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# Stereoisomerism and Chirality

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***Abstract***
*The purpose of this study is to give a basic introduction to stereoisomerism and chirality. In this paper I discuss about the mechanisms involved behind their formation and their types. Chiral compounds play an important role in daily organic working. Homochirality, a controversial topic, is also discussed by showcasing its unconventional occurrence and results from a computer stimulated study by Chen Y, Ma W. Types of stereoisomers and how they occur in nature has also been discussed. This review will give you a basic idea about the opticality involved inorganic compounds specifically stereoisomers and its subsidiaries.*

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## I. Introduction

Stereochemistry, Term originated *c.* 1878 by Viktor Meyer (1848–97) for the study of stereoisomers (*see* isomer). Louis Pasteur had shown in 1848 that tartaric acid has optical activity and that this depends on molecular asymmetry, and Jacobus H. van't Hoff and Joseph-Achille Le Bel (1847–1930) had independently explained in 1874 how a molecule with a carbon atom bonded to four different groups has two mirror-image forms. Stereochemistry deals with stereoisomers and with asymmetric synthesis. John Cornforth (b. 1917) and Vladimir Prelog (1906–98) shared a 1975 Nobel Prize for work on stereochemistry and stereoisomerism of alkaloids, enzymes, antibiotics, and other natural compounds.

Beginning early in the 19th century, developments in crystallography, optics, and chemistry in France set the stage for the discovery of molecular chirality by *Louis Pasteur* in 1848. He found that the crystallization of the sodium ammonium salt of '*paratartaric acid*', a mysterious '*isomer*' of natural (+)-tartaric acid (TA), produced two different crystal types that were non-superimposable mirror-image forms of each other. He separated the two types and found their optical rotations in solution opposite in direction and equal in absolute magnitude. This led him to conclude that paratartaric acid is a combination of two mirror-image molecule types of TA that are '*dissymmetric*', an existing term he adapted to the connotation of todays '*chiral*'. In 1857, he found that the two enantiomers of TA were metabolized by a microorganism at drastically different rates, and thereby discovered biological enantioselectivity. In 1886, Italian chemist *Arnaldo Piutti* discovered D-asparagine and found that it tasted intensely sweet, in contrast to the known L-asparagine which had no taste. This was the discovery of stereoselectivity at biological receptors. As a result of advances in stereoselective synthesis and enantioselective chromatography during the last decades of the 20th century, in the 1990s the importance of molecular chirality in drug action and disposition began to receive serious attention from drug-regulatory authorities and the pharmaceutical industry, the overall result of which has been the near-complete disappearance of racemic drugs as newly introduced pharmaceuticals.

**Stereoisomerism**

Isomers are organic compounds that have the same molecular formula but different structural formal. The type of isomerism in which the compounds differ in spatial arrangement is known as stereoisomerism. There are two types of stereoisomers.

Diastereomer isomers are not mirror images of each other each and are non-superimposable. Cis and trans isomers fall under this category. Difference between them is that cis isomers are polar whereas trans are non-polar. A simple way to identify them in organic compounds is that cis isomers contain functional groups on the same side of the carbon chain whereas the functional groups are on opposite sides in trans isomers. A diastereomer with two chiral carbon has four isomers. the physical and chemical properties of diastereomers can differ and consequently, their chemical characterization is easy and their biological activities are often different. But-2-ene can be arranged in a specific way to obtain cis and trans arrangements.

Enantiomers are non-superimposable mirror images of each other just like a human hand. Optical activity showcases that in what direction an enantiomer rotates when placed in front of mirror. When observed from a viewer's standpoint if the compounds rotate in clockwise then the molecule is dextrorotary and if the

molecule spins in anticlockwise direction, then it is levorotary. If the mirror images are super imposable then the molecule is optically inactive. A solution containing an equal amount of each member of a pair of enantiomers is called racemic mixture or racemate. A racemate is designated as R, S. Each R- and S-enantiomers can rotate plane-polarized light, therefore they can be designated as R (+) or R (-) and S (+) or S (-). These solutions are optically inactive: there is no net rotation of plane-polarized light since the amount of dextrorotatory and levorotatory molecules is exactly the same.

Another type stereoisomer is mesomer. In mesomers there are two chiral centers which makes the net rotation of plain polarized light zero for these compounds. So mesoisomers are optically inactive. They can also be called achiral compounds. Mesomeric compounds are superimposable. This functionality of mesomeric compounds give rise to mesomeric or resonance effect. In addition, they also have an internal mirror which bisects the molecule into two halves which are mirror images of each other. Meso compounds can be classified as diastereomers, namely, stereoisomers which are not enantiomers. Mesomeric effects result from π-electron delocalization, and contribute significantly to changes in the strength of acids and bases caused by remote substituents, especially via double bonds in conjugation with the ionizable center, including ortho or para (but not meta) substituents in aromatic or heteroaromatic systems. Mesomeric effects can cause relatively large variations in local diamagnetic shielding. The mesomeric effect (M) produces, as a result of an interaction through the π-electrons, an electron excess or deficiency depending on the nature of the substituents. If a substituent having double bond or nonbonding electrons is directly attached to a conjugated system, the electron density and consequently the chemical shift will change.

**Chirality**

Enantiomers are also chiral compounds. Chiral compounds are non-superimposable mirror images of each other. The most common cause of chirality in a molecule is the presence of a chirality center or chiral center, also called asymmetric center, namely, an atom that bears a set of atoms or functional groups in a spatial arrangement so that the resulting molecule can exist as two enantiomers. If a compound has carbon in the chiral center, then it is considered an asymmetric carbon atom. Stereocenter is also a term used to imply a chiral center because chiral compounds are stereoisomers. All chiral compounds are optically active. For a molecule with n chirality centers, the maximum number of possible stereoisomers is $2^n$. The spatial arrangement of a chiral compound is determined by nuclear magnetic resonance or/and X-ray crystallography diffraction. The R/S tridimensional configuration allows to explain the interaction of enantiomers with their biologic receptors.

Homochirality is the biological chirality in which all biologic compounds have the same chirality such as all L-amino acids are encoded in proteins, and D-sugars form the backbones of DNA and RNA. People have long been curious about the fact that central molecules in the living world (biopolymers), i.e., nucleic acids and proteins, are asymmetric in chirality (handedness), but as the relevant background, the chemical world is symmetric in chirality. Now that life should have originated from a prebiotic non-life background, how could this dissymmetry have occurred? Previous studies in this area focused their efforts on how the chirality-symmetry may have been broken at the monomer level (i.e., nucleotides or amino acids), but have achieved little advance over decades of years. The origin of life is a field full of controversies, which is not surprising when considering we have not even reached a consensus on the definition of life. In this field, relevant issues are often not clearly defined. However, the origin of homochirality is an exception. People realized that homochirality is crucial to biopolymers, almost all previous studies in this area assumed that homochirality originated before the emergence of biopolymers. Considering that homochirality is so important for the genetic and functional roles of biopolymers, the feasibility that homochirality arose after the emergence of the biopolymers could not be discarded. With a model based on the RNA world scenario Chen Y, Ma W showcased that the biased-chirality could have been established at polymer level, just deriving from a racemic mixture at the level of monomers.

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