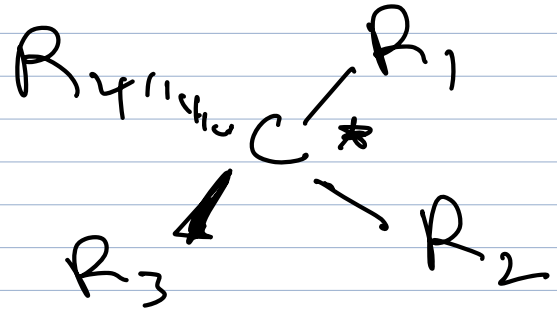
Stereoisomers ⟶ molecules with the same connectivity of atoms, but different orientations of groups in three-dimensional space

enantiomers ⇓

(Stereoisomers that are mirror images of each other but not identical)

diastereomers ⇓

stereoisomers that are NOT enantiomers

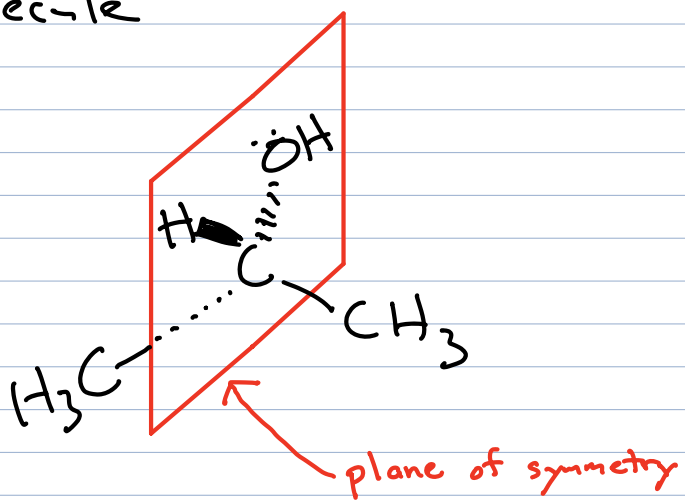


An sp^3 carbon atom that is tetrahedral with four different groups → it is chiral

