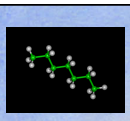
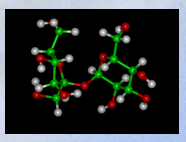


Carbon Chemistry

Organic Chemistry:
Chemistry of Living Systems

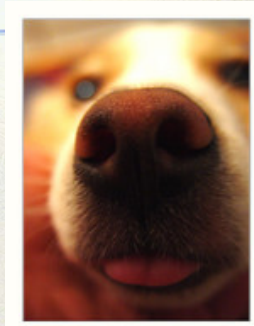


1.Let's review bonding & Lewis Structures

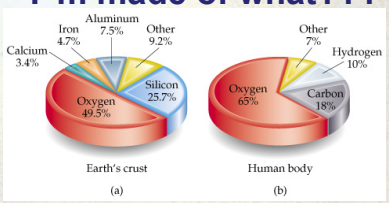
Chemistry of Living Things

- Living things are a lot like laboratories…
- There's some serious chemistry going on inside.
- Your body is an incredibly complex chemical machine taking in chemicals & food, and causing countless reactions to occur every second.
- **Biochemistry** is the study of substances & processes occurring in all living organisms.

What are living things made of?



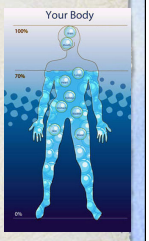
I'm made of what???



- Guess how many elements your body is made up of?
  - **25** elements make up all living things
- About 97% of your body's mass is made of just 4 elements: **oxygen**, **carbon**, **hydrogen**, & **nitrogen.**
- Two other major elements are **phosphorous** & **sulfur**.

Major Compounds

- The human body also relies on **water** & **salt**.
- The human body typically consists of **60-65%** water.
- In other words, 2/3 of your body weight is water. Water is important because many of our body's chemical reactions can only occur in solutions containing water.
- Blood, sweat, urine… all mostly water!
- Salt is also important because of how it can separate into its two ions: Na^+ and Cl^-.
- Sodium ions regular the amount of water in our cells, while chlorine ions help our body digest food.



Minor Elements

- Of course, other elements are also important, but they're often found in small amounts.
- They may seem insignificant, but they're not.
- For example, iron makes up only 0.004% of your body mass, but you can't live without it!

The most important element is…

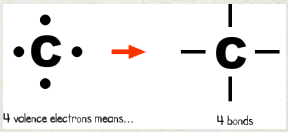
Carbon

- It may not be the most abundant element in living things, but it is the most important.
- Scientists called these carbon compounds **organic** compounds.
- Not all substances made of carbon are living.
- **Diamonds** & **graphite** are pure forms of carbon.

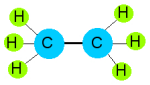
2. Diamonds & Graphite Movie

What makes carbon so special?

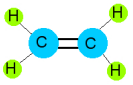
- It has a "central" role in all living organisms.
- It has **4 valence** electrons.
- It makes **4 covalent** bonds.
- It bonds to itself over & over



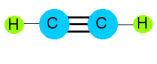
3 Types of Carbon Bonds



Single Bond



Double Bond

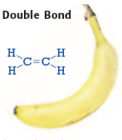


Triple Bond

Single Bond

The **propane** in this camping stove contains only single bonds.

Double Bond

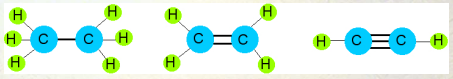


Fruits make **ethene**, which is a compound that helps ripen the fruit.

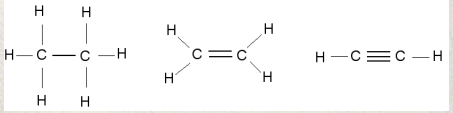
Triple Bond

Ethyne is better known as *acetylene*. It is burned in this miner's lamp and in welding torches.

Lots of ways to draw this…



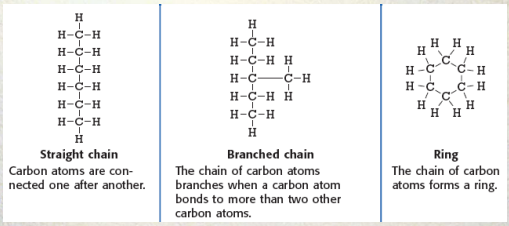
Full Structural Formulas



Simplified Structural Formulas

$CH_3 — CH_3$ $CH_2 = CH_2$ $CH \equiv CH$

3 Types of Carbon Backbones



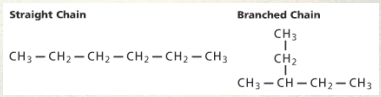
Straight chain
Carbon atoms are connected one after another.

