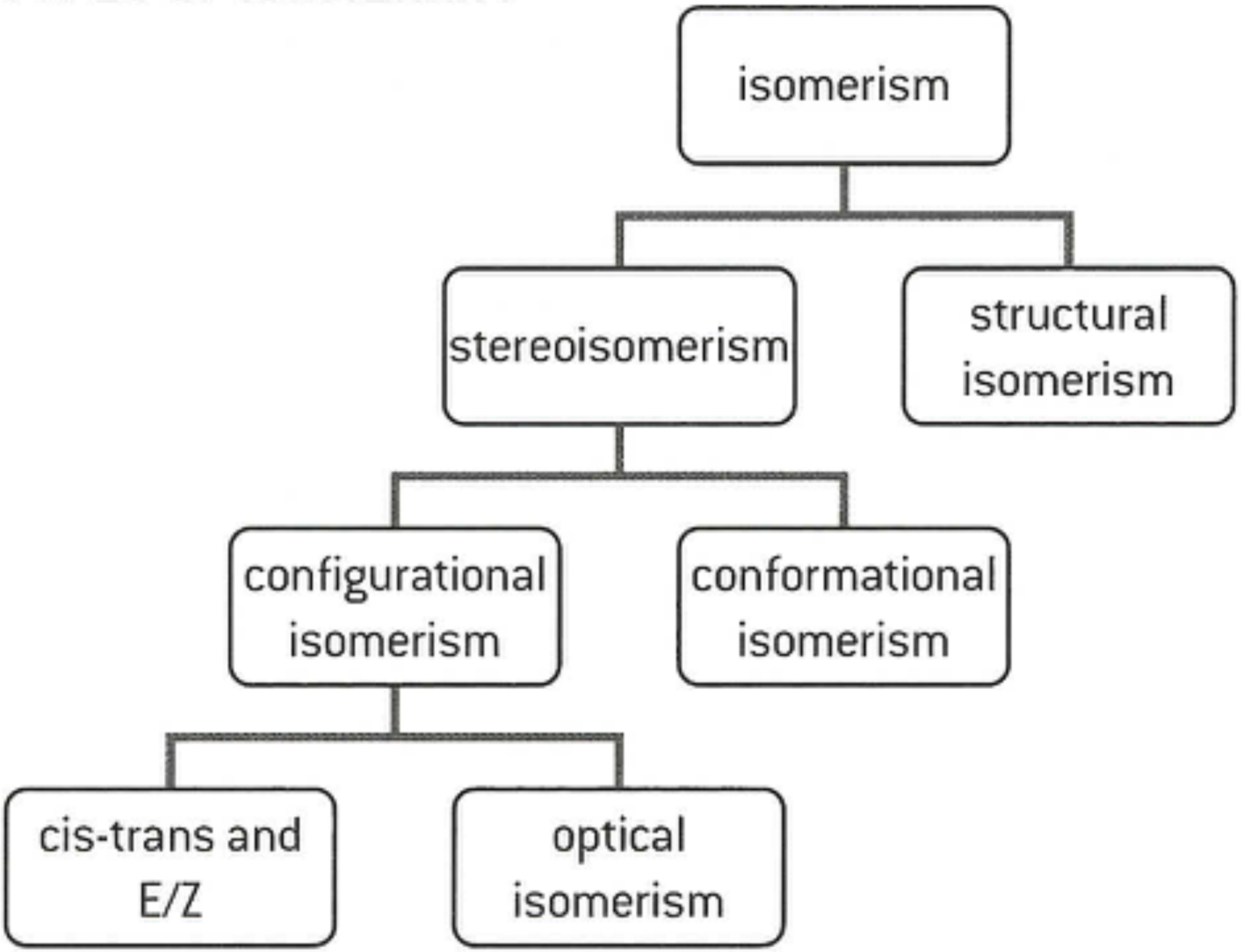
20.3 Stereoisomers

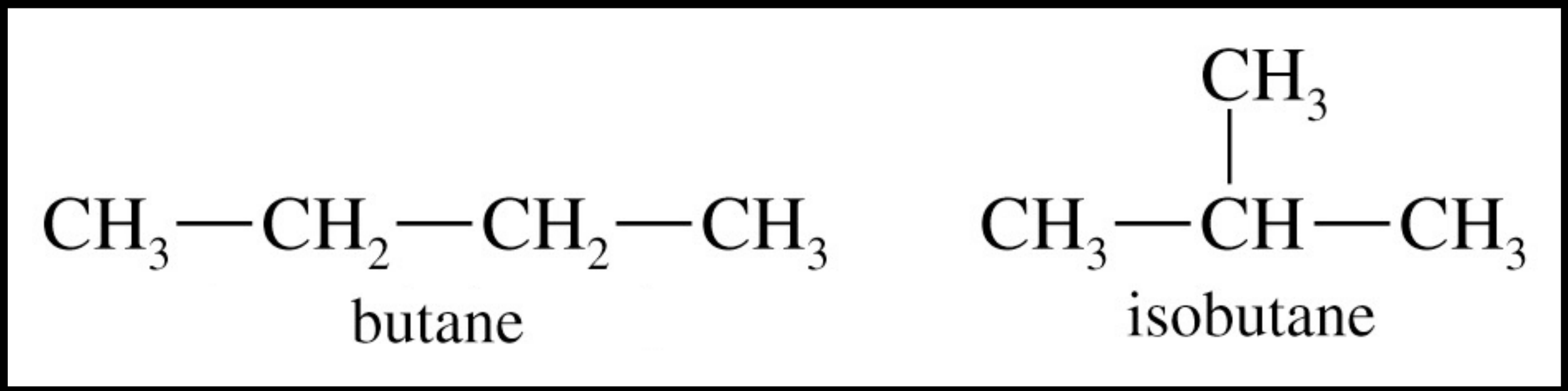
Isomers: molecules with the same molecular formula, but different structural formulas.

