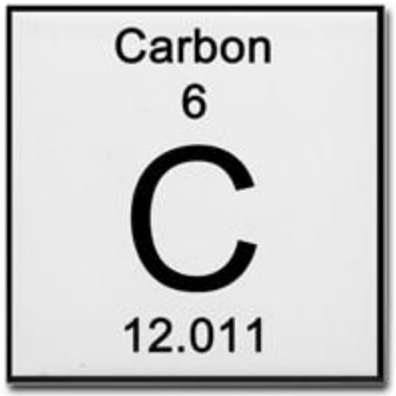
Organic Chemistry Basics

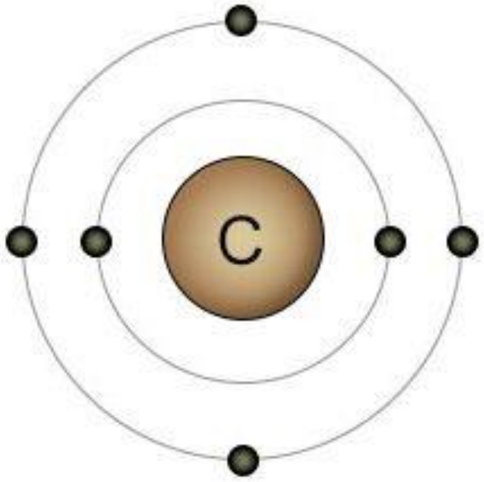
SBI4U

MS. FRANKLIN

Carbon –Backbone of Biological Molecules

Organic Chemistry is the study of compounds that contain carbon-hydrogen bonds. Carbon is an important element that is present in all biological molecules, for example, macromolecules.

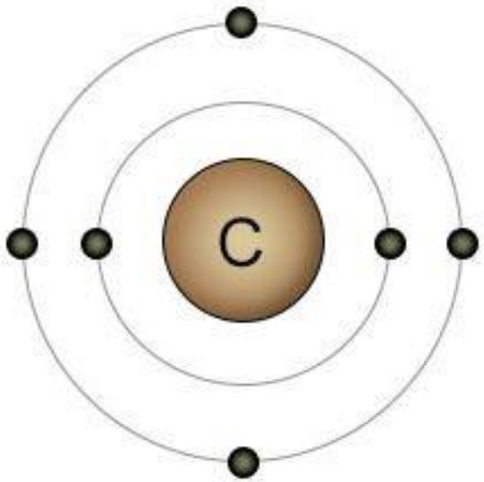


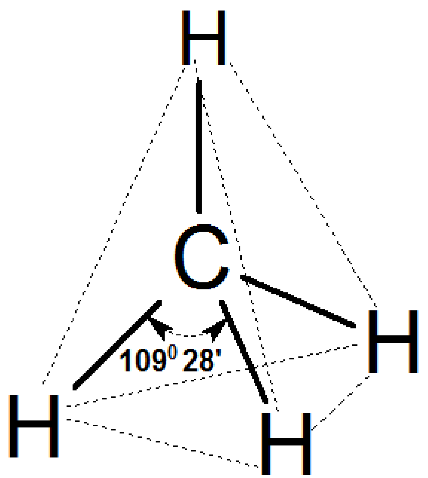


*All compounds that contain carbon are known to be **'organic compounds'**. Most of these organic molecules contain hydrogen atoms attached to the carbon element.*

Carbon –Backbone of Biological Molecules

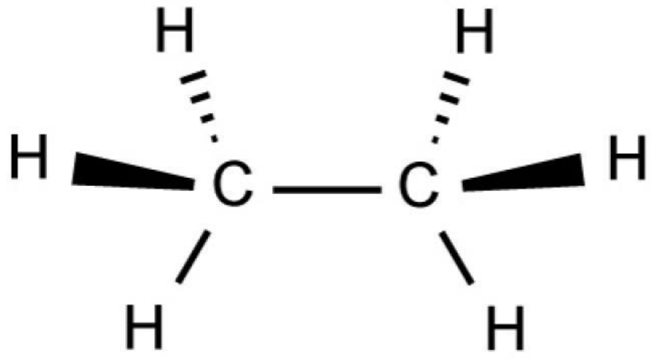
Carbon has four valence electrons and is in turn able to form four covalent bonds ***'tetravalence'.*** This enables carbon to create complex molecules.





