

## Projection structures of stereoisomers

Since paper and blackboards are two dimensional, it is very difficult and inconvenient to represent the three-dimensional molecules in two dimensions of paper or blackboard. Therefore, several two-dimensional projection formulas have been developed to represent molecules having three dimensional structures. These are:

1. Fischer projection
2. Sawhorse projection
3. Newman projection

Before knowing these projections, one must understand **Flying Wedge (Three-Dimensional) Representation**. The flying wedge representation, also known as the three-dimensional (perspective) representation, is a convenient method to show the actual spatial arrangement of atoms in a molecule on a two-dimensional surface such as paper or a blackboard. This representation is especially useful in stereochemistry to depict the orientation of bonds around a chiral centre. In this method, three different types of lines are used:

- Normal (straight) line

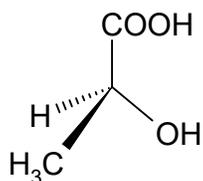
A normal straight line ( — ) represents a bond lying in the plane of the paper.

- Solid wedge (  )

A solid wedge represents a bond projecting out of the plane of the paper towards the observer. It indicates that the attached atom or group is closer to the viewer.

- Hashed or dashed wedge (  )

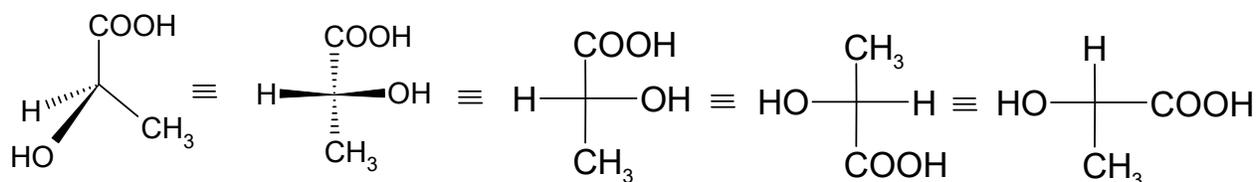
A hashed (or dashed) wedge represents a bond projecting behind the plane of the paper, away from the observer. The attached atom or group is farther from the viewer.



Thus, the flying wedge representation provides a clear three-dimensional picture of molecular geometry.

## 2. Fischer Projection

The Fischer projection is a conventional method used to represent the three-dimensional configurational relationship of molecules containing chiral centres in a two-dimensional, planar form. In a Fischer projection, the molecule is oriented in such a way that the chiral carbon atom lies in the plane of the paper or blackboard. The four bonds attached to the chiral centre are represented by two vertical and two horizontal straight lines. The point of intersection of these lines represents the chiral centre, though the carbon atom itself is not shown by an atomic symbol. For example, a single enantiomer of lactic acid ( $\text{CH}_3\text{-CHOH-COOH}$ ) can be represented in different but equivalent Fischer projections, which can be interconverted by permissible rotations.



### Conventions of Fischer Projection

To correctly interpret Fischer projections, the following conventions must be clearly understood:

#### 1. Orientation of bonds

- The two vertical bonds represent bonds projecting away from the observer, that is, below the plane of the paper.
- The two horizontal bonds represent bonds projecting towards the observer, that is, above the plane of the paper.

Although all bonds are drawn as plain straight lines, this three-dimensional orientation must always be kept in mind while visualising the structure.

#### 2. Rotation of Fischer projections

For the purpose of comparison between two Fischer projections, rotation of the entire projection by  $180^\circ$  within the plane of the paper about an axis perpendicular to the paper is permitted. Such a rotation does not change the configuration of the molecule. However, rotation by  $90^\circ$  or  $270^\circ$  within the plane of the paper is not permissible, as it changes the apparent configuration and leads to incorrect stereochemical interpretation.

#### 3. Restriction on turning the projection

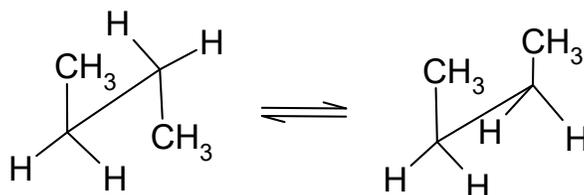
Since a Fischer projection is a two-dimensional representation, it must never be lifted out of the plane of the paper or turned over. If this is done, the vertical bonds (originally

directed away from the observer) would appear to project towards the observer, and the horizontal bonds would appear to project away. This would violate the basic conventions of Fischer projection and result in an incorrect structure.

