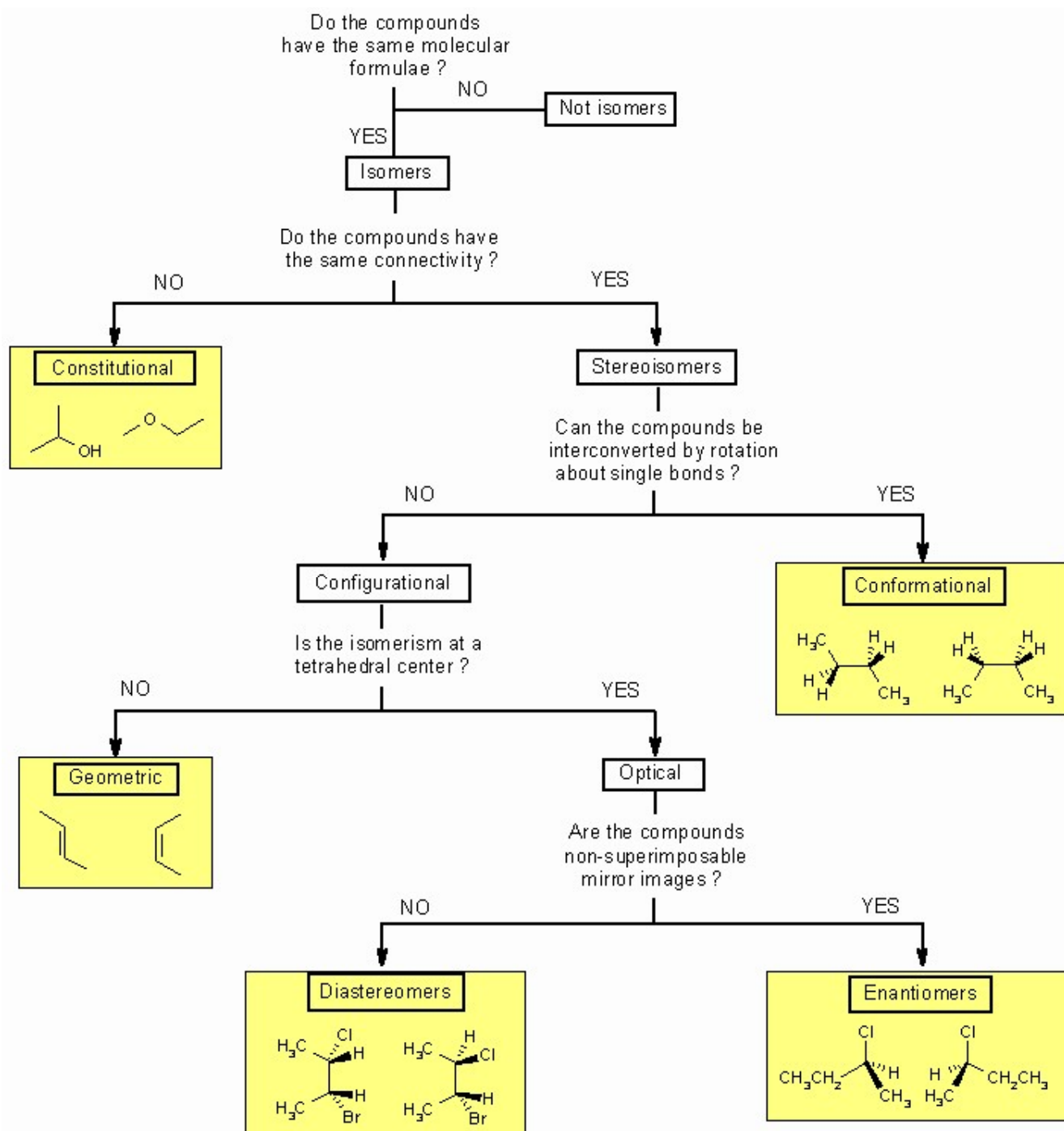


Stereochemistry

Stereochemistry

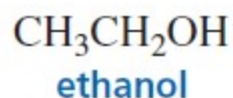
- Stereochemistry refers to the 3-dimensional properties and reactions of molecules. It has its own language and terms that need to be learned in order to fully communicate and understand the concepts.



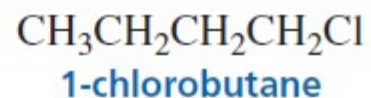
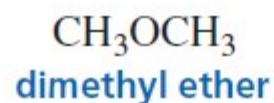
Constitutional isomers

- Same Molecular formula
- Differ in the way their atoms are connected

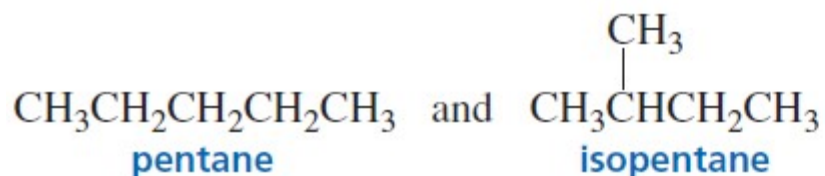
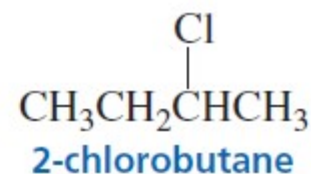
constitutional isomers



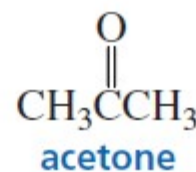
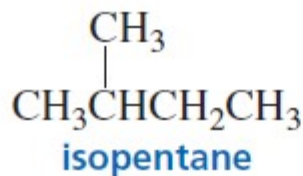
and



