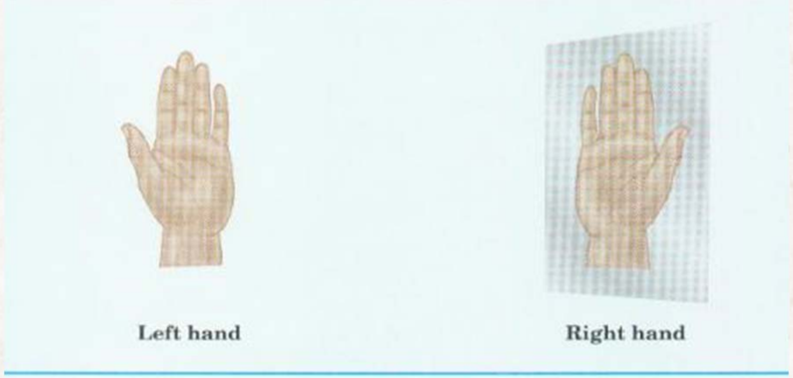
Stereochemistry

CONTENTS

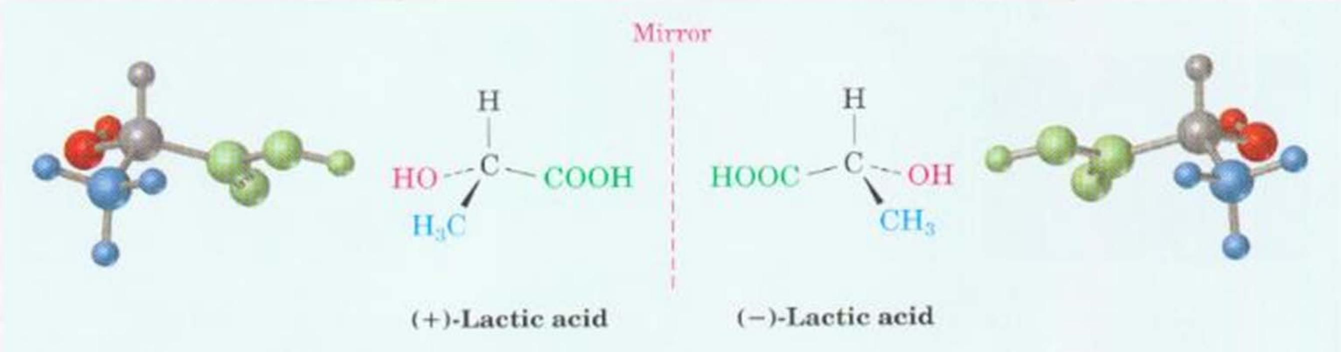
1. Introduction

- All chemical rxns occur in three dimensional space
- Carbon has the tetrahedral bondings which are sp^3-hybridized orbitals
- So, we must always consider the phenomena of stereomers
- look at your hands



2. The important terms & phenomenon

- Enantiomers : a pair of two mirror-image molecules that are not superimposable



- Chirality : molecules existed in enantiomeric forms to each other are said to be chiral
- A chiral center : a carbon atom(or other tetrahedrally structural atoms) is bonded to four different groups

⇨ Is the molecules with one or more chiral centers absolutely chiral?

3. How to determine the chirality of the molecule

- A molecule is not chiral if it contains a plane of symmetry

FIGURE 9.3

The meaning of *symmetry plane*. An object like the flask (a) has a symmetry plane cutting through it, making right and left halves mirror images. An object like a hand (b) has no symmetry plane; the right "half" of a hand is not a mirror image of the left "half."

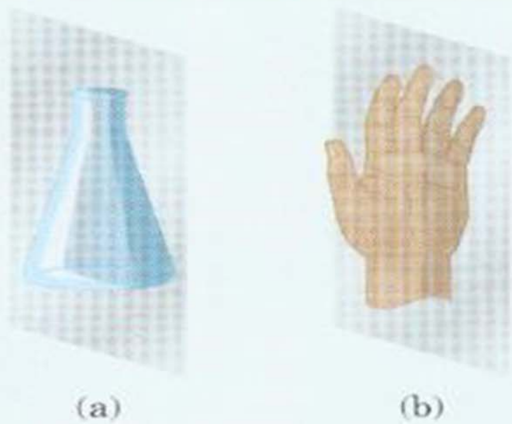
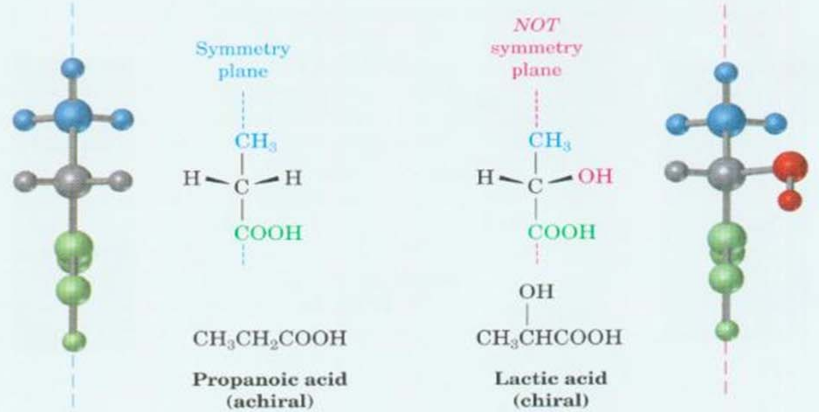


