Organic 1

Subject: Sterochemistry

Dopamine

لجان الدّفعات

DOPAMINE ACADEMY

Pharmaceutical Organic Chemistry-1

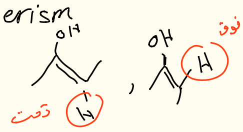
Chapter-5: Stereoisomerism

Isomers: مركبات لها نفس ال molecular formula
ولكنها تختلف في :

1 -(connectivity) تختلف في إتصال الذرات مع بعضها البعض ينتج عن اختلاف ف connectivity → structural / constitutional isomers

مثال : CH_3CH_2OH, CH_3OCH_3 $\xleftarrow[\text{نفسها}]{\text{molecular formula}}$ C_2H_6O

2 - (spatial arrangement) تختلف في ترتيب الذرات في الفراغ ينتج عن وجود spatial arrangement → Stereoisomerism

مثال 

Isomers

- Constitutional Isomers
  - skeletal
  - functional
  - positional
- stereoisomerism
  - conformational
    - Ring flip
    - newman
  - configurational
    - geometrical
    - optical

مقدمة كيف بيجي السؤال في الإمتحان وكيف طريقة الحل بشكل عام:

- what is the relation between the following compounds:

a) same

b) different

c) constitutional isomers

d) stereoisomers

- خطوات الحل بشكل عام:

1- نقوم بعدّ أنواع الذرات وعدد كل نوع لمعرفة الصيغة الجزيئية

[في حال كان المركبان يختلفان في الصيغة فهما مختلفان (b-different)
وإذا كان لهما نفس الصيغة يتم الإنتقال للخطوة الثانية]

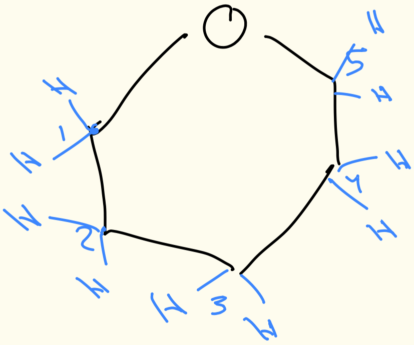
2- نقوم بالتأكد من الـ "Connectivity" "ارتباط الذرات ببعضها".

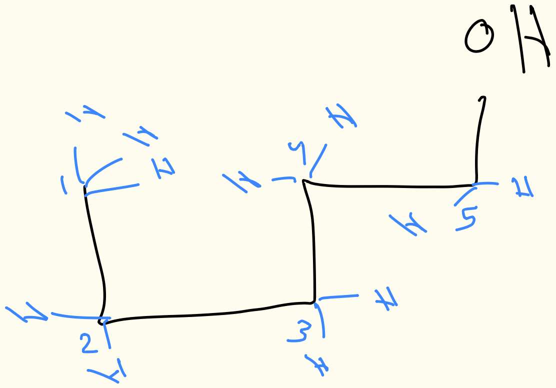
[في حال كان المركبان مختلفان في الـ connectivity فهما (C - constitutional isomers)
وفي حال كانا متشابهان يتم الإنتقال للخطوة 3]

3- نقوم بالتأكد من "spatial arrangement" ترتيب
الذرات في الفراغ

[في حال كان المركبان مختلفان بالترتيب في الفراغ فهما (d-stereoisomers)
وفي حال كانا متشابهين في الترتيب في الفراغ فهما (a - the same)

: Jûo



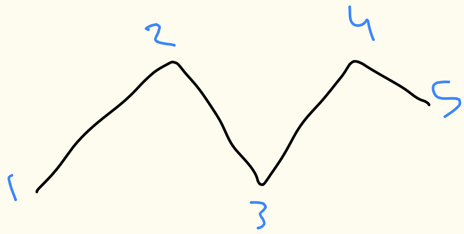


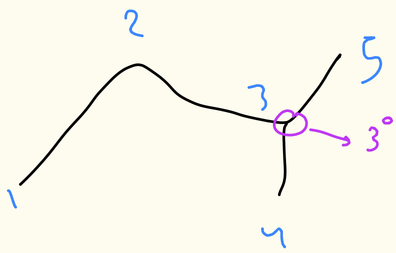
C : 5
O : 1
H : 10
$\rightarrow C_5H_{10}O$

C : 5
O : 1
H : 12
$\rightarrow C_5H_{12}O$

مختلف

different compound





3° tertiary carbon

C : 5
H : 12
$\rightarrow C_5H_{12}$

C : 5
H : 12
$\rightarrow C_5H_{12}$

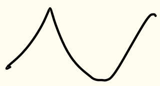
Same

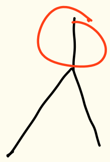
not the same connectivity $\rightarrow$ structural isomers

Answer

what is the relation between compounds?

ex:

A.  C_4H_{10}

B.  C_4H_{10}

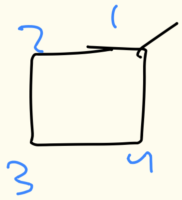
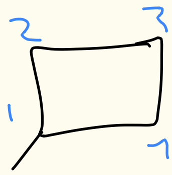
C.  C_4H_{10}

same

B is constitutional isome for A and C

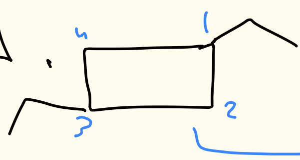
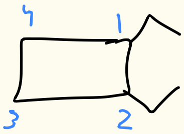
A and C are the same → there is no different in molecular formula, connectivity and spatial arrengment

ex:

A.  B. 

the same

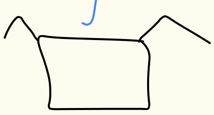
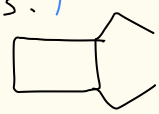
Ex:

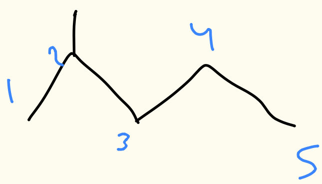
A.  B. 

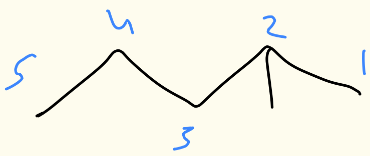
positional constitutional isomer

ex:

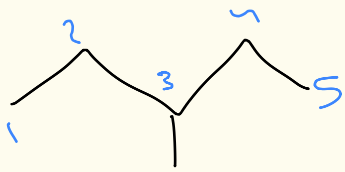
the same

A.  B. 

A. 

B. 

the same

C. 

A and B with C are constitutional isomers

Chirality & Stereochemistry

- An object is ***achiral*** (not chiral) if the object and its mirror image are identical

إذا رسمت خط وقسمت المركب إلى قسمين متماثلين فحيكون مطابق لصورته بالمرآة
وبالتالي achiral

- A ***chiral*** object is one that cannot be superposed on its mirror image

(متطابق)

chiral: ذرة C عليها 4 ذرات مختلفة

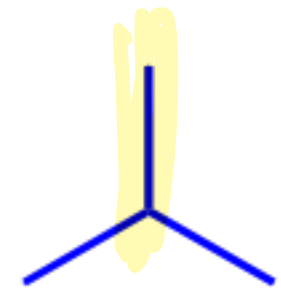
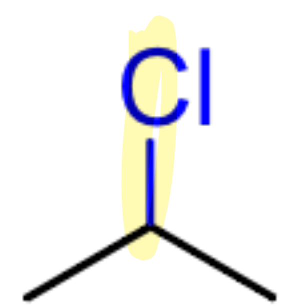
1. Isomerism: Constitutional Isomers & Stereoisomers

1A. Constitutional Isomers

- **Isomers**: different compounds that have the same molecular formula
  - **Constitutional isomers**: isomers that have the same molecular formula but different connectivity –their atoms are connected in a different order

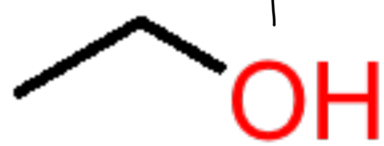
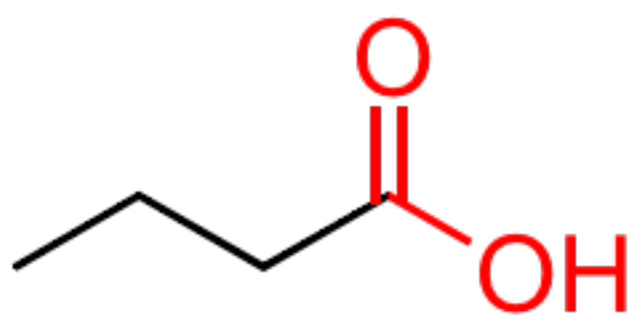
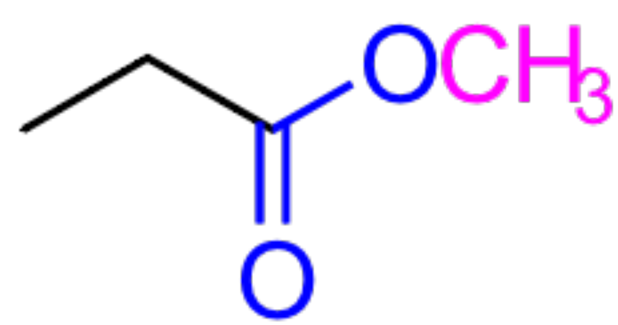
❖ Examples

لا تختلف في ال connectivity لا تعتبر constitutional isomers

Molecular Formula	Constitutional Isomers		
C_4H_{10}	 Butane	and	 2-Methylpropane
C_3H_7Cl	 1-Chloropropane	and	 2-Chloropropane

لما إذا اختلف الإسم فهو constitutional isomers

❈ Examples

Molecular Formula	Constitutional Isomers		
C_2H_6O	O رابطة مع C واحدة  Ethanol	and	O رابطة مع كربونتين CH_3-O-CH_3 Methoxymethane
$C_4H_8O_2$	 Butanoic acid	and	 Methyl propanoate

Functional constitutional isomers:-

- في حال المركبين اختلفوا بال functional groub

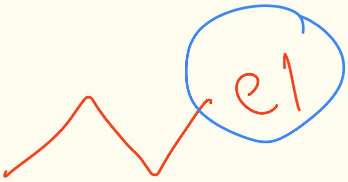
مثال :-

Ethanol × methoxymethane

positional constitutional isomers:-

- في حال اختلاف موقع ال functional groub

مثال :-



×

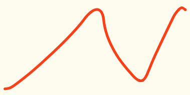
1-chloro propane

2-chloro propane

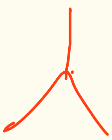
Skeletal constitutional isomers:-

- في حال اختلاف مكان الكربون

مثال :-



×



butane

2-methyl butane

(معلومات إضافية للتوضيح)

1B. Stereoisomers

- Stereoisomers are **NOT** constitutional isomers

- **Stereoisomers** have their atoms connected in the same sequence but they differ in the arrangement of their atoms in space. The consideration of such spatial aspects of molecular structure is called ***stereochemistry***

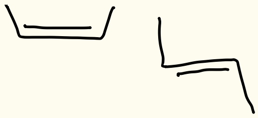
Stereoisomers (S.I)

Conformational

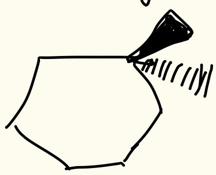
- Ring flip
- eclipsed and staggred

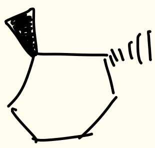
Configurational

- Geometrical / diasteromers
  - Cis / trans
    - double bond



    - Ring





- optical (enantiomers)

conformational

$SI \rightarrow A \rightleftharpoons B$

إذا A بتتحول إلى
B و B بتتحول إلى
A بسهوله

$SI \rightarrow A \rightleftharpoons A$

إذا A و B ما بتحولوا
لبعض بسهوله

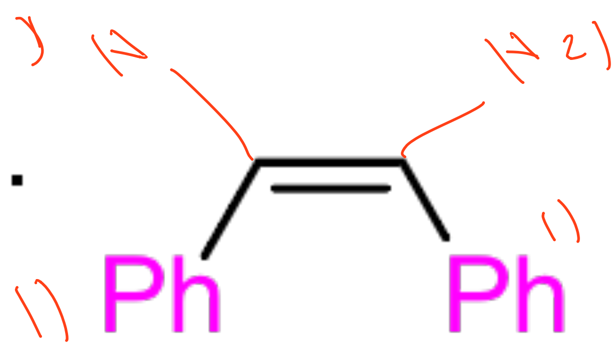
configurational

1C. Enantiomers & Diastereomers

- Stereoisomers can be subdivided into two general categories: *enantiomers* & *diasteromers*
  - **Enantiomers** – stereoisomers whose molecules are nonsuperposable mirror images of each other
  - **Diastereomers** – stereoisomers whose molecules are not mirror images of each other

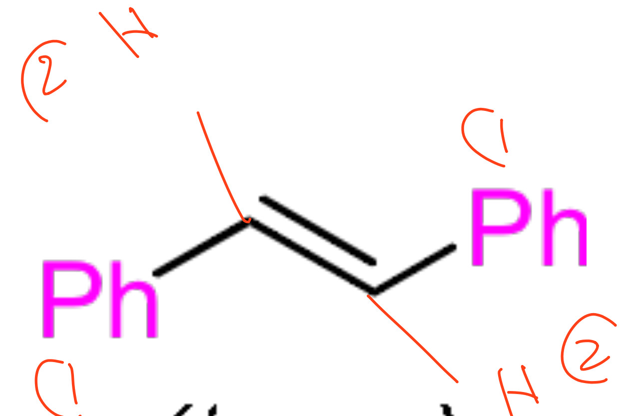
- Geometrical isomers (*cis* & *trans* isomers) are:
  - *Diastereomers*

e.g.

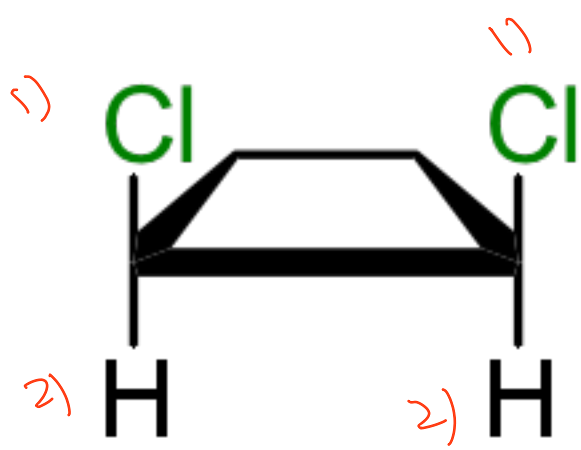


(*cis*)

and

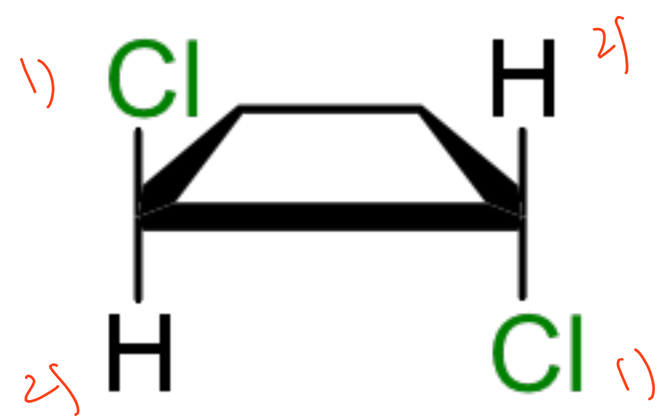


(*trans*)



(*cis*)

and



(*trans*)

Subdivision of Isomers

Isomers
(different compounds with same molecular formula)

Constitutional Isomers
(isomers whose atoms have a different connectivity)

Stereoisomers
(isomers that have the same connectivity but differ in spatial arrangement of their atoms)

Enantiomers
(stereoisomers that are nonsuperposable mirror images of each other)

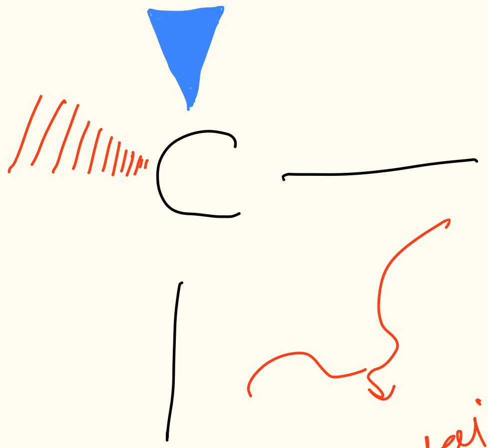
Diastereomers
(stereoisomers that are NOT mirror images of each other)

2. Enantiomers and Chiral Molecules

- Enantiomers occur only with compounds whose molecules are **chiral**
- A chiral molecule is one that is **NOT** superposable on its mirror image
- The relationship between a chiral molecule and its mirror image is one that is ***enantiomeric***. A chiral molecule and its mirror image are said to be enantiomers of each other

Solid -dash

(خارج من الصفحة) solid

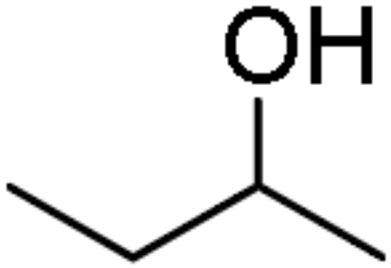


(داخل إلى الصفحة) dash

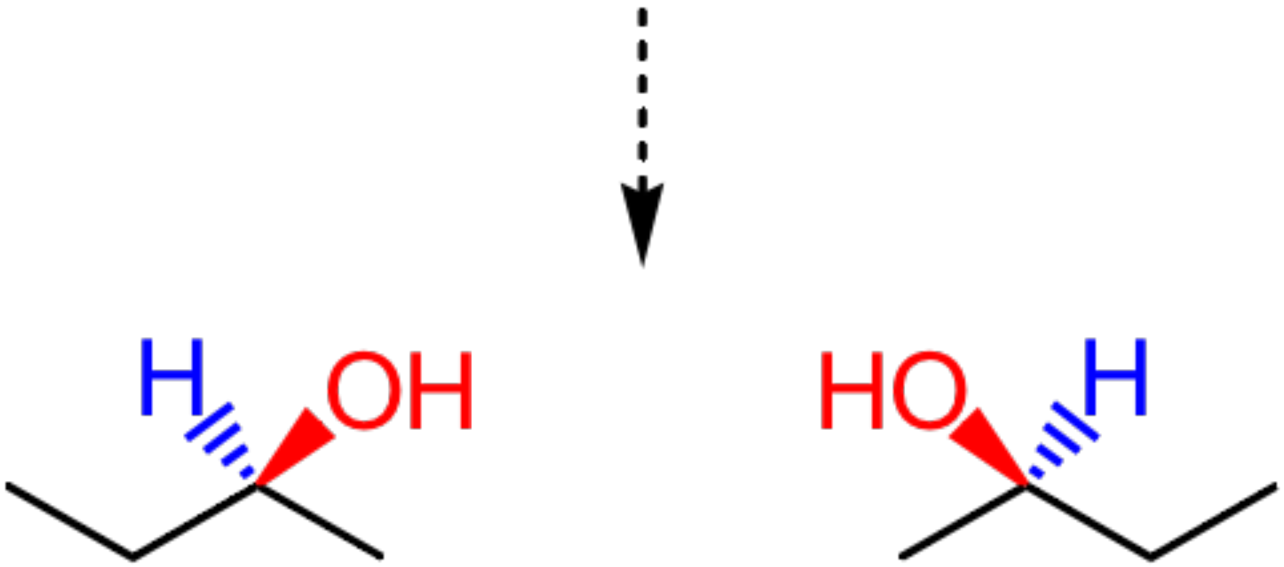
Containing
(على مستوى الصفحة)

تبين هذه الخطوط اتجاهات الذرات في الفراغ

- عند البحث في العلاقة بين اي مركبين في حال كان لهما نفس ال Connectivity نبحث في ال spatial arrangement في حال عدم وجود Ringflip أو eclipssed & staggered لا يعتبر conformational نبحث في كونه diastromer لوجود cis-trans سواءً في double bond أو Ring في حال عدم وجودها نبحث في كونه enantiomers في حال كان achiral لا يعتبر enantiomers وفي حال كونه chiral نبحث بمدى تطابقه مع انعكاس مرآته في حال كان متطابق لا يعتبر enantiomers وإذا كان غير منطبق يعتبر enantiomers

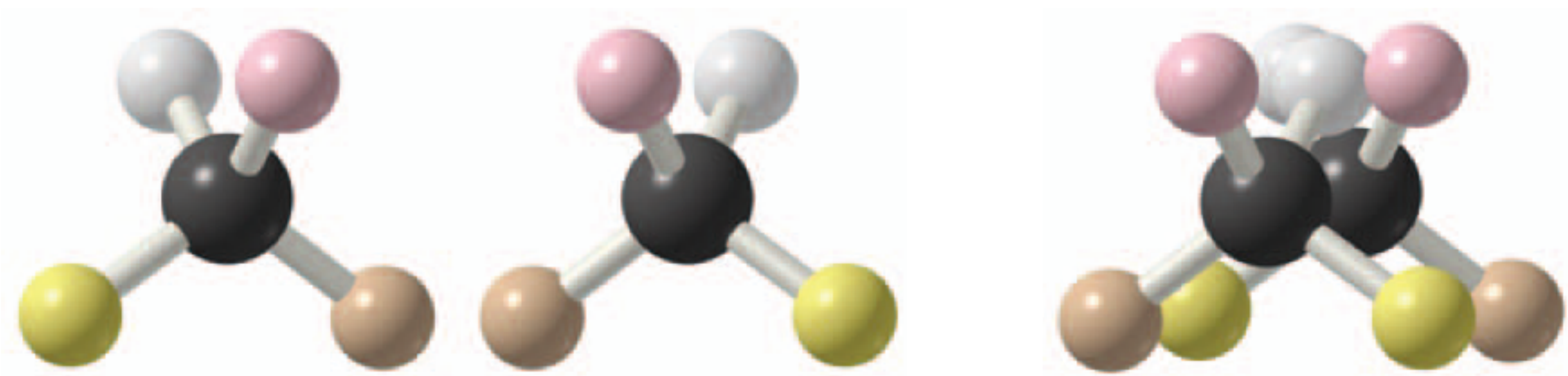


(2-Butanol)



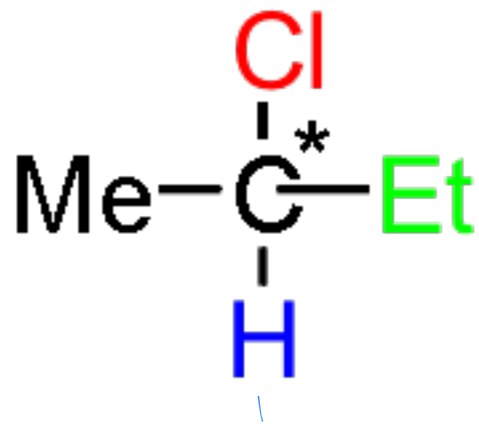
(I) (II)

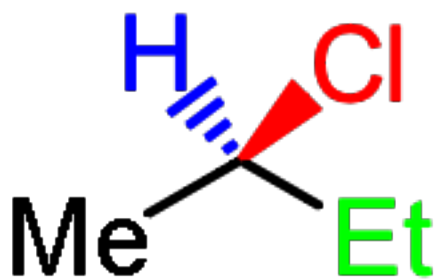
(I) and (II) are nonsuperposable mirror images of each other



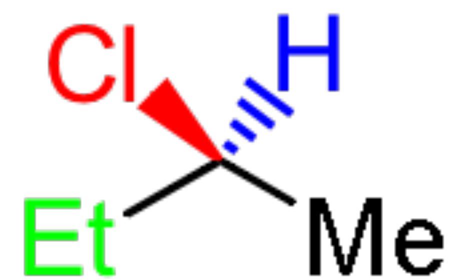
3. A Single Chirality Center Causes a Molecule to Be Chiral

- The most common type of chiral compounds that we encounter are molecules that contain a carbon atom bonded to *four different groups*. Such a carbon atom is called an *asymmetric carbon* or a ***chiral center*** and is usually designated with an asterisk (*)





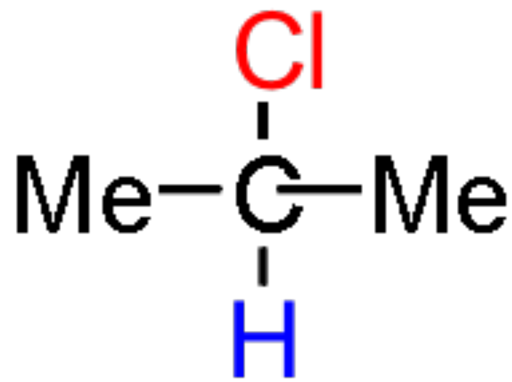
(III)

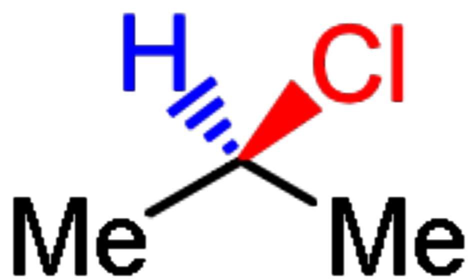


(IV)

mirror

(III) and (IV) are nonsuperposable mirror images of each other





(V)

(VI)

