



**Al-Mustaqbal University**  
**College of Science**



# **Drug Stereochemistry**

**Third Year Students / 2<sup>nd</sup> Semester**

**2025-2026**

## **Chirality**

*By*

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# Chirality

Molecules that can exist as enantiomers are said to be chiral; they are non-superimposable on their mirror images.

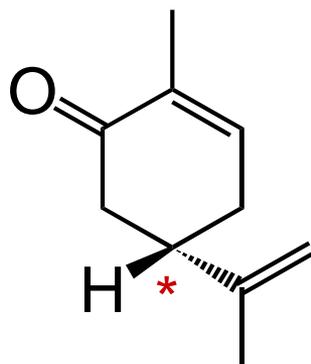
Chirality is a necessary and sufficient condition for the existence of enantiomers.

“cheir” - Greek meaning “hand”

Molecules that are superimposable on their mirror images are said to be achiral.

# Tetrahedral stereogenic centres

A carbon atom bonded to four different groups is called a tetrahedral stereogenic centre, asymmetric centre, or chirality centre.

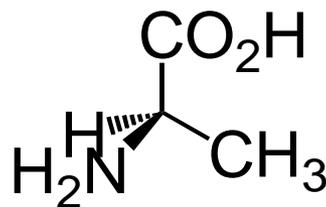
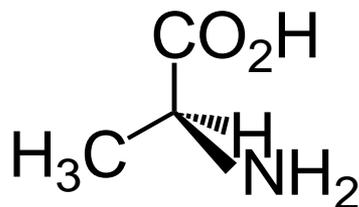
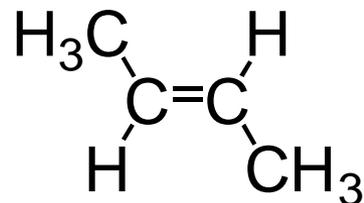
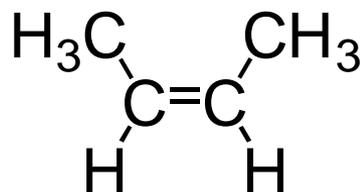


(+)-carvone

(+)-Carvone is responsible for the odour of caraway seed oil.

# Stereogenic centres

A centre where a swapping of groups leads to a stereoisomer:

