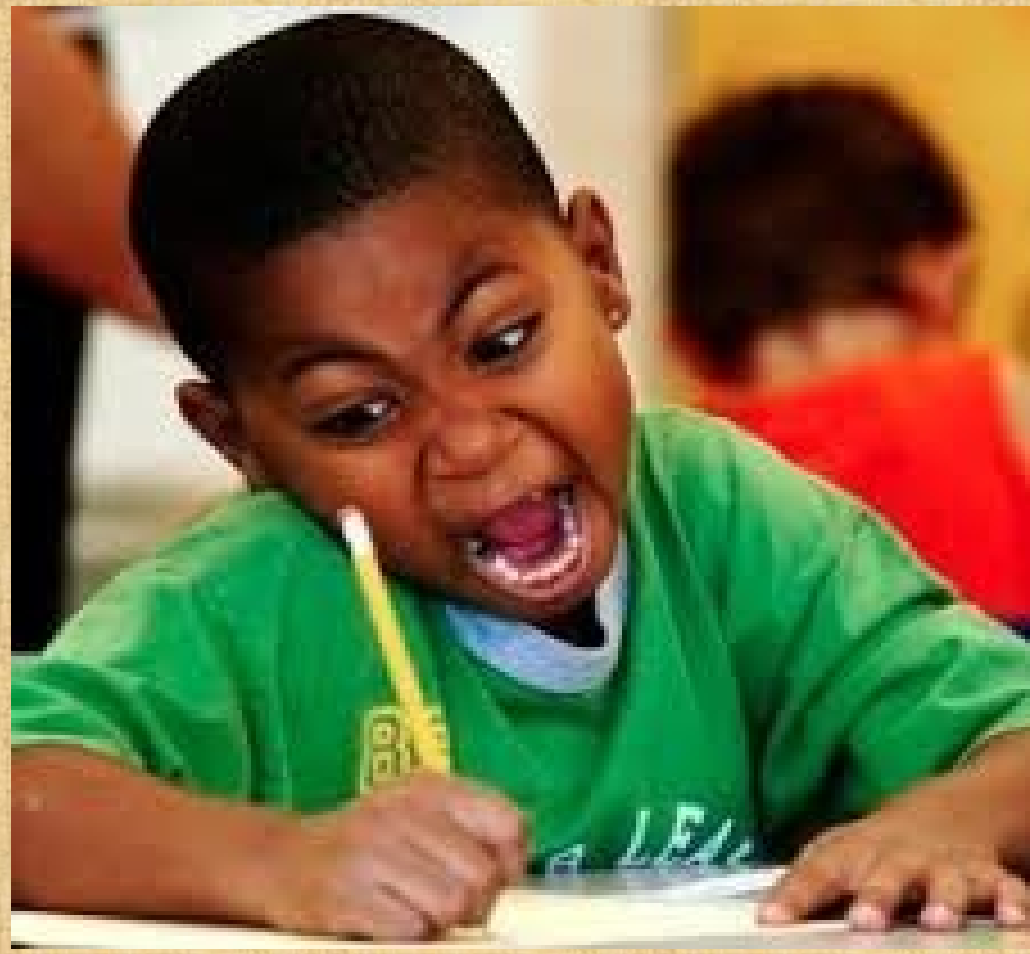
**Course Lecturer: Joseph C. Oguegbulu**
**joseph.oguegbulu@binghamuni.edu.ng**

# LECTURE III

- BONDING IN ORGANIC MOLECULES
  - IONIC
  - COVALENT
    - POLAR COVALENT BONDING
  - SOME INTERMOLECULAR BONDING
    - PARTICULARLY HYDROGEN BONDING