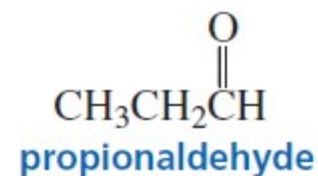
and



and

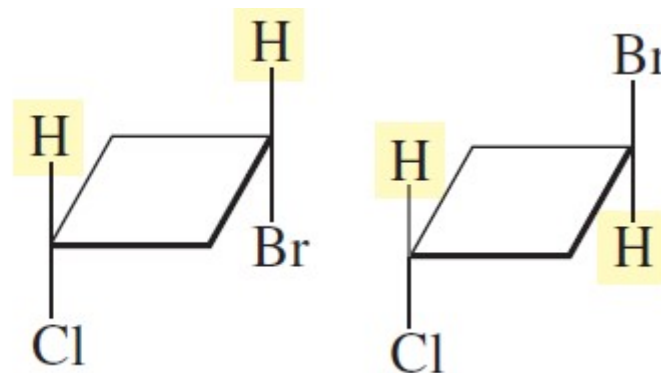
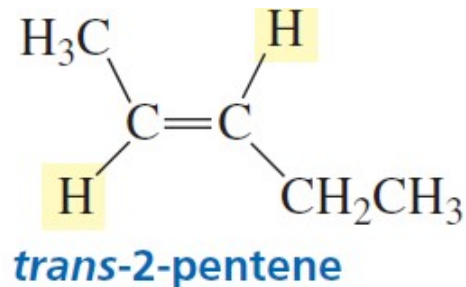
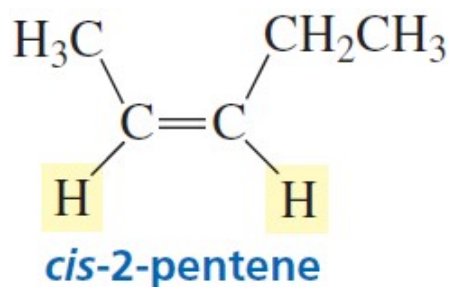


and



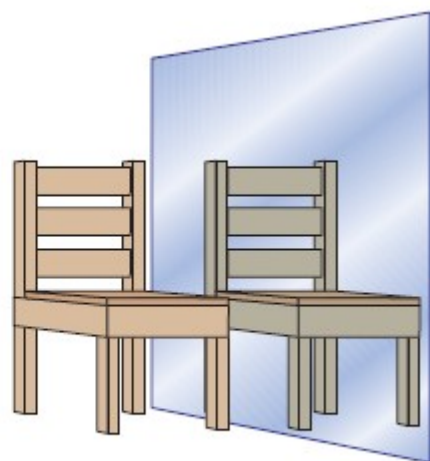
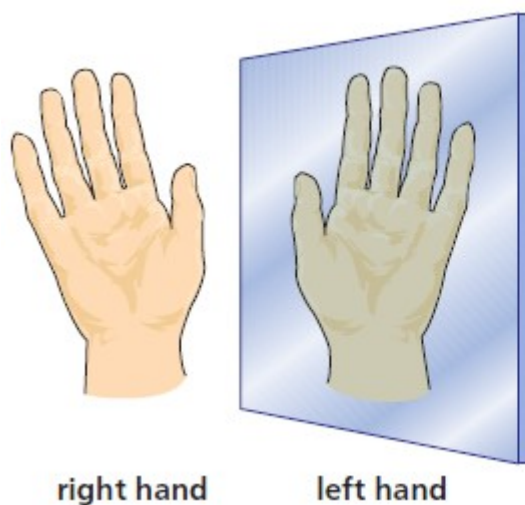
Stereoisomers

- the atoms in stereoisomers are connected in the same way
 - Configurational Isomers
 - Cis–Trans Isomers:** result from restricted rotation
 - restricted rotation about a carbon–carbon double bond
 - Cyclic compounds



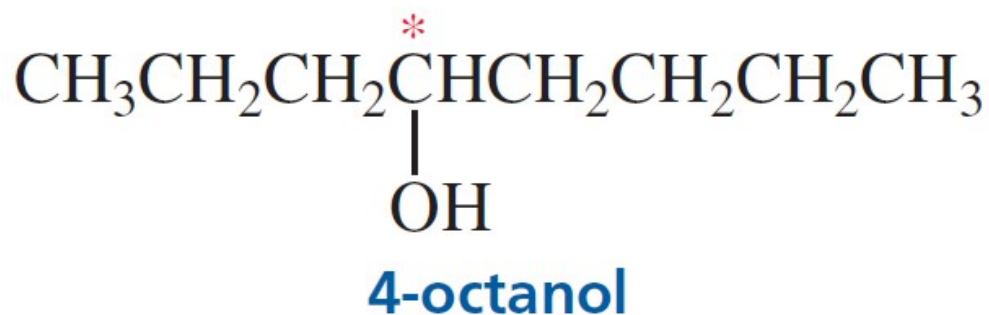
Optical isomers

- **Chirality:**
- A **chiral** object has a nonsuperimposable mirror image
- An **achiral** object has a superimposable mirror image

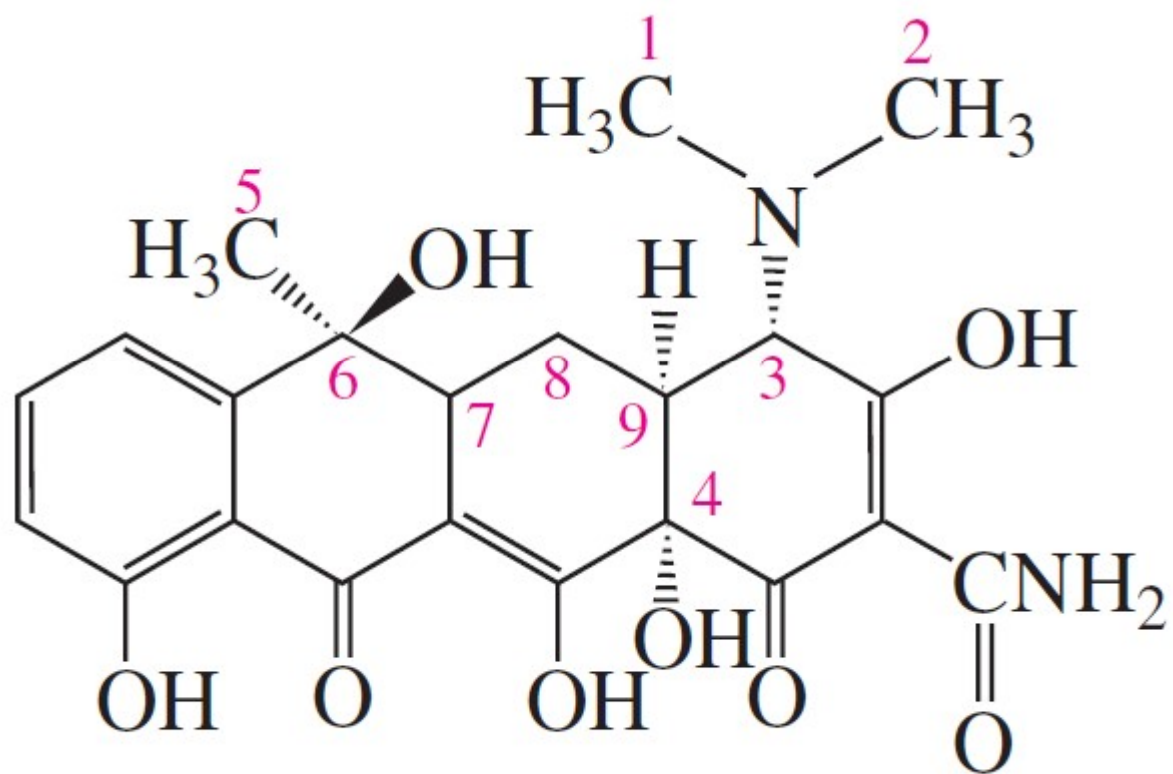


Optical isomers

- **Chirality in molecules:**
- An **asymmetric carbon**: carbon atom that is bonded to four different groups