CH_4 (methane)

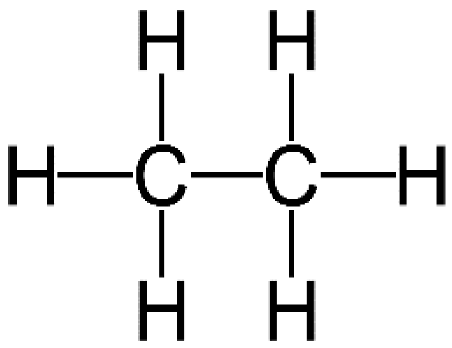
Due to its tetravalence, carbon usually forms a tetrahedron with angles of 109.5°.

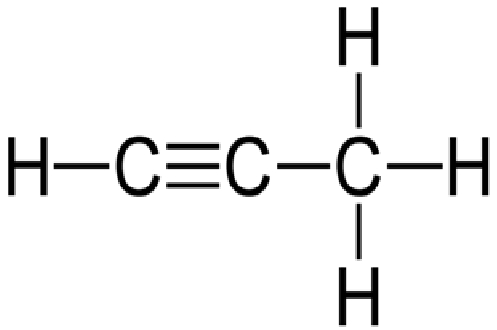


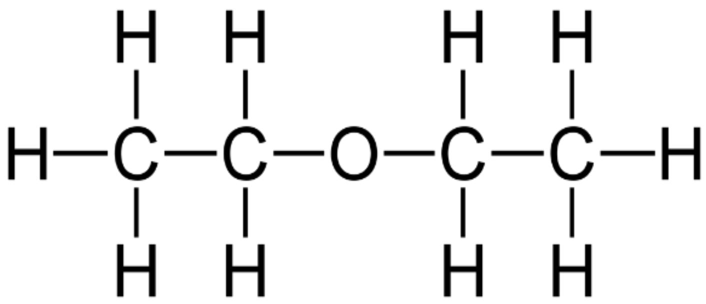
C_2H_6 (ethane)

Carbon –Backbone of Biological Molecules

Carbon atoms always form four bonds, as shown below.

