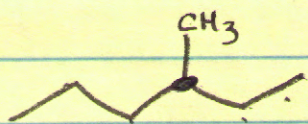


Ch 5-1

Stereoisomerism

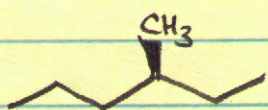
- This is an important 3-dimensional evaluation of organic molecules. The way groups are uniquely ordered spatially can have profoundly different biological effects.

We learned how to name the following alkane



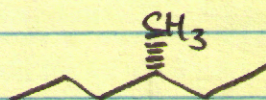
3-methylhexane

but the carbon with the dot on it can have 2 different spatial orientations.



the CH₃ group is
coming toward you

OR

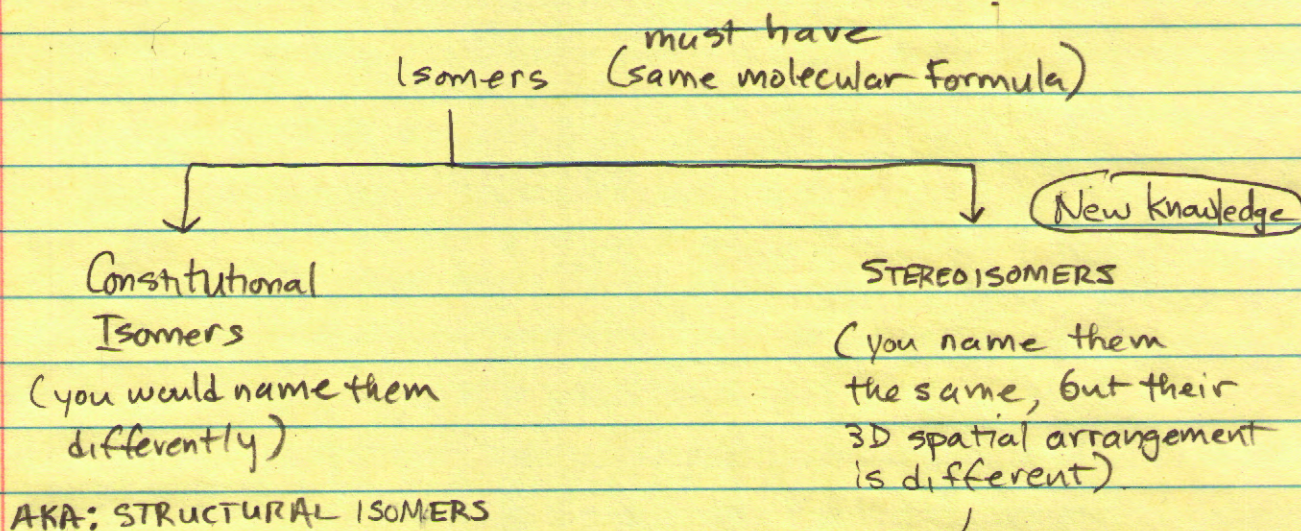


the CH₃ group is
pointing away from you.

These are different molecules!

Ch5-2

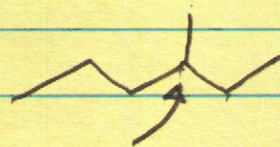
Here is what we learned so far about 'isomers'



For organic chemistry we focus on the stereoisomerism created by the carbon atom. (Other atoms and spatial arrangements can create stereoisomerism, but for now we will focus on carbon (C)).

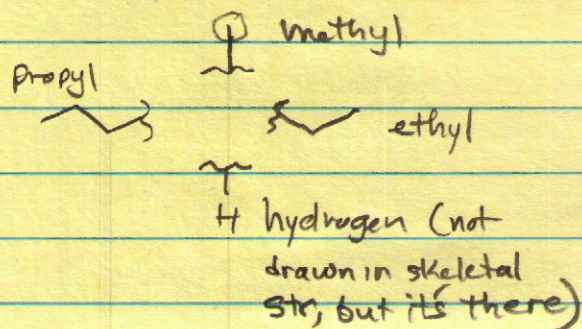
Chiral center: A carbon atom in a molecule attached to 4 different substituents/groups $\therefore$ the carbon atom must be sp^3 hybridized!