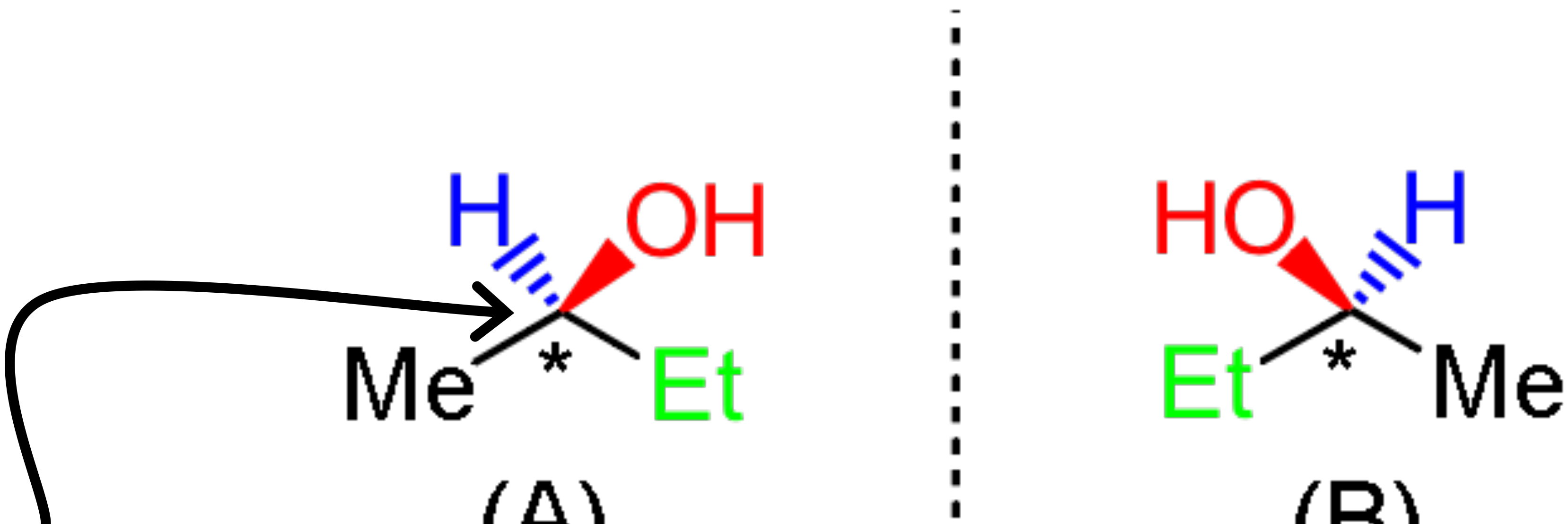
mirror

(V) and (VI) are superposable

⇒ not enantiomers ⇒ **achiral**

3A. Tetrahedral vs. Trigonal Stereogenic Centers

- Chirality centers are ***tetrahedral stereogenic*** centers



(A) (B)

Tetrahedral stereogenic center
⇒ chiral

mirror

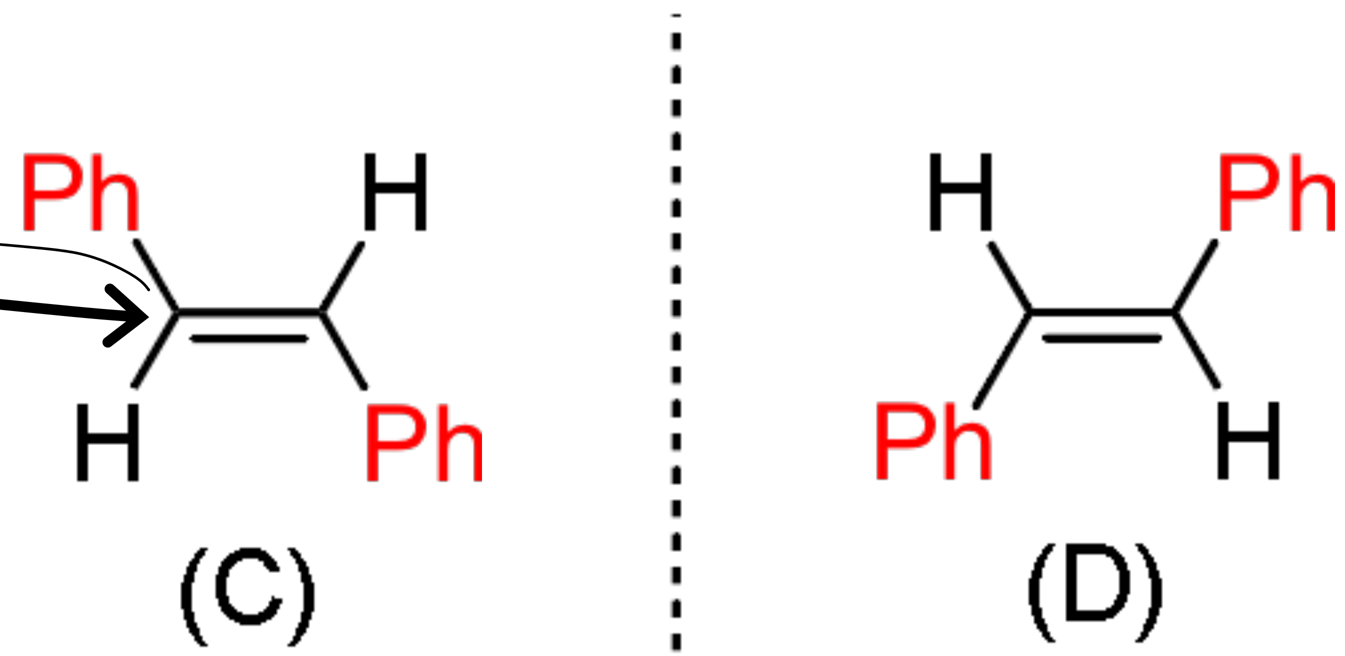
(A) & (B) are enantiomers

- *Cis* and *trans* alkene isomers contain trigonal stereogenic centers

تهجين

sp^2

بالتالي الشكل



mirror

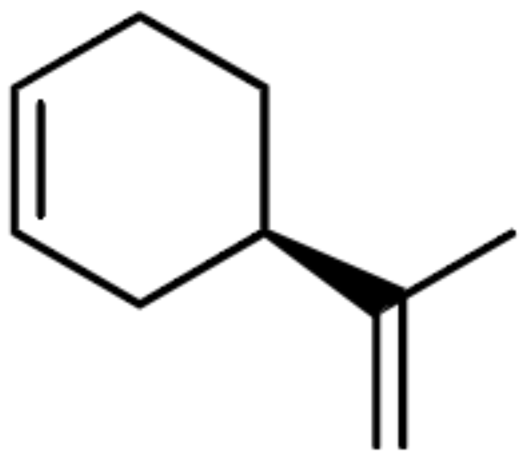
Trigonal stereogenic center

⇒ achiral

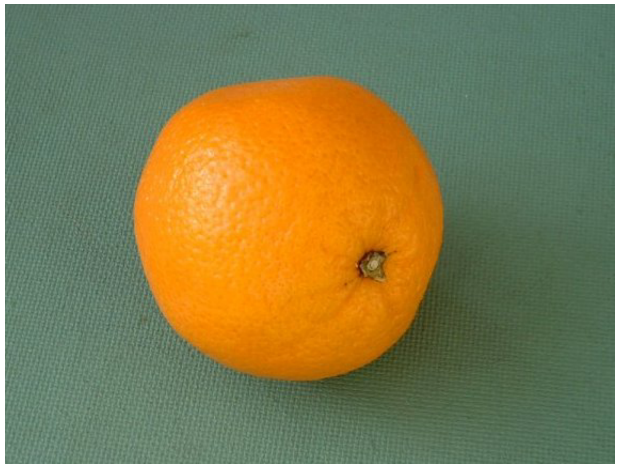
إزاي في C عليها رابطة ثنائية او ثلاثية مستحيل يكونوا chiral

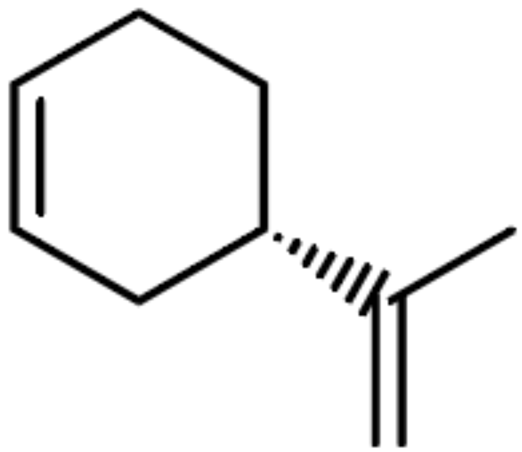
(C) & (D) are identical

4. More about the Biological Importance of Chirality



(+)-Limonene
(limonene enantiomer found in oranges)





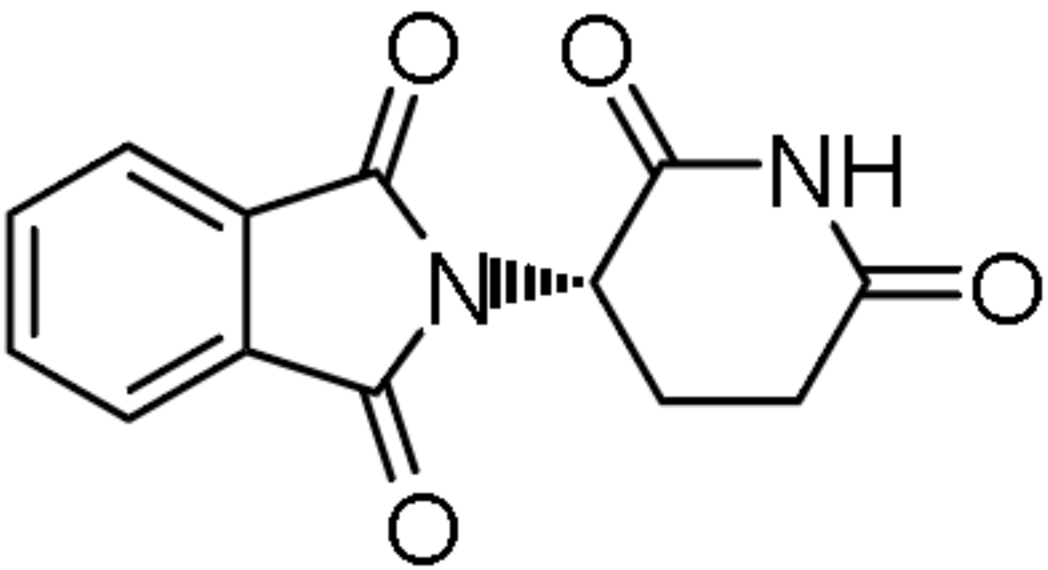
(-)-Limonene
(limonene enantiomer found in lemons)

Thalidomide

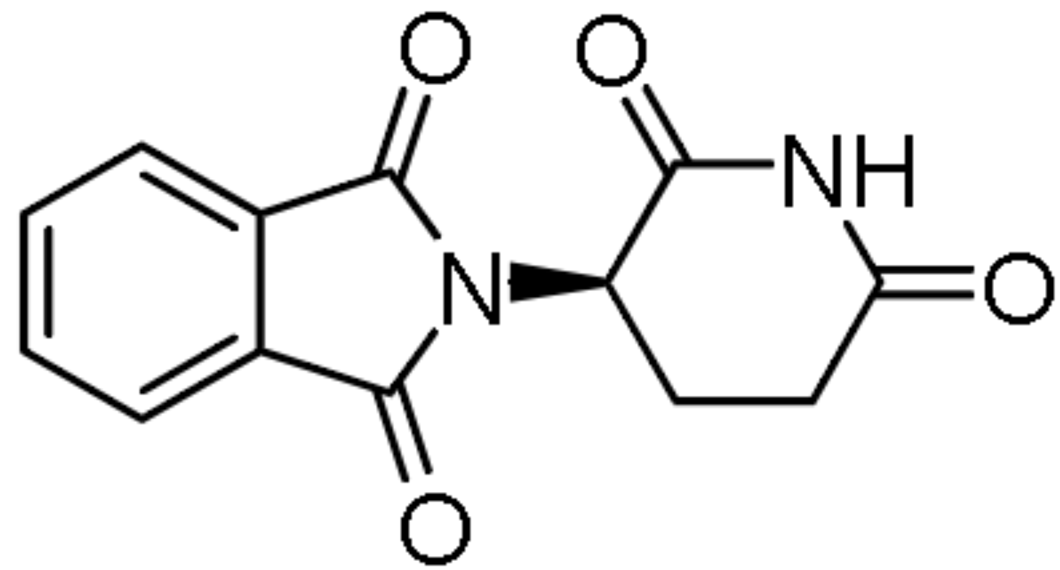
- The activity of drugs containing chirality centers can vary between enantiomers, sometimes with serious or even tragic consequences

- For several years before 1963 thalidomide was used to alleviate the symptoms of morning sickness in pregnant women

- In 1963 it was discovered that thalidomide (sold as a mixture of both enantiomers) was the cause of horrible birth defects in many children born subsequent to the use of the drug



Thalidomide
(cures morning sickness)

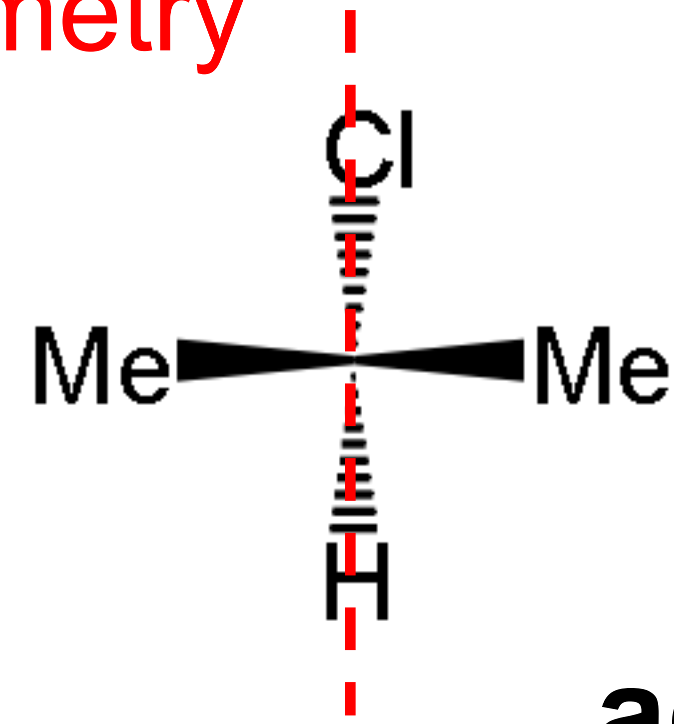


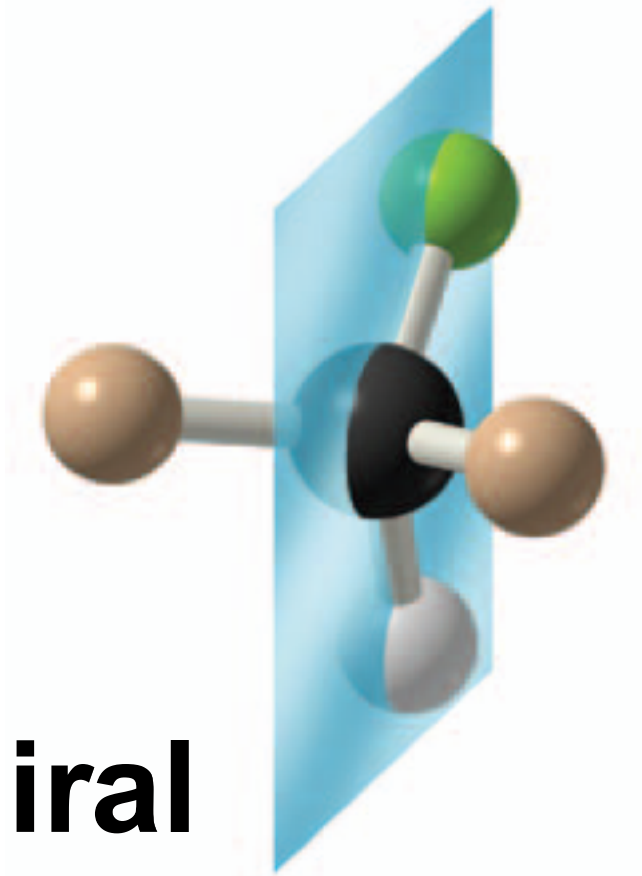
enantiomer of Thalidomide
(causes birth defects)

5. How to Test for Chirality: Planes of Symmetry

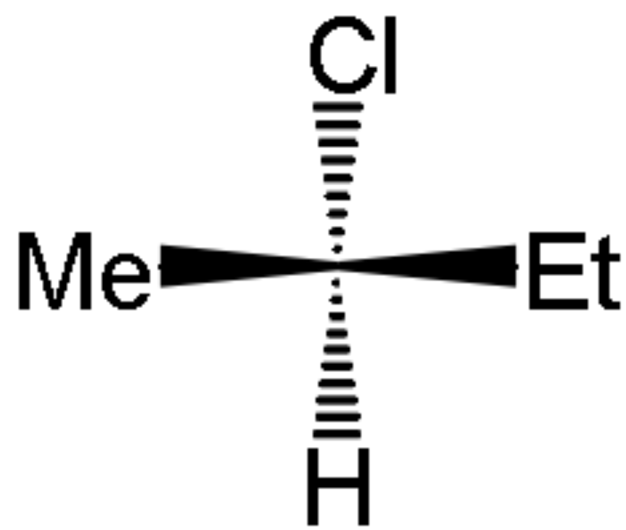
- A molecule will not be chiral if it possesses a plane of symmetry
- A plane of symmetry (mirror plane) is an
  ينصف
  imaginary plane that bisects a molecule such that the two halves of the molecule are mirror images of each other
- All molecules with a plane of symmetry in their most symmetric conformation are ***achiral***

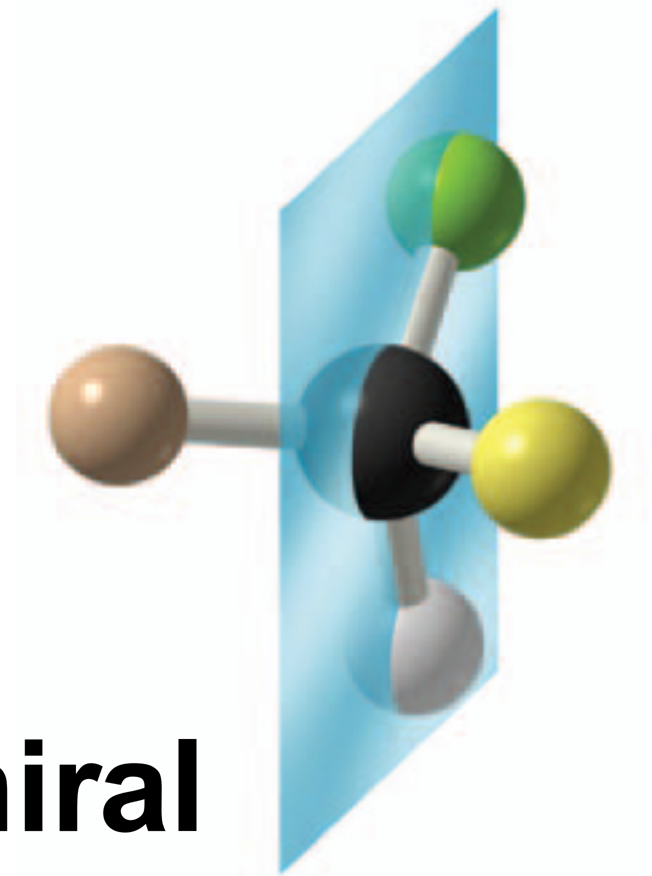
Plane of symmetry





achiral



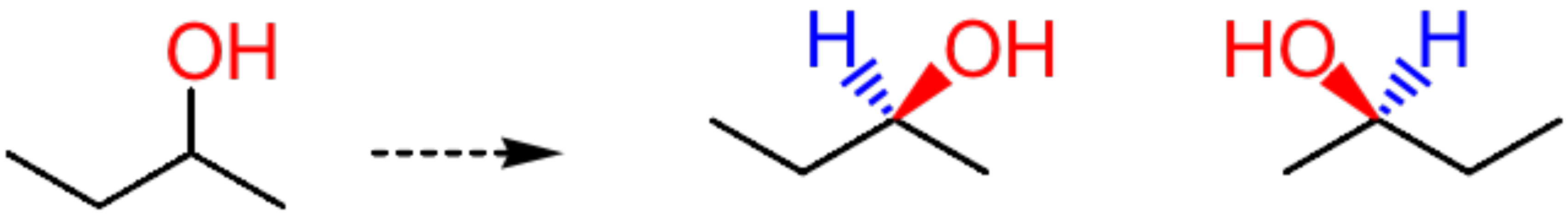


chiral

No plane of symmetry

6. Naming Enantiomers: *R*,*S*-System

Recall:



(I) (II)

- Using only the IUPAC naming that we have learned so far, these two enantiomers will have the same name:
  - **2-Butanol**
- This is undesirable because each compound must have its own distinct name

6A. How to Assign (R) and (S) Configurations

- Rule 1
  - Assign priorities to the four different groups on the stereocenter from highest to lowest (priority bases on atomic number, the higher the atomic number, the higher the priority)

increasing the atomic number

I > Br > Cl > S > P > F > O > N > C > H

- Rule 2
  - When a priority cannot be assigned on the basis of the atomic number of the atoms that are directly attached to the chirality center, then the next set of atoms in the unassigned groups is examined. This process is continued until a decision can be made.

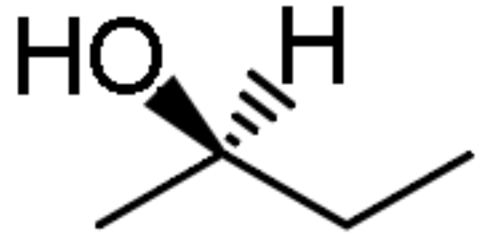
مع عقارب الساعة ← R

عكس عقارب الساعة ← S

❖ Rule 3 تخيل

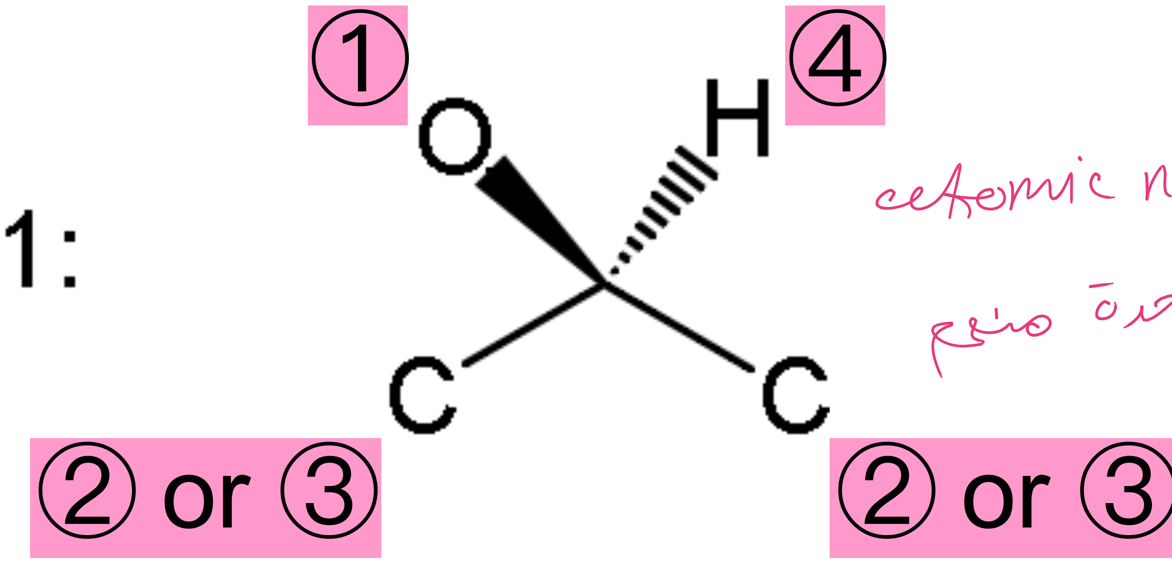
- Visualize the molecule so that the lowest priority group is directed away from you, then trace a path from highest to lowest priority. If the path is a clockwise motion, then the configuration at the asymmetric carbon is (*R*). If the path is a counter-clockwise motion, then the configuration is (*S*)

