What you need to know

Important concept → Energy and stability are relative terms that are related to each other → "relative" because they need comparisons to make sense

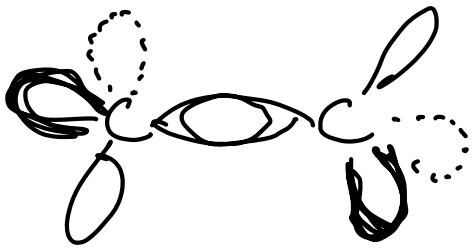
A molecule with higher energy is less stable

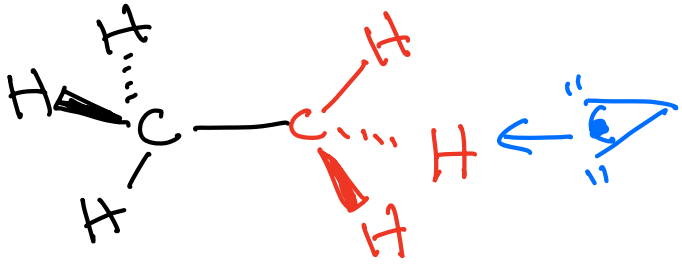
A molecule with lower energy is more stable

Strain → in molecules raises energy and decreases stability

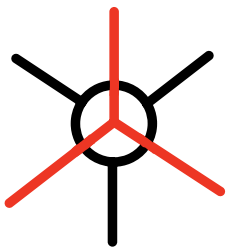
⇒ Molecules are found predominantly in their lowest energy (most stable) form.

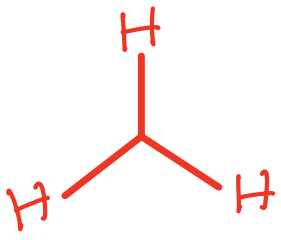
Carbon - Carbon sigma bonds rotate rapidly at room temperature