### 3. Sawhorse Projection

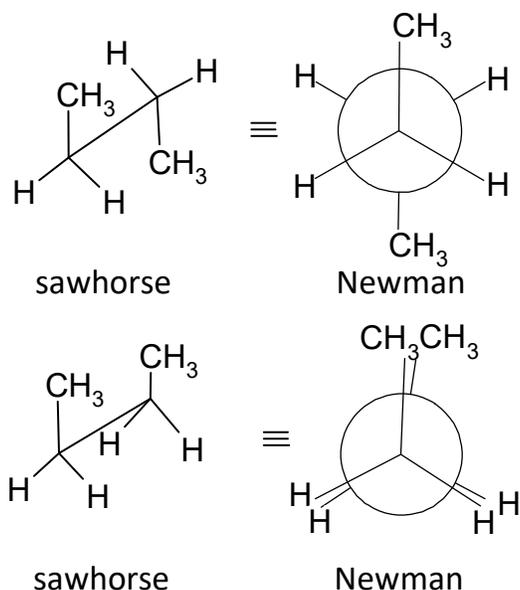
In a sawhorse projection, the two key atoms (usually two carbon atoms) connected by a single bond are shown by a diagonal line lying in the plane of the paper. This diagonal line represents the C–C bond axis, with one carbon placed at the lower left and the other at the upper right of the diagram. Each carbon atom is shown with two or three short straight lines representing bonds to substituents. These bonds are drawn such that the substituents around each carbon are separated by approximately  $120^\circ$ , reflecting the tetrahedral geometry of  $sp^3$ -hybridised carbon atoms.

The relative positions of substituents in the sawhorse projection allow clear distinction between different conformations, such as staggered and eclipsed forms. Rotation about the C–C bond can be visualised by rotating the front or rear carbon either clockwise or anticlockwise with respect to the bond axis. Such rotations change the conformation of the molecule without breaking any bonds. It is particularly useful for illustrating conformational isomerism arising due to rotation about a C–C  $\sigma$ -bond.



### Newman Projection

The Newman projection is used to represent the spatial arrangement of substituents around a carbon–carbon single bond by viewing the molecule directly along the C–C bond axis. The front carbon is shown as a point and the rear carbon as a circle, with bonds arranged at  $120^\circ$  to reflect tetrahedral geometry. It is especially useful for visualising conformational changes during clockwise or anticlockwise rotation about the C–C bond.



### Interconversions of Projection Formulae

In stereochemical analysis, it is often necessary to convert one type of projection formula into another in order to compare configurations and avoid misinterpretation of stereoisomers.

#### Fischer Projection to sawhorse Projection and vice versa

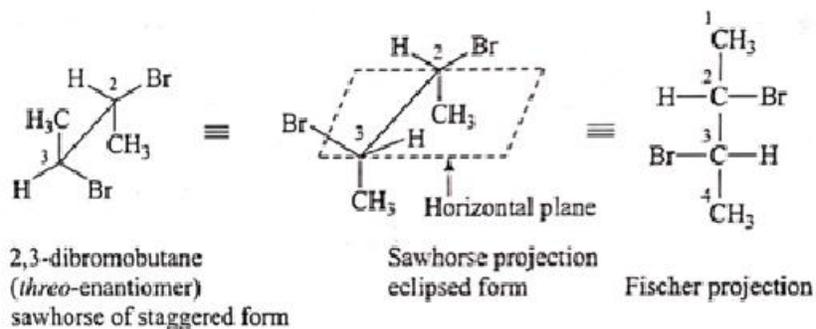
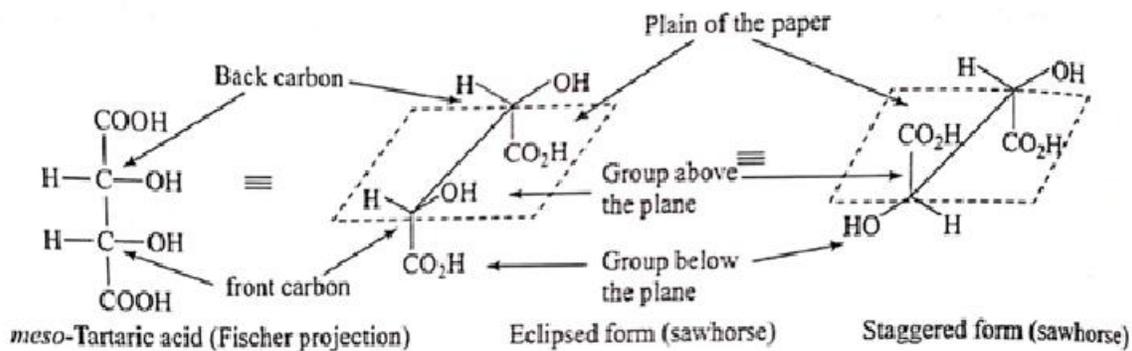
Conversion between Fischer and sawhorse projections is most conveniently carried out via the eclipsed sawhorse form.

While converting:

1. The carbon-carbon bond in the Fischer projection is treated as the bond axis.
2. The upper chiral centre (counting from the top) is usually taken as the back carbon, and the lower one as the front carbon in the sawhorse projection.
3. The Fischer projection formula actually represents a molecule in eclipsed conformation. So, an eclipsed sawhorse form is first drawn, maintaining the relative positions of substituents (above or below the plane).
4. Eclipsed conformation is energetically unfavourable, so this eclipsed form must then be rotated about the C-C bond to obtain the staggered sawhorse conformation.

#### *Important Caution in Fischer-Sawhorse Interconversion*

During interconversion, interchanging the front and back carbons in the sawhorse projection will result in the mirror image (enantiomer) of the original molecule. Therefore, proper numbering and identification of carbon atoms is essential to preserve the correct configuration.



### Fischer Projection to Flying wedge and vice versa