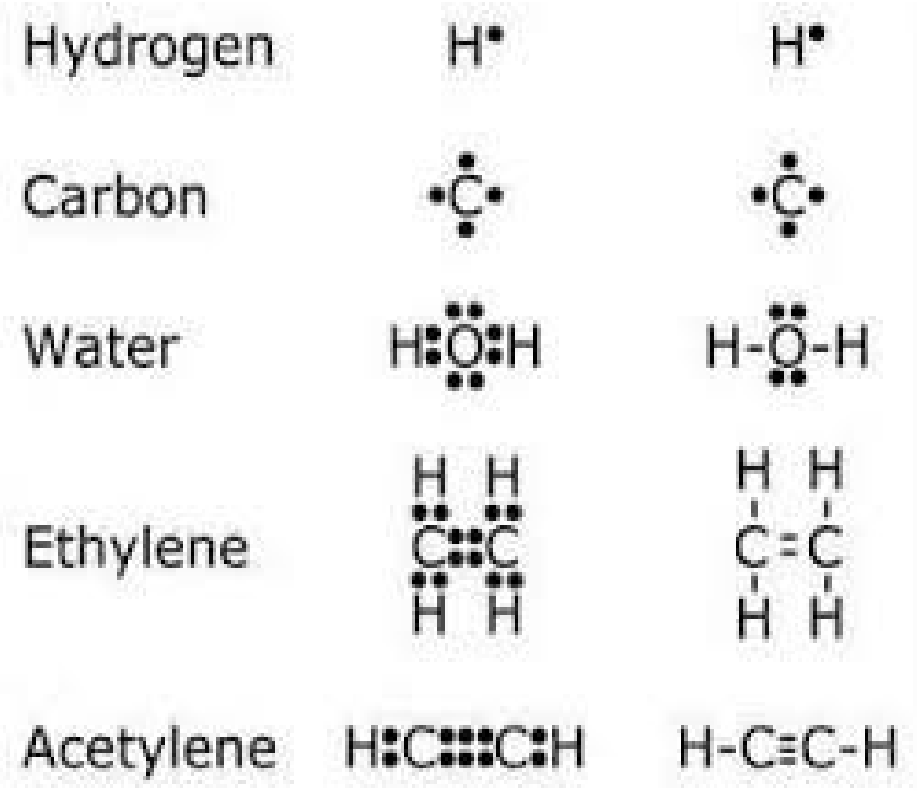
# OBJECTIVES: At the end, you should be able to…

- Explain bonding in organic cmpds
- Differentiate between ionic, covalent and polar covalent bonds
- Differentiate b/w intra-molecular and inter-molecular bonding
- Explain Hydrogen bonding examples



# BONDING IN ORGANIC MOLECULES

- The attractive force between atoms
- Only valence electrons are involved
- Every chemical bond has **2 electrons**
- Valence electron =outermost electrons
- Atoms seek to attain greater stability by reaching an **Octet or duplet**
- Can be Intramolcular **(ionic, covalent)** or Intermolecular **(hydrogen bonding, v.d.w, dipole-dipole, etc)**