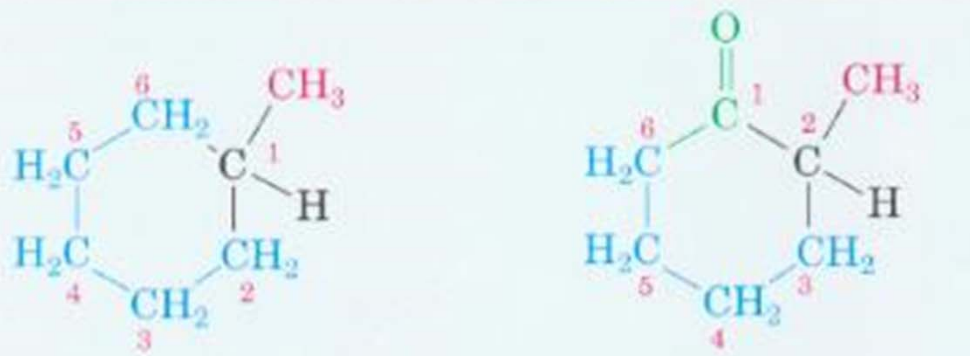
FIGURE 9.4

The achiral propanoic acid molecule versus the chiral lactic acid molecule. Propanoic acid has a plane of symmetry that makes one side of the molecule a mirror image of the other side. Lactic acid, however, has no such symmetry plane.



Propanoic acid (achiral)

Lactic acid (chiral)



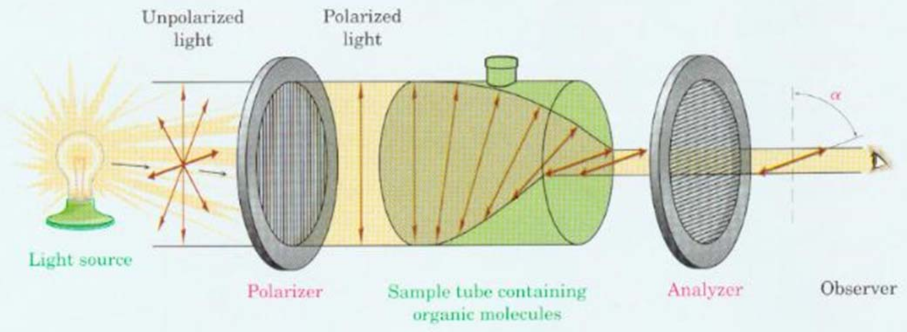
Methylcyclohexane (achiral)

2-Methylcyclohexanone (chiral)

4. Optical activity and specific rotation

FIGURE 9.5

Schematic representation of a polarimeter. Plane-polarized light passes through a solution of optically active molecules, which rotate the plane of polarization.



· levorotatory(−)

: counterclockwise

– dextrorotatory(+)

: clockwise

TABLE 9.1 Specific Rotation of Some Organic Molecules

Compound	$[\alpha]_D$ (degrees)	Compound	$[\alpha]_D$ (degrees)
Penicillin V	+233	Cholesterol	−31.5
Sucrose	+66.47	Morphine	−132
Camphor	+44.26	Acetic acid	0
Monosodium glutamate	+25.5	Benzene	0

5. Sequence rules for specification of configuration

- A pictorial representation & the verbal method for
  Indicating the three-dimensional arrangement of atoms
- The sequence rule

Rule-1 : Assign priorities in order of decreasing atomic number in four atoms of chiral center. The atom with highest atomic number is ranked first, the atom with lowest atomic number is ranked fourth

Rule-2 : If rule-1 is imposable, compare atomic numbers of the second atoms in each substituent, continuing on as necessary through the third or fourth atoms until the first point of differece is reached

Rule-3 : Multiple bonded atoms are equivalent to the same number of single-bonded atoms

6. Diastereomers

FIGURE 9.10

The four stereoisomers of 2-amino-3-hydroxybutanoic acid (threonine).