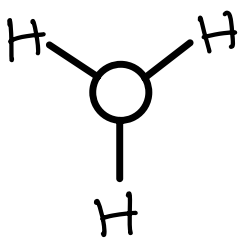




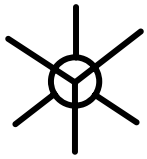
Newman Projection







Two extremes

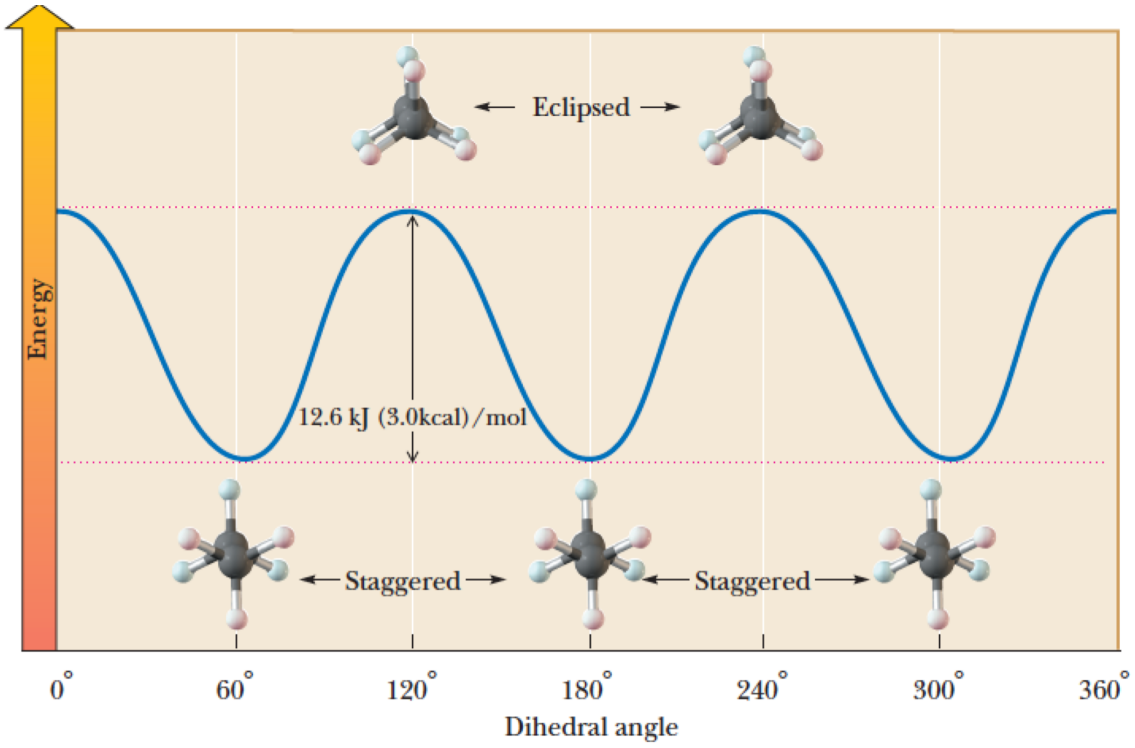


Staggered Conformation

Eclipsed Conformation

Torsional Strain ⟶

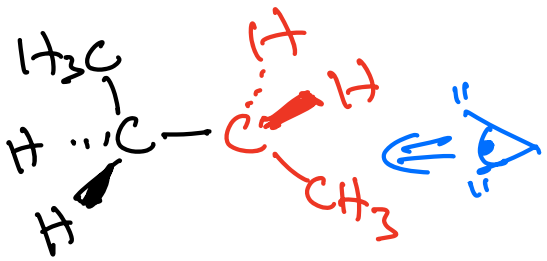
hyperconjugation


Eclipsed
Energy
12.6 kJ (3.0kcal)/mol
Staggered
Staggered
0°
60°
120°
180°
240°
300°
360°
Dihedral angle

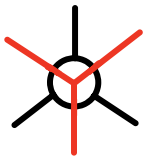
New type of strain → important for alkanes of 4 or more carbon atoms

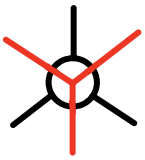
Steric strain →

Butane → 4 carbon atoms



3 different staggered conformations



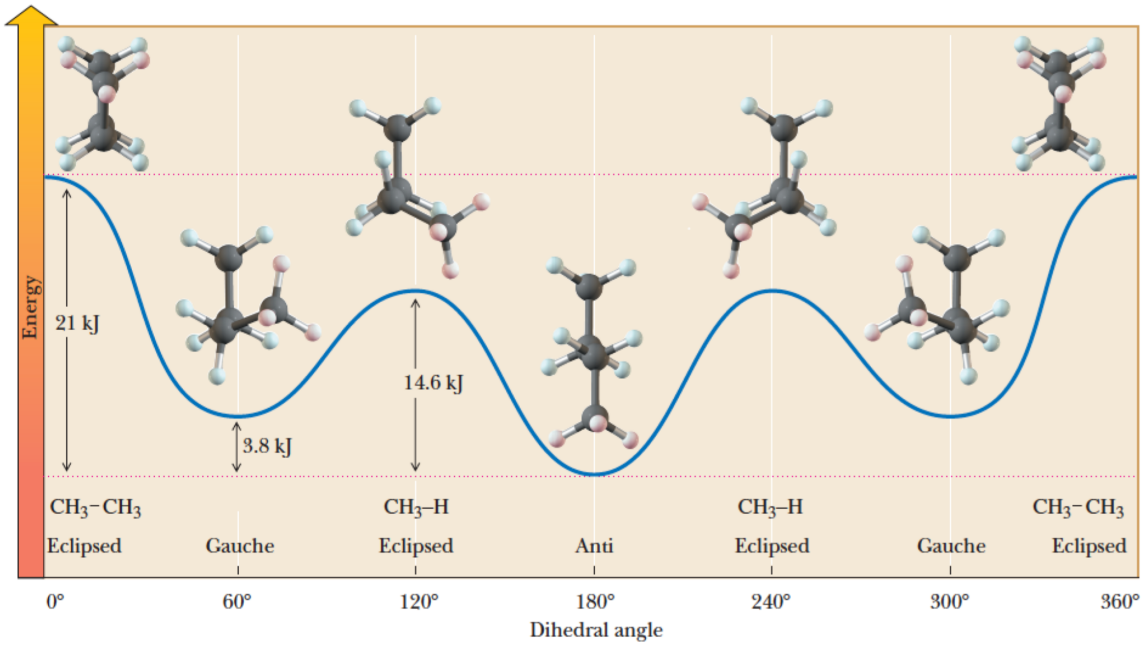


Anti

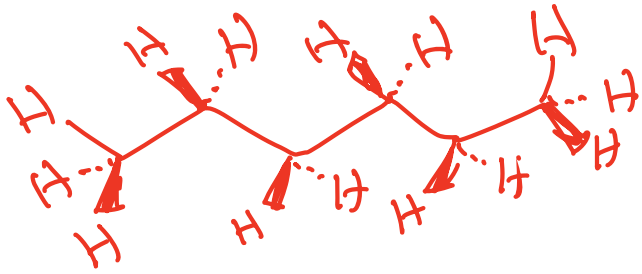
(methyl groups are as far apart as possible