# IONIC BONDING

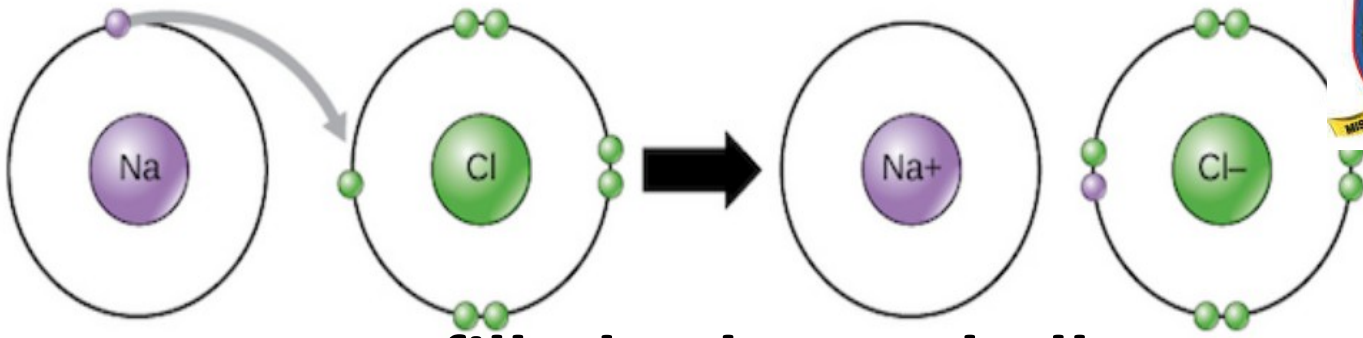
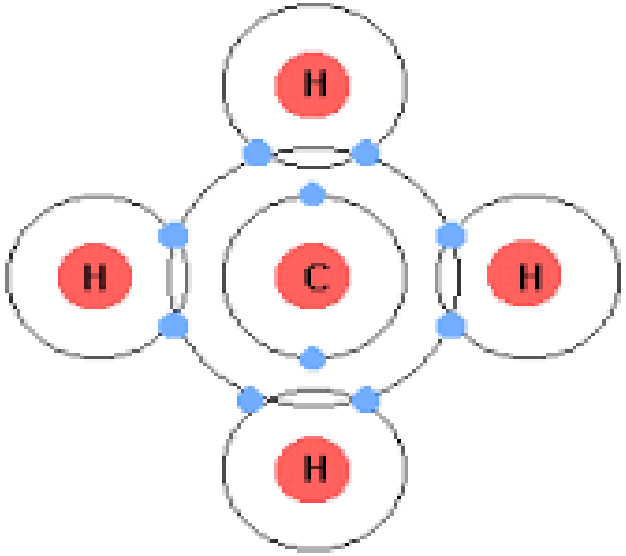


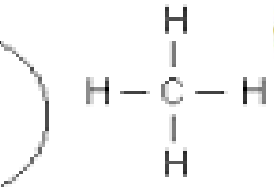

Image credit: OpenStax Biology.

- Electron gain/loss gives an atom a **filled valence shell**
- Hence, atoms become more stable **by gain/loss of electrons**
- When they do so, **ions are formed** (cations and anions)
- **Ionic bonds** are formed b/w **oppositely charges** ions
- E.g. +vely charged ($Na^+$) & -vely charged chloride ions ($Cl^-$)
  - To make sodium chloride NaCl (table salt)
- All ionic compounds are **Polar**

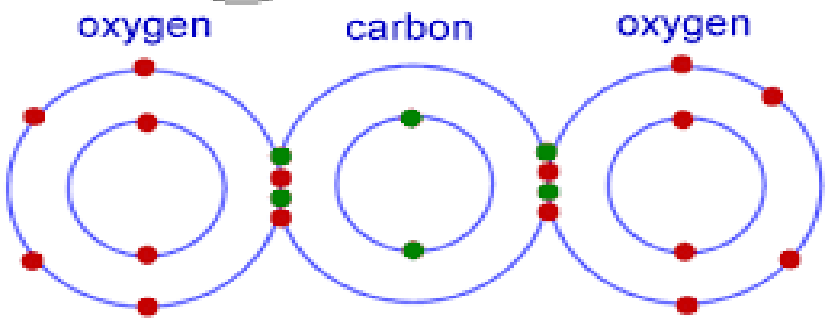
# COVALENT BONDING

- Occurs by electron sharing between atoms of same or different elements
- More common in Organic Chemistry
- B/c carbon mostly bonds covalently
- Two/three e- pairs may be shared between atoms, resulting in single, double, or triple bonds respectively

