Organic Chemistry:

Organic Chemistry: is the branch of chemistry that involves molecules of carbon.

The chemistry of carbon molecules is extremely important because 90% of all molecules/compounds ever produced contain this one element!!

Organic Chemistry got its name in the 1800's. It was defined as the chemistry of compounds that come from living things (organisms). In fact, most of our body is made from only 4 elements – carbon, hydrogen, oxygen, and nitrogen.

What's so special about Carbon?:

Carbon is a unique element because:

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Some of the unique properties of molecules containing carbon (organic molecules) are:

- low melting points
-are very often liquids or gases
- are polar or non-polar, but never ionic.

Organic molecules are extremely abundant. They include:

1/ Synthetic chemicals such as pesticides, herbicides, antibiotics, pharmaceuticals, soaps, detergents, plastic, and fibres.

2/ Petrochemicals and coal - which are made from the products of decayed living tissues of organisms that lived long ago. These products are called FOSSIL FUELS.

3/ Natural Molecules from living organisms such as: hormones, neurotransmitters, starches, sugars, proteins, amino acids, and fats.

Before we really get started, there are a couple of terms that you will need to know. HYDROCARBONS are molecules that have only carbon and hydrogen in them (like fats, oils, gasoline, and plastics). CARBOHYDRATES have carbon, hydrogen, and oxygen (like sugars, cellulose, starch, and many other biological molecules).

<u>The Chemistry of Carbon</u>:

Carbon is a TETRAVALENT element, which means that it will always form 4 bonds. Carbon forms COVALENT or POLAR COVALENT bonds with itself and other elements and can have SINGLE, DOUBLE, or TRIPLE bonds as part of the structure. Carbon is also unique in that it can form LONG CHAINS by bonding with itself.

<u>Types of Formulae</u>:

<u>Empirical formula</u>: is the smallest ratio of atoms. It is the simplest formula possible that still has the correct ratio

<u>Molecular Formula</u>: has the true number and type of atoms in the molecule.

<u>Structural Formula</u>: has the true number and type of atoms in the molecular formula, but is arranged in such a way so as to show which atoms are bonded together.

Ex: C_6H_{14}

Empirical:

Molecular:

Structural:

A/ <u>Hydrocarbons</u>:

* Remember that hydrocarbons are molecules that only contain carbon and hydrogen.

* Hydrocarbons generally have a structure that consists of a long chain of carbons with hydrogen's sticking off the ends. The long chain of carbons is called the CARBON BACKBONE.

* When one or more of the hydrogen's is replaced by another element (like chlorine), it is called a HYDROCARBON DERIVATIVE.

* The CARBON BACKBONE may be completely straight or branched. The straight one would be called a STRAIGHT-CHAIN MOLECULE and the branched one a BRANCHED MOLECULE.

Types of Hydrocarbons:

* Hydrocarbons are grouped according to how the carbons are bonded together:

single bonds = alkanes
double bonds = alkenes
triple bonds = alkynes

1/ The Alkanes:

* the alkanes have all carbons in the chain bonding with single bonds (which remember is when they share a pair of electrons. Each carbon is singly bonded to 4 other atoms.

* Alkanes are called SATURATED because they are 'saturated' with hydrogen's. When the carbons are bonded singly, they are able to take on the greatest amount of hydrogen's possible. You will encounter the other possibility later.

Ex:

* All alkanes will have the same geometry (3D shape). There is a theory called the VSEPR theory, which tells us how bonds will arrange themselves in space. Briefly, all bonds try to stay as far away from one another as possible. This makes sense because bonds are just electrons and electrons repel one another.

* Because of the VSEPR theory, all alkanes are TETRAHEDRAL. There will be angles of 109.5º between each carbon (yes, they have actually measured that). To draw this shape onto paper, we need some symbols to show the 3D aspect of it.

* The process of naming organic molecules (or any compound/molecule) is called NOMENCLATURE. It follows strict and exhaustive rules. These rules where agreed upon by IUPAC (the International Union of Pure and Applied Chemists). These rules apply so that all chemists (no matter where they live) will understand each other and can work together. Unfortunately, there are still COMMON NAMES, which are not agreed upon internationally and just confuse things sometimes. We will be using the IUPAC naming system.

* The IUPAC naming system uses a combination of prefixes and suffixes.

* For alkanes, the suffix is ~ANE. All alkanes end in ~ane.