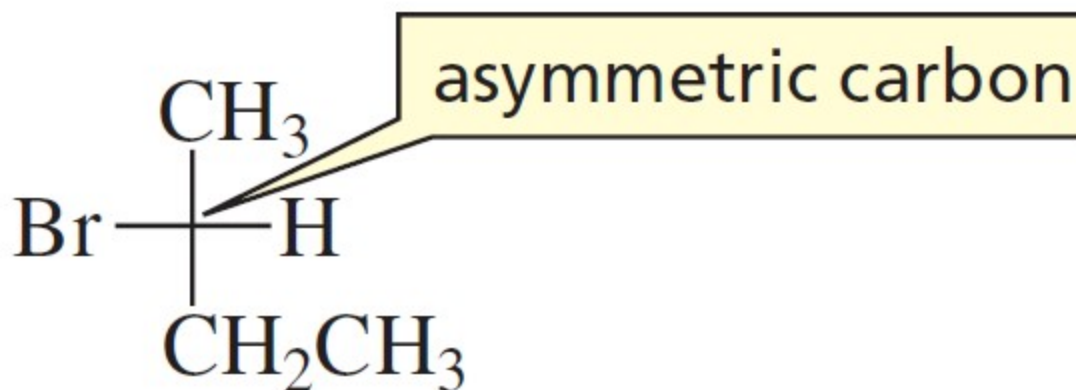
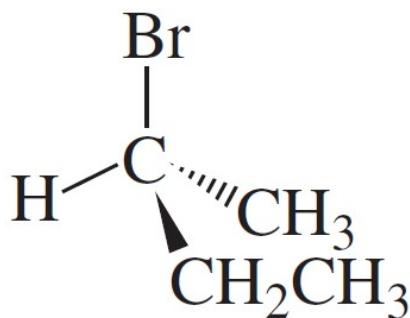
- sp^2 and sp hybridized carbons cannot be asymmetric carbons



tetracycline

Enantiomers

- **Enantiomers** – stereoisomers that are non-superimposable mirror image molecules; only properties that differ are direction (+ or -) of optical rotation
- **Drawing Enantiomers:**
 - **Perspective formulas** and **Fischer projections**



CIP Priority Rules

- Higher atomic number precedes lower
 - S>F>O>N>C>H
- Higher atomic mass precedes lower
 - T>D>H
- Cis precedes Trans and R precedes S

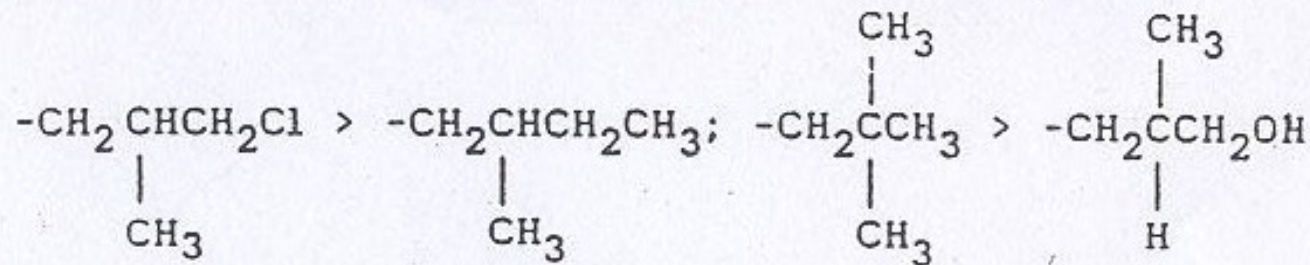
CIP Priority Rules

- Atoms directly attached to the central chiral atom must be sequenced first



(Decision is reached at the italicised atoms)

- In case a ligand bifurcates, one must proceed along the branch providing the highest precedence until a difference is encountered.



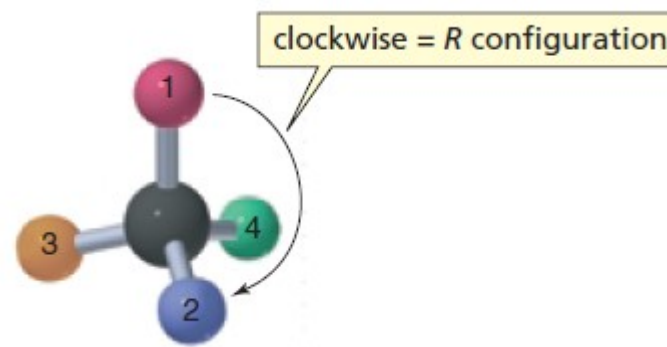
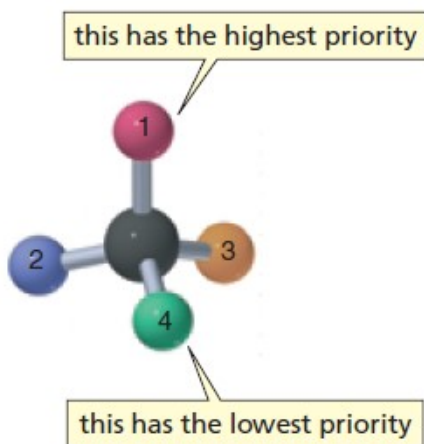
CIP Priority Rules