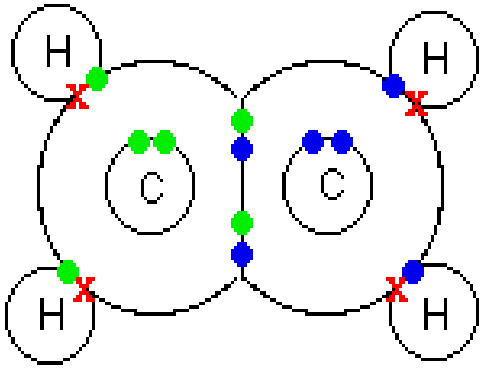


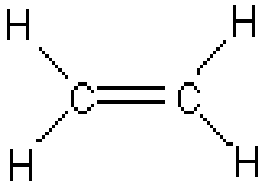

$CH_4$




carbon dioxide $CO_2$




or



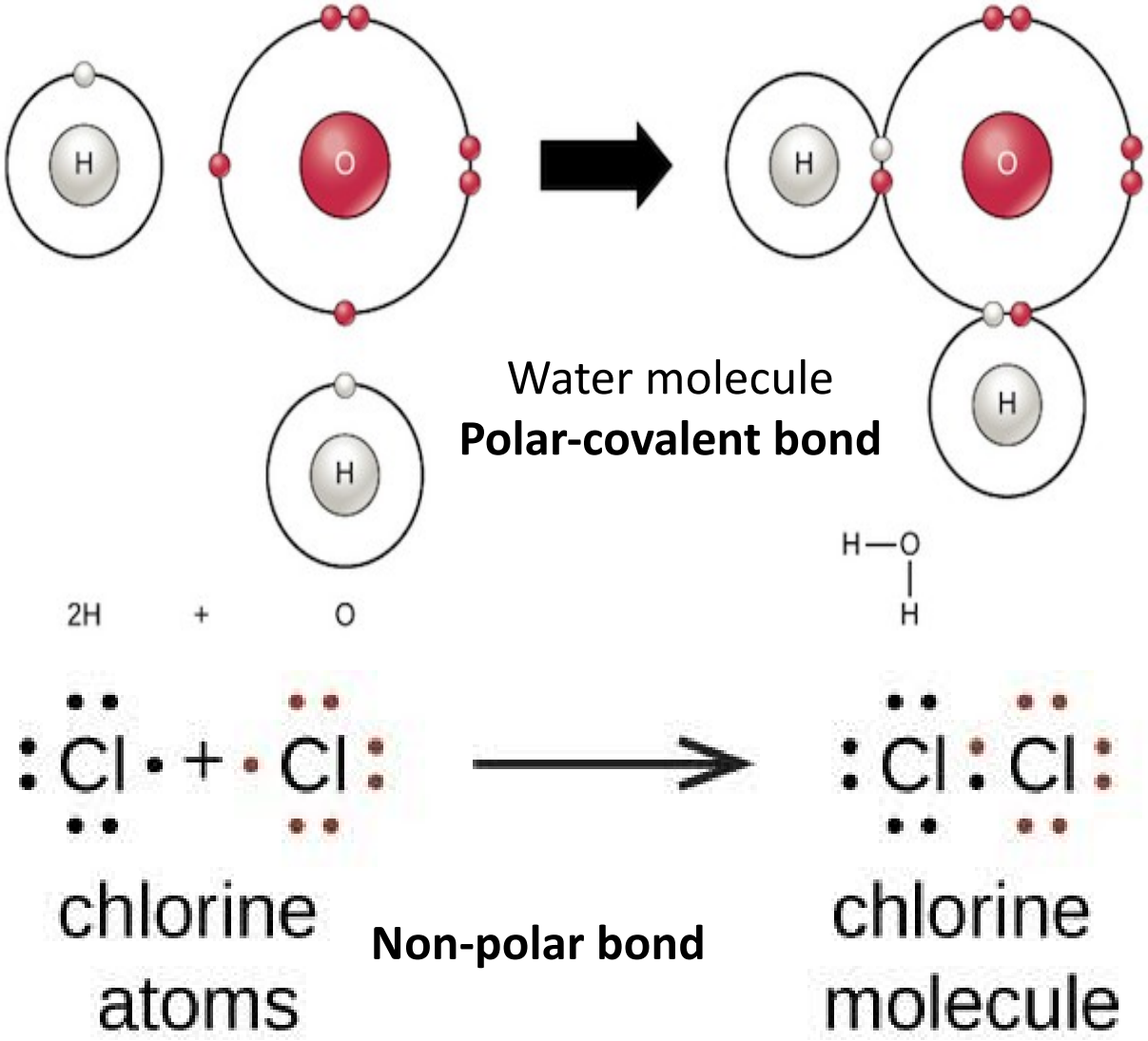

$H_2C=CH_2$

# COVALENT BONDING

- Also found in smaller inorganic molecules e.g. **$H_2O$, $CO_2$, $O_2$ $Cl_2$**

- Covalent Bonds can be…
  - **Polar covalent bonds** or
  - **Non-polar covalent bonds**

- Depending on the two atoms involved



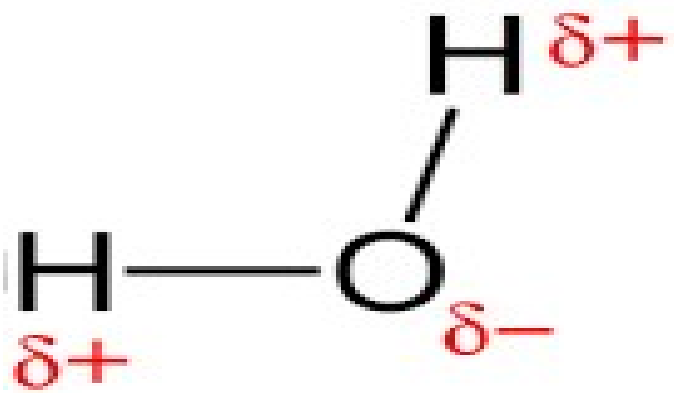
# POLAR COVALENT BONDING

- Covalent bonds can be polar in nature if
  - There's *electronegativity difference* bw 2 covalently bonded atoms

**Q3…What is electronegativity???**

- Think of it as the tendency of an atom to attract electrons
- Groups 5,6,7 ≡ Generally electronegative; Groups1,2,3, = Not
- There's no *electronegativity diff.* b/w **C-C or Cl-Cl or O-O, C-H**
