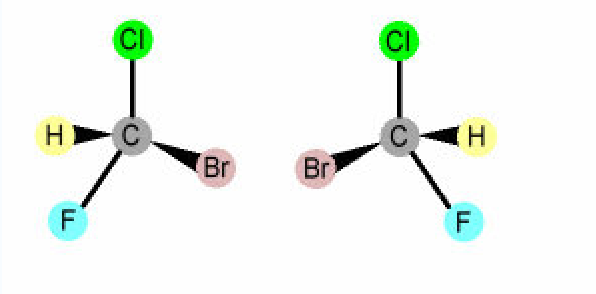
Chirality in Chemical Molecules.

Molecules which are active in human physiology largely function as keys in locks. The active molecule is then called a ligand and the lock a receptor.

The structures of both are **highly specific** to the degree that if one atom is positioned in a different position than that required by the receptor to be activated, then no stimulation of the receptor or only partial activation can take place. Again in a similar fashion if one tries to open the front door with a key that looks almost the same than the proper key for that lock, one will usually fail to get inside. A simple aspect like a lengthwise groove on the key which is on the left side instead of the right side, can mean that you can not open the lock if your key is the "chirally **in**correct" one.

The second aspect to understand is which molecules display chirality and which do not. The word *chiral* comes from the Greek which means "hand-like". Our hands are mirror images of each other and as such are **not** identical. If they were, then we would not need a right hand and left hand glove. We can prove that they are not identical by trying to lay one hand on top of the other palms up. When we attempt to do this, we observe that the thumbs and fingers do not lie on top of one another. We say that they are **non-super imposable** upon one another. Since they are not the same and yet are mirror images of each other, they are said to exhibit chirality. Hands are therefore chiral. The right hand is chirally correct for a right hand glove and the left hand for a left hand glove.

Another example: A molecule is **chiral** if it is not superimposable on its mirror image regardless of how it is contorted. Chiral molecules are often described as being 'left handed' or 'right-handed'. Here are chiral molecules:



Any object whose mirror image is not identical to it (in other words non-super imposable) will be chiral. Other examples besides our left and right hand would include ears, shoes (have you ever tried to put your right shoe on your left foot?), gloves (tried wearing a right hand glove on the left hand?), and the two sides of a car. All of these exhibit chirality. Anything which is chiral has a left and right side.

Other objects are said **not** to exhibit chirality. These objects have mirror images that can be superimposed upon one another. In other words such an object is identical with its mirror image when placed on top of each other. A baseball bat, a hammer, most socks all do not exhibit chirality and are referred to as **achiral** objects.

Biological molecules just like other objects are capable of exhibiting chirality. These chiral molecules have certain characteristics which are different from other molecules that do **not** exhibit chirality. Chiral molecules have the following characteristics:

1. Chiral molecules will have their mirror images non-super imposable as we saw was the case with all chiral objects above.

2. Chiral molecules must **not** have **an internal plane of symmetry.** This is fairly easy to determine. Molecules that do have an internal plane of symmetry will be able to be split in half and each half will be a mirror image of the other. An example of this is 2-Propanol (Fig 1 below). If we construct a plane that cuts the molecule in half that would run through the Hydrogen atom of the middle carbon and the Hydroxyl group, the two halves would be mirror images of one another (See Fig 1 below). Such a molecule would be achiral not capable of exhibiting chirality.