TYPES OF ISOMERISM



1.) Structural isomers have a different order of bonding:

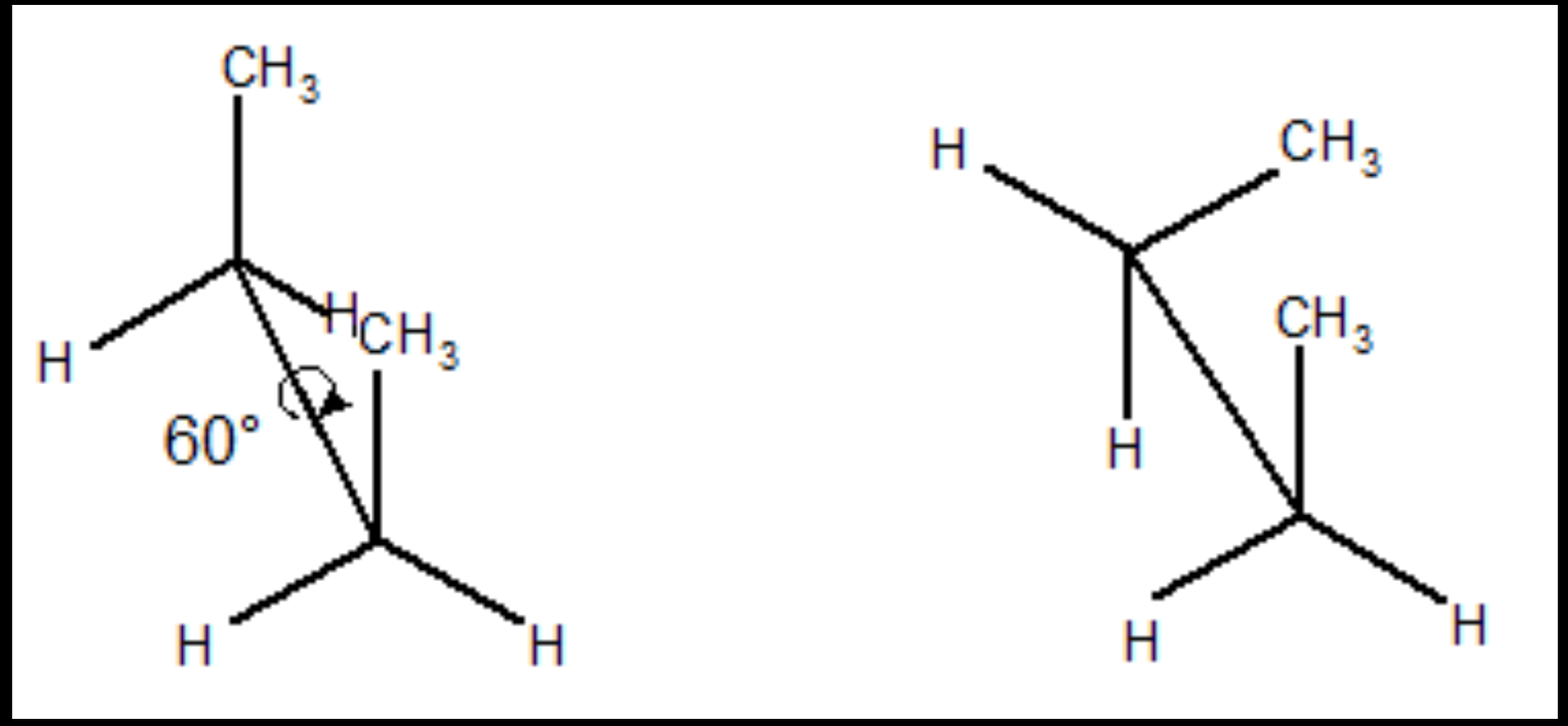
C_4H_{10}



2.) Stereoisomers have the same bonding, but differ in their arrangement in space.

<u>Two categories</u>

i. Conformational isomers interconvert by rotation about a sigma (single) bond.



ii. Configurational isomers can only be interconverted by the breaking of bonds.

