Organic Chemistry BASICS (welcome to the O.C.)

Carbon is the central atom to organic chem. Carbon has 4 valence electrons, so it can and must make 4 bonds. These bonds can be to hydrocarbons, other carbons, or almost any other atom or group. The concept of hydrocarbon means that the compounds are made only of hydrogen and carbon. When other atoms, such as oxygen, nitrogen, etc., are added to the compound, they are not hydrocarbons anymore.

The simplest hydrocarbons are the chained hydrocarbons. They are the alkanes, alkenes, and the alkynes. The names are all close but different.

These chains are labeled first by the number of carbons they contain. Counting in proper prefixes, from one to ten are as follows:

meth, eth, prop, but, pent, hex, hept, oct, non, dec.

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Alkanes have only C-C single bonds, and all the carbons are bonded to as many hydrogen atoms that they can be bonded to (4 bonds total per carbon). Since these hydrocarbons hold the MAXIMUM number of hydrogen atoms possible, they are called saturated hydrocarbons.

Alkanes have this GENERAL FORMULA: C_nH_{2n+2} where n=the number of carbon atoms.

Example: an alkane with 25 carbon atoms has a chemical formula of $C_{25}H_{52}$.

Alkanes include methane, ethane, propane, butane, pentane, hexane, heptane, octane, nonane and decane. That is “in order” for carbon number 1 to 10.

Alkanes always end with the suffix –ane.

We will come back to alkanes later in the diary, when we discuss adding “special” functional groups to give these chained, saturated, hydrocarbons more properties.

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Alkenes have at least one C=C double bonds, and all the carbons are bonded to as many hydrogen atoms as they can be bonded to (4 bonds total per carbon). Since these hydrocarbons hold LESS THAN THE MAXIMUM number of hydrogen atoms possible, they are called unsaturated hydrocarbons.

Alkenes have this general formula: C_nH_{2n} where n=the number of carbon atoms.

Since this double bond can be anywhere in the compound, we have to “NAME” the carbon that it’s attached to. The carbons of the chain are numbered from the “short” end of the chain. To which ever side of the structure the double bond is closer to is where the “first” numbered carbon is labeled.

Examples:

$CH_3CH_2CH_2CH_2CH{=}CHCH_3$ has the double bond closer to the right side of this molecule. with seven total carbons, this gets named as a hept– prefix. The carbons that are double bonded together are the number 2 and the number 3 carbon. We name these by telling the lowest number carbon that the bond is attached to, hence, this is 2-heptene. If you count the “wrong” way, this could be called 5-heptene, but this is the exact same thing, but with an improper name. We ALWAYS name from the “short” end of the molecule.

$CH_3CH_2CH{=}CH_3$ this molecule has the double bond between carbon number 1 and 2, so it would be called 1-butene. Each carbon has 4 bonds, with four total carbons it is called by the but– prefix.

Alkenes are always labeled with the suffix –ene.

We will come back to alkenes later in the diary, when we discuss adding “special” functional groups to give these chained, saturated, hydrocarbons more properties.

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Alkynes have at least one C≡C triple bonds, and all the carbons are bonded to as many hydrogen atoms as they can be bonded to (4 bonds total per carbon). Since these hydrocarbons hold LESS THAN THE MAXIMUM number of hydrogen atoms possible, they are called unsaturated hydrocarbons.

Alkynes have this general formula: C_nH_{2n-2} where n=the number of carbon atoms.

Since this triple bond can be anywhere in the compound, we have to “NAME” the carbon that it’s attached to. The carbons of the chain are numbered from the “short” end of the chain. To which ever side of the structure the double bond is closer to is where the “first” numbered carbon is labeled.

Examples:

$CH_3CH_2CH_2C{\equiv}CCH_3$ has the triple bond closer to the right side of this molecule. With six total carbons, this gets named as a hex– prefix. The carbons that are triple bonded together are the number 2 and the number 3 carbon. We name these by telling the lowest number carbon that the bond is attached to, hence, this is 2-hexyne.
If you count the “wrong” way, this could be called 4-hexyne, but this is the exact same thing, but with an improper name. We ALWAYS name from the “short” end of the molecule.

$CH_3CH_2CH_2C{\equiv}CH$ this molecule has the triple bond between carbon number 1 and 2, so it would be called 1-pentyne. Each carbon has 4 bonds, with four total carbons it is called by the but– prefix.

Alkynes are always labeled with the suffix –yne.

We will come back to alkynes later in the diary, when we discuss adding “special” functional groups to give these chained, saturated, hydrocarbons more properties.

FUNCTIONAL GROUPS (Table R)

Hydrocarbons will all react in pretty much the same way, they combust, they make some reactions (we'll learn them later), but they don't have a lot of "flair". In order to make the very neat and wonderful organic molecules that "function" more, such as medicines, drugs, odors, etc., they need to add functional groups to themselves.