Let's go back to 3-methylhexane and evaluate carbon-3

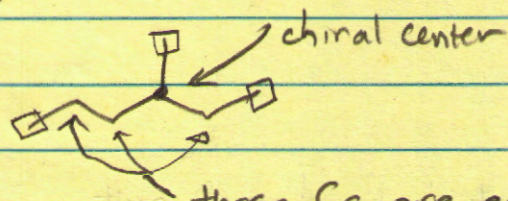


this carbon is attached to

$\therefore$ C3 is a chiral center



Ch 5-3



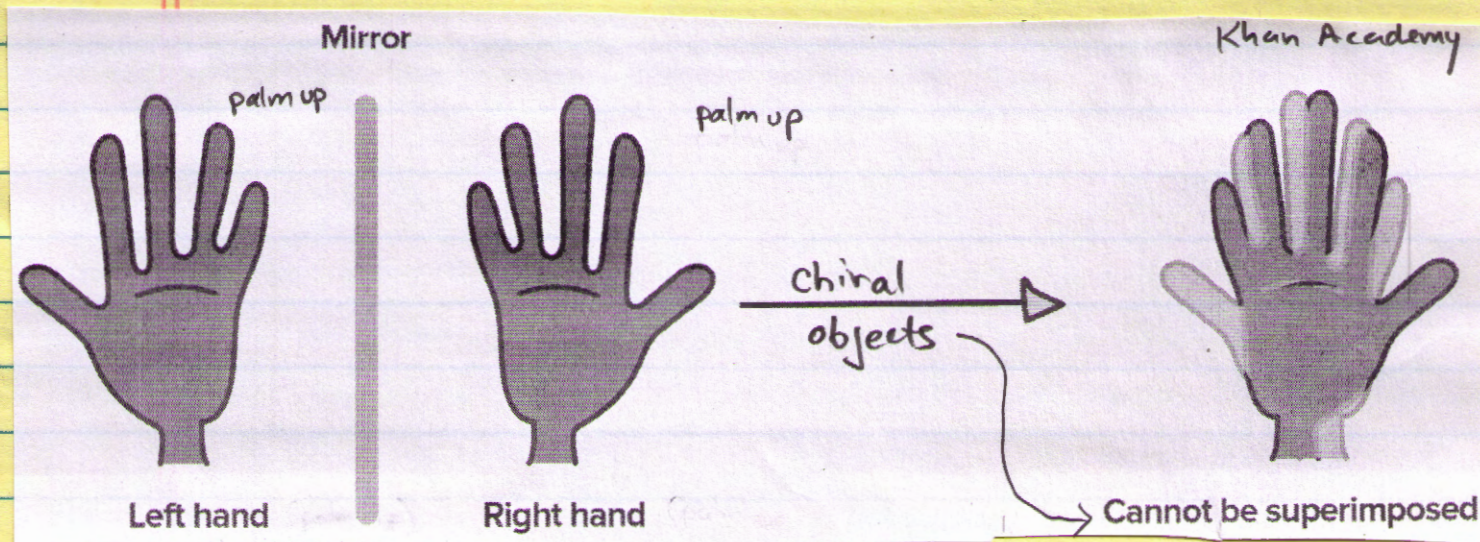
these Cs are each bonded to 2H
 $\therefore$ they are NOT chiral centers

Cs in a box (above) are each bonded to 3H
 $\therefore$ they are NOT chiral centers.

What is special about a molecule that has 1 chiral center? Well, the molecule will be chiral!

chiral (derived from Greek = *cheiros* $\Rightarrow$ "handed")