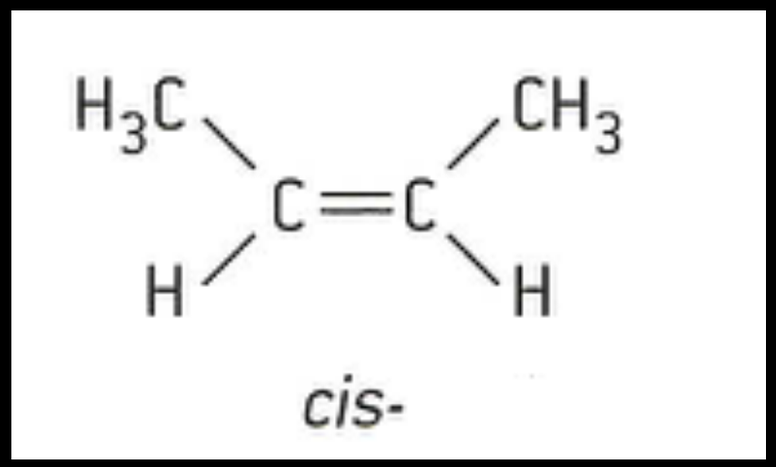
<u>Two classifications</u>

a. Cis-trans and E/Z
b. Optical isomerism

Cis-trans isomers:

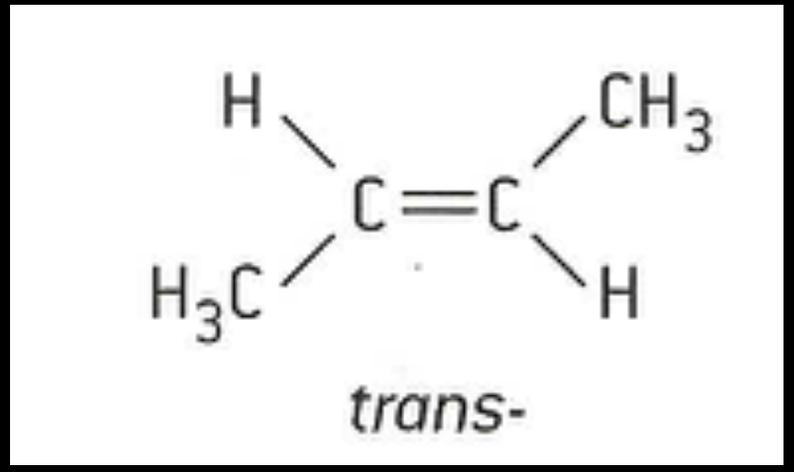
Isomers that differ in their arrangement about restricted bond rotation.

cis- Latin for "on this side"

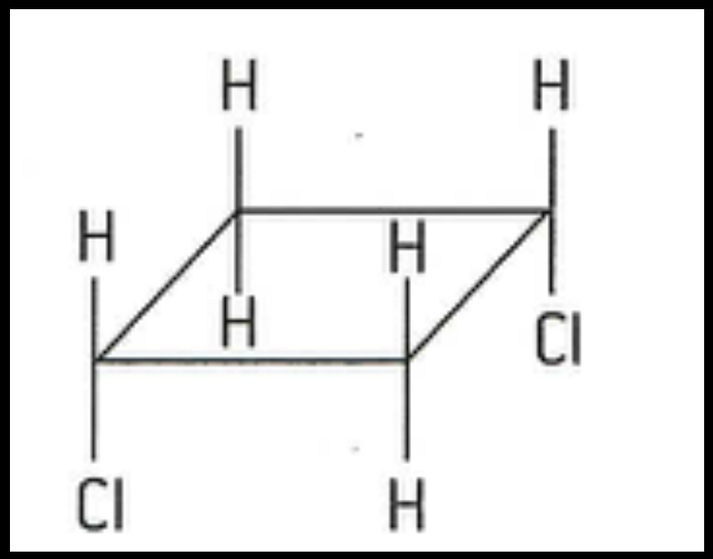


cis-2-butene (cis-but-2-ene)

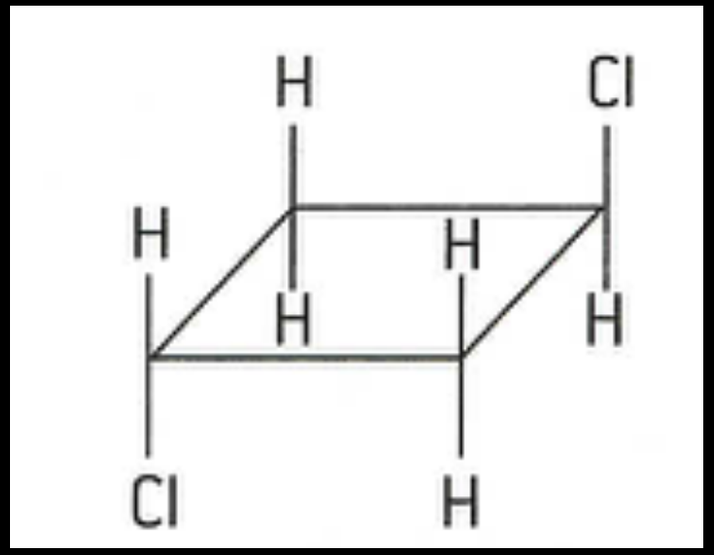
trans- Latin for "across"



trans-2-butene (trans-but-2-ene)



cis-1,3-dichlorocyclobutane



trans-1,3-dichlorocyclobutane

E/Z isomers:

Isomers based on the Cahn-Ingold-Prelog (CIP) rules which assign priority around a double bond based on the atomic numbers of attached atoms.

The higher the number, the higher the priority.