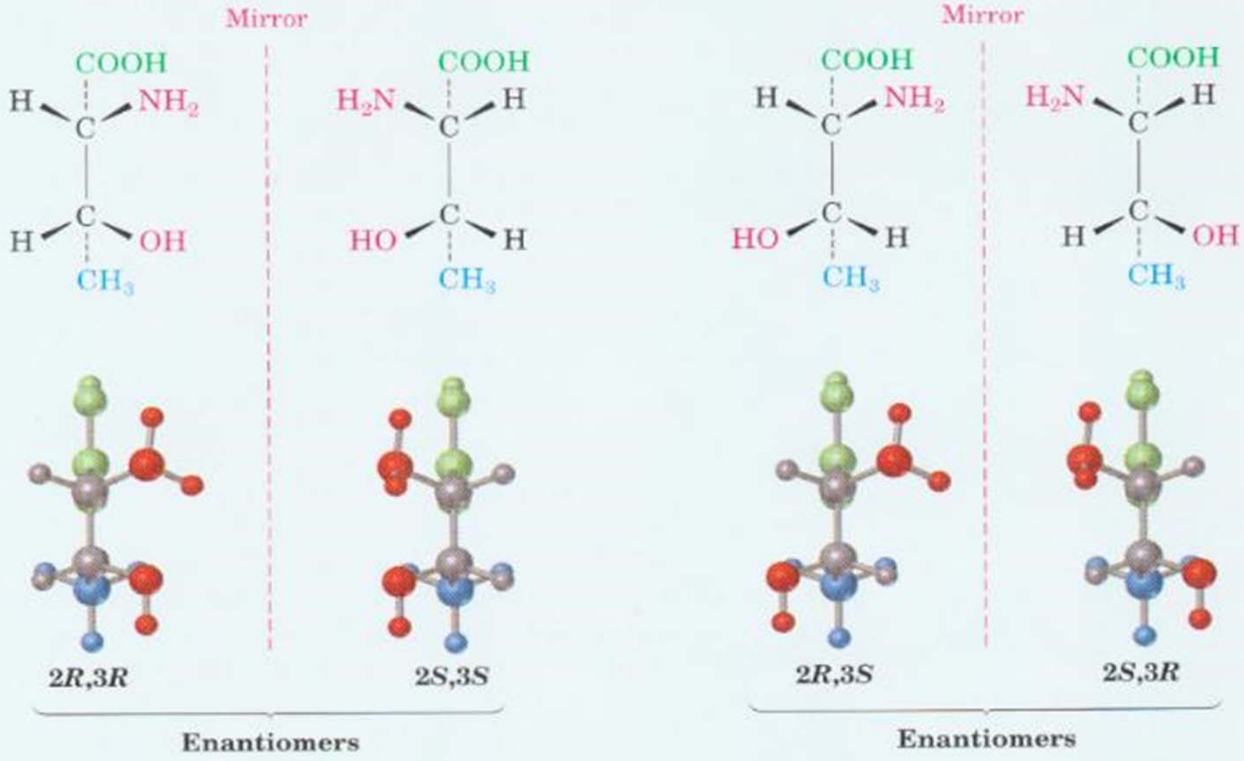
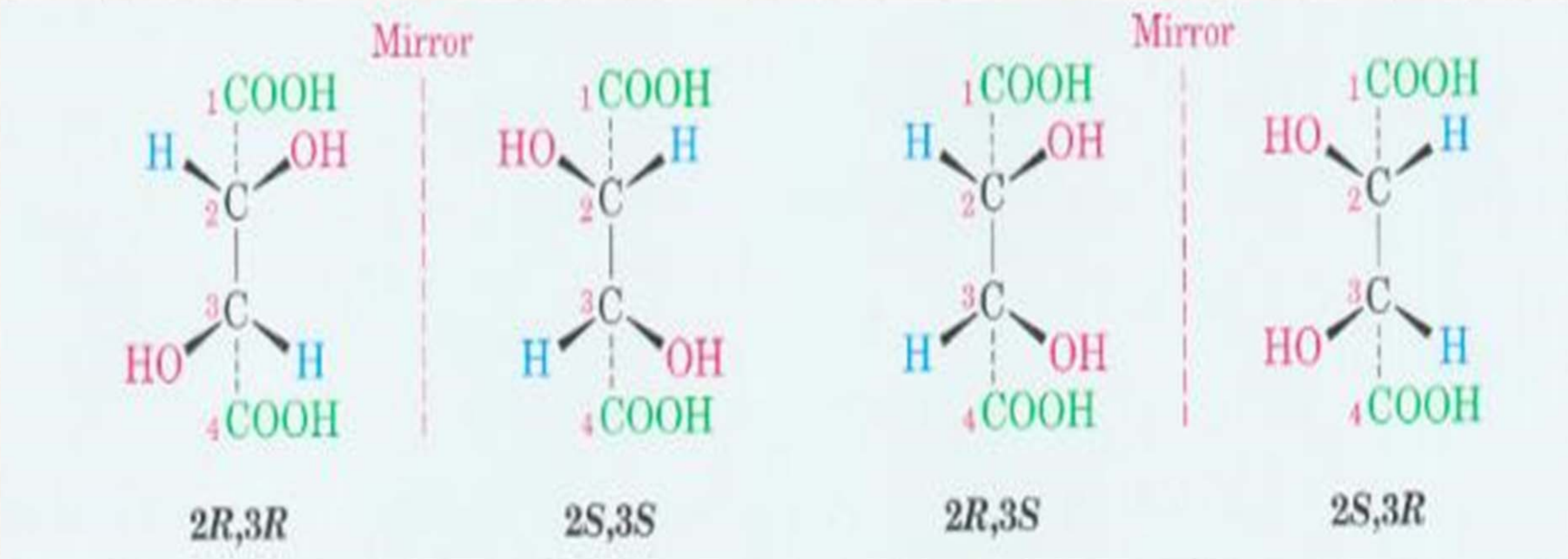


