Organic Chemistry

Stereochemistry

by
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Chapter Description

- Aims
  - The students should **understand** the fundamental of organic chemistry in terms of stereochemistry
  - The students should be able to **explain** the fundamental of organic chemistry in terms of stereochemistry

- Expected Outcomes
  - Explain the basic knowledge in stereochemistry
  - Describe enantiomer, diastereomer and meso compounds concept
  - Describe the cis and trans compound in stereochemistry

- References

  - Janice Gorzynski Smith (2008), Organic chemistry,Mc Graw-Hill
  - T. W. Graham Solomons. (2008). Organic chemistry, 9th ed, Mc Graw-Hill
  - Sharma, R. K. (2007). Stereochemistry. New Delhi: Discovery Publications

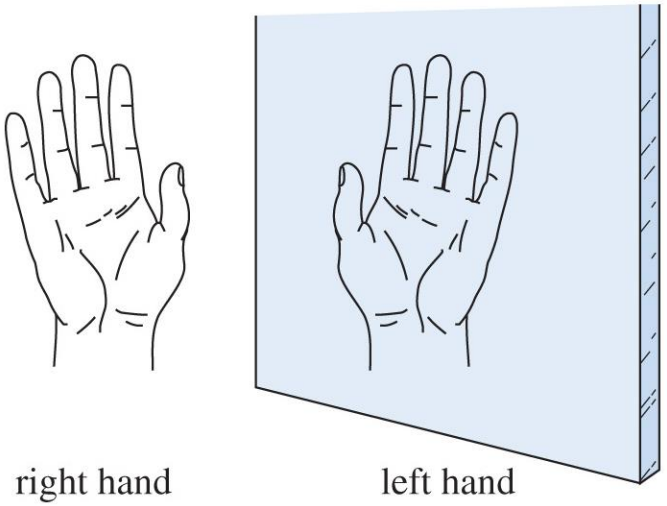
Stereochemistry

Stereochemistry refers to the **3-dimensional properties** and reactions of molecules. It has its own language and terms that need to be learned in order to fully communicate and understand the concepts.

More Definitions

- **Asymmetric center** – sp^3 carbon with 4 different groups attached
- **Optical activity** – the ability to rotate the plane of plane –polarized light
- **Chiral compound** – a compound that is optically active (achiral compound will not rotate light)
- **Polarimeter** – device that measures the optical rotation of the chiral compound

Chirality

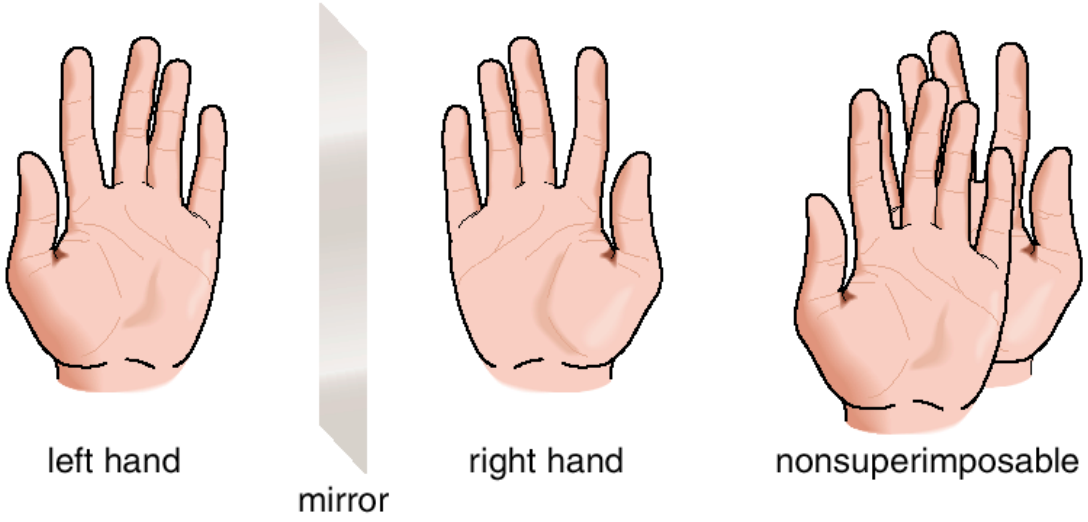


- "Handedness": Right-hand glove does not fit the left hand.
- An object is **chiral** if its mirror image is different from the original object.