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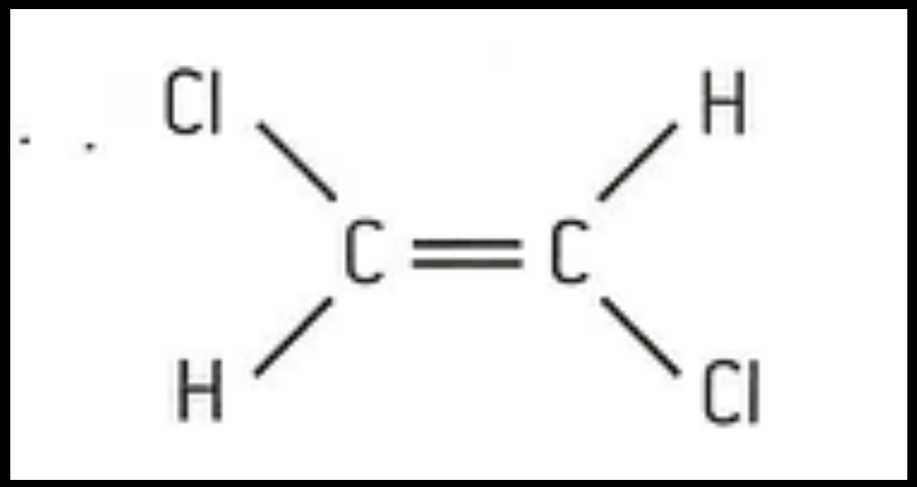
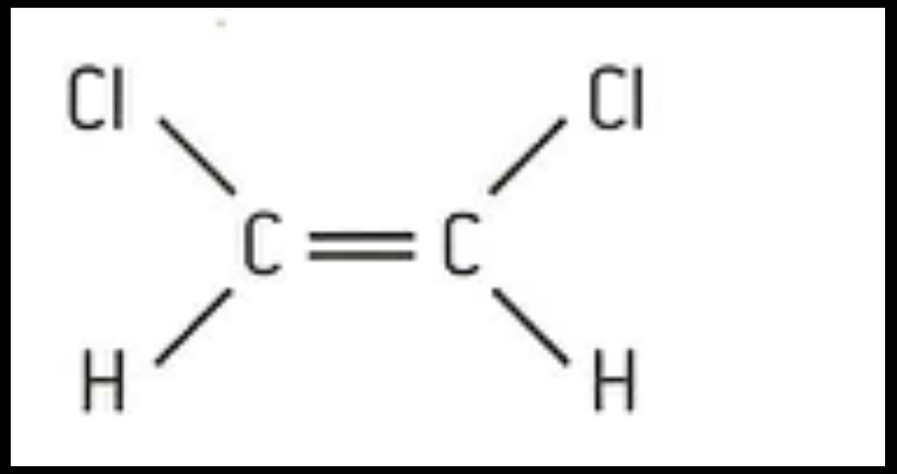
Here the chlorines have a higher priority (atomic #) than H



Chlorines on opposite sides: E

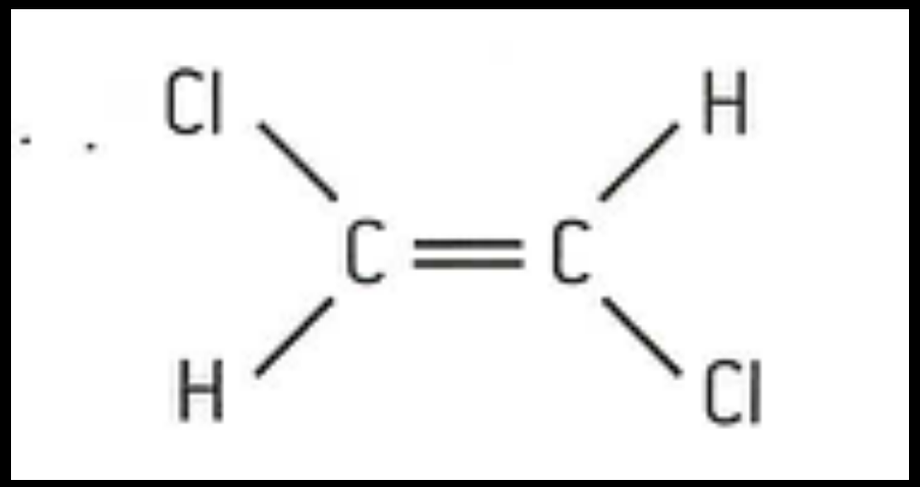


Both chlorines on the same side (together): Z

E and Z come from German words:

E from entgegen (opposite)

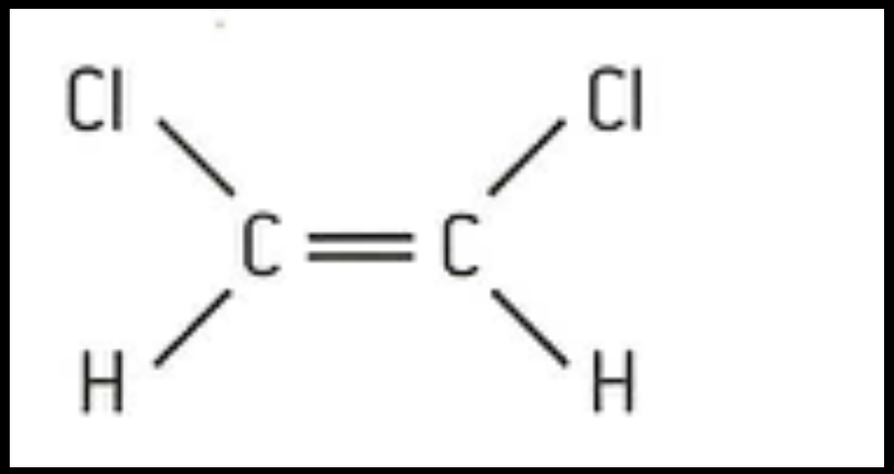
Z from zusammen (together)



