Handedness: What makes your hands or your feet have handedness?

Does the large LEGO minifigure have a right hand?

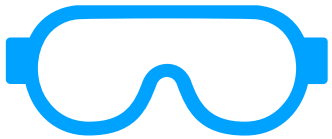
Handedness: What makes your hands or your feet have handedness?

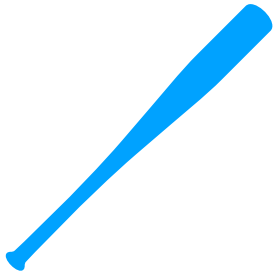
Try again… Does the large LEGO minifigure have a right arm?

The mirror image of a chiral object is not superposable on the original object

Which of the following are chiral?

Think about the object, not the drawing



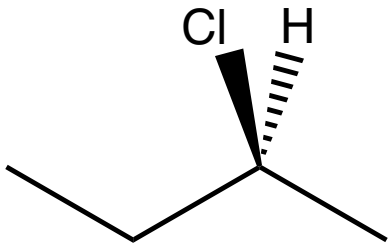

Build

2-chlorobutane

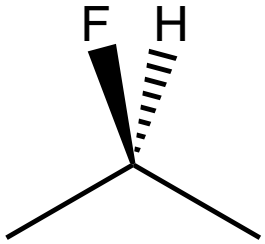
2-fluoropropane

The mirror image of a Chiral Object is not superposable on the original object

A chiral object cannot have an internal mirror plane (a.k.a. plane of symmetry)*



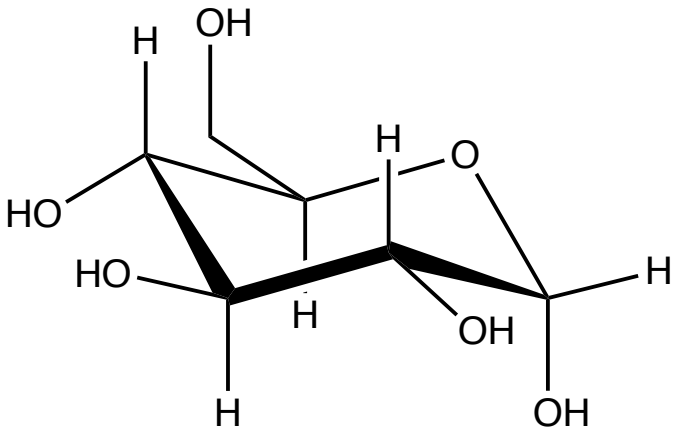
vs



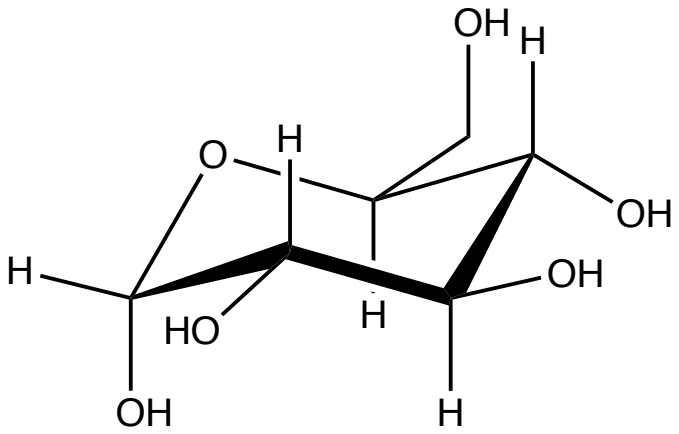
*Technically, it's an improper axis of rotation, but a mirror plane is an S_1 and a center of inversion is an S_0, and almost every point group that contains an S_n axis also contains a mirror plane of some sort. The S_4 point group is only point group that has an improper axis of rotation and doesn't also have a plane of symmetry. The Ci point group is the only point group that has a center of inversion and doesn't also have a plane of symmetry.

Why Do I care?