Stereochemistry

Chiral and Achiral Molecules

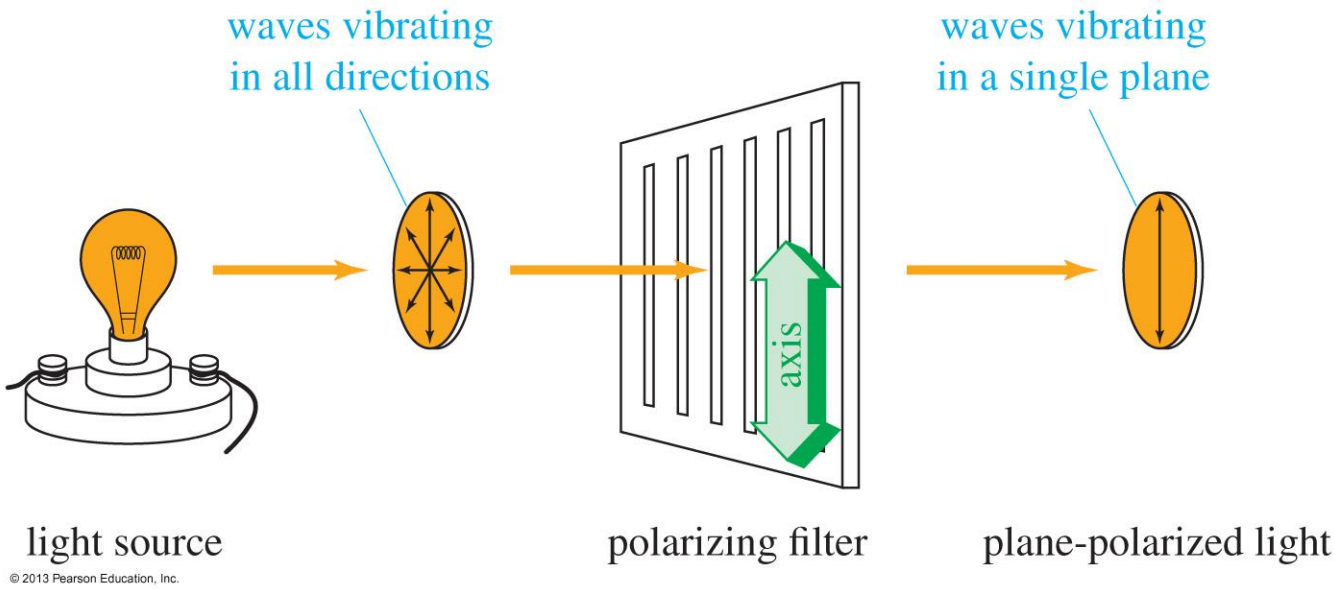
- Although everything has a mirror image, mirror images may or may not be superimposable.
- Some molecules are like hands. Left and right hands are mirror images, but they are not identical, or superimposable.