❖ Example



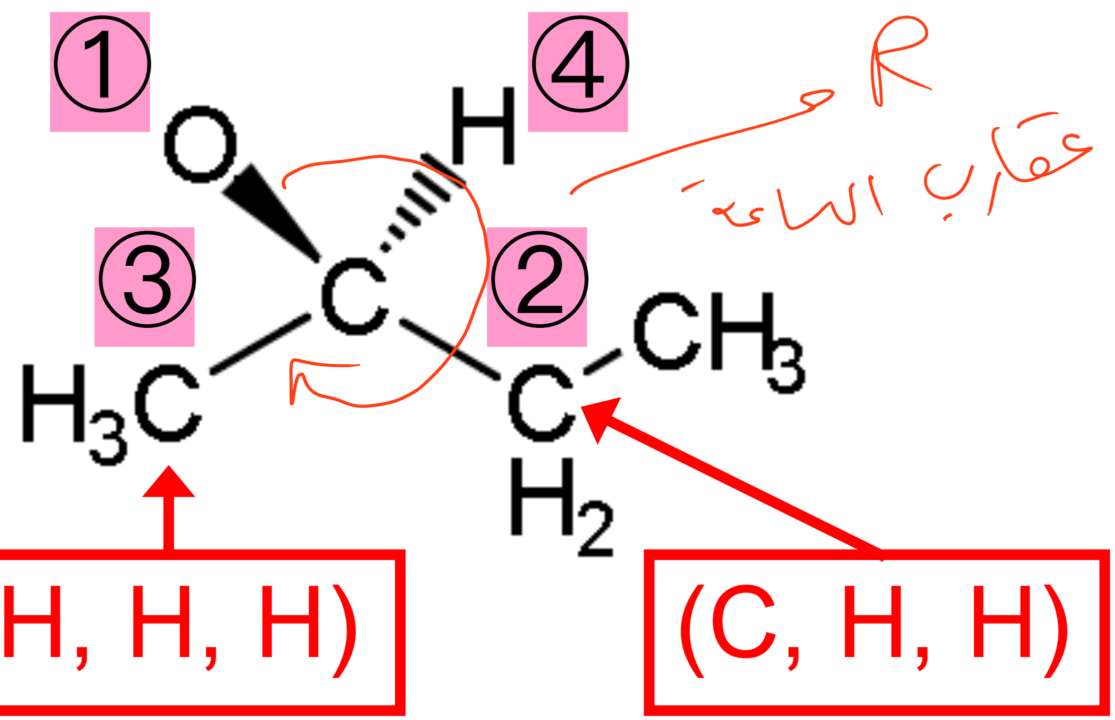
(2-Butanol)

Step 1:

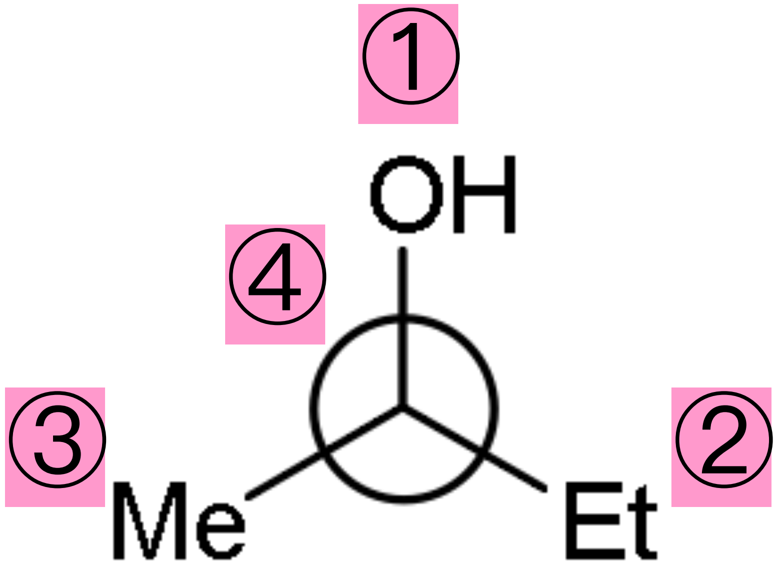


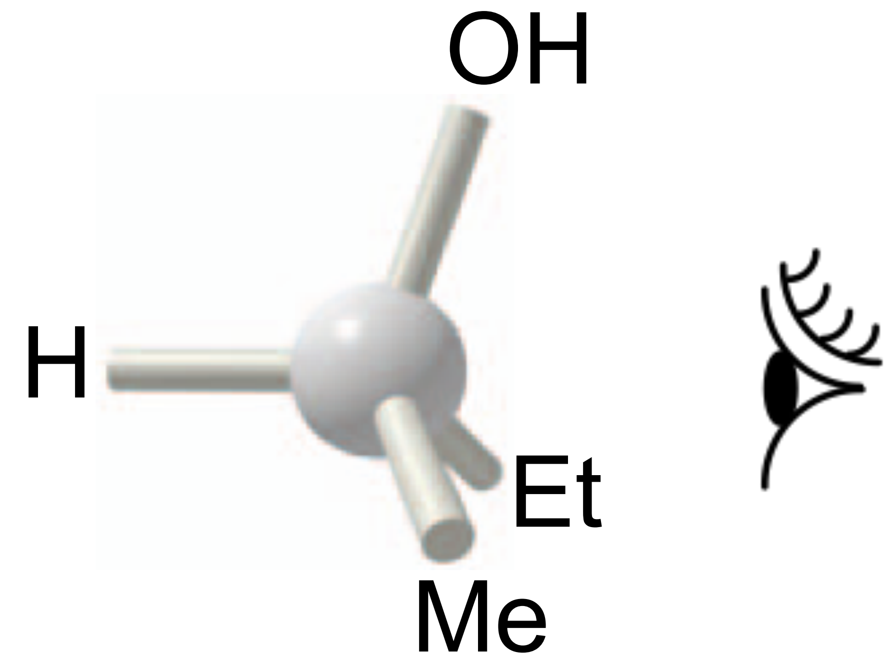
إذا تساوت الذرتين المرتبطات
بال stereocenter بال atomic number
نقارن بين الذرات المرتبطة بكل واحدة منهم

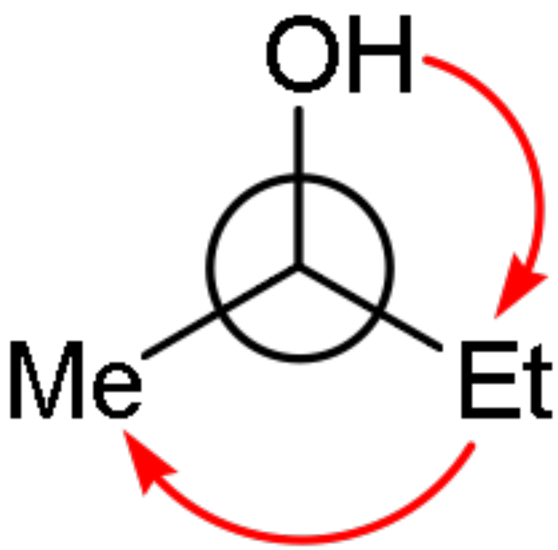
Step 2:

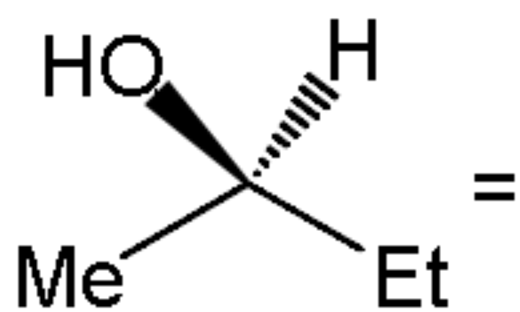


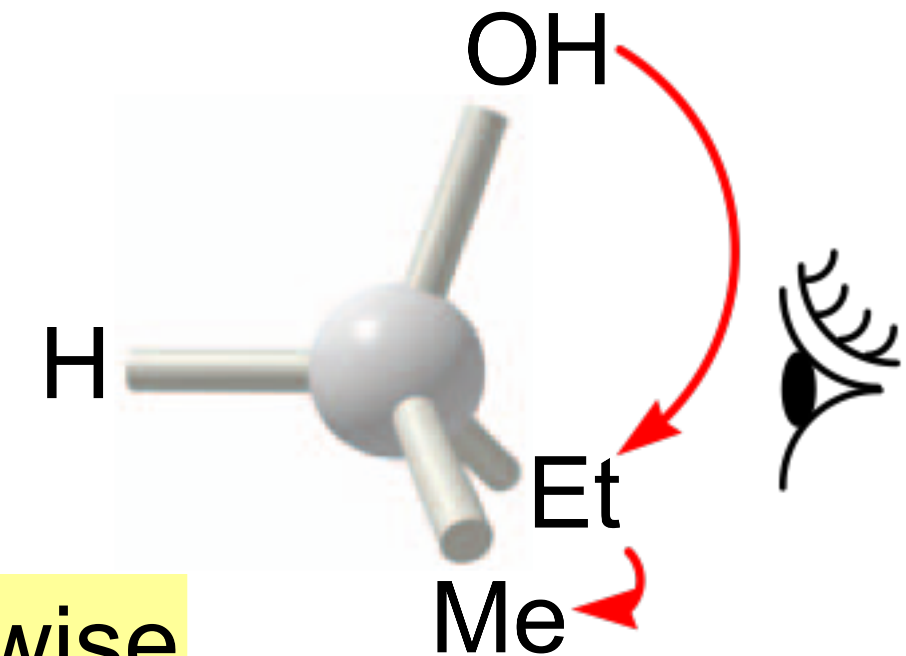
R
مع عقارب الساعة







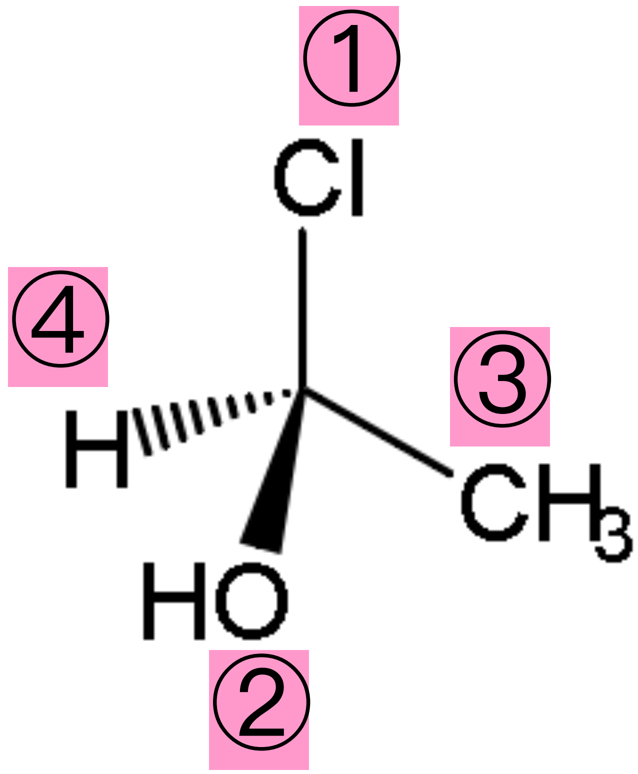




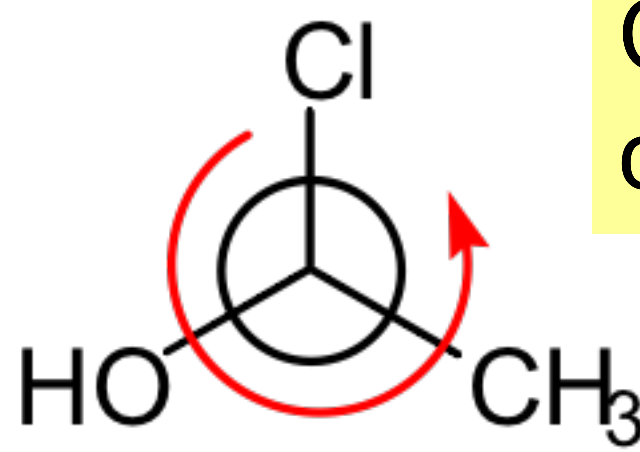
Arrows are clockwise

(*R*)-2-Butanol

❖ Other examples



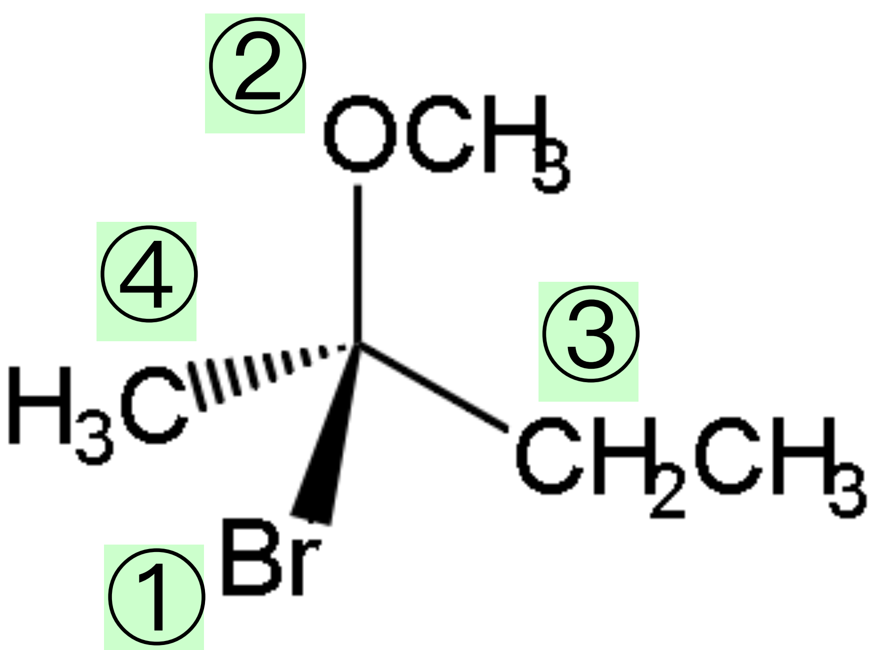
⇒



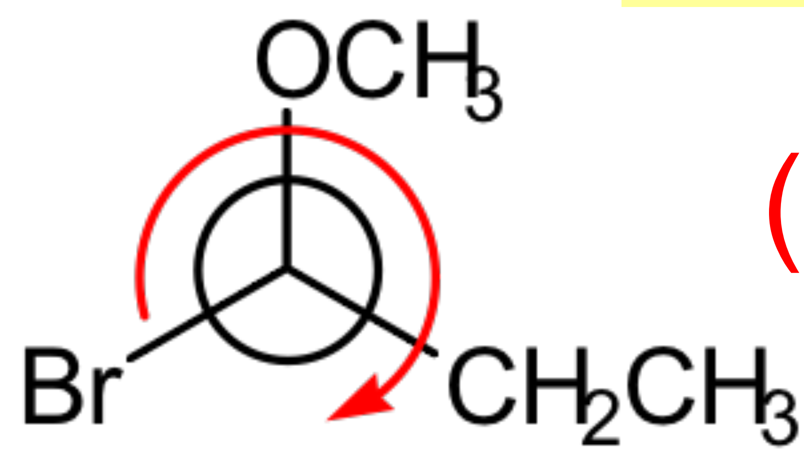
Counter-clockwise

(*S*)

Clockwise



⇒



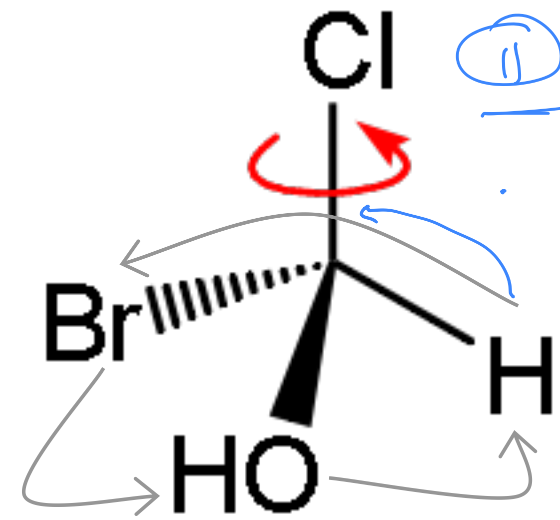
(*R*)

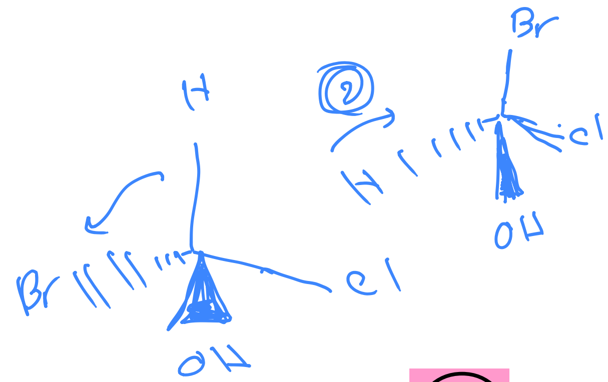
❖ Other examples

- Rotate C–Cl bond such that H is pointed to the back

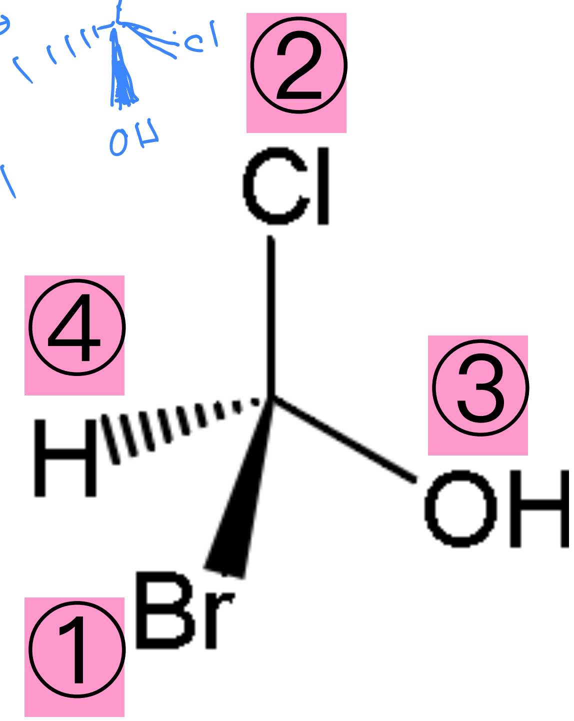
2 → even

R يبقى R





⇒



3 حالات على شكل

continuous على H

H ←

3 حالات

1. (|||||) dash على 4 إذا كان الفرع الي تم ترقيمه

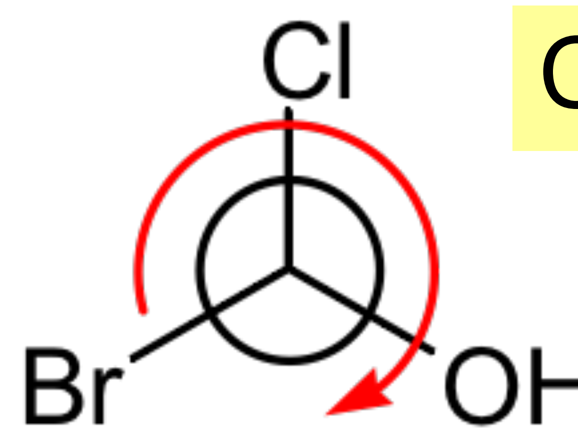
→ S إذا → يضل S

→ R إذا → يضل R

2. (solid) على 4 إذا كان → إذا R بتحول S

→ إذا S بتحول R و

⇒

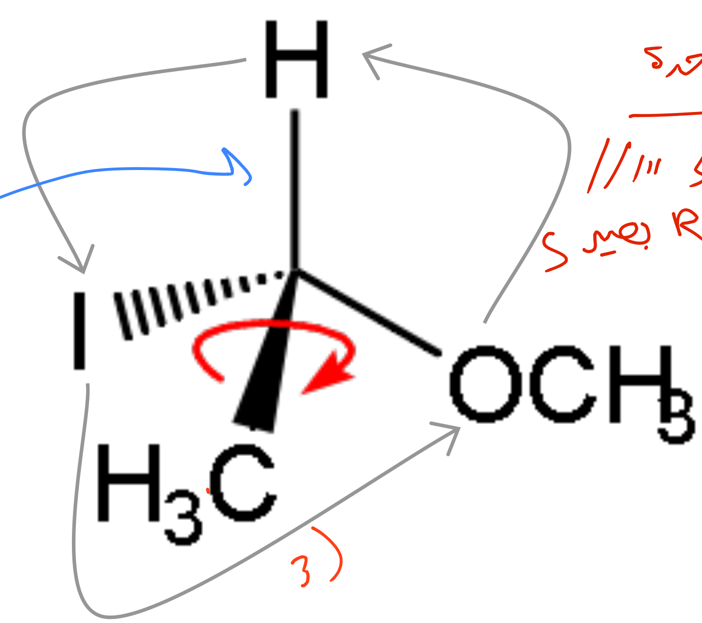


Clockwise

(*R*)

❖ Other examples

- Rotate C–CH_3 bond such that H is pointed to the back

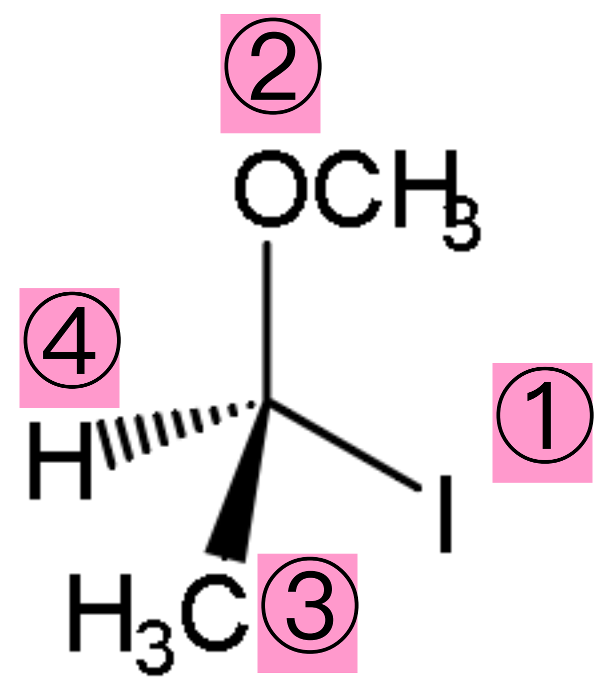


احتجت لدورة واحدة

عشان H يجي على ////

وبالتالي odd ف R يصير S

⇒



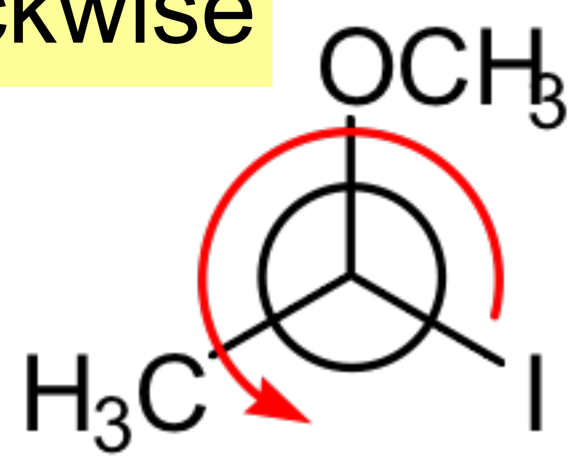
Counter-clockwise

3. (—) continous لو 4 ازا

مثال للتوضيح بالسلايد اللي فوق

- odd
  - R → S
  - S → R
- even
  - R → R
  - S → S

⇒

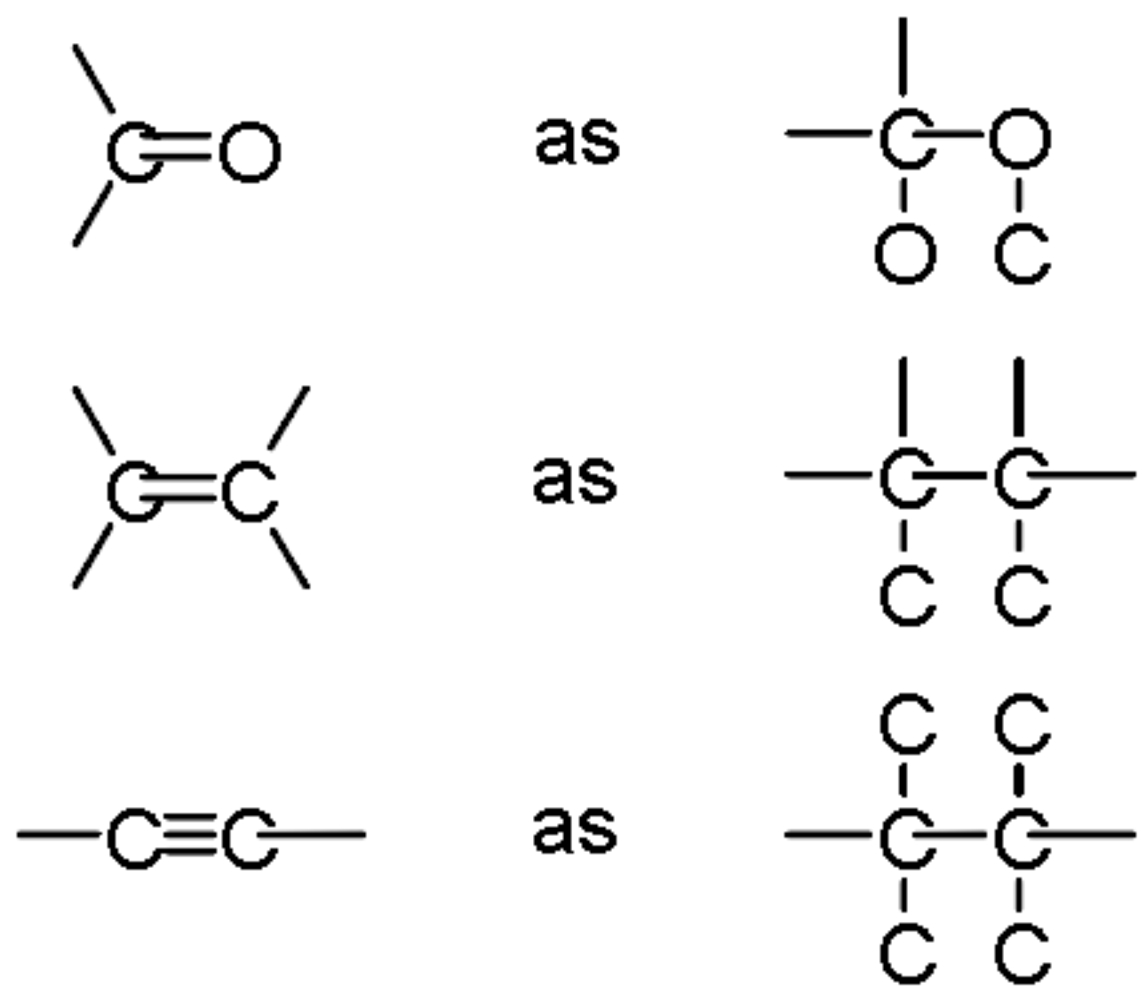


(S)

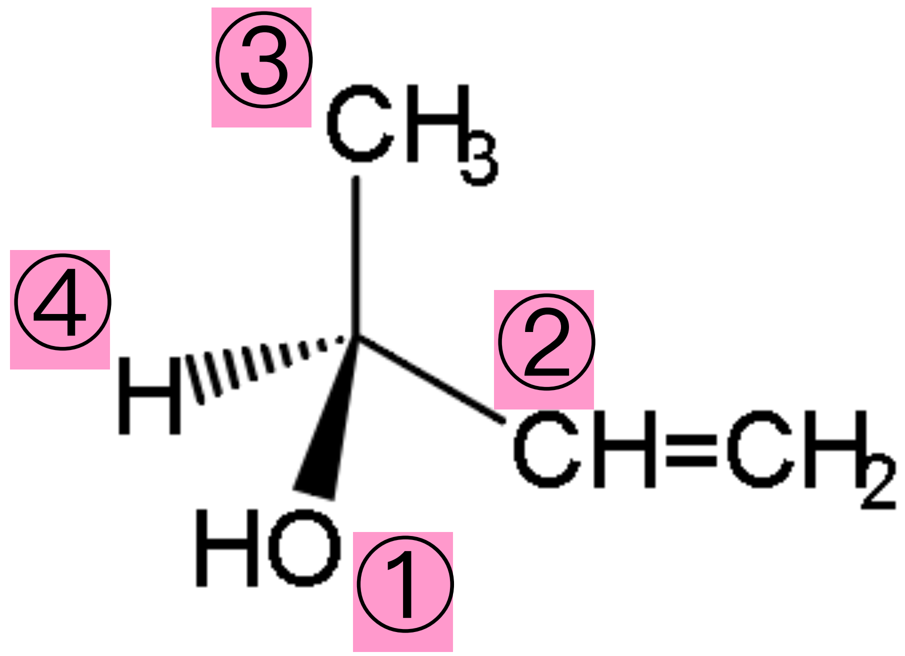
❖ Rule 4

- For groups containing double or triple bonds, assign priorities as if both atoms were duplicated or triplicated

e.g.