- There's *electronegativity diff.* b/w **C-O, H-O, C-Cl, C-N, etc**

# POLAR COVALENT BONDING




- In Polar covalent bonds, the bond electrons are unequally shared by the two bonded atoms
- The **e**$^-$ spend more time closer to the electronegative atom
- O, N, S, Cl, Br, F are examples of electronegative atoms
- E.g. in a H-O bond, the bonding **e**$^-$ are closer to O than H
- Hence creating slight (+) & (-) charges on atoms
- E.g. $H_2O$, $CH_3Cl$, $NH_3$, $CH_3NH_2$ are **all polar because of this**

# POLAR COVALENT vs NON-POLAR COVALENT

Q6

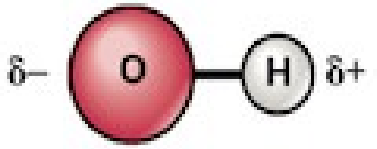
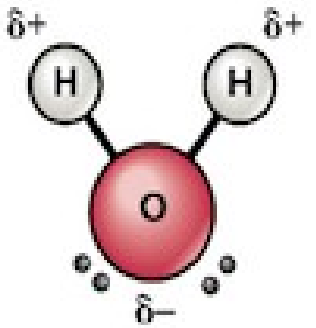
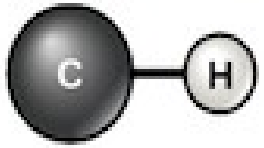
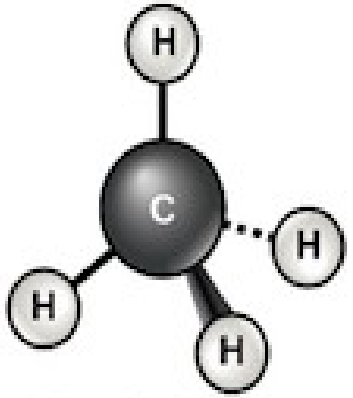
- Classify the following bonds as either "Polar covalent" or "Non-polar covalent"