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

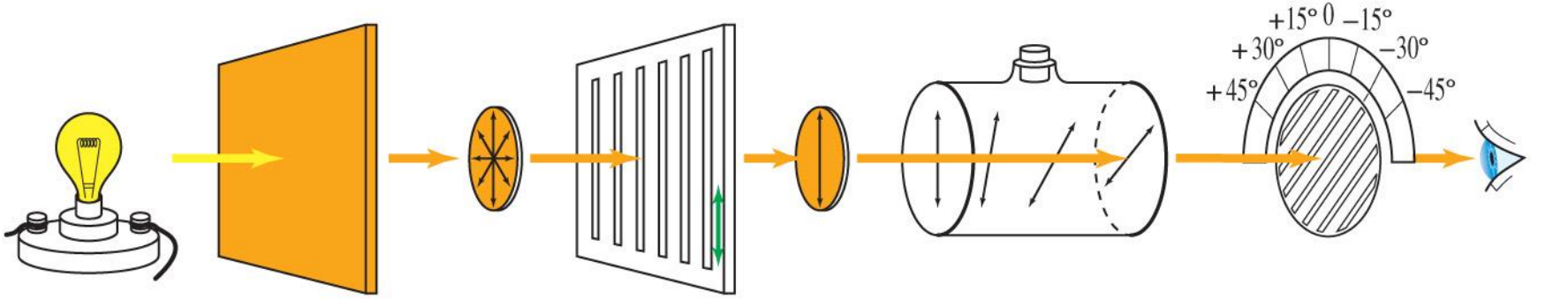
Polarized Light

Plane-polarized light is composed of waves that vibrate in only one plane.

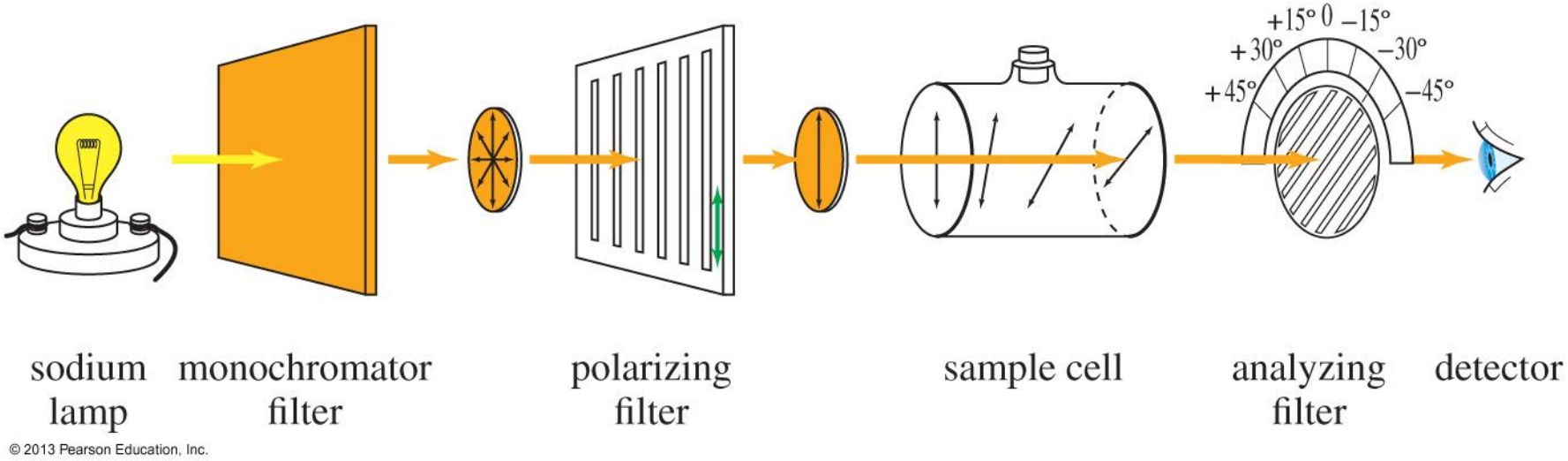


Optical Activity

- Enantiomers rotate the plane of polarized light in opposite directions, but same number of degrees.