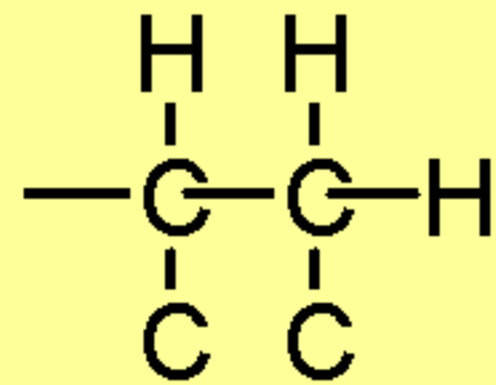


❖ Example



(S)

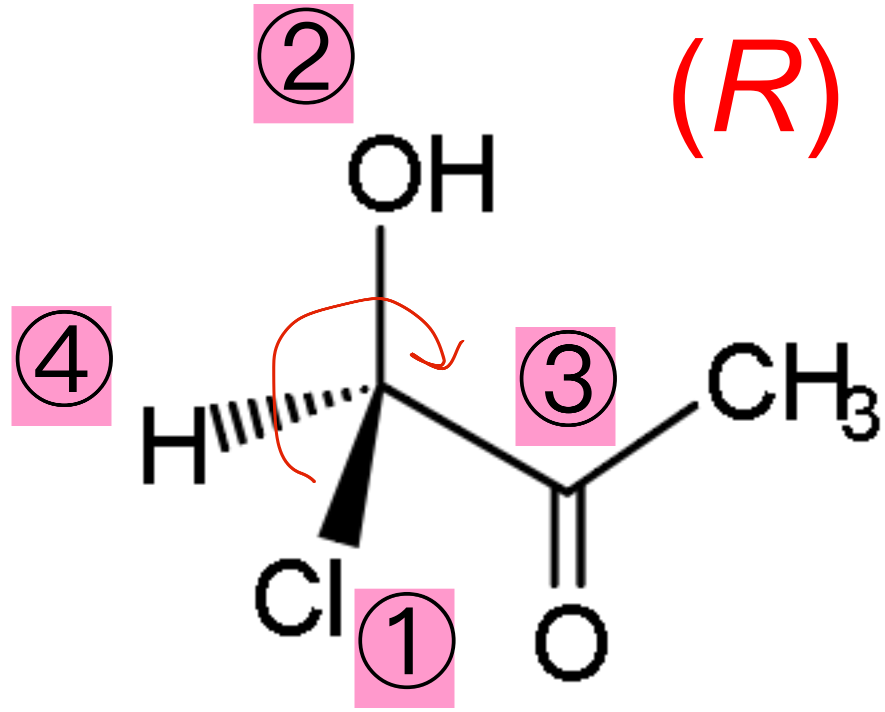
Compare $—CH_3$ & $—CH{=}CH_2$:

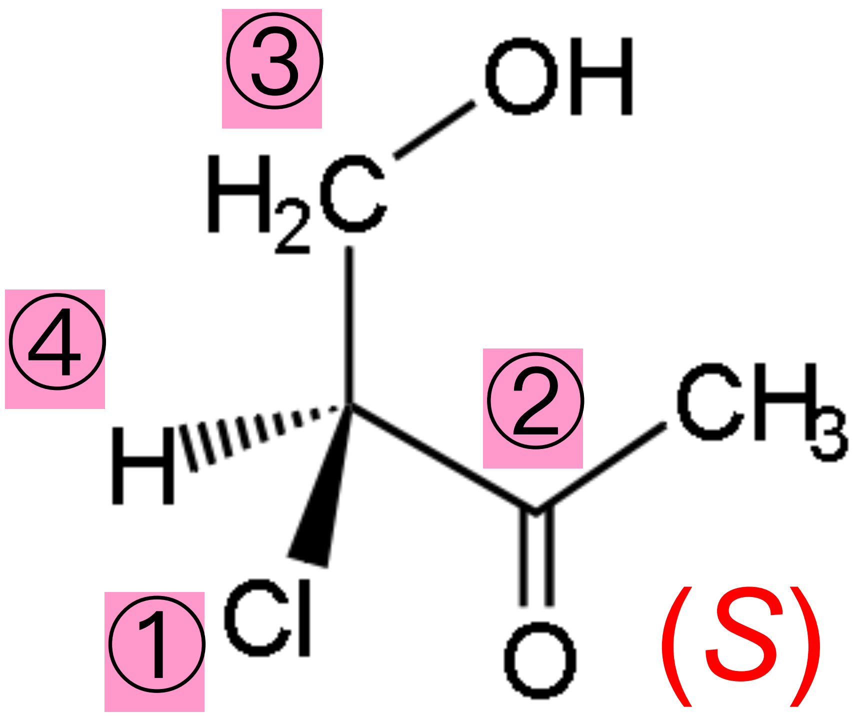
$—CH{=}CH_2$ equivalent to 

Thus, $—CH_3 \Rightarrow (H, H, H)$

$—CH{=}CH_2 \Rightarrow (C, C, H)$

❈ Other examples



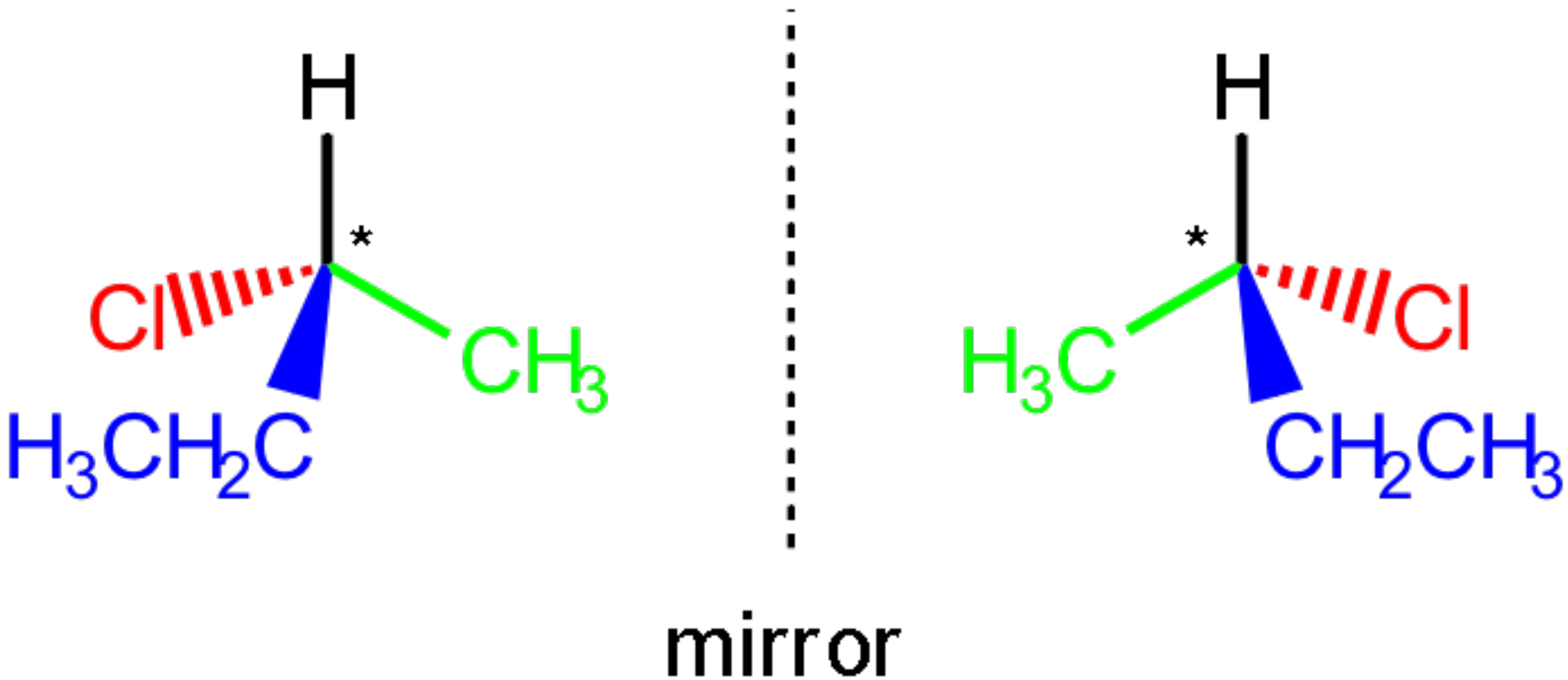


② C $\Rightarrow$ (O, O, C)

③ C $\Rightarrow$ (O, H, H)

7. Properties of Enantiomers: Optical Activity

- Enantiomers
  - Mirror images that are not superposable

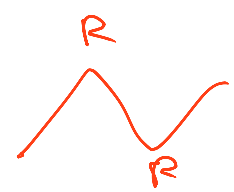


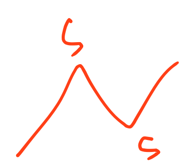
- Enantiomers have identical physical properties (e.g. melting point, boiling point, refractive index, solubility etc.)

معامل الإنكسا

Compound	bp (^{o}C)	mp (^{o}C)
(*R*)-2-Butanol	99.5	
(*S*)-2-Butanol	99.5	
(+)-(*R*,*R*)-Tartaric Acid		168 – 170
(–)-(*S*,*S*)-Tartaric Acid		168 – 170
(+/–)-Tartaric Acid		210 – 212

enantiomer
كل R لازم يصير
S وكل S لازم يصير R



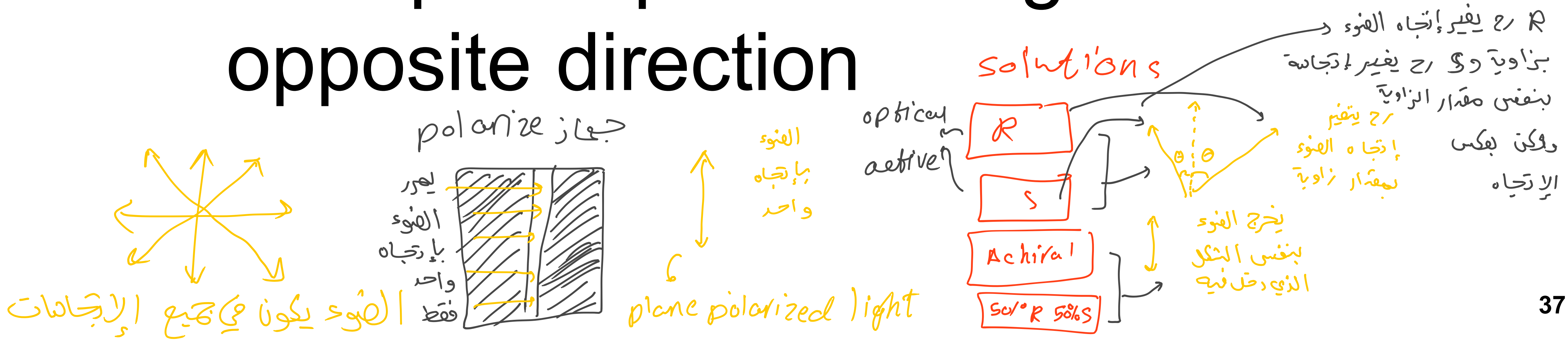


enantiomers

لا يعتبر enantiomers مع
بالتالي تختلف في bp و mp

تختلف R و S بال reactivity
لما chiral يتفاعل مع cheiral

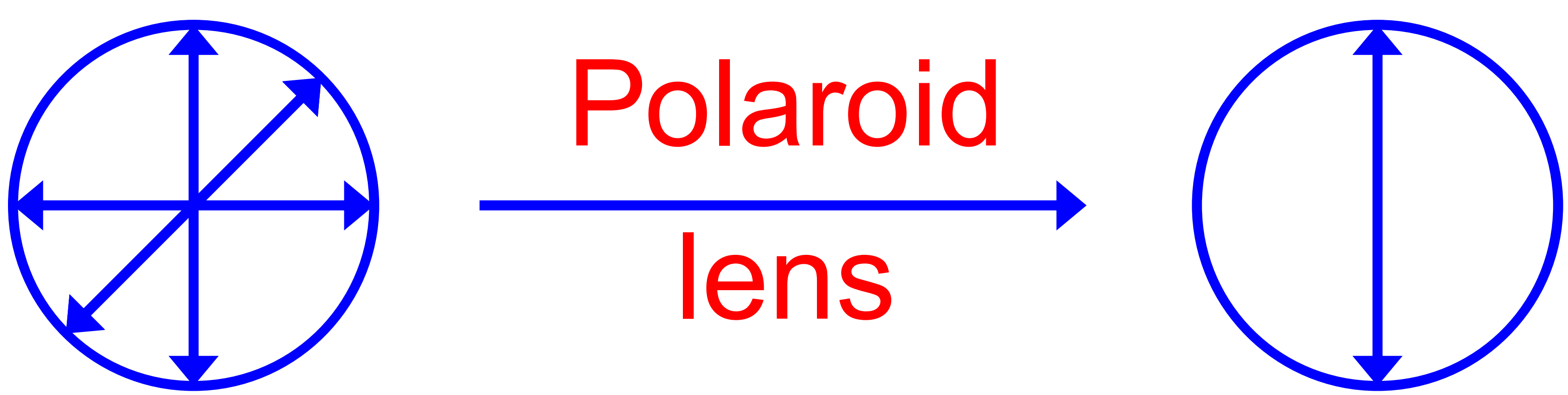
- ❖ Enantiomers
  - Have the same chemical properties (except reaction/interactions with chiral substances)
  - Show different behavior only when they interact with other chiral substances
  - Turn plane-polarized light on opposite direction



- Optical activity
  - The property possessed by chiral substances of rotating the plane of polarization of plane-polarized light

7A. Plane-Polarized Light

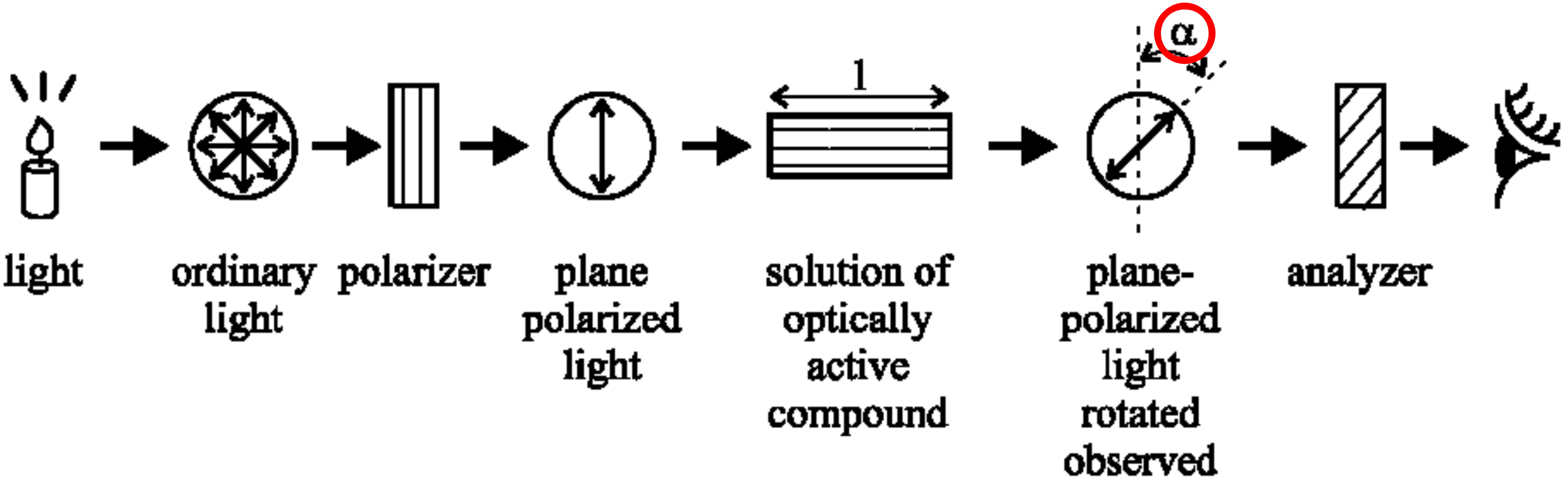
- The electric field (like the magnetic field) of light is oscillating in all possible planes
متذبذب
- When this light passes through a polarizer (Polaroid lens), we get plane-polarized light (oscillating in only one plane)



7B. The Polarimeter

- A device for measuring the optical activity of a chiral compound

α = observed optical rotation



7C. Specific Rotation

$$[\alpha]_D^{25} = \frac{\alpha}{c \times \ell}$$

temperature

observed rotation

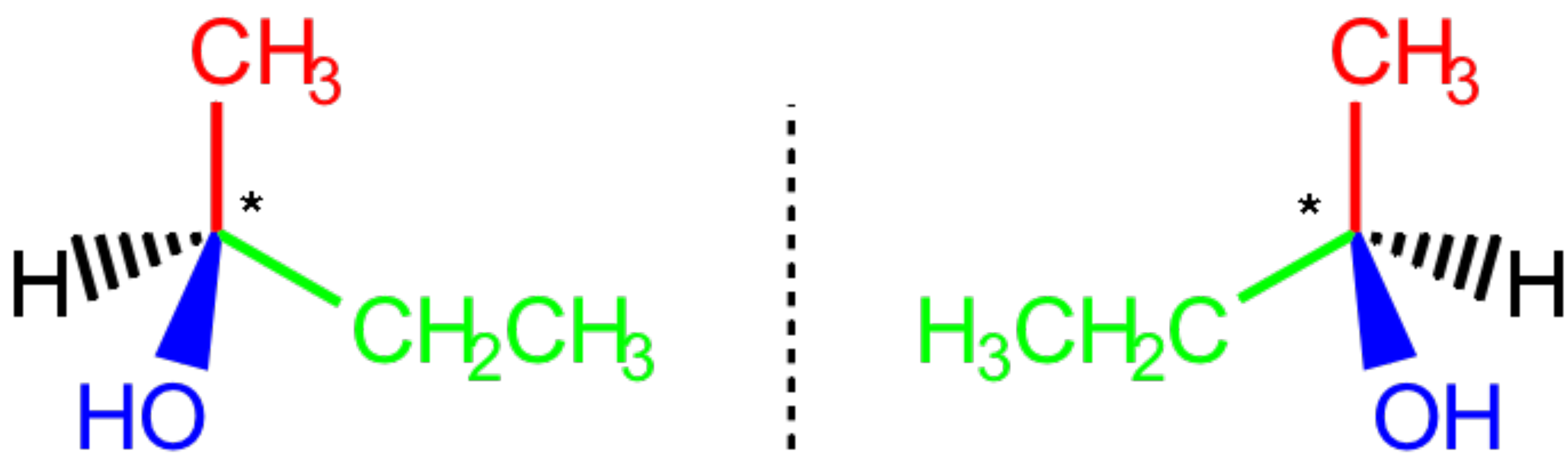
wavelength of light (e.g. D-line of Na lamp, λ=589.6 nm)

concentration of sample solution in g/mL

length of cell in dm (1 dm = 10 cm)

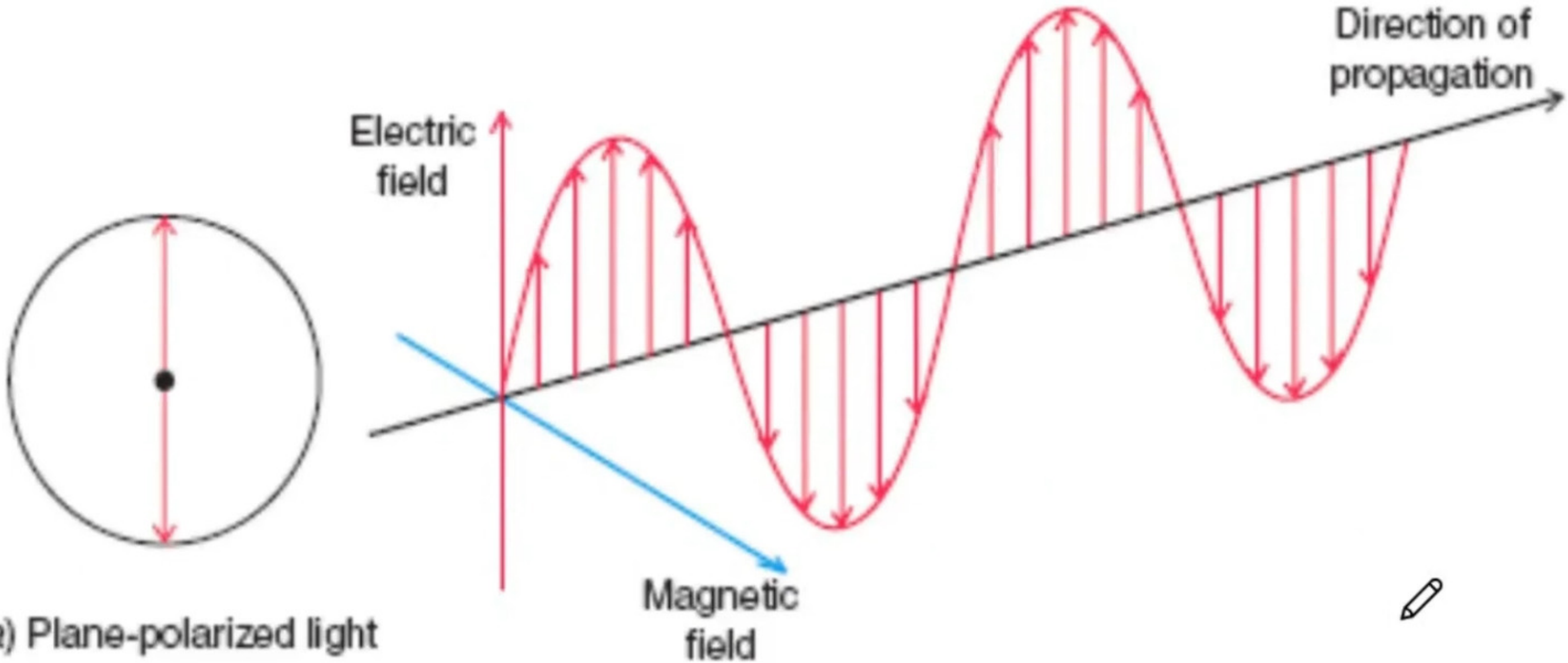
- The value of α depends on the particular experiment (since there are different concentrations with each run)
  - But specific rotation $[\alpha]$ should be the same regardless of the concentration

- Two enantiomers should have the same value of specific rotation, but the signs are opposite



$[\alpha]_D^{25} = +\ 13.5^{o}$ mirror $[\alpha]_D^{25} = -\ 13.5^{o}$

8. The Origin of Optical Activity



(*a*) Plane-polarized light

ملاحظة اضافية

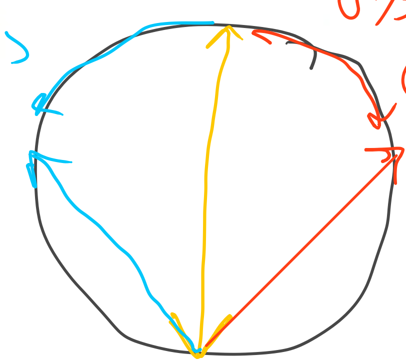
الحركة للضوء بسبب وجود chiral compound

دوران لليسار

levo (L)