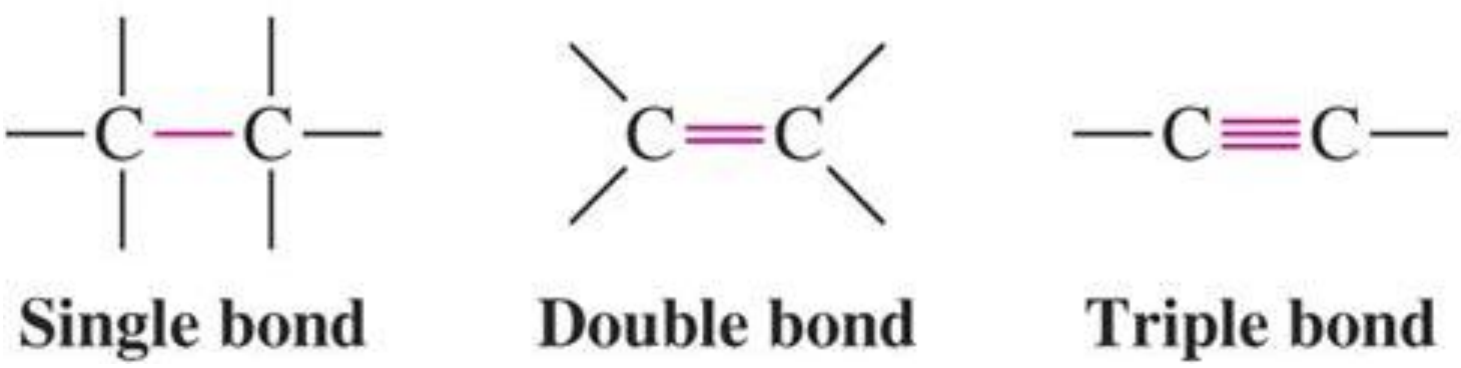




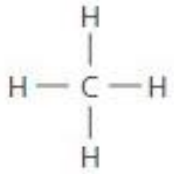
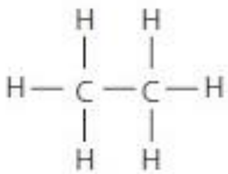
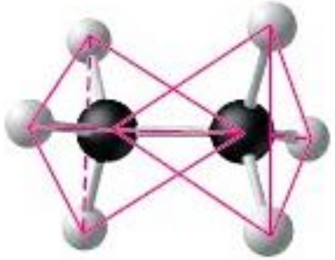
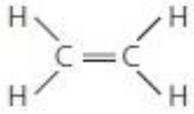
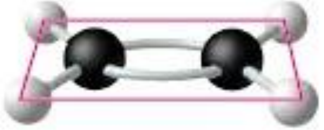


Carbon – Carbon Covalent Bonds

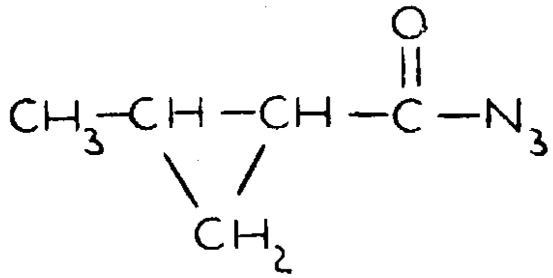
Due to its tetravalence, carbon atoms are able to join with one another and form single, double or triple bonds. Depending on the type of bond formed, the shape of the molecule will change.



Shapes of Simple Organic Molecules

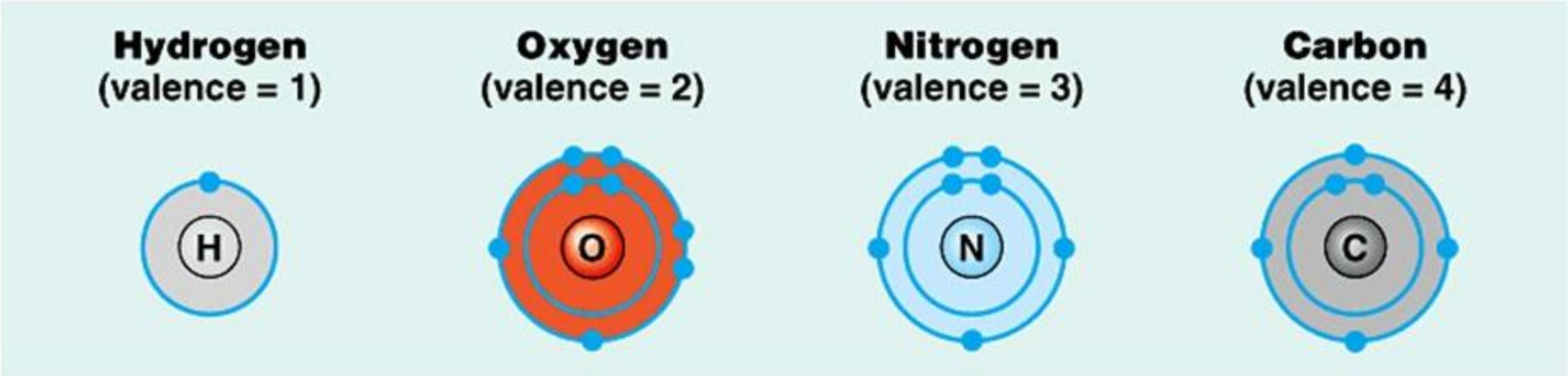
Name and Comment	Molecular Formula	Structural Formula	Ball-and-Stick Model (molecular shape in pink)
(a) Methane. When a carbon atom has four single bonds to other atoms, the molecule is tetrahedral.	CH_4		
(b) Ethane. A molecule may have more than one tetrahedral group of single-bonded atoms. (Ethane consists of two such groups.)	C_2H_6		
(c) Ethene (ethylene). When two carbon atoms are joined by a double bond, all atoms attached to those carbons are in the same plane; the molecule is flat.	C_2H_4		

The 3D shape of an organic molecule will change depending on the carbon-carbon bonds.