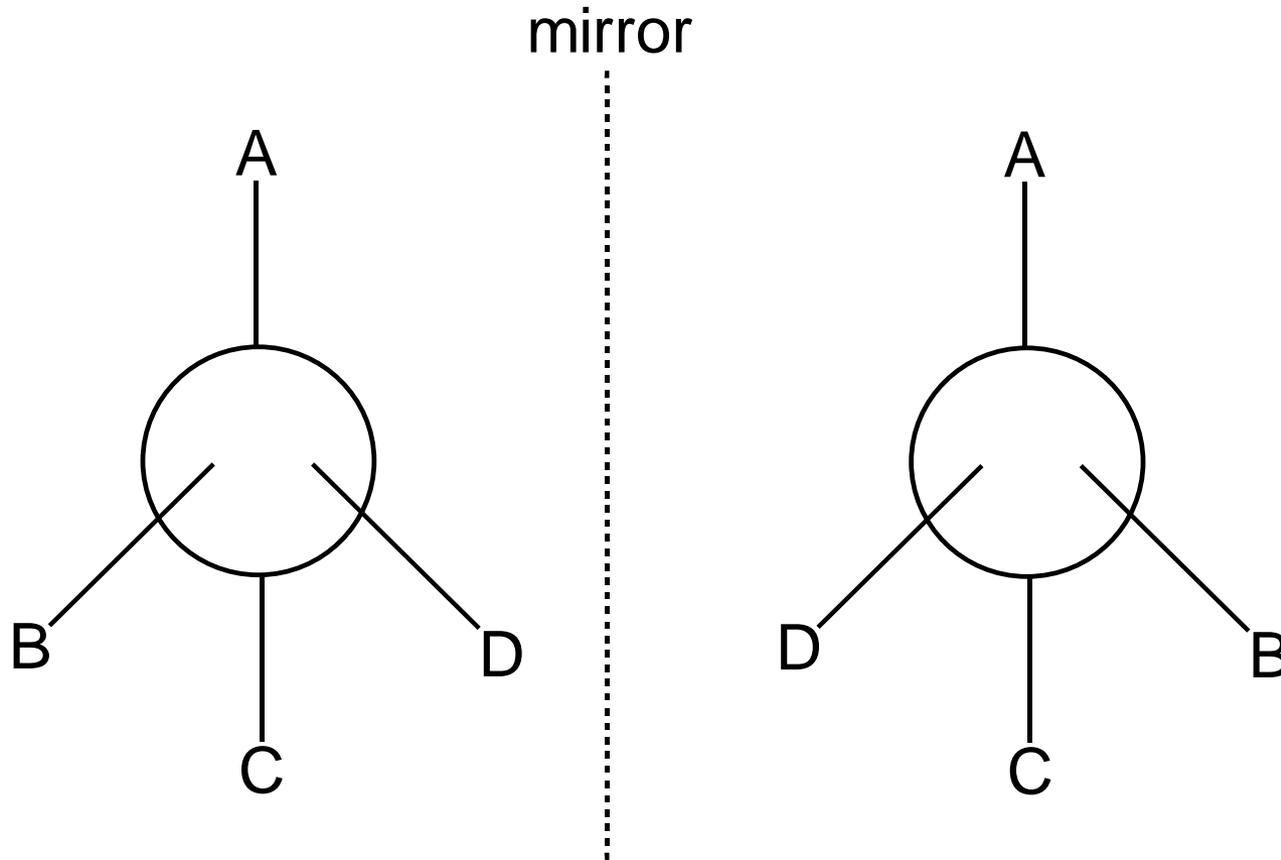


alanine

# Historical origin of stereochemistry

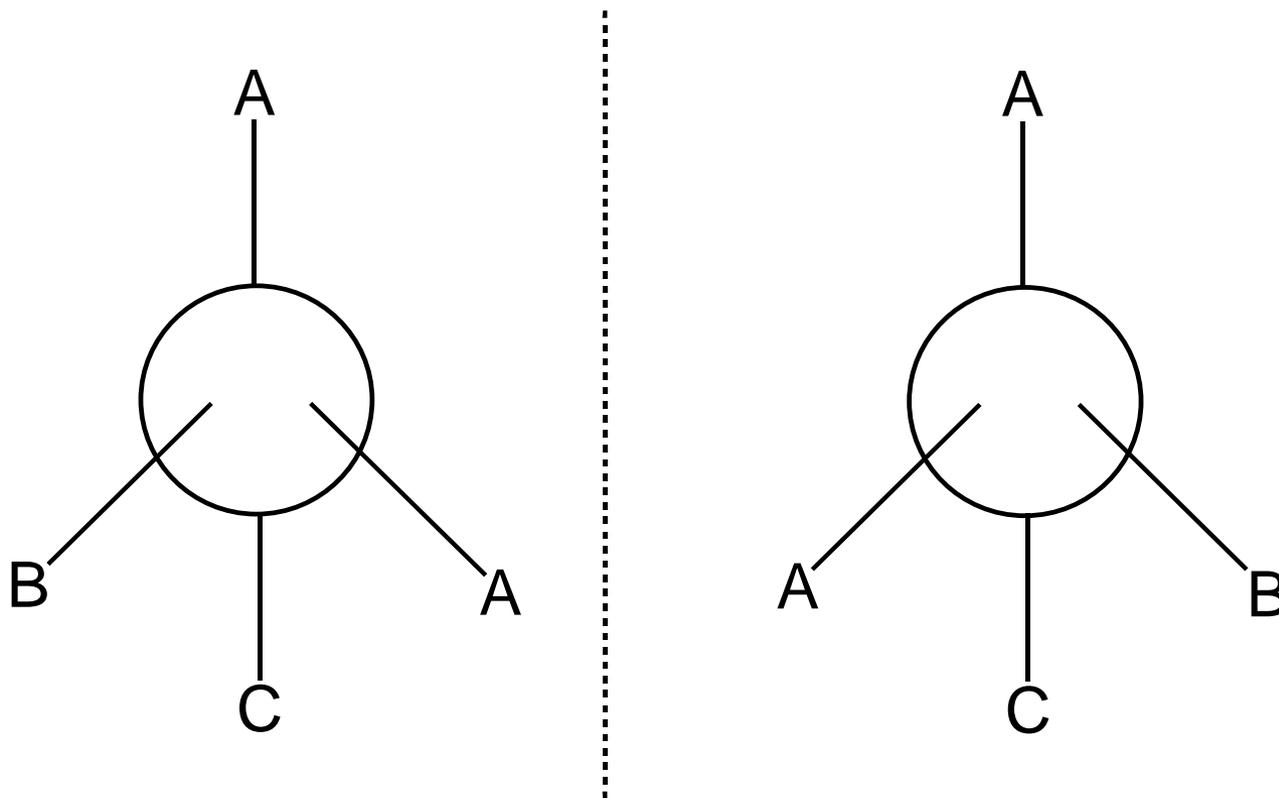
- Only one compound with the formula  $\text{CH}_3\text{X}$  is ever found.
- Only one compound with the formula  $\text{CH}_2\text{XY}$  is ever found.
- Two compounds with the formula  $\text{CHXYZ}$  are found – a pair of enantiomers.

# van't Hoff and Le Bel



The two are non-superimposable, mirror images. Such isomers are called **enantiomers**.