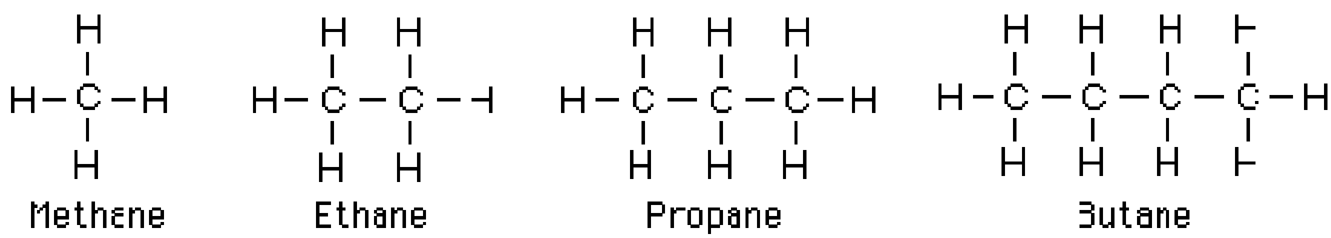
These functional groups act as bridges between hydrocarbons, or special endings to chains, or just insertions to the hydrocarbons. The functions they add make for endless new molecules, which will make a world of beautiful chemicals and smells (and lots of bad ones too!).

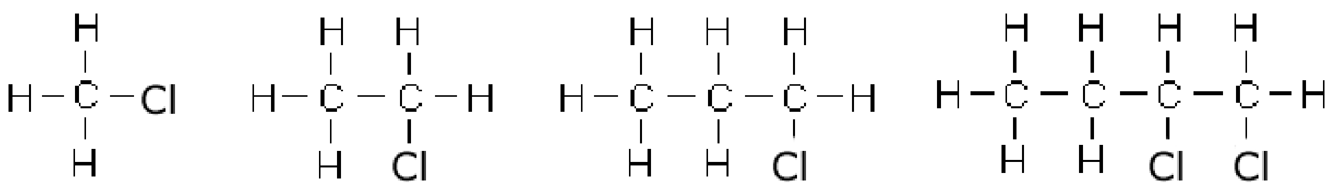
Table R shows us the main groups that we are responsible to recognize. They are ordered, and always follow the same patterns as you have in the table. The chains get longer, special ring structures are added, but all organic molecules follow a few patterns that we will practice.

HALIDES (halocarbons).

The substitution of a halogen atom (F, Cl, Br, or I) for a hydrogen forms a halocarbon. That's a hydrocarbon with a halogen inserted where a hydrogen was.

FOUR alkanes in a row are shown, then below them are HALOCARBONS, with chlorine atoms substituted into the molecules. They are named below.





chloromethane chloroethane 1-chloropropane 1,2 dichlorobutane

In the first molecule, one atom of chlorine is substituted in, and since the molecule moves around in 3 dimensions, and it's attached to the ONLY carbon, it does not need to be "numbered" as 1-chloromethane, as it has to be linked to that single carbon.

In chloroethane, since the Cl is attached to a carbon atom, and since the molecules can turn, either could be the "first" or #1 carbon atom, so it too does not need to be "numbered" as 1-chloroethane.

In the 3rd molecule, the chlorine is on one of the end carbons (as opposed to be bonded to the central, or second, carbon atom. This is called 1-chloropropane. If the carbon was attached to the central carbon atom, it would be called 2-chloropropane.

In the final molecule, there are 2 added chlorines, and they are attached to the first and second carbon atoms (counted from the right). This is called 1,2 dichlorobutane.

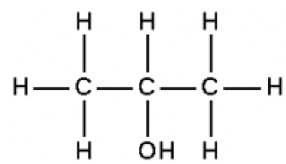
The 2 chlorines (di) are attached to the number 1 and number 2 carbons, of a butane base chain. If you call it 1 chloro, 2 chloro butane, that is technically improper, but clearly is understandable. We use di for 2 of the same additions, tri for three, and tetra for four similar additions.

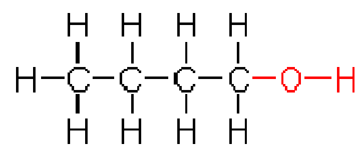
Alcohols

To form an alcohol in organic chemistry we have a hydrocarbon to which an –OH group is added in. This –OH group is NOT a base. Bases are ionic compounds that dissociate in solution, putting the hydroxide ions into solution. The hydroxide ions in solution make a base. When an –OH group is attached to a hydrocarbon, it does not dissociate in solution. The –OH group does not form a hydroxide ion. The molecule stays intact, and forms an alcohol.

The alcohol that we are most familiar with is the kind that is in wine and beer. That alcohol is called ethanol. Ethanol has the “2 carbon prefix” plus the alcohol suffix. With 2 carbons, the –OH group can be attached to either carbon atom, and the same molecule forms. There is no need to number the carbon atom that the –OH group attaches to, until its placement is actually going to make a difference.

$CH_3–OH$ $CH_3–CH_2–OH$





The two smallest alcohols are methanol (one carbon) and ethanol (two carbons). The third alcohol is called propanol, and the one here is actually 2-propanol because the alcohol –OH group is attached to the central carbon rather than a carbon on the end of the short chain.

In the fourth alcohol shown, 1-butanol, the alcohol group is shown in red attached to the first carbon on the right. The bonding there is clearly shows that the carbon bonds to the oxygen, and it is the oxygen which bonds to the hydrogen. Since we already know that oxygen makes 2 bonds, and in alcohols the oxygen always has a hydrogen atom partner, it is often shown just as an –OH group.
It is “really” an –O-H group.

Ethers

Ethers are neat molecules that contain an “oxygen bridge”, that is a single oxygen atom that joins 2 hydrocarbon chains together. To name an ether, we name the side chains in alphabetical order.

$$CH_3–CH_2–O–CH_3$$

This molecule is called ethyl methyl ether. The ethyl group is the 2-carbon chain at left of the oxygen, the methyl group is the very short single carbon chain at right. The groups are named in alphabetical order, not necessarily left to right.