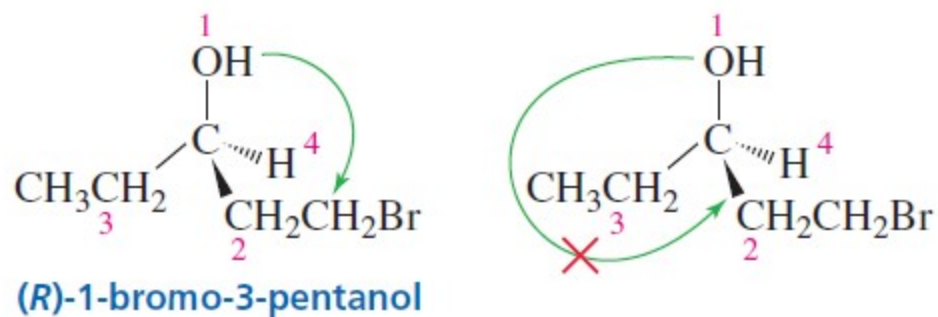
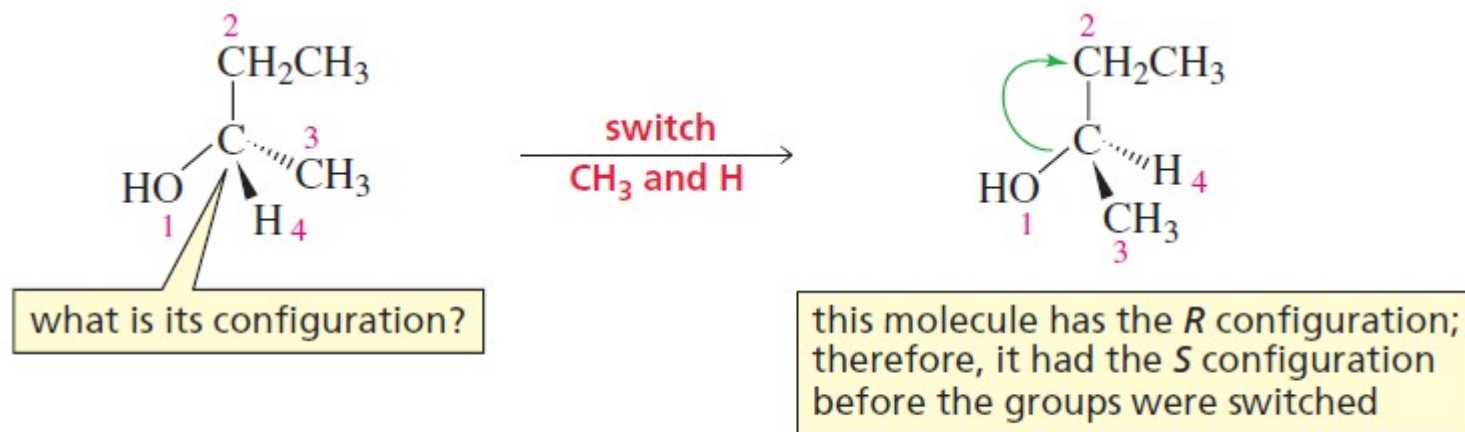
Table 4.1 Atoms and groups with increasing priority

1. H	10. CH = CH ₂	19. CO ₂ R	28. OCOR
2. D	11. C(CH ₃) ₃	20. NH ₂	29. F
3. CH ₃	12. C ≡ CH	21. NHCH ₃	30. SH
4. CH ₂ CH ₃	13. C ₆ H ₅	22. N(CH ₃) ₂	31. SR
5. CH ₂ (CH ₂) _n CH ₃	14. CH ₂ OH	23. NO	32. SOR
6. CH ₂ - CH = CH ₂	15. CH = O	24. NO ₂	33. SO ₂ R
7. CH ₂ - C ≡ CH	16. COR	25. OH	34. Cl
8. CH ₂ C ₆ H ₅	17. CONH ₂	26. OCH ₃	35. Br
9. CH(CH ₃) ₂	18. CO ₂ H	27. OC ₆ H ₅	36. I

Naming Enantiomers

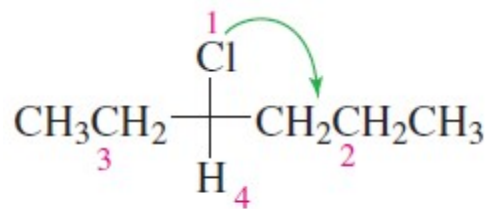
- **R,S** System of Nomenclature:
 1. Rank the groups (or atoms) bonded to the asymmetric carbon in order of priority
 2. Orient the molecule so that the group (or atom) with the **lowest priority (4) is directed away from you**. Then draw an imaginary arrow from the group (or atom) with the highest priority (1) to the group (or atom) with the next highest priority (2).



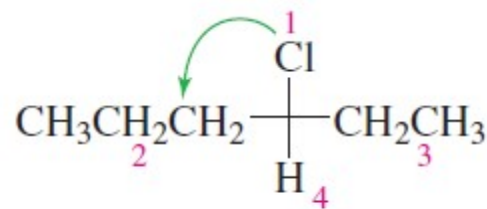


Fischer Projection

- Rank the groups (or atoms) that are bonded to the asymmetric carbon in order of priority.
- Draw an arrow from the group (or atom) with the highest priority (1) to the group (or atom) with the next highest priority (2). If the arrow points **clockwise**, the enantiomer has the ***R configuration***



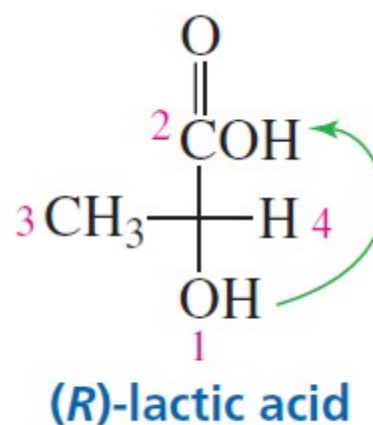
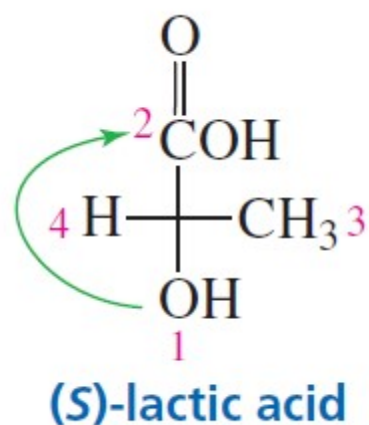
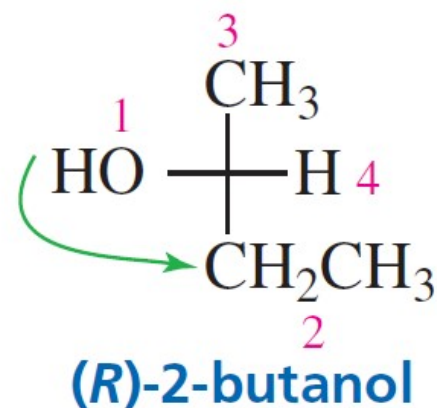
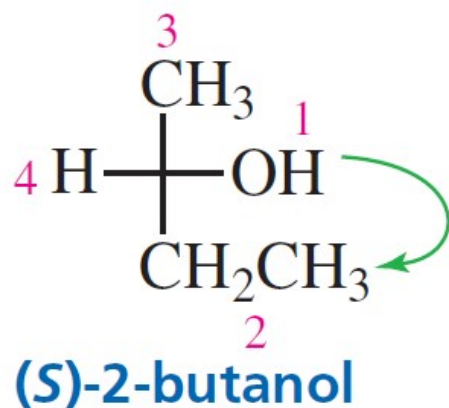
(R)-3-chlorohexane