Our hands are chiral: that is, they are not superimposable



$\therefore$ each hand is
chiral

$\rightarrow$ i.e. each hand is not superimposable on its mirror image

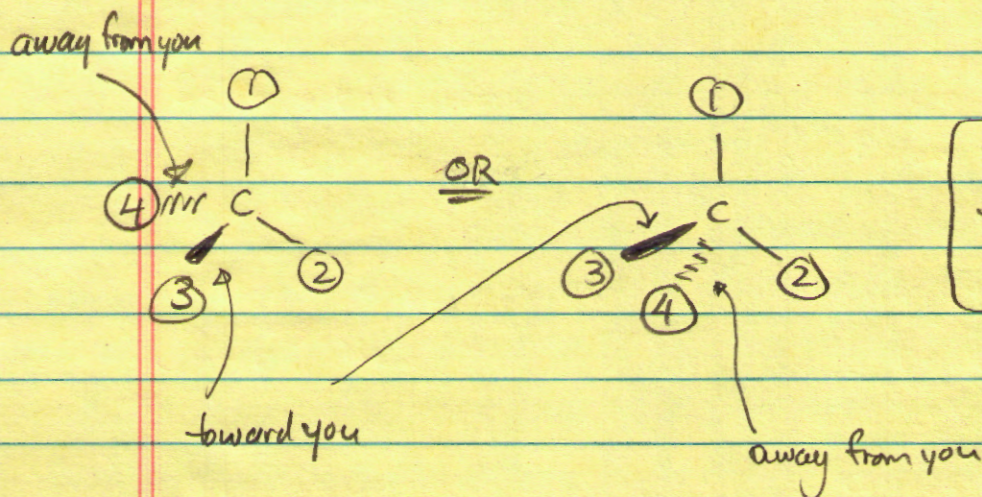
Ch5-4

To recap.

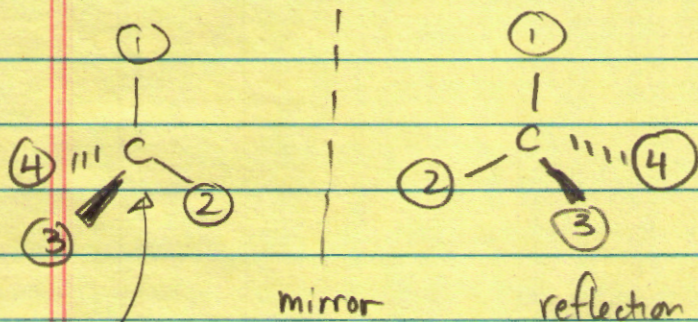
chiral center = C

= sp^3

= attached to 4 unique (different) substituents (groups)



These are identical, only thing that has changed in angle of view.



Like the "hands" on the chiral molecule on the left is NOT superimposable on its mirror image on the right.

one chiral center

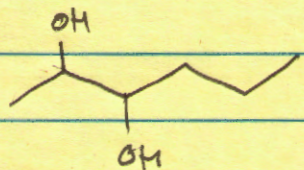
∴ molecule is chiral

Enantiomer: is a stereoisomer that is non-superimposable on its mirror image. ∴

an enantiomer is a chiral molecule

Ch5-5

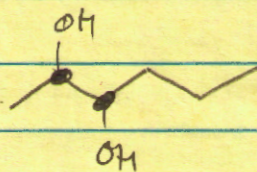
Draw a dot on the carbons that are chiral centers



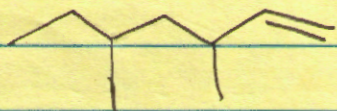
What you rehearse
in your mind:

- ① is it a carbon?
- ② is C sp^3 hybridized?
- ③ are there 4 different "substituents" or groups attached to C?

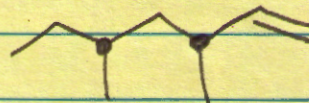
YES, to all? draw dot!