Branched chain
The chain of carbon atoms branches when a carbon atom bonds to more than two other carbon atoms.

Ring
The chain of carbon atoms forms a ring.

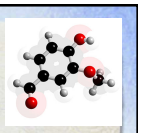
Carbon forms long chains

- One carbon chain may contain hundreds of carbon atoms.

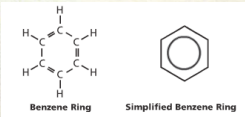


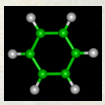
- Notice how the CH_2 units repeat.
- A very large carbon-based molecule made of repeating units is called a **polymer**.
- Polymers can be *thousands* of atoms long.

Carbon forms Rings



- One of the most important carbon rings is **benzene**.
- It has 6 carbons & 6 hydrogens , with alternating double bonds.





- Many compounds are based on Benzene.
- They often have very strong smells or aromas, so they are called **aromatic** compounds.
- An example of one aromatic compound is a molecule called vanillin. Guess what that smells like!

Silicon is similar to carbon. Why are there is no life forms based on silicon?

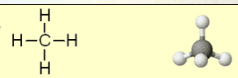
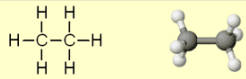
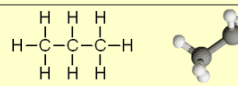
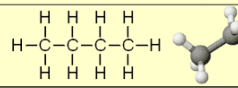
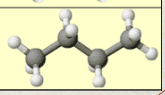
- Silicon is unsuitable because, although it is a valence IV element like carbon (4 electrons to share),
- BUT the silicon-silicon covalent bond is not strong enough for it to form long stable chains.
- So, it can not form molecules of the complexity needed to make up cells like carbon can!

3. Covalent Bonding Review

Long Chain Hydrocarbons & their Names

- The alkanes make up a series of straight chain hydrocarbons, and are the foundation for how hydrocarbons are named.
- The first four members of the series are gases at room temperature and are called:
- methane, CH_4
- ethane, C_2H_6
- propane, C_3H_8
- butane, C_4H_{10}

Alkanes

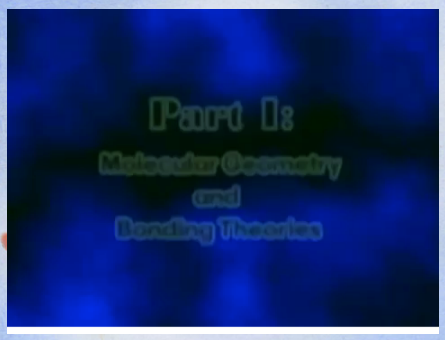
methane CH_4		
ethane C_2H_6		
propane C_3H_8		
butane C_4H_{10}		

- Alkanes with increasing numbers of carbon atoms have names are based on the Greek word for the number of carbon atoms in the chain of each molecule.
- So you can get, for example,
- **pentane (5),**
- **hexane (6),**
- **heptane (7)**
- **and octane (8).**

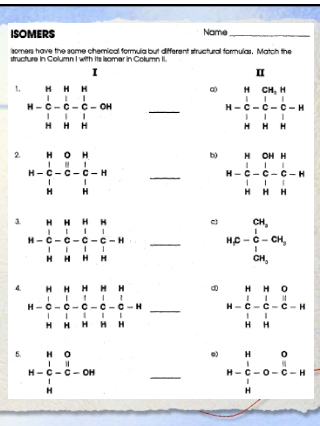
Lots of carbon compounds seem to be isomers. What is an isomer?

- In organic chemistry, there are many examples of different compounds which have the same molecular formula as each other,
- **But different arrangements or <u>structures</u>** of the atoms in their molecules.
- These are called **<u>isomers.</u>**

4. Molecular Geometry



You Try It!



ISOMERS

Name _____

Isomers have the same chemical formula but different structural formulas. Match the structure in Column I with its isomer in Column II.

I

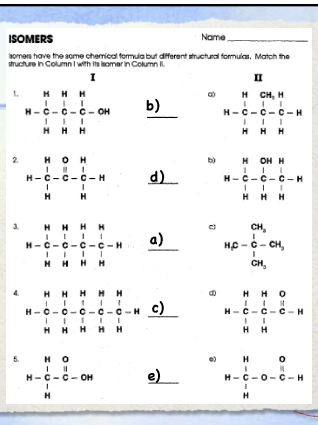
1.
2.
3.
4.
5.

II

c)
b)

d)
e)

How did you do?



ISOMERS

Name _____

Isomers have the same chemical formula but different structural formulas. Match the structure in Column I with its isomer in Column II.

I

1. b)
2. d)
3. a)
4. c)
5. e)

II

c)
b)

d)
e)

Other organic compounds

- Take a cheeseburger.... hamburger, covered with American (yellow) cheese on a hamburger bun... yummy!