Section 5.1 – 5.5

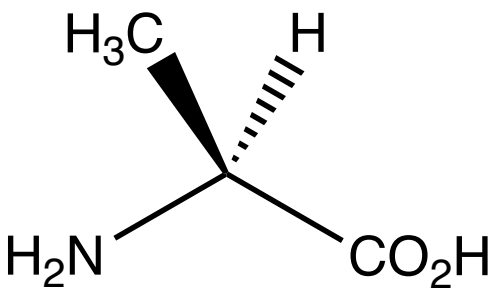


D-glucose
11¢ per gram

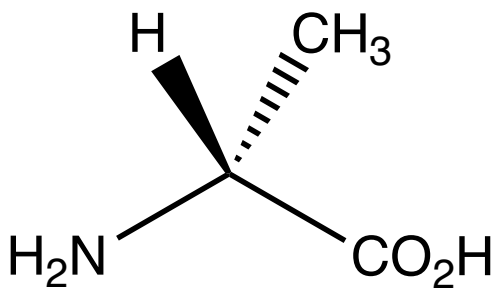


L-glucose
$130 per gram

Fisher Scientific, 2024



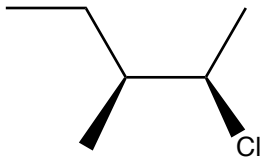
L-alanine

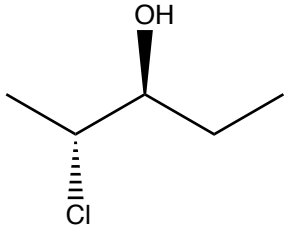


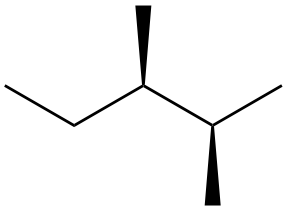
D-alanine

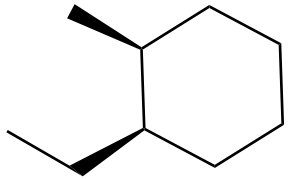
Practice Recognizing centers of chirality

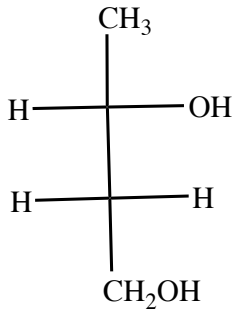
Section 5.1 – 5.5

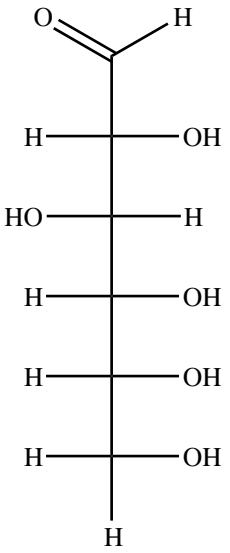












Definitions

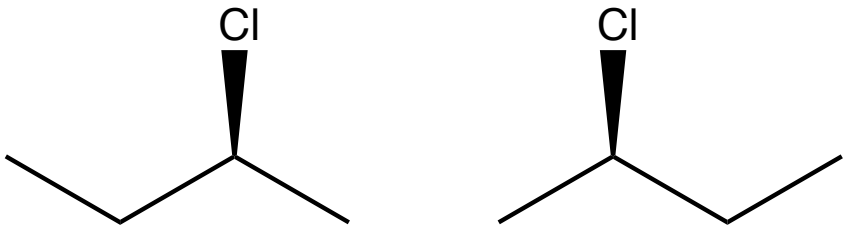
stereoisomers are molecules that have the same connectivity but different 3-D relationships between parts of the molecules

e.g. (*R*)-2-chlorobutane vs (*S*)-2-chlorobutane

The word **enantiomer** describes the relationship between two stereoisomers.

enantiomers are stereoisomers that are nonsuperposable mirror images of each other and an object must be chiral to have an enantiomer

e.g. (*S*)-2-chlorobutane vs (*R*)-2-chlorobutane



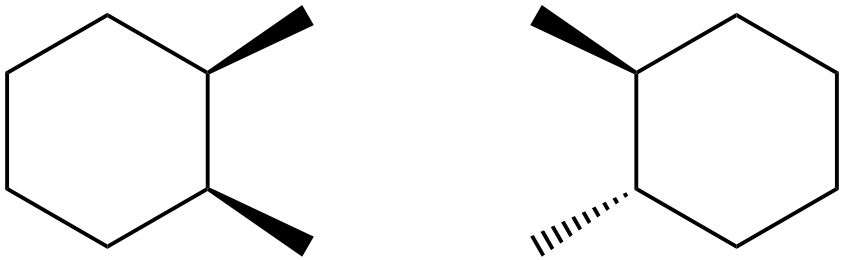
Definitions

stereoisomers are molecules that have the same connectivity but different 3-D relationships between parts of the molecules

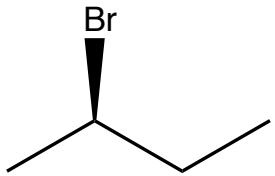
e.g. (*cis*)-1,2-dimethylcyclohexane vs (*trans*)-1,2-dimethylcyclohexane

The word **diastereomer** describes the relationship between two stereoisomers.

