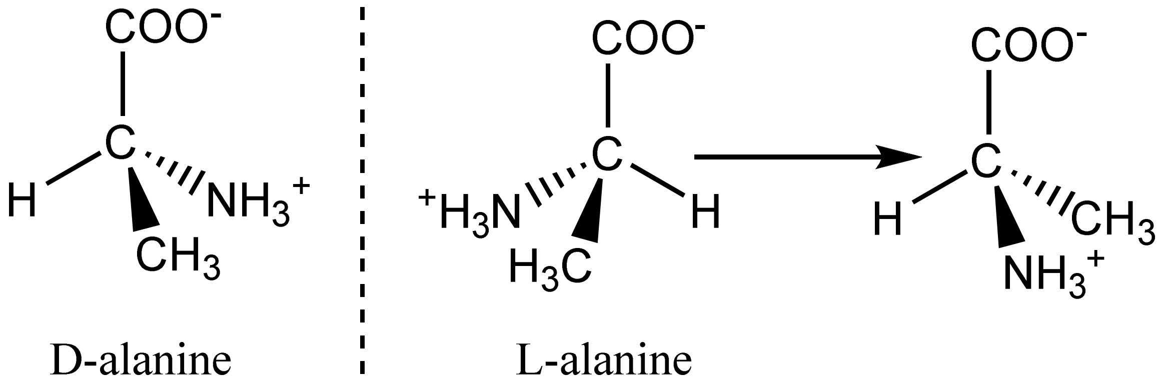
TC1 - Amino Acids and Chirality

OPTICAL ISOMERS AND CHIRALITY

Most amino acids have four different groups attached to the central carbon atom (excluding glycine, which as you have seen has two hydrogen atoms). This means that they are **chiral** and the central carbon atom is a **chiral centre**. Chirality means that an object cannot be superimposed onto its mirror image. Therefore, each amino acid has two **enantiomers** whose mirror images cannot be superimposed onto one another – this is a type of stereoisomerism called **optical isomerism**.

The word chiral comes from the Greek ‘kheir’, which means hand. This is because hands are also chiral. Each hand reacts differently to other chiral objects, such as gloves. A hand will only ‘react’ with a glove of the right chirality.



D-alanine

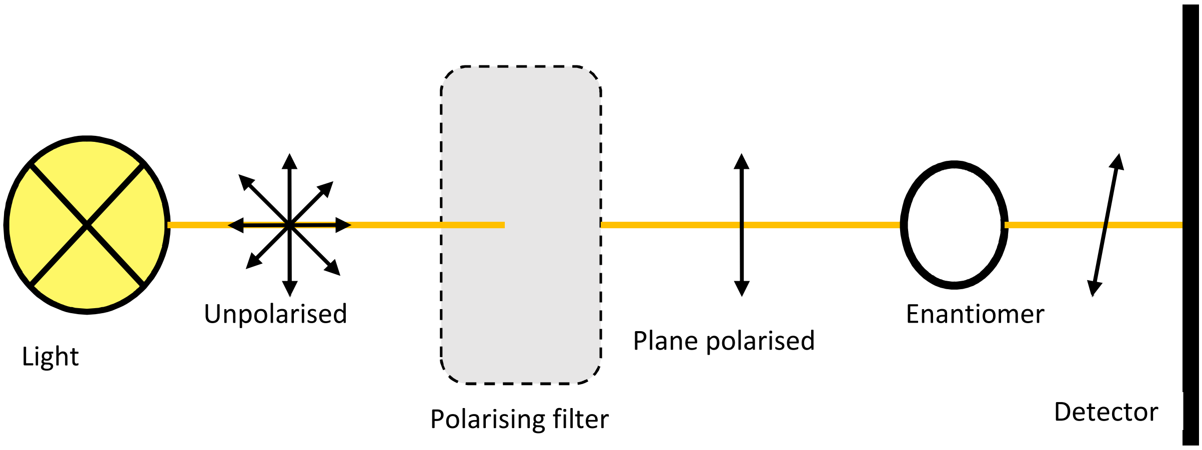
L-alanine

Take some time to make sure that you understand how we can convert the normal representation of an amino acid into this one shown. The key part here is the chiral centre – the carbon atom with 4 distinct chemical groups on it. When you draw the structure in 3D, it becomes clear that the ordering of the groups around the chiral centre is key. When the amino acid is made, that’s it! You can’t swap the groups around; they’ll stay as they are!

If you want to show that a molecule is chiral, then draw one of the enantiomers out first, it doesn’t matter which one. Then draw a mirrored line, and draw the mirror image of the molecule out like above. We need to make sure that the central atom we draw is the chiral one. If a molecule is chiral, then it will be impossible to superimpose one onto the other. Try it now, imagine rotating the L-alanine so that the H and carboxylate groups are superimposed. What happens to the other two groups? If you draw out the L-alanine like this, then you have proved that the two structures that you have drawn are enantiomers – mirror image isomers which cannot be superimposed.

Produced by Lucy Jakubecz at Newcastle University as part of an MChem project.
Edited by Adam Stubbs at Newcastle University as part of a summer outreach project.

Enantiomers have **identical chemical and physical properties except for in two situations: reactions with other chiral molecules, and their effect on plane-polarised light**. Plane-polarised light is light which has been made to oscillate in just one plane by passing it through a polariser, as shown below. When we shine plane-polarised light onto a chiral molecule, the light will be rotated in a different direction by each enantiomer. If it is rotated clockwise, then it is labelled as D-, and if it rotates it anticlockwise, then it is labelled L-. To determine which way an enantiomer rotates the plane of plane-polarised light, you have to perform the experiment using a device called a **polarimeter,** such as the one modelled below.



CHIRALITY AND DRUG CHEMISTRY

Enzymes are proteins in the body which act as biological catalysts. They help to break down and metabolise drugs. Proteins made from amino acids. This means that the enzymes in an organism are chiral, as the amino acids which make them up are. This is very important to consider when designing medicinal drugs. If a drug exists in two enantiomeric forms, then each will interact slightly differently with an enzyme. Only one of the enantiomers may bind, one may bind better than the other, or one may even bind somewhere else unexpectedly and trigger an unexpected response.

Thankfully, it is possible to differentiate, and to isolate enantiomers chemically. This means that if the D-enantiomer of one drug binds better than the L-enantiomer, then we could isolate just the D-form and give the patient a smaller dose for the same effect. Similarly, if one enantiomer produces dangerous side effects, then we can remove that enantiomer from the drug, and stop the side-effects.

Isolation can be quite expensive and time-consuming though, so if there are no noticeable/harmful effects, then we can just administer the medicine as a mixture – often this is a **racemic** mixture (50:50 mix).

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