If both sides of the ether contain the SAME size hydrocarbon chain, rather than say methyl methyl ether, it is proper to use “di-methyl” ether instead.

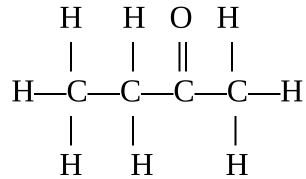
At left is dimethyl ether, at right is diethyl ether. Both have the “oxygen bridge” holding a pair of alkyl groups.

$CH_3–O–CH_3$ $CH_3–CH_2–O–CH_2–CH_3$

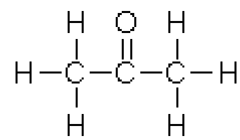
Ketones

Ketones contain a double bonded oxygen to a carbon. The carbon is attached on both sides to other carbons or what are called "R" groups. R is for radical, but R means hydrocarbon groups.

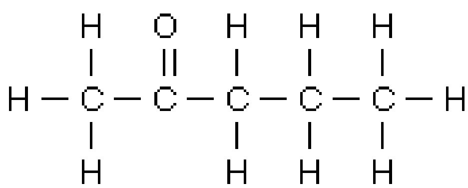
At right is a simple ketone, with 4 carbons.
It would be called 2-butanone. The "2" is necessary because the ketone group is attached to the number 2 carbon atom in the short chain.
"But-" is the prefix, because there are three carbons in this chain. Finally, "-anone" is the suffix for a ketone.



2 more ketones are shown here: propanone has 3 carbons. Since all ketones have the oxygen double bonded to a carbon that is located centrally in a molecule, it "must" be on this central carbon, so <u>it does not need to be numbered</u> as 1-propanone.



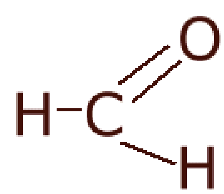
Just below is 2-pentanone. The ketone double bonded oxygen is attached to the second carbon in this chain. Note that in all cases, each carbon atom has 4 bonds. This is true throughout organic chemistry. This WOULD NOT be called 4-pentanone, we ALWAYS count with smaller numbers than larger.



Aldehydes

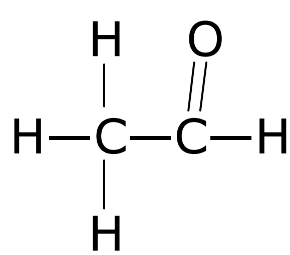
When the ketone seems to be hanging off the end of a chain, the difference is subtle, but a new kind of functional group exists. An aldehyde has a carbon with a double bonded oxygen, but the difference is that this carbon is at the end of a chain. It has an "R" group attached on one side, and then just a hydrogen off the other side. This is a terminal, or end of the chain functional group. Examples below:

A commonly known aldehyde is formaldehyde, from biology class. That is its old fashioned name. We call it methanal, for 1-carbon aldehyde suffix.

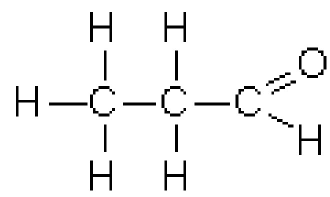


The next larger aldehyde is with 2 carbons, hence the name ETHANAL, for 2 carbons, aldehyde suffix.

The aldehydes are named by the chain length of the hydrocarbons, and do not need to be numbered, as the aldehyde is ALWAYS at the end of the chain.



The aldehyde at right is a 3 carbon, propanal. No numerics are needed for aldehydes, all the aldehyde groups must be on the end carbon in the chain.



Organic Acids

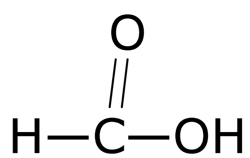
Acids were covered well in our Acid Base section of chemistry, but these acids are different. They release hydrogen ions in aqueous solution, but the part that is not the acid is a hydrocarbon chain rather than a single anion or tiny polyatomic anion.

The most common organic acid is ethanoic acid, which we learned is the same thing as acetic acid. The formula for acetic acid is $HC_2H_3O_{2(AQ)}$ and that is the same number of atoms as $CH_3COOH_{(AQ)}$, but it is written differently. Acetic acid is ethanoic acid. Both are the exact same molecule, just two different ways to imagine it. They have the same number of atoms of each kind, but they are expressed differently on paper.

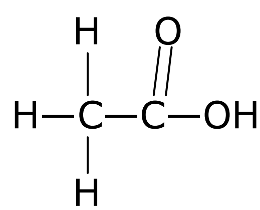
The acid group is called a –COOH group. The carbon is double bonded to one oxygen, and is single bonded to an –OH group. This –OH group is part of the acid functional group, and is not to be considered an alcohol, or ketone, or aldehyde group.

Examples are as follows: one carbon, two carbon, and three carbon acids.

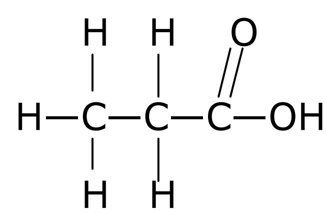
Methanoic Acid



Ethanoic Acid



Propanoic Acid



The number of carbons sets the acid PREFIX, and the suffix is always –anoic Acid.