(−)

ممكن R او S



دوران لليمين

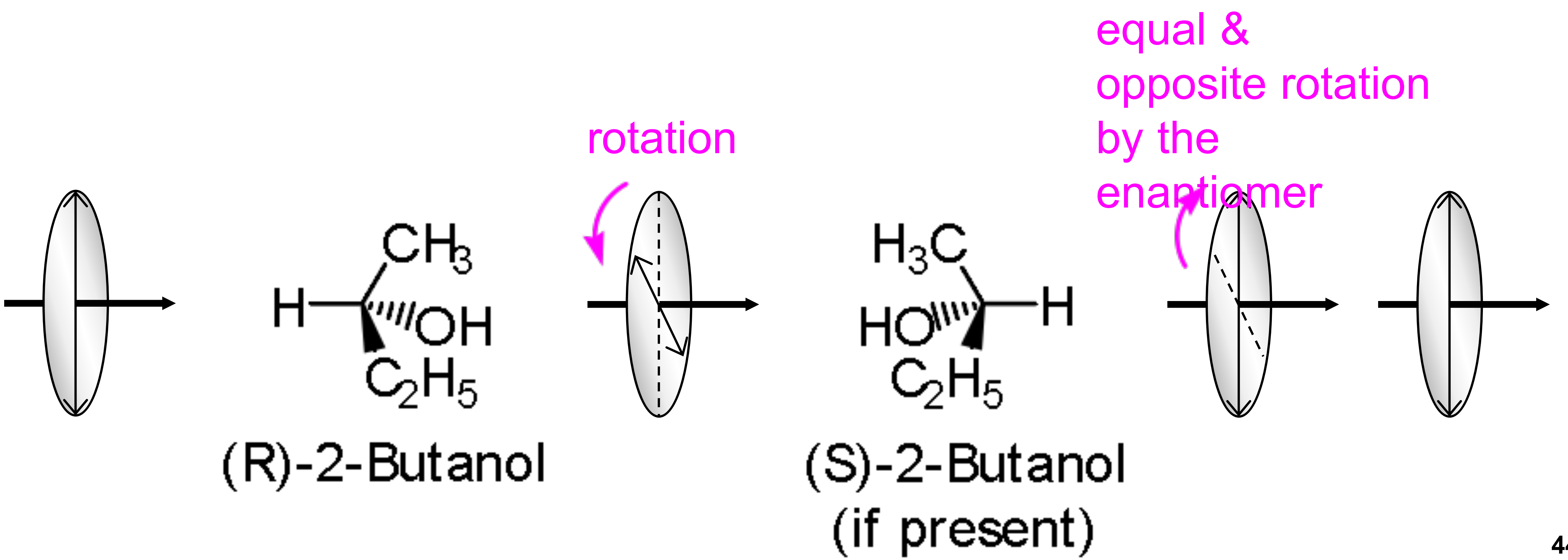
(d) dextro

+

ممكن R او S

8A. Racemic Forms

- An equimolar mixture of two enantiomers is called a racemic mixture (or *racemate* or *racemic form*)
- A racemic mixture causes no net rotation of plane-polarized light



8B. Racemic Forms and Enantiomeric Excess

- A sample of an optically active substance that consists of a single enantiomer is said to be **enantiomerically pure** or to have an **enantiomeric excess** of 100%

- An enantiomerically pure sample of (*S*)-(+)-2-butanol shows a specific rotation of +13.52

لو بدأت بـ (+) وضفت
(-) رح تقل α وما رح
توصل للصفر لو بدأت (-)
و ضفت موجب رح تزيد α
لحد ما توصل للصفر (R=S)

$$[\alpha]_D^{25} = +13.52$$

- A sample of (S)-(+)-2-butanol that contains less than an متساوي equimolar amount of (*R*)-(–)-2-butanol will show a specific rotation that is less than 13.52 but greater than zero
- Such a sample is said to have an *enantiomeric excess* less than 100%

❖ Enantiomeric excess (ee)

- Also known as the optical purity

$$\%\ \text{enantiomeric excess} = \frac{\begin{pmatrix}\text{mole of one}\\ \text{enantiomer}\end{pmatrix} - \begin{pmatrix}\text{moles of other}\\ \text{enantiomer}\end{pmatrix}}{\text{total moles of both enantiomers}} \times 100$$

- Can be calculated from optical rotations

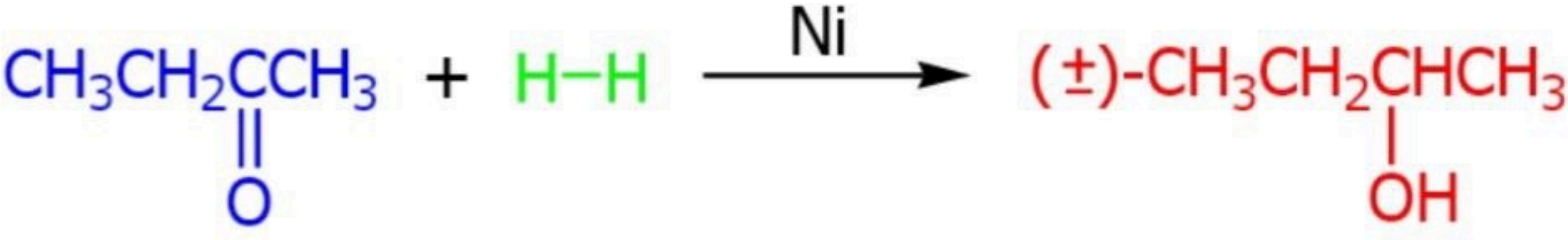
$$\%\ \text{enantiomeric excess}^{*} = \frac{\text{observed specific rotation}}{\text{specific rotation of the pure enantiomers}} \times 100$$

- Example
  - A mixture of the 2-butanol enantiomers showed a specific rotation of +6.76. The enantiomeric excess of the (S)-(+)-2-butanol is 50%

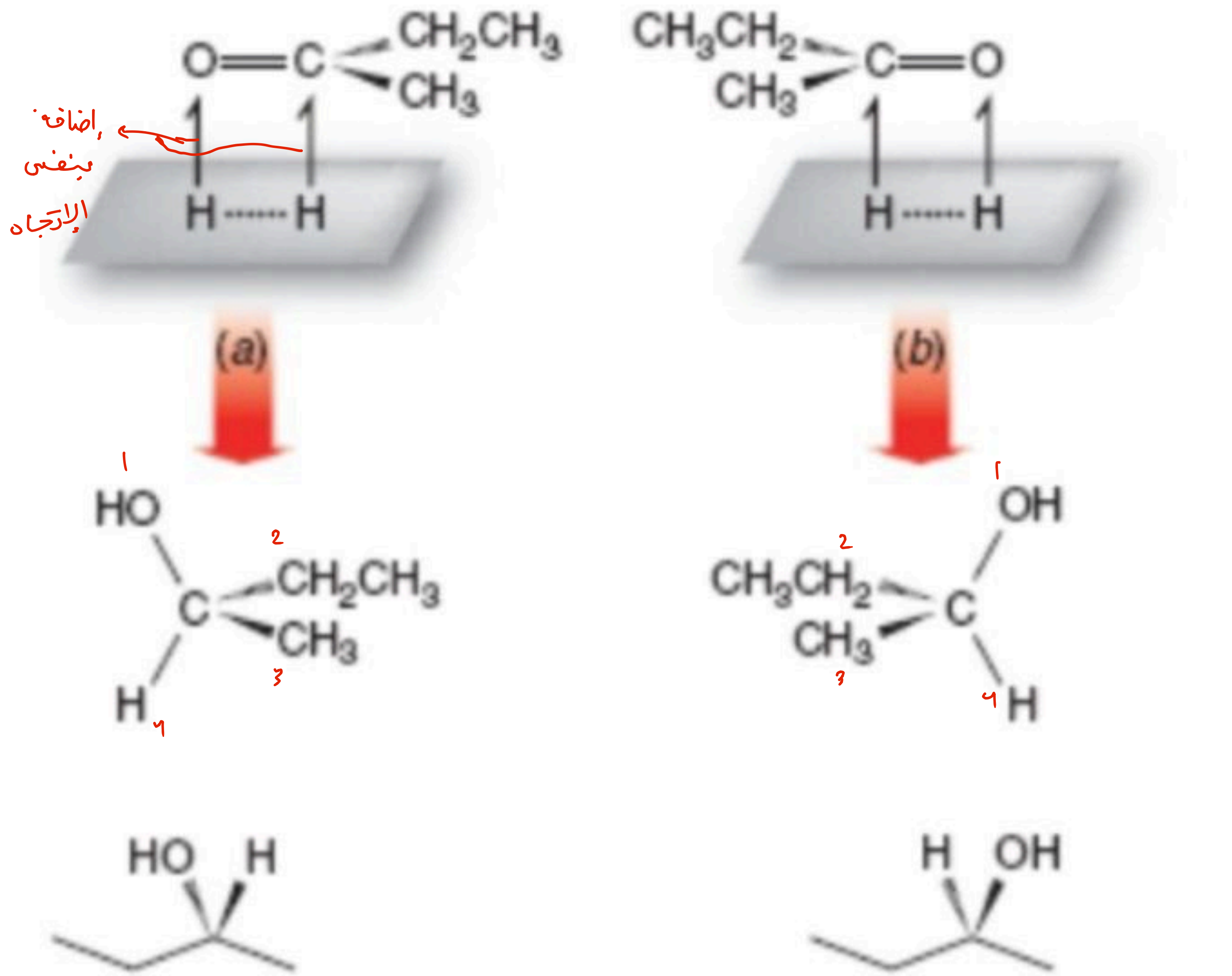
$$\text{\% enantiomeric excess *} = \frac{+6.76}{+13.52} \times 100 = 50\%$$

9. The Synthesis of Chiral Molecules

9A. Racemic Forms



Butanone (achiral molecules)	Hydrogen (achiral molecules)	(±)-2-Butanol (chiral molecules; but 50:50 mixture (*R*) & (*S*))



(R)-(−)-(2)-Butanol (50%)

(S)-(+)-(2)-Butanol (50%)

9B. Stereoselective Syntheses

- **Stereoselective reactions** are reactions that lead to a preferential formation of one stereoisomer over other stereoisomers that could possibly be formed

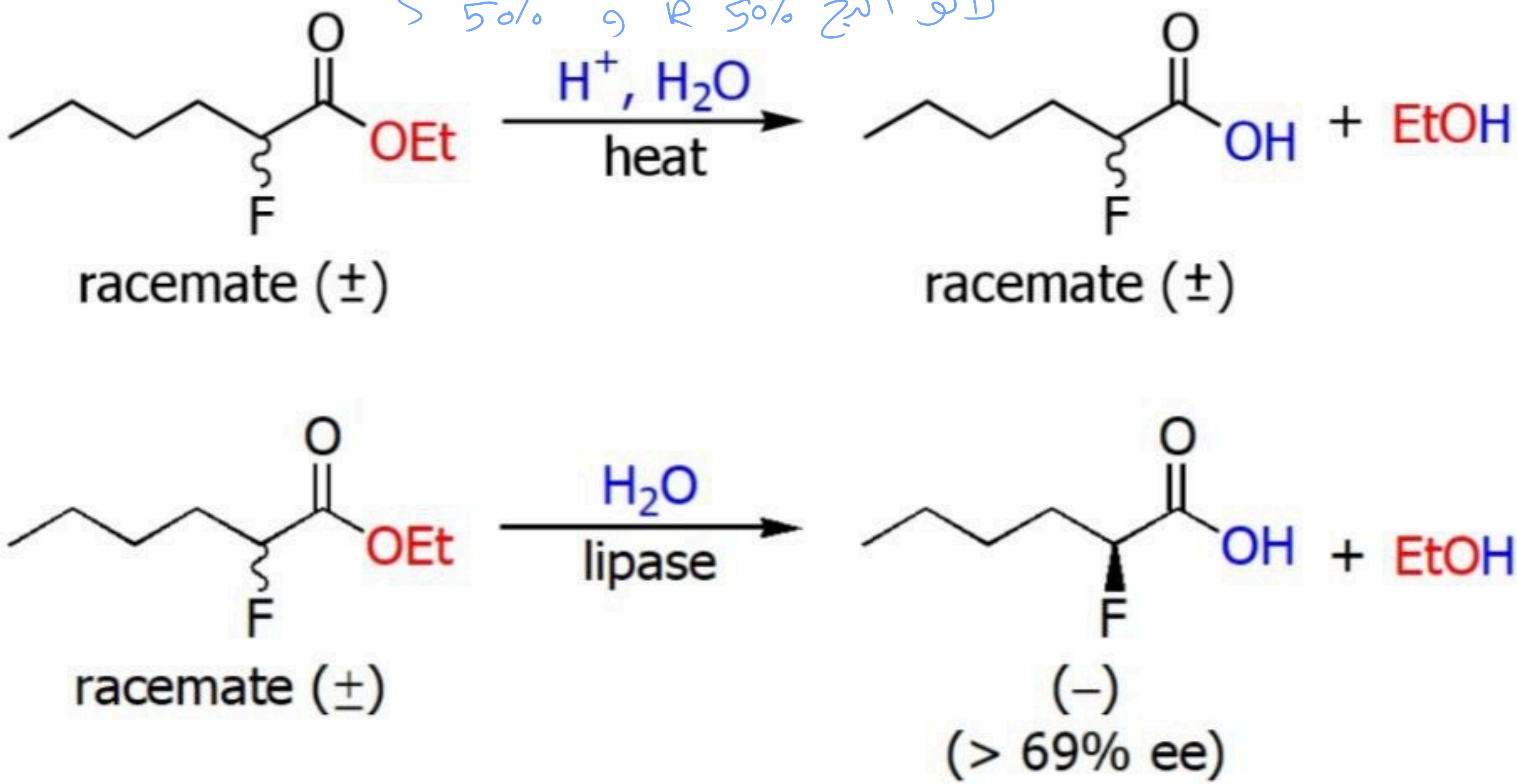
  تفضيلي تكوين

  لازم التفاعل يعطي ناتجين كمية واحد منهم اكبر من الثانية والعلاقة بينهم stereoisomers

  - **enantioselective** – if a reaction produces preferentially one enantiomer over its mirror image
  - **diastereoselective** – if a reaction leads preferentially to one diastereomer over others that are possible

لا يعد stereoselective reaction

لانو انتج 50% R و 50% S



10. Molecules with More than One Chirality Center

❖ Diastereomers

- Stereoisomers that are not enantiomers
- Unlike enantiomers, diastereomers usually have substantially different chemical and physical properties

إلى حد كبير

إذا كان في مركب عنده اكثر من one carbon chilar

سواء كان chailar كلهم R او كلهم S او وحدة R ووحدة S

R , R
S , S
R , S
S , R

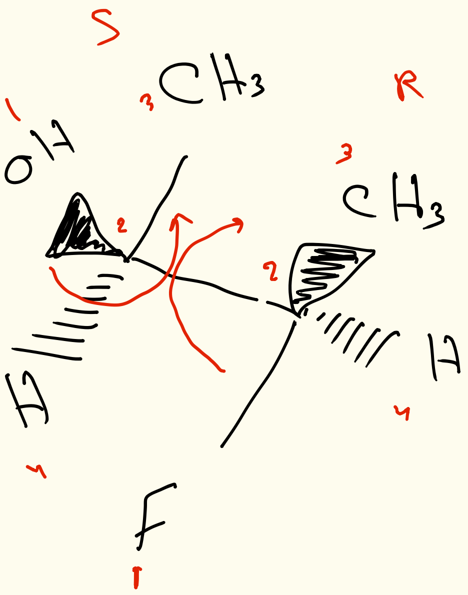
عشان يكونوا enantiomers في لازم كل R تصير S وكل S تصير R

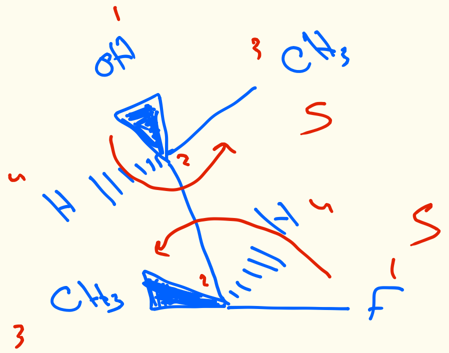
R , R → S , S
R , R
S , R
R , S → S R , S

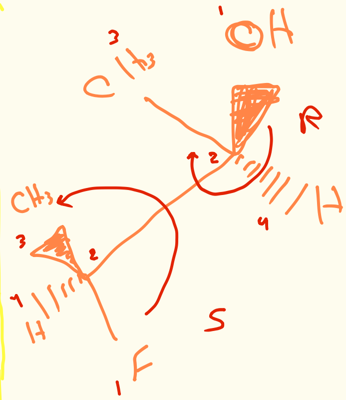
لو انعكس فقط واحد من والثاني chairal ضل زي ما هو حيعطيني diastereomers

R , S → S , R
R , R
S , S

مثال للتوضيح







(2s,3R)-3-Floro-2-butanol

(2R,3s)-3-floro-2-butanol

the relation is diasteromer

(لإنو هو كل chiral انعكست)

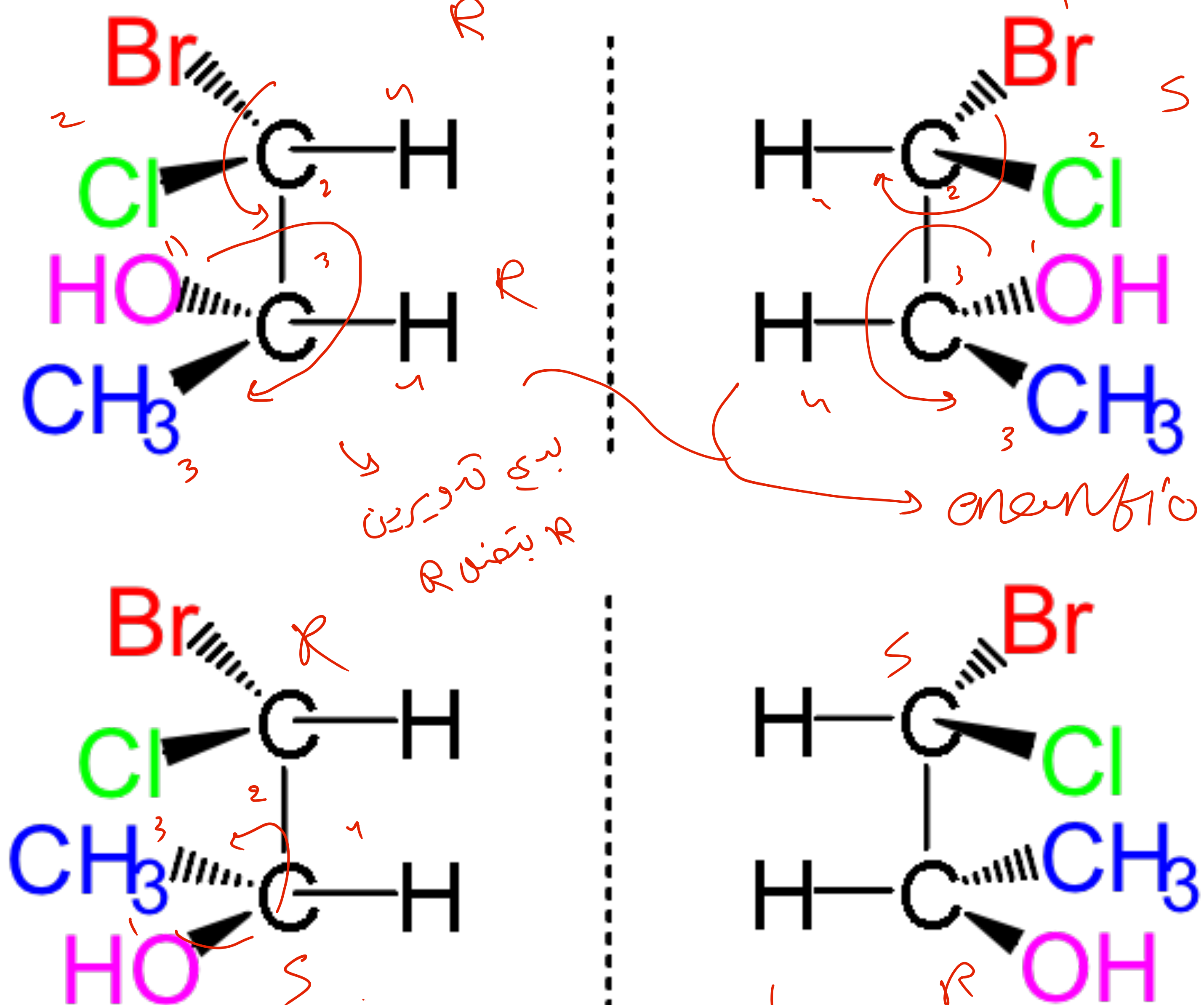
enantiomers

S صار R

R صار s

(I) (II)

(III) (IV)



بدي تدوير واحد عشان H تصير على dash (////) لـ S بتتحول إلى R

بدي تدويرين R بتضل R

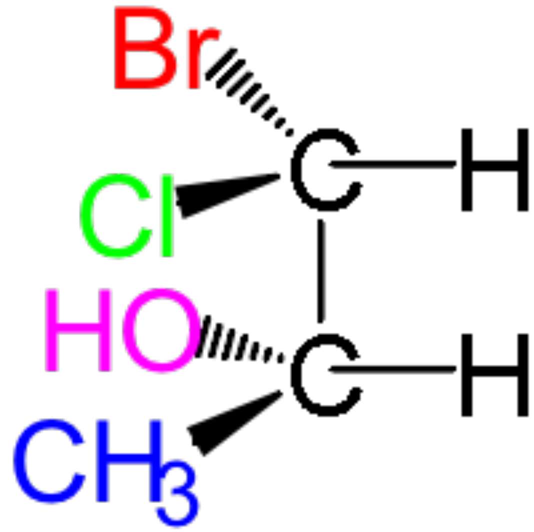
enantiomers

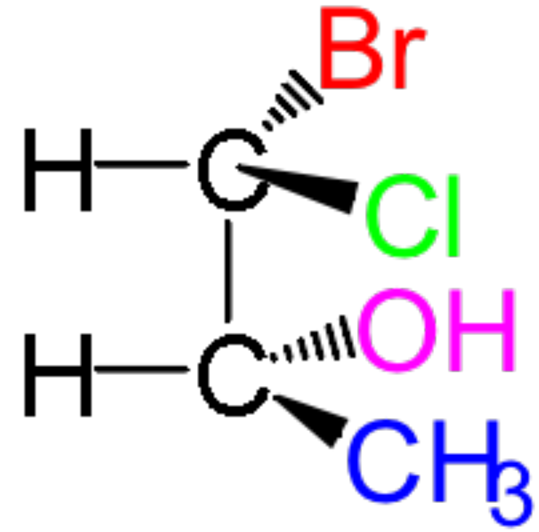
enantiomers

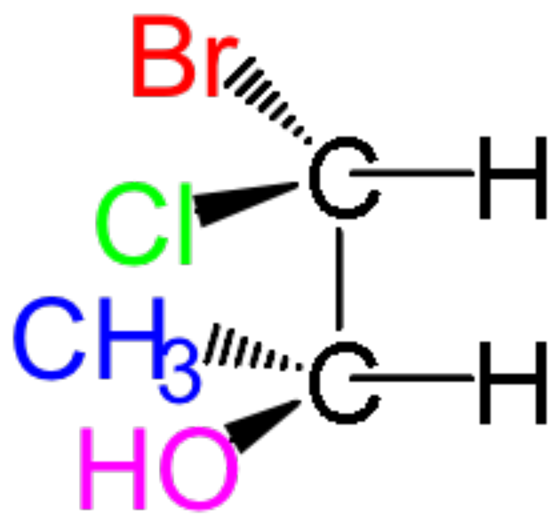
Note: In compounds with *n* tetrahedral stereocenters, the maximum number of stereoisomers is 2^n.

