For an authoritative treatment of Organic stereochemistry see:

Relationships Between two Molecules:

**Isomers:** Two distinct molecules with the same molecular formula

- **Constitutional Isomers:** Isomers that differ in constitution.
  Constitutional refers to the nature and/or sequence of the bonding between the atoms. *Constitutional isomers* differ in this connectivity. Interconversion of constitutional isomers generally requires breaking of bonds.

- **Configurational Isomers:** Isomers that differ in configuration.
  Configuration in molecules refers to a particular spatial arrangement of atoms without regard to arrangements that differ only by torsion about one or more single bonds. *Configuration isomers* differ in the configuration about one or more stereogenic centers in a molecule. Interconversion of *configuration isomers* usually requires breaking of bonds [notable exception are the rotation around a double bond or the Ar-Ar bond rotation of a chiral biaryl species].

- **Enantiomers:** (enantiomers)
  A configurational isomer that has a non-superimposable mirror image. A chiral molecule has one and only enantiomer.

- **Diastereoisomers:** (diastereomers)
  Configurational isomers that are not enantiomers. Some molecules have many diastereomers.

- **Conformational Isomers:** (conformers)
  Conformation refers to the different spatial arrangements of atoms in a molecule obtained upon torsion (twisting) about one or more single bond. *Conformational isomers* have the same molecular formula, constitution, and configuration but different geometries. Interconversion of *Conformational isomers* usually requires bond rotation does not requires breaking of bonds.

**Stereoisomers:**

Two molecules that differ only in the spatial arrangement of their atoms. Thus, technically, configurational and conformational isomers together represent the collection of stereoisomers of a given molecule. *Practical usage of the term stereoisomers is usually limited to just the configuration isomers.*
Sites within a Single Molecule:

**Stereogenic Center:** (stereocenter)

A point about which interchange of any two groups produces a stereoisomer. Examples of these centers are the carbon atoms designated as R or S.

**Chirotopic Point:**

Any point that resides within a chiral environment, except those points that remain invariant under a rotation or reflection operation.

**Topicity:**

- **Homotopic:**
  1) Sites with identical molecular environments in every aspect
  2) Interchangeable by rotation about a Cn-axis
  3) Substitution with test groups (another group) results in no isomer formation

- **Heterotopic:**
  1) Sites with non-identical molecular environments in every aspect

  **Enantiotopic**
  1) Interchangeable by Sn rotation/reflection operation only
  2) Substitution with test groups (another group) results in an enantiomer.

  **Diastereotopic**
  1) Non-interchangeable by symmetry operation
  2) Substitution with test groups (another group) results in an diastereomer.

Properties of a Single Molecule:

**Achiral:** (stereocenter?)

A molecule is achiral if it is superimposable on its mirror image. A molecule that has reflection symmetry or center of symmetry are achiral.

**Chiral:** (stereocenter?)

A molecule is chiral if it is not superimposable on its mirror image. A molecule that lacks reflection symmetry will be chiral. An important point to remember is that the term chiral should not be used to mean “optically pure,” “optically active,” “enantiomerically enriched,” or “non-racemic.”
Properties of Groups of Chiral Molecule:

**Racemic:** (stereocenter)

A group of molecule is racemic if it is made up of an equal mixture of two enantiomeric molecules.

**Scalemic:** (enantioenriched)

A group of molecule is scalemic if it is made up of an unequal mixture of two enantiomeric molecules.

**Enantiomer excess** (ee)

In a mixture of a pure enantiomer (R or S) and a racemate (R and S) ee is the percent excess of the enantiomer over the racemate.

**Enantiomerically pure** (enantiopure)

Having an enantiomer excess equal to 100%.

**Enantiomerically enriched** (enantioenriched)

Having an enantiomer in excess greater than 0% but less than 100%.
**How Many isomers?**

Hexane isomers

Dimethyl-cyclohexane regioisomers

1,2-Dimethyl-cyclohexane stereoisomers

1,3-Dimethyl-cyclohexane stereoisomers

1,4-Dimethyl-cyclohexane stereoisomers
Hexane isomers

1,2-Dimethyl-cyclohexane
1,3-Dimethyl-cyclohexane
1,4-Dimethyl-cyclohexane

Dimethyl-cyclohexane regioisomers

1,2-Dimethyl-cyclohexane stereoisomers

1,3-Dimethyl-cyclohexane stereoisomers

1,4-Dimethyl-cyclohexane stereoisomers
How Many stereogenic centers?

Hexane isomers

Dimethyl-cyclohexane regioisomers

1,2-Dimethyl-cyclohexane  1,3-Dimethyl-cyclohexane  1,4-Dimethyl-cyclohexane

1,2-Dimethyl-cyclohexane stereoisomers

1,2-Dimethyl-cyclohexane  1,2-Dimethyl-cyclohexane  1,2-Dimethyl-cyclohexane

1,3-Dimethyl-cyclohexane stereoisomers

1,3-Dimethyl-cyclohexane  1,3-Dimethyl-cyclohexane  1,3-Dimethyl-cyclohexane

1,4-Dimethyl-cyclohexane stereoisomers

1,4-Dimethyl-cyclohexane  1,4-Dimethyl-cyclohexane
Chiral/Achiral?

1,2-Dimethyl-cyclohexane stereoisomers

1,2-Dimethyl-cyclohexane 1,2-Dimethyl-cyclohexane 1,2-Dimethyl-cyclohexane

1,3-Dimethyl-cyclohexane stereoisomers

1,3-Dimethyl-cyclohexane 1,3-Dimethyl-cyclohexane 1,3-Dimethyl-cyclohexane

1,4-Dimethyl-cyclohexane stereoisomers

1,4-Dimethyl-cyclohexane 1,4-Dimethyl-cyclohexane

Butene isomers

cis or Z trans or E
What is the isomeric relationship?

1,2-Dimethyl-cyclohexane stereoisomers

1,2-Dimethyl-cyclohexane 1,2-Dimethyl-cyclohexane 1,2-Dimethyl-cyclohexane

1,3-Dimethyl-cyclohexane stereoisomers

1,3-Dimethyl-cyclohexane 1,3-Dimethyl-cyclohexane 1,3-Dimethyl-cyclohexane

1,4-Dimethyl-cyclohexane stereoisomers

1,4-Dimethyl-cyclohexane 1,4-Dimethyl-cyclohexane

Butene isomers

cis or Z  trans or E
1,2-Dimethyl-cyclohexane stereoisomers

1,3-Dimethyl-cyclohexane stereoisomers

1,4-Dimethyl-cyclohexane stereoisomers

Butene isomers

cis or Z

trans or E
Which isomer is more stable?

1,2-Dimethyl-cyclohexane stereoisomers

1,2-Dimethyl-cyclohexane 1,2-Dimethyl-cyclohexane 1,2-Dimethyl-cyclohexane

1,3-Dimethyl-cyclohexane stereoisomers

1,3-Dimethyl-cyclohexane 1,3-Dimethyl-cyclohexane 1,3-Dimethyl-cyclohexane

1,4-Dimethyl-cyclohexane stereoisomers

1,4-Dimethyl-cyclohexane 1,4-Dimethyl-cyclohexane

Butene isomers

\[ \text{cis or Z} \quad \text{trans or E} \]