TABLE 9.2 Relationships Among Four Stereoisomers of Threonine		
Stereoisomer	**Enantiomeric with**	**Diastereomeric with**
2*R*,3*R*	2*S*,3*S*	2*R*,3*S* and 2*S*,3*R*
2*S*,3*S*	2*R*,3*R*	2*R*,3*S* and 2*S*,3*R*
2*R*,3*S*	2*S*,3*R*	2*R*,3*R* and 2*S*,3*S*
2*S*,3*R*	2*R*,3*S*	2*R*,3*R* and 2*S*,3*S*

- Diastereomers are stereomers that are not mirror image of each other

7. Meso compounds

- Optically inactive
- A molecule with chiral centers



- A molecule with n chiral centers has a maximum of 2^n stereomers

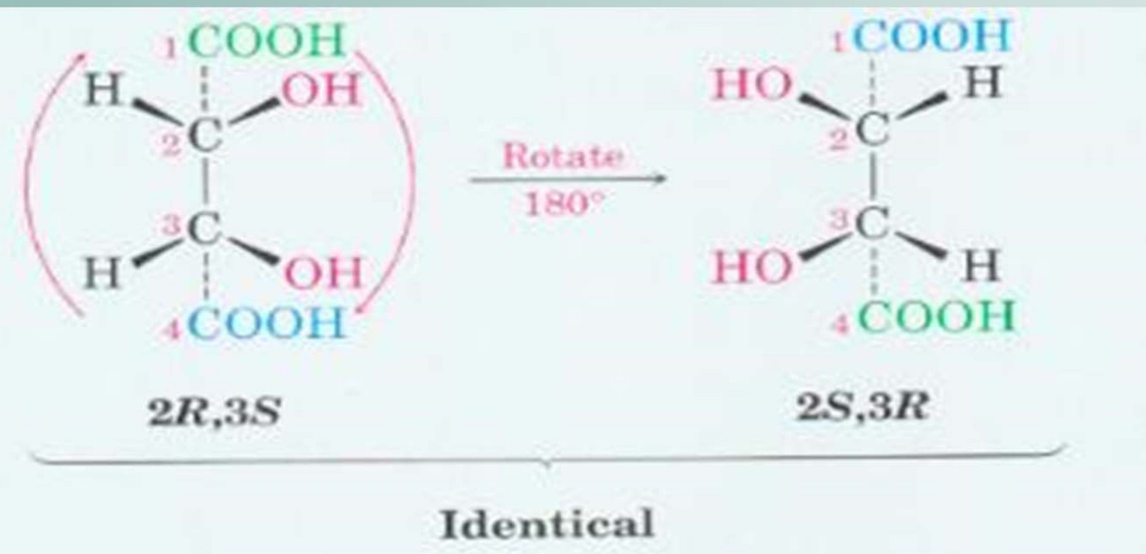
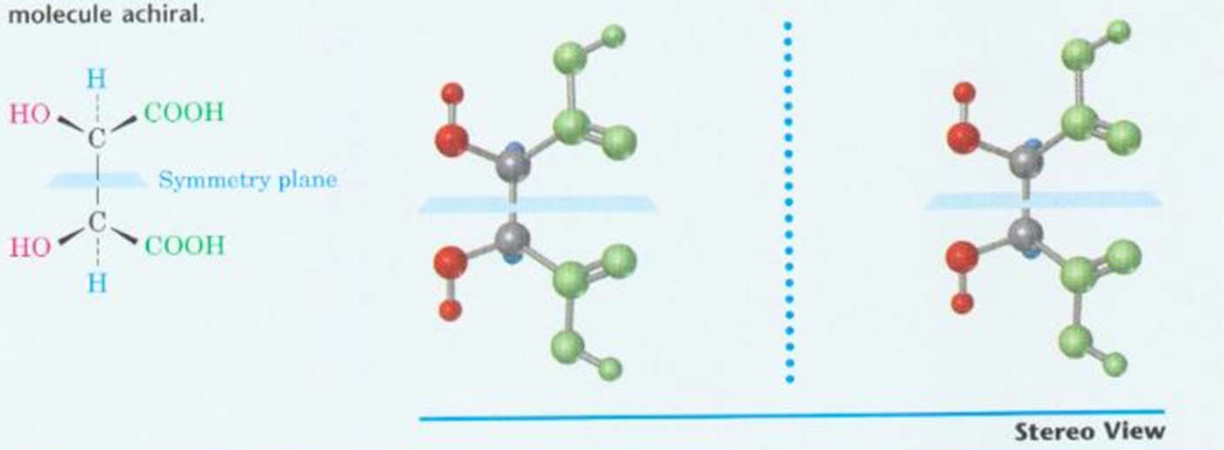