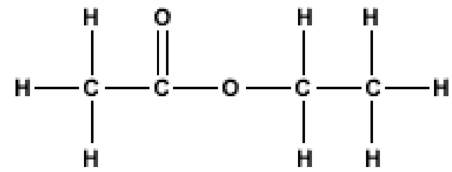
The rest of the organic acids you must recognize are called: butanoic, pentanoic, hexanoic, heptanoic, octanoic, nonanonic and decanoic acid. All have that –COOH group at one end.

It is the “H” in the –COOH group that is the particular hydrogen that forms the H^{+1} ion in solution, making each follow the Arrhenius acid rule.

Esters

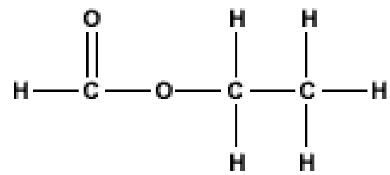
Esters are the nicest and worst smelling organic molecules. They always have a carbon double bonded to an oxygen. This carbon has a chain of hydrocarbon to one side, and to the other is first, another single bonded oxygen, THEN, another hydrocarbon group.

At right is a simple ester; attached to the oxygen is an ethyl group, and there are 2 carbons in the chain attached to the other side of the –COO group.



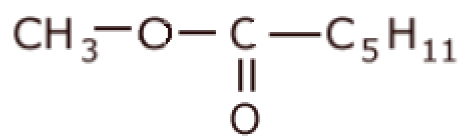
This is called ethyl ethanonate. Ethyl for the 2-carbon group attached to the oxygen, and eth (2 more carbons) and finally -anoate (ester group) on the other side. It's a 2 carbon X 2 carbon ester.

Here is a slightly different ester, with an ethyl group attached to the oxygen again, but only ONE carbon attached to the other side. This is ethyl methanoate.



This third ester, drawn "upside down" compared to the others, is actually the ester that makes bananas smell as they do. This is the actual chemical that gives bananas their odor.

Attached to the oxygen is just a small methyl group. Attached to the other side is a total of 6 carbons, so this is methyl hexanoate.

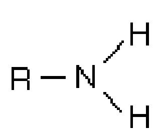


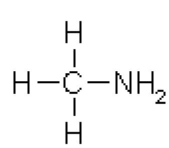
Amines

Amines contain nitrogen. Nitrogen can make <u>and</u> must make 3 bonds. The amine group can be added anywhere to a carbon (like an alcohol group) and therefore are usually numbered to show exactly where in the compound they are. Often the nitrogen atom is attached to just 2 hydrogen atoms.

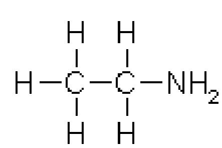
Chains attached are often abbreviated as "R" chains. An "R" chain is a hydrocarbon chain. One is the "R" chain, a second one in the same molecule would be R´ and read as R PRIME. In our class to keep things simple we will only attach "H" atoms, not additional R chains.

Examples are…

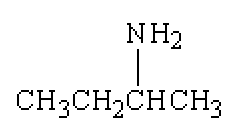




Methanamine



ethanamine

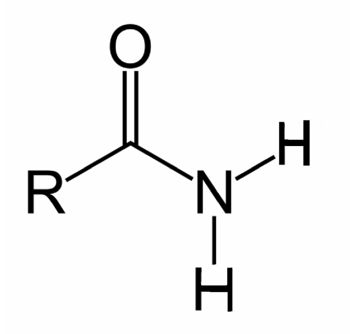


2-butanamine

Above are the functional group for amines ($-NH_2$) attached to a generic "R" grouping, and three amines.

The fourth molecule has a 2 in its name that is required. This "2" is for the fact that the amine group is attached to the second carbon in the short 4-carbon chain.

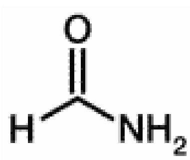
Amides



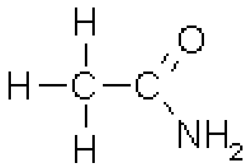
Amides are similar to amines but with a clear difference.
The carbon that attaches to the $–NH_2$ group must also be attached to an oxygen by double bond. This is shown here; the R group can be of any length, and the amide is named by the R group.

Amides are always at the end of the chain, because if they were central, the carbon attached to nitrogen and doubled to oxygen can only make one more bond, it CAN'T be central in the molecule, it can only bond on one side.

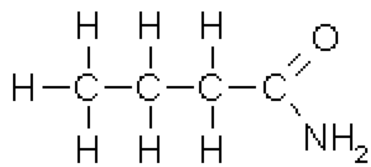
Examples here are the one carbon amide, the two carbon amide, and the four carbon amide.



Methanamide has 1 carbon



Ethanamide has 2 carbons



Butanamide with 4 carbons

Methyl, Ethyl, and Propyl Groups (etc.)

More possibilities exist to make our organic molecules more complex (and fun to name). Also able to attach to hydrocarbon chains are shorter chains, usually 1, 2 or 3 carbons in length, but any size group is theoretically possible. Long chains can attach to esters or ethers as well.

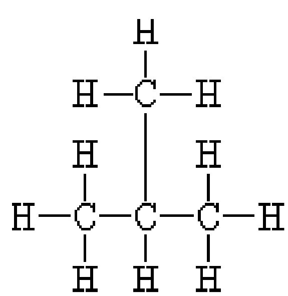
A molecule of methane is CH_4. A molecule of ethane is CH_3CH_3. Propane is $CH_3CH_2CH_3$.