* The prefixes are determined by the number of carbons in the LONGEST, CONTINUOUS CHAIN. They are:

1 carbon ----- meth	6 carbons ------- hex
2 carbons ---- eth	7 carbons ------- hept
3 carbons ---- prop	8 carbons ------- oct
4 carbons ---- but	9 carbons ------- non
5 carbons ---- pent	10 carbons ------ dec

Examples:

Try some:

* Also, single bonds are relatively long (meaning that the distance between carbon atoms is great), are relatively weak, and can rotate freely around the carbons. All of these things make them different than alkenes and alkynes.

* When the chains get really long (5 carbon or more), it becomes possible for the first carbon and the last carbon to bond. When this happens, they form a ringed structure. It would now be called a CYCLIC ALKANE. It is still an alkane because all the carbons are bonded singly. In order to name these, we just put the prefix CYCLO in front.

Examples:

Derivatives of Alkanes:

* Derivatives are formed when hydrocarbons have had the hydrogen's on the carbon backbone replaced with other elements or group of elements

* The name will depend on the group that is replacing the hydrogen:

Cl – chloro	Br – bromo	NO_2 – nitro
I – iodo	F – Fluoro	CH_3 – methyl
C_3H_7 – propyl	C_2H_5 – ethyl	

* notice that when an organic group is attached (called an ALKYL GROUP), it has one less hydrogen and the ~ANE is replaced with ~YL

*We need to use numbers to signify where the new group is attached (because it could be anywhere). In order to do this we need to NUMBER THE CARBONS ON THE LONGEST CONTINUOUS CHAIN.

* When numbering carbons and determining where to put the numbers, we must remember to make sure that the lowest possible numbers are used and the number is separated from the name by a dash.

* If there is more than one of the same group, we add prefixes to show how many. These prefixes are the same as in molecule naming (di, tri, tetra, penta, etc)

* One more thing, if there is more than one group attached to our chain, they are listed in ALPHABETICAL order.

* In each case, we need to make sure that we pick the LONGEST CONTINUOUS CHAIN of carbons.

Ex: C_5H_{12}

This is not the same thing as:

* Both of the molecules drawn above have the same molecular formula, but different structural formulas. They are called STRUCTURAL ISOMERS.

* They are not the same molecule. In order to be the same molecule, they must have the same empirical, molecular and structural formulas.

Ex: Draw 4 structural isomers of C_8H_{18}.   Name them.

Try one: Draw 4 structural isomers of C_6H_{14}. Name them.

More Examples:

Try some naming and structural formulas:

2/ <u>The Alkenes:</u>

* Alkenes are hydrocarbons that have at least one double bond in the molecule. Remember that a double bond is a sharing of 2 pairs of electrons.

* Alkenes are called UNSATURATED because through the process of having 2 bonds with the carbon next door, it can no longer have every possible bond taken up by hydrogen. This is the difference between saturated and unsaturated margarine. Poly-unsaturates have alkenes in them

* The general formula for an alkene is C_nH_{2n}.

* We have to be really careful when drawing the structural formulas because carbon can only have 4 bonds.

* The prefixes are the same as in alkanes.
* The suffix for alkenes is ~ENE for molecules with 1 double bond and ~ADIENE for those with 2 and ~ATRIENE for 3.

* Also, we have to find some way to identify where the double bond is. In order to do this we need to NUMBER THE CARBONS ON THE LONGEST CONTINUOUS CHAIN.

* When numbering carbons and determining where to put the numbers, we must remember to make sure that the lowest possible numbers are used and the number is separated from the name by a dash.

Ex:

Ex:

* When naming alkenes with more than one double bond, we separate the numbers with commas and they go from lowest to highest.

Try some:

* The double bond is stronger, more rigid, and shorter than the single bond. It cannot rotate around the carbons. As a result, the
things 'stuck' on the double-bonded carbons cannot move. This will become important later.

* The angle between atoms in an alkene is 120º.

* One more thing, alkenes, when the backbone is long enough, can also bend back on itself and become a CYCLOALKENE. Again, the naming will be the same as for an alkene, but we add the prefix CYCLO. Also, for cycloalkenes with only one double bond, we don't have to number the carbons because we assume that carbon number 1 is where the double bond is.

Ex:

Derivatives of Alkenes:

* There are also GEOMETRIC ISOMERS. These isomers exist when two molecules differ only in the way that their atoms are arranged. Remember that the bonds in alkanes can rotate around the carbon-carbon bond. The way that atoms are arranged in space is not fixed. This is not true of alkenes.

Ex:

The chlorine atoms are fixed in space. The names are the same and the structural formulas are essentially the same. BUT they are still different.
* When the chlorine atoms are on the same side of the double bond we call them CIS and when they are on opposite sides, they are called TRANS.