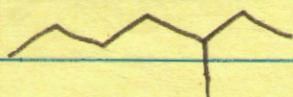
2 chiral centers



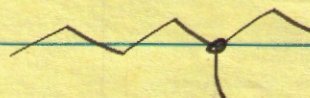
rehearsal
speech



2 chiral centers



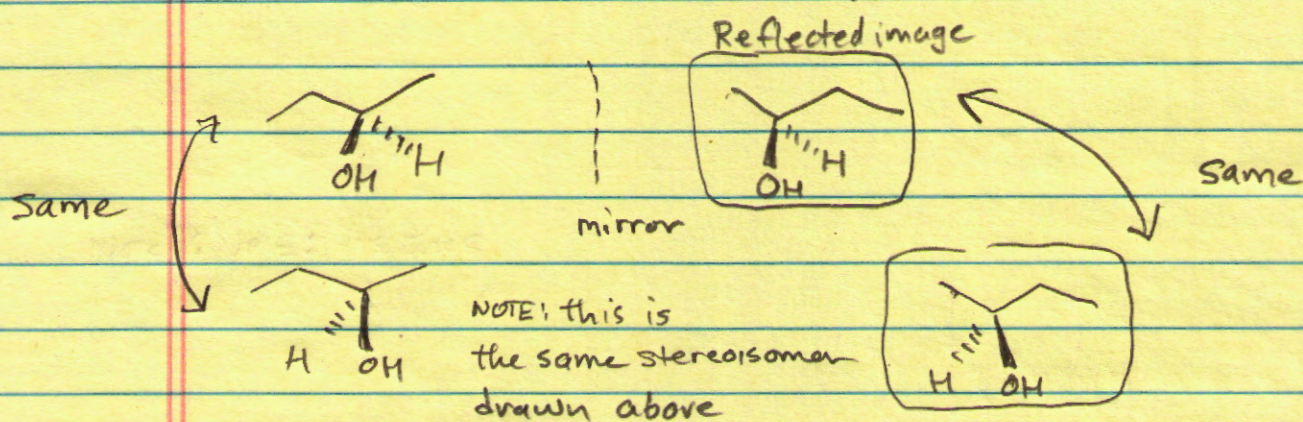
rehearsal
speech



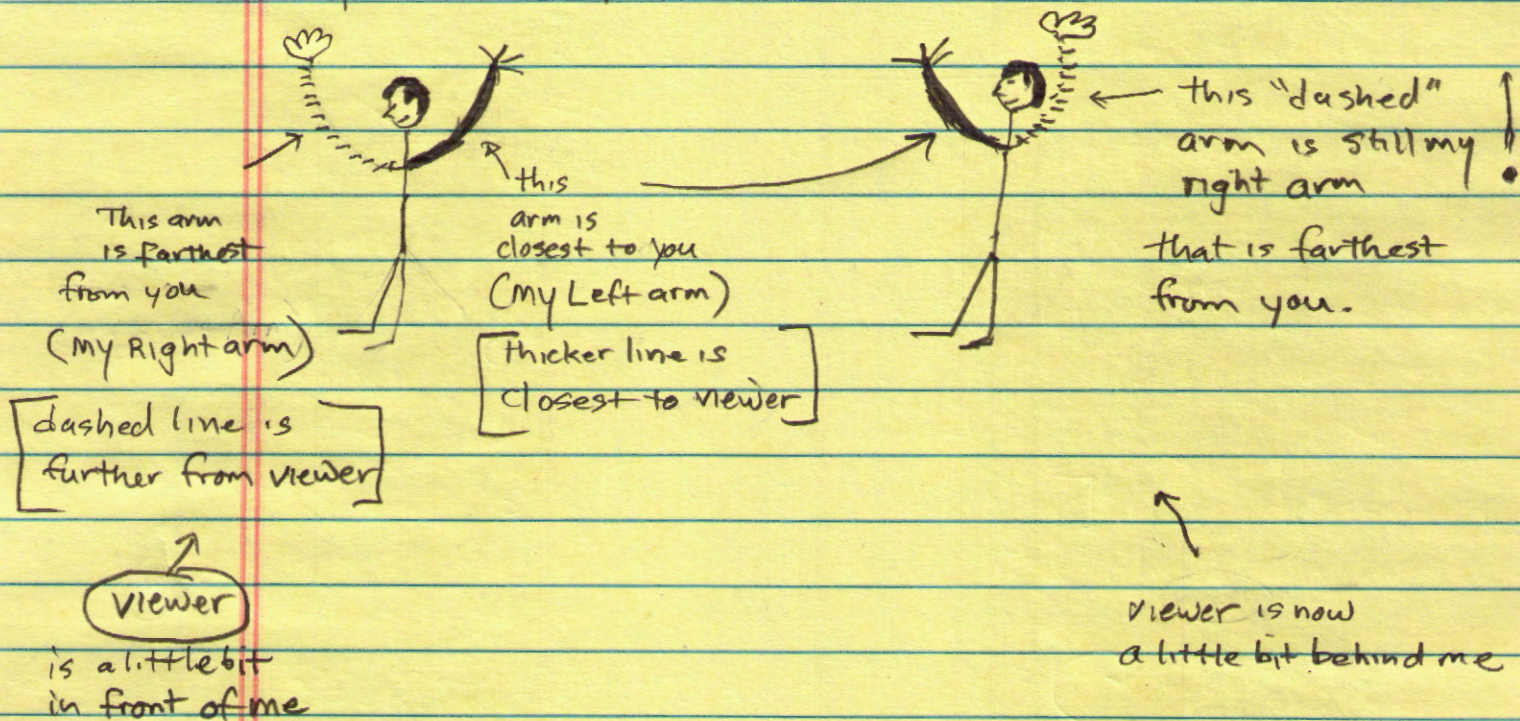
1 chiral center

Ch 5-6

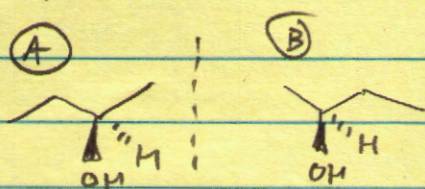
How to draw an enantiomer...



Why are the compounds listed as "same" above



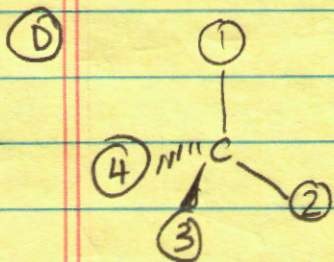
Back to topic



are enantiomers (A) is the enantiomer of (B) and (B) is enantiomer of (A)

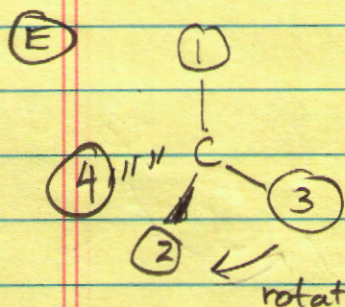
Ch 5-7

Recall.