- Now, if you made this cheeseburger with Swiss cheese and put it on slices of rye bread,
- (or used Buffalo beef and no bun)

- you' d end up with a "cheeseburger" but one that tasted totally different ...
- you would notice that the substitutions affected the taste...

- Chemists make similar changes to organic compounds...
- these changes produce compounds called
  " **substituted hydrocarbons"**
- A substituted hydrocarbon has had one or more of it's **hydrogen atoms** or groups of atoms **replaced by other atoms**.

Alcohol: -OH

- alcohol is the name of a family of compounds formed when a hydroxyl (-OH) group **replaces one or more hydrogen atoms** in a hydrocarbon chain.
- (ex: thanolis produced by sugar fermenting in corn, grains & fruits)
- Structure challenge:
- **Isopropyl alcohol:** The -OH is on the middle carbon of the 3 carbon chain
- **Propyl alcohol:** Has the -OH on the end C

Write this on your cheat sheet!

Alcohols

Characterized by the **hydroxyl group**

-OH

Write this on your cheat sheet!

Alcohols

Nomenclature:

CH_3-OH

methanol
(methyl alcohol)

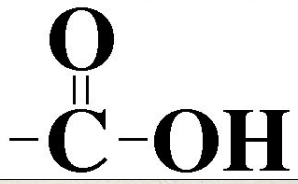
Carboxylic Acid: -COOH

- a carboxylic acid is formed when a **-CH_3 group is replaced** by a carboxyl acid: (-COOH)
- (The simplest carboxylic acid is methanic acid or formic acid which is made by ants and is injected into your skin when they bite you)

Write this on your cheat sheet!

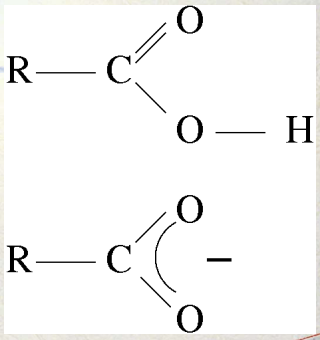
Carboxylic Acids

Characterized by the **Carboxyl Group**



R means: Repeating Hydrocarbons- or CH_2

The R is where the long chain of hydrocarbons would be attached



Amines:- NH_2

- In these, Nitrogen forms bonds with the carbon and hydrogen.
- The amine group **(-NH_2) replaces the hydrogen** in the hydrocarbon. Methylamine is the simplest amine.
- (EX: novicane in the dentist's office, caffeine in soft drinks... are all hydrocarbons substituted with nitrogen)
- Example: **Ethylmethylamine: $CH_3NHCH_2CH_3$**

Write this on your cheat sheet!

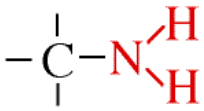
Amines

Characterized by Nitrogen joined to at least one alkyl group.

$-NH_2$

Amino Group

Amino

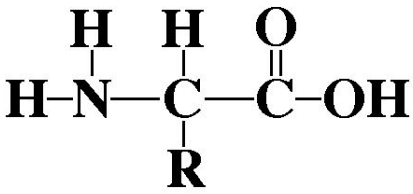


Amino Acids:

- Amino acids have both:
- **-COOH (the acid)**
  and
  $-NH_2$ (the amino)
- as the substituted hydrocarbons- replacing more than 1 hydrogen

Write this on your cheat sheet:
R means Repeating Hydrocarbons

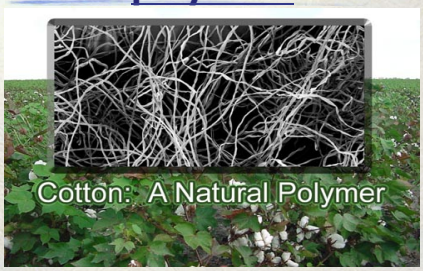
Amino Acid Structure



Polymers:

- Milk, blood muscle, cassette tapes & athletic shoes are all made of organic compounds with **very large molecules** called Polymers.
- Polymers are made up of smaller organic compounds that are linked together to form new bonds.
- Polymers are also found in the biological compounds that make up living things.

polymers



The word

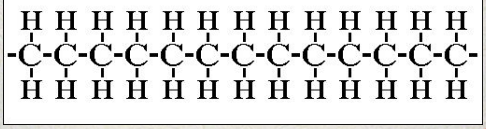
Polymer

comes from the Greek

poly, meaning *"many"* and *meros*, meaning *"parts"*

Addition Polymerization

The simplest and most widely used addition polymer is polyethylene



- In our next class we'll talk more about "monomers" and polymers and biomolecules.