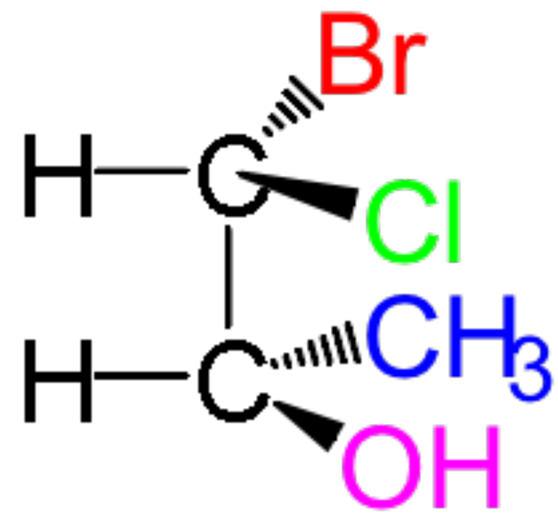
المركب 2 chiral centers عند فحسب القانون

4 stereoisomers حيكون عند ← $4 = 2^2 = 2^{(\text{عدد chiral center})}$

(I) 

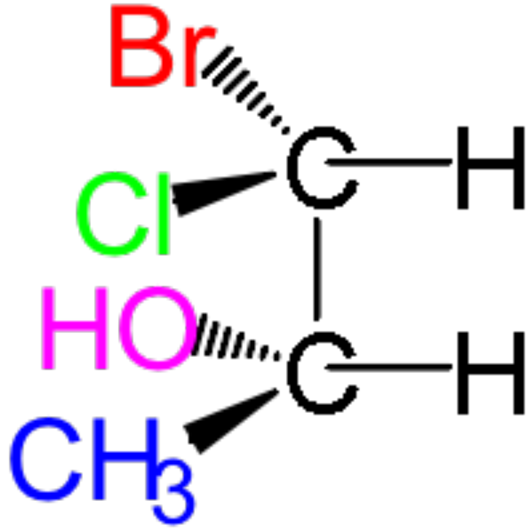
 (II)

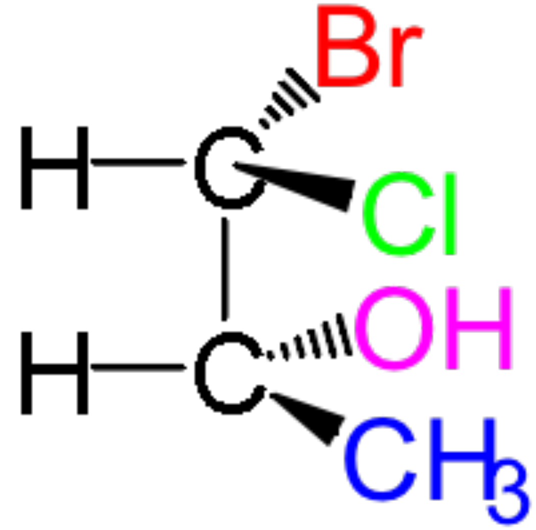
(III) 

 (IV)

- (I) & (II) are enantiomers to each other
- (III) & (IV) are enantiomers to each other

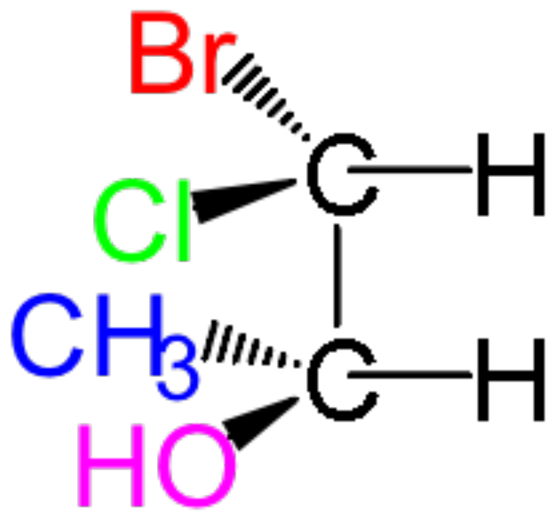
(I)

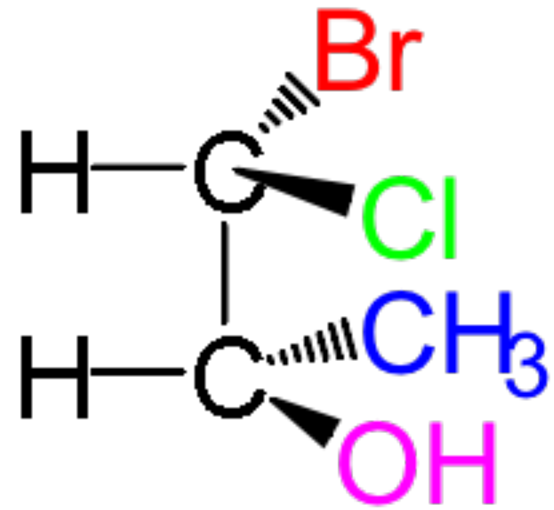




(II)

(III)





(IV)

- Diastereomers to each other:
  - (I) & (III), (I) & (IV), (II) & (III), (II) & (IV)

10A. Meso Compounds

- Compounds with two stereocenters do not always have four stereoisomers ($2^2 = 4$) since some molecules are achiral (not chiral), even though they contain stereocenters
- For example, 2,3-dichlorobutane has two stereocenters, but only has 3 stereoisomers (not 4)

شروط ال meso compound

1- فيه 2 charial center على الأقل

2- chiral center اي فيه مرتبطين بنفس التفرعات

3- لازم وحدة من chiral center تكون (S) والثانية (R)

التميز في meso compound

- على الرغم بإنو يحتوي 2 chairal center على الأقل

إلا انو يعتبر Achairal compound و optically unactive

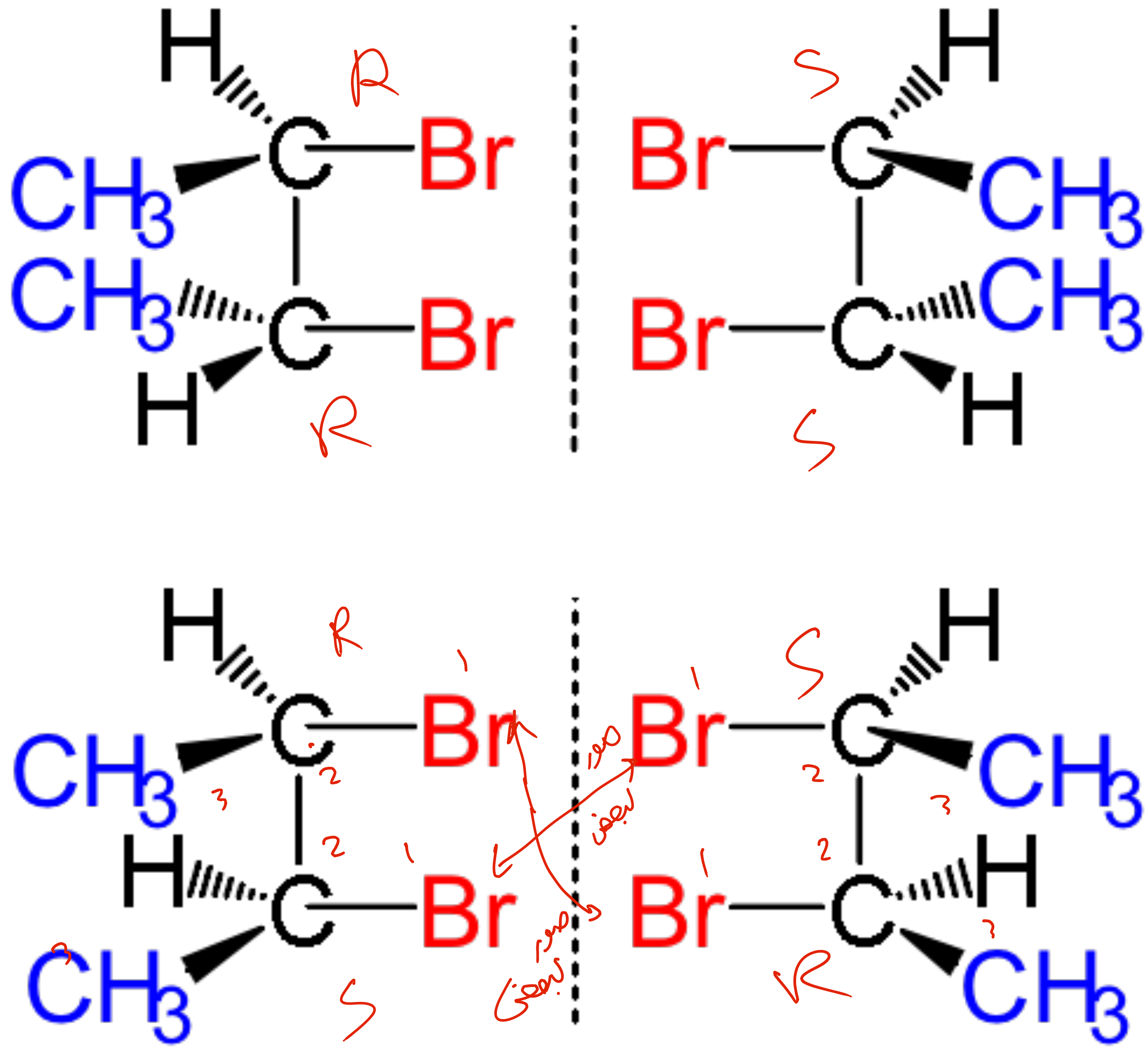
(I)

(II)

meso compound

meso مع S - R
أو
R - S
→ identical
(same)

meso مع (S,S) أو (R,R)
→ diastereomers

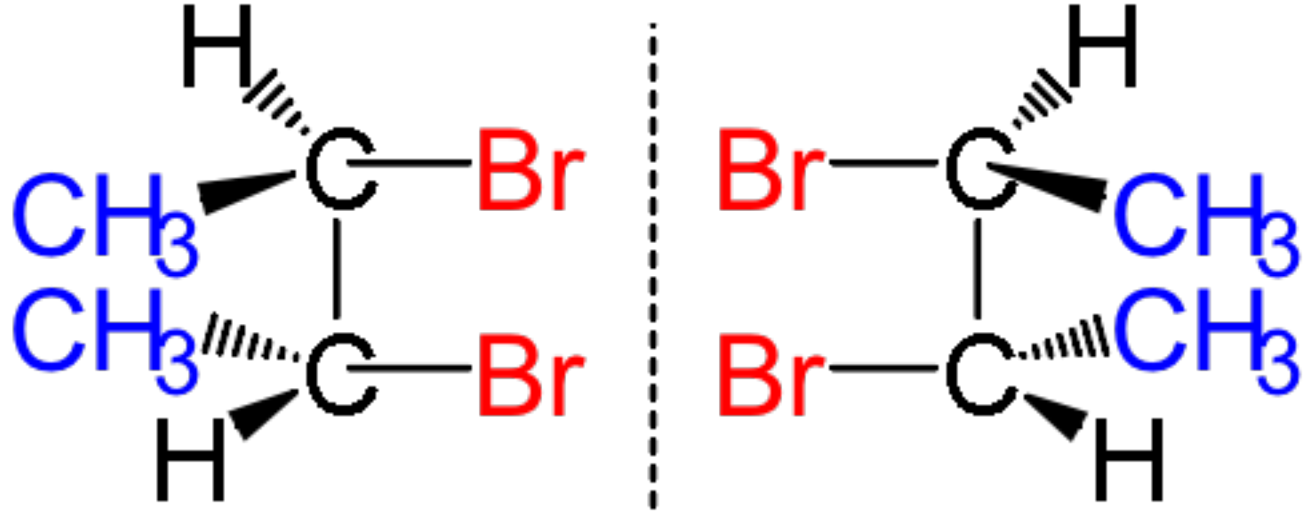


(III)

(IV)

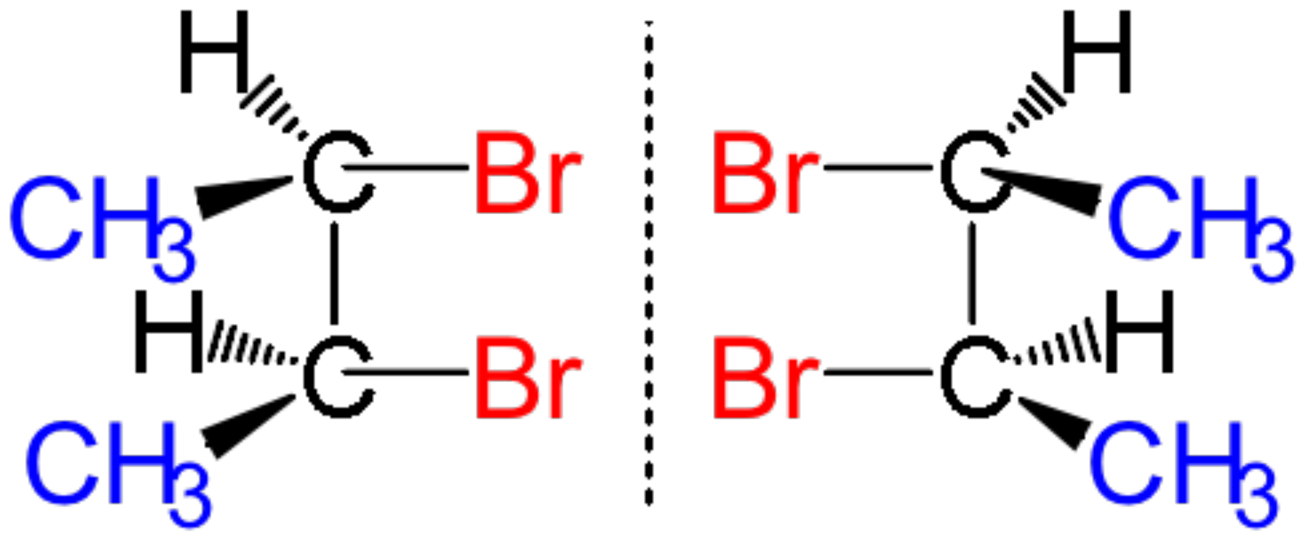
Note: (III) contains a plane of symmetry, is a meso compound, and is achiral ([α] = 0°).

(I)



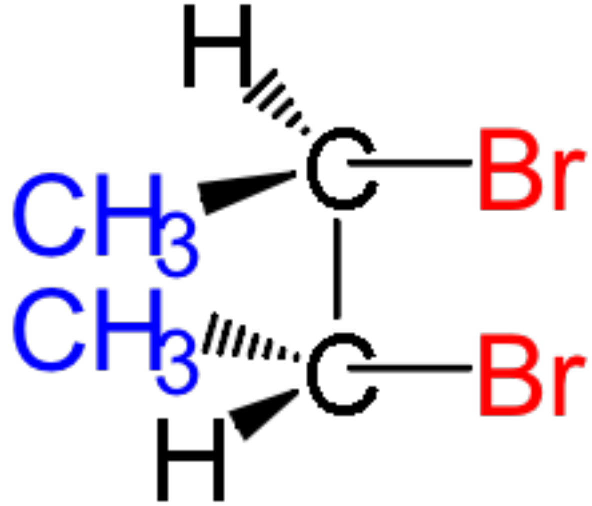
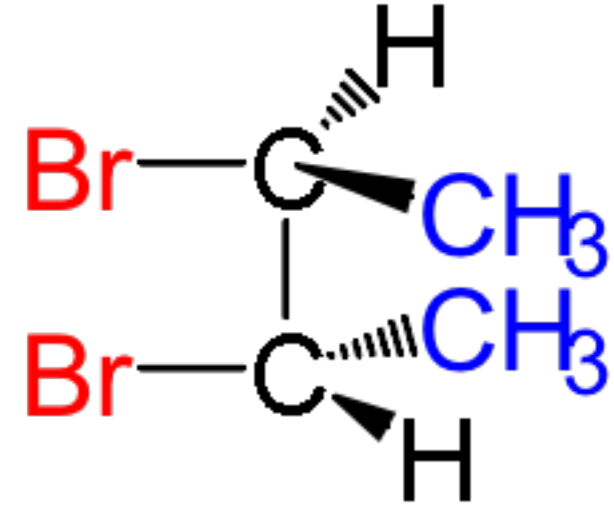
(II)

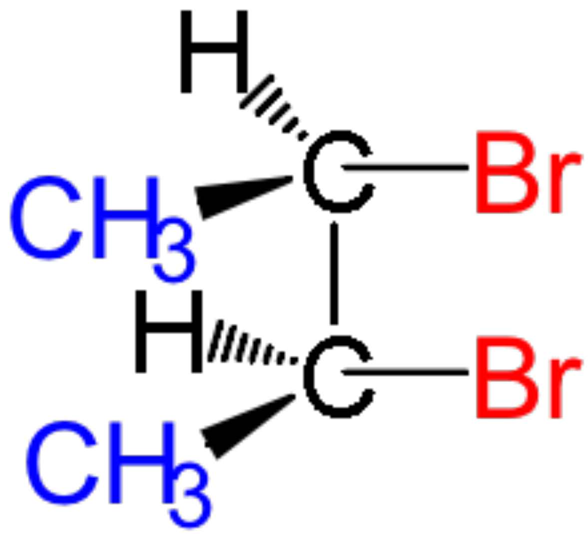
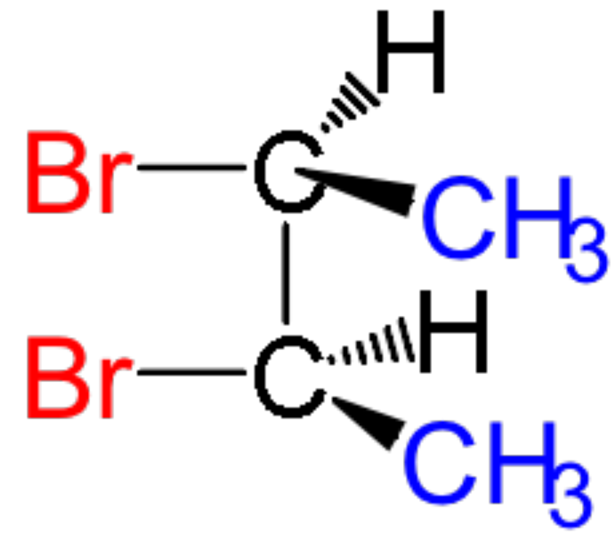
(III)



(IV)

- (I) & (II) are enantiomers to each other and chiral
- (III) & (IV) are identical and achiral

(I)   (II)

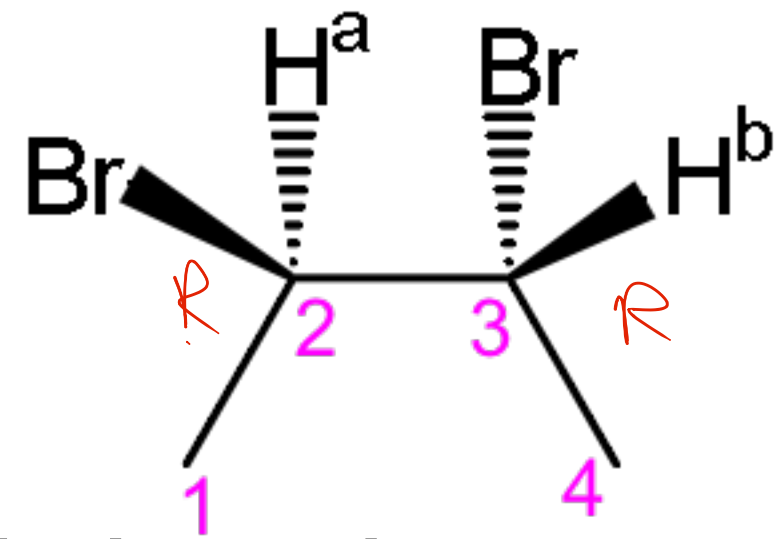
(III)   (IV)

- (I) & (III), (II) & (III) are diastereomers
- Only 3 stereoisomers:
  - (I) & (II) {enantiomers}, (III) {meso}

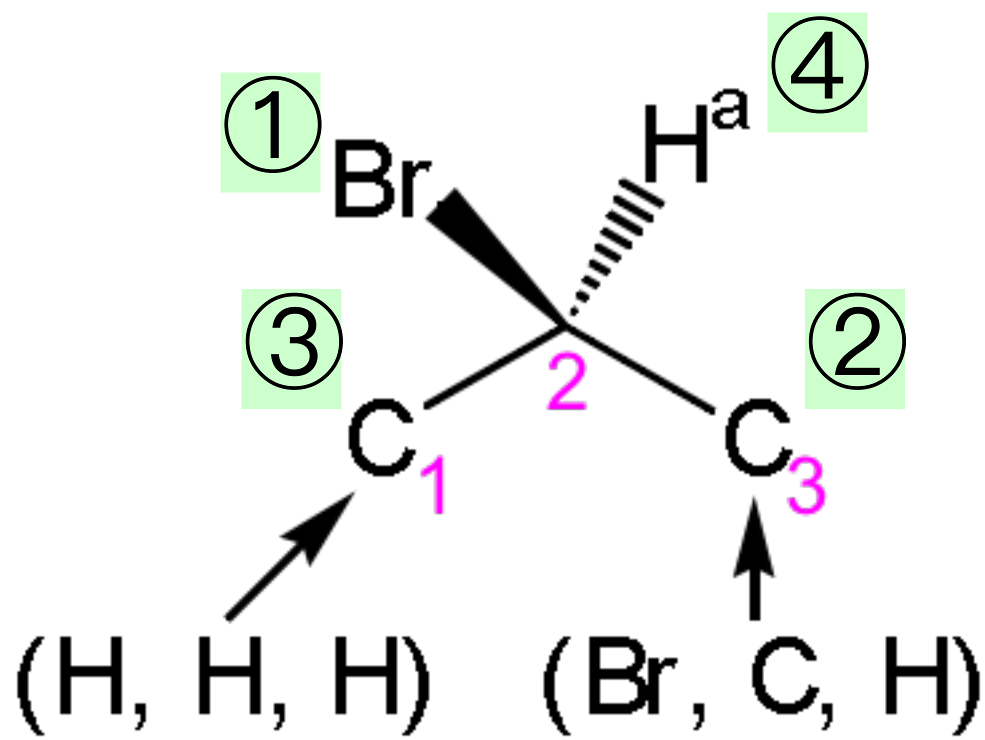
$2^2 - 1 = 4 - 1 = 3$ = stereoisomers ال عدد