# Are these enantiomers?



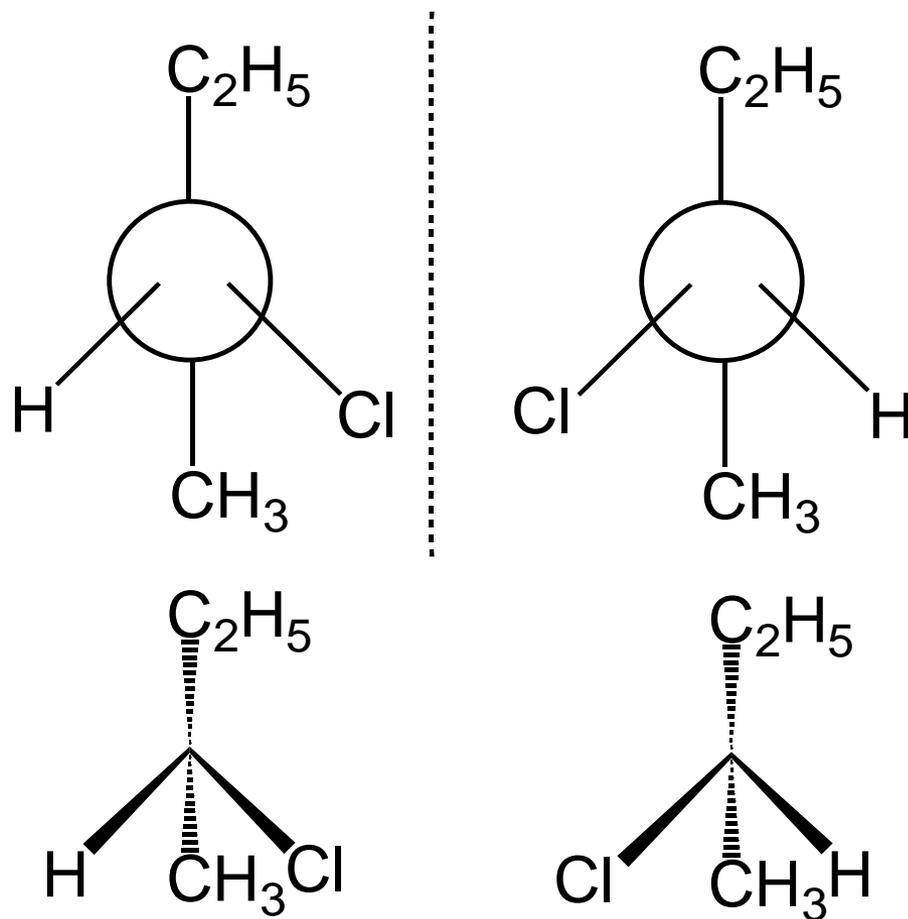
# Configurations

The particular arrangement of atoms in space that is characteristic of a given molecule is called its configuration.

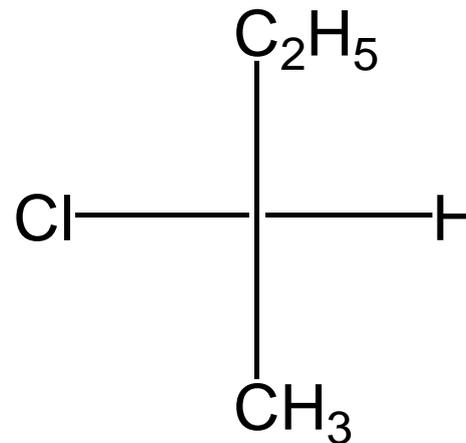
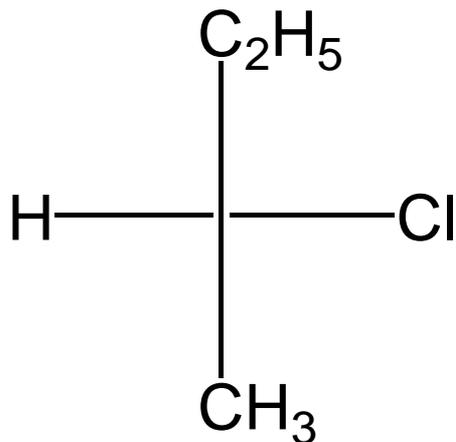
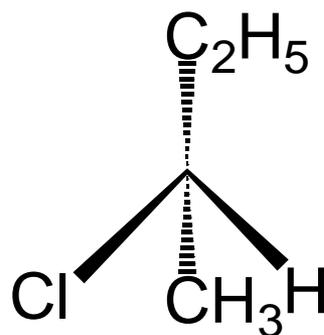
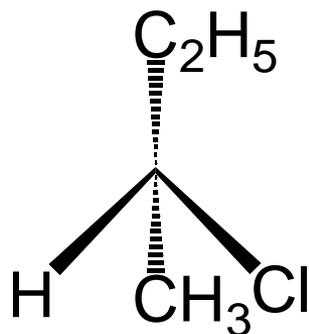
Configurations are not the same as conformations.

Conformations are interconvertible by rotation about single bond(s) whereas bonds must be broken to change one configuration into another.

# How do we “draw” a chirality centre?



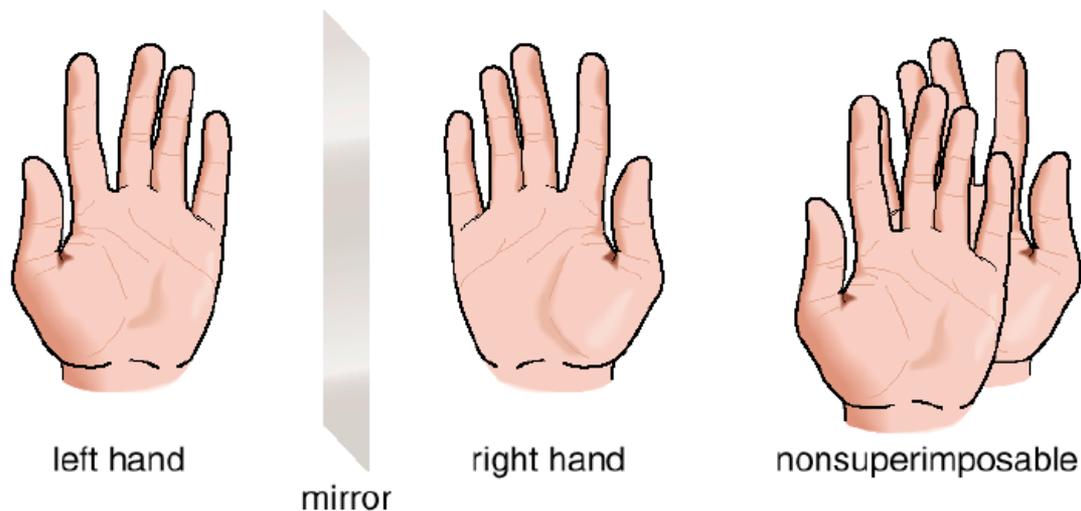
# How do we “draw” a chirality centre?



Fischer structures.....

# Chirality

- Every object has a mirror image: mirror images may or may not be **superimposable**.
- Some molecules are like hands. Left and right hands are mirror images, but they are not identical, or **superimposable**.