FIGURE 9.11 ▼

A symmetry plane through the C2–C3 bond of *meso*-tartaric acid makes the molecule achiral.

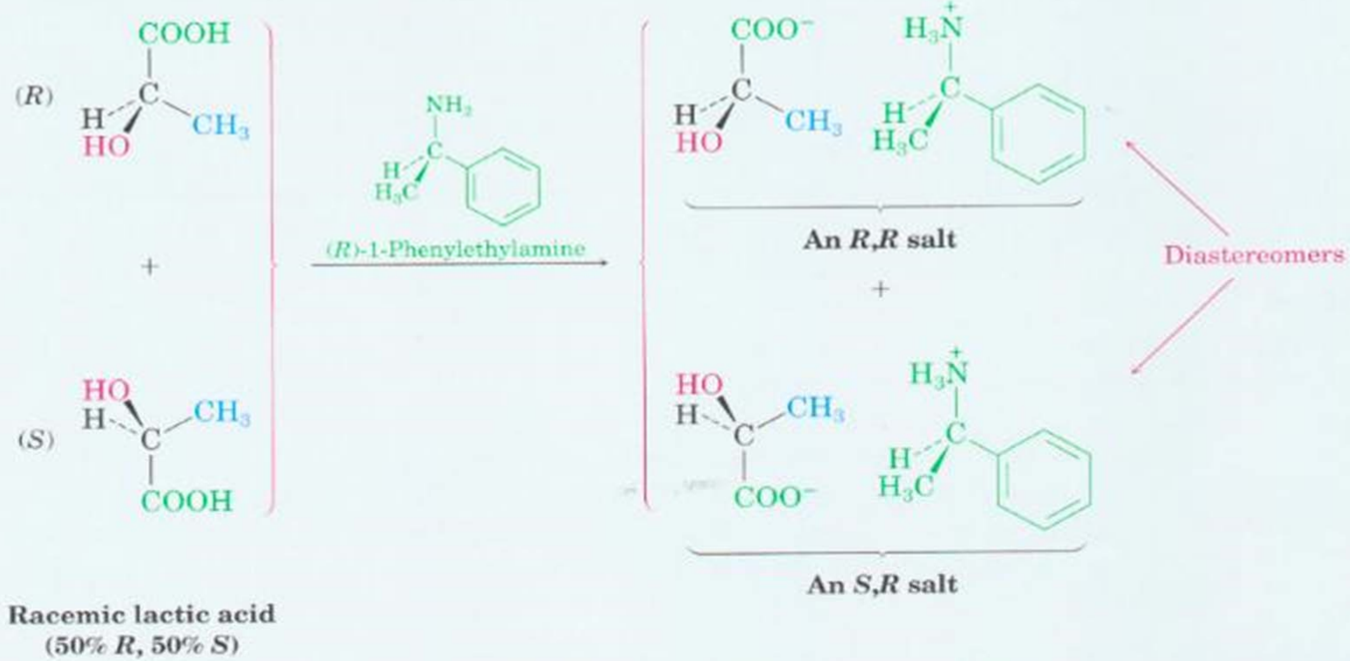


8. Racemic mixture and their resolution

- A 50:50 mixture of the two chiral enantiomers

FIGURE 9.13

Reaction of racemic lactic acid with (*R*)-1-phenylethylamine yields a mixture of diastereomeric ammonium salts.