[E]-1,2-dichloroethene

or

trans-1,2-dichloroethene

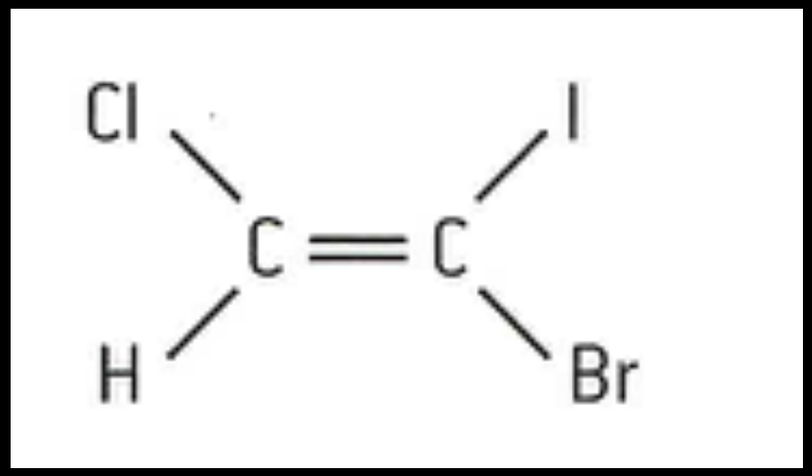


[Z]-1,2-dichloroethene

or

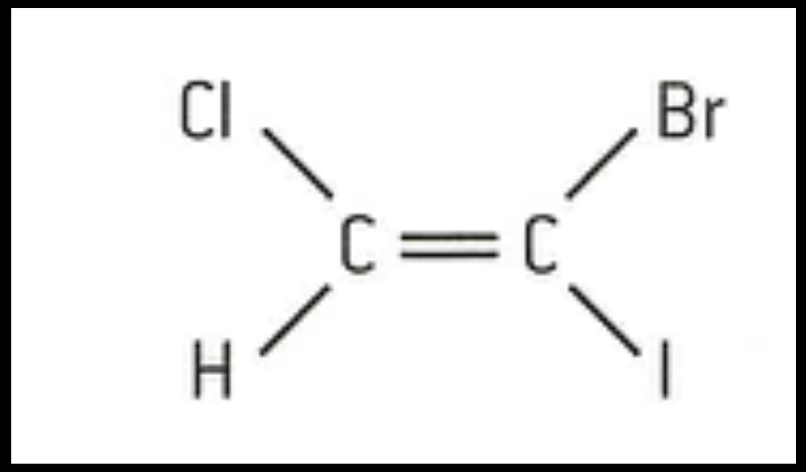
cis-1,2-dichloroethene

However, when all atoms around the double bond are different, only the E/Z system will work…



Here Cl and I have the highest priority (atomic #) on their respective carbons.