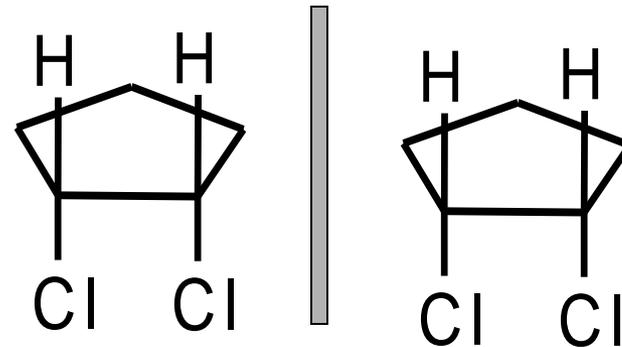
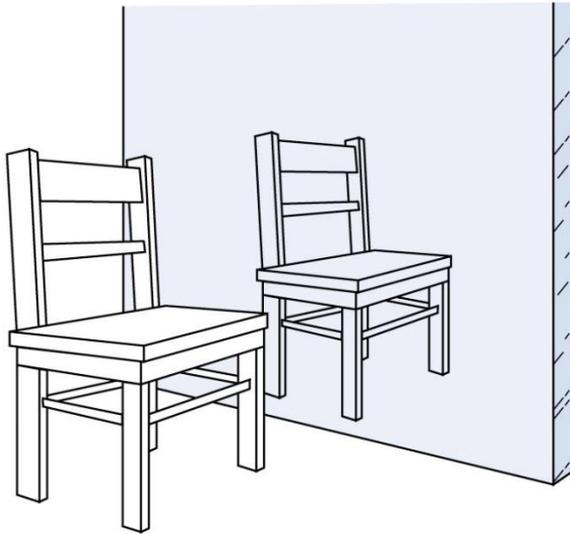
- A molecule (or object) that is *not* superimposable on its mirror image is said to be *chiral*.

4

A molecule that is not identical to its mirror image is said to be **chiral** (**ky**-ral, from the Greek *cheir*, meaning “hand”).

# Achiral

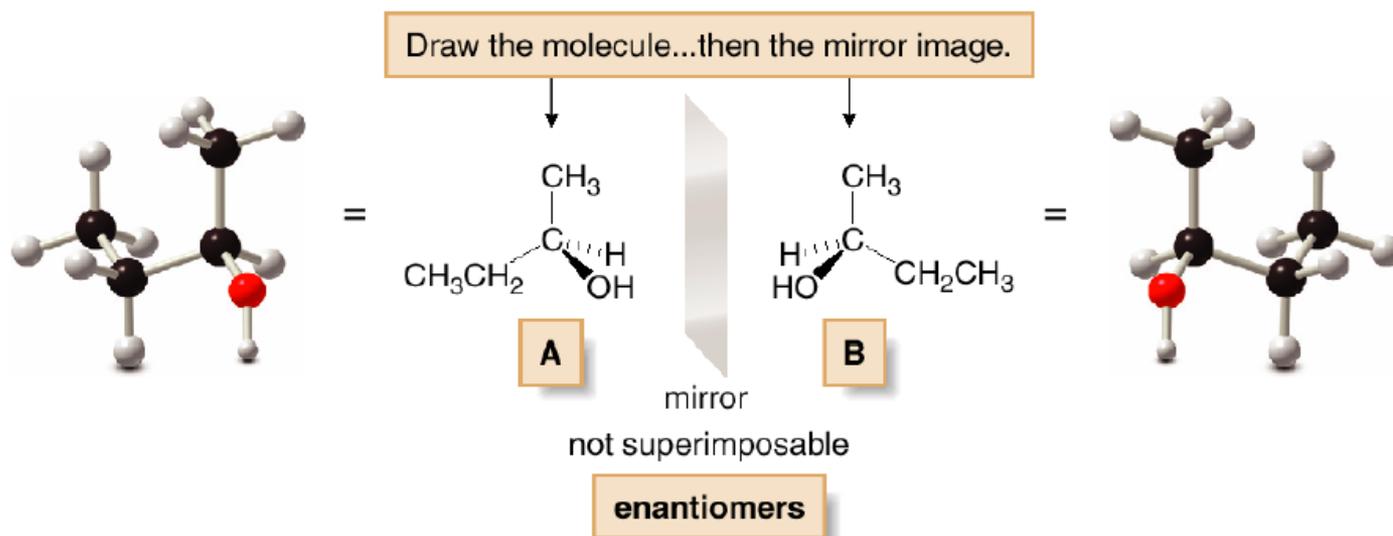
- Many molecules and objects are **achiral**:
  - identical to its mirror image
  - not chiral



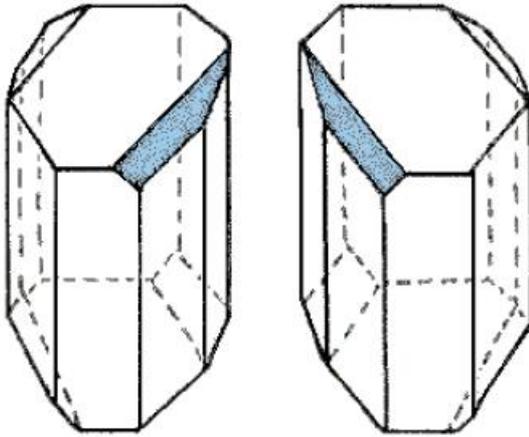
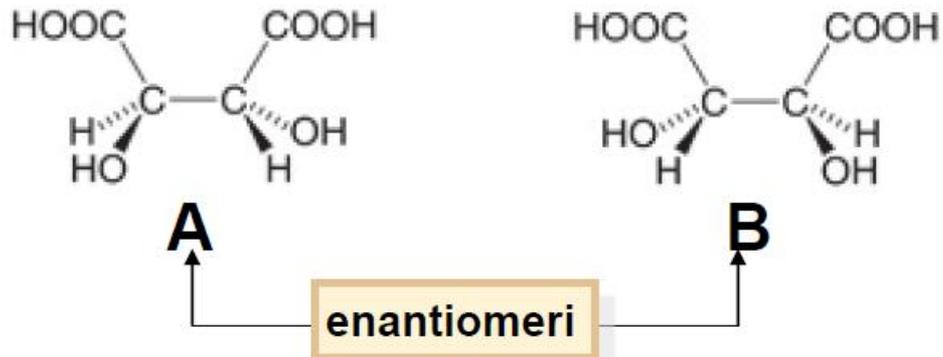
# Chirality

Molecules that are not identical to their mirror images are a kind of stereoisomer called **enantiomers** (Greek *enantio*, meaning “opposite”). Enantiomers are related to each other as a right hand is related to a left hand and result whenever a tetrahedral carbon is bonded to four different substituents (one need not be H).