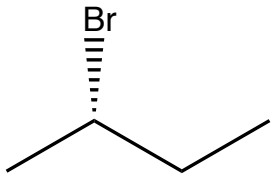
Diastereomers are stereoisomers that are nonsuperposable but are **NOT** mirror images of each other



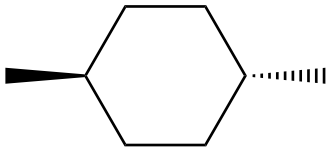
Recognizing Enantiomers and Diastereomers: Why is it important?



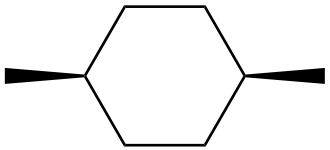
BP = 91 °C



BP = 91 °C*



BP = 119 °C†

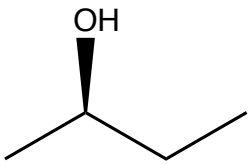


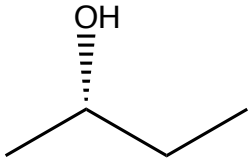
BP = 125 °C††

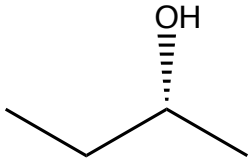
*https://en.wikipedia.org/wiki/2-Bromobutane
†https://us.vwr.com/store/product/16811100/trans-1-4-dimethylcyclohexane-95-0-by-gc
††https://us.vwr.com/store/product/9559540/cis-1-4-dimethylcyclohexane-98-0

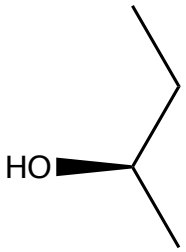
What's the Relationship?

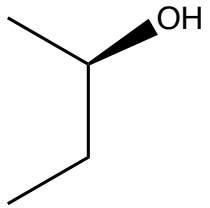
Section 5.1 – 5.5











different view of the same molecule/rotamer or enantiomer or diastereomer

Assign Priorities

highest priority is given to the group with the highest atomic number for the atom directly bonded to the chirality

in a tie, consider the atomic numbers of the atoms attached to the atom that is bonded to the chirality center

if the atom that is attached to the chirality center has a doubly bonded or triply bonded atom attached to it the atom is treated like there are two or three atoms

for isotopes, the mass number is used (D vs H, 12C vs 13C)