Major Elements in Organic Molecules

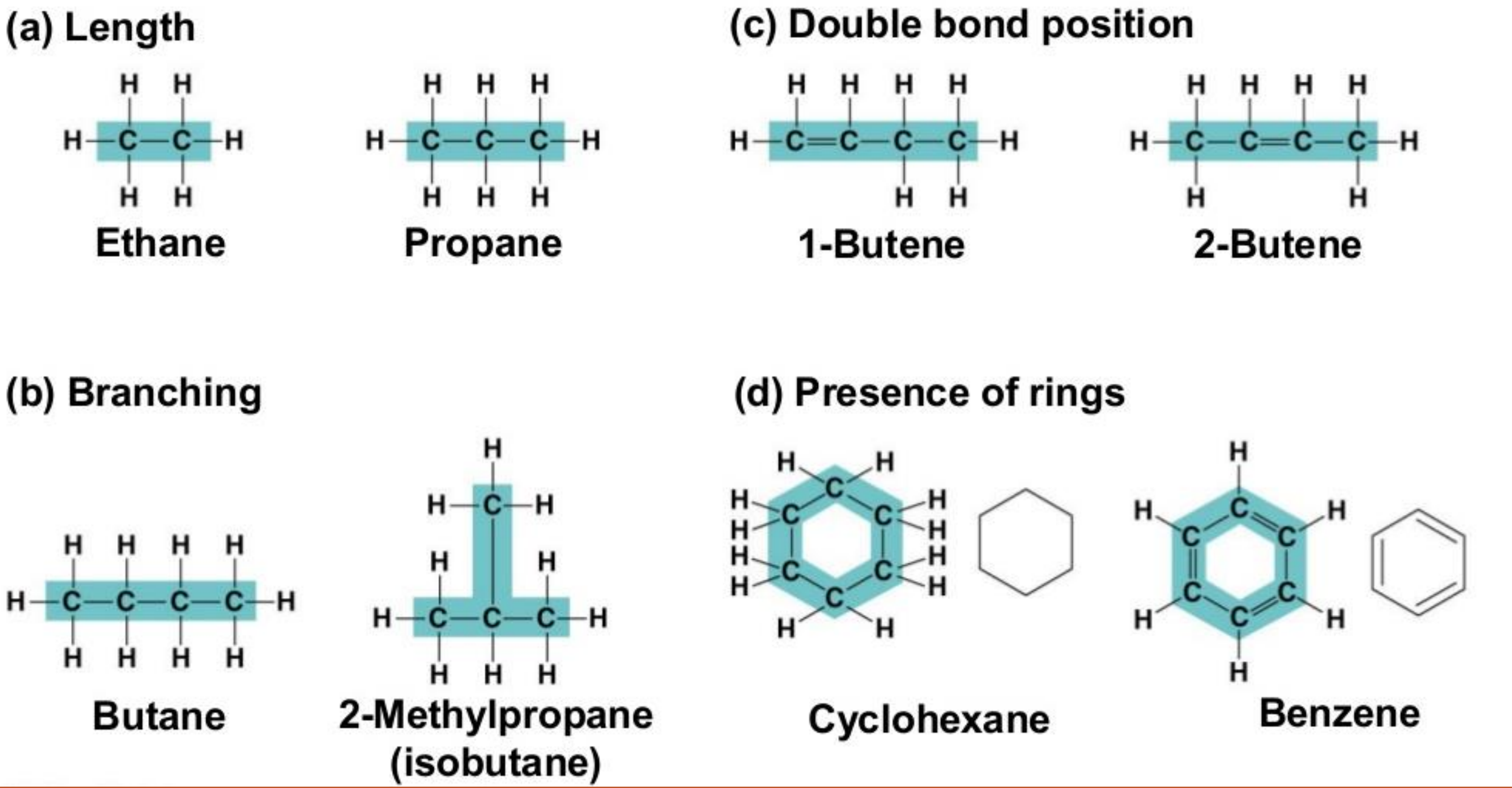
Due to its tetravalence, carbon atoms tend to bind to one another or to three other common elements; ***hydrogen, oxygen and nitrogen.***



