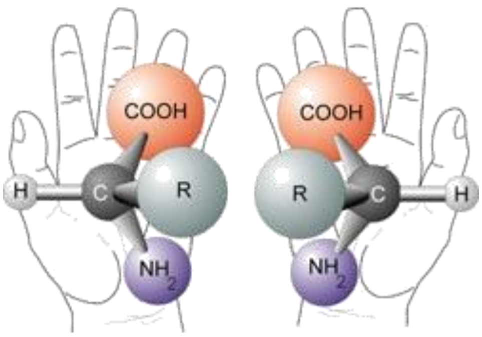
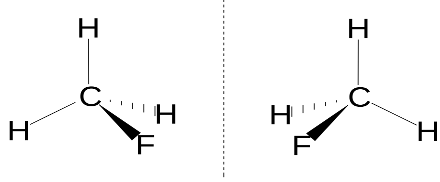
F1- Optical Isomers Theory Sheet

Optical isomers, also known as enantiomers, are another example of stereoisomerism. This occurs when molecules have the same molecular formula and structural formula, but one cannot be superimposed by the other.

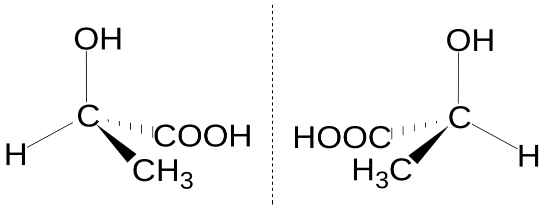


lawrencekok.blogspot.com

Another way to think of it is that they are mirror images of each other. One example of this is human hands, they are like mirror images but if you rotate one then it will never match the other hand! You are probably thinking so why are they called optical isomers? This is because of their effect on plane polarised light.



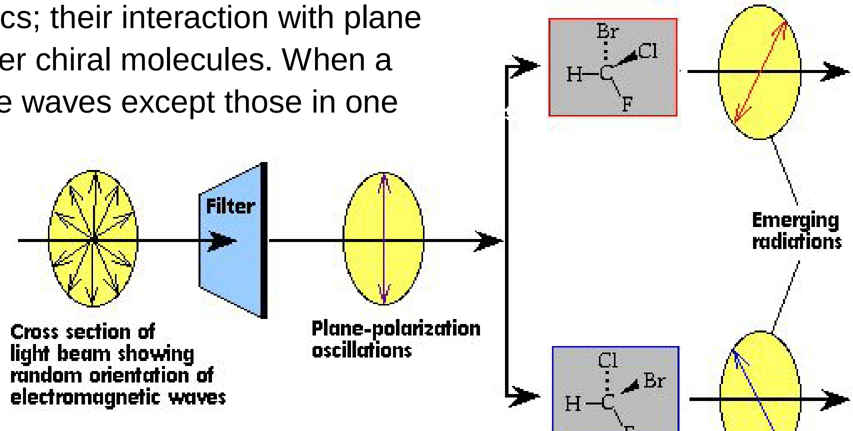
All molecules have a mirror image, but for most molecules the mirror image is the same molecule. Look at the example above, fluoromethane. Both images are the same moleucle as you can rotate the mirror image and get the original molecule.



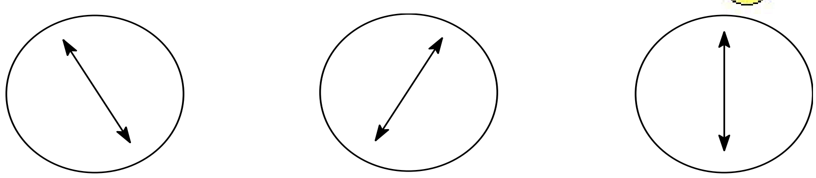
However, some molecules have a mirror image that is non-superimposable. In other words, you cannot rotate one to get the other, so therefore they are different molecules and have different names. For example, the image in the left hand side is (-) lactic acid in sour milk and the image on the right is (+) lactic acid in muscles.

This happens when a carbon atom has 4 different groups attached, this is called a **chiral centre** or **asymmetric carbon**. The two molecules are referred to as chiral or optically active. There are only ever two optical isomers formed for each chiral centre. If there are two chiral centres, then there will be two pairs of optical isomers.