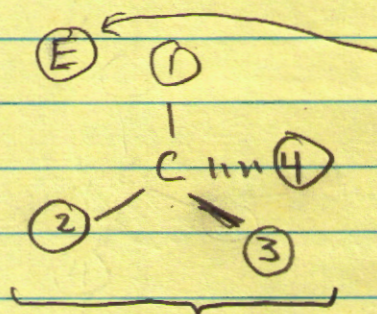


we can draw the enantiomer (non-superimposable mirror image of ①) by switching ANY two numbers

Let's switch ② and ③ (chosen randomly) to make ⑤

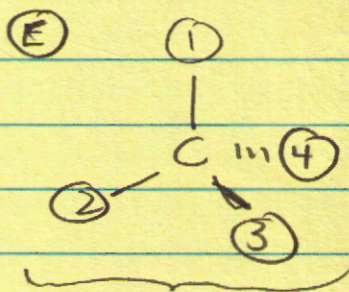
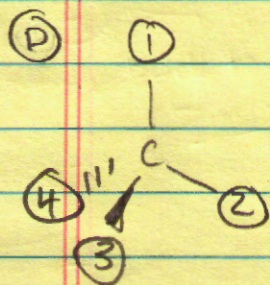


rot



this is STILL ⑤
just rotated
 109° while
① is kept
in place.

compare
this to ① above



enantiomer of ① just by switching
two numbers (or groups) to make ⑤

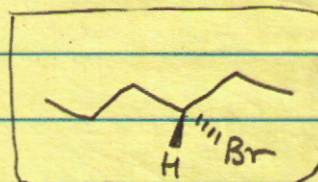
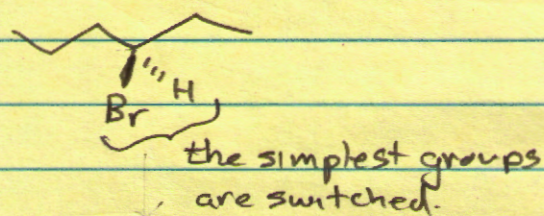
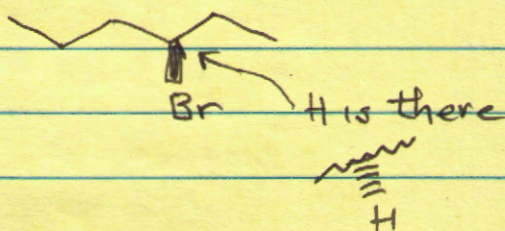
For ⑤, switch ③ and ④ what is its relationship to ①?