Hydrocarbons: *organic molecules consisting only of carbon and hydrogen.*

Carbon Skeleton Variation

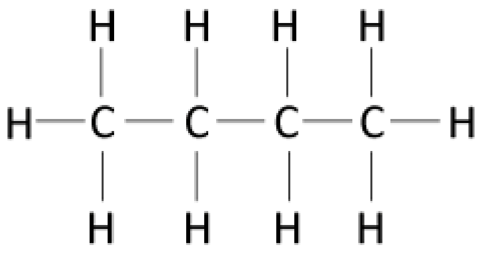
Carbon chains can vary in terms of their length, bonds, branching and ring structures. The differences enable each of the molecules to play a different role in a biological system.



Unsaturated carbon chains may contain ***double or triple bonds*** *between the carbon atoms.*

Saturated vs. Unsaturated Carbon Chains

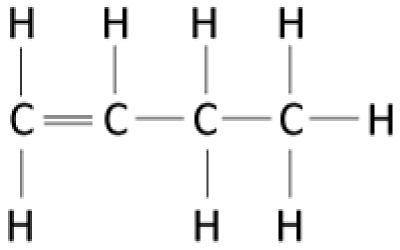
Saturated



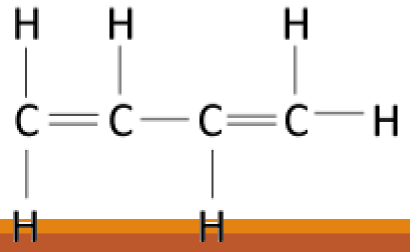
(C_nH_{2n+2})

alkane

Unsaturated

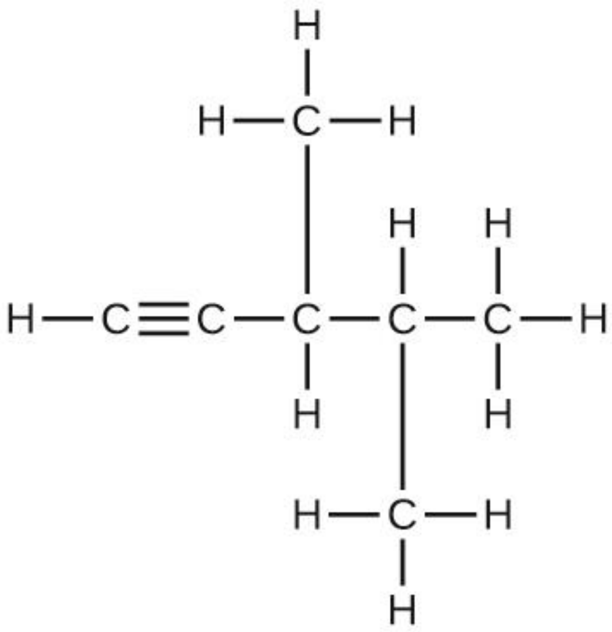


Polyunsaturated



(C_nH_{2n})

alkene



(C_nH_{2n-2})

alkyne

Checking for Understanding

Which of the following hydrocarbons has a double bond in its carbon skeleton?

A) C_3H_8

B) C_2H_6

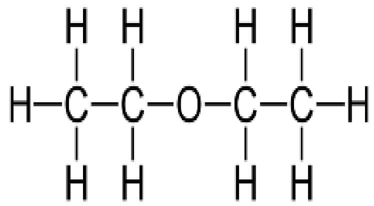
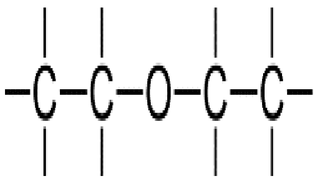
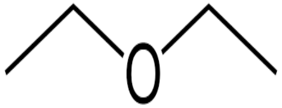
C) CH_4