The isomers only differ in two characteristics; their interaction with plane polarised light and how they react with other chiral molecules. When a beam of light is filtered (polarised) all of the waves except those in one plane are removed. This image shows the plane polarised light has been rotated when passed through to the isomers. However, the light is rotated in opposite directions for each isomer, but by the same angle either way. You might think that since they are different molecules that they will have different physical properties, but this isn't the case. They are distinguished by +/-, D/L or R/S. A 50/50 mixture of the two enantiomers is called a racemic mixture or a racemate.



http://www.wiredchemist.com/files/shared/images/figure39.gif

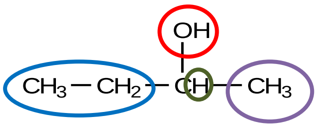


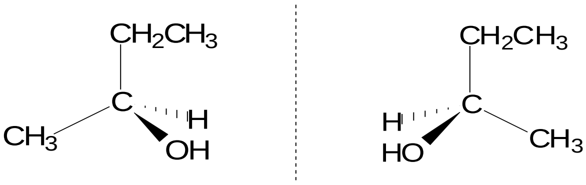
(-)-enantiomer (anticlockwise rotation) | (+)-enantiomer (clockwise rotation) | (±)-racemate (no overall effect)

Produced by Emma Burnett at Newcastle University as part of a Nuffield Bursary Project.
Edited by Steven Carman as part of a MChem project.

Identifying chiral carbon atoms!

Butan-2-ol





This molecule has a chiral carbon, C2, because this carbon is attached to four different groups. (–H –CH_3 –OH –C_2H_5)

TOP TIP!
The easiest way to determine if the molecule has optical isomers is to draw their displayed formulae!

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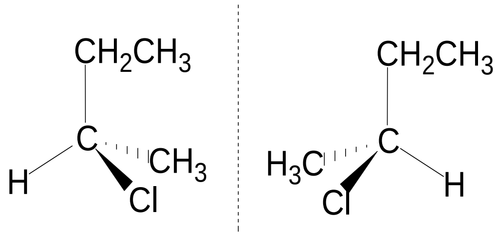
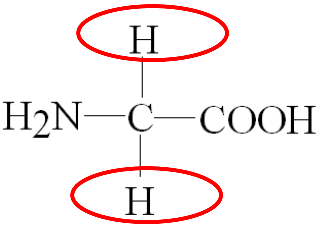
It is just as important that you are able to draw isomers as is it to identify them. The three-dimensional arrangement around the chiral carbon must be drawn correctly. The hardest part is drawing the first molecule as you have to distinguish which group goes where, but once you figure this out, the rest is easy! All you have to do is draw the mirror image and place a dashed line, to represent the mirror.



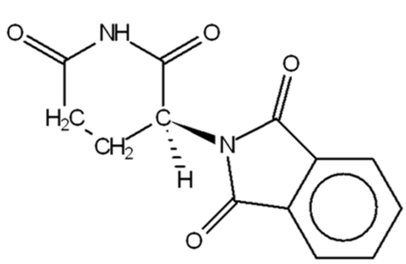


Many α-amino acids (except glycine) have optical isomers in which the chiral carbon is attached to four different groups. These are normally naturally occurring amino acids, and they rotate polarised light to the left. The exception, glycine has two hydrogen atoms attached to the central carbon so therefore won't have four different groups. The two mirror image forms (enantiomers) of a chiral molecule often react differently with other chiral molecules as they don't fit into one another to react. Let's look back at the hand analogy, this is like trying to fit a right glove on your left hand, it just won't fit, well it's the same for isomers.

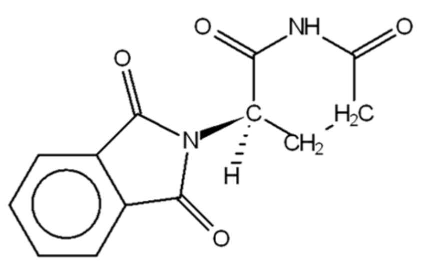
Optical isomers are useful in biology and in many cases, one of the optical isomers can be used as a drug. Many natural molecules are chiral and most natural reactions are affected by enantiomers. In plants and animals, only one of the isomers is synthesised naturally, and often only one will interact with an enzyme due to stereospecific nature of enzymes. Many chiral drugs only contain one isomer that produces the beneficial effect, but in some drugs the other isomer can actually be dangerous.

For example, in the 1960's the drug thalidomide; which was a racemic mixture of both isomers, was given to pregnant women to reduce the effects of morning sickness. The harmful enantiomer led to many disabilities in babies and early deaths in many cases. The drug was banned worldwide, but is now starting to be used in treating leprosy and HIV, but it is still not allowed to be used on pregnant women.

Use refcodes THALID03 & THALID11 to view the two optical isomers shown below:



S thalidomide (effective drug)



R thalidomide (dangerous drug)

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