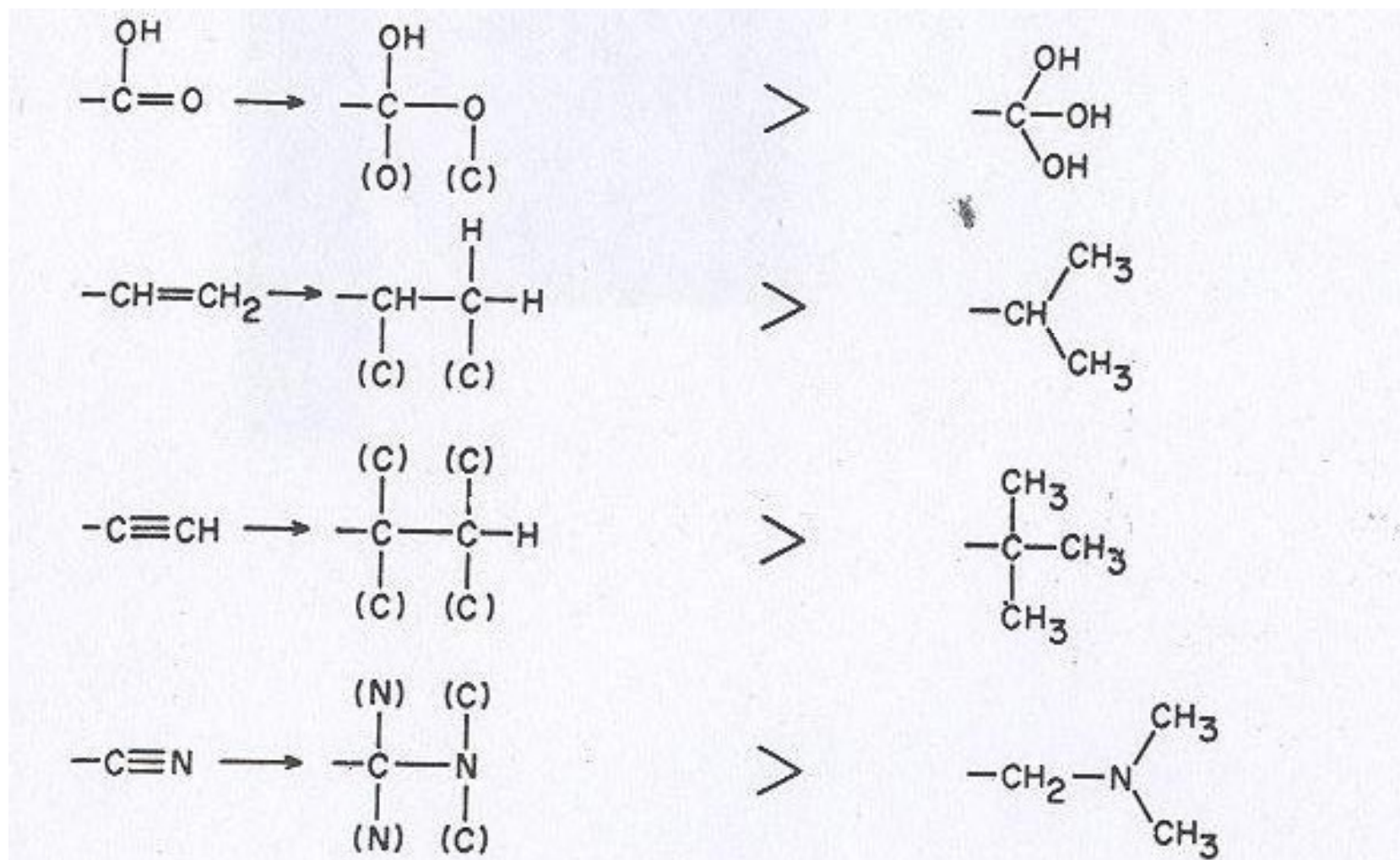
(S)-3-chlorohexane

Fischer Projection

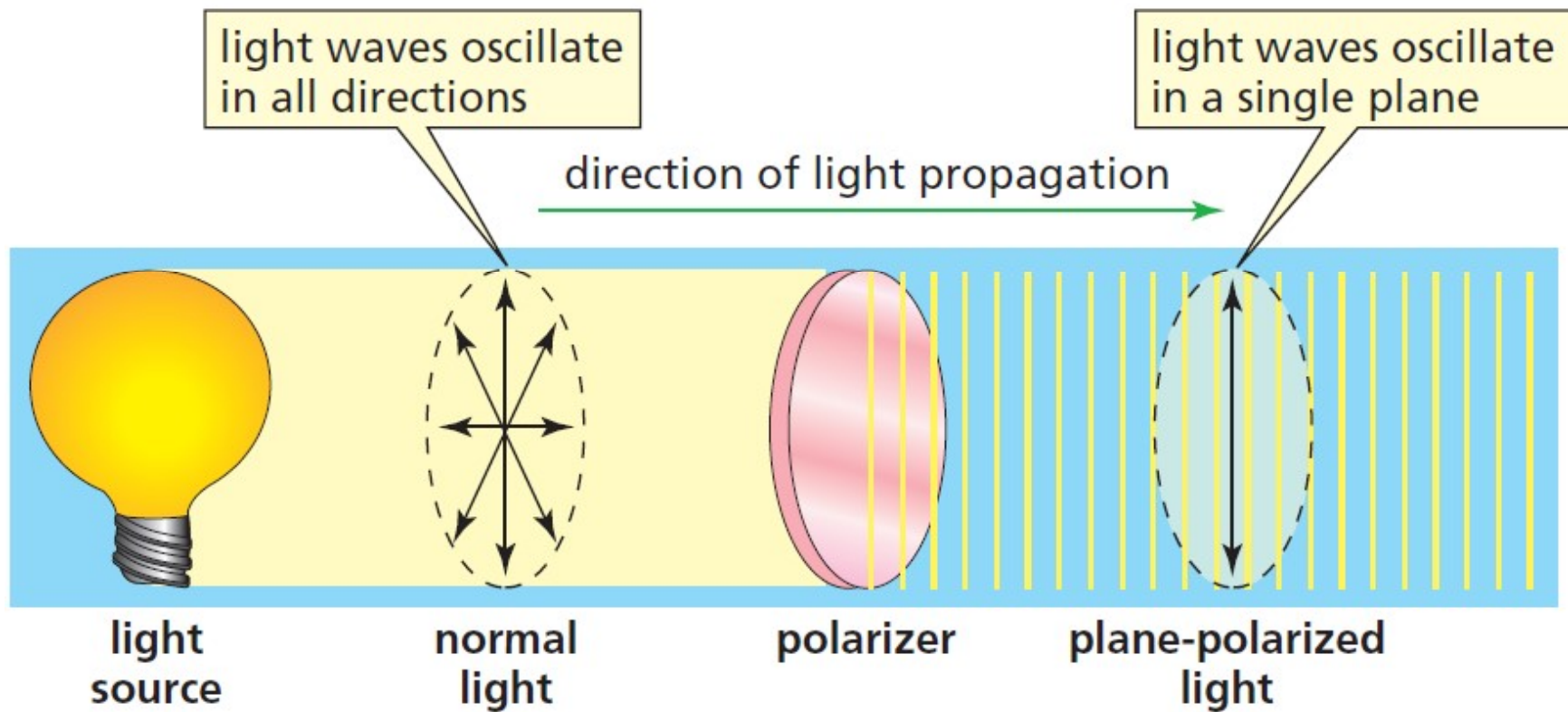
- the lowest priority is on a **vertical bond**