Gauche

(methyl groups are adjacent)



Important consequence → for longer alkanes →



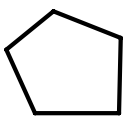
Dynamics →

Angle strain →

Cycloalkanes

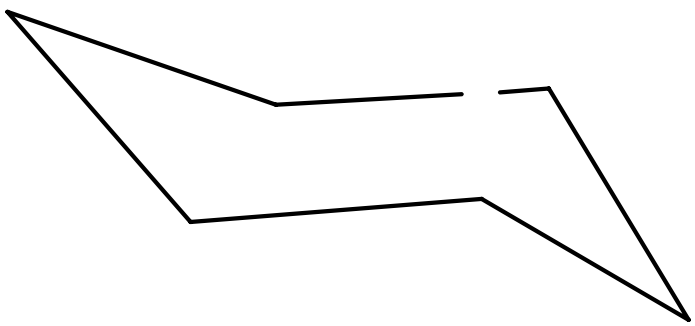
Cyclopropane 

Cyclobutane 

Cyclopentane 

Cyclohexane → most stable cyclohexane

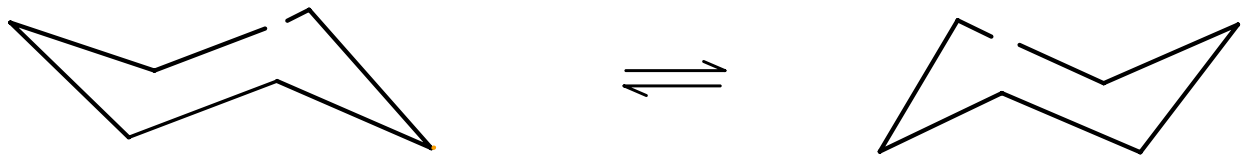
You will need to know how to draw a great chair cyclohexane



Axial H atoms

Equatorial H atoms

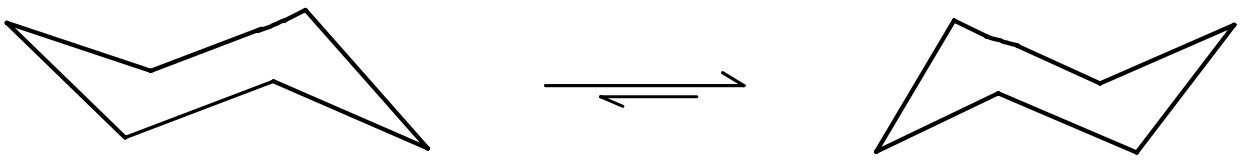
The cyclohexane chair can "flip" at room temperature

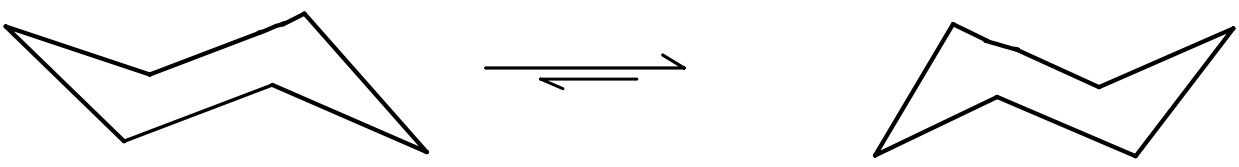


When the chair flips -

As chairs flip,

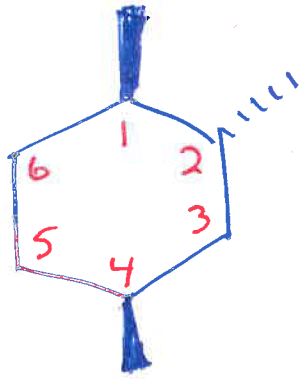
In a cyclohexane chair conformation, any group larger than an H atom will prefer to be equatorial to avoid steric strain ("crunching")