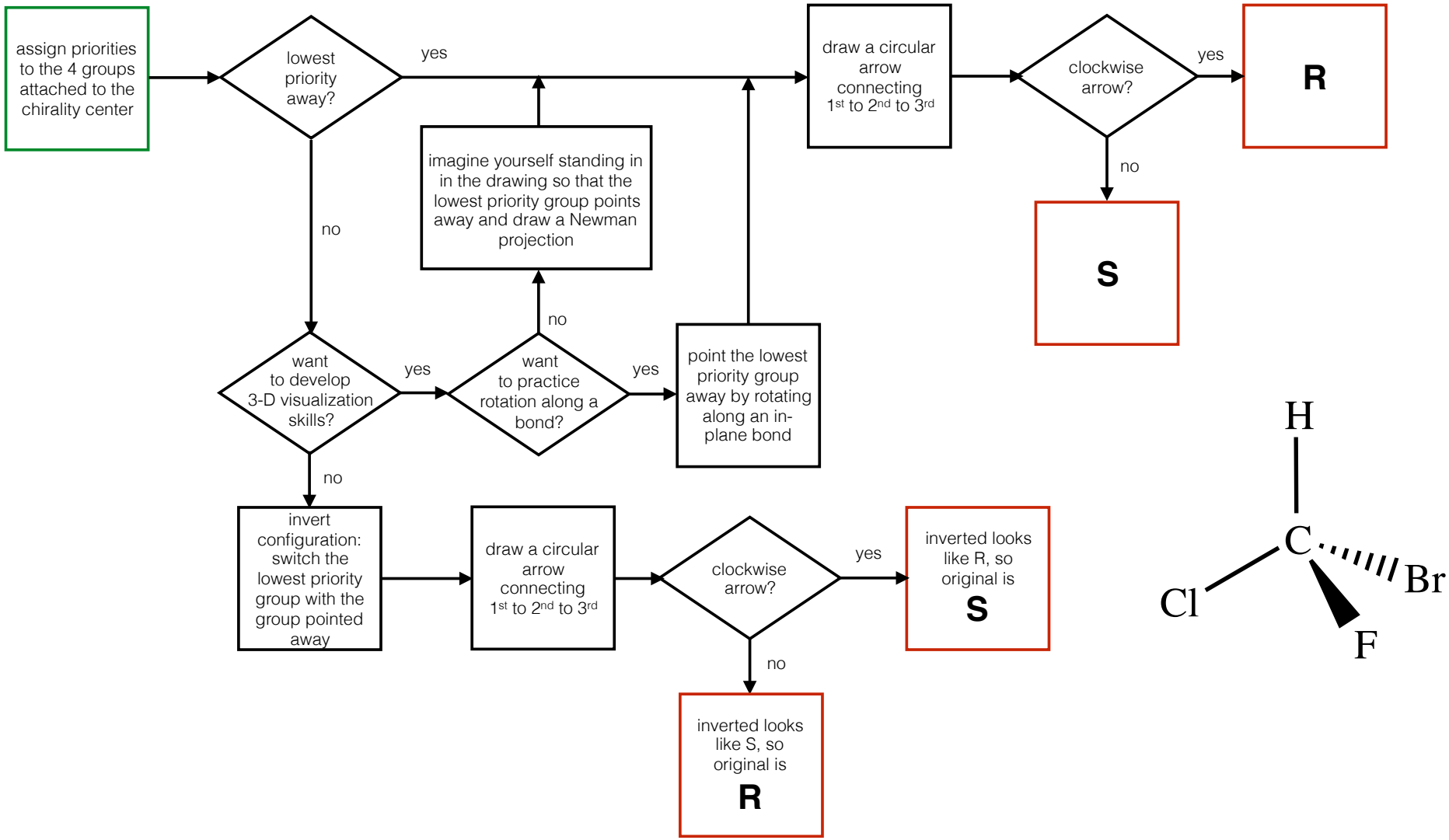
Point lowest priority group away

Draw a circle from 1st to 2nd to 3rd priority groups

Clockwise circle is **R** configuration

Counter Clockwise circle is **S** configuration

Determining Configuration (*R* vs *S*)

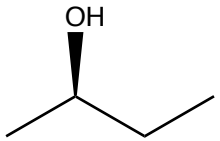


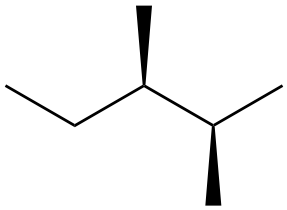
Practice determining the configuration of centers of chirality Section 5.1 – 5.5

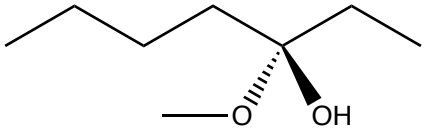
Priorities are based on the atomic number of the atoms bonded to the chiral center.

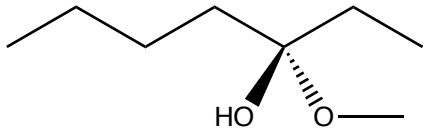
Highest atomic number is 1st place to lowest atomic number in 4th place

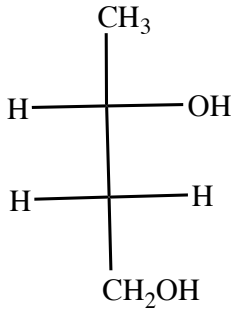
In a tie, go one bond further out.