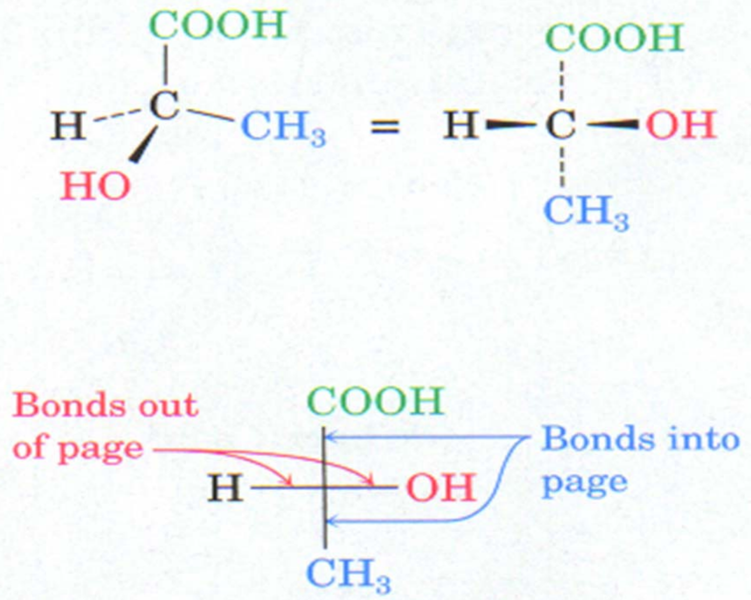
- Resolution : the seperation of racemates into its (+) and (−) enantiomers
- Medically very important

⇨ Physical properties of stereoisomers

TABLE 9.3 Some Properties of the Stereoisomers of Tartaric Acid

Stereoisomer	Melting point (°C)	$[\alpha]_D$ (degrees)	Density (g/cm^3)	Solubility at 20°C (g/100 mL H_2O)
(+)	168–170	+12	1.7598	139.0
(−)	168–170	−12	1.7598	139.0
Meso	146–148	0	1.6660	125.0
(±)	206	0	1.7880	20.6