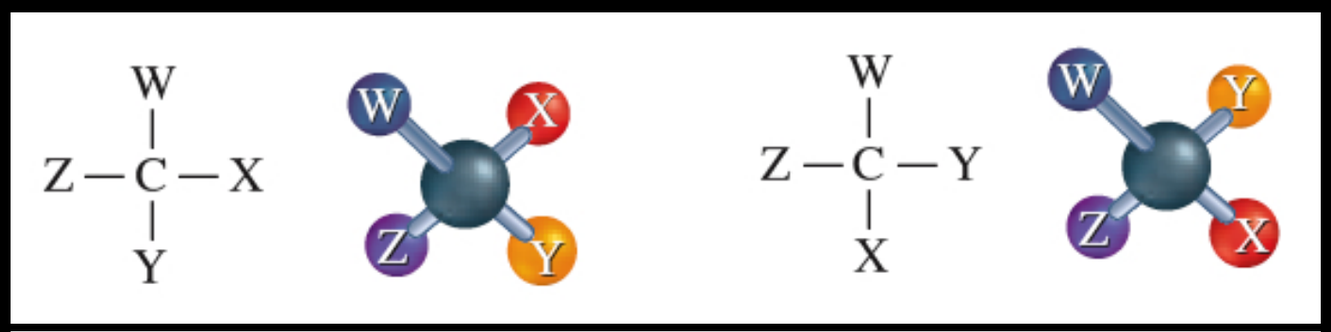
[Z]-1-bromo-2-chloro-1-iodoethene

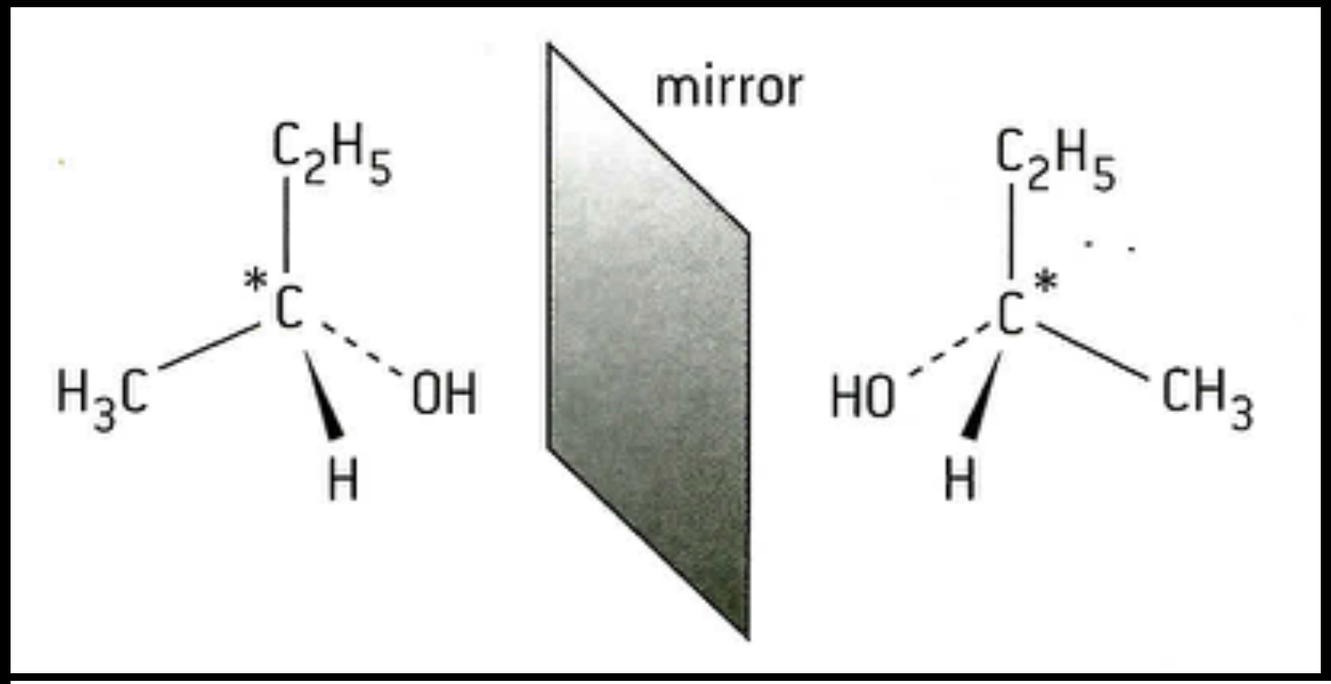


[E]-1-bromo-2-chloro-1-iodoethene

Optical isomers:

Isomers that have two possible arrangements of four different atoms or groups bonded to the same carbon atom.