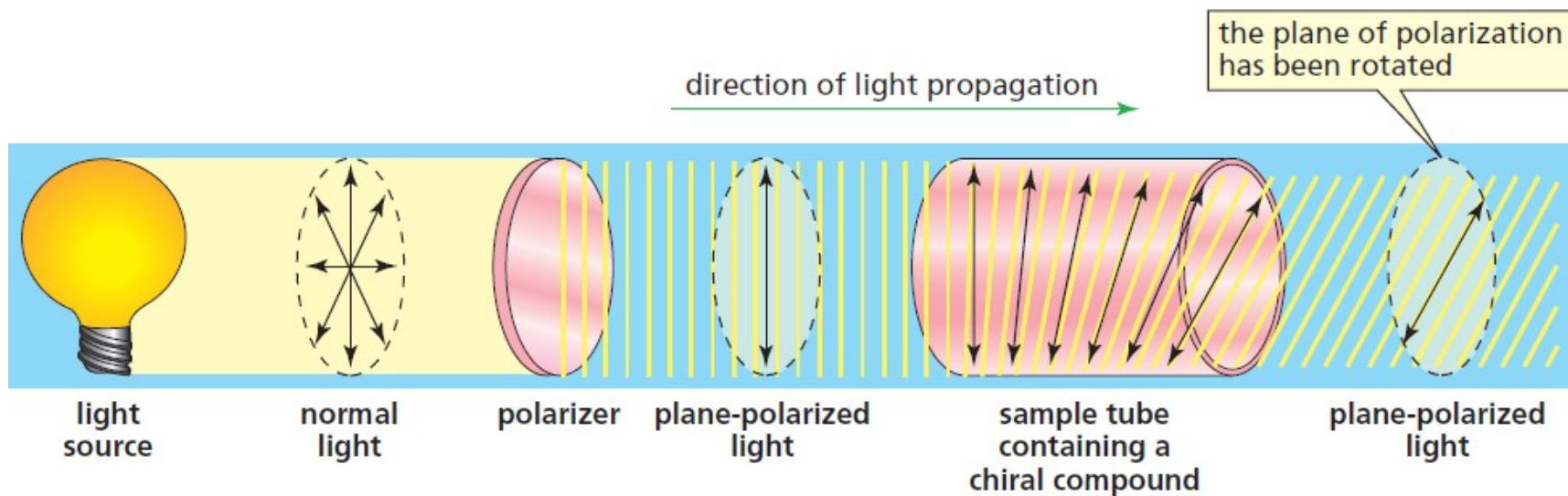
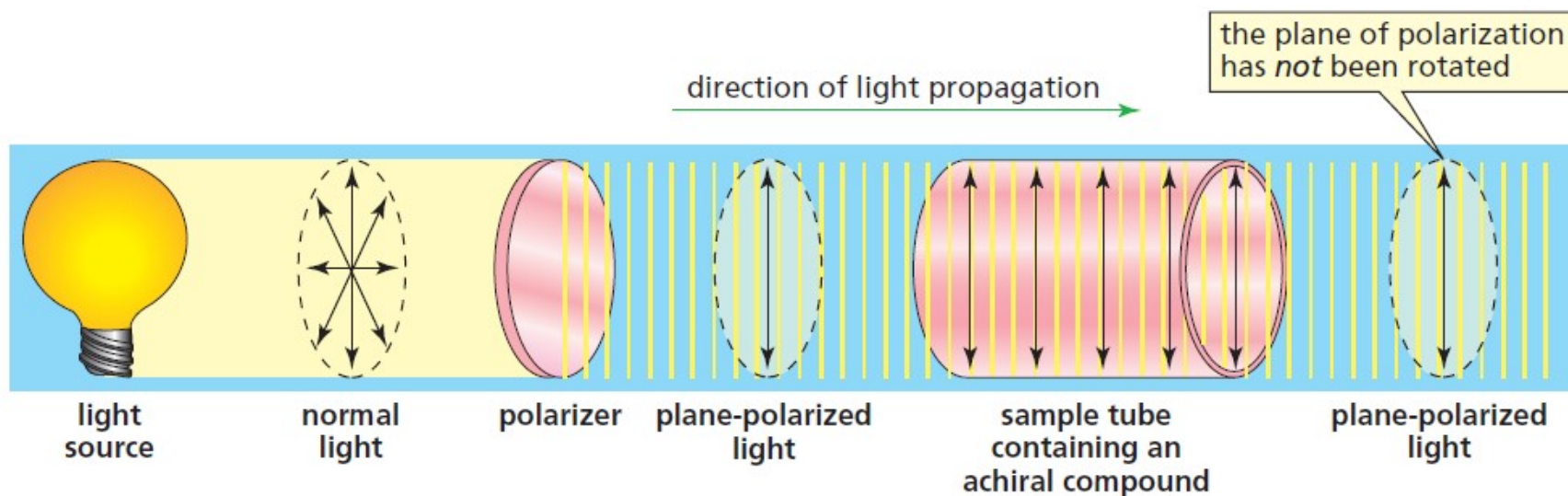
Phantom Atoms in CIP Priority