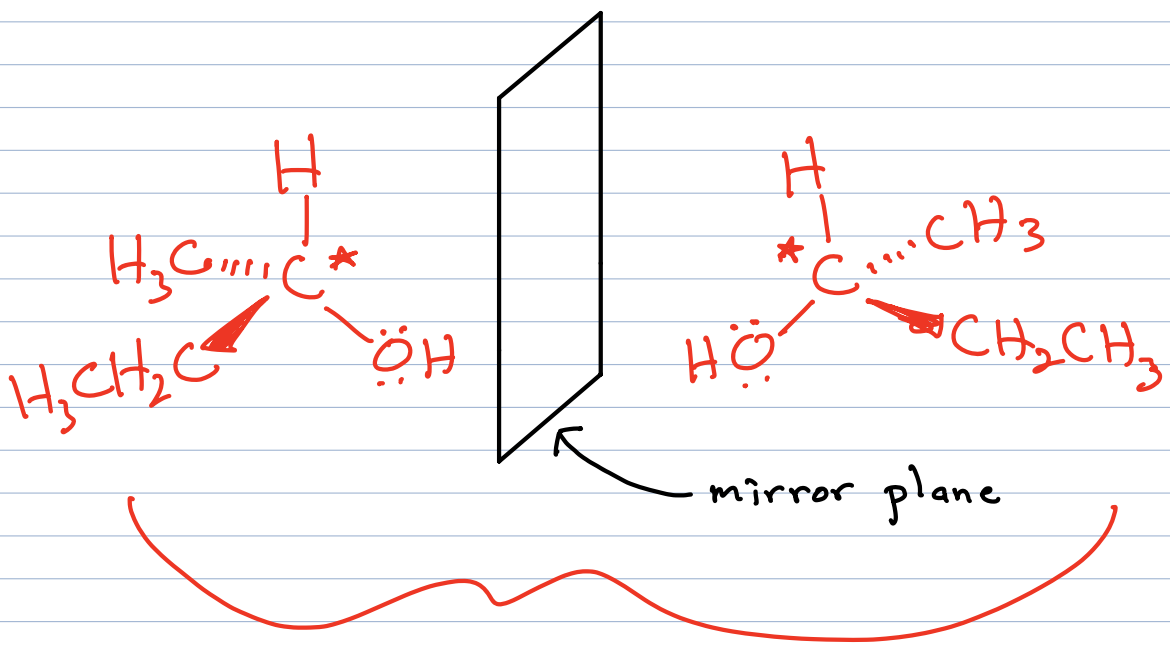
⇒ Called a chiral center

Not superimposable on its mirror images

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

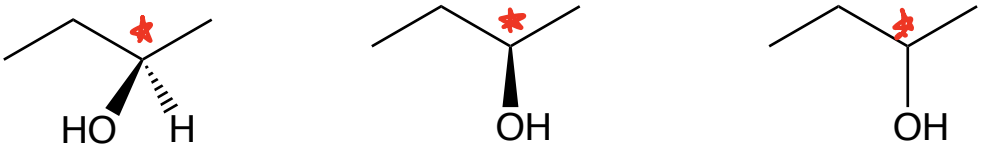


A pair of enantiomers

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

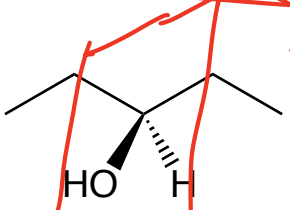
Rings → track each direction for sp^3 carbon atoms in a ring to look for differences

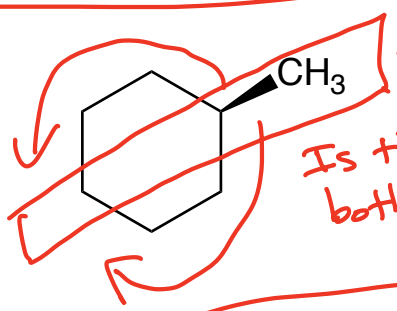
Chiral



Not Chiral

plane of symmetry

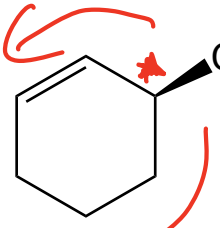




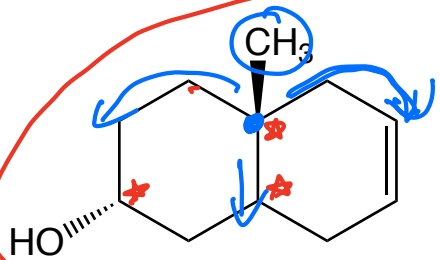
plane of symmetry

Is the same in both directions

Chiral

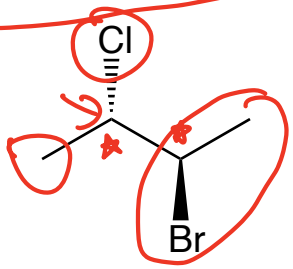


The two directions do NOT match



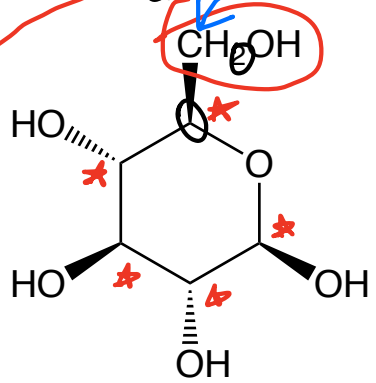
3 chiral centers

Chiral



Chiral

This carbon is not chiral (2 Hs)



5 chiral centers!

Chiral

Really hard part → naming the enantiomers

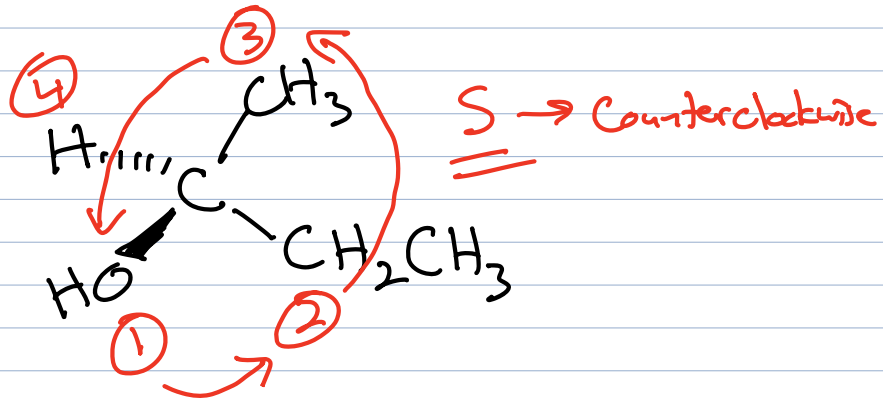
R,S convention →
Cahn, Ingold, Prelog (CIP) rules
For a carbon with four different groups:

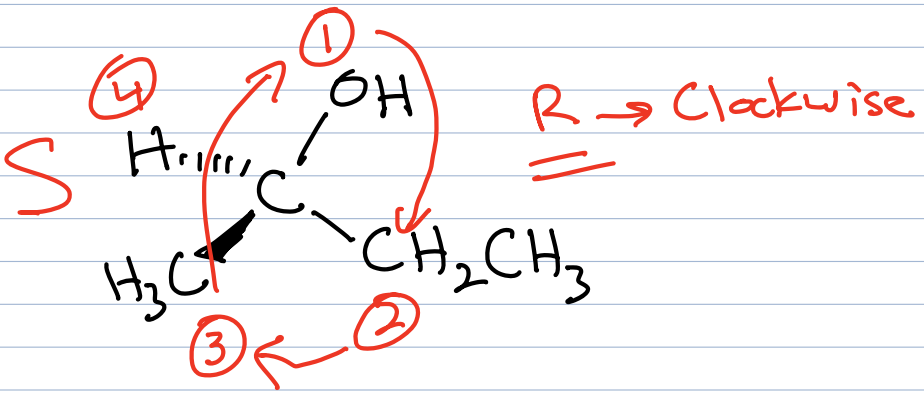
1) Assign atomic number priorities for each group, ranking them 1→4
First point of difference wins

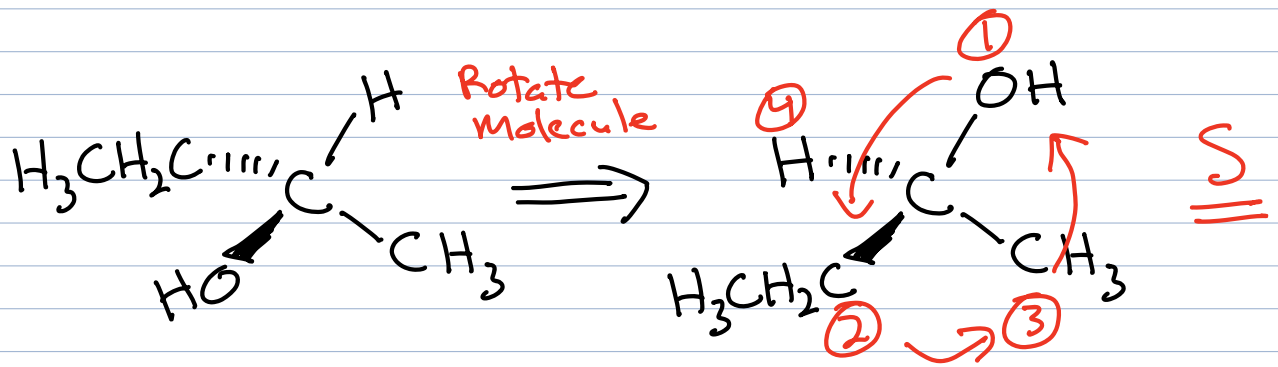
2) Position the molecule so you are looking down the C→4 bond

Lowest priority group, often an H atom

3) Count the remaining three groups in order → If 1→2→3 is clockwise → R
→ If 1→2→3 is counterclockwise → S







Diastereomer → stereoisomers that are not enantiomers

→ Applies to molecules with two or more chiral centers

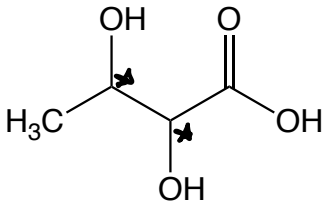
Molecules with 2 Chiral Centers

1) If a molecule contains n chiral centers there are 2^n possible stereoisomers → fewer if symmetry is present (see "meso")