By removing a single hydrogen atom from each, the rest of that group can attach, and these are called methyl, ethyl, and propyl groups. $-CH_3$ $-CH_2-CH_3$ $-CH_2-CH_2-CH_3$

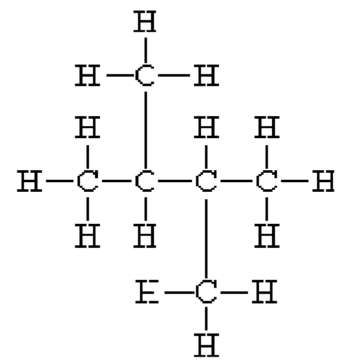
Where the missing H atom opening is, that is how these groups bond to other chains.

These groups can attach to longer hydrocarbon chains, or functional groups, alone or in pairs or even groups. We name them alphabetically, and by numbering the carbons in the base chain.

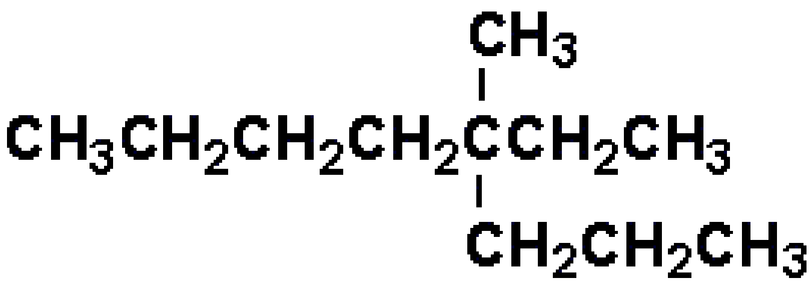
This molecule at right is called methyl propane, because there is a methyl group attached to the central carbon in a 3 carbon chain (the propane part). The LONG bond between the methyl group and the propane part is just a diagrammatic extension.
In a three dimensional molecule there is less distortion of shape.
That bond is quite like the other C–C bonds in the molecule.



At right is a hydrocarbon with a 4 carbon chain, with two methyl groups attached.
This is called 2,3 dimethyl butane.

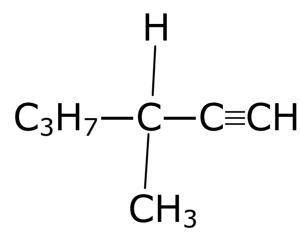


The 2,3 are indicating that the two methyl groups attach to the second and third carbon of the butane chain.
We say “dimethyl” rather than 2 methyl, 3 methyl, by formal rules.



Above is a much bigger branched chain hydrocarbon. The longest chain is 8 carbons, left to right, down and to the bottom right corner. That means that connected from the 4th carbon (the only C with no hydrogen atoms next to it) has a methyl group above and an ethyl group to the right.
This is 4-ethyl, 4-methyl octane.

This last one is 3 methyl,1-hexyne. The methyl group is attached to the third carbon in a chain that has a triple bond on the number one carbon.



Multiple chains can be attached, and get prefixes like tri-methyl, or 2, 4, 5 tri-ethyl octane, etc.

Organic Reactions

There are many organic chemical reactions to learn about, but we will focus on six of them. As a reminder, you already are supposed to remember these... synthesis, decomposition, single replacement, double replacement, combustion, and acid base neutralization already.

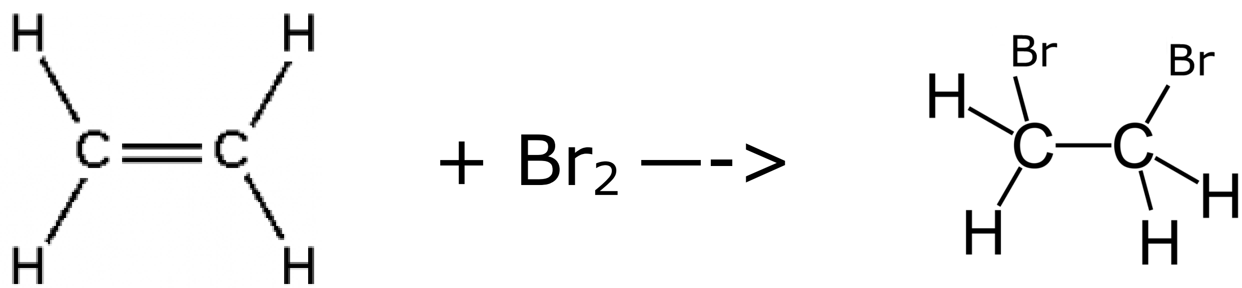
Organic Reactions you need to learn are called
ADDITION, SUBSTITUTION, ESTERFICATION, POLYMERIZATION, FERMENTATION, and SAPONIFICATION.

Here goes…

Addition Reactions

When an unsaturated hydrocarbon (alkenes and alkynes) combine with halogen molecules (F_2, Cl_2, Br_2, or I_2) they can join, or be added together into a bigger molecule.

A double bond will open up, allowing a pair of atoms to join the molecule. For example, ethene can open up under certain chemical circumstances and allow a halogen molecule to join, one halogen atom per carbon, as follows:



NOTE: one bromine atom joins each carbon that was part of the double bond that broke open. Both bromine atoms would not join just one carbon, [which would form the compound 1,1 di bromo ethane].

This addition process would work with a triple bond opening up to become a double bond, allowing a pair of atoms to add into the original molecule.