- C-O
- C-C
- O-H
- C-N
- C-Li
- O-O
- C-H

# POLAR COVALENT vs NON-POLAR COVALENT

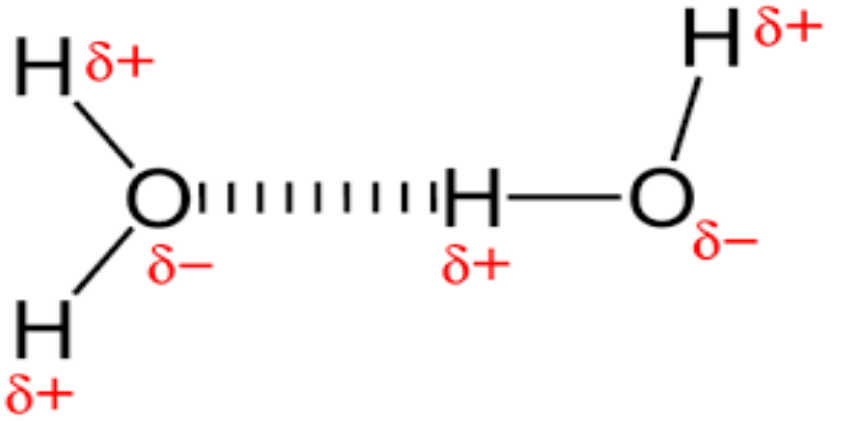
- Polarity in organic compounds affects their physical and chemical properties such as
  - Melting and boiling points
  - Stability and reactivity, etc

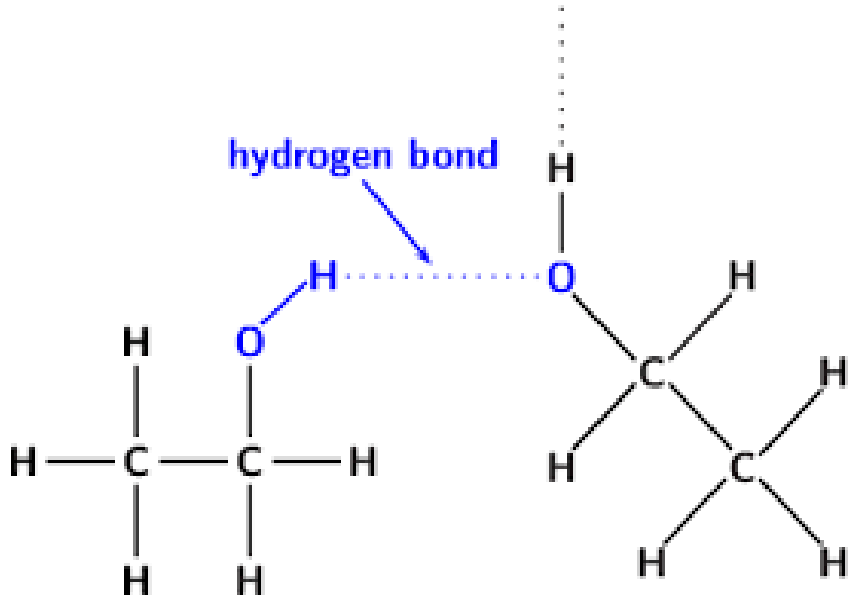
- This is largely because polar organic cmpds can undergo…
  - **HYDROGEN BONDING**

| | Bond type | Molecular shape |
|---|---|---|
| Water |  Polar covalent |  Bent |
| Methane |  Nonpolar covalent |  Tetrahedral |