- A and B are stereoisomers—specifically, they are **enantiomers**.
- A carbon atom with four different groups is a tetrahedral **stereogenic center**.



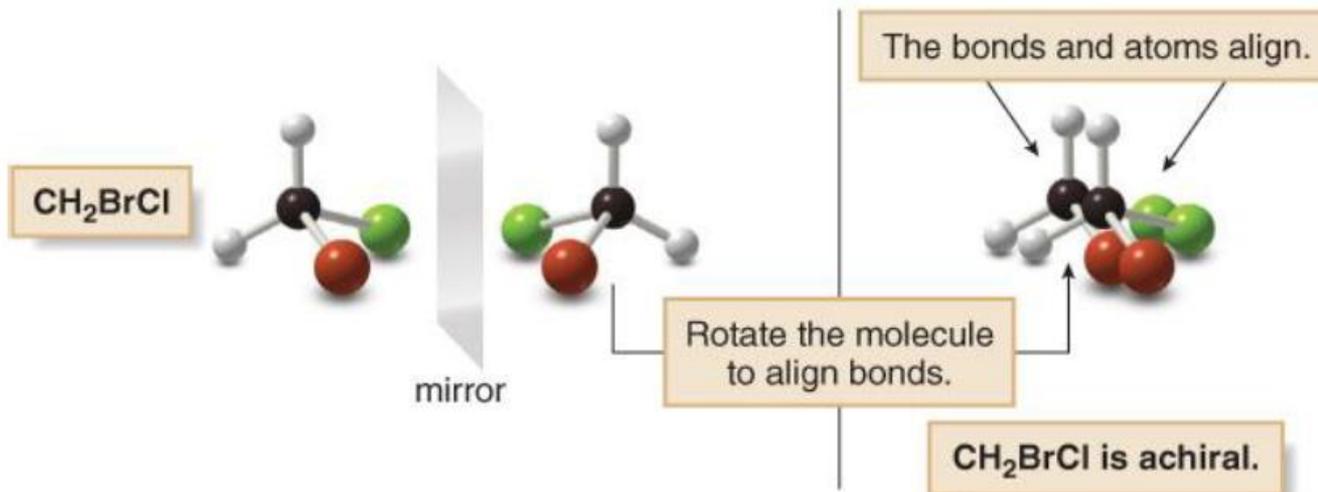
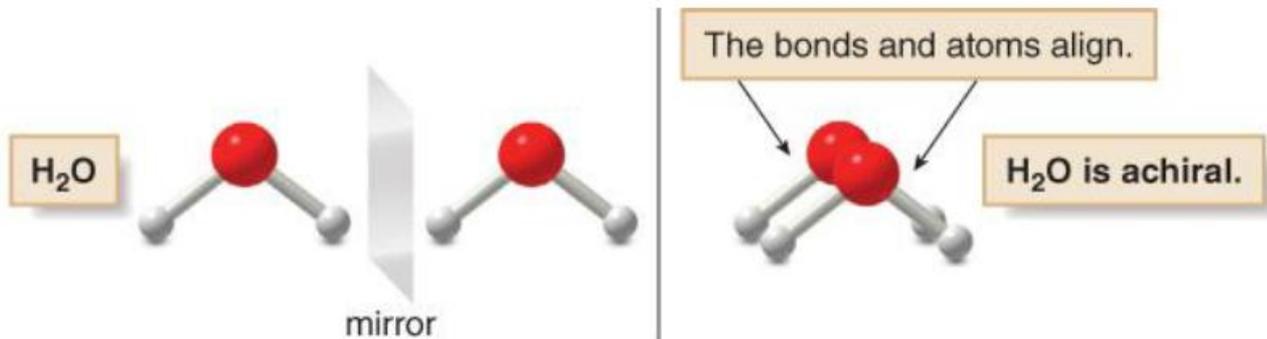
# Tartaric acid