Polarimeter



Clockwise

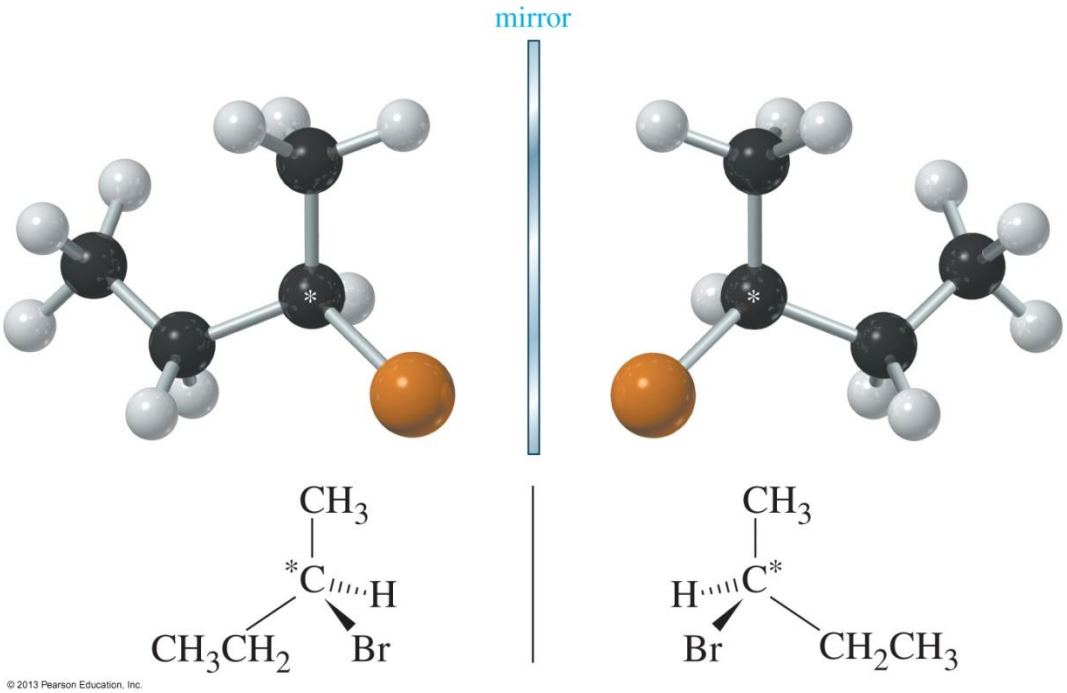
Dextrorotatory (+)

Counterclockwise

Levorotatory (-)

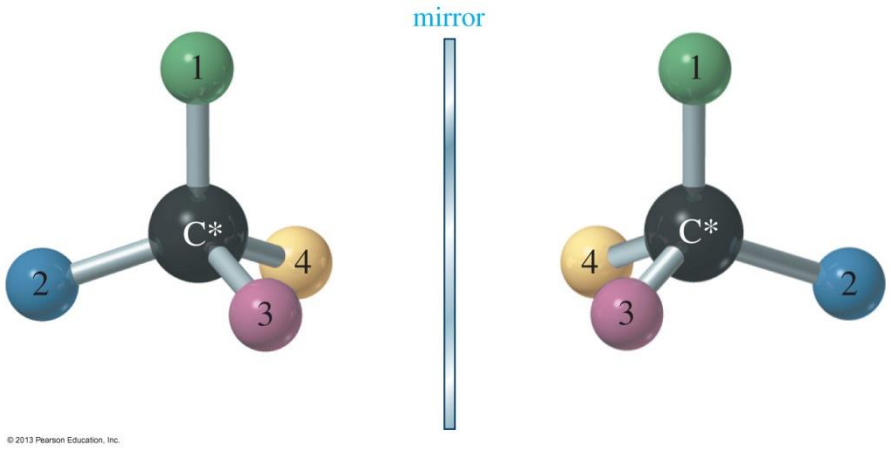
Stereoisomers

Enantiomers: Compounds that are nonsuperimposable mirror images. Any molecule that is chiral must have an enantiomer.



Chiral Carbon Atom

- Also called *asymmetric carbon* atom.
- Carbon atom that is bonded to four different groups is chiral.
- Its mirror image will be a different compound (enantiomer).