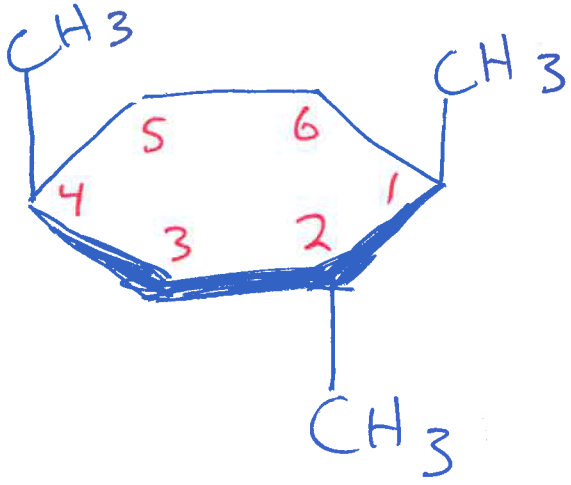


Drawing cyclohexane chairs all of the time can be difficult → so we draw different versions to describe the structures

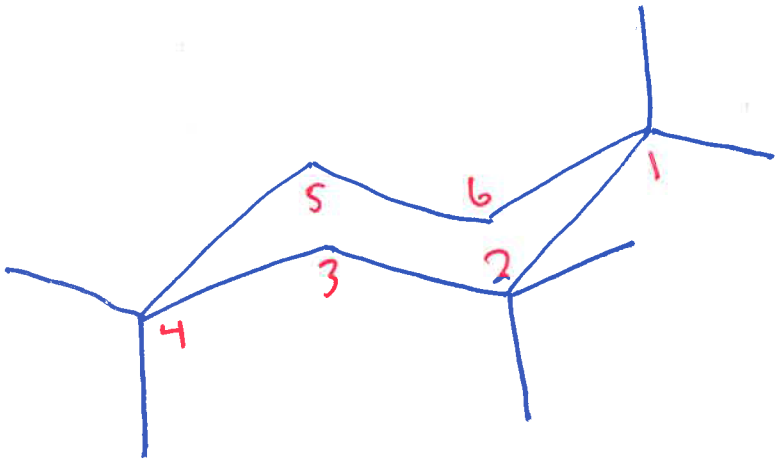
- "Flat"
- "Haworth Projections"

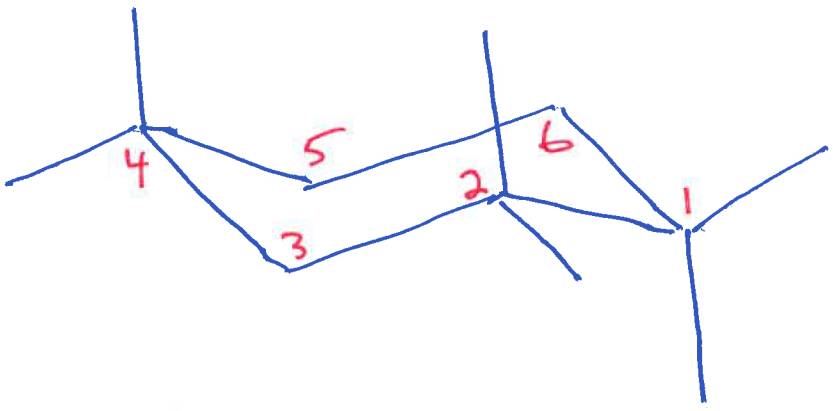


Drawn Flat



Haworth Projection





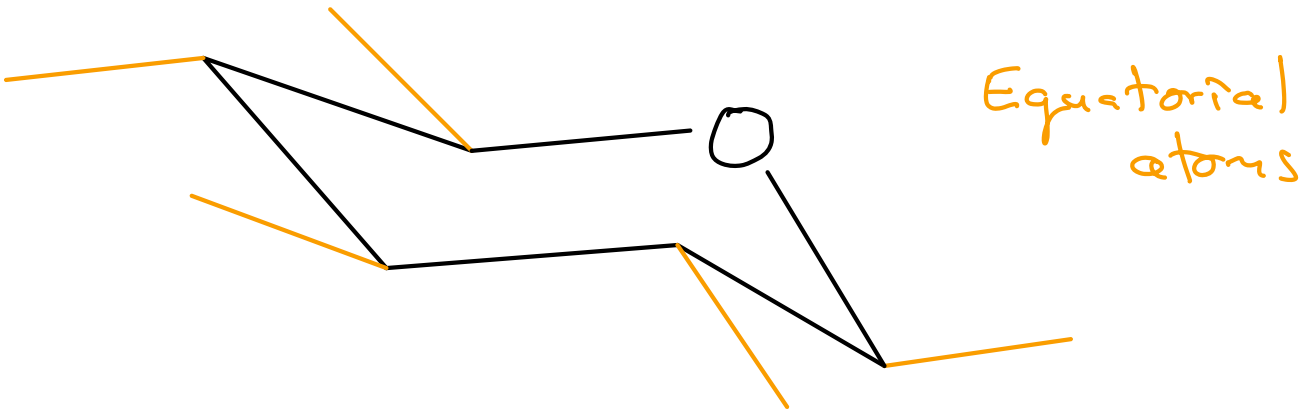
The structure is more stable than the structure