9. Fisher projection



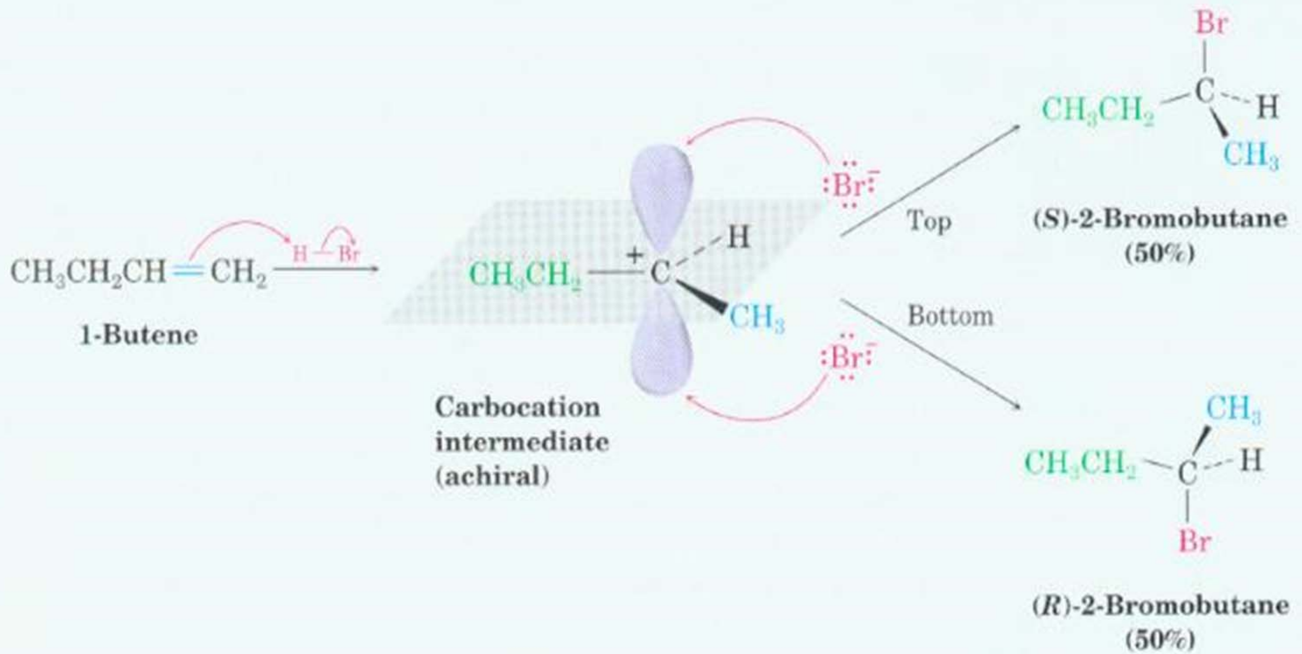
Fischer projection
(*R*)-Lactic acid

10. Stereochemistry of rxns

- Addition of HBr to alkenes

FIGURE 9.15 ▼

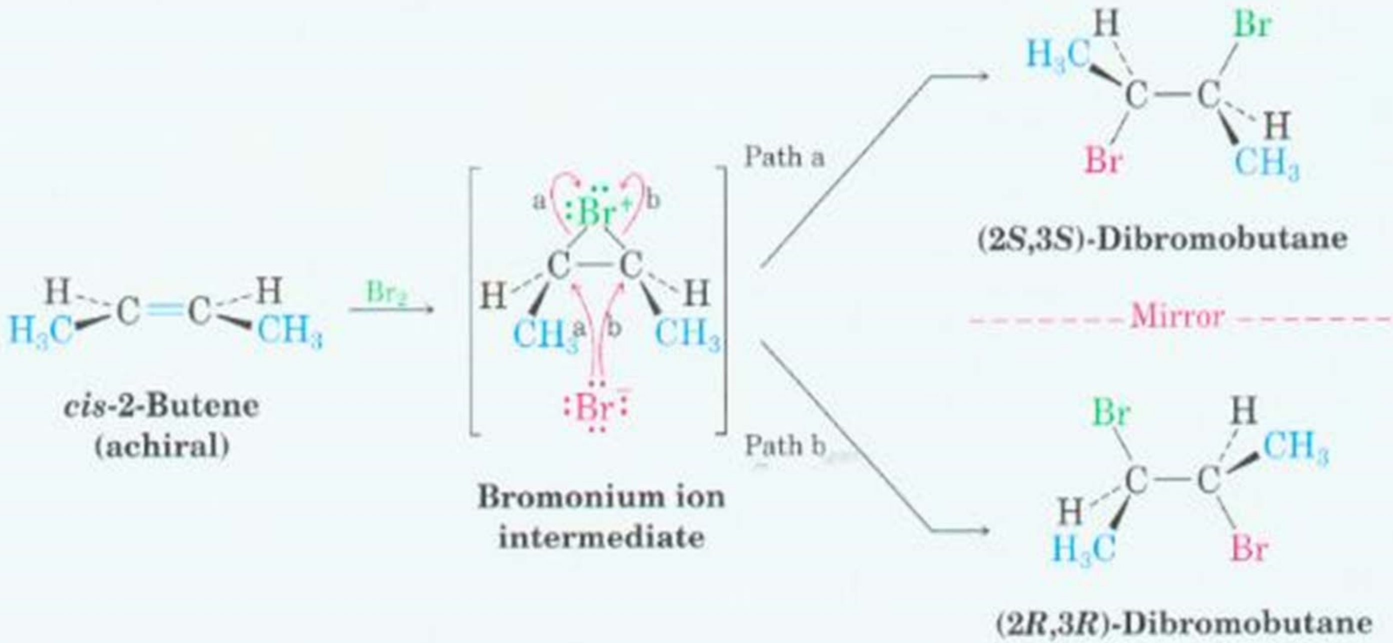
Stereochemistry of the addition of HBr to 1-butene. The achiral intermediate carbocation reacts equally well from both top and bottom, giving a racemic product mixture.