Addition works only with unsaturated hydrocarbons, and only will allow for the addition of 2 atoms each time. Trying to add a single atom would leave a carbon "unbonded", which would be so unstable that the reaction would not likely even happen.

Substitution Reactions

If you have a saturated hydrocarbon (alkanes) and wanted to add in some atoms (halogens are easy to use), the alkane could not accept more atoms into the compound, the alkanes are SATURATED, all full up. Rather than add the new atoms in, they can allow a hydrogen atom to be substituted out to make room for a new atom.

This works only for ONE ATOM per reaction. Watch how methane takes in chlorine through four reactions, and forms new halocarbons each time.

$$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$$
$$CH_3Cl + Cl_2 \rightarrow CH_2Cl_2 + HCl$$
$$CH_2Cl_2 + Cl_2 \rightarrow CHCl_3 + HCl$$
$$CHCl_3 + Cl_2 \rightarrow CCl_4 + HCl$$

One atom of chlorine at a time can be substituted into the alkane. Each time the bumped out hydrogen finds the "lonely" chlorine atom left by its twin.

Esterification Reactions

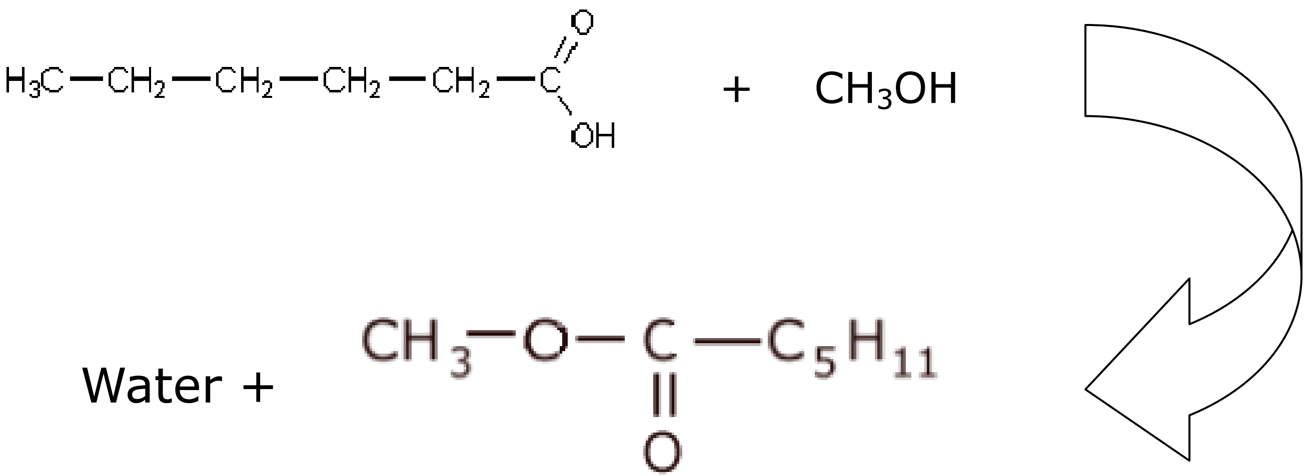
The formation of esters is wonderful, as many of them make our favorite smells, such as banana, berry, flowers, etc. To make an ester, this is the simple version:

Organic acid + alcohol $\longrightarrow$ ester + water

Water is removed by this reaction. When water is removed in a chemical reaction, this can also be called a hydrolysis reaction (the removal of water). Many reactions are hydrolytic, but this is not part of our course, just interesting!

If you combine:

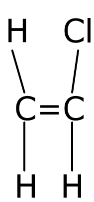
hexanoic acid + methanol —-> methyl hexanoate + water



Methyl hexanonate is what makes bananas smell like bananas.

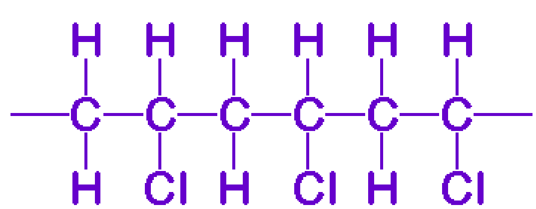
Polymerization

Poly means many. “Mer” means units or bodies. A polymer is a long chain of repeating units, all bonded together. Many plastics are polymers, such as polyethelene, polyester, poly vinyl chloride, Kevlar, Teflon, polystyrene, etc. Normal polymers, such as polyethelenes are about 2000 units long. They form fibers, that weave together, creating a variety of plastic substances.



Chloroethene is a compound that can be induced to break open the double bond between the carbons. If this happens to many chloroethenes, all at once, they will all form chloro ethane, and link up, one right after another, creating what we call PVC, also called poly vinyl chloride plastic (white plumbing pipe).

Three units of chloroethane are shown linked here at right. The bonds off the right and left are openings for this repeating polymer to continue to grow. Polymers can be of an length.



Fermentation

The process of fermentation has had profound effects on all societies of the world. Since being discovered, man has been making alcohol to consume. This has led to the gamut of celebration to disease and death, social and religious experiences to violence, to temperance and outright banning, to boot legging. It's all organic chemistry to those educated enough to grasp it. You are that bright and that educated.

Sugars can be broken down by yeast, in a non-aerobic energy release, called fermentation. The waste products of this energy producing reaction are carbon dioxide and ethanol, the alcohol that people consume. Proper balance of sugar and fruit flavors, and time, will yield cheap or very expensive champagnes, and other alcoholic solutions.