D) C_2H_4

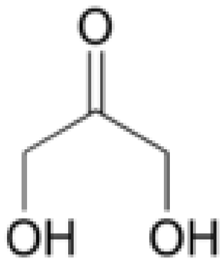
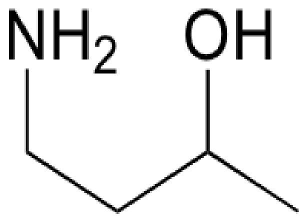
E) C_2H_2

Representing Organic Molecules

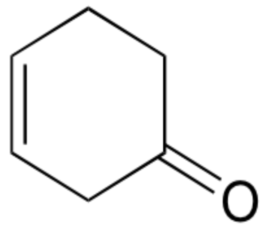
Considering that C and H atoms are the basis of every organic molecule, it is not necessary to draw them out every single time. There are other simplified methods that can be used to represent organic molecules.

Molecular Formula	Structural Formula	Modified Structural Formula	Line Diagram (skeletal Formula)
$C_4H_{10}O$			

Let's Practice

Line Diagram	Structural Formula	Molecular Formula
		
		

Let's Practice

Line Diagram	Structural Formula	Molecular Formula
		

Isomers

Isomers are compounds that share the same molecular formula. Thus, the molecules will have the same types and number of elements, but the manner in which they are arranged will differ.

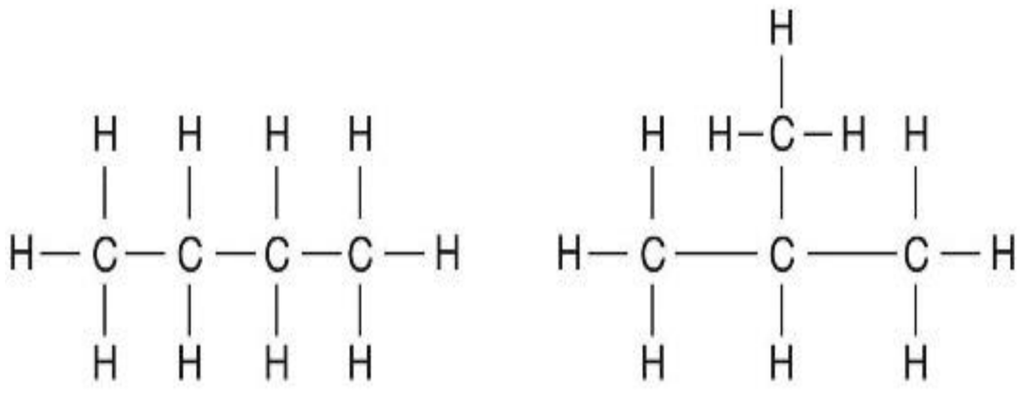
<u>Three Types of Isomers:</u>

1. **Structural Isomer:**

2. **Geometric Isomer:**

3. **Enantiomers:**

1. Structural Isomers



Butane Isobutane

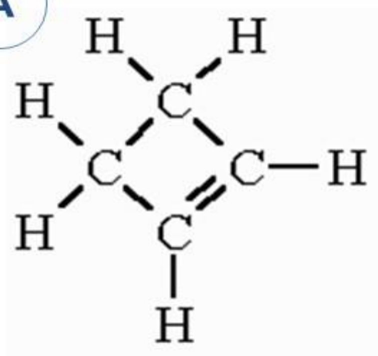
Butane and isobutane are two compounds that have the exact same molecular formula.

What is the molecular formula?

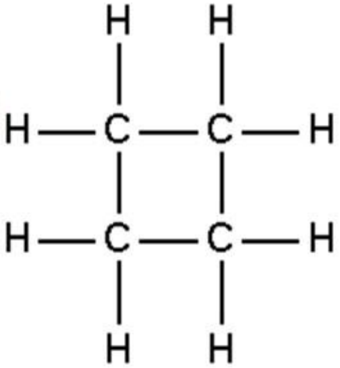
1. Structural Isomers - Practice

Circle the molecules that are isomers. (Hint: Determine the molecular formula)