● Addition of Br_2 to alkenes

FIGURE 9.17

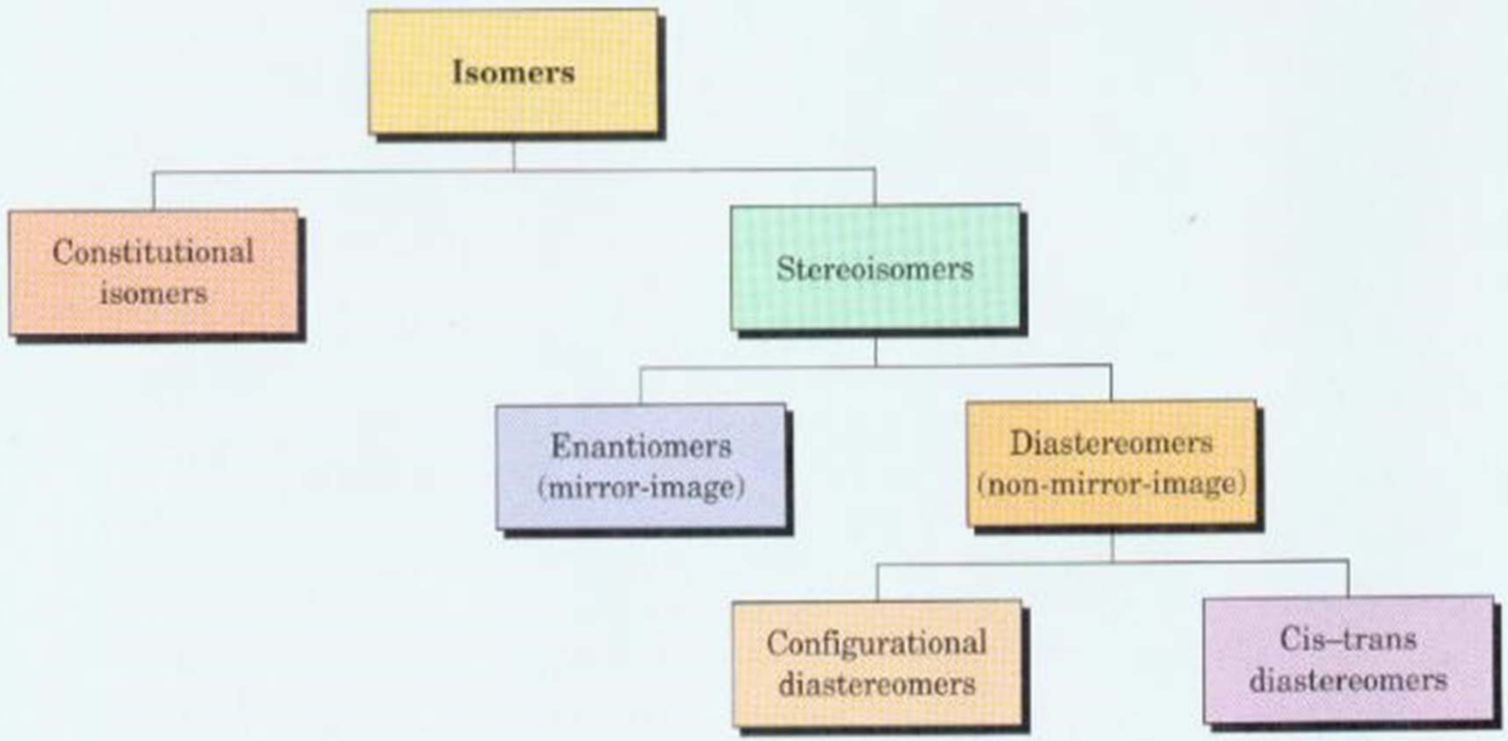
Stereochemistry of the addition of Br_2 to *cis*-2-butene. A racemic mixture of 2*S*,3*S* and 2*R*,3*R* products is formed because attack of Br^- on both carbons of the bromonium ion intermediate is equally likely.



A brief review of isomerism

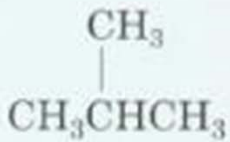
FIGURE 9.14

A flow diagram summarizing the different kinds of isomers.



● Constitutional isomers

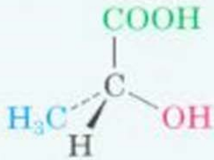
Different carbon skeletons



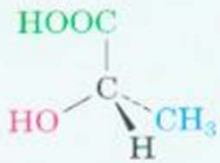
and $CH_3CH_2CH_2CH_3$

Isobutane **Butane**

Enantiomers
(nonsuperimposable mirror-image stereoisomers)



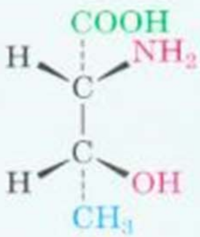
(*R*)-Lactic acid



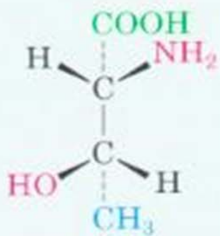
(*S*)-Lactic acid

Diastereomers
(nonsuperimposable, non-mirror-image stereoisomers)

Configurational diastereomers



2*R*,3*R*-2-Amino-3-hydroxybutanoic acid



2*R*,3*S*-2-Amino-3-hydroxybutanoic acid

● Stereoisomers

Different functional groups	CH_3CH_2OH **Ethyl alcohol**	and	CH_3OCH_3 **Dimethyl ether**
Different position of functional groups	NH_2 | CH_3CHCH_3 **Isopropylamine**	and	$CH_3CH_2CH_2NH_2$ **Propylamine**

Although the different enantiomers of a chiral molecules have the same physical properties, they usually have different biological properties