Although this is very well controlled by humans, they still need the yeast to do the real work! They provide the enzymes that break down the sugars to release energy. It's the waste products of theirs that are what humans are seeking!

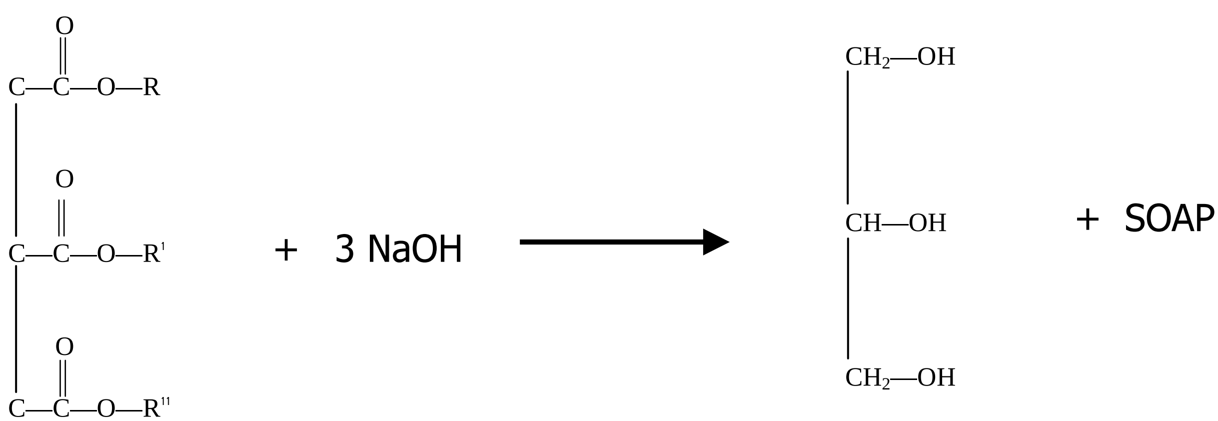
$$C_6H_{12}O_6 \xrightarrow{\text{ENZYMES}} 2CO_2 + 2C_2H_5OH$$

We will use the fermentation of glucose to be our example. Many other types of sugars like fructose, maltose, etc. are fermented, the balancing is complicated and we're only peeking at fermentation.

Saponification Reactions

If you misspell this reaction, and type the first four letters this way: S-O-A-P, you realize that this reaction produces soaps. It's that easy, and that difficult!

A triple ester combines with three strong bases (say 3 KOH) and yields a triple alcohol plus SOAP. Soap reactions are fairly complex.

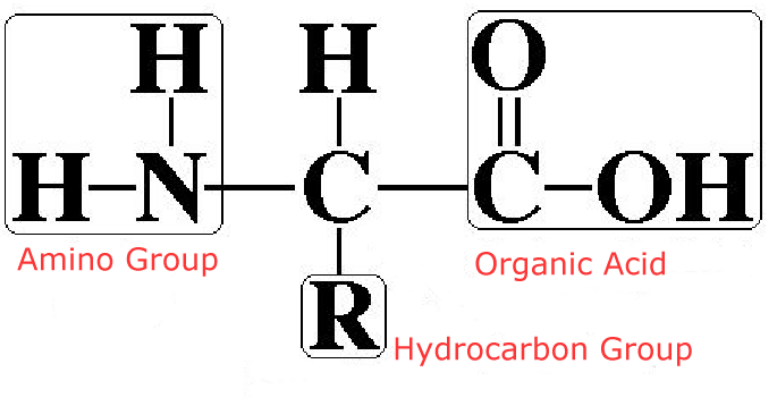


TRIPLE ESTER (note the ester groups)	+	Strong Base	→	TRIPLE ALCOHOL (glycerol)	+	SOAP

Learn to recognize the TRIPLE ester, TRIPLE alcohol and REMEMBER SOAP = SAPONIFICATION.

Amino Acids

Making amino acids are also a bit outside our class, but what they are is not. Amino acids make up proteins and all of the most important chemistry of living organisms. They combine an amine group compound with an organic acid. This slide is from the internet, and is excellent in simplicity and clarity. Open your brains up now…

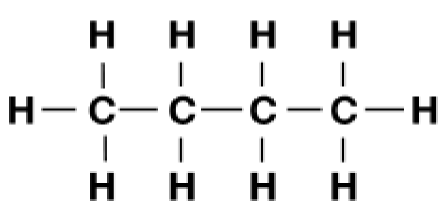


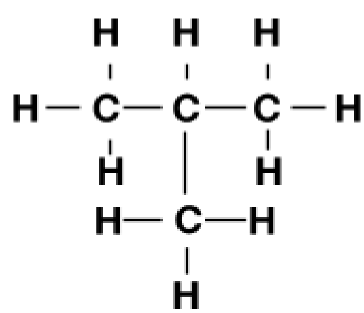
VOCABULARY WORDS...

Isomers: isomers are organic molecules that share exact chemical formulas (also called molecular formulas), and therefore have the exact same numbers of the same atoms in their individual compounds, but they have DIFFERENT STRUCTURES, which also gives different properties.

Examples:

Butane can be drawn as a straight chain, or as a branched chain. The straight chain can be called n-butane (for normal). The second compound can be called isobutane (isomer of butane). We call them butane and methyl propane by IUPAC formal rules.