10B. How to Name Compounds with More than One Chirality Center

- 2,3-Dibromobutane

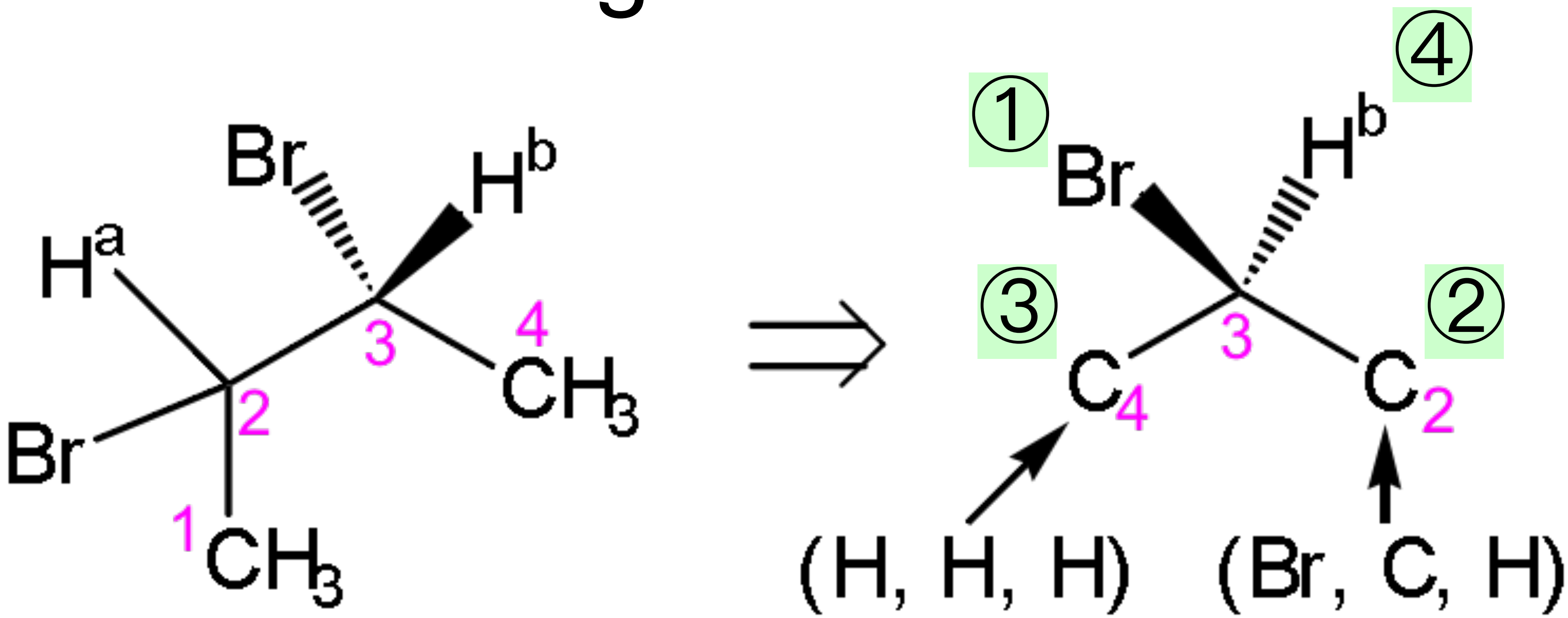


  - Look through C2–Hᵃ bond



C2: (*R*) configuration

- Look through C3–H^b bond



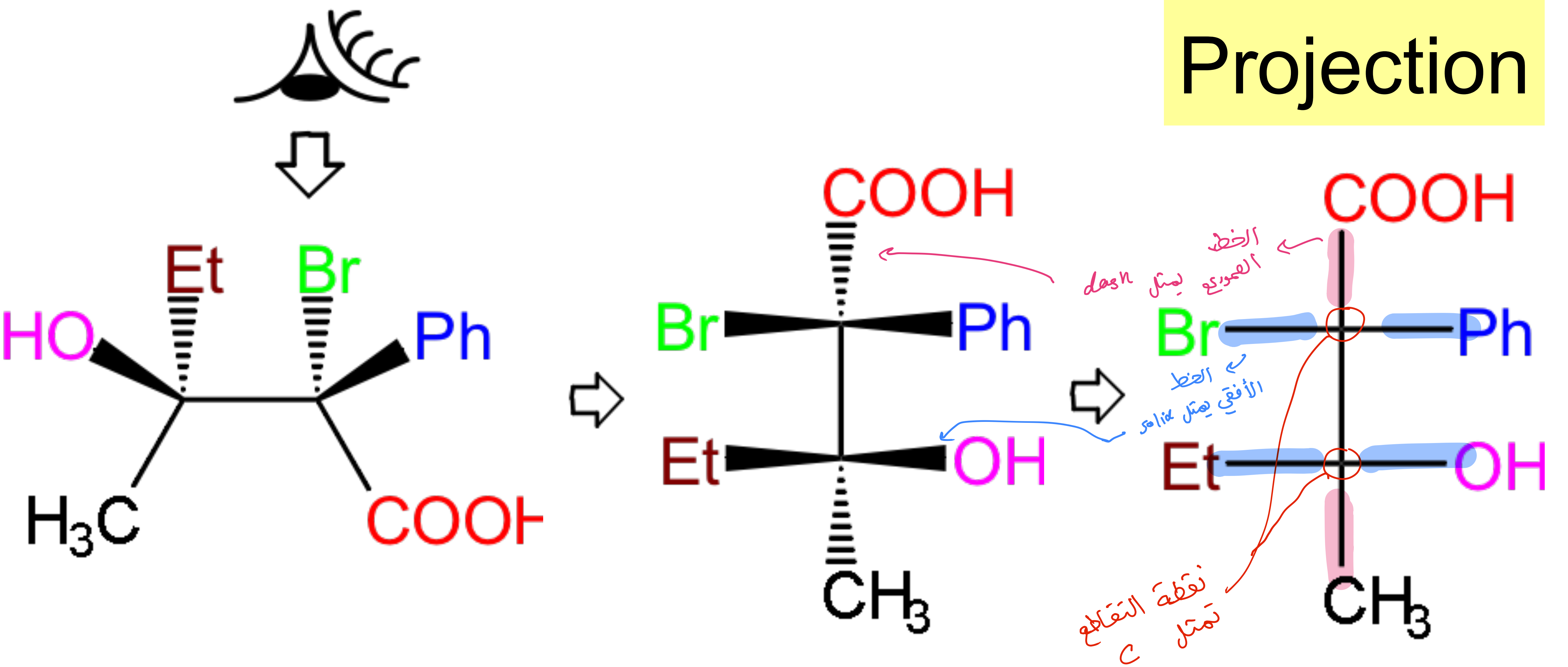
C3: *(R)* configuration

- Full name:
  - *(2R, 3R)*-2,3-Dibromobutane

11. Fischer Projection Formulas

11A. How To Draw and Use Fischer Projections

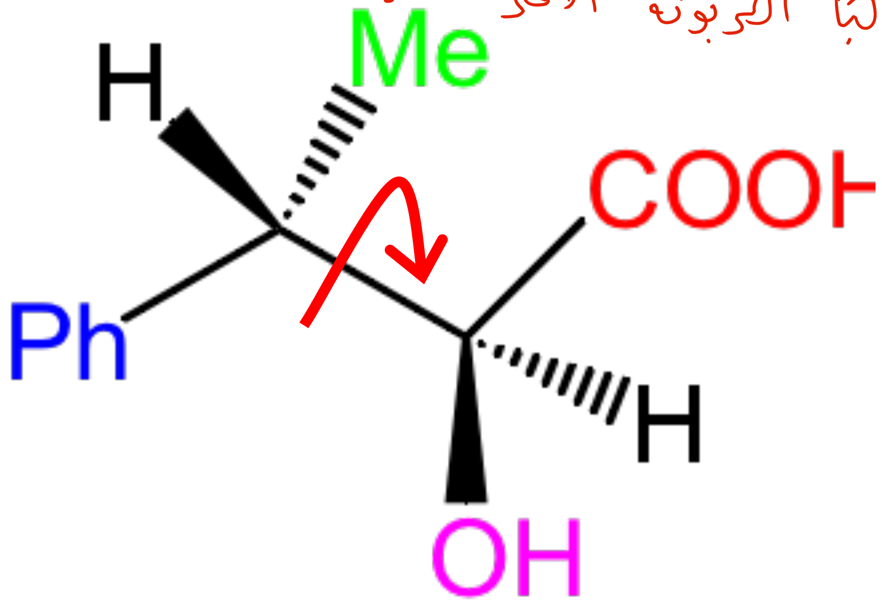
Fischer Projection

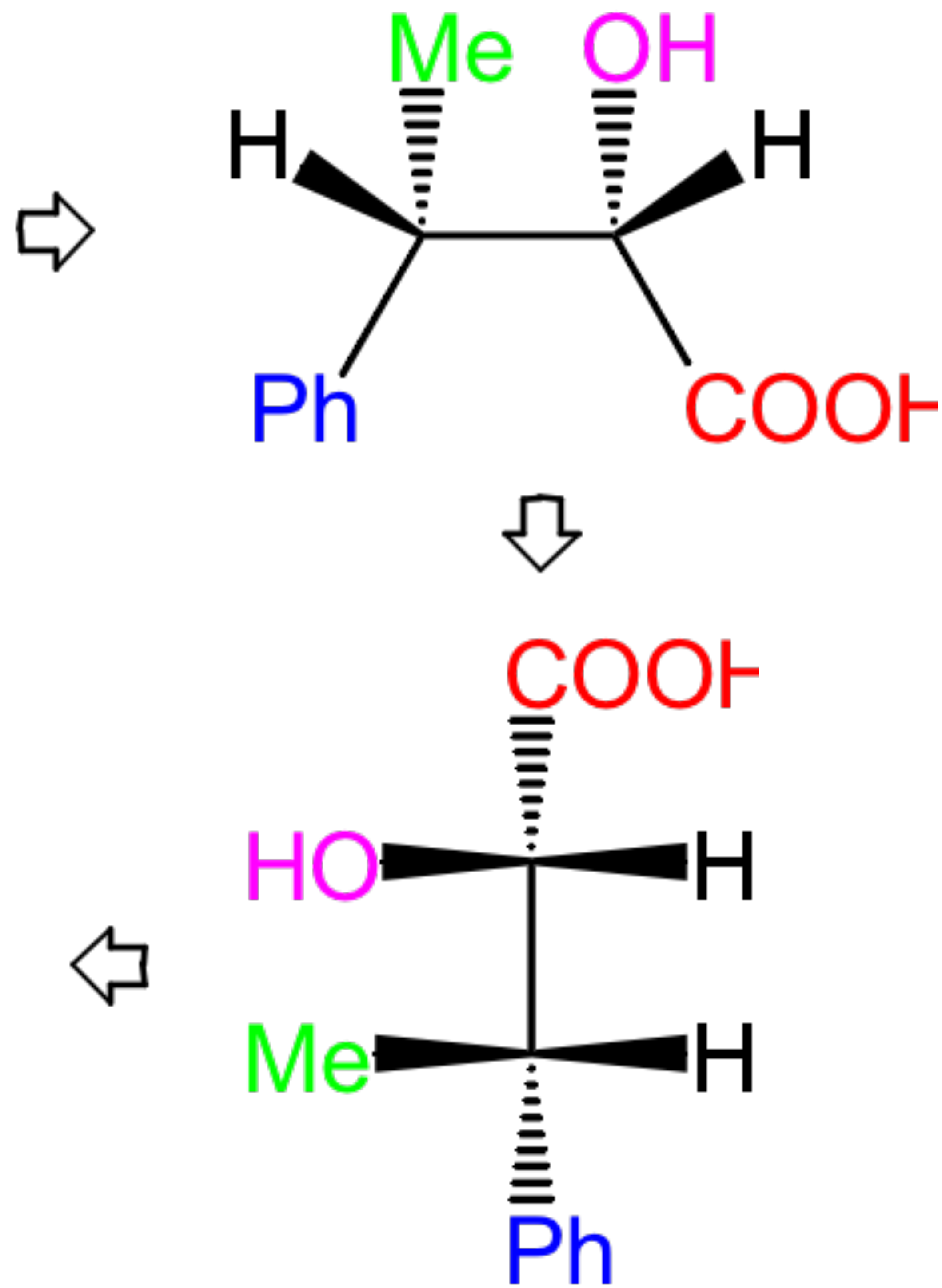


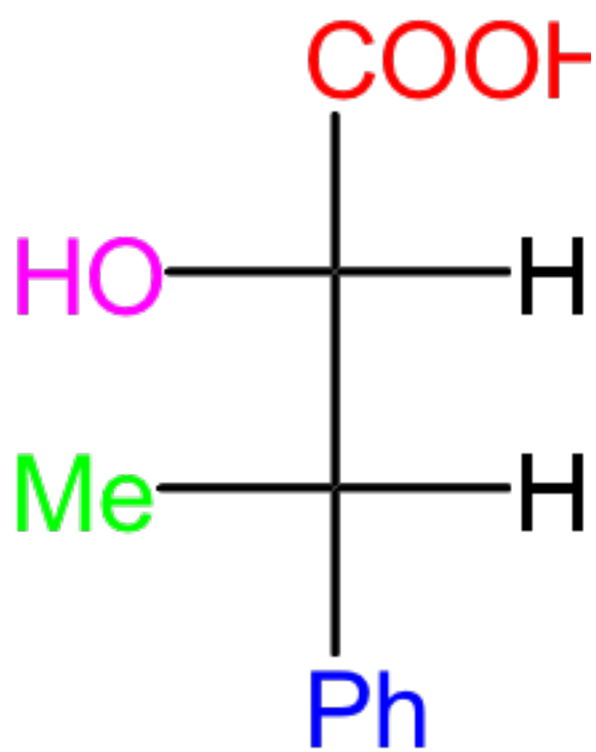
عشان ارسم Fischer projection بحدد R أو S في المركب المطلوب

برسم الخطوط الأفقية والعمودية عند كل تقاطع (كربون) برسم الذرات المرتبطة فيه وغالبًا الكربونة الأعلى أولوية بيكون عند الخط الرأسي (فوق)

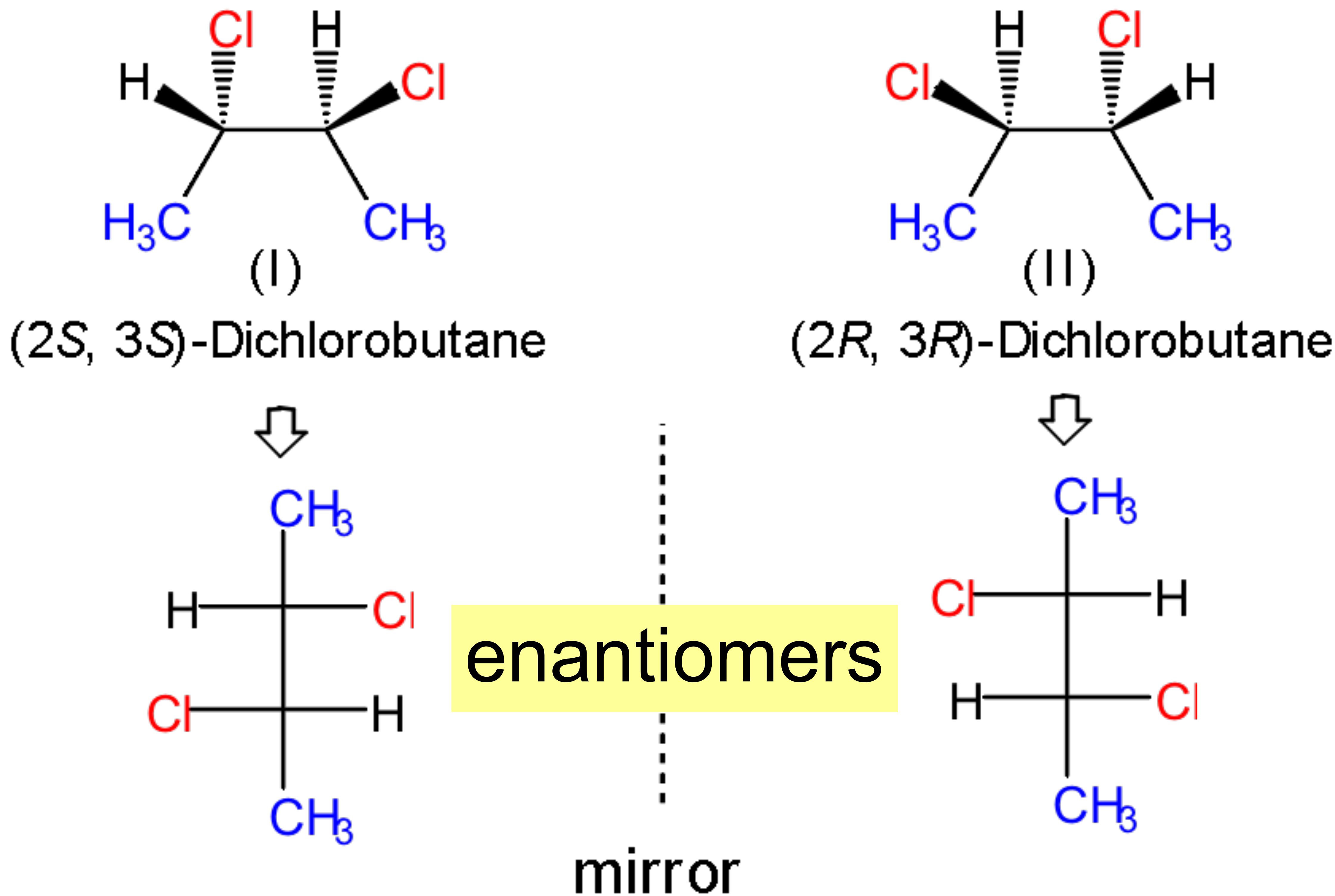
وبعدين بزبط الترتيب عشان يزبط S و R مع المركب الأصلي



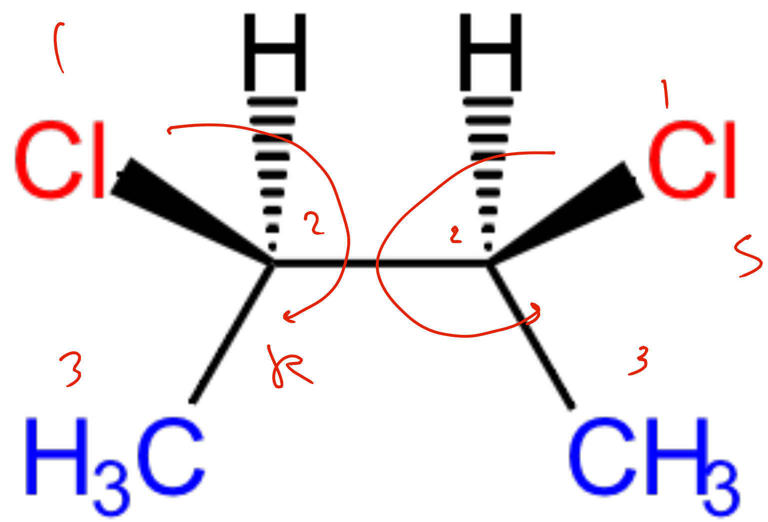




Fischer Projection

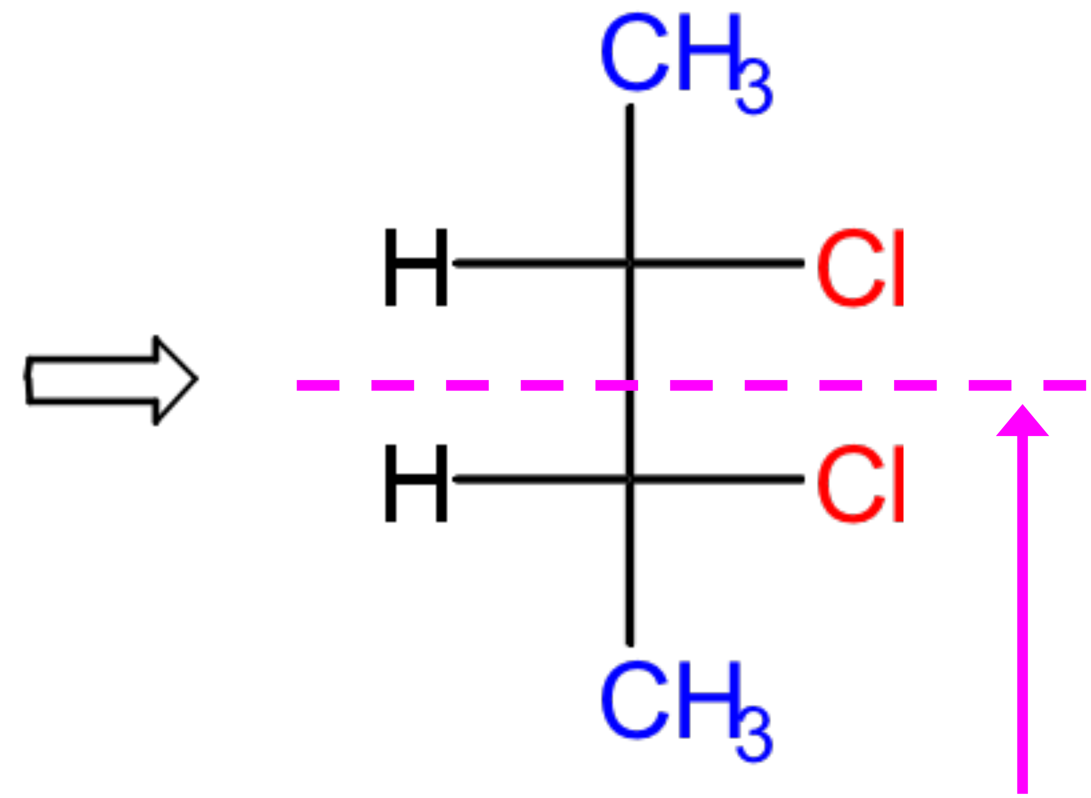


- (I) and (II) are both chiral and they are enantiomers with each other



(III)

(2*S*, 3*R*)-Dichlorobutane

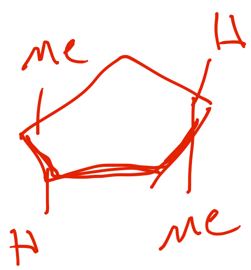


- (III) is achiral (a meso compound)
- (III) and (I) are diastereomers to each other

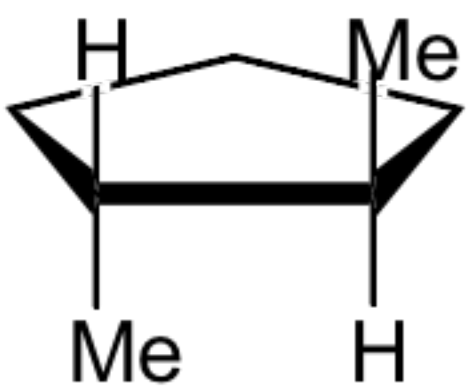
12. Stereoisomerism of Cyclic Compounds

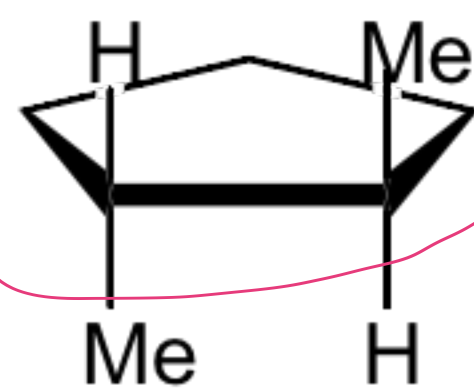
a meso compound
achiral

mirror

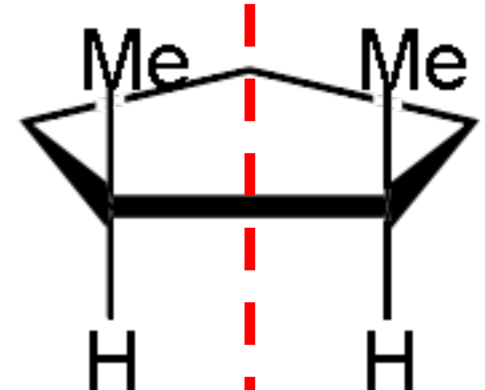


نفس
هذا المركب
لو لفيته





لو
لفيت
المركب
بزاوية رح
يعطي



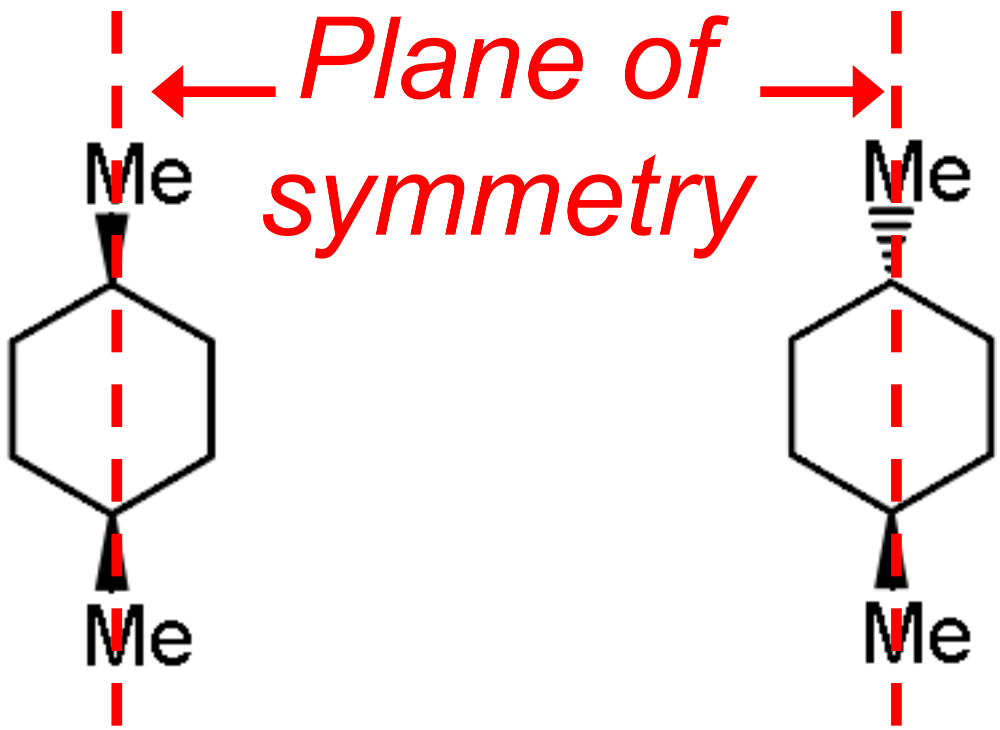
enantiomers

mirror
image

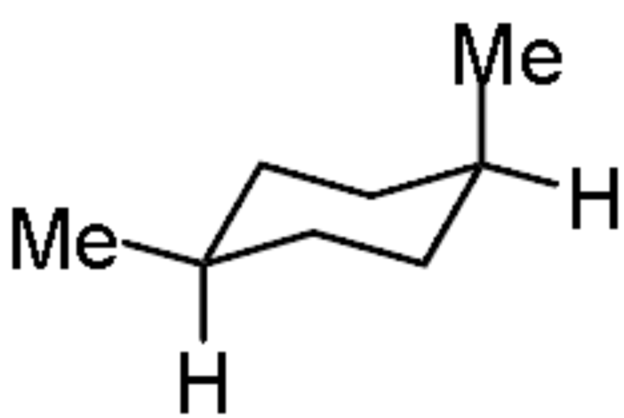
Plane of
symmetry

12A. Cyclohexane Derivatives

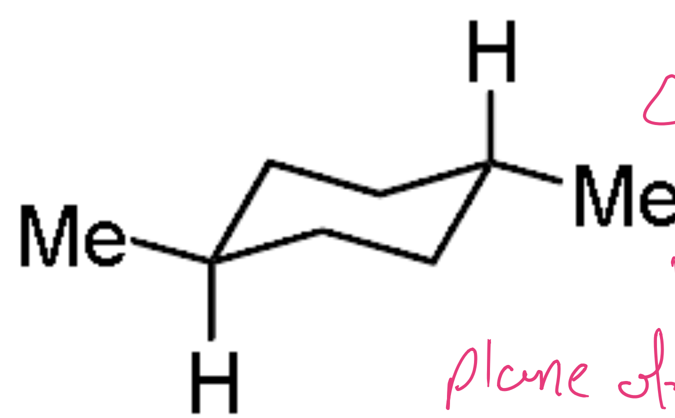
❖ 1,4-Dimethylcyclohexane



- Both *cis*- & *trans*-1,4-dimethylcyclo-hexanes are ***achiral*** and optically inactive