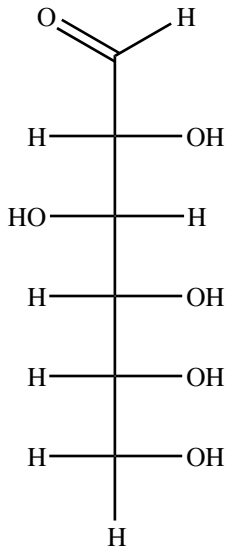




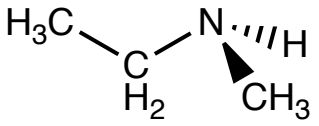


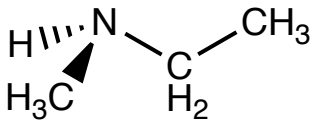


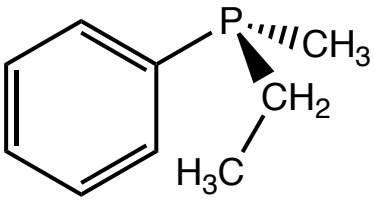

CH3
H
OH
H
H
CH2OH

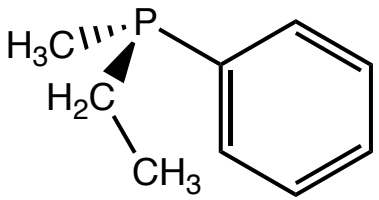

O
H
H
OH
HO
H
H
OH
H
OH
H
OH
H

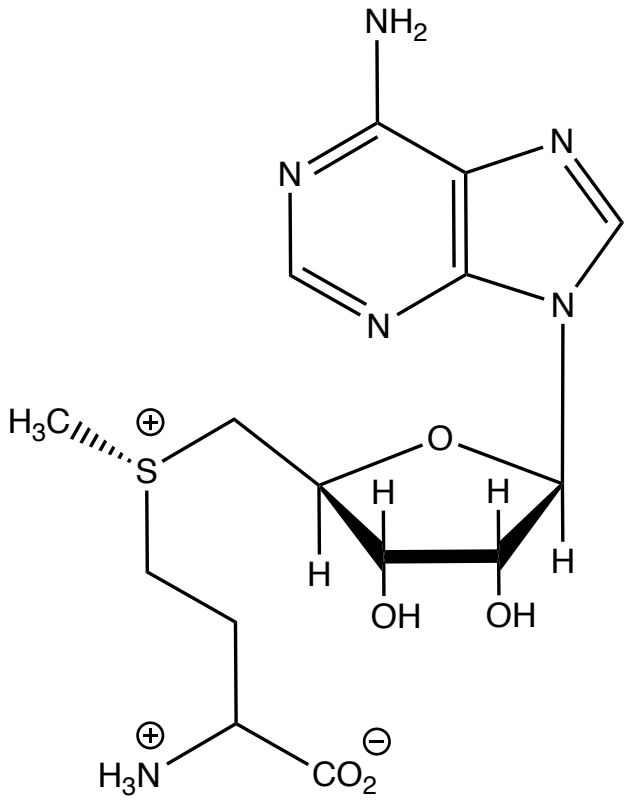
N and P Chirality Centers?





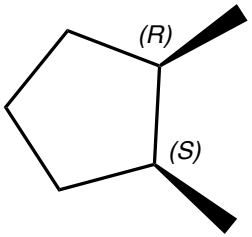


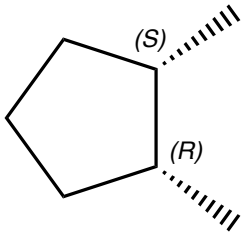


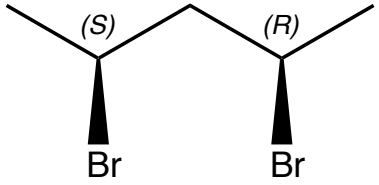


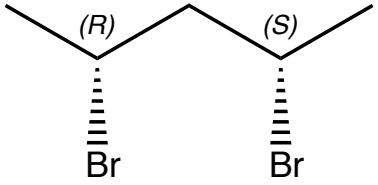
(*S*)-S-adenosylmethionine

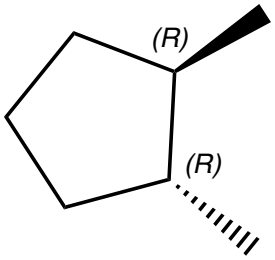
Enantiomers		Diastereomers
molecules that are **nonsuperposable** and **mirror images** of each other		molecules that have the same connectivity and are **nonsuperposable** but **NOT mirror images** of each other
The relationship can be identified using *R*,*S* system of nomenclature		
If all chirality centers in a chiral molecule have opposite configurations and Z,E alkenes, if present, remain the same There's a big BUT…		In molecules with more that one chirality center at least one pair but not all pairs of chirality centers have opposite configurations. In molecules with stereogenic alkenes (*Z*/*E* configuration) the alkenes have opposite configurations

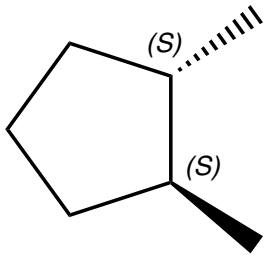

(R)
(S)