Optical Activity



Optical Activity



- **Dextrorotatory:** optically active compound rotates the plane of polarization **clockwise (+)**
- **Levorotatory:** optically active compound rotates the plane of polarization **anticlockwise (-)**
- **Specific rotation** is the number of degrees of rotation caused by a solution of 1.0 g of the compound per mL of solution in a sample tube 1.0 dm long at a specified temperature and wavelength.

$$[\alpha]_{\lambda}^T = \frac{\alpha}{l \times c}$$

(±) Racemic mixture

- A mixture of equal amounts of two enantiomers—such as (R)-lactic acid and (S)-lactic acid—is called a **racemic mixture** or a racemate.
- optically inactive

Optical Purity

$$\text{optical purity} = \frac{\text{observed specific rotation}}{\text{specific rotation of the pure enantiomer}}$$

- the specific rotation of (*S*)-2-bromobutane is +23.1°. If a sample of 2-bromobutane has an observed specific rotation of +9.2°. Then optical purity is 0.40

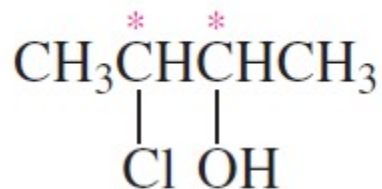
Enantiomeric Excess

- If the mixture has a 40% enantiomeric excess (S enantiomer is in excess), then 70% of the mixture is the S enantiomer and 30% is the R enantiomer

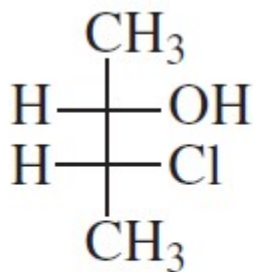
$$\text{enantiomeric excess} = \frac{\text{excess of a single enantiomer}}{\text{entire mixture}} \times 100\%$$

More than One Asymmetric Carbon

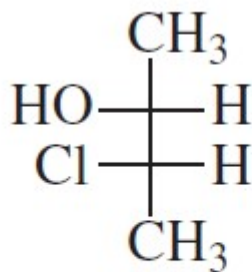
- a compound can have a maximum of 2^n stereoisomers (provided it doesn't have any other stereocenters), where n equals the number of asymmetric carbons.



3-chloro-2-butanol

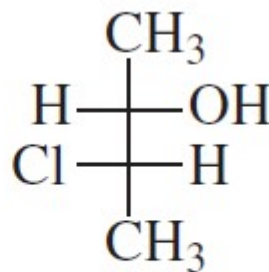


1

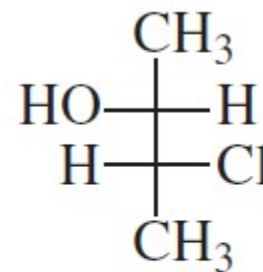


2

erythro enantiomers



3



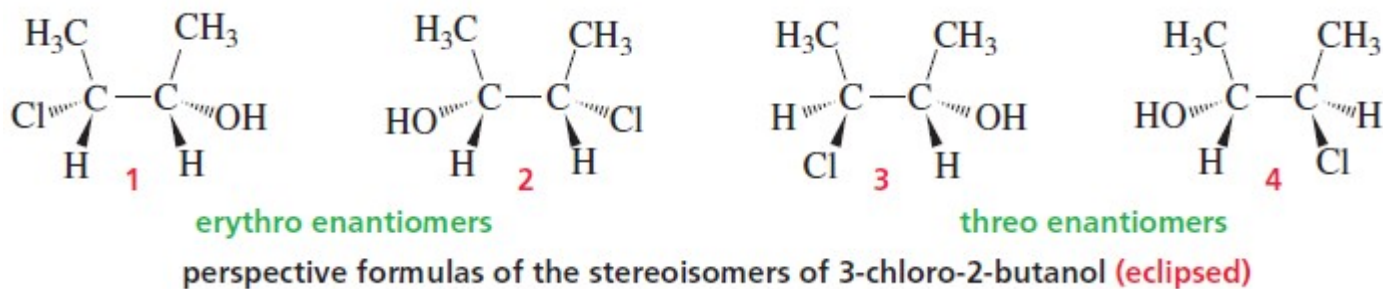
4

threo enantiomers

Diastereomers

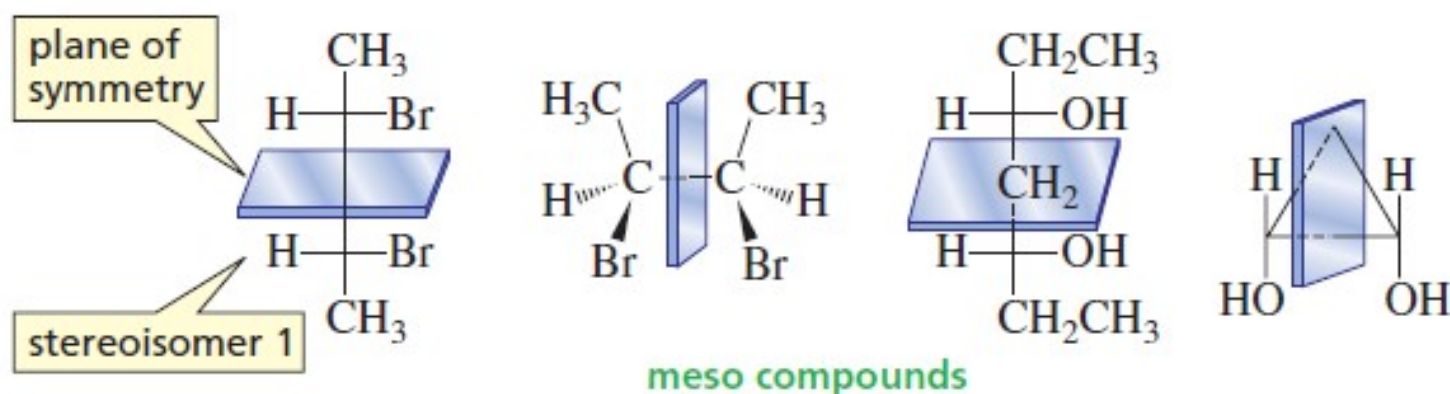
- Stereoisomers that are not mirror images
- Enantiomers have identical physical properties (except for the way they interact with polarized light) and identical chemical properties
- Diastereomers have different physical properties and different chemical properties