Upper Structure →

Lower Structure →

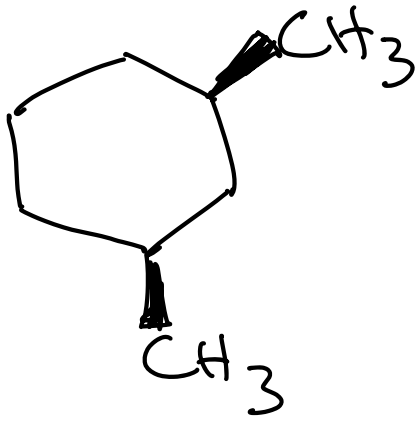
Why do we care so much about chairs anyway?

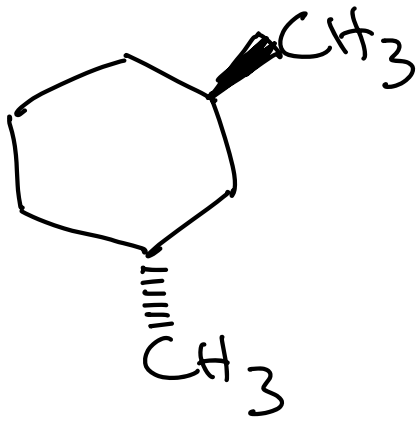
Most common molecule in the biosphere:



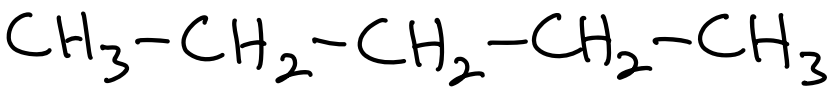
β-D-Glucose

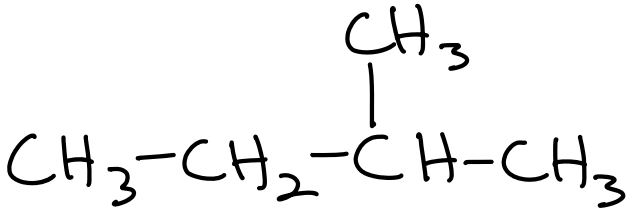
Stereoisomers → two molecules with the same connectivity of atoms, but different orientations of groups in three-dimensional space