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Stereocenters

- An asymmetric carbon atom is the most common example of a **chirality center.**
- Chirality centers belong to an even broader group called *stereocenters.* A ***stereocenter*** *(*or *stereogenic atom)* is any atom *at* which the interchange of two groups gives a stereoisomer.
- Asymmetric carbons and the double-bonded carbon atoms in *cis-trans* isomers are the most common types of stereocenters.

Definitions

- **Stereoisomers** – compounds with the same connectivity, different arrangement in space
- **Enantiomers** – stereoisomers that are non-superimposible mirror images; only properties that differ are direction (+ or -) of optical rotation
- **Diastereomers** – stereoisomers that are not mirror images; different compounds with different physical properties

Properties of Enantiomers

- Same boiling point, melting point, and density.
- Same refractive index.
- Rotate the plane of polarized light in the same magnitude, but in opposite directions.
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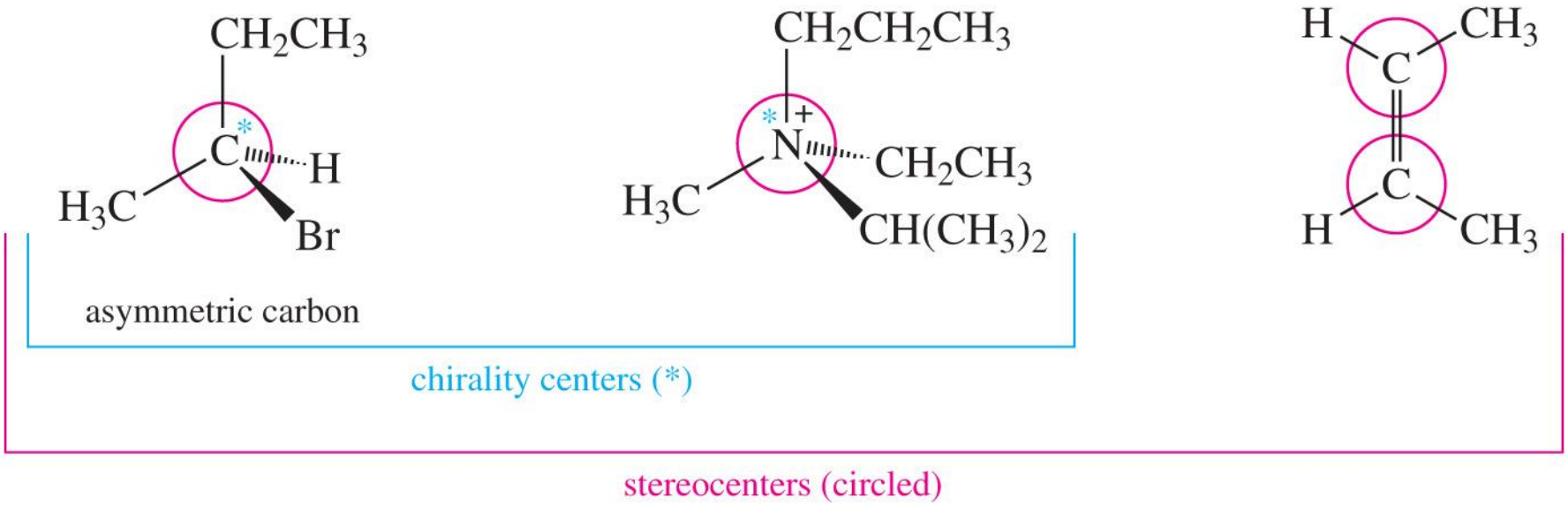
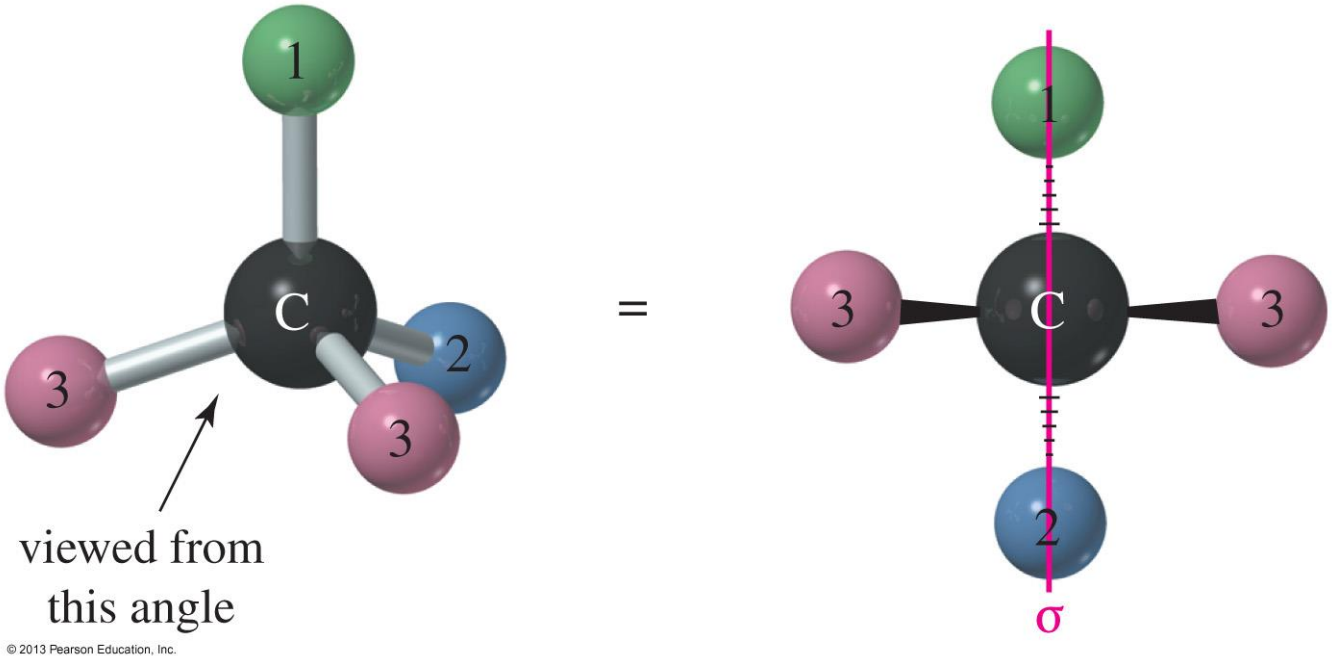
Examples of Chirality Centers



