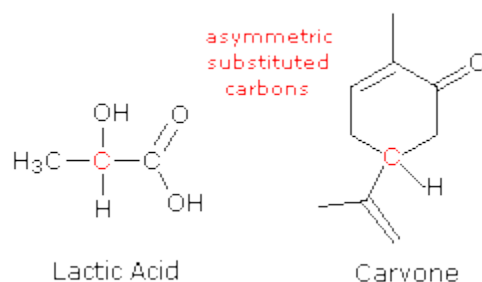


Enantiomorphism

A consideration of the chirality of molecular configurations explains the curious stereoisomerism observed for lactic acid, carvone and a multitude of other organic compounds. Tetravalent carbons have a tetrahedral configuration. If all four substituent groups are the same, as in methane or tetrachloromethane, the configuration is that of a highly symmetric "regular tetrahedron". A regular tetrahedron has six planes of symmetry and seven symmetry axes (four C_3 & three C_2) and is, of course, achiral. If one of the carbon substituents is different from the other three, the degree of symmetry is lowered to a C_3 axis and three planes of symmetry, but the configuration remains achiral. The tetrahedral configuration in such compounds is no longer regular, since bond lengths and bond angles change as the bonded atoms or groups change. Further substitution may reduce the symmetry even more, but as long as two of the four substituents are the same there is always a plane of symmetry that bisects the angle linking those substituents, so these configurations are also achiral.

A carbon atom that is bonded to four different atoms or groups loses all symmetry, and is often referred to as an **asymmetric carbon**. The configuration of such a molecular unit is chiral, and the structure may exist in either a right-handed configuration or a left-handed configuration (one the mirror image of the other). This

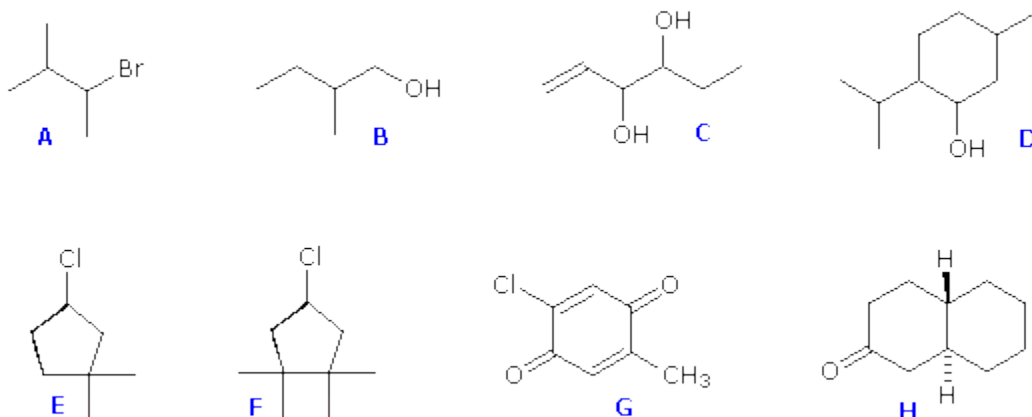


type of configurational stereoisomerism is termed **enantiomorphism**, and the non-identical, mirror-image pair of stereoisomers that result are called **enantiomers**. The structural formulas of lactic acid and carvone are drawn on the right with the asymmetric carbon colored red. Consequently, we expect, and find, these compounds to exist as pairs of enantiomers. The presence of a single asymmetrically substituted carbon atom in a molecule is sufficient to render the whole configuration chiral, and modern terminology refers to such asymmetric (or dissymmetric) groupings as **chiral centers**. Most of the chiral centers we shall discuss are asymmetric carbon atoms, but it should be recognized that other tetrahedral or pyramidal atoms may become chiral centers if appropriately substituted. When more than one chiral center is present in a molecular structure, care must be taken to

analyze their relationship before concluding that a specific molecular configuration is chiral or achiral. This aspect of stereoisomerism will be treated later.

A useful first step in examining structural formulas to determine whether stereoisomers may exist is to identify all stereogenic elements. A **stereogenic element** is a center, axis or plane that is a focus of stereoisomerism, such that an interchange of two groups attached to this feature leads to a stereoisomer. Stereogenic elements may be chiral or achiral. An asymmetric carbon is often a chiral stereogenic center, since interchanging any two substituent groups converts one enantiomer to the other. However, care must be taken when evaluating bridged structures in which bridgehead carbons are asymmetric. Alkenes having two different groups on each double bond carbon (e.g. $abC=Cab$) constitute an achiral stereogenic element, since interchanging substituents at one of the carbons changes the cis/trans configuration of the double bond. Chiral stereogenic axes or planes may be present in a molecular configuration, as in the case of allenes, but these are less common than chiral centers and will not be discussed here.

Structural formulas for eight organic compounds are displayed in the frame below. Some of these structures are chiral and some are achiral. First, try to identify all chiral stereogenic centers. Formulas having no chiral centers are necessarily achiral. Formulas having one chiral center are always chiral; and if two or more chiral centers are present in a given structure it is likely to be chiral, but in special cases, to be discussed later, may be achiral. Once you have made your selections of chiral centers, check them by pressing the "Show Stereogenic Centers" button. The chiral centers will be identified by red dots.



Structures **F** and **G** are achiral. The former has a plane of symmetry passing through the chlorine atom and bisecting the opposite carbon-carbon bond. The similar structure of compound **E** does not have such a symmetry plane, and the carbon bonded to the chlorine is a chiral center (the two ring segments connecting this carbon are not identical). Structure **G** is essentially flat. All the carbons except that of the methyl group are sp^2 hybridized, and therefore trigonal-planar in configuration. Compounds **C**, **D** & **H** have more than one chiral center, and are also chiral. **Remember, all chiral structures may exist as a pair of enantiomers.** Other configurational stereoisomers are possible if more than one stereogenic center is present in a structure.

Source : <http://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/sterism2.htm#isom9>