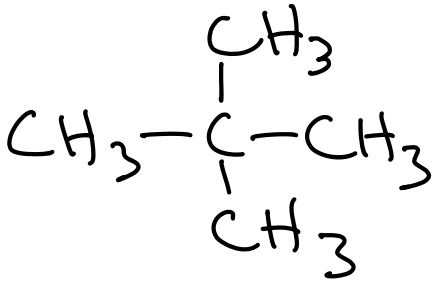




Classification of carbon atoms

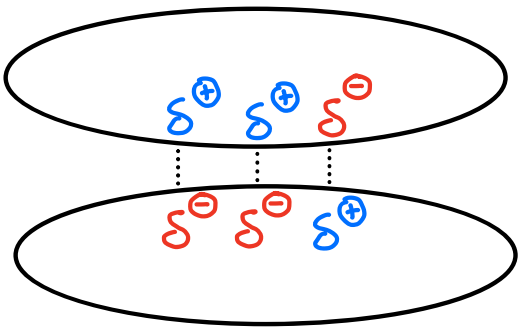






Boiling points (b.p.) of alkanes → More

Dispersion forces →



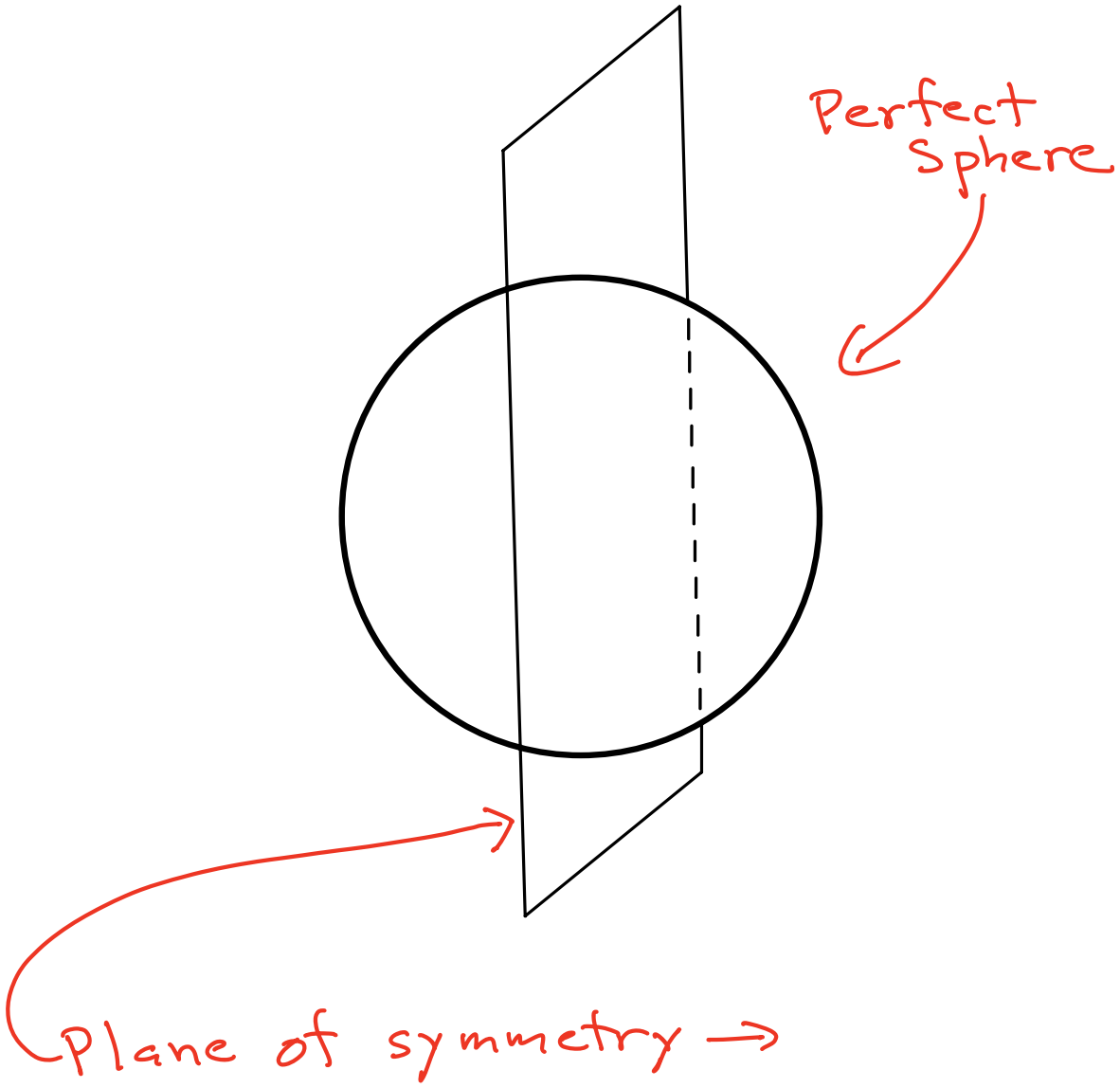
These opposite small partial charges on adjacent molecules attract each other ⇒

Stereochemistry

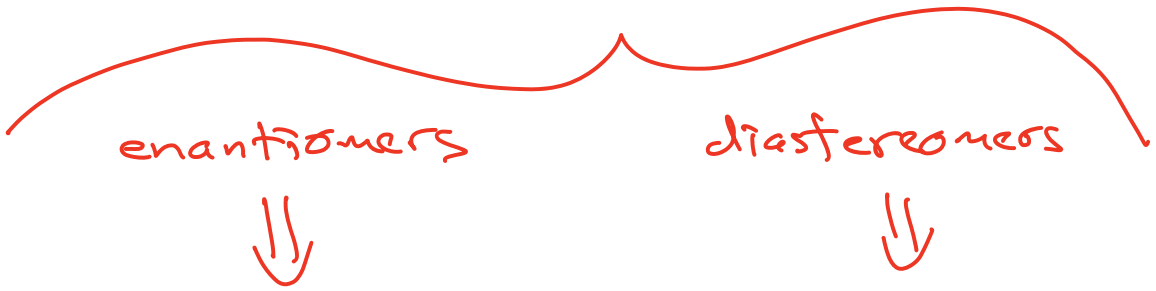
Chiral Object Chiral Molecule

1)