Just do it!

Ch5-8

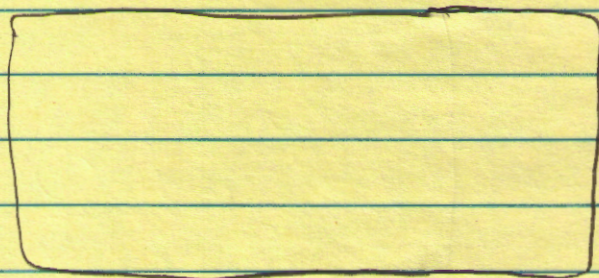
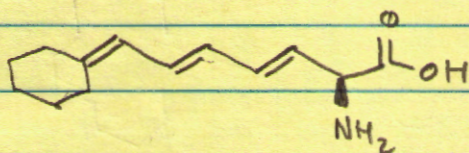
∴ rather than drawing a mirror plane, just switch groups of compound below.

Draw enantiomer of compound below



enantiomer

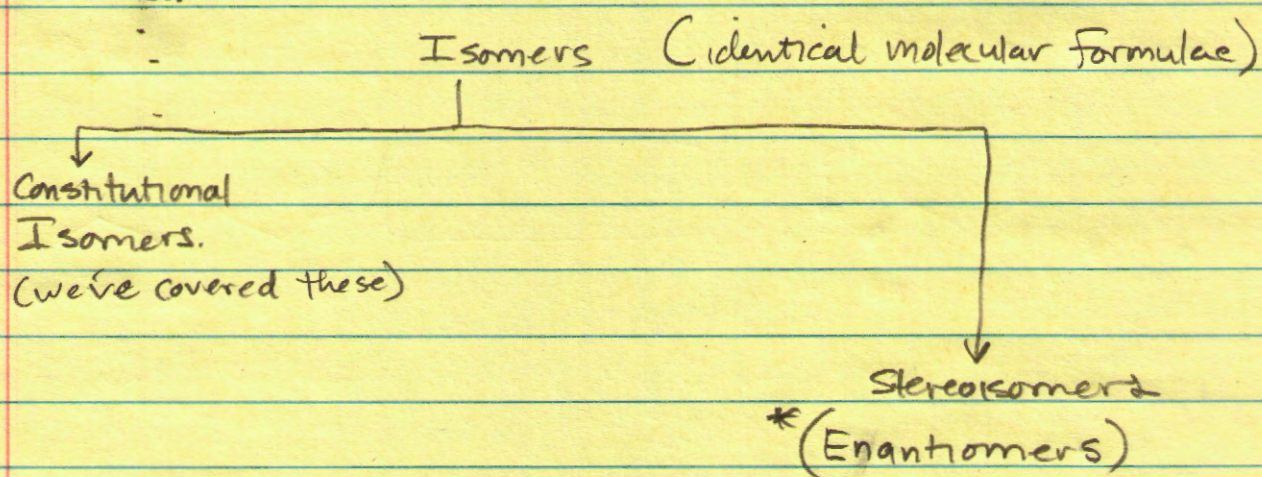
Draw the enantiomer of



enantiomer

if it takes more than ~10 min max to draw this, please consult your TA.

Ch5-8a



* Mirror image molecules that are not superimposable

If a molecule has 1 chiral center, then the molecule is chiral.

We use an IUPAC (International Union of Pure and Applied Chemistry) convention to define ^{the} stereoisomerism of chiral centers

R and S [Cahn-Ingold-Prelog] rules to assign the stereochemistry of a chiral center

[R] = Rectus (Right)

[S] = Sinister (Left)

↻ "turn of a steering wheel"

↺ "turn of a steering wheel"

Ch5-9

To assign **[R]** and **[S]** stereochemistry we will use the spirit of the Olympic Games

1st place: commercial endorsements, talk shows etc.

2nd place: city greeting, local newspaper write-up

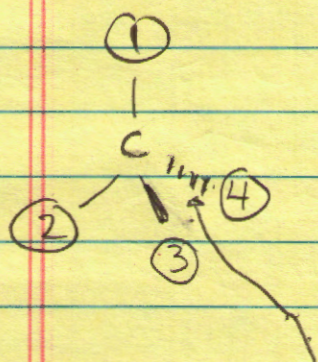
3rd place: party in the driveway of their neighborhood

4th place: ignored no fanfare, back to work as professor.