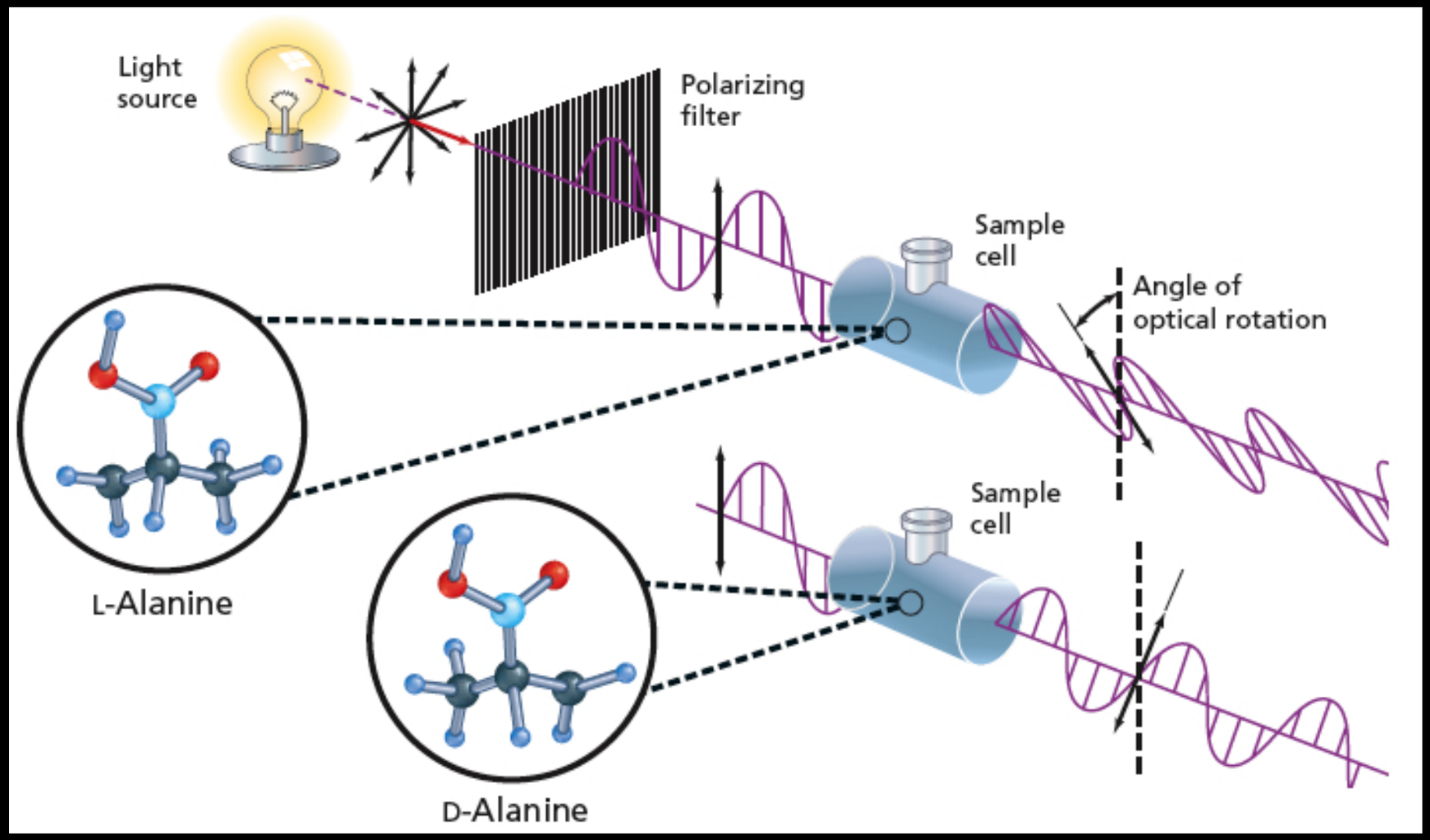


This will always occur whenever a carbon is bonded to four different atoms and/or groups.

This property is called chirality (from the Latin chiro, meaning "hand").

(* asymmetric carbon/chiral carbon/stereocentre)

Optical isomers will rotate polarized light:



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D-form (aka [+] form): clockwise rotation, from the Latin dextro (right)

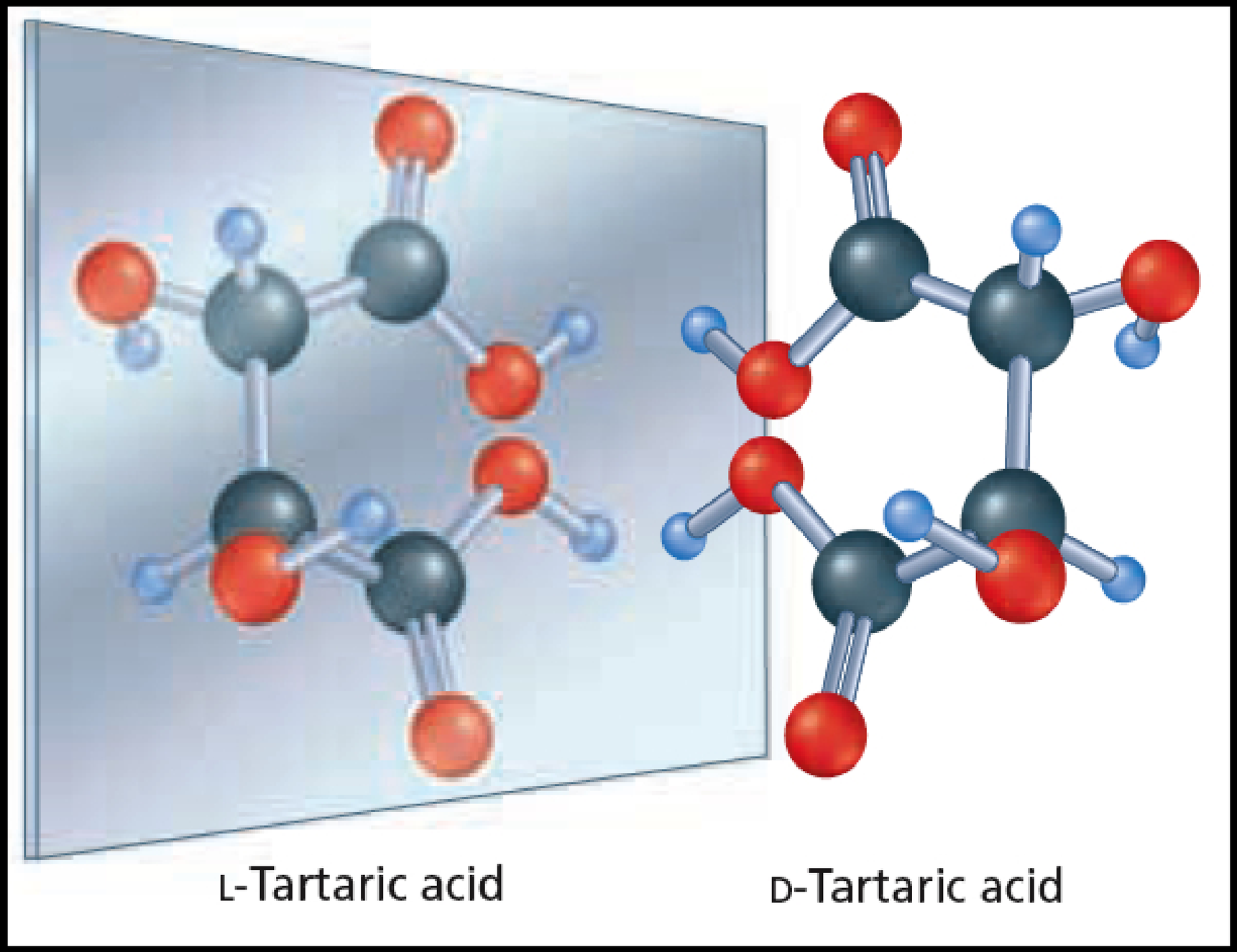
L-form (aka [-] form): counterclockwise rotation, from the Latin levo (left)

However,

> The symbols *d* (for dextro) and *l* (for levo) are now obsolete as stipulated by IUPAC and have been replaced by (+) and (−).