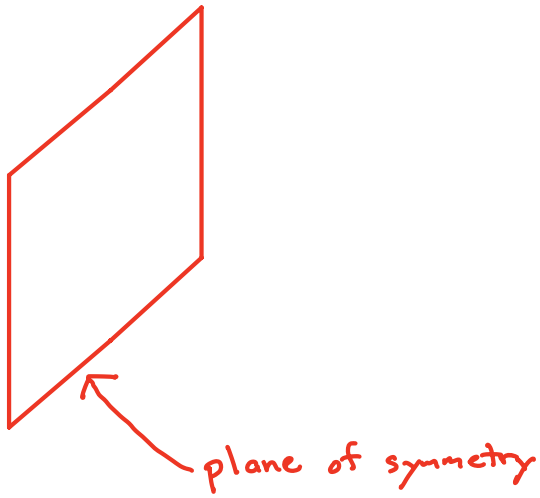
2)


Perfect Sphere
Plane of symmetry →

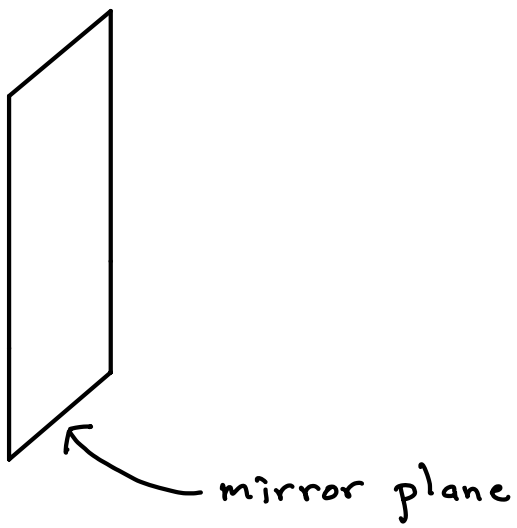
Stereoisomers →



A chiral object/molecule does NOT have a plane of symmetry → If a plane of symmetry is present the object/molecule is NOT chiral

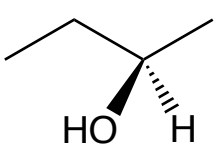


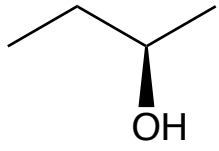
A carbon atom that is not chiral will have a plane of symmetry

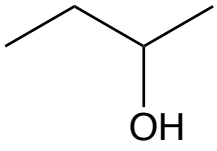


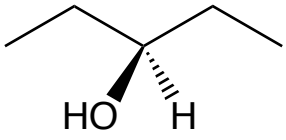
You need to be able to identify chiral centers in complex molecules → 4 different groups on an sp^3 carbon atom

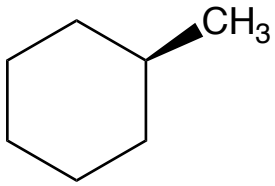
Rings → track each direction for sp^3 carbon atoms in a ring to look for differences