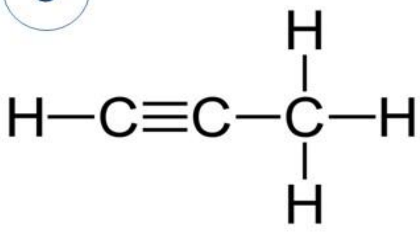
A



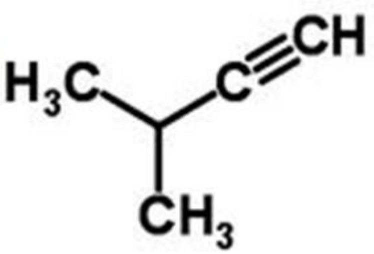
B



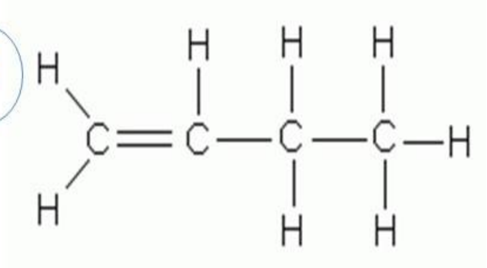
C



D



E



1. Structural Isomers – Practice

There are five isomers of hexane (C_6H_{14})... **How many can you draw?**

Additional details: there are only single bonds, and there are no ring structures.

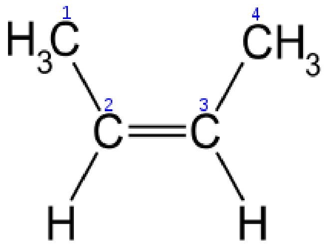
2. Geometric Isomers

Geometric isomers are also known as ***'cis-trans isomers'.*** The double or triple bond can change the orientation of substituent groups.