①, ②, ③ are important ④ is ignored

Cahn -
Ingold
-Prelog

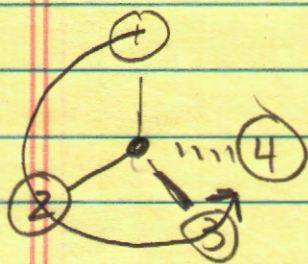
R, S ①, ②, ③, ④ rankings are determined by the atom directly attached to the chiral carbon



		# of Protons (Atomic #)	Ranking
Br	Br	35	①
Cl	Cl	17	②
C	C	6	③
H	H	1	④

④ is on dotted line and in back, so in this structure, it is already ignored. So focus on ①, ②, ③

Ch5-10

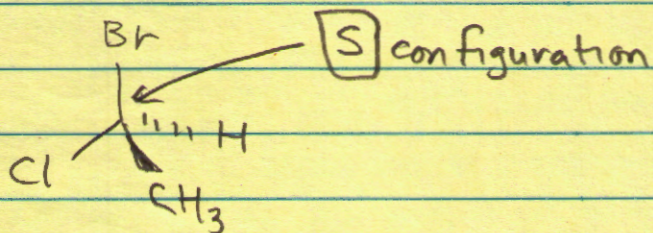


- ① connect ① → ② → ③ with one line and IGNORE ④
- ② place arrowhead at end of your line
- ③ Redraw line in blank area of page

↻ turn steering wheel in that direction
turns you to the LEFT

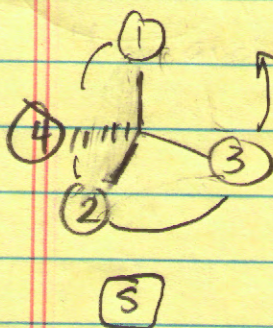
Sinister

∴ the chiral center of this molecule has 'S' stereochemistry

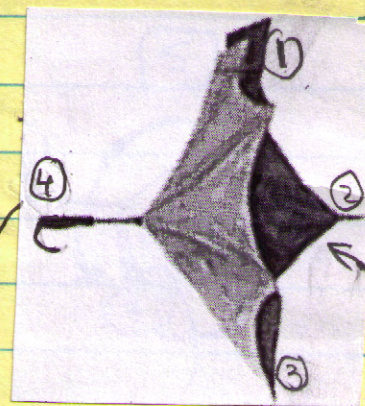


Ch 5-11

Notice how ④ in previous example was conveniently in the back, because that's the way the molecule was drawn.



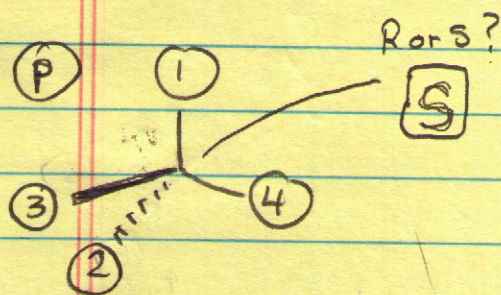
Look at these 3D structures as if you were looking into an inverted umbrella



④ is the handle ignored

Looking into "cavity of inverted umbrella"

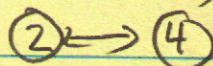
What if drawn like this ... ④ is not on the (dashed) line



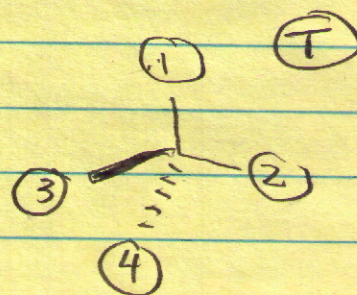
Let's get it there!

① What happens if I exchange ANY two numbers? I make the enantiomer of (P)!