D-form (aka [+] form): clockwise rotation, from the Latin dextro (right)

L-form (aka [-] form): counterclockwise rotation, from the Latin levo (left)


L-Tartaric acid
D-Tartaric acid

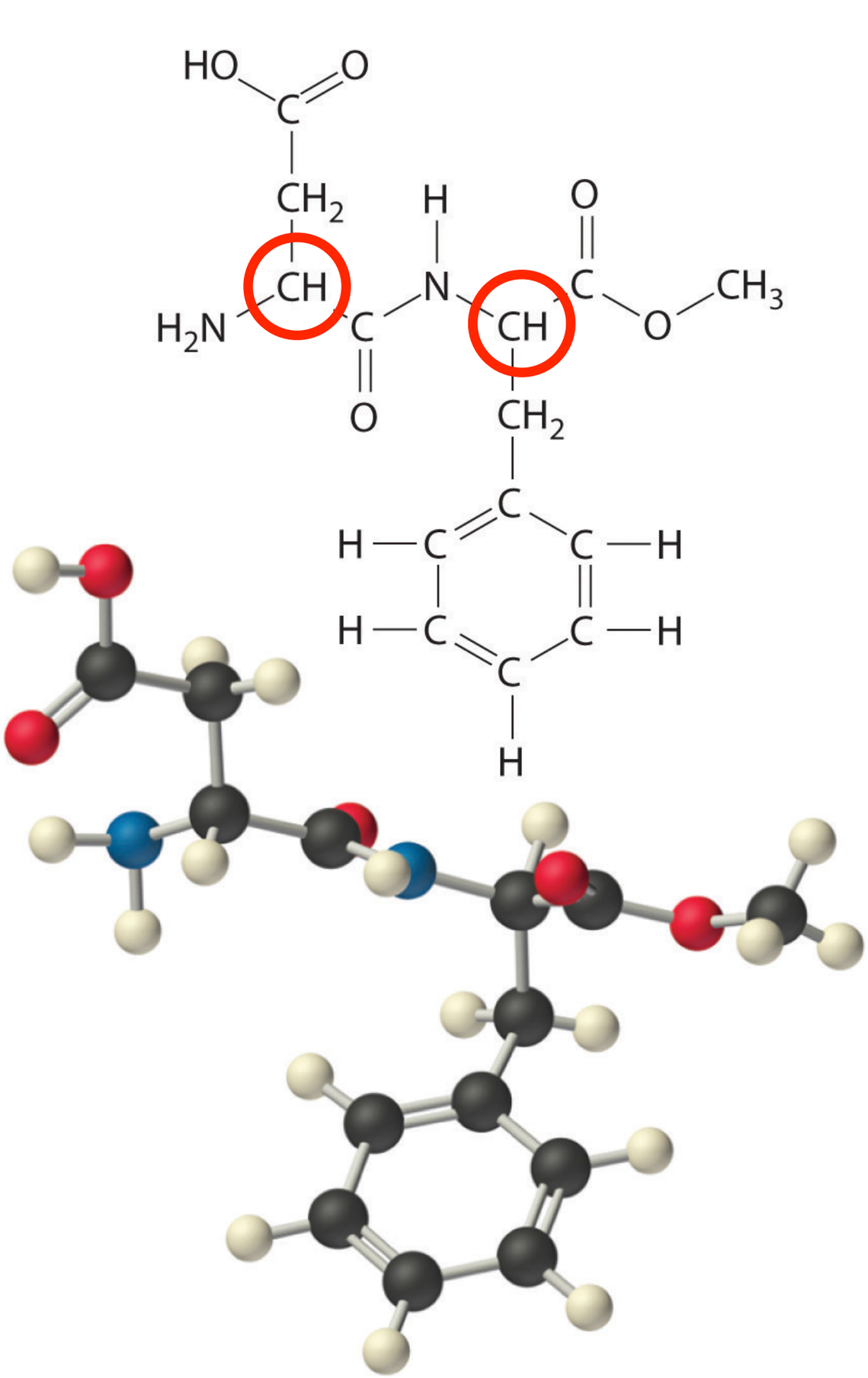
Optical isomers are called <u>enantiomers</u> (from the Latin enantio, meaning "opposite").

A <u>racemic mixture</u> contains equal amounts of two enantiomers and is optically inactive - i.e., each cancels the effect of the other.

Enantiomers have identical physical and chemical properties, but may have different physiological effects.

For example:

The artificial sweetener Aspartame is an optical isomer,
one of its enantiomers tastes sweet, the other bitter.



Aspartame

Aspartame is also an example of a <u>diastereomer</u>, a stereoisomer that has two or more chiral carbons.

Aspartame has two. Can you find them?

Note:
Diastereomers are not mirror images of each other.