cis-1,4-dimethyl cyclohexane



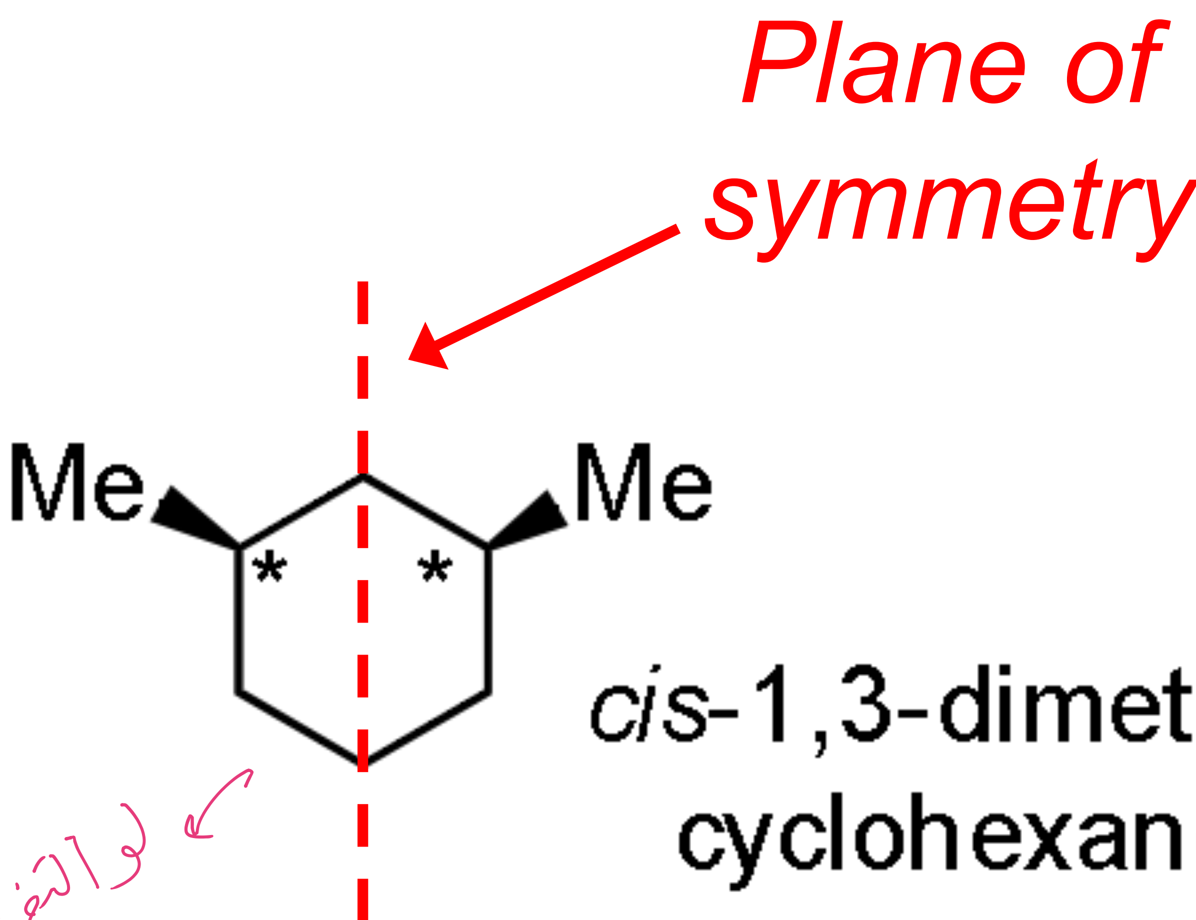
trans-1,4-dimethyl cyclohexane

في حال وجود chairal center يجب

في وجود plane of symmetry طالما

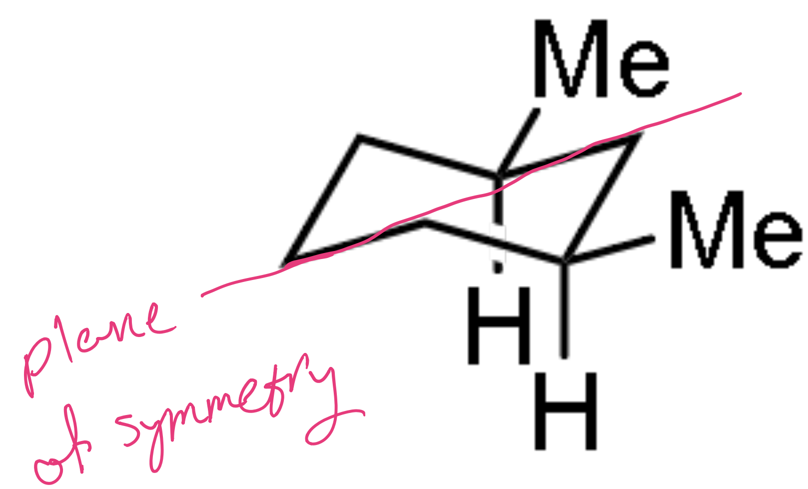
مافي chairal ما في plane of symmetry

❖ 1,3-Dimethylcyclohexane



cis-1,3-dimethyl cyclohexane

لو التفرعين بنفس الإتجاه ونقدر احط خط وبصير يجمع نعتبره meso

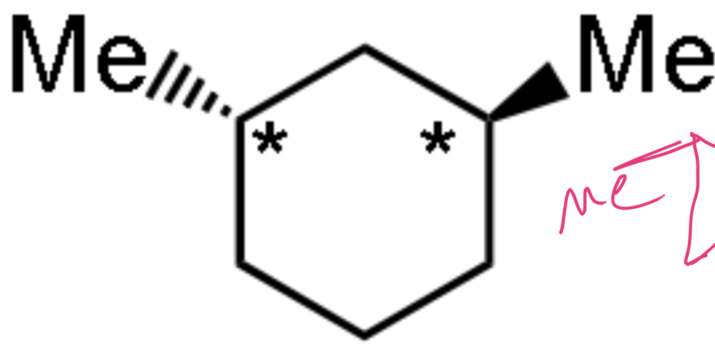


(meso)

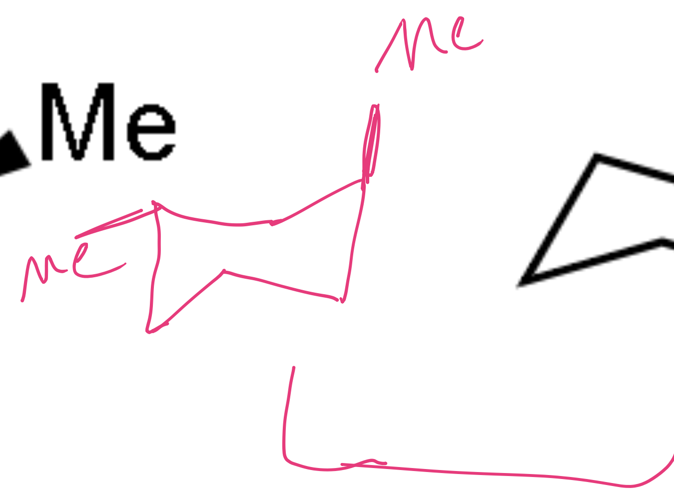
- *cis*-1,3-Dimethylcyclohexane has a plane of symmetry and is a meso compound

❖ 1,3-Dimethylcyclohexane

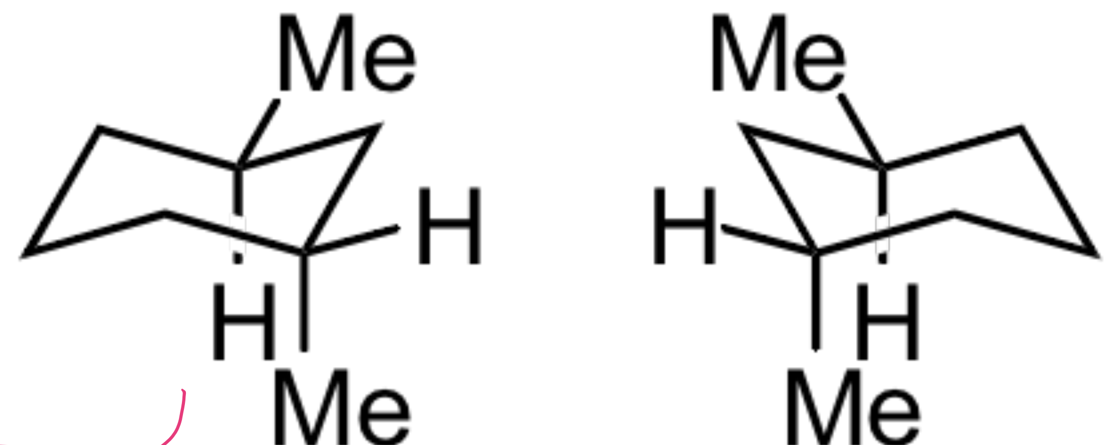
NO *plane of symmetry*



trans-1,3-dimethyl
cyclohexane



Ring flip



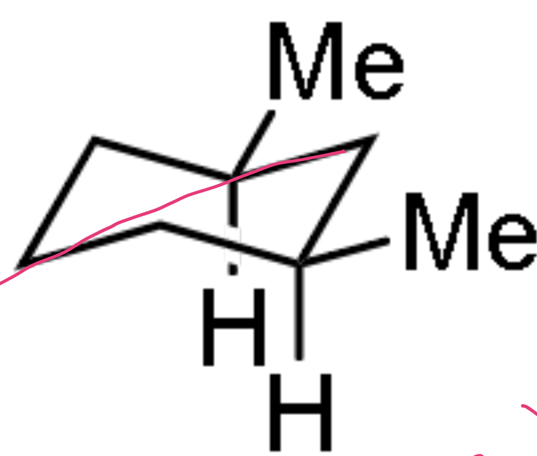
enantiomers

- *trans*-1,3-Dimethylcyclohexane exists as a pair of enantiomers

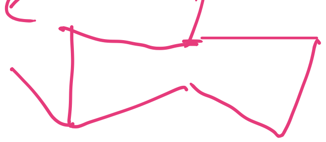
- 1,3-Dimethylcyclohexane
  - Has two chirality centers but only ***three*** stereoisomers

cis-1,3-dimethyl cyclohexane

فيه plane of symmetry



mirror image



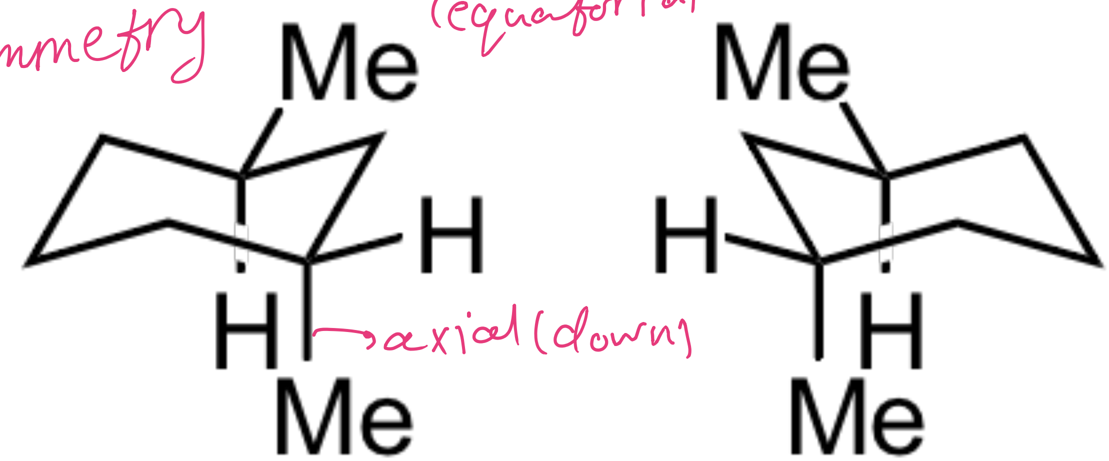
(meso)

relation is same

trans-1,3-dimethyl cyclohexane

لا يوجد plane of symmetry

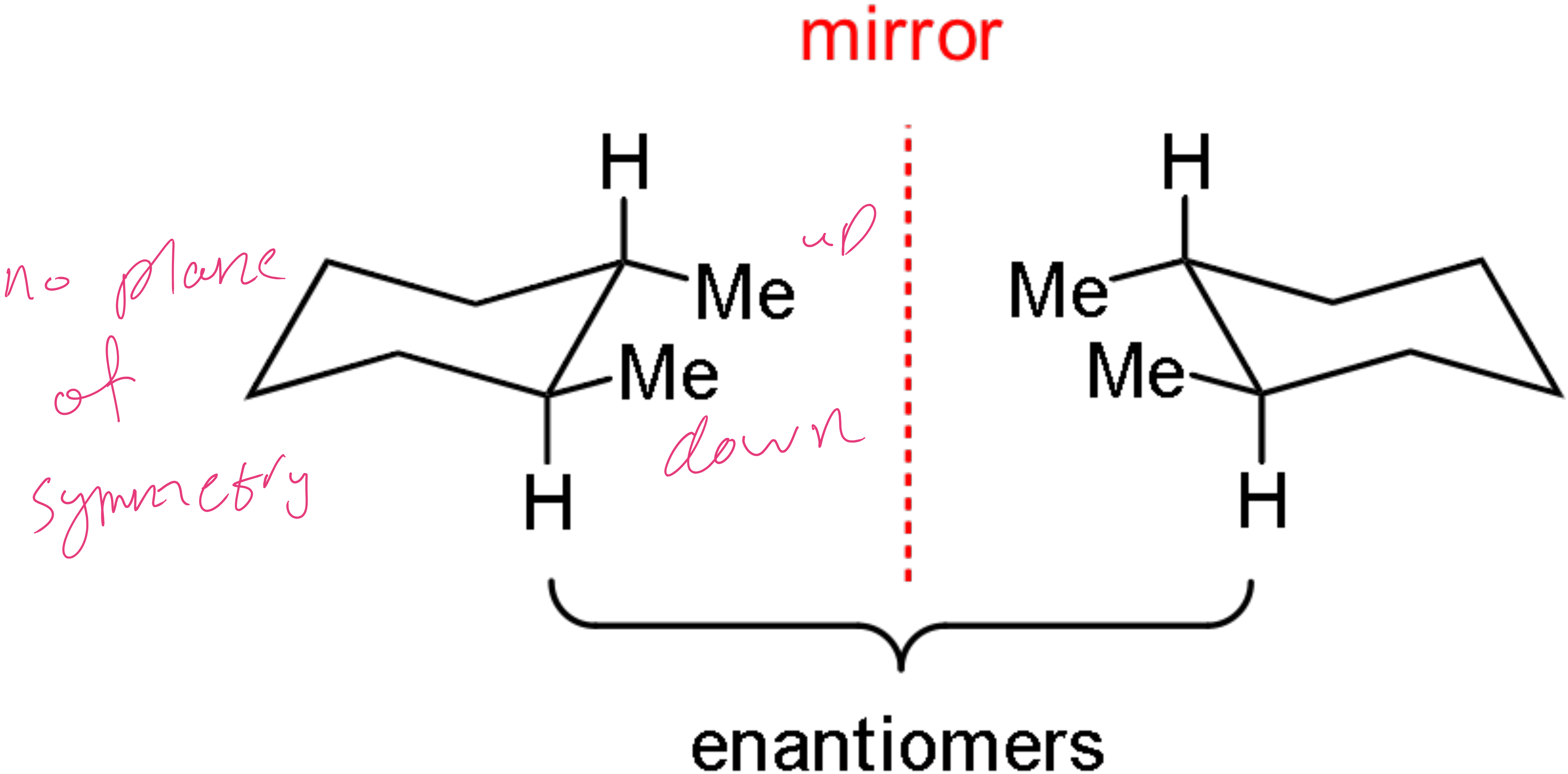
(equatorial up)



axial (down)

enantiomers

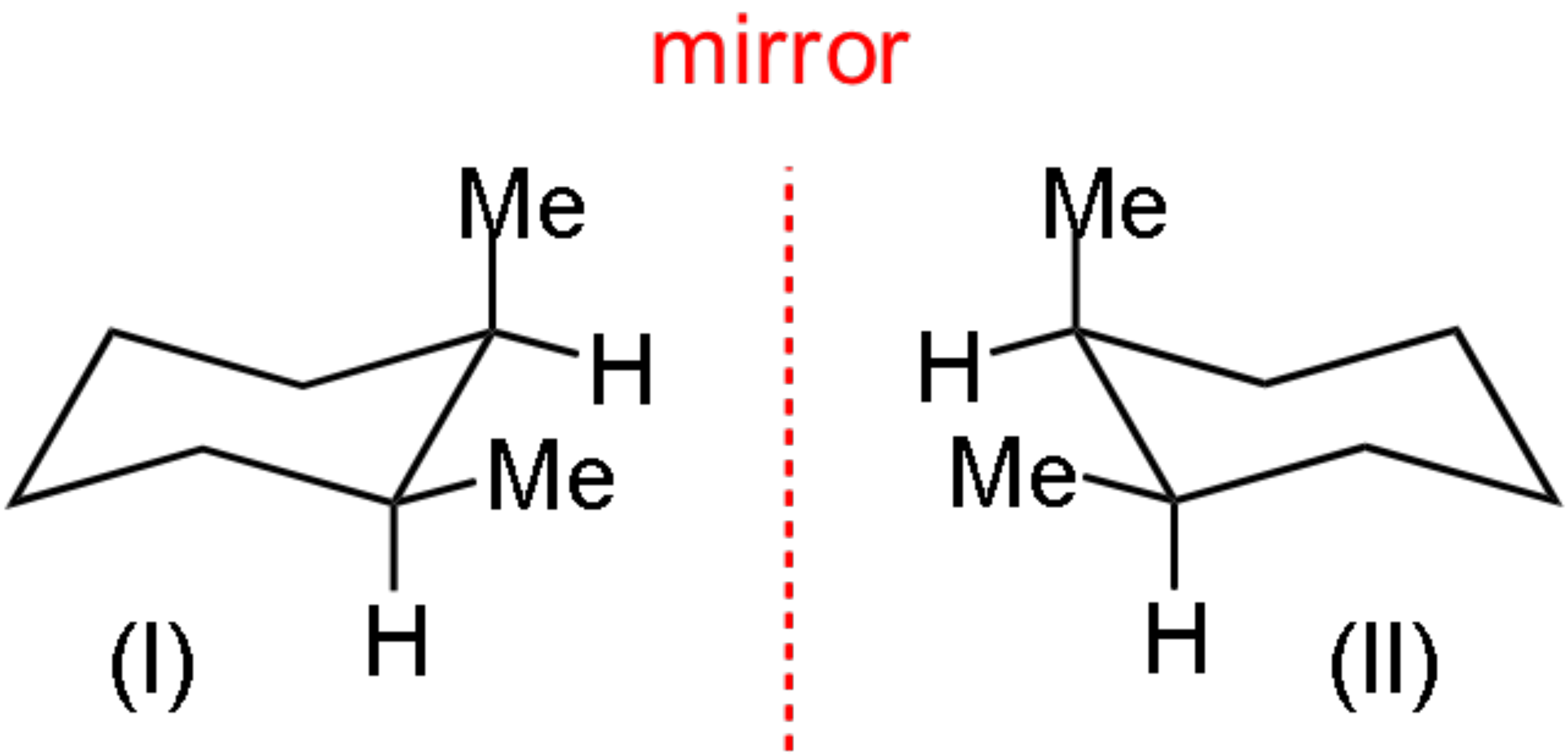
❖ 1,2-Dimethylcyclohexane



- *trans*-1,2-Dimethylcyclohexane exists as a pair of enantiomers

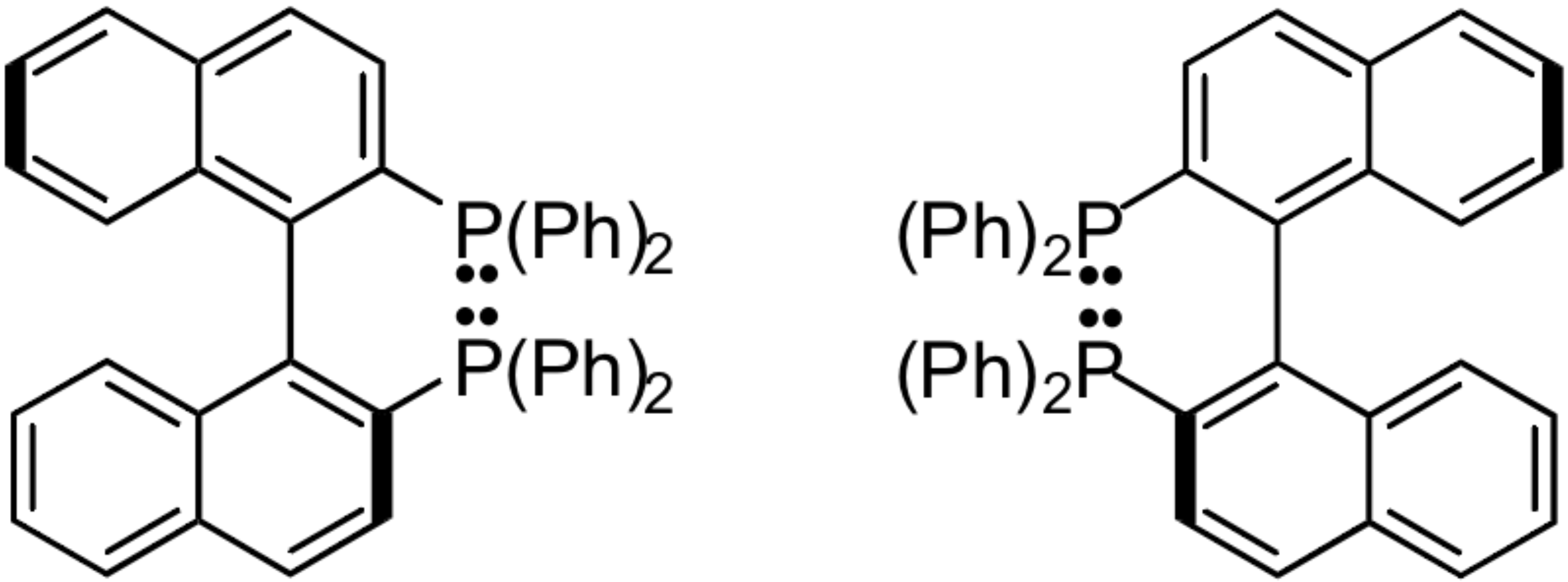
❖ 1,2-Dimethylcyclohexane

- With *cis*-1,2-dimethylcyclohexane the situation is quite complicated



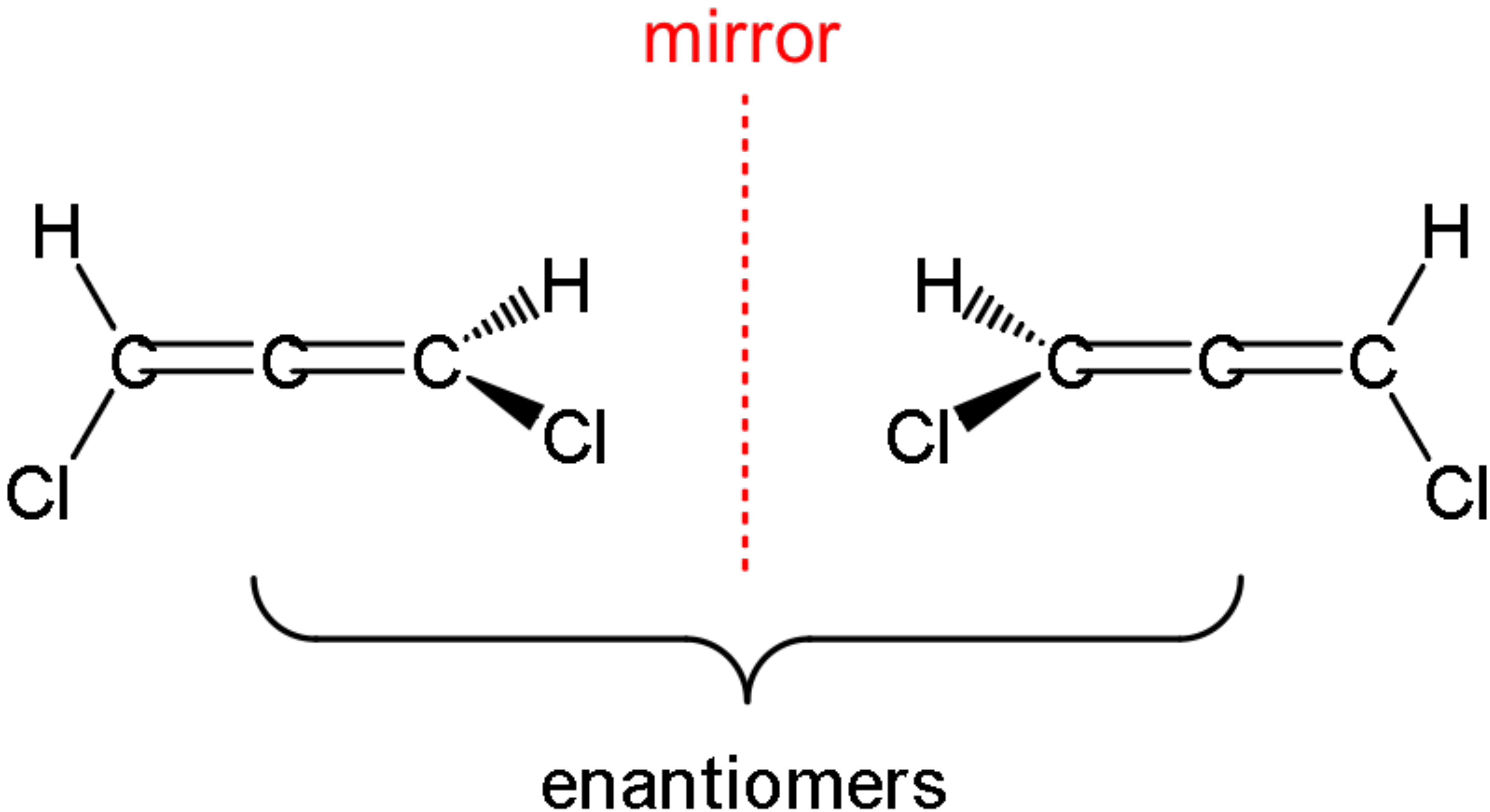
- (I) and (II) are enantiomers to each other

13. Chiral Molecules That Do Not Possess a Chirality Center



(*S*)-BINAP (*R*)-BINAP

enantiomers


mirror
H
H
Cl
Cl
H
H
Cl
Cl
enantiomers