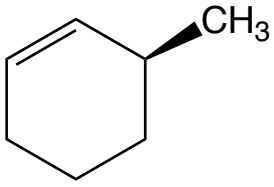


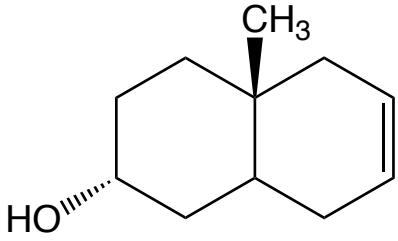


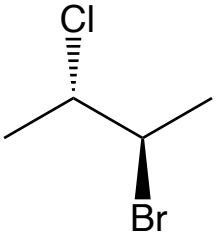


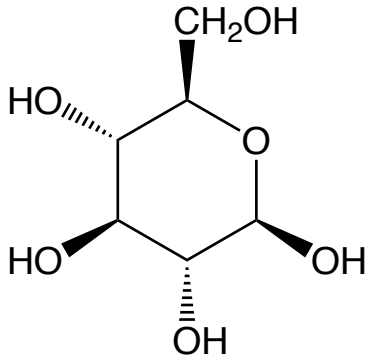










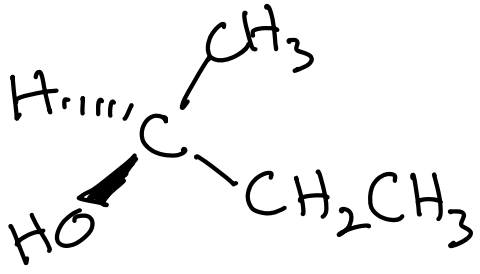


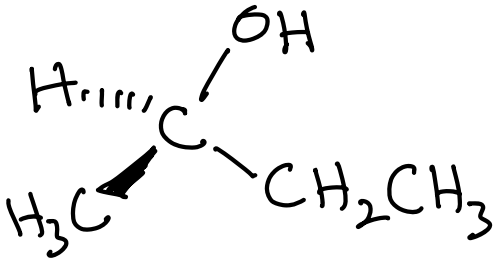
Really hard part → naming the enantiomers

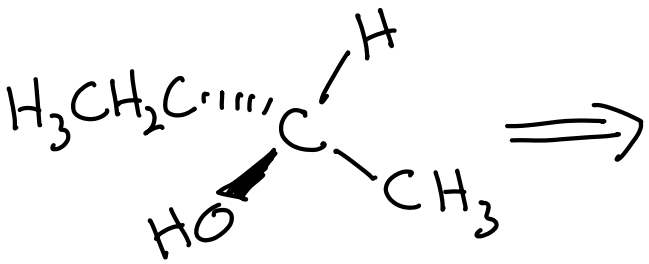
1) Assign atomic number priorities for each group, ranking them 1→4

2) Position the molecule so you are looking down the C→4 bond

3) Count the remaining three groups in order







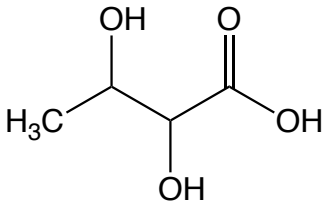
Diastereomer → stereoisomers that are not enantiomers

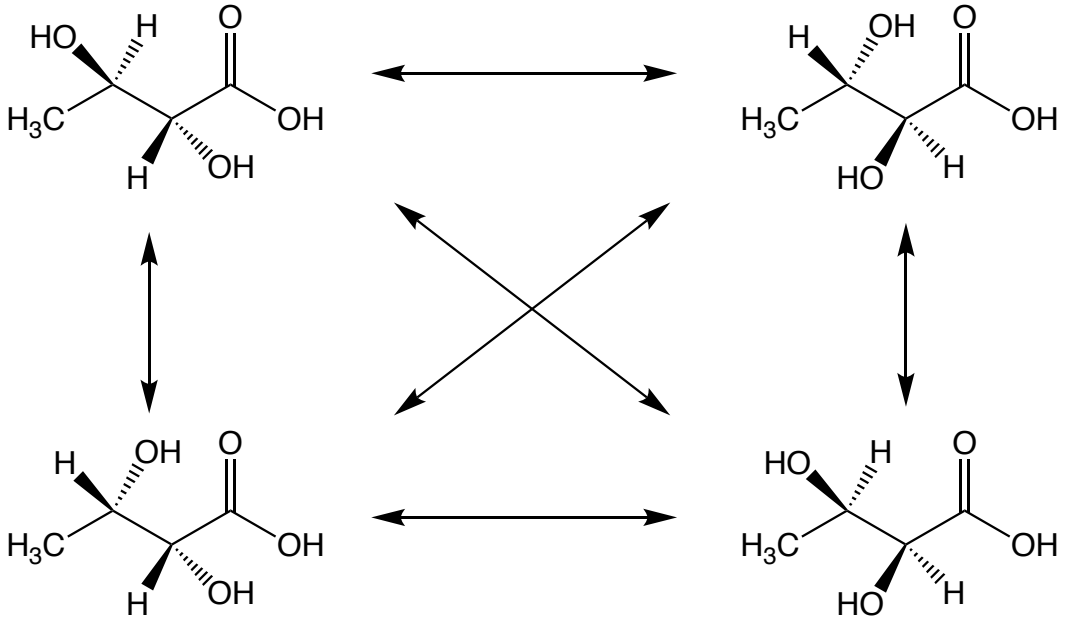
Molecules with 2 Chiral Centers

1) If a molecule contains n chiral centers there are 2^n possible stereoisomers

2) R,R and S,S are
   R,S and S,R are
   All other pairs are (Ex. R,R and R,S)

3) To identify stereoisomer relationships





4) A meso compound has chiral centers but is not chiral due to symmetry (plane of symmetry)