② So let's exchange the number on (dashed) bond with ④

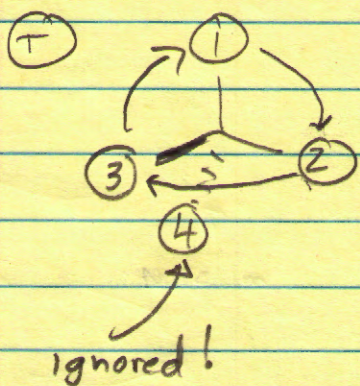


(T) is the enantiomer of (P) if we connect 1,2,3 we will get the opposite configuration of (P)



CH5-12

Let's figure out if (T) is R or S,

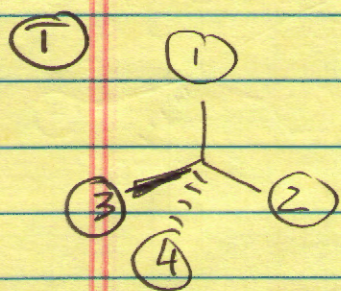


right $\therefore$ cpd (T) has R stereochemistry

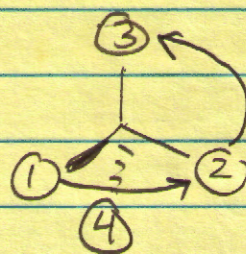
$\therefore$ cpd (P) on previous page has S stereochemistry.

Alternatively, we know (T) is the enantiomer of (P), so if I switch any other two numbers that does not include (4) (4 must stay on wavy line) then I make the enantiomer of (T) which is (P)

Let's do it



Leave (4) on (wavy) line but switch say (1) and (3)



left turn

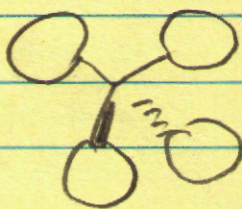
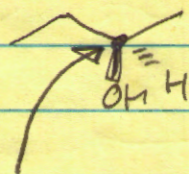
S

just like we determined above by switch R configuration of (T) to get the S configuration of (P)

here we determined S directly from 'double Switch' structure!

Ch 5-13

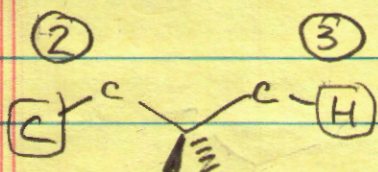
CIP (Cahn-Ingold-Prelog) practice



R or S



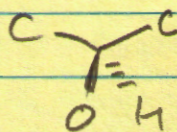
- 1 ID that 4 different groups are attached to chiral C



2 Atoms attached to Chiral C

C	atomic # 6	tie
C	" # 6	tie
O	" # 8	1
H	" # 1	4

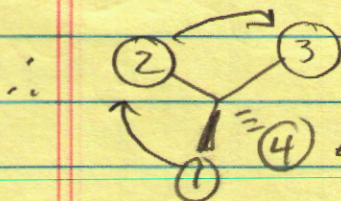
Ranking



Sing this:
"what is the next highest atomic # atom attached"

C beats H

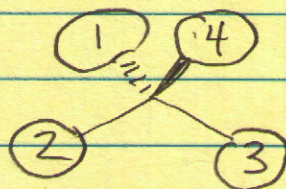
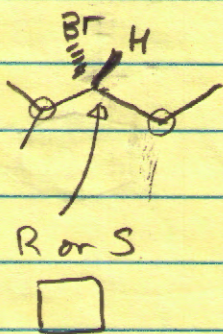
∴ ranking after 1 for Oxygen above is 2 and 3



connect 1, 2, 3

right turn ⇒ **R**

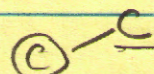
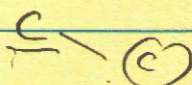
Ch5-14



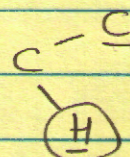
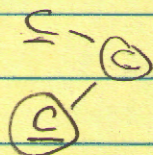
(C)

(C) (1) tie

(2) Sing (see previous page)



still tied, go back to (C)



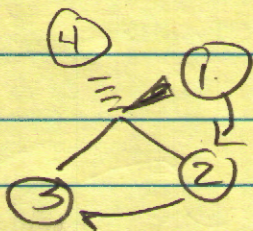
C beats H

(4) is in front, get it to back by switching w/ # ^{currently in} back!

(a) switch (1) and (4)

(b) switch (2) and (3)

(c) connect 1, 2, 3 ignore (4) assign R or S



(C) right turn (R)