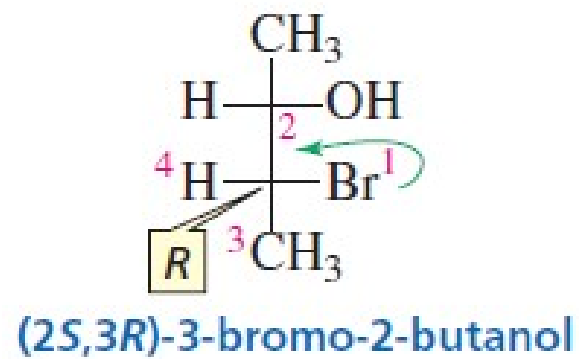
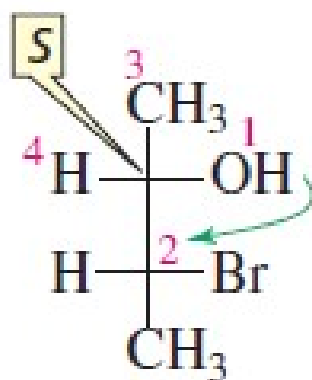
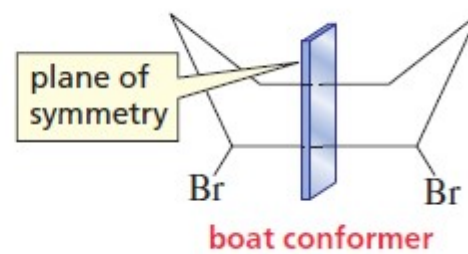
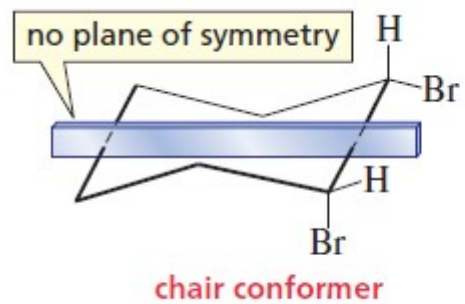
- A Fischer projection does not show the three-dimensional structure of the molecule, and it represents the molecule in a relatively unstable eclipsed conformation



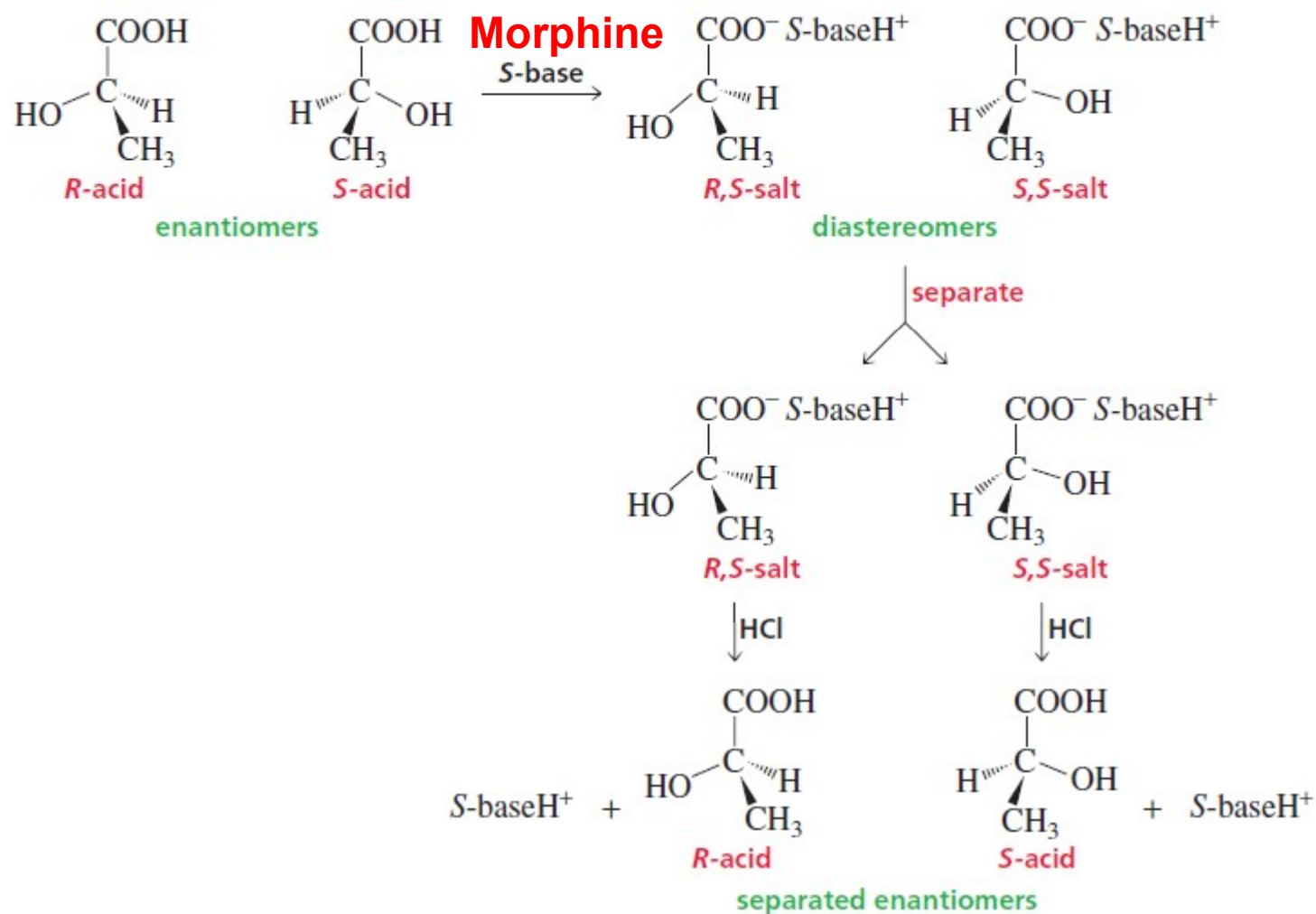
Meso Compounds

- Even though a meso compound has asymmetric carbons, it is an achiral molecule because it is superimposable on its mirror image
- Meso compound has a plane of symmetry, hence achiral





Separating Enantiomers



Biological Activity

(R)(+) Thalidomide



a sedative and hypnotic

(S)(-) Thalidomide



a teratogen