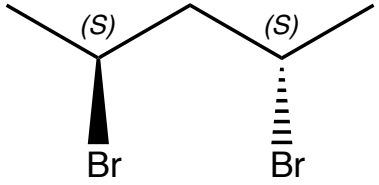

(S)
(R)

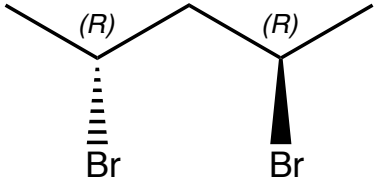

(S)
(R)
Br
Br


(R)
(S)
Br
Br


(R)
(R)

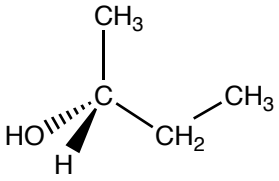

(S)
(S)

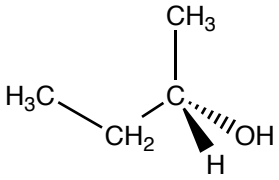

(S)
(S)
Br
Br

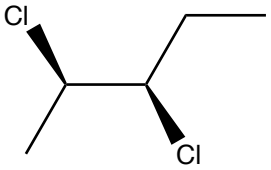

(R)
(R)
Br
Br

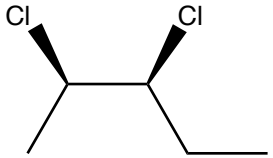
Enantiomers		Diastereomers
molecules that are **nonsuperposable** and **mirror images** of each other		molecules that are stereoisomers **nonsuperposable** but **NOT mirror images** of each other
The relationship can be identified using *R*,*S* system of nomenclature		
If all chirality centers in a chiral molecule have opposite configurations and Z,E alkenes, if present, remain the same Unless the compound is a meso complex Can occur when chirality centers have the same four different groups bonded to each chirality center		In molecules with more that one chirality center at least one pair but not all pairs of chirality centers have opposite configurations. In molecules with stereogenic alkenes (*Z*/*E* configuration) the alkenes have opposite configurations. In a chiral cyclic molecules with *cis*/*trans* relationships the *cis*/*trans* relationship changes

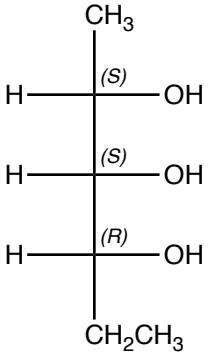
Practice Recognizing Relationships between molecules

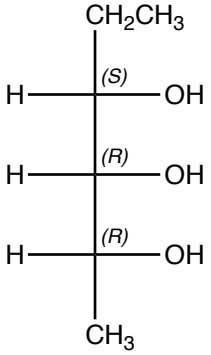


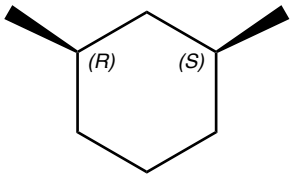


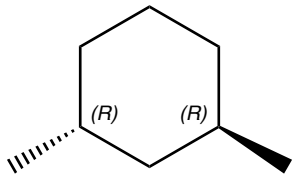


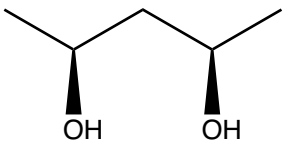


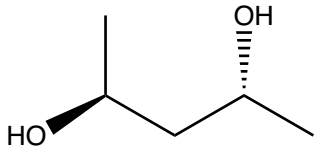


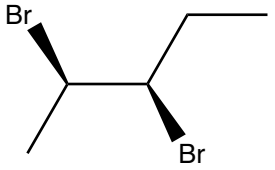


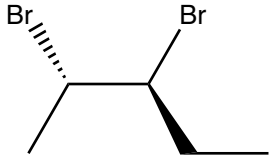












1. Draw a tetrahedral C atom

2. Assign priorities to the groups

3. Place the lowest priority group so that it points away

4. Draw in priority groups 1 through 3 in the correct (clockwise or counterclockwise) orientation.

(*R*)-2-chloropentane

(2*S*,3*S*)-2-bromo-3-chloropentane

1. Draw the molecule

2. Assign priorities and check if the correct configuration is drawn

3. a. If correct, celebrate, you're done

3. b. If incorrect version is drawn, redraw molecule switching the positions of 2 (and only two) substituents.

(*R*)-2-chloropentane

(2*S,3*S)-2-bromo-3-chloropentane