Figure 1 : Achiral

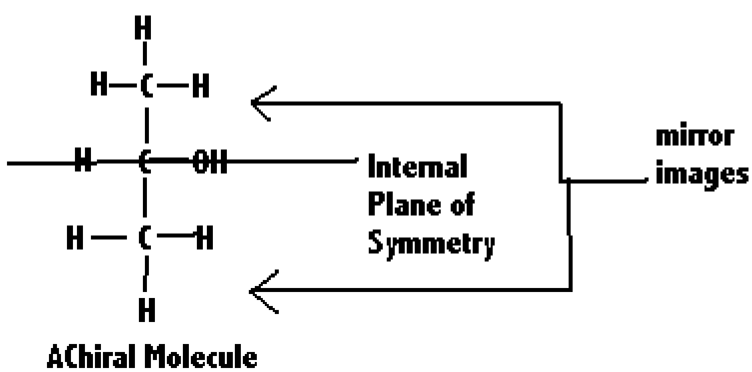


Fig 1- Achiralty and Internal Plane of Symmetry

Figure 2: Chiral

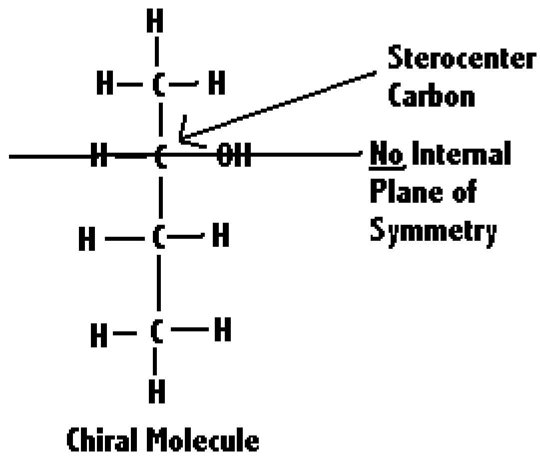
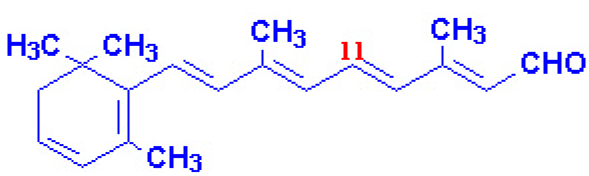


Fig 2-Chirality, Internal Planes, and Stereocenters

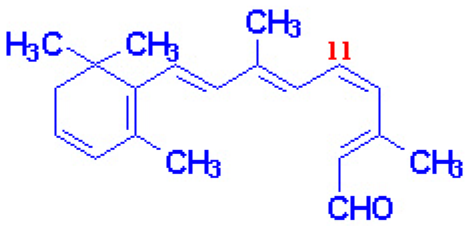
In this molecule it depends on which side the OH group in the internal plane of symmetry sits whether it will be called Left or Right.

When we talk about vitamins in general, simply look at the molecular structure of the molecule. If one can draw a straight line (internal line of symmetry) through the molecule to create two identical halves, then the molecule is achiral. Vitamins used in skin therapy however are all chiral molecules.

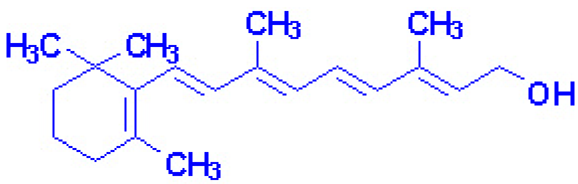
When we look at vitamin A's structure in particular, it clearly does **not** have an internal plane of symmetry and *is therefore chiral.*



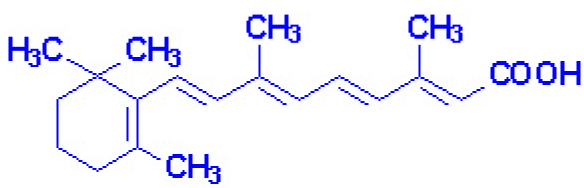
All-*trans*-retinal



11-*cis*-retinal



Retinol



Retinoic Acid

A much more important question to answer however, is if a particular receptor system requires only a single chirally correct molecule of one kind only, or whether it requires both shapes of that particular molecule to be fully active? Such a mixture where both the chiral forms appear is called **racemic**.

In the case of vitamin A the receptor systems require a racemic mixture, that is both the chiral types, left and right. It would therefore mean that any description of a so called chirally correct vitamin A by implication should include all of the different shapes of each class of vitamin A, otherwise this will be incorrect. It would make more sense and be more accurate to say that the vitamin A in a particular preparation is in the **correct racemic mixture**. This latter description is accurate, whilst the former is misleading as it implies that the vitamin A system in humans require only one of the chiral forms.

Environ And Chirality Of Other Vitamins:

Environ uses the chirally correct versions of vitamin C in all of their products and Lactic acid, and panthenol, and tocopherol (in some of the products). Vitamin A is not a molecule that has to be used only in one form: both are used: generally in its trans form e.g. all-trans-retinoic acid does most of the work on DNA, but cis-retinoic acid and di-dehydro-retinoic acid are essential for other DNA activities. The vitamin E that we use is either as chirally correct tocopherol, or racemic tocopherol acetate.

The subject of chirality is an important one in science in general and has applications in chemistry, mathematics and physics. It still receives an enormous amount of attention in the scientific world. More information at the following website:

http://chirality2005.unipr.it/index2.htm

References:

1. R. H. Logan, Instructor of Chemistry, Dallas County Community College District, North Lake College. All textual content copyrighted (c) 1997 R.H. Logan, Instructor of Chemistry, DCCCD

2. Wikipedia Encyclopedia : Chirality (Chemistry)http://en.wikipedia.org/wiki/Chirality