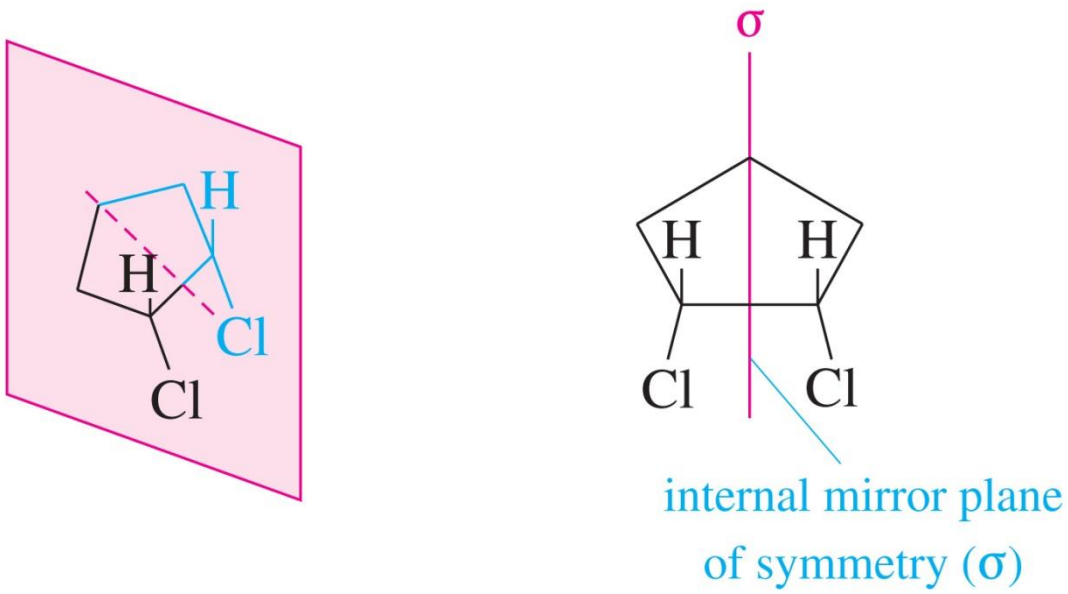
Asymmetric carbon atoms are examples of chirality centers, which are examples of stereocenters.