* We identify which one we have by putting that prefix in front. The IUPAC names for the molecules above are:

Try Some: Name or draw

3/ Alkynes:

* Alkynes have at least 1 triple bond somewhere in the structure. Remember that a triple bond is a sharing or 3 pairs of electrons.

* Again, we have to number the carbons in the same manner as for alkenes, and the prefixes are the same.

* The general formula for an alkyne is C_nH_{2n-2}.

* The suffix for alkynes is ~YNE if there is only 1 triple bond, ~ADIYNE if there are two, etc.

* The triple bond is even shorter, stronger, and more rigid than the double bond.

* The bond angle for alkynes is 180º (completely linear). Because of this, it can’t form rings.

4/ <u>Aromatic Hydrocarbons</u>:

* All of the molecules that we have seen so far are called ALIPHATIC molecules because of their electron structure. AROMATIC molecules are different in that they are CYCLICAL structures that have ALTERNATING DOUBLE-SINGLE BONDS.

* All aromatic molecules have a formula of C_nH_n and have bond angles of 120º.

* While we won't be naming the aromatics, they are extremely important, as much of the important molecules in the body are aromatic. Hormones, drugs, and some particularly nasty pollutants are also aromatic.

* Aromatics are extremely stable. Their electrons are DELOCALIZED, which means that they have no permanent location, but instead, cycle around the ring.

* Benzene is the most common and first aromatic to be discovered. Its formula is C_6H_6. It can be drawn in a number of different ways:

Functional Groups:

* Functional groups are very special groups that can attach to hydrocarbons to give derivatives. When they do, they form molecules with unique chemical properties. Because they are unique, they have their own naming rules.

The Functional Groups: (R means an alkyl group)

Creates alcohols

Creates Ethers

Creates Amines

Creates Amino Acids

Creates Ketones

Creates Esters

Creates Amides

Creates Carboxylic Acids

Creates Aldehydes

1/ Alcohols:

* Are characterized by a hydroxyl group (OH) attached by a single bond to a carbon.

* We still name the LONGEST CONTINUOUS chain as we always did, but this time, we replace the E on the ~ANE with ~OL (methane becomes methanol). They are not treated like other groups. They become part of the base name, not a prefix.

Examples:

2/ Ethers:

* Are characterized by oxygen in between carbon atoms bonded together with single bonds (remember that oxygen can only form 2 bonds).

* The naming of ethers does not follow simple rules so you are not responsible for naming them, but you do have to identify them.

Examples:

3/ Ketones:

* Are characterized by a carbon attached to a CARBONYL GROUP (C=O).

* Again, instead of a prefix, ketones become part of the base name. The E in the ANE is replaced by ~ONE.

Examples:

4/ Carboxylic Acids:

* Carboxylic acids are characterized by having a carbonyl group and a hydroxyl group attached to the SAME CARBON.

* Aspirin and the prostaglandin hormones are examples of carboxylic acids.

* For naming, the E in ANE is replaced with ~OIC ACID.

Examples:

5/ Aldehydes:

* Aldehydes are a little like ketones in that they have a carbonyl group on the carbon, but in the case of aldehydes, that carbon is also attached to a hydrogen, not an alkyl group.

* For naming, the E in ANE is replaced with ~AL.

Examples:

6/ Esters:

* Esters are derivatives of carboxylic acids and they are made by reacting alcohols with carboxylic acids. The usually have a strong smell and add aroma to perfumes and fruits.

* You won't have to name them, but you will have to recognize them. They have a carbon carbonyl group attached to an oxygen which is attached to an alkyl group.

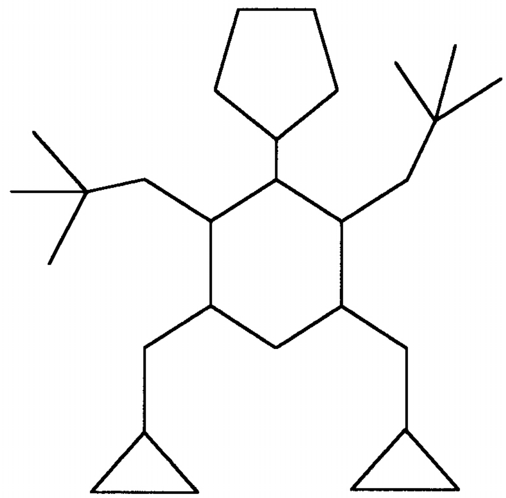
Examples:

7/ Others:

Examples:

Try some: For each molecule below, identify what it is and name it (except if it is an ether, ester or from the other group)

To You It's a Stick Figure....



...To Us It's
1-cyclopentyl-*bis*-2,6-(2,2-dimethyl)propyl-*bis*-3,5-cyclopropylmethyl-cyclohexane.