## Louis Pasteur

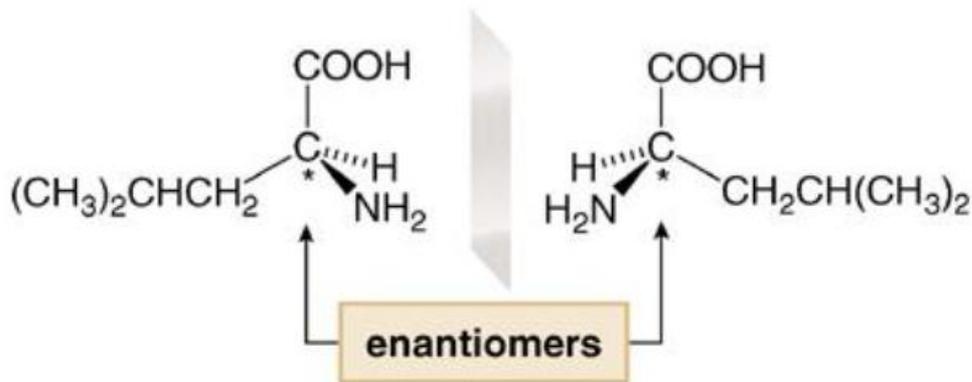


# Chirality



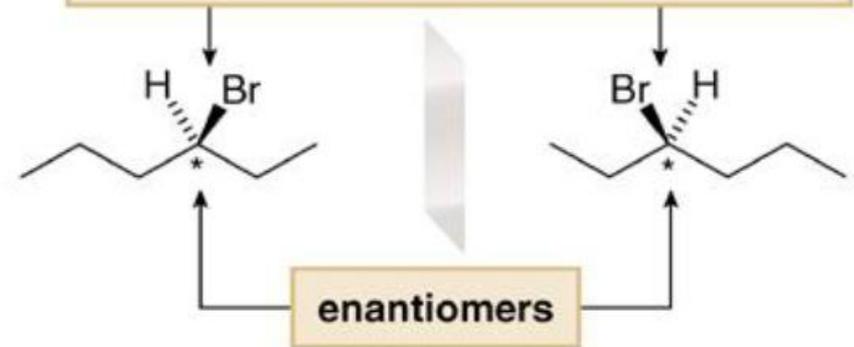
# Stereogenic Centers

Leucine, an amino acid



3-Bromohexane

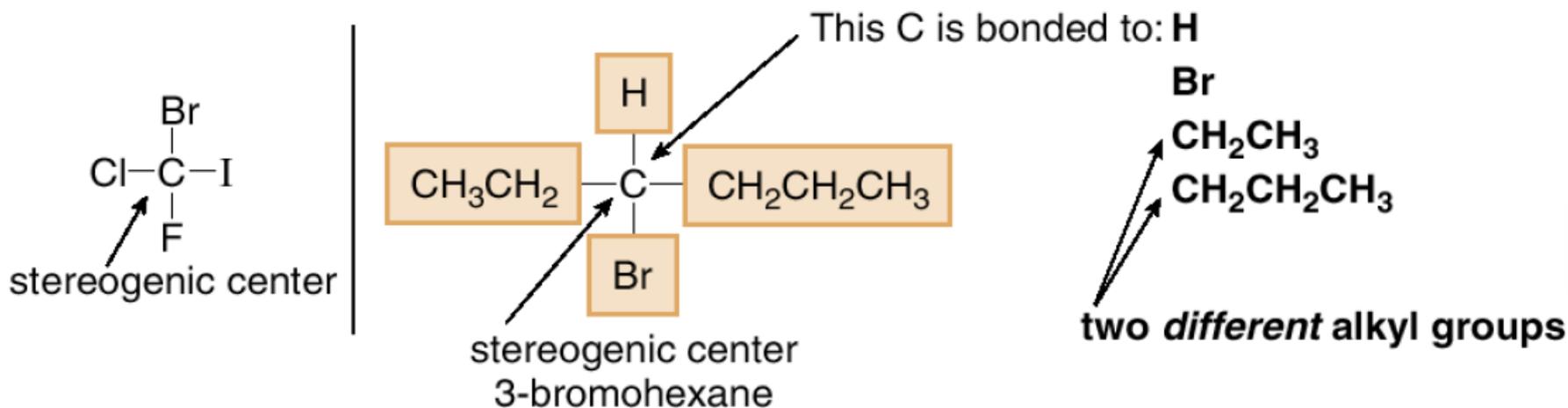
Remember: H and Br are directly aligned, one behind the other.



[\* = stereogenic center]

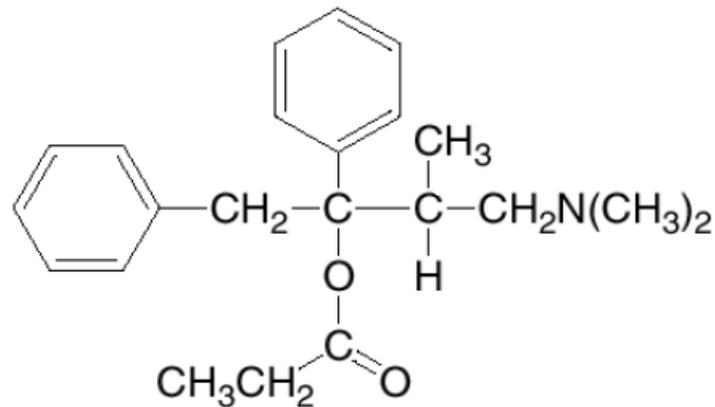
# Stereogenic Centers

- To locate a stereogenic center, examine each tetrahedral carbon atom in a molecule, and look at the four groups—not the four atoms—bonded to it.
- Always omit from consideration all C atoms that cannot be tetrahedral stereogenic centers. These include
  - $\text{CH}_2$  and  $\text{CH}_3$  groups
  - Any  $sp$  or  $sp^2$  hybridized C

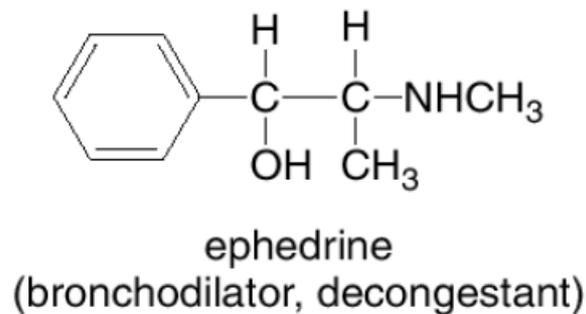


# Stereogenic Centers

- Larger organic molecules can have two, three or even hundreds of stereogenic centers.