Hexane with 6 carbon atoms has 5 isomers (try to draw them!)

n-hexane		2 methyl pentane
3 methyl pentane	2,3 dimethyl butane	2,2 dimethyl butane

Isomers, continued

Hydrocarbon alkane chains with $C_{10}H_{22}$ have 75 isomers. $C_{20}H_{42}$ has 366,319 isomers. $C_{30}H_{62}$ has an incredible 4,111,846,763 isomers! (that's BILLIONS!) They have not all been made, but they are all possible!

Imagine adding in a few halogen atoms here and there, or functional groups, or multiple functional groups. Organic chemistry is ENDLESS!

Other important isomers include how ETHERS and ALCOHOLS are isomers with each other. Count the number of carbons in the ether (both sides) and that is how many carbons total up in the alcohol. Examples:

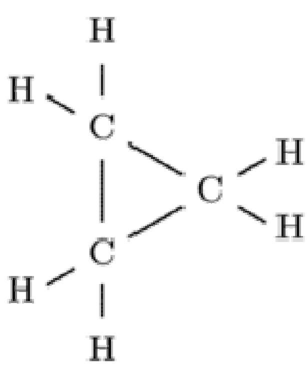
Dimethyl ether (2 carbons) = ethanol Chemical Formula C_2H_5OH

Methyl ethyl ether (3 carbons) = propanol Chemical Formula C_3H_8O

Diethyl ether (4 carbons) = butanol Chemical Formula $C_4H_{10}O$

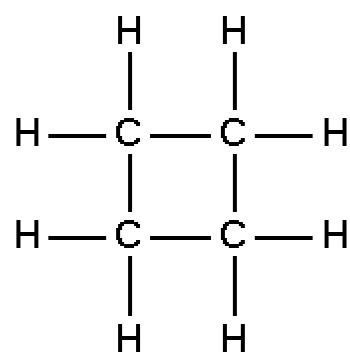
Ring Hydrocarbons

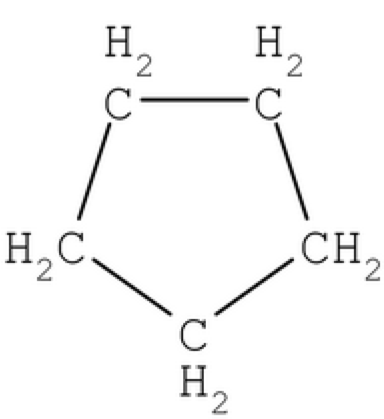
Besides chains and chains with functional groups, hydrocarbons can form rings of various sizes, say 3, 4, 5, or 6 or more carbons all bonded together with single or double bonds. Various functional groups, methyl, ethyl, etc. groups can also bond. This is not in our class, but really neat and important to organic chem as well. The prefix cyclo– is used.



Cyclopropane

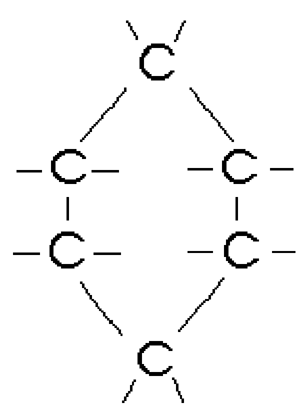
Cyclobutane





Cyclopentane

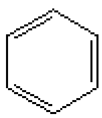
Cyclohexane



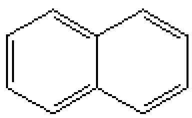
Benzene Rings are extremely important to organic chem but again, not to our class. This is optional but worthwhile.

Benzene is a 6 carbon ring structure with alternating double and single bonds. These bonds “resonate” back and forth with each other constantly. They act as if there are always 1½ bonds between each carbon (but this is complicated to describe here).

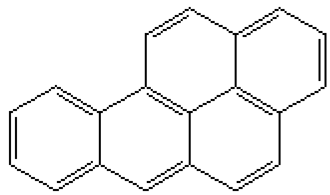
The benzene rings combine to all sorts of groups and to other rings.
Below are a variety of ring structures (there are millions more!). Enjoy.



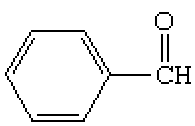
benzene



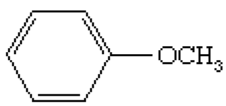
naphthalene



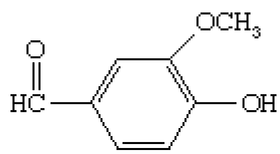
benz[a]pyrene



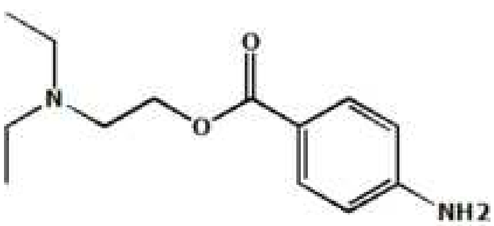
benzaldehyde



anisole



vanillin



At left is NOVOCAINE, what your dentist gives you when you need a filling. You should recognize most of that molecule, with all the hidden carbons & hydrogen atoms.

At the bottom is epinephrine, the chemical that gets pumped into your blood when you are confronted with a wild dog about to bite your leg, or when you get nervous before you take your first high dive! Double bonds, alcohols, amines, benzene rings, etc. You recognize it all too, even if naming this funky molecule seems difficult. It’s all just C, H, O, N, and some single and double bonds.

Organic chem is every where!