Planes of Symmetry



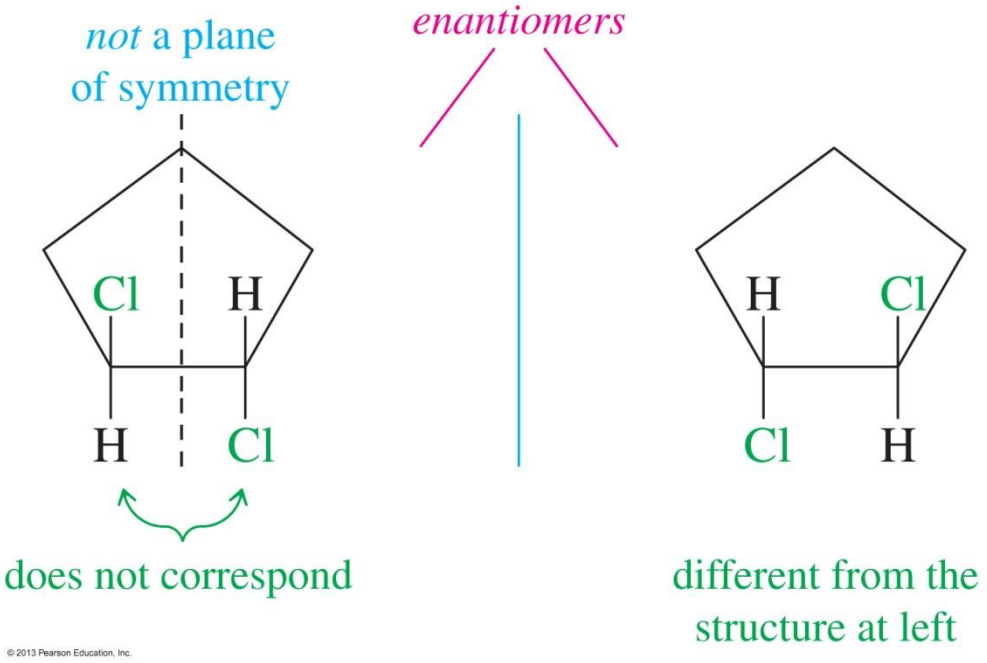
- A molecule that has a plane of symmetry is ***achiral***.

Cis Cyclic Compounds



- *Cis*-1,2-dichlorocyclohexane is achiral because the molecule has an internal plane of symmetry. Both structures above can be superimposed (they are identical to their mirror images).

Trans Cyclic Compounds



- *Trans*-1,2-dichlorocyclohexane does not have a plane of symmetry so the images are nonsuperimposable and the molecule will have two enantiomers.

Conclusion of The Chapter

- Conclusion #1
  - The fundamental of stereochemistry with its classification were understandable.
- Conclusion #2
  - The fundamental of stereochemistry included the concept of enantiomer, diastereomer and meso compound were practically explained.
- Conclusion #3
  - The information of cis and trans classification in stereochemistry was practically described.

Co-author Information

Nurlin Abu Samah is an analytical chemistry lecturer since 2010 and currently she further her PhD study in Universitat Autonoma de Barcelona, Spain. She was graduated from Universiti Kebangsaan Malaysia for her Master of Science in Chemistry. During her undergraduate, she was studied in Universiti Sains Malaysia, Penang.

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