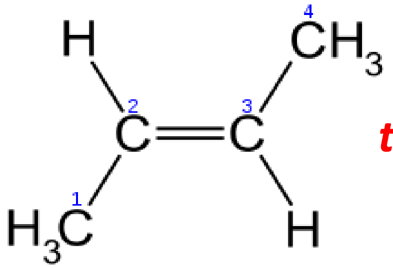
cis = Groups are on same side

trans = Groups are on different sides

Ex. 1

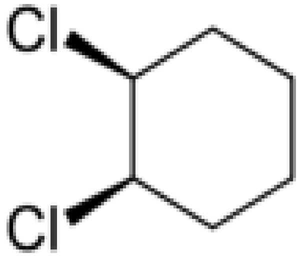


cis-2-butene

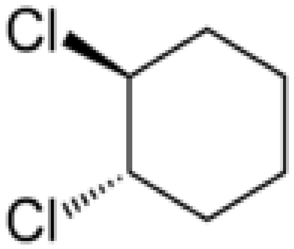


trans-2-butene

Ex. 2



cis-1,2-dichlorocyclohexane

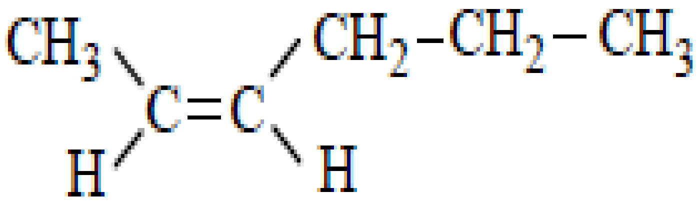


trans-1,2-dichlorocyclohexane

2. Geometric Isomers – Practice

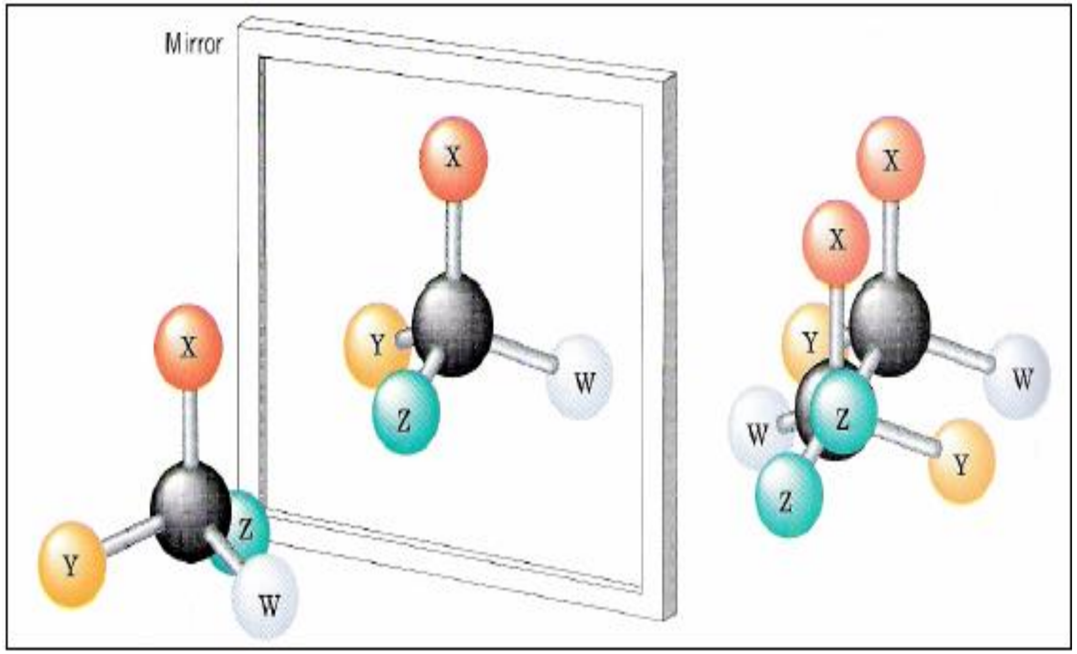
1. Complete the name of this cis/trans isomer.

2. Draw and name the other geometric isomer of this molecule.

	
______ - 2- hexene	______ - 2- hexene

3. Enantiomers

Enantiomers differ in their arrangement of atoms around the chiral carbon. A ***chiral carbon*** is bonded to four different atoms.

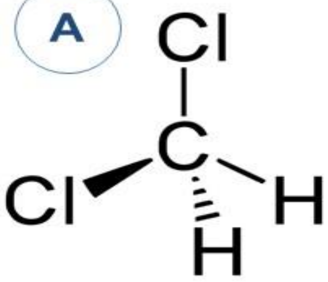


Because they are mirror images of one another, they cannot be superimposed.

3. Enantiomers – Practice

Circle the molecules that can have enantiomers.

A



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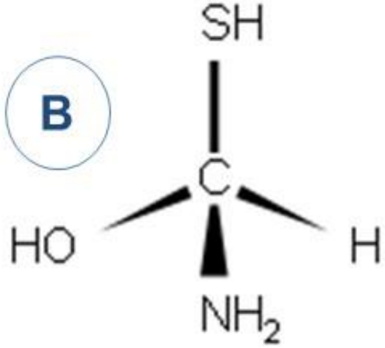

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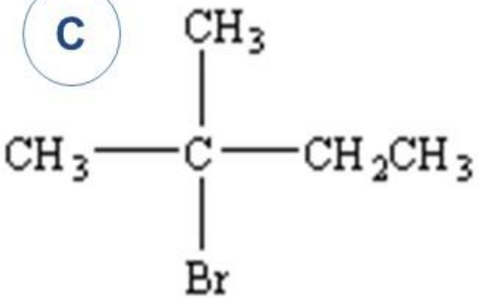

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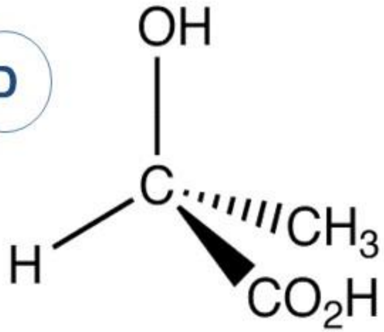
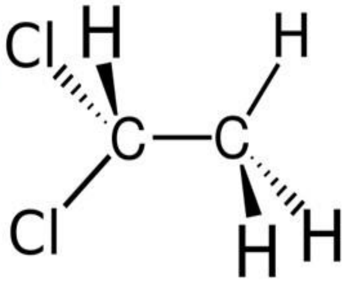


E



Homework

- Complete the worksheets given in class