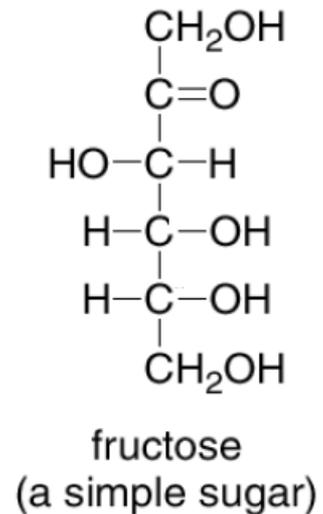


propoxyphene  
Trade name: Darvon  
(analgesic)



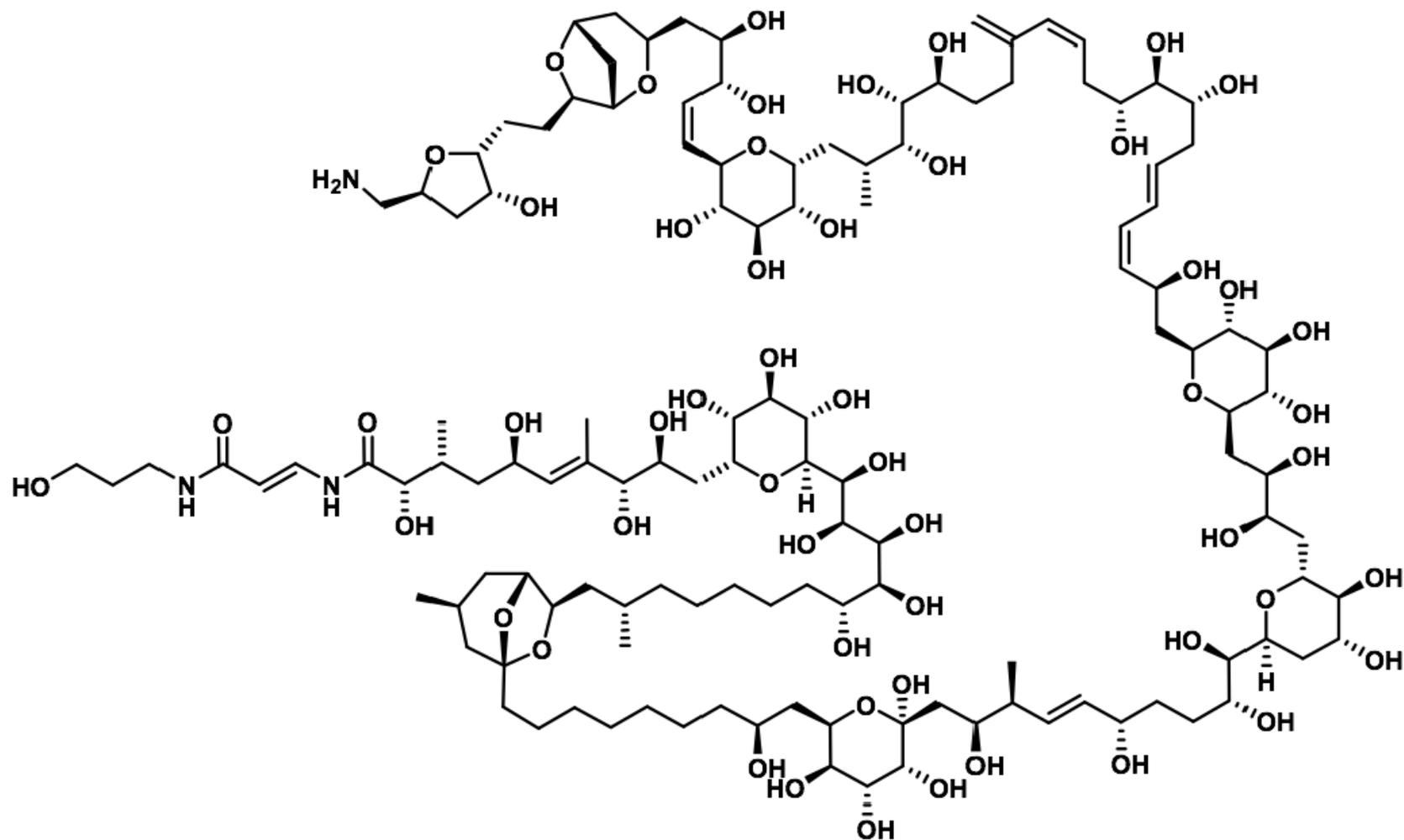
ephedrine  
(bronchodilator, decongestant)

[\* = stereogenic center]



fructose  
(a simple sugar)

# Stereogenic Centers

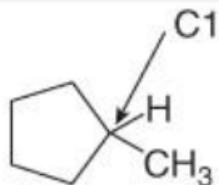


Palytoxin: 64 chiral centers

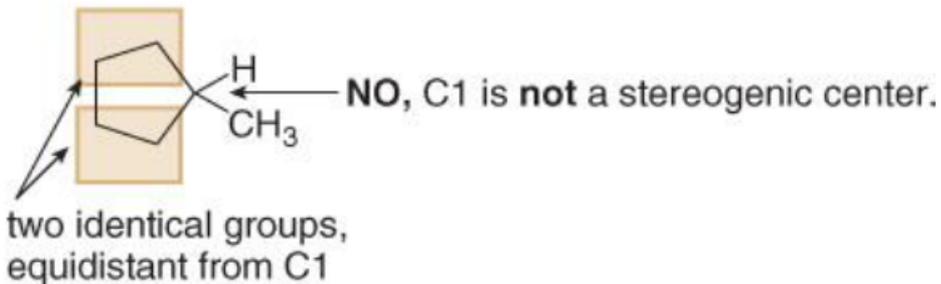
# Cyclic Compounds

- Stereogenic centers may also occur at carbon atoms that are part of a ring.
- To find stereogenic centers on ring carbons, always draw the rings as flat polygons, and look for tetrahedral carbons that are bonded to four different groups.