# HYDROGEN BONDING

- A type of **INTER**-MOLECULAR bonding
  - i.e. only exists **between** molecules
  - Not within a molecule
- Only exists where there is
  - A Polar hydrogen **(HBD)** &
  - An **electronegative atom (HBA)** e.g. O, N, X in the neighbouring molecules
- Other intermolecular bond types e.g. **van da Waal** exist in **nonpolar cmpds**

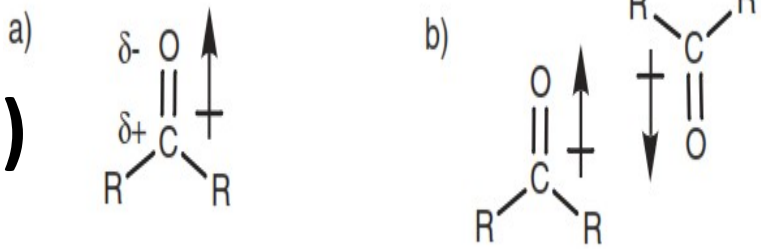


# OTHER INTERMOLECULAR BOND TYPES

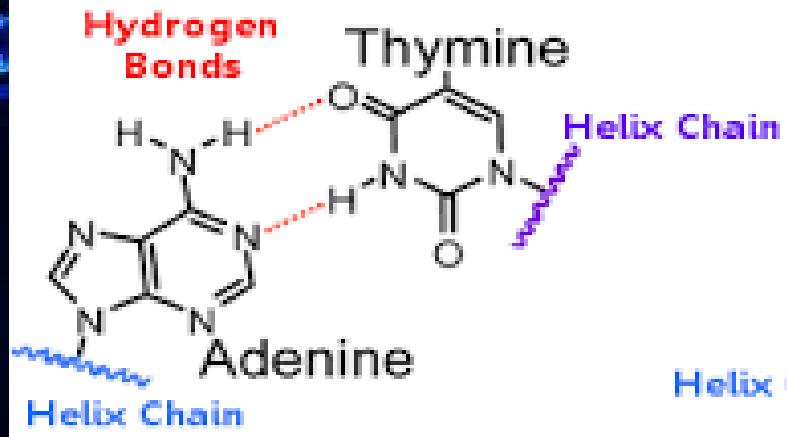
Other intermolecular bond types include

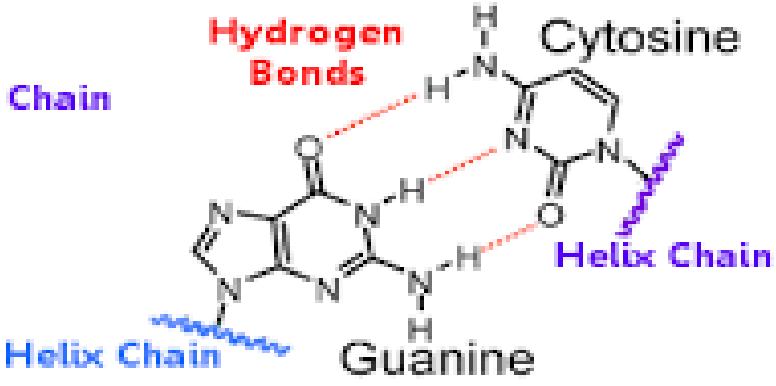
- van da Waal (**B/w Non-polar cmpds**)
- Dipole-dipole interactions **(B/w Polar cmpds)**
- Electrostatic interactions **(B/w Polar cmpds)**
- Metallic bonding **(B/w metals).** etc



# DID YOU KNOW???

- Hydrogen bonding is one of the most important things in nature!
- It's the reason water boils at 100°C (very high for a small molecule like $H_2O$)
- It is also responsible for the integrity of GENETIC information by holding together your DNA




Questio