Tutorial 18: Chirality, Stereoisomers and Fischer Projections

Goals:

- ✓To learn about stereoisomers and the subcategories of stereoisomers: enantiomers and diastereomers.
- ✓To be able to recognize a chiral carbon and determine if a molecule exists as a pair of enantiomers.
- ✓To be able to interpret and draw molecules in Fischer Projection.

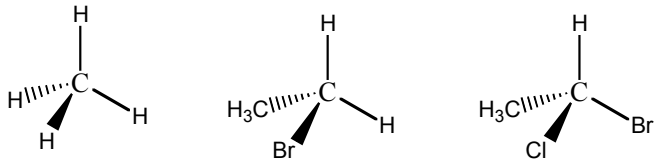
Chirality and Enantiomers

- Objects that have handedness are **chiral**. They can not be superimposed on their mirror image (see example below). Objects that can be superimposed on their mirror image are **achiral** (without chirality).

- The two mirror image forms of a chiral molecule are called **enantiomers**. Molecules that are related as enantiomers will share all of the same physical properties except optical activity and all of the same chemical properties except when reacting with other chiral compounds.

- If a molecule has an internal symmetry plane it is achiral. Thus, the lack of an internal symmetry plane indicates chirality. In the examples below we will determine which are chiral and which are achiral.

Examples:



Optical Activity

- Light travels in waves at all angles. Light can be plane polarized so that it travels only in one plane rather than at all angles. Whether light is plane polarized or not, it will appear the same to you and me!

- A chiral compound and its non-superimposable mirror image make up a pair of enantiomers. Enantiomers are often referred to as optical isomers because they are optically active, meaning that they rotate plane polarized light (PPL).

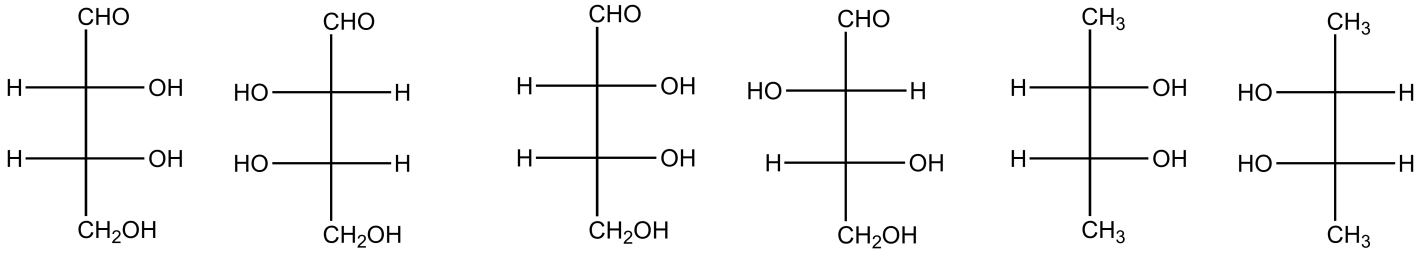
- An optically active molecule will rotate PPL either to the left (levorotatory) or the right (dextrorotatory). Two molecules that are related as enantiomers will rotate PPL the same number of degrees, but in the opposite direction!

Fischer Projections

- If a molecule has two or more chiral centers, life gets more complicated due to the presence of meso compounds and diastereomers. In an attempt to make life a little easier, we will always draw these molecules as Fischer Projections.

- In a Fischer Projection:
  - all chiral carbons are shown as the intersection of two perpendicular lines
  - the horizontal lines represent bonds that are coming out of the plane of the paper
  - the vertical lines represent bonds that are moving in to the plane of the paper

- In Fischer Projection, it is far easier to analyze the relationship between two molecules.



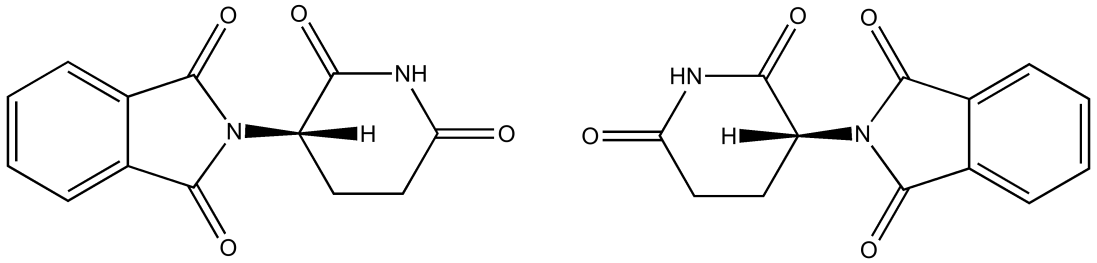
enantiomers diastereomers identical (meso)

- A meso compound contains two or more chiral centers, but has an ISP so it is achiral. Note that a meso compound can NOT have an enantiomer because it's mirror image will be superimposable (thus, it is identical to it's mirror image), but it can have diastereomers!

The Significance of Enantiomers

- Enantiomers react differently with chiral compounds. Life is made up of chiral compounds. Amino acids used for biosynthesis in animals are always of the L conformation. We can obtain energy only from the D forms of carbohydrates. Thus, enantiomers can be the difference between life and death!

- Enantiomers are important to:
  - Pharmaceutical companies
  - Agricultural industries
  - Food additive companies



- Thalidomide is a drug that is currently used in some cancer treatments, but in the 1960s it was an approved drug in Europe for the treatment of nausea, especially for pregnant women. The enantiomer shown above on the right (R-thalidomide) is responsible for the therapeutic affect of the drug. Unfortunately, the enantiomer shown above on the left (S-thalidomide) is a teratogen. It interferes with the development of fetal blood vessels and causes severe birth defects.

Summary of Isomers