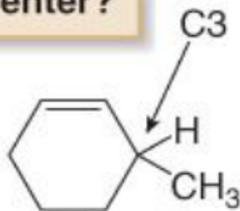
Is C1 a stereogenic center?



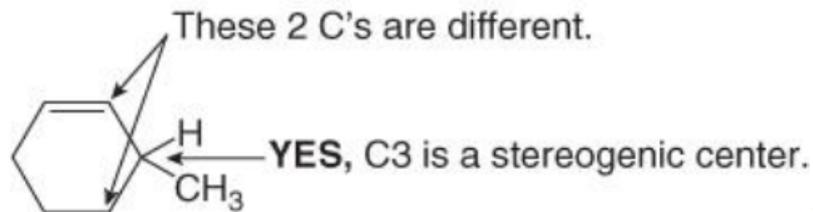
methylcyclopentane



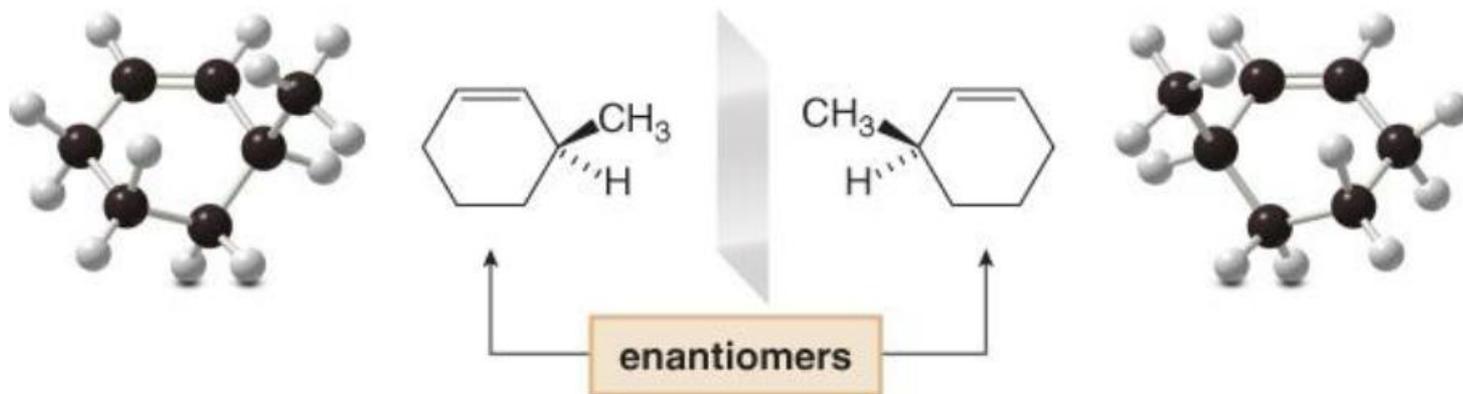
Is C3 a stereogenic center?



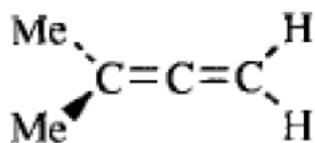
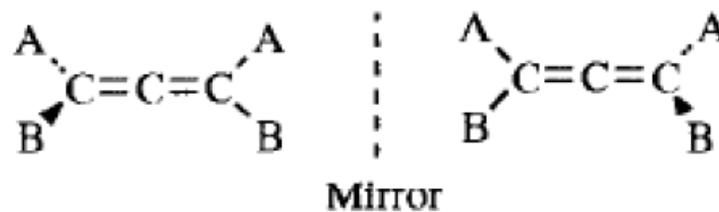
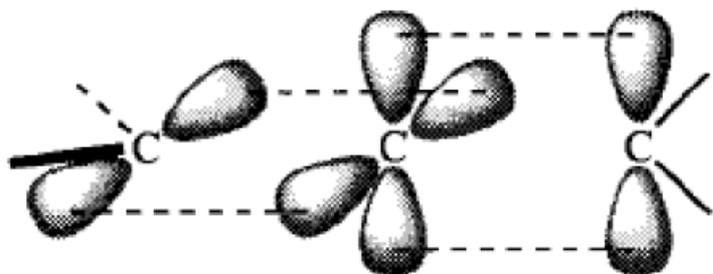
3-methylcyclohexene



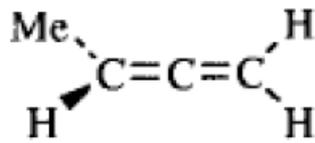
# Cyclic Compounds



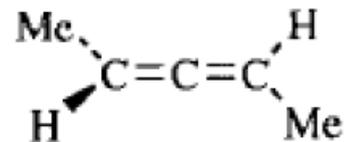
# Allenes



Inactive

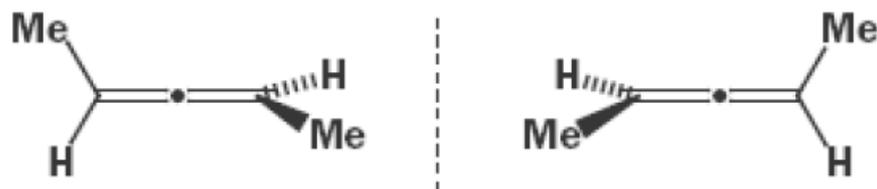


Inactive



Active

## Enantiomers



# Chirality and Symmetry

- A stereogenic center is a sufficient but not necessary condition for chirality.
- With one stereogenic center, a molecule will always be chiral.
- With two or more stereogenic centers, a molecule may or may not be chiral.
- Achiral molecules usually contain a **plane of symmetry** but chiral molecules do not.
- A plane of symmetry is a **mirror plane** that cuts the molecule in half, so that one half of the molecule is a reflection of the other half.