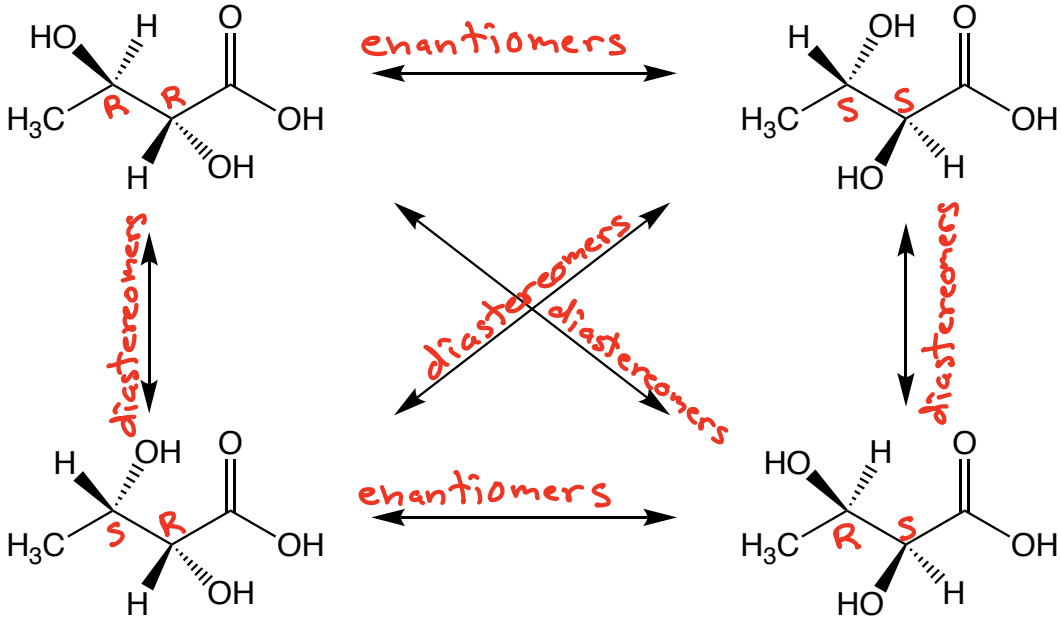
2) R,R and S,S are enantiomers
R,S and S,R are enantiomers
All other pairs are diastereomers (Ex. R,R and R,S)

3) To identify stereoisomer relationships → assign R and S to each chiral center and see Rule 2) above

$2^2 = 4$ stereoisomers

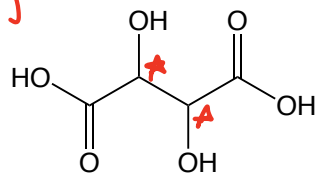


2 chiral centers → no overall symmetry

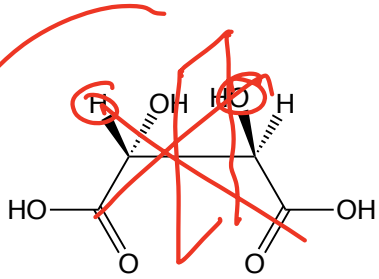


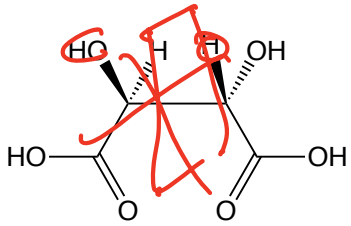
4) A meso compound has chiral centers but is not chiral due to symmetry (plane of symmetry)

You need to draw the molecule in the most symmetric possible conformation to look for symmetry → eclipsed is OK

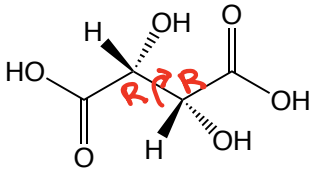


2 chiral centers → symmetry → both chiral centers have the same four groups

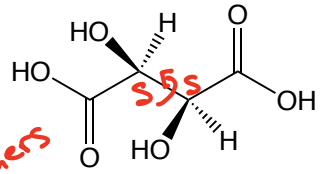




This molecule has only three stereoisomers!!



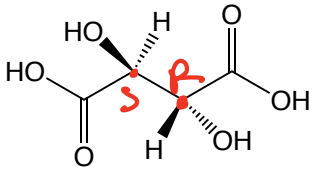
enantiomers



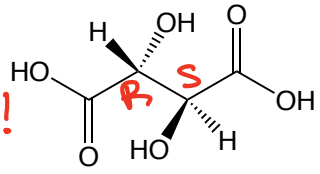
diastereomers

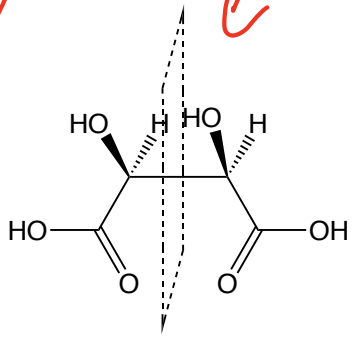
diastereomers

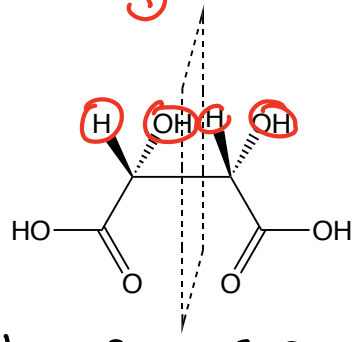
diastereomers



SAME MOLECULE!







5) Meso compounds will always be the R,S = S,R